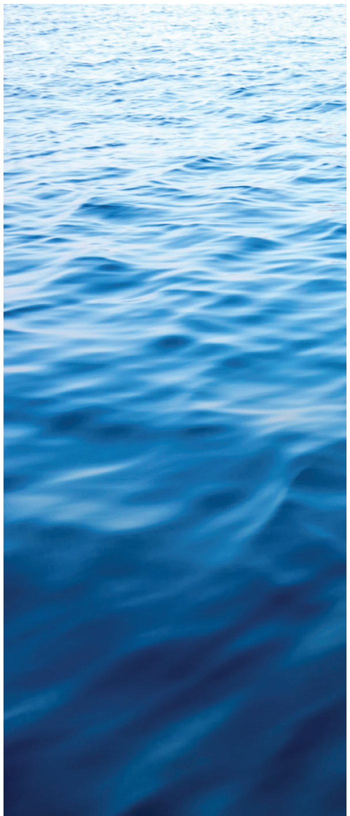

Environmental Impact Assessment

Gas to Energy Project

Esso Exploration and Production Guyana Limited

Volume I Environmental Impact Assessment

ERM

April 2022

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Acronym	Definition
°	degree
°C	degrees Celsius
%	percent
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
µm	micrometer
µmol/kg	micromoles per kilogram
µS/cm	microsiemens per centimeter
3D	three dimensional
4D	four dimensional
AC	alternating current
AIDS	acquired immunodeficiency syndrome
amsl	above mean sea level
AOI	Area of Influence
APE	Area of Potential Effects
API	American Petroleum Institute
Application	Application for Environmental Authorisation
AQS	air quality standard
AMSE	American Society of Mechanical Engineers
ASPT	average score per taxon
ASTM	American Society for Testing and Materials
AUV	automated underwater vehicle
barg	bars-gauge
BCA	bird concentration area
BDL	below detection limit
bgs	below ground surface
BLEVE	boiling liquid expanding vapor explosion
bmsl	below mean sea level
BMWP	biological monitoring working party score
BP	before present
BPD	barrels per day
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAPEX	capital expenditure
CARICOM	Caribbean Community
CARITRANS	Caribbean Transportation Consultancy Services Company Limited
C1	methane

Acronym	Definition
C2	ethane
C3	butane
C4	propane
C5+	pentanes+
CCPS	Centre for Chemical Process Safety
CDC	Community Development Council
CEMCO	Caribbean Engineering & Management Consultants Inc.
CGM	Community Grievance Mechanism
CH&PA	Central Housing and Planning Authority
CIA	cumulative impact assessment
CJIA	Cheddi Jagan International Airport
CLBD	Centre for Local Business Development
cm/s	centimeter per second
CMI	Caribbean Mariculture Inc.
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
Consultants	Environmental Resources Management, E&A Consultants, Inc., Caribbean Engineering & Management Consultants Inc., the University of Guyana Centre for the Study of Biological Diversity, Leon Moore Nature Experience; Caribbean Transportation Consultancy Services Company Limited; and SLR International Corporation
CORMIX	Cornell Mixing Zone Expert System
COVID-19	coronavirus disease 2019
CR	Critically Endangered (IUCN)
CSBD	University of Guyana Centre for Study of Biological Diversity
CSP	Construction Surveillance Plan
CTD	conductivity, temperature, and depth
CWMP	Comprehensive Waste Management Plan
dB	decibel
dBA	A-weighted decibel
DC	direct current

Acronym	Definition
DD	Data Deficient
DDMAC	didecyldimethylammonium chloride
DF	dilution factor
DO	dissolved oxygen
DP	Dynamic Positioning
DWBC	Deep Western Boundary Current
E&A	E&A Consultants Inc.
EBD	East Bank of Demerara [Public Road]
EBS	environmental baseline survey
EBSA	Ecologically or Biologically Significant Area
ECIA	Eugene F. Correira International Airport
EDIA	Economic Development Incubator and Accelerator
EEPGL	Esso Exploration and Production Guyana Limited
EEZ	Exclusive Economic Zone
EHS	environmental health and safety
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transparency Initiative
EN	Endangered (IUCN)
EP Act	Environmental Protection Act
EPA	Guyana Environmental Protection Agency
ERL	Effect Range Low
ERM	Environmental Resources Management
ERM	Effects Range Median
ESMMP	Environmental and Socioeconomic Management and Monitoring Plan
ESS	ecosystem services
ExxonMobil	Exxon Mobil Corporation
FEED	Front-End Engineering Design
FHWA	U.S. Federal Highway Administration
FOC	fiber optic cable
FPSO	Floating Production, Storage, and Offloading (vessel)
FTU	Formazine Turbidity Unit
FUND	International Fund for Compensation for Oil Pollution Damage, 1992
g/m^2	grams per square meter
GDP	gross domestic product
GEMSS	Generalized Environmental Modeling System for Surfacewaters
GGMC	Guyana Geology and Mines Commission
GGI	Greater Guyana Initiative
GHG	greenhouse gas
GIFT	Generalized Integrated Fate and Transport
GIIP	good international industry practice
GIS	geographic information system
GLSC	Guyana Lands and Surveys Commission
GMSA	Guyana Manufacturing and Services Association
GNBS	Guyana National Bureau of Standards
GOC	Guyana Office Complex
GPS	global positioning system
GSEIP	Guyana Secondary Education Improvement Project
GTE	Gas to Energy (Project)
GuySuCo	Guyana Sugar Corporation
GWI	Guyana Water Inc.
GYD	Guyanese dollar
GYSBI	Guyana Shore Base Inc.
H_2S	hydrogen sulfide
Handbook	Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets
HBL	Haags Bosch Landfill
HCIL	Hope Coconut Industries Limited
HDD	horizontal directional drilling
HFBI	Hilsenhoff Family Level Biotic Index
HIV	human immunodeficiency virus
IAQM	United Kingdom Institute of Air Quality Management
IBA	Important Bird Area
ICZM	Integrated Coastal Zone Management
ID	identification
IDB	Inter-American Development Bank
IFC	International Finance Corporation
ILO	International Labour Organization
IMO	International Maritime Organization

Acronym	Definition
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
kg/m^3	kilograms per cubic meter
km^2	square kilometer
KP	kilometer post
L/min	liters per minute
LADCP	Lowered Acoustic Doppler Current Profiler
LA_{eq}	A-weighted equivalent sound level
LA_{max}	A-weighted maximum sound level
LBI	La Bonne Intention
LC	Least Concern (IUCN)
LCDS	Low Carbon Development Strategy
L_{dn}	estimated day-night sound level
L_{eq}	A-weighted equivalent sound level
LFC	low-frequency cetacean
L_{max}	maximum sound level
LME	Large Marine Ecosystem
LMNE	Leon Moore Nature Experience
LMP	Liquid Mud Plant
LNG	liquefied natural gas
LOS	Level of Service
m^2	square meter
m^3	cubic meter
m^3/d	cubic meters per day
m^3/hr	cubic meters per hour
m^3/s	cubic meters per second
MARAD	Maritime Administration Department
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
MCL	maximum contaminant level
MFC	Mid-frequency cetaceans
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MICS	Multiple Indicator Cluster Survey
MLGRD	Ministry of Local Government and Regional Development
mm	millimeter
MMscfd	million standard cubic feet per day
$MMsm^3/d$	million standard cubic meters per day
MOC	North Atlantic Meridional Overturning Circulation
MOF	material offloading facility
MSDS	material safety data sheet
MW	megawatt
NAAQS	[U.S.] National Ambient Air Quality Standards
NAREI	National Agricultural Research and Extension Institute
NBC	North Brazil Current
NDC	Neighbourhood Democratic Councils
NEAP	National Environmental Action Plan
NEBA	Net Environmental Benefit Analysis
NECC	North Equatorial Counter Current
ng/L	nanograms per liter
NGL	natural gas liquids
NGO	non-governmental organization
NICIL	National Industrial and Commercial Investments Limited
NLUP	
NO_2	nitrogen dioxide
NOAA	U.S. National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NT	Near Threatened (IUCN)
NTU	Nephelometric Turbidity Unit
OCNS	Offshore Chemical Notification Scheme
ODU	optical distribution unit
OIMS	Operations Integrity Management System
OSRP	Oil Spill Response Plan
OWMS	Oilfield Waste Management Services
PAC	Project-Affected Communities
PAH	polycyclic aromatic hydrocarbons
PC	Project Contribution
PCB	polychlorinated biphenyl
PEC	Predicted Environmental Concentration
pH	potential of hydrogen
Phast	Process Hazard Analysis Software
PM	particulate matter

Acronym	Definition
$PM_{2.5}$	particulate matter with aerodynamic diameter of less than 2.5 micrometers
PM_{10}	particulate matter with an aerodynamic diameter of less than 10 micrometers
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
Project	Gas to Energy Project
PS	Performance Standard
PSC	Private Sector Commission
psi	pounds per square inch
PSO	Protected Species Observer
psu	practical salinity unit
PTS	Permanent Threshold Shift
PUC	Public Utilities Commission
RCNM	Roadway Construction Noise Model
RDC	Regional Democratic Council
RoW	right-of-way
RP	Recommended Practice
SBPA	Shell Beach Protected Area
SDB	Sea Defence Board
SEP	Stakeholder Engagement Plan
SES	Sustainable Environmental Solutions Guyana, Inc.
SHC	saturated and aliphatic hydrocarbons
SLR	SLR Consulting
SO_2	sulfur dioxide
sp.	species
SPAW Protocol	Protocol for Specially Protected Areas and Wildlife
SSCV	Subsea Check Valve
SSS	side-scan sonar
SURF	Subsea, Umbilicals, Risers, and Flowlines
SVOC	semi-volatile organic compound
TB	tuberculosis
TC	Town Council
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TRG	Tiger Rentals Guyana Inc.
TS	total solids
TSHD	trailing suction hopper dredger
TSS	total suspended solids
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	U.S. dollars
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USOS	Upper Slope and Outer Shelf
VC	Village Council
VEC	Valued Environmental and Social Component
VOC	volatile organic compounds
VSP	Vertical Seismic Profile
VU	Vulnerable (IUCN)
WBD	West Bank of Demerara [Public Road]
WHO	World Health Organization
WRF	Weather Research and Forecasting
WRI	World Resources Institute
WSG	Works Services Group
WWF	World Wildlife Fund
WWTP	wastewater treatment plant

GLOSSARY

This table lists key terms used in the Gas to Energy Project Environmental Impact Assessment, including terms defined in the Environmental Protection Act 1996 (as amended in 2005) used in a manner consistent with the definitions provided in the Act. Any changes from the express definitions used in the Act have been made for clarity purposes only and are indicated by brackets.

Term	Definition
activity	Industrial or commercial activity or activity of any other nature whatsoever, and for those purposes the keeping of a substance is to be regarded as an activity.
adverse effect	• Impairment of the quality of the natural environment or any use that can be made of it • Injury or damage to property or to plant or animal life • Harm or material discomfort to any person • An adverse effect on the health of any person • Impairment of the safety of any person • Rendering any property or plant or animal life unfit for use by human or unfit for its role in its ecosystem • Loss of enjoyment of normal use of property • Interference with the normal conduct of business
agriculture	Includes horticulture, fruit growing, seed growing, dairy farming, fish farming, the breeding and keeping of livestock (including any animal kept for the production of foot, closing or for the purpose of farming of land), the use of land as grazing land, meadow land, market gardens and nursery grounds, the use of lands for woodlands where that is ancillary to the farming land for other purposes the harvesting and utilization of forest resources, and aquaculture.
ambient air quality standards	Limits that define the allowable concentration of a particular contaminant in a given area
anthropogenic	Made by humans or attributable to human activity.
Application	An Application for an Environmental Authorisation made in accordance with regulation 4.
aqua regia digestion	Provides a strong partial digest, releasing into solution metals associated with the fines fraction within the sediments (but does not extract all trace elements associated with the coarse fraction).
artesian	Refers to situations where the groundwater is confined under pressure below low-permeability layers.
biogenic	Made by living organisms or attributable to the activity of living organisms.
biomagnification	Increasing concentration of a persistent substance, usually a pollutant or toxin, in the tissues of organisms at successively higher levels in a food chain.
circumtropical	Distributed throughout the world's tropical latitudes.
commerce	Of or pertaining to business, trade, or manufacture.
contaminant	Any solid, liquid, gas, odor, sound, vibration, radiation, heat, or combination of any of them resulting directly or indirectly from human activities that may cause an adverse effect.

Term	Definition
colonial waterbirds	Birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons).
commensal	Living in close association, such that one species benefits without harming the other.
congregatory	Tending to gather in large groups on a cyclical or otherwise regular and/or predictable basis.
cumulative impact	An impact that results from the successive, incremental, and/or combined effects of an action, project, or activity added to effects from other existing, planned, and/or reasonably certain actions, projects, or activities.
cuttings	Broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil.
decibel	A unit, which describes the sound pressure level or intensity of sound.
developer	The applicant for environmental authorization for a project or the State initiating a project.
discharge	The release of any liquid, solid or gaseous substance or a combination of them into the environment resulting directly or indirectly from human activities that may cause an adverse effect.
ecosystem services	The benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment.
effluent	Any liquid, including particles of matter and other substances in suspension in the liquid.
environment or natural environment	All land, area beneath the land surface, atmosphere, climate, all water, surface water, ground water, sea, seabed, marine and coastal areas and natural resources, or any combination or part thereof.
environmental authorization	An environmental permit, a prescribed process license, a construction permit, or an operation permit.
environmental impact assessment	An assessment as provided in [Part IV, Environmental Impact Assessments, of the Environmental Protection Act].
equipment	Apparatus, device, mechanism, or structure.
embedded control	Physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.
eutrophication	Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae.
fireball	A phenomenon that occurs when an instantaneous release of flammable material is ignited, resulting in a fire that is spherical and rises through the air due to the buoyancy of the hot combustion products.
flare	In the oil and gas industry, a system of piping and burners used to dispose (by burning) of surplus gas or vapors.
flash fire	A nonexplosive combustion of a flammable vapor cloud, which is diffused in open air; the duration of the fire is very short and depends on the mass of material in the cloud.
Floating Production Storage and Offloading (FPSO) vessel	A floating vessel that is used for offshore oil and gas operations and is designed to process hydrocarbons and store oil until the oil can be offloaded onto a tanker ship.

Term	Definition
free-field	A modeling term used to describe a release that is into open space and not into confined or congested areas.
freehold property	Property owned by the land user, not leased.
freshwater lenses	Vertically-separate layers of the water column that are formed near the surface of a marine environment when fresh (non-saline) water from rivers or rainfall enters a marine/saline waterbody. Freshwater is lighter and floats to the top of the saline water column, creating a layer (lens) of fresh, lower salinity water.
hazardous waste	A waste or combination of waste which, because of its quality, concentration, or physical, chemical, or infections characteristics, may pose a substantial hazard to human health and belong to any category contained in Schedule I [List of Hazardous Waste to be Controlled] unless they do not contain any of characteristics contained in Schedule II [List of Hazardous Characteristics] and includes waste that is: • Hazardous industrial waste • Acute hazardous waste chemical • Hazardous waste chemical • Severely toxic waste • Flammable waste • Corrosive waste • Reactive Waste • Radioactive waste • Clinical waste • Leachate toxic waste, or polychlorinated biphenyl waste, and includes a mixture of acute hazardous waste chemical, hazardous waste chemical, pathological waste, radioactive waste or severely toxic wastes, and any other waste or hazardous material
hazardous waste generation	The act or process of producing hazardous waste.
hazardous waste management	The systematic control of the collection, source, separation, accumulation, transportation, processing, treatment, recovery, and disposal of hazardous wastes.
high-probability landforms	In the context of cultural resources, areas assessed as having a high likelihood of containing significant cultural resources. These areas are generally identified by distinct landforms and deposits that have been shown in other similar surveys to contain archaeological sites, that environmentally could have served as optimal locations for habitation, or that have experienced limited disturbance.
holder	A person or corporate entity.
horizontal directional drilling	A trenchless method of installing underground piping along a prescribed underground path using a surface-based drilling rig.
hydrographic	Relating to the characteristic features (such as flow or depth) of bodies of water.
hydrostatic test	A way in which facilities such as pipelines, plumbing, gas cylinders, boilers, pressure vessels, and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurizing the vessel or pipe system to the specified test point. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.
hypoxia	The state of deficiency in dissolved oxygen concentrations.

Term	Definition
ichthyoplankton	Fish eggs and larvae that drift with the ocean currents, usually near the surface, prior to developing directional swimming ability.
improved sanitation facility	A facility that flushes or pour-flushes to a piped sewer system, a septic tank, a pit latrine, a ventilated improved pit latrine, or a pit latrine with slab.
improved water source	Any of the following types of supply: piped water into dwelling, compound, yard, to neighbor, or to public tap/standpipe; tube well/borehole; protected well; protected spring; and rainwater collection. Bottled water is considered an improved water source only if the household is using an improved water source for handwashing and cooking.
industrial	Of or pertaining to the manufacture, processing, handling, transport, importation, storage, or disposal of materials (including the extraction and conversion of mineral resources, raw materials, materials in the process of manufacture, manufactured materials, by-products, and any waste or water materials whether hazardous or not.
inland waters	Any reservoir, pond, lake, river, stream, creek, canal, drain, spring, well, a part of the sea that are on the landward side of the territorial baselines, and any other body of natural or artificial surface or subsurface water.
institution	Health care establishments, medical facilities, hospitals, schools, and zoos.
intelligent pigging	An inspection technique whereby an inspection probe, often referred to as a "smart" pig, is propelled through a pipeline while gathering data, such as the presence and location of corrosion or other irregularities on the inner walls of the pipeline.
isohaline	Areas in an aquatic system that have the same salinity.
itinerant	Moving from place to place.
jet fire	A combustion of flammable material as it is being released from a pressurized source.
judgmental shovel testing	Shovel testing (i.e., excavation of shallow pits to assess for the presence of archaeological resources) done in random locations outside of a systematic grid pattern or survey design. Such tests are commonly used to target high-probability landforms or specific site locations, or as a means of obtaining insight into the subsurface stratigraphy of a study area. In many cases, judgmental shovel testing may be employed to supplement pedestrian survey of areas with high ground surface visibility and/or severely disturbed deposits (e.g. agricultural fields), if it is deemed necessary.
labor force	The sum of employed persons and unemployed persons.
Lagrangian model	A type of model in which particles or parcels are moved under the influence of external forcing (winds, currents, buoyancy, turbulence, etc.) based on its individual location. The term is often used to differentiate such models from Eulerian models, where a field is established representing properties of interest (mass, concentration, etc.) in a discrete gridded space, and external forcing is applied to the entire property of that grid.
laydown area	An area that has been cleared for the storage of equipment and supplies.
leptocephalus	The flat and transparent larva of the eel, marine eels, and other members of the superorder Elopomorpha.
manifolds	Gathering points or central connections made up of valves, hubs, piping, sensors, and control modules.
marine safety exclusion zone	A specific area of water where persons, vessels, and other activities are prohibited as the area has been designated for exclusive use by an activity; a

Term	Definition
	form of safety control measure used to keep unauthorized persons and vessels away from a higher risk activity/event.
Material offloading facility	A facility that is used to dock vessels transporting construction bulk materials and pre-fabricated modules.
mobile sources	Any source of air pollution other than stationary sources, including but not limited to motor vehicles, off-road vehicles, marine vessels, and aircraft.
natural gas	A highly compressible, highly expansible mixture of hydrocarbons, which at atmospheric conditions of temperatures and pressure are in a gaseous phase.
natural gas liquids	Components of natural gas that are separated from the gas state in the form of liquids.
natural resources	The living plants, animals and organisms, ecosystems, forests, waterways, soils, and other biological factors within the natural environment, and the geologic formations, mineral deposits, renewable and non-renewable assets, and the habitat of the living plants, animals, and organisms.
open-cut	A method of pipeline installation that involves opening up the surface of the ground to the required depth for installing a pipeline.
overpressure	The pressure caused by the shockwaves of an explosion.
parameter limit	The result of the analysis of any of the chemical factors which the [Guyana Environmental Protection Agency] may specify.
passive margin	An area where continents have drifted apart to become separated by an ocean. Passive margins are found at every ocean and continent boundary that is not marked by a strike-slip fault or a subduction zone.
person responsible	In relation to any project, enterprise, construction, or development, includes any person who owns, operates, or exercises economic power or control over at whose order or on whose behalf the project, enterprise, construction, or development will be or, as the case may be, is being undertaken.
photo-oxidation	The process of chemical breakdown caused by exposure to sunlight.
pig	A specially designed device that is placed in the flowline at a launcher at one end and pushed by pressure until it reaches a receiving trap or catcher at the other end. Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines and pipelines.
pollution of the environment or environmental pollution	Pollution of the environment by the release into the natural environment of any contaminant.
Project Footprint	Includes areas used for the Project on a long-term basis (i.e., for the life of the Project) as well as areas used on a temporary basis such as onshore construction laydown areas and marine and aerial routes transited by support vessels and aircraft during drilling, installation, and hook-up/commissioning stages.
reservoir	In the oil and gas industry, a porous and permeable sedimentary rock containing oil and gas.
shorebase	A land-based facility that provides logistical and material support.
shorebirds	Found mainly on beaches and mudflats between the low and high water marks and are typically migratory, using Guyana’s coastline during the course of their biannual migrations.
social cohesion	Refers to the strengths of relationships in communities and the sense of solidarity among families and communities.
sludge	Any viscous, semisolid, or residue generated from a process

Term	Definition
sound-making device	Any mechanism that is intended to, or which actually produces noise when operated or handled [Note: the remainder of the definition in the Act, which relates to musical sound, is omitted from this definition for the purposes of this EIA].
stationary source	Any source of air pollution that is produced by a fixed or stationary location, including but [not] limited to electrical installations.
transporter	Any person engaged in the transportation of hazardous waste.
trophic	Relating to a specific rank or position in the food chain.
waterfowl	Species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese).
worker camp	A building or group of buildings erected for shelter and/or temporary residence of workers and laborers, typically during the execution of a construction project or similar activity.
WYE connection	Used to combine two different branch lines into a single line. One of the branch lines typically enters at a 45-degree angle.

ENVIRONMENTAL IMPACT STATEMENT

EXECUTIVE SUMMARY

Esso Exploration and Production Guyana Limited (EEPGL), on behalf of itself and its co-venturers (Hess Guyana Exploration Limited and CNOOC Petroleum Guyana Limited), and in accordance with the Guyana Environmental Protection Act, is seeking an environmental authorization from the Guyana Environmental Protection Agency (EPA) for the Gas to Energy Project (GTE or Project). The Project will use an offshore resource (associated natural gas) produced from the Liza field in the Stabroek Block.

The Government of Guyana is pursuing a separate project to construct a power plant (the Power Plant) that would use a portion of this associated natural gas as a fuel source. Accordingly, EEPGL, at the request of the Government of Guyana, is proposing the Project to provide fuel for the Power Plant.

Accordingly, the Project will involve capturing associated gas produced from crude oil production operations on the Liza Phase 1 (Destiny) and Liza Phase 2 (Unity) Floating, Production, Storage, and Offloading (FPSO) vessels, transporting approximately 50 million standard cubic feet per day (MMscfd; 1.4 million standard cubic meters per day [MMsm^3/d]) of rich gas via a subsea pipeline and then an onshore pipeline to a natural gas liquids (NGL) processing plant (NGL Plant), treating the gas to remove NGLs for sale to third parties, and ultimately delivering dry gas meeting government specifications for use at the Power Plant.

The purpose of the Environmental Impact Assessment (EIA) is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL's Application for Environmental Authorisation for the Project. EEPGL conducted a robust public consultation program to both inform the public about the Project and to understand community and stakeholder concerns so this feedback could be incorporated and addressed in the EIA, as applicable.

The primary components of the Project include new connections to the existing Destiny and Unity FPSOs, an offshore pipeline, an onshore pipeline, an NGL Plant, and various ancillary facilities. These ancillary facilities include a temporary worker camp, a temporary material offloading facility (MOF), and a heavy haul road. The Project will use existing third-party support facilities such as shorebases, fabrication facilities, fuel supply facilities, and waste management facilities. The Project will also use ground-based vehicles, marine and riverine vessels, and helicopters to provide logistics support throughout all Project stages. EEPGL will use proven and good international industry practices and has incorporated many embedded controls into the overall Project design to reduce environmental and socioeconomic impacts.

Subject to receipt of environmental authorization. Construction will begin as soon as possible after receiving all necessary authorizations (with a target date of August 2022 for start of NGL Plant site preparation) and will take approximately 3 years. The combined offshore and onshore pipeline system is targeted to be ready to deliver rich gas by end of 2024, and the NGL Plant is targeted to be operational by mid-2025. The Project has a planned life cycle of at least 25 years).

The Project is expected to employ up to 800 workers at peak during the Construction stage, approximately 40 full-time equivalents workers during the Operations stage, and approximately 50 workers during the Decommissioning stage.

The planned Project activities are predicted to have **Negligible** to **Moderate** impacts on physical resources, **Negligible** to **Moderate** impacts on biological resources, and **Negligible** to **Moderate** impacts on socioeconomic resources—with a number of positive impacts on socioeconomic conditions.

In the case of physical resources, the higher significance ratings stem from potential Construction-stage impacts related to potential noise and dust impacts on residential properties in the portions of the onshore pipeline construction corridor that will be in close proximity to existing communities or isolated residences (approximately 3.5 kilometers of the approximately 25-kilometer onshore pipeline corridor).

In the case of biological resources, the higher significance ratings stem from potential Construction-stage impacts related to mortality and injury of marine benthic organisms from offshore pipeline installation.

In the case of socioeconomic resources, the higher significance ratings stem from potential impacts from infrequent and short-term periods of noise during Construction and Operations stages, potentially leading to increased stress-related mental health impacts for nearby residents. For cultural heritage resources, the higher significance rating will only apply if the Project is unable to avoid removal of the silk cotton tree identified in the temporary pipeline right-of-way (RoW) at Kilometer Point 4.1.

The significance ratings of these potential impacts are reduced through the suite of embedded controls that will be incorporated into the Project design and execution. These same embedded controls contribute to the lower significance ratings for the other potential impacts assessed for planned Project activities. Additionally, the Consultants have recommended a suite of mitigation measures to reduce potential impact significance to as low as reasonably practicable.

Unplanned events, such as a vessel fuel spill or a loss of integrity of Project infrastructure resulting in a fire or explosion, are considered unlikely to occur due to the extensive preventive measures employed by EEPGL; nevertheless, events such as these are considered in this assessment. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the nature and location of an unplanned event, as well as the ambient conditions (e.g., wind speed/direction, river flow conditions). The EIA describes (1) modeling of fuel spill scenarios to evaluate a range of possible spill trajectories and rates of travel, and (2) modeling of loss of process infrastructure integrity scenarios to evaluate a range of potential consequences from such an event.

Based on the limited volume of fuel that would likely be released to the environment in the unlikely event of a marine fuel spill from one of the offshore pipeline installation vessels or a support vessel, and the fact that marine diesel would weather (i.e., evaporate, degrade, and partition to the water column) very rapidly once in the ambient environment, the impacts from this type of an event would be expected to be short-term and limited in extent. Socioeconomic resources (e.g., to fisheries or shorelines) would only be expected if the spill occurred in the nearshore/shore crossing segments of the offshore pipeline.

In the case of a riverine spill, the same limited spill volume and rapid weathering would reduce the level and extent of potential impact. However, the constrained geography within the Demerara River would lead to a high likelihood of shoreline impact, with the length of shoreline oiled being a function of spill location and ambient river conditions (i.e., flow volume and tidal stage) at the time of the spill. This event, assuming a spill of the nature reflected in the modeled scenario, would therefore have a high likelihood of affecting biological and socioeconomic resources in the Demerara River and potentially along the shoreline adjacent to the river.

The magnitude of impact for either a marine or riverine fuel spill would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when biological resources are more abundant in the area affected by the spill). Effective implementation of EEPGL's Oil Spill Response Plan (OSRP; Volume III, Management Plans, of the EIA) would reduce the risk to resources primarily by efforts to protect shorelines from oiling.

With respect to a potential loss of integrity of Project infrastructure leading to a release of hydrocarbons—and potentially a fire or explosion—the EIA included a preliminary analysis of the potential consequences of such an event, including evaluation of multiple scenarios that could lead to an accidental release of hydrocarbons. The highest risk associated with this type of event would be associated with the portions of the onshore pipeline segment located in close proximity to communities (i.e., where human receptors would have the highest likelihood of being affected by the event). As with a potential fuel spill, EEPGL's primary focus is on prevention of such an event through the rigorous design, construction, and operations procedures that will be put in place. However, in the unlikely situation that such an event occurs, EEPGL will have an Emergency Response Plan (see the Environmental and Socioeconomic Management and Monitoring Plan [ESMMP] in Volume III, Management Plans, of the EIA) in place prior to introduction of natural gas into Project infrastructure, and EEPGL will conduct regular training and drills to facilitate Project readiness to address an emergency event of this nature.

Additional unplanned events, the likelihood of which are reduced due to the preventive measures that will be employed, could include a loss of integrity of the offshore pipeline; collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting marine birds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the NGL Plant. The impact extent from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL will put in place if such an event were to occur (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) would also serve to reduce the likely extent of impact.

It is recommended that all of EEPGL's planned embedded controls, as well as the mitigation measures described herein, and appropriate ESMMP components, including an OSRP (Volume III of the EIA), be adopted. With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Project is expected to pose only manageable risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

1. INTRODUCTION

This Environmental Impact Statement has been prepared for the GTE Project in accordance with the Guyana Environmental Protection Act (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), good international oilfield practice, EEPGL's standards, and the Project's Final Terms and Scope (21 September 2021) for the Project EIA.

The EIA was conducted by a team of consultants including Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in the preparation of EIAs for offshore oil and gas development projects; SLR Consulting; and the Guyanese consultancies Caribbean Engineering and Management Consultants (CEMCO), Leon Moore Nature Experience (LMNE), and the University of Guyana Centre for the Study of Biological Diversity (CSBD). ERM, SLR Consulting, CEMCO, LMNE, and CSBD are collectively referred to herein as "the Consultants."

1.1. PROJECT SPONSOR

EEPGL is the designated Operator of the Stabroek Block and is seeking authorization for the Project on behalf of itself and Hess Guyana Exploration Limited and CNOOC Petroleum Guyana Limited (EEPGL's "co-venturers"). EEPGL will be the operator of the Project and is used in this EIA to represent the joint venture. EEPGL is an indirectly owned affiliate of Exxon Mobil Corporation.

1.2. PROJECT CONTEXT

The Project will use an offshore resource (associated natural gas) produced from the Liza field in the Stabroek Block. The plan for each of EEPGL's EPA-approved FPSO facilities in Guyana has been to re-inject this gas into the underground oil formation to maintain reservoir pressures and promote oil recovery.

The Government of Guyana is pursuing a separate project to construct a power plant (the Power Plant) that would use a portion of this associated natural gas as a fuel source. Accordingly, EEPGL, at the request of the Government of Guyana, is proposing the Project to provide fuel for the Power Plant. The Power Plant will not be owned and operated by EEPGL and is being proposed by a separate proponent under a separate Environmental Authorisation process. The Power Plant thus is not included in the Project within the EIA (with the exception that the Power Plant is considered as part of the cumulative impact assessment).

1.3. PURPOSE OF THE PROJECT

The purpose of the Project is to utilize a portion of the associated gas produced as part of the Liza Phase 1 and Liza Phase 2 development operations to produce NGLs and dry natural gas to for use by third parties, including the Government of Guyana, who plans to use the dry natural gas to generate electricity for the benefit of Guyana, reducing the country's dependence on foreign imports of diesel fuel (heavy fuel oil) for power production.

1.4. REGULATORY FRAMEWORK AND PURPOSE OF THIS EIA

To develop the Project, EEPGL has applied for a Project environmental authorization from the EPA in accordance with the Guyana Environmental Protection Act (as amended in 2005). To that end, EEPGL filed its application with the EPA on 24 June 2021 (Application). As part of its regulatory role, the EPA, taking into consideration recommendations from the Environmental Advisory Board and other government entities, is responsible for deciding whether and under what conditions to approve EEPGL's Application. Based on an initial assessment of the Project, the EPA determined that an EIA is required. The purpose of the EIA is to provide the factual and technical basis required by EPA to make an informed decision on EEPGL's Application.

2. PROJECT DESCRIPTION

The Project includes the construction and operation of a natural gas pipeline from the Liza Phase 1 (Destiny) and Liza Phase 2 (Unity) FPSO vessels via a subsea and then onshore natural gas pipeline to an onshore NGL Plant. The pipeline will transport up to approximately 50 MMscfd of dry gas to the NGL Plant. The NGL Plant will drop the pressure of the gas; dehydrate the gas; separate out the NGLs (i.e., propane, butane, and pentanes+) for sale to third parties; and treat the remaining "dry" gas to the specifications appropriate for use as fuel or raw materials by third parties.

The Government of Guyana's planned Power Plant will use at least some of the dry gas from the NGL Plant to generate electricity. The Power Plant will likely be owned and operated by the Government of Guyana, although the government may also consider alternative options for ownership and/or operation. For these reasons, the Power Plant, and any associated electric substations and transmission lines, are not included in the scope of this EIA, except for its consideration when addressing cumulative impacts.

Figure EIS-1 provides a schematic of the proposed Project facilities in relation to the Government of Guyana's planned Power Plant and electricity transmission components for context.

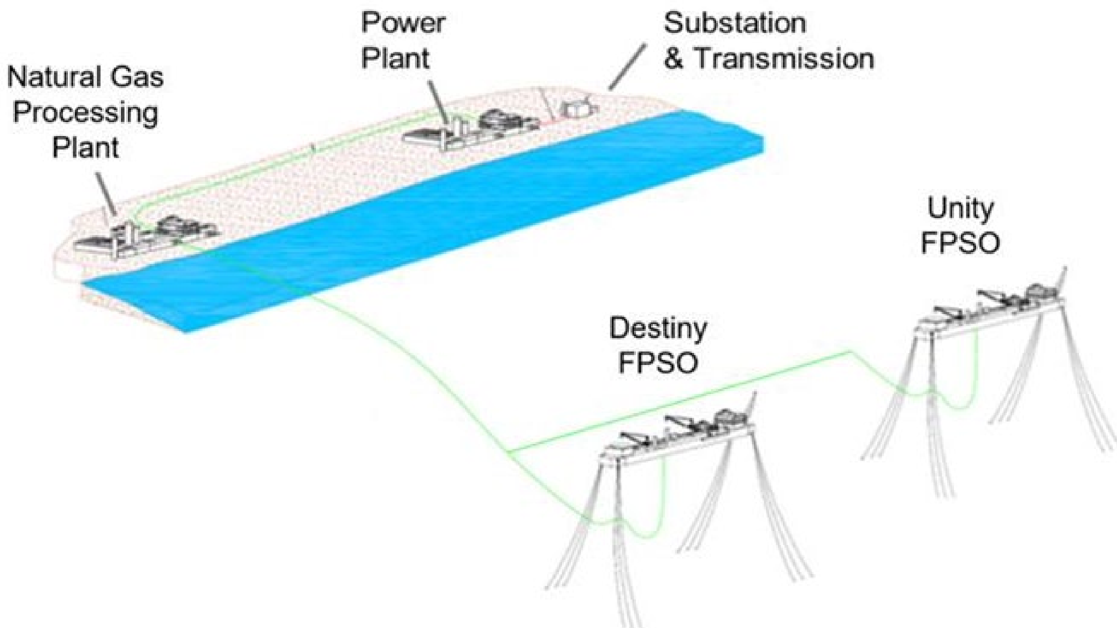

Figure EIS-1: Schematic of the GTE Project and Planned Government of Guyana Facilities

Also separate from the Project's Environmental Authorisation process, the EPA has issued a no-objection letter authorizing selected early works activities that will support the proposed construction activities for the Project. The approved early works relate primarily to the upgrading, rehabilitation, and repair of approximately six bridges and approximately 11 kilometers of roads along the West Bank of Demerara (WBD) Public Road from the village of Patentia south toward the NGL Plant site to provide improved access to the site. The early works activities will also include the establishment of an approximately 5-hectare laydown area to stockpile aggregate, which is needed for the early works road improvements. All road and bridge improvements are expected to generally remain within the existing road RoW. These early works activities are essentially maintenance of existing facilities and are described here simply to present a full description of other activities that will be conducted to support the proposed Project-related activities. In addition to supporting the needs of the Project, these improvements are expected to result in improved vehicular access and enhanced safety for residents in this area, who currently only have dry-season vehicular access in some areas because of poor existing road conditions. Since these early works activities are subject to a separate EPA approval—and will not result in any significant adverse environmental or social impacts, they are not discussed in the EIA.

The proposed Project facilities will be comprised of the following primary components, located as follows (Figure EIS-2):

- Offshore pipeline—an offshore component that involves approximately 220 kilometers of a subsea pipeline extending from new subsea tie-ins at the Destiny and Unity FPSOs in the Stabroek Block to a proposed shore landing, located approximately 3.5 kilometers west of the mouth of the Demerara River.
- Onshore pipeline—an onshore pipeline, which is a continuation of the offshore pipeline, that extends linearly approximately 25 kilometers from the shore landing to a proposed NGL Plant.
- NGL Plant—the NGL Plant and associated infrastructure (e.g., heavy haul road, temporary MOF, and worker camp) located approximately 23 kilometers upstream from the mouth of the Demerara River on the west bank.

All of these facilities are located within Region 3 of Guyana. Some existing facilities within Region 4 (e.g., shorebases, heliport, roads) will also be used to support Project activities, principally related to transporting equipment, supplies, products, and workers to and from the Georgetown area to the above locations of the Project components.

The Project life cycle will consist of three main stages: (1) Construction, (2) Operations, and (3) Decommissioning.

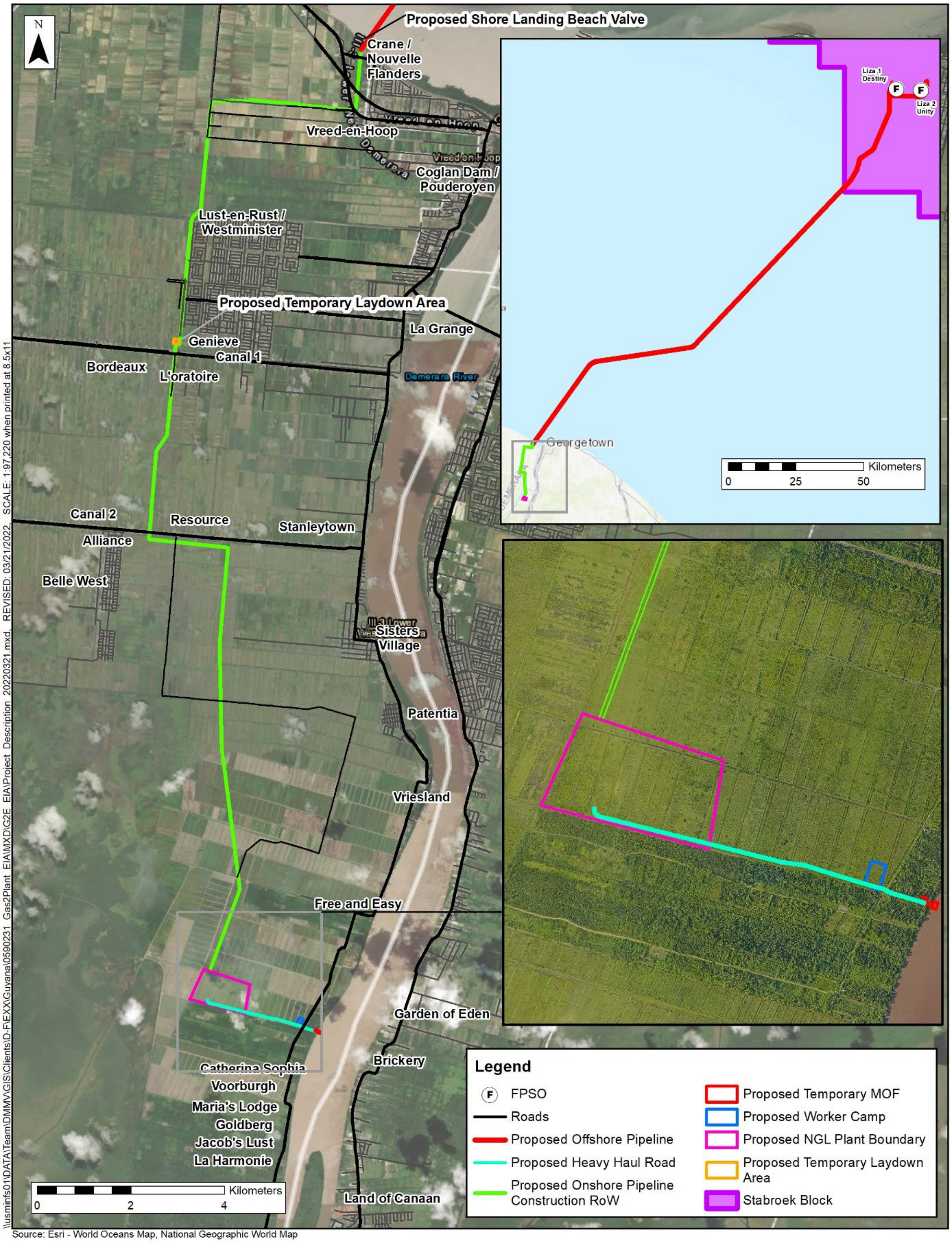

Figure EIS-2: Project Location

2.1. Project Land Requirements

Table EIS-1 shows the Project's estimated onshore land area required for the Construction and Operations stages. The onshore pipeline will require an approximately 23-meter-wide temporary construction RoW, which will be expanded in certain designated areas—primarily to accommodate the additional area needed for horizontal directional drilling (HDD) of the onshore pipeline beneath some features such as roads and canals. Typically, HDD entry and exit locations each require an area of 50 meters by 100 meters. The onshore pipeline permanent operational RoW will be approximately 12 meters wide.

There is no designated RoW for the offshore pipeline. The area of disturbance for the offshore pipeline installation will be a function of the equipment selected to install the offshore pipeline in the portions of the offshore pipeline where the pipeline will be buried. For the purpose of the EIA, it is envisioned that the width of the offshore pipeline trench will be on the order of 3 to 4 meters at the top of the trench.

As Table EIS-1 indicates, several of the Project features that will involve land use / disturbance are temporary and will only be occur during the Construction stage, including the portion of the onshore pipeline temporary construction RoW outside of the permanent RoW, as well as temporary laydown areas and HDD work areas along the onshore pipeline corridor, the worker camp, and the temporary MOF.

Table EIS-1: Estimated Project Onshore Land Requirements

Project Component	Temporary (Construction Stage) (hectares)	Permanent (Operations Stage) (hectares)
NGL Plant	75.0	75.0
Onshore Pipeline [a]	57.9	24.3
Heavy Haul Road	1.6	1.3
Temporary MOF	0.2	—
Worker Camp	1.9	---
Onshore Pipeline Temporary Laydown Area	1.0	---
Total [b]	137.5	100.6

[a] Temporary area includes construction RoW (22.9 meters) and HDD areas in the RoW.
[b] Totals may not match sum of components due to rounding for each component.

Approximately half of the Project land disturbance, including the majority of the NGL Plant site, is currently shrubland/swamp. The NGL Plant site, as well as most of the onshore pipeline RoW, is land that was formerly used for sugarcane cultivation by the Guyana Sugar Corporation (GuySuCo), a state-owned corporation. GuySuCo has stopped its sugarcane operation within the area, and much of the land now supports various pioneer plant species, which are generally 1 to 4 meters in height.

The onshore pipeline corridor traverses primarily active and inactive agricultural lands and herbaceous/grass swamp. Although the onshore pipeline route selection process was conducted to reduce routing through existing communities, the onshore pipeline route is in proximity to several communities, as identified on Figure EIS-2. There are no known residences within the NGL Plant site, but there is some subsistence sugarcane farming and cattle rearing occurring on and/or near the NGL Plant site. There are several residents in the immediate vicinity of the temporary MOF site.

2.2. NEW CONNECTIONS TO FPSOS

The Project will use the existing Destiny and Unity FPSOs which have pre-installed facilities to allow for gas export. These export facilities include the required piping, equipment (e.g., drains, pig launcher, associated instrumentation), and flow control elements (e.g., orifice flowmeter, flow control valves, associated control instrumentation) to support the Project. Given that the original design for each FPSO included provisions for gas export, the minor equipment upgrades in gas export equipment required on the two FPSOs to support the Project are limited.

Each FPSO will have the capability of exporting the full 50 MMscfd (1.4 MMsm^3/d) design gas flow for the Project, and will be able to control export rates to as low as 10 MMscfd (0.28 MMsm^3/d). The current plan is for the Destiny FPSO to typically provide approximately 30 MMscfd (0.85 MMsm^3/d) and the Unity FPSO to typically provide approximately 20 MMscfd (0.57 MMsm^3/d) of natural gas.

2.3. OFFSHORE PIPELINE

The offshore pipeline will extend from the Destiny pipeline end termination (PLET) to a shore landing point. An infield pipeline from the Unity FPSO, approximately 18 kilometers in length, will tie into the Destiny PLET. The offshore pipeline from the Destiny PLET to the shore landing will have a total length of approximately 195 kilometers (Figure EIS-3). A description of the proposed offshore pipeline segments (including the infield pipelines) at different water depths is provided in Table EIS-2.

Table EIS-2: Overview of Offshore Pipeline Segments

Segment	Approximate Water Depth (meters)	Approximate Length (kilometers)
Infield Pipelines (Deep)	1,400–1,700	23
Offshore Pipeline (Deep)	600–1,400	18
Offshore Pipeline (Intermediate)	20–600	130
Offshore Pipeline (Shallow)	1.6–20	34
Offshore Pipeline (Nearshore)	0–1.6	12
Shore Crossing	0	0.5
Total	—	217.5

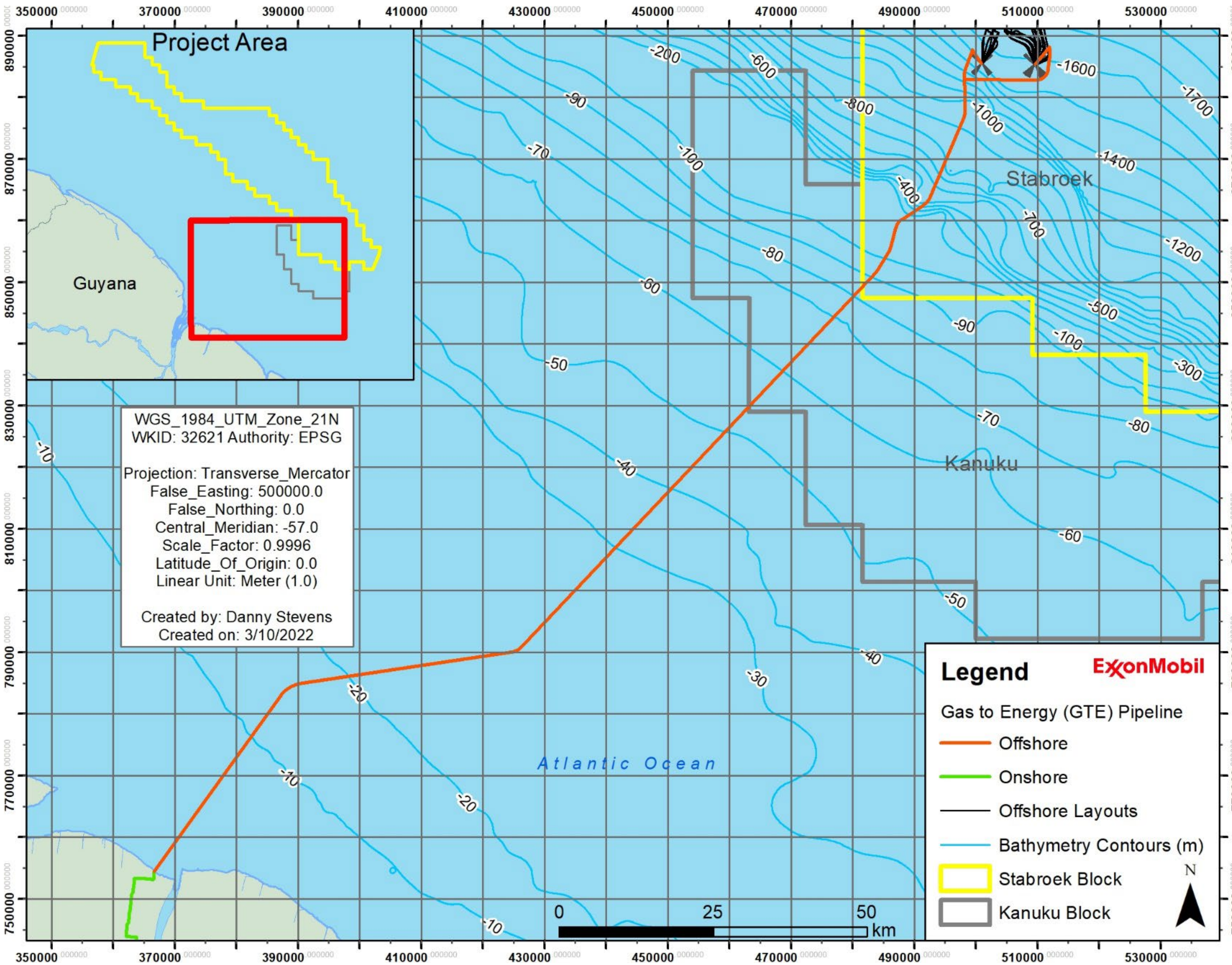

Figure EIS-3: Offshore Pipeline Route

In water depths greater than 600 meters (i.e., deep segments), the offshore pipeline will be laid directly on the seabed. At water depths between 20 and 600 meters (i.e., intermediate segment), the offshore pipeline may be laid on the bottom or buried, depending on local conditions. In water depths less than 20 meters up to the approximately 1.6-meter depth (i.e., the shallow segment), the pipeline will be laid in a trench for protection purposes (e.g., damage from vessels, potential for net fouling), at a depth sufficient to achieve a minimum cover of 1.2 meters. For the nearshore segment, the offshore pipeline will be installed by pulling in on the seabed or through a drilled bore. For the shore crossing segment, the pipeline may be installed using either HDD or open-cut trenching techniques.

2.4. ONSHORE PIPELINE

The onshore pipeline, with a design capacity of 120 MMscfd (3.4 $MMsm^3/d$), will transport the natural gas approximately 25 kilometers from the offshore pipeline shore landing to the NGL Plant site (Figure EIS-2). An aboveground shore landing beach valve will be located within the onshore pipeline RoW near the shore landing; this will demarcate the boundary between the offshore and onshore pipelines. It will be used to control the flow of gas within the pipeline and can be used to shut down the pipeline for inspection and maintenance. The aboveground valve compound will be equipped with anti-cut / anti-climb perimeter fencing around the valve, with fiber optic intrusion detection, 24-hour-per-day closed-circuit television monitoring of the compound, and security lighting.

The onshore pipeline will be installed below ground with a minimum cover depth of 1.22 meters. A fiber optic cable system will be installed in the same trench for communication and to detect leaks and/or third-party intrusion.

The only aboveground facilities associated with the onshore pipeline other than the aboveground valve will include a cathodic protection system; no compressor stations will be required. The cathodic protection system will help prevent corrosion of the underground pipeline facilities. These systems typically include a small, aboveground transformer-rectifier unit and an associated anode ground bed located underground. The ground bed will be installed at the NGL Plant. Rectifiers and test stations will be installed along the onshore pipeline corridor at distances ranging from 160 to 320 meters from the pipeline.

A receiving facility just upstream of the NGL Plant will include the following:

- A below-ground to aboveground transition with an associated monolithic isolation joint;
- An emergency shutdown valve;
- A pig receiver with associated valves and instrumentation; and
- A slug catcher designed to accommodate the maximum anticipated slug size.

Another short segment of piping will extend from the NGL Plant to the planned third-party Power Plant site, to deliver dry gas to the Power Plant. Since the location of the Power Plant has not been finalized, the route for and length of this length of piping is not yet known; however, it is assumed for the purpose of this EIA that the Power Plant will be located within less than 1 kilometer of the NGL Plant.

2.5. NGL PLANT

The purpose of the NGL Plant is to process the natural gas from the FPSOs into "dry gas" (methane [C1] and ethane [C2]) to be sent to the Power Plant, by removing impurities and extracting the heavier NGLs (i.e., butane [C3], propane [C4], and pentanes+ [C5+]) for sale to third parties.

2.5.1. NGL Plant Facilities

The NGL Plant will include the following key facilities:

- Metering skid, located at an inlet receiving section, to measure the volume of gas delivered to the NGL Plant, a slug catcher / liquid separation, and a heated pressure letdown station to reduce the incoming pressure of the gas to plant operating pressure;
- Mercury and H_2S removal facilities;
- An NGL Recovery Unit to extract NGLs and dehydrate the gas to the specifications required for use as fuel for the Power Plant;
- Various utility systems necessary to support plant operation;
- A flare system to accommodate safety, operational, and non-routine flaring, as needed;
- NGL storage and truck loading facilities; and
- An additional metering skid on the Power Plant delivery pipeline, which will serve as the point of custody for transfer of natural gas to the Power Plant.

The NGL Plant will include the following buildings:

- Control Room, including meeting and office space
- Warehouse/Maintenance Shop
- Motor Control Center
- Loading Control Room
- Guard Shack
- Residue Compressor Shed
- Essential Generator Shed
- Emergency Generator Shed

The exact locations of the above facilities and buildings within the NGL Plant will be finalized during detailed design. Figure EIS-4 provides a generalized block plot plan pending this future detailed design.

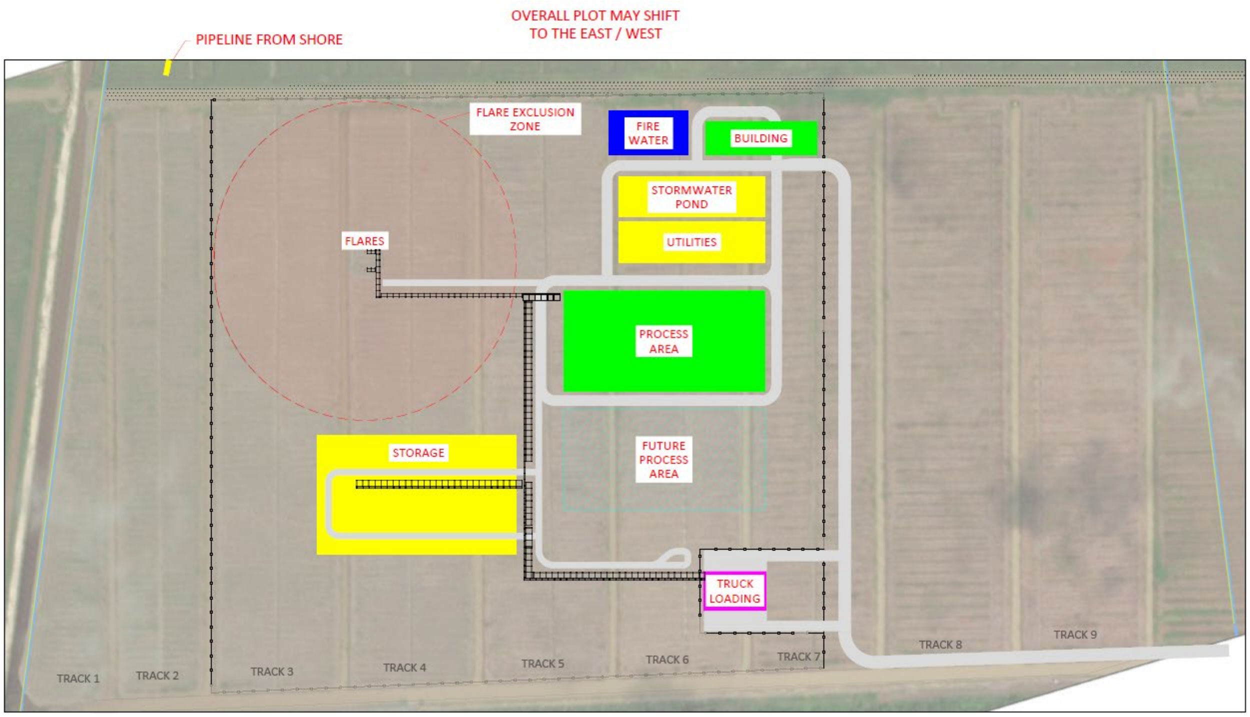

Figure EIS-4: Preliminary NGL Plant Site Layout

2.5.2. Ancillary Facilities

The Project will require a variety of temporary and permanent ancillary facilities to provide access to, or to support, construction activities, including a worker camp, infrastructure upgrades, a temporary MOF, and various support facilities and logistics support. Some of these facilities will be temporary (i.e., only needed during construction), and some—such as infrastructure upgrades—will remain in place after Project construction is complete.

The Project is considering alternatives for accommodating non-local workers during construction. One alternative is to house the workers in existing lodging (likely in the Georgetown area) and another alternative is to establish a worker camp near the proposed temporary MOF (Figure EIS-2). If this alternative is selected, the worker camp would have the capacity to accommodate 150 workers. In addition to providing housing, the worker camp would also provide a cafeteria, medical clinic, recreation center, and office facilities. These structures would be prefabricated and placed on a concrete pad.

A temporary MOF will be constructed on the west bank of the Demerara River near the NGL Plant site for offloading of heavy modules and imported material or equipment from barges and vessels (Figure EIS-2). The temporary MOF is expected to consist of the following:

- Unloading area (approximately 48 meters by 30 meters);
- Trestle (approximately 11 meters by 60 meters) extending from the unloading area to a heavy haul road;
- Two winch platforms (approximately 10 meters by 8.5 meters each); and
- Four mooring dolphins (two extending from each side of the rear of the unloading area).

The temporary MOF will be designed with the intention to allow docking of a range of vessels (e.g., cargo barges, ferries, etc.), with maximum delivery loads of up to 200 tonnes. Approximately 1,500,000 m^3 of dredging will be required for the construction and operation of the temporary MOF. This quantity accounts for temporary MOF construction, connecting the existing ship channel to the temporary MOF, and providing a turning basin for the range of vessels anticipated for the Project. It is expected that dredging will be performed with locally available equipment, using locally approved methods (e.g., trailing suction hopper barge, with spoils to be disposed upstream of the Project location).

2.5.3. Existing Support Facilities

Existing shorebases, storage and pipe yards, fabrication facilities, warehouses, fuel supply facilities, and waste management facilities are planned to support the Construction, Operations and Decommissioning stages. EEPGL plans to use existing Guyana shorebases to support the Project; new onshore facilities in Guyana may also be used by the Project (these would be developed by third parties as separate projects). All onshore support facilities will be owned/operated by others and will not be dedicated to the Project.

A variety of aggregate materials (sand, loam, and various sizes of crushed stone) will be required for onshore construction activities. Large quantities of sand and loam are readily available in Guyana, and therefore, the Project will attempt to maximize the use of local sand and/or loam for bulk backfill material. The remaining quantities of required aggregate that may not be readily available in Guyana (e.g., crushed stone) are expected to be brought in via barge from other countries in the Caribbean Community (CARICOM) region.

The Project will use helicopters and marine and riverine vessels to provide logistics support throughout all Project stages. Logistical support will be optimized and shared among other EEPGL operating facilities (e.g., Liza Phase 1, Liza Phase 2, Payara, and [pending authorization] Yellowtail), as well as exploration drilling operations. The number of Project-related vessel trips between an overseas port and a Guyana shorebase is estimated at approximately 50 trips during the Construction stage to support importation of line pipe, equipment modules, and materials for construction. The frequency of Project-related vessel trips between a Guyana shorebase and an offshore pipelay vessel is estimated at approximately twice per week during the offshore portion of the Construction stage. The frequency of Project-related vessel trips between a Guyana shorebase and the temporary MOF is estimated at approximately eight to ten per week during the onshore portion of the Construction stage for site preparation, civil, and infrastructure (2023). During the equipment installation and hookup portions of the onshore Construction stage (2024), Project-related vessel trips between a Guyana shorebase and the temporary MOF are estimated to decrease to two to three per week. Use of support vessels during the Operations stage will be rare, as the only offshore facility will be the offshore pipeline, which requires little vessel support other than periodic inspection and maintenance, and the temporary MOF will ultimately be removed.

2.6. PROJECT WORKFORCE

EEPGL estimates it will require a workforce of approximately 800 persons at the peak of the Construction stage, approximately 40 persons during the Operations stage, and approximately 50 persons during the Decommissioning stage. Of these estimates, the offshore pipeline construction will require approximately 300 workers at peak; onshore pipeline construction will require approximately 100 workers at peak; and NGL Plant construction approximately 400 workers at peak.

2.7. PROJECT SCHEDULE

Construction will begin as soon as possible after receiving all necessary authorizations (with a target date of August 2022 for start of NGL Plant site preparation) and will take approximately 3 years. The combined offshore and onshore pipeline system is targeted to be ready to deliver rich gas by end of 2024, and the NGL Plant is targeted to be operational by mid-2025. The Project has a planned life cycle of at least 25 years. A preliminary Project schedule is provided in Figure EIS-5.

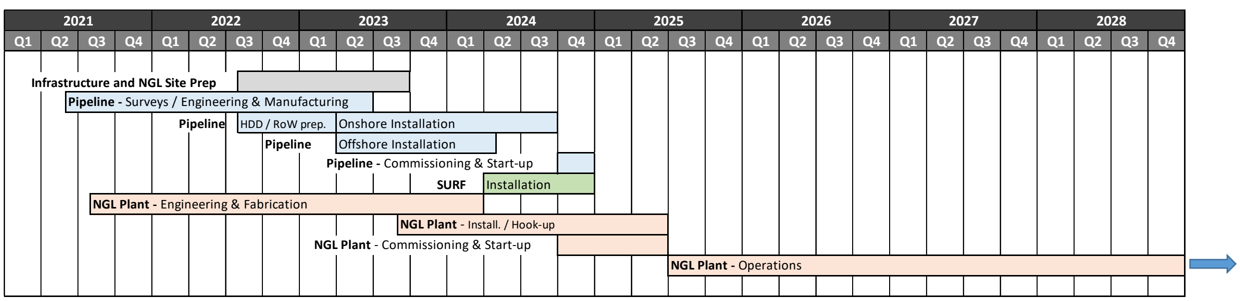

Figure EIS-5: Preliminary Project Schedule

2.8. PUBLIC CONSULTATION

EEPGL and the Consultants have conducted a robust public consultation program to both inform the public about the Project, gather information to inform the preparation of the EIA, and understand stakeholder concerns so they could be incorporated into the EIA, as appropriate. The different stages of the Project each require stakeholder engagement that is tailored in terms of its objectives and intensity, as well as the forms of engagement used. The various engagements completed to date in support of the EIA are summarized below.

- EEPGL has held a number of engagements and workshops on specific topics with the government and agencies related to offshore oil and gas exploration and development in general and the Project specifically.
- As part of the 2021 baseline data collection efforts supporting the EIA, the Consultants conducted a quantitative socioeconomic survey of businesses and households within and around the Direct Area of Influence (AOI), complemented by a series of key informant interviews and focus groups.

- During scoping and the EIA development, EEPGL and/or the Consultants:
  - Held 11 in-person public scoping consultation meetings in Regions 1 to 6, and two virtual public scoping consultation meetings;
  - Engaged with 36 representatives from the Neighbourhood Democratic Councils in Region 3 during focus groups;
  - Surveyed 150 businesses in Regions 3 and 4 during the 2021 socioeconomic business surveys;
  - Surveyed 370 individuals in Region 3 during the 2021 socioeconomic household surveys, including 122 individuals categorized as members of vulnerable groups.

These meetings are documented in the Stakeholder Engagement Plan and information received from these engagements was incorporated into the existing conditions and impact assessment components of the EIA, as appropriate.

2.9. ALTERNATIVES

The EIA considered a range of potential Project alternatives, as summarized below.

2.9.1. System Alternatives

The system alternatives considered included different ways of meeting the purpose of the Project, including alternative energy sources, alternative methods for transporting natural gas, and alternative means of accessing Project locations.

- EEPGL and the Government of Guyana have considered alternative sources of energy, including alternative fuel sources for supplying the government's planned power plant. A thermoelectric power plant could be fueled by natural gas, biomass (e.g., wood residuals), or bagasse (sugar cane residuals). Power could also be generated by solar, wind, or hydropower generation facilities. Studies have shown that the capacity to meet Guyana's peak demand differs among these energy source alternatives, with gas and hydropower constituting readily available firm capacity, as opposed to intermittent sources such as solar and wind, or sources constrained by seasonal availability of fuel such as biomass or bagasse. While hydropower is an opportunity in the long-term, and other renewable energy sources are available in the interim, natural gas presents a transition fuel opportunity that could reduce electricity costs and promote economic growth. The flexibility of gas generation can also buffer seasonal variations in hydropower availability. Natural gas also has the advantage of being feasibly used for power generation near existing transmission lines along the Guyana's coast, where most of the electricity demand is based. In contrast, existing transmission infrastructure is limited or absent near potential sources of hydropower, requiring significant transmission line construction from the potential points of generation in the interior to the coast. Therefore, natural gas was selected as the preferred energy source for the Project.

- Natural gas could be transported from the Liza Phase 1 and Liza Phase 2 FPSOs to shore either via pipeline or via an LNG vessel. Transport via a pipeline was selected for a number of technical, environmental, and economic reasons. Transporting natural gas in the form of LNG would require the construction of additional infrastructure offshore and onshore, including an offshore liquefaction vessel and a coastal regasification plant, in addition to one or more specialized LNG vessels. The LNG vessel(s) may be limited in size and capacity by the limited draft (water depths) near shore and in Guyana's major rivers. Further, the potential greenhouse gas (GHG) emissions from a pipeline approach are expected to be less than those of an LNG liquefaction, transport, and regasification system. Therefore, the selected alternative for gas transportation was a pipeline to shore.
- With respect to accessing the Project footprint for construction, some degree of construction access road development and/or improvement will be required for the Project, specifically for the transport of oversize loads related to the construction of the NGL Plant. The two alternatives considered were; (1) improve existing roads and/or construct new roads, both of which create congestion for existing road users, especially across the Demerara Harbour Bridge; and (2) construct a temporary MOF affording the ability to deliver materials via water to suitable locations near the onshore construction areas. The selected alternative was to use a temporary MOF, which will enable the transport of oversize loads, minimize the effects of existing traffic congestion on the Project, minimize the environmental impacts associated with the construction of new roads and bridges and the improvement of existing roads and bridges, and reduce the impact of the Project on other road users in the community.

2.9.2. Location Alternatives

The primary elements of the Project for which location alternatives are available and meaningfully different are the NGL Plant, the pipeline corridor, and the temporary MOF.

- EEPGL commissioned a desktop and field survey to evaluate environmental, socioeconomic, and engineering/project development conditions for multiple sites identified by the Government of Guyana for potentially siting the shoreward portion of the Project, which includes the onshore pipeline and NGL Plant. Potential road transit routes from shorebases to each site were also assessed. An initial desktop-based screening evaluated several sites identified by the Government of Guyana as potential locations for supporting the shoreward components of the Project. This screening included screening criteria related to environmental, socioeconomic, constructability, and feasibility issues. Out of 20 sites considered initially, nine sites were short-listed for further assessment. A site in the Wales Estate was identified as the preferred location for the NGL Plant among the sites evaluated. The selected site is located in an area of abandoned cane fields with low biodiversity. Compared to another alternative considered in the Wales Estate, the proposed location is farther from established neighborhoods. Although this requires a longer pipeline, the proposed location is preferred for social and health and safety reasons. Areas farther south, east, or west of the proposed location have more biodiversity value than the proposed location.

- The location of the offshore starting point for Project infrastructure is dictated by the location of the existing Liza Phase 1 and Liza Phase 2 FPSO vessels. Accordingly, there are no feasible alternative starting points. However, there was some flexibility in routing the pipeline corridor. A series of environmental and technical parameters were considered for the offshore pipeline route. The selected route minimizes geotechnical and constructability challenges, and does not conflict with existing subsea infrastructure, including cables belonging to Guyana Telephone and Telegraph and fiber optic cables belonging to EEPGL. In addition, the offshore pipeline follows the same general corridor of the EEPGL Fiber Optic Cable for approximately half of the route to minimize overall footprint and optimize use of the seafloor.
- For the onshore portion of the pipeline, EEPGL commissioned studies on engineering/constructability, soils and geotechnical, biodiversity, socioeconomic, land use, and other factors. Field teams assessed the pipeline route options from potential shore landing locations to Vreed-en-Hoop, Wales, and Ogle, and potential road transport routes from GYSBI to Vreed-en-Hoop, Wales, and Ogle. In addition, specialists acquired and reviewed high-resolution satellite imagery of the sites and pipeline routes to supplement the field survey efforts and support desktop analysis of inaccessible portions of the pipeline routes. After considering the findings of these studies, including the selection of the Wales Estate for the NGL Plant location, two onshore pipeline routes were considered: a Western Option and an Eastern Option. The preferred route is the Western Option because it allows the predominant use of open-cut construction, reduces impacts on private land, and uses available easements under the government's control along canals and associated access roads.
- Four temporary MOF location alternatives were considered: three closely situated sites on the west bank of the Demerara River at the Wales Estate, and a separate site downstream of the Wales Estate, but upstream of the Demerara Harbour Bridge. The criteria used to evaluate the temporary MOF location alternatives included: (1) proximity to the NGL Plant location; (2) minimization of impacts on mangroves; (3) minimization of physical displacement of persons/homes; and (4) minimization of the length of new roads and improvement of existing roads. The preferred site was the one closest to the NGL site, which would require the least existing road improvements, and would require the least environmental impact, although it will require some physical resettlement.

2.9.3. Construction Alternatives

Construction alternatives considered in the development of the Project included the following:

- Offshore pipeline construction alternatives (laying on the seabed, trenching and burying, and HDD methods) – for which a combination of all three alternatives was selected based on the depth of water for each pipeline segment;

- Onshore pipeline construction alternatives (open-cut trenching and HDD) – for which a combination of both alternatives was selected based on the features to be crossed along the onshore pipeline corridor (i.e., with HDD being used for larger canal and road crossings);
- MOF construction alternatives (temporary or permanent; with dredge disposal onshore or in-water) – for which a temporary MOF concept was selected based on the primary intended use of the MOF being during Construction; in-water dredge disposal was selected based on direction from the Maritime Administration Department (MARAD).
- NGL Plant construction alternatives (modular or "stick build") – for which a combination of both alternatives was selected using modular where possible, but with some stick-build where modular is not feasible for a given component.

2.9.4. Technology Alternatives

Technology alternatives considered in the development of the Project included the following:

- Potable and utility water systems (connect to public water system, truck water to NGL Plant, develop groundwater wells) – for which a ground water well was selected, based on this option providing a reliable source of water for Project demands.
- Flaring technology (elevated flare, enclosed ground flare) – for which a decision has not yet been made pending further detailed design.
- Water discharge (trucking out wastewater, septic system, modular sewage treatment plant) – for which a modular sewage treatment plant was selected based on challenges with reliable truck transport and limitations on a leach field for a septic system.

2.9.5. No Project Alternative

The "no Project" alternative means that the Project would not be executed. In this scenario, Guyana would continue to obtain electric power in the manner it currently does (i.e., mostly from thermoelectric generation fueled by imported heavy fuel oil / diesel fuel). A range of factors were considered comparing the potential impacts with the Project and the impacts of not developing the Project.

The Project would provide a reliable source of fuel for the Government of Guyana's planned gas-fired power plant. This fuel also results in less air emissions per unit of electric power and is less carbon-intensive than fuel sources currently in use. Thus, the Project would support Guyana's Low Carbon Development Strategy. The Project would have a positive impact on the economy of Guyana by contributing to the provision of more affordable and reliable electricity, as well as increased local employment and procurement opportunities. However, there would also be temporary and permanent impacts in the immediate vicinity of the offshore and onshore pipelines, the NGL Plant, and the temporary MOF. Under the No Project alternative, neither the positive nor negative impacts of the Project would occur.

3. ASSESSMENT OF POTENTIAL PROJECT IMPACTS

This section summarizes the potential environmental and socioeconomic impacts of the Project resulting from planned activities and the potential risk to resources associated with unplanned events, as well the Project's anticipated contributions to potential cumulative impacts on resources. The resources considered in this analysis are listed in Table EIS-3. The potential impacts of the Project were evaluated against the conditions of the existing environment, as described in Chapters 7, 8, and 9 of the EIA.

Table EIS-3: Resources and Receptors Considered in this EIA

Physical Resources	Biological Resources	Socioeconomic Resources
Geology and Groundwater	Protected Areas	Socioeconomic Conditions
Soils	Marine and Coastal Biodiversity	Community Health and Wellbeing
Sediments	Terrestrial Biodiversity	Social Infrastructure and Services
Water Quality	Freshwater Biodiversity	Transportation
Sound and Vibration	Ecological Balance and Ecosystems	Cultural Heritage
Air Quality, Climate, and Climate Change	Special Species Status	Land Use and Ownership
Waste Management Infrastructure Capacity		Landscape and Visual Resources
		Ecosystem Services
		Indigenous Peoples

3.1. PLANNED ACTIVITIES

The Project has both offshore and onshore components that will have a range of potential impacts on the physical, biological (marine, freshwater, and terrestrial), and socioeconomic environment. The Project will generate benefits for the citizens of Guyana through increases in employment, select Project purchasing from Guyanese businesses, and facilitation of improved energy independence and reliability through its support of the Government of Guyana's proposed Power Plant. The resources with the potential to incur meaningful impacts (impacts with a significance rating of Minor or higher) from planned Project activities include physical resources (sound and vibration, air quality, and climate / climate change), biological resources (marine and coastal, terrestrial, and freshwater biodiversity; and ecological balance and ecosystems), and a number of socioeconomic resources. These resources and their residual significance ratings (after mitigation measures are considered) are discussed briefly below. Resources that are not expected to incur impacts with significance ratings higher than Negligible from planned Project activities are not discussed in this section.

3.1.1. Sound and Vibration

The impacts of planned Project activities on sound and vibration will derive from both Construction stage and Operations stage activities. Construction stage impacts will derive from operation of the onshore pipeline construction spread, in particular along segments of the onshore pipeline corridor that pass close to communities. Operations stage impacts derive form the normal continuous operations of NGL Plant process equipment, with the potential for intermittent of higher-noise operations such as the flare and high-pressure drop valve.

The assessment of potential sound impacts was completed based on the estimation of noise levels at potential residential structures during both daytime and nighttime Project activity periods. Based on the assessment of pre-mitigation significance levels for potential impacts, a suite of mitigation measures are recommended. Considering implementation of the mitigation measures, a summary of the residual impact significance ratings is as follows:

3.1.1.1. Construction Stage

- For NGL Plant construction activities, there will be no potential residential structures predicted to be exposed to noise levels above a **Negligible** significance.
- For onshore pipeline segments completed using open-cut techniques, there will be potential residential structures that could be exposed to as much as a **Moderate** level of noise exposure. These potential residential structures are located along a total of approximately 3.5 kilometers of the onshore pipeline corridor. Based on the estimated rate of progress for open-cut trenching, a given structure would be exposed to elevated noise levels for a limited amount of time (on the order of a few days) as the pipeline construction crew drew closer, passed, and then drew further from the structure. This operation will occur only during daytime hours.
- For HDD activities completed during daytime hours, there will be potential residential structures distributed across four HDD segments that could be exposed to as much as a **Minor** level of noise exposure, depending on the side of the HDD segment on which the HDD rig is positioned. Based on the length of the HDD segments and the estimated rate of progress for HDD activities, the duration of exposure for a given residential structure will be between 2 and 4 days.
- For HDD activities completed during nighttime hours (an infrequent instance, which will be avoided to the extent practicable), there will be potential residential structures that could be exposed to as much as a **Moderate** level of noise exposure, depending on the side of the HDD segment on which the HDD rig is positioned. The duration of exposure for a residential structure during nighttime HDD activities would be expected to be less than one night (and likely no more than a few hours).

3.1.1.2. Operations Stage

- For normal operations stage, there will be no potential residential structures predicted to be exposed to noise levels above a **Negligible** significance for both daytime and nighttime hours.
- For intermittent operations (involving the intermittently operating flare and high-pressure drop valve), there will be no potential residential structures predicted to be exposed to noise

levels above a **Negligible** significance for daytime hours, but there will be potential residential structures that could be exposed to noise levels of up to a **Moderate** level of noise exposure during nighttime hours.

3.1.2. Air Quality, Climate, and Climate Change

Potential air quality impacts from the Project will derive from Construction and Decommissioning (principally related to short-term dust emissions) and Operations (principally related to long-term criteria pollutant emissions from NGL Plant operations). A suite of embedded controls will reduce emissions to air. Additionally, based on the assessment of pre-mitigation significance levels for potential impacts on air quality, a suite of mitigation measures are recommended to address potential Construction stage air quality (dust) emissions. Considering implementation of the mitigation measures, a summary of the residual impact significance ratings for the Construction and Decommissioning stages is as follows:

- For open-trenching segments of the onshore pipeline, potential residential structures could be exposed to dust levels up to a **Moderate** significance level. These potential residential structures are located along a total of approximately 3.5 kilometers of the onshore pipeline corridor. Based on the estimated rate of progress for open-cut trenching, a given structure would be exposed to elevated dust levels for a limited amount of time (on the order of a few days) as the pipeline construction crew drew closer, passed, and then drew further from the structure.
- For HDD activities, there will be no potential residential structures predicted to be exposed to dust levels above a **Negligible** significance level.
- For the NGL Plant construction earthworks phase and Decommissioning stage, there will be a small number of residential structures (near the heavy haul road and temporary MOF) that could be exposed to dust levels up to a **Moderate** significance level.
- For the NGL Plant construction post-earthworks phase, there will be no potential residential structures predicted to be exposed to dust levels above a **Negligible** significance level.

Air quality dispersion modeling was conducted for the NGL Plant operations, and concluded that predicted maximum ground-level concentrations of criteria pollutants will be no more than 5.4 percent of the associated World Health Organization (WHO) and U.S. Environmental Protection Agency (USEPA) ambient air quality guideline concentrations. Accordingly, a **Negligible** significance rating is assigned for potential impacts on air quality from the Project.

The NGL Plant operations will result in an increase in GHG emissions, but the percentage increase relative to national GHG emissions is less than 1 percent, and the percentage increases relative to regional and global emissions are all several orders of magnitude below 1 percent. However, recognizing that climate change has a high importance as a global concern and that the Project will contribute to an increase in global GHG emissions, a pre-mitigation significance rating of **Minor** is assigned for the Operations stage.

3.1.3. Marine and Coastal Biodiversity

The potential impacts of planned Project activities on marine and coastal biodiversity will be mostly habitat-driven rather than mortality- or injury-driven. Potential impacts on coastal biological resources will be limited to temporary disturbance of the shore at the proposed shoreline crossing, which is located approximately 3.5 kilometers west of the mouth of the Demerara River. The location is armored with rip-rap and the shallow marine zone is a sand and mud flat which is expected to recover quickly from disturbance associated with installing the pipeline.

Most impacts on the habitat will occur during the Construction stage. The offshore pipeline will be installed using a combination of direct lay, jetting, and trenching. Conservatively assuming that all 205 kilometers of pipeline in the shallow, intermediate, and deep sections are laid directly on the seafloor, the maximum amount of benthic habitat lost within the footprint of the pipeline will be 6.62 hectares. Jetting and trenching will produce temporary turbidity plumes at the installation site, hydrodynamic modelling indicates that an additional 623 hectares of benthic habitat will be temporarily disturbed by elevated turbidity during construction of the offshore pipeline.

Black and grey wastewater from pipeline installation vessels will be treated with a combination of digesters, biological treatment, and/or chemical treatment according to regulatory requirements and the specific treatment facilities available onboard the installation and support vessels. These effluents will be discharged to the sea according to applicable standard international practices (i.e., International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 [MARPOL 73/78]). The potential discharge of pipeline hydrostatic test water may also create toxicological impacts due to the presence of one or more test chemicals in the hydrostatic test water within 100 to 500 meters from the discharge location depending on which hydrostatic testing chemicals are used and flow conditions at the time of the discharge.

Several management measures have been incorporated into the Project design as embedded controls to minimize the significance of the Project-related impacts on marine and coastal biodiversity. With these measures in place, residual impacts on marine and coastal biodiversity are expected to range from **Negligible** to **Moderate**.

3.1.4. Terrestrial Biodiversity

The primary potential impacts of the Project on terrestrial biodiversity involve habitat loss and conversion, injury/mortality of biota, degradation of habitat, and disturbance/displacement of wildlife, but these impacts are minor and are not expected to have population-level impacts on any species or permanently alter the ecological condition or value of the Project AOI. The direct impacts to vegetation and habitat from the Project are small and exclusively limited to previously disturbed areas that have been modified by anthropogenic disturbance, particularly agriculture and related water management features (canal and dam systems). As such, potential impacts from the loss of these habitats on terrestrial biodiversity are expected to be correspondingly small. The majority of terrestrial wildlife species in the area are common, generalist species with moderate to high tolerance for human disturbance. Localized wildlife disturbance and displacement will occur as a result of human activity, light, sound, and vibration, particularly during vegetation clearance and facility construction. Working hours during the Construction stage will be limited to daytime hours, but use of artificial lighting for nighttime security along the construction work fronts and at Project facilities during operation will be necessary. Displacement could cause affected wildlife to lose access to foraging habitat, mates, or dependent young. It could also increase intra- and inter-species competition in the new areas where displaced wildlife relocate. However, once human activities and related sound largely subside after the Construction stage, wildlife, particularly species that are tolerant of human activity, is expected to quickly repopulate the area.

Colonial waterbird breeding colonies and communal roost sites are particularly vulnerable to disturbance, and human activity can cause desertion of the nesting and roosting sites. Several waterbird nesting and roosting areas occur in the lower Demerara River, including Inver Island, which is a forested island located in the middle of the Demerara River near Land of Canaan, approximately 2 kilometers upstream from the temporary MOF site that supports thousands of roosting and breeding birds. Installation of the temporary MOF and dredging of the access channel will disturb and likely displace some riverine birds due to increased human activity and sound but the influence of sound, light, and human activity associated with the temporary MOF will be limited to the area within close proximity to the temporary MOF site and should not extend to any known bird concentration areas.

Several management measures have been incorporated into the Project design as embedded controls to minimize the significance of the Project-related impacts on terrestrial biodiversity. Additional measures have been suggested by the Consultants to further mitigation these impacts. With the embedded controls and mitigation measures in place, residual impacts on terrestrial biodiversity are expected to range from **Negligible** to **Minor**.

3.1.5. Freshwater Biodiversity

The onshore pipeline will intersect several canals. Most of the canals will be crossed using HDD techniques, and Project-related impacts on these canals will derive from runoff from temporarily disturbed work areas entering adjacent canals and disturbance of riparian habitats.

A temporary MOF will be constructed on the Demerara River to facilitate transport of construction materials and equipment to the NGL Plant and pipeline construction sites. The primary biological impact associated with constructing and operating the temporary MOF is disturbance of riverine species caused by underwater noise from vessel traffic. The Demerara River is already subject to noise from passing commercial and artisanal vessel traffic. Although an increase in overall vessel traffic is expected during the operation of the temporary MOF, the additional vessel trips associated with the temporary MOF represent a minimal percentage increase in vessel traffic near the temporary MOF.

Operation of the pipeline will not entail any routine operational discharges; however, operation of the NGL Plant will produce sanitary and industrial wastewater effluents via a combined effluent stream that will be discharged from the facility's stormwater management pond. Discharges from the Project would be managed to World Bank Group Environmental, Health, and Safety (EHS) Guidelines for Natural Gas Processing Facilities.

Several management measures have been incorporated into the Project design as embedded controls to minimize the significance of the Project-related impacts on freshwater biodiversity. Additional measures have been suggested by the Consultants to further mitigate these impacts. With the embedded controls and mitigation measures in place, residual impacts on freshwater biodiversity are expected to range from **Negligible** to **Minor**.

3.1.6. Ecological Balance and Ecosystems

All planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to basic ecosystem functions such as nutrient cycling, carbon cycling, gene flow, maintenance of biodiversity, habitat structure and connectivity, and drainage patterns. The significance of potential residual impacts on ecological balance and ecosystems was concluded to be **Negligible** to **Minor**. Most impacts are predicted to be **Negligible**, but residual impacts on changes in biodiversity are rated as **Minor** due to the potential for introductions of invasive species in ballast water, primarily because the global movement of ballast water is considered the largest transfer mechanism for marine non-indigenous species. The Project has included several embedded controls in the Project design that will minimize the potential for introduction of non-native species to Guyana's marine environment.

3.1.7. Special Status Species

There are 119 marine, freshwater, and terrestrial special status species that have the potential to occur in the Project AOI. The Project will have minor to moderate impacts to these species as a result of habitat loss and conversion, habitat degradation, injury/mortality of biota, and disturbance/displacement of biota. These impacts will affect habitat for special status species and individuals but it is not expected to result in population-level impacts to any special status species. As such, the Project will not alter the conservation status of any species. Several management measures have been incorporated into the Project design as embedded controls to minimize the significance of the Project-related impacts on special status species. Additional measures have been suggested by the Consultants to further mitigate these impacts. With the embedded controls and mitigation measures in place, residual impacts on special status species are expected to range from **Negligible** to **Moderate**. The moderate ratings relate to potential impacts to marine turtles during the Construction from increased turbidity during offshore pipeline installation and the potential for entrainment of young in the water intake for hydrostatic testing. Embedded controls incorporated into the Project design and targeted mitigation measures will minimize these impacts to the extent possible.

3.1.8. Socioeconomic Conditions

The Project is not expected to cause a significant influx to the area and, as such, is not expected to cause noteworthy population shifts or impacts to education systems (i.e., by overburdening schools). The planned Project activities that could affect economic attributes of the Project AOI are broadly relevant to economic development, employment and business growth, and existing livelihood activities. The Project will have direct and indirect potential impacts resulting from employment of Guyanese nationals, use of local companies to supply various goods and services, and capacity building programs. There will also be revenue generation and increased tax revenues for the government as a result of the induced expenditures from Project-driven employment. Therefore, the potential impacts on economic development that will result from Project employment, procurement, and worker spending are considered to be **Positive**.

As the Project is the first of its kind in the Project AOI, there are heightened expectations related to job opportunities and business benefits as a result of the Project for local community members within Region 3. There could be a potential cost of living increase due to a higher demand for some goods and services, either through direct Project procurement or through Project worker purchases. Furthermore, it is very likely that women will not have equal access to Project employment opportunities with Guyanese businesses unless they are directly targeted for recruitment. EEPGL will develop contract language for pipeline and NGL Plant contractors encouraging recruitment and training of women for various Project-related construction roles, as well as advertising the types of goods and services they will procure locally (within the Direct AOI). It is anticipated that these mitigations will decrease rates of unhealthy local competition driving up the cost of living and improve gender disparity during the Construction stage. EEPGL will also proactively communicate the Project’s limited direct staffing requirements and the number and types of jobs expected to be contracted during the Construction stage. The significance of these potential residual impacts on unmet employment and business opportunity expectations, cost of living increases, and gender disparity during the Construction stage is **Minor**.

There will be new temporary marine safety exclusion zones associated with the major installation vessels during offshore pipeline installation in the Construction stage. It is anticipated that these temporary marine safety exclusion zones, which will move with major installation vessels during the Construction stage, may impact commercial vessels that operate in deeper waters and artisanal fisherfolk vessels that operate in shallower waters – in particular in the nearshore offshore pipeline segments and at the shore landing site. It is anticipated that the safety exclusion zone for a portion of the nearshore pipeline segment will remain in place throughout the Operations stage, resulting in the prohibition of any fishing activity in that area to prevent accidental damage to the pipeline in shallower waters. EEPGL will maintain active communication with various stakeholders within the fishing industry to communicate Project activities and aid fishing vessel operators to avoid Project vessels. EEPGL will also will proactively engage with nearshore artisanal fisherfolk in advance of construction and advertise a cut-off date for all fisherfolk to remove fishing equipment from the nearshore project exclusion zone. The significance of this potential residual impact on commercial fishing livelihoods as a result of the temporary exclusion zone was assessed as **Negligible** considering the small number of operators that currently participate in deep-sea fishing and the temporal nature of the zone during Construction stage. However, for artisanal fisherfolk who may not carry radios, may use remote ports, and/or may not receive notices of increased vessel activity issued by the Project, the significance of this potential residual impact on artisanal fishing livelihoods as a result of the temporary exclusion zone was assessed as **Minor** in the Construction stage. For both commercial and artisanal fisherfolk, the significance of the potential residual impact related to the permanent nearshore exclusion zone around the offshore pipeline and long-term disruption of fishing activities was assessed as **Minor** in the Operations stage.

3.1.9. Community Health and Wellbeing

The key potential impacts on community health and wellbeing as a result of planned Project activities are increased risk of communicable disease transmission, decreased social cohesion as a result of the presence of Project workers, increased public anxiety over presence of onshore natural gas facilities, increased risk of physical and mental health concerns as a result of public safety issues (crime, increased traffic, reduced access to social infrastructure and services), general nuisance from increased noise (potentially causing stress on mental health), overburdening of medical and health services and temporary restriction of access to medical/healthcare facilities.

An influx of workers from other parts of the country or foreign countries has the potential to change transmission patterns of some communicable diseases, particularly if workers originate from countries or regions with higher rates of diseases that are transmitted through person-to-person contact. Social cohesion within communities, especially smaller and more vulnerable populations, can also be affected by the presence of a large workforce originating from outside of the community area. This can cause strain in familial relationships and tension among community members who may have differing viewpoints on the presence of the workforce. An estimated 125 to 250 workers during the Construction stage will be foreign and/or relocate from other regions within Guyana. As an embedded control, regardless of worker origin, the Project will establish a worker health-screening program and take precautions to avoid internal and external communicable disease risks, including coronavirus disease 2019 (COVID-19). Depending on which worker camp scenario is implemented, the Project's potential impact on communicable disease transmission or social cohesion is considered to be **Negligible** (under a "closed" camp scenario) to **Minor** (if there is no camp, or if camp access is unrestricted) significance.

Oil and gas represents the newest sector in Guyana's economy, and concerns exist among those living in coastal communities about oil and gas activities and their perceived potential impact on livelihoods and the environment. The onshore Project components—specifically the NGL Plant and the onshore pipeline—has the potential to create anxiety in particular with those located in the Direct AOI, who will have the most interaction with the Project. Public anxiety related to perceived impacts from oil and gas operations in general has been evident for a number of years in Guyana, and anxiety related to perceived risks from the Project in particular was evident in isolated instances during community engagement conducted to support the EIA. Recognizing that this impact is driven by perception of risk, it may affect a wider area or range of people than that which could potentially be affected by potential physical health impacts. Levels of anxiety are anticipated to decrease as the local population's understanding of the Project—and in particular the system of embedded controls to prevent unplanned events—increases. The anticipated residual impact is expected to have a **Minor** significance during the Construction and Operations stages.

Changes in traffic patterns (including pedestrian amenity, delays, and other changes), crime (possibly related to population influx), and access to community roads, canals, and other infrastructure could lead to impacts on public safety. To mitigate these concerns, EEPGL will prepare a traffic and access management plan prior to initiation of onshore construction activities, and will implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to Project vehicle movements. Considering the mitigation measures, the significance of the residual impact is considered to be **Negligible** during the Construction and Operations stages.

Noise generated during the Construction and Operations stages could impact nearby residents, resulting in general nuisance and potential stress-related mental health impacts. Potential impacts on mental health will be infrequent and of limited duration, and will only affect a few individuals. As potential receptors are conservatively considered to have a high level of sensitivity, mitigation of noise-related impacts will include reasonable efforts to communicate with the residents ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts. Furthermore, during that communication, EEPGL will share how affected persons can use the community feedback mechanism to discuss any nuisance or stress related to elevated noise levels. With these measures in place, the residual impact significance rating is determined to be **Moderate**.

Activities during the Construction stage may have implications for local community members' abilities to access health resources. It is possible that construction equipment and general construction activities may require temporary blockage of roads and access points through communities (particularly in areas along the Canal 1 and Canal 2), which could in turn restrict some residents' access to healthcare in portions of the Direct AOI—either for emergency or routine needs. To mitigate this impact, EEPGL will prepare a traffic and access management plan to provide secondary means of access for vehicles and pedestrians to eliminate restrictions of public movement. Accordingly, the residual impact significance is considered to be **Minor**.

During the Construction stage, Project-related demand for medical and health services could create an indirect impact on non-Project users of these services, particularly as local Guyanese medical facilities are often overburdened because of limited availability and the COVID-19 pandemic. The Project's reliance on local facilities will be limited, primarily due to the inclusion of Project-dedicated medical resources including a dedicated medical clinic at the NGL Plant site to treat workers for minor medical issues. In the event of a more serious illness or injury that cannot be handled by the Project's dedicated medical professionals, workers will be medically evacuated to a healthcare facility in Georgetown, depending on the type of medical issue. In the event a worker requires medical evacuation/referral, Project-dedicated medical professionals will be available to support the referral. The residual impact significance is considered to be **Minor**.

3.1.10. Social Infrastructure and Services

The planned Project activities with the potential to impact social infrastructure and services include Project worker presence in Region 3 and Region 4 Georgetown area during the Construction stage (with the potential to impact demand or use of lodging, housing/utilities and water/sanitation infrastructure leading to reduced availability and/or increased cost), and construction of the onshore pipeline (with the potential to affect usability of canals for household use).

Potential impacts on non-Project related users of lodging (leisure and business travelers to Guyana, specifically Georgetown) as a result of Project related demand or use of lodging are expected to be limited to Georgetown and Region 3. There is enough existing capacity in Georgetown-based lodging, and the support companies and their workers supporting the Project construction may take advantage of a wider range of lodging opportunities. The Project will proactively communicate the Project's limited staffing requirements to reduce the magnitude of potential population influx to Region 3 and Georgetown from job seekers. On this basis, the residual impact significance on lodging is rated as **Minor** for the Construction stage (when Project workforces will be at the highest levels) and **Negligible** during the Operations and Decommissioning stages, when the Project workforce will be significantly reduced.

The Project is considering a worker camp to house up to 150 workers during the Construction stage. Should the Project proceed with the worker camp, the residual impact significance on increased demand or use of housing and utilities, leading to reduced availability and / or increased cost, would be **Minor**. However, a scenario also exists where the worker camp is not built resulting in the entire onshore foreign workforce at peak (125 to 500 people, assuming 50 to 75 percent are expected to be Guyanese already with their housing needs met) being housed (either individually or in small groups) in communities near the Project area or within daily commuting distance, and not lodged in hotels. EEPGL will require Project primary contractors to complete a worker housing survey to understand Project housing demands and requirements. On this basis, the residual impact significance on housing and rental markets (and associated utilities) is rated as **Minor** for the Construction stage (when Project workforces will be at the highest levels) and **Negligible** during the Operations and Decommissioning stages (when the Project workforce is significantly reduced).

Construction could cause erosion and sedimentation into canals, affecting usability for households as well as preventing temporary loss of canal access, preventing household use for water and sanitation needs. A number of embedded controls (such as backfilling, temporary erosion controls and dewatering practices) will reduce the potential for impacts on canals adjacent to the onshore pipeline corridor. On this basis, the residual impact significance on water and sanitation is **Minor** during the Construction stage. There will be no ground-disturbing activities during the Operations and Decommissioning stages with the potential to impact canals currently being used by communities, so the residual impact significance during these stages is rated as **Negligible**.

3.1.11. Transportation

Marine Transportation

Direct Project impacts on marine transportation will include increased vessel traffic in and near the Project's Offshore Direct AOI. Project materials and components will originate in other CARICOM countries as well as other countries in North America, South America, and Europe, resulting in vessel shipments from various overseas locations to shorebases within Georgetown Harbour. Offshore pipeline installation will require approximately two vessel round-trips weekly between shorebases in Georgetown Harbour and the offshore pipeline construction corridor. Georgetown Harbour experiences a high volume of vessel traffic, including cargo, tanker, fishing, and passenger vessels, and the Project would not substantially increase vessel traffic in the harbor. The residual impact significance ranges from **Negligible** (commercial cargo vessels) to **Minor** (commercial and subsistence fishing vessels).

Marine vessel transportation will also be potentially impacted by ongoing offshore pipeline installation work and vessel activity over the estimated 13-month period for offshore pipeline installation. Anchored pipelay barges and crane barges generally will remain within the offshore pipeline construction corridor, moving along the corridor as pipeline installation progresses. All non-Project vessels will need to navigate around the offshore work areas. The residual impact significance ranges from **Negligible** (commercial cargo vessels) to **Minor** (commercial and subsistence fishing vessels).

The Operations stage will require only occasional vessel traffic related to offshore pipeline inspections and maintenance. The impact intensity on marine transportation during this stage will thus be **Negligible**.

River Transportation

During the Construction stage, the Project will use the Demerara River as the primary transportation route for moving aggregate and sand, heavy equipment, NGL Plant modules, and other materials and supplies from shorebase locations in Georgetown Harbour to the proposed temporary MOF. Installation and operation of the temporary MOF will include river dredging to allow barges to travel from the main river channel to the temporary MOF pier, and to allow barge maneuvering at the temporary MOF. Project-related barge round-trips will add an average of one to two daily barge trips to the Demerara River in this area, increasing total vessel traffic by 5 to 10 percent in this area of the river, compared to existing conditions. Project construction will also generate vessel traffic between shorebases on the east and west sides of the river, representing a 0.6 to 1.2 percent increase in existing vessel traffic in this area. The potential impact during the Construction stage is considered to be of **Minor** significance.

Operation of the NGL Plant is not expected to generate regular vessel traffic, yielding an impact of **Negligible** significance. Decommissioning of the NGL Plant may require transport of decommissioned equipment from the NGL Plant site via river vessel. Based on an assumption that—if river transportation of decommissioned equipment is required—the intensity of vessel traffic impacts will be no more than during the Construction stage, the significance during the Decommissioning stage is also considered to be of **Minor** significance.

Road Transportation

Project construction-related traffic could potentially have impacts on road function and condition. Project activities with the potential to affect road traffic include movement of workers and supplies during the Construction and Operations stages.

During the Construction stage, the onshore pipeline will cross the WBD Public Road, Stanleytown Road, Canal 1 Road, and nine unnamed roads using HDD methods, allowing uninterrupted road use throughout construction. Other public roads and most private roads will be crossed by open-cut methods, requiring temporary closure of the roads and the establishment of detours. Most open-cut road crossings will require only a few days to complete. People affected by these road closures are considered to have a high degree of sensitivity due to a lack of alternate routes. Where open-trench crossings are used, EEPGL will minimize the time of road closure to the extent practicable, and provide adequate detours. Accordingly, the residual impact from pipeline installation across roads is considered to be **Minor**.

Project-related traffic during the Construction stage will include buses carrying personnel, light vehicles, and flatbed delivery trucks. Traffic for personnel and supplies for onshore pipeline installation will use the WBD Public Road and roads extending west to various points along the onshore pipeline corridor. The anticipated Project vehicle trips will result in an increase in the peak hourly traffic on the order of 4 to 7 percent at the four intersections studied along the WBD Public Road during the Construction stage. Project traffic to and from the NGL Plant during the Operations stage will consist of personnel commuting trips (for an estimated 40 full time equivalent employees), visitors, chemical/water /waste transport, and product transport. All traffic will use the WBD Public Road. The total anticipated traffic generation results in an increase in the peak hourly traffic on the order of 1 to 3 percent at the four intersections studied along the WBD Public Road. Decommissioning of the NGL Plant is conservatively considered to have a traffic impact similar to that of the Construction stage. To address impacts on traffic congestion, the Project will maximize the use of bus transportation, schedule movements during non-peak hours, engaging with local stakeholders, and surveying access routes. With these measures in place, the residual impact is considered to be **Minor** during the Construction, Operations, and Decommissioning stages.

Although some Project-affected roads have paved segments, many are unpaved and some are tracks only. Project-related traffic, and especially heavy vehicle traffic (buses, delivery trucks, and waste hauler trucks) will contribute to wear and deterioration of the WBD Public Road and local roads used for transportation to the onshore pipeline worksites. As an embedded control, EEPGL will restore areas affected by Project construction activities, including repairs to key roads used by the Project. Project-related road traffic is expected to have a **Negligible** impact on road conditions during Construction, Operations, and Decommissioning stages.

3.1.12. Cultural Heritage

Most of the planned seabed disturbance area for the Project has been subjected to geophysical surveys to assess the presence of any underwater cultural heritage, and the as-of-yet unsurveyed portions of the disturbance area will be surveyed prior to initiation of seabed disturbance activities. On the assumption that any resources identified during the future survey activities will be avoided if they are identified, this increases the level of certainty that planned Project activities will not disturb significant underwater cultural heritage. However, the possibility of a chance find during offshore construction activities exists. For this reason, a Chance Find Procedure is recommended as a mitigation measure to be adopted and implemented by the Project during offshore construction activities. In the event of a chance find, the Chance Find Procedure requires temporary cessation of Project activities, assessment of such a find by a cultural heritage specialist, and development of a treatment plan for significant chance finds in consultation with the National Trust of Guyana and other cultural heritage stakeholders, as appropriate. The residual impact significance on underwater cultural heritage during the Construction stage is considered to be **Negligible**

Onshore, despite the historic character of the landscape, modern development has likely destroyed any significant archaeological deposits or sites that may be present within the Project's onshore construction footprint. Based on this, and on the results of field surveys, the Consultants have concluded that no archaeological resources of significant cultural value are likely present within the planned area of disturbance. However, as with underwater cultural heritage, the possibility of a chance find during onshore construction activities exists, and a Chance Find Procedure is recommended as a mitigation measure. Furthermore, given the proximity of the temporary MOF construction area to the Demerara River, it is recommended that initial ground disturbance at the temporary MOF location should be conducted with the presence of an archaeological monitor. With these measures in place, the residual impact on terrestrial cultural heritage (archaeological) during the Construction stage is considered to be **Negligible**.

Three silk cotton trees (*Ceiba pentandra*), though not confirmed to have terrestrial archaeological value, are significant to the cultural landscape and local oral traditions associated with local residents. Currently, two of these trees (C1 and C3) are located within the Project's permanent RoW, while one (C2) is outside the permanent RoW. As embedded controls, the Project plans to avoid removal of C3 tree and EEPGL is currently assessing whether it is possible to also avoid removal of C1. If avoidance cannot be effected, it is recommended that EEPGL notify the National Trust prior to removal of a silk cotton tree, to discuss the resource and the cultural ramifications of its removal; and to consult with local community leaders regarding the tree's spiritual significance. In the event that potentially affected trees are avoided (i.e., no silk cotton trees are removed), the residual significance of the impact is considered to be **Minor**; whereas if one or more trees are removed—subject to engagement with authorities and local stakeholders—the significance is considered to be **Moderate**.

Potential impacts on historic structures would be limited to potential viewshed alterations and visual disturbances. HDD construction methods will avoid impacts on the portion(s) of the onshore pipeline corridor in which identified historic structures are present. On this basis, the residual impact significance, is characterized as **Negligible**.

3.1.13. Land Use and Ownership

Potential physical displacement and relocation associated with the Project includes one suspected residential property within the planned onshore pipeline route approximately 175 meters south of the shore crossing; and four dwellings currently located within 500 meters of the heavy haul road and temporary MOF facilities. The Government of Guyana is responsible for Project-related land acquisition. Regardless, the displacement and relocation of these persons—and the loss of any assets or improvements associated with their use of the land in this area—is recognized as a Project impact. Although relocation would be a one-time event, the expected consequence will be significant for the affected households, who are expected to lack formal land tenure and display a high degree of vulnerability. EEPGL will support the Government of Guyana to develop and implement a Resettlement and Livelihood Restoration Strategy aligned with international standards; on the basis of this mitigation, the residual impact is considered to be of **Moderate** significance.

In addition to physical displacement or relocation, the Project may also result in a change in the nature of land ownership or tenure for all or part of a property, parcel, or land use area. Most notably, a 12.2-meter-wide permanent RoW will be established for the operation and maintenance of the onshore pipeline. Land use in the permanent RoW will be restricted, and growing crops or construction of any structures will not be permitted in the permanent RoW. The legal formation of the RoW may result in changes to existing private property boundaries and/or the details of licenses, leases, permits, or other tenures related to the use of affected public lands. The RoW crosses populated areas in the vicinities of Crane, Canal 1, and Canal 2. Notably, the populated areas at Canal 1 and Canal 2 will be crossed by HDD, avoiding or reducing the physical disturbance of individual properties, although any rights or restrictions associated with the permanent RoW will still be in effect. Although the RoW will be minimal in width and largely aligned with the existing canals and drainage channels, in the absence of specific information about private properties or other land tenures, this assessment considers that the impact on land ownership and/or tenure will be of **Minor** significance during the Construction and Operations stages.

Agricultural activities (crops and livestock) are the most significant land uses in the Primary Study Area. The Project's use of land during the Construction and Operations stages will reduce access to affected land for agricultural or other purposes. This loss of access could result in temporary and/or permanent economic displacement for people who may depend on these lands for their livelihoods, employment, and/or income-generating activities. Based on the available information, displacement of agricultural land use is expected occur along the onshore pipeline route in relation to rice fields (near Crane, and west of Westminister / Lust-en-Rust), and pineapple / mixed crops (between Canal 1 and Canal 2). Near the proposed NGL Plant, impacts could occur in relation to a section of mixed crops south of the proposed NGL Plant and heavy haul road, and possible sugarcane and grazing areas in/near to the NGL Plant footprint. These changes could affect farmers' ability to engage in their current livelihood(s) at the same level of productivity. EEPGL will support the Government of Guyana to develop and implement a Resettlement and Livelihood Restoration Strategy aligned with international standards; on the basis of this mitigation, the residual impacts are considered to be of **Moderate** significance during the Construction stage, and **Minor** significance during the Operations stage.

Regardless of displacement, the Project could also result in a change in the quality of agricultural crops harvested from the Primary Study Area. This could result as an indirect effect of dust deposition during the Construction stage, which could conceivably extend beyond the Project footprint to affect adjacent areas. Dust levels will be actively monitored so that additional dust management measures can be implemented if required. Timely revegetation of disturbed areas will also be implemented following construction; success of revegetation efforts will also be monitored. Based on the result of dust monitoring during onshore pipeline construction, additional mitigations will be developed, as needed. With these measures in place, the residual impact on the quality of agricultural production is considered to be of **Minor** significance.

3.1.14. Landscape, Visual Resources, and Light

The area west of Vreed-en-Hoop, especially the view of the ocean, is considered a key viewpoint, and the open ocean is considered a visually sensitive resource. During the portion of the offshore pipeline installation within view of shoreline, a change to the scenic integrity of the landscape will be perceptible; during this stage, the scenic integrity may change, but any such change will cease to exist post-construction. Once installed, the offshore pipeline will be underwater and not visible from on the water or from onshore viewpoints. The residual impact is considered to be **Minor** during the Construction stage and **Negligible** during the Operations stage.

The shore crossing has the potential to impact the scenic and visual character of the Guyana shoreline, a key viewpoint with a moderate scenic integrity rating. EEPGL proposes to construct this section of the pipeline using HDD or open trenching techniques, but in either case the pipeline will not be visible once installed. In the event open trenching is conducted, any alterations to existing features at the shore crossing (e.g., sea defense features) will be restored to a pre-construction condition. An aboveground valve station will be installed near the shore crossing, but this will be relatively low-profile and landward of the shoreline in a less sensitive visual location as compared to shoreline. If the HDD method is used, there will be no significant changes to scenic integrity of the shore crossing area (as the installation will occur underground with no surface disturbance). If open trenching followed by restoration is used, a change to the scenic integrity of the shore crossing area will be perceptible, but not to the extent that it would result in a change in scenic integrity level. During the Construction stage, the residual impact is considered to be **Minor** for a trenching approach and **Negligible** for an HDD approach; the residual impact is considered to be **Negligible** during the Operations stage.

The onshore pipeline will be installed below ground either in an open trench—which will be backfilled and revegetated following pipeline installation, or via HDD—which will eliminate any visual character alteration along the respective segment. In either case, the pipeline will not be visible once installed. For segments installed using open trenching, the RoW will be restored and revegetated, with the permanent RoW maintained (i.e., free of significant woody and other tall vegetation) throughout the Operations stage. The scenic integrity of this landscape is rated as low, as it has been moderately altered by agricultural and clusters of mixed-use development. EEPGL plans to use HDD techniques to minimize visual impacts on key viewpoints during both Construction and Operations stages. The residual impact is considered **Negligible** for all segments of the onshore pipeline during the Construction and Operations stages.

The NGL Plant will be located in what is currently fallow agricultural land that was previously part of the GuySuCo Wales Estate. The construction and presence of Project features at the NGL Plant site will result in a change to the scenic and visual character of the landscape, by introducing an industrial character to an otherwise natural/agricultural area. The scenic integrity of this landscape at the NGL Plant site is rated as low, reflecting a moderately altered landscape that is now converting back to a more natural landscape through natural succession. No key viewpoints or visually sensitive resources are identified in this landscape. A **Negligible** impact is expected during the Construction stage. During the Operations stage, the taller above-ground structures will be visible from key viewpoints, and an impact of **Minor** significance is expected.

The temporary MOF will be constructed along the west bank of the Demerara River in a section that currently exhibits relatively natural shoreline vegetation. The Project will clear a small section of riverbank vegetation for the trestle portion of the temporary MOF, with the bulk of the temporary MOF pier structure extending into the water. This will introduce an industrial character to an otherwise relatively natural setting. The principal key viewpoint relevant to the temporary MOF is from the river looking toward the West Bank of the Demerara River. The naturally vegetated shoreline along the West Bank of the Demerara River is considered a visually sensitive resource, and the scenic integrity of this landscape is rated as moderate. The construction and presence of the temporary MOF will result in a small change in scenic integrity, and this is considered to be a **Minor** significance impact during the Construction and Operations stages.

With respect to nighttime lighting, construction activities would change the nighttime setting through security and safety lighting. Construction of the NGL Plant would change the nighttime visual setting of the site (currently fallow agricultural fields) by introducing security and safety lighting (during both Construction and Operations) into an otherwise natural/agricultural area with no current or past artificial lighting. The Project will mitigate nighttime visual setting impacts through industry standard night sky light fixtures, on/off control measures, and use of the minimum required lighting intensity. On the basis of these mitigation measures, potential impacts on the nighttime visual setting from lighting will range from **Negligible** to **Minor**.

3.1.15. Ecosystem Services

Ecosystem services represent the benefits that people derive from natural ecosystems, including provisioning, regulating, supporting, and cultural services. Considering the planned Project activities, and related content addressed in other sections of the EIA, six potential impacts on ecosystem services were assessed, primarily related to activities during the Construction stage.

Provisioning Services

Harvesting of crabs is reported to occur year-round in mangroves. Construction of the shore crossing has the potential to impact 0.29 hectare of coastal strand vegetation including mangrove-associated species. Construction of the temporary MOF has the potential to impact 0.06 hectare of riparian forest including mangrove-associated species. Therefore, changes to crab habitat and/or crab populations that could change the availability of crabs for harvesters is identified as a potential impact on this ecosystem service. Considering the conclusions of freshwater and coastal biodiversity assessments, the Project is anticipated to have a **Negligible** impact on the provisioning service provided by mangroves.

The existing network of existing canals provides a source of freshwater for irrigating crops and household gardens, and the canals are occasionally used for domestic water (particularly during the dry season) as well as swimming and bathing. Canals provide a means for travel, including access to fields that are not accessible by overland road; farmers use the canals to transport produce from their fields. Fishing also occurs in the canals. Livelihood and wellbeing impacts will be avoided for most beneficiaries; however, some localized impacts on livelihoods and/or wellbeing may be experienced by some beneficiaries. To mitigate impacts, EEPGL will work with the Government of Guyana to proactively engage with affected parties, and the residual significance is on the provisioning services provided by the canals therefore considered to be **Minor**.

The Demerara River provides both a travel route and source of freshwater fishing. The Project may affect these provisioning services during in-river works and dredging associated with construction—and later decommissioning—of the temporary MOF. Construction activities will restrict access to areas actively subject to dredging activities, for a duration of approximately 1 year. The location of these activities will be dynamic in the river adjacent to the temporary MOF, and dredging vessels will navigate in a manner that allows other vessels to safely pass upstream and downstream. Considering the conclusions of the transportation and freshwater biodiversity assessments, the impact on the provisioning services provided by the Demerara River is considered to be **Negligible**.

Regulating Services

In addition to the provisioning services associated with freshwater, travel, and fishing, these canals are an integral part of the hydrological system and regulate the movement of water throughout the region. Upstream, the forests and wetlands of the Boerasirie Conservancy act as the source of most freshwater that feeds the canals between the Conservancy and the Demerara River. Residential areas downstream of the conservancy include the Primary and Secondary Study Area communities, including, but not limited to, Canal 1, Canal 2, Westminister / Lust-en-Rust, and the settlements in the South Wales area. The potential impact on the regulating services provided by the canal network for water and flood regulation is considered to be **Negligible**.

Riparian vegetation zones, including mangroves, are located along the Demerara River and support shoreline stability. Along the Atlantic coast, the existing seawall and mangrove-associated species provide similar stability for the coastline. These coastal and riverside shoreline protections represent regulating ecosystem services. Construction of the shore crossing has the potential to impact 0.29 hectare of coastal strand vegetation including mangrove-associated species along approximately 200 meters of the coastal shore frontage, and—if open-cut methods are used to construct the shore crossing—could temporarily remove a section of the seawall. Construction of the temporary MOF has the potential to impact 0.06 hectare of riparian forest including mangrove-associated species along approximately 30 meters of river shore frontage. The Project construction could therefore impact the regulating service provided in terms of coastal and/or shoreline protection in these areas. Construction will be conducted with an effort to minimize the footprint of activities and preserve coastal strand and riparian forest as much as practicable, and shoreline stability will be monitored and will be reinforced as required to reduce erosion. After construction, pre-existing shoreline protection will be re-established through revegetation or armoring of disturbed areas, and may be supplemented by other forms of support and/or stabilization, if required. The anticipated impact on the regulating service provided by existing vegetative and/or man-made shoreline protection is considered to be **Minor** significance for the shore crossing at the Atlantic coast, and **Negligible** on the Demerara River.

Cultural Services

Access to the coastal shore is valued by local residents. The beach is a place of prayer and religious rites for Hindu ceremonies and jhandi (prayer) flags have been observed on the beach near the shore crossing. Construction of the shore crossing will temporarily restrict access to the beach near Crane, and a footbridge east of the shore crossing will be temporarily inaccessible to the public while shore crossing construction is underway. This restriction may impact the cultural service provided by the beach, if people are unable to access areas used for prayer and religious practices and/or recreational activities. Although certain temporary access restrictions may be unavoidable, Project-related construction activities will avoid disturbance of existing jhandi (prayer) flags, and will engage local and/or religious stakeholders as required. With these mitigations in place, the residual impact on the cultural service provided by the shoreline is considered to be **Negligible**.

3.1.16. Indigenous Peoples

Santa Aratak is the nearest Amerindian village to the Project, located in Region 3 approximately 14 kilometers southwest of the proposed NGL Plant, respectively. Construction of the Project will involve shoreline and river-based construction activities on the Demerara River to support construction of the temporary MOF and supply of equipment and materials in support of NGL Plant construction. The Santa Aratak community uses the Demerara River for access to and from the community (via Kamuni Creek, more than 10 kilometers upstream of the proposed temporary MOF site), and Project-related activities in the river could therefore affect Indigenous Peoples living in Santa Aratak, including residents' access to/from the community and areas where they practice their livelihoods. Interference with river travel will be intermittent and river-based activities (e.g., dredging) will be conducted so as to maintain navigability for other vessels traveling upstream or downstream. The residual impact is anticipated to be of **Minor** significance.

3.2. UNPLANNED EVENTS

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., oil spills, accidents), but that could potentially occur. Since such events are not planned, they are evaluated in a different manner from planned events—specifically, by evaluating the consequence/severity of a realistic scenario for an unplanned event and taking into consideration the likelihood that the event could occur.

For the EIA, the following types of unplanned events were considered:

- Marine or riverine fuel spill
- Loss of integrity of offshore pipeline, resulting in a natural gas release
- Vessel collision with a third-party vessel, structure, or animal (non-spill-related)
- Onshore hydrocarbon release from:
  - Loss of integrity of onshore pipeline
  - Loss of integrity of natural gas liquids processing plant (NGL Plant) facilities
- Untreated wastewater release at NGL Plant
- Vehicular accident

3.2.1. Marine or Riverine Fuel Spill

The construction of the offshore pipeline and new subsea tie-in infrastructure will involve the use of marine installation and support vessels and helicopters that use petroleum products for fuel. In the riverine environment (i.e., the Demerara River), vessels will be used to transport equipment, materials, and workers between shorebases and the temporary MOF. Multiple layers of control are in place with respect to these activities; however, if multiple controls fail, there is the potential for a fuel spill to occur. For the scenarios considered, fuel could potentially be released into the environment in the form of marine diesel (vessels operating on the open ocean or in the Demerara River, either as a result of a vessel collision or a marine bunkering system failure) or aviation fuel (as a result of a helicopter ditching while traveling to/from offshore pipeline installation vessels).

The potential for offshore vessel collisions (e.g., collisions between Project installation or support vessels, or between these vessels and a third-party vessel) to occur during the Project is limited by the following safety measures that will be put in place:

- MARAD will issue notices to mariners concerning safety at sea and the location of major installation vessels. EEPGL will also communicate major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners. Through a stakeholder engagement process, EEPGL will communicate Project activities, where possible, to those individuals to facilitate their avoidance of Project vessels. Marine safety exclusion zones with a 500-meter radius will be established around the major installation vessels. No unauthorized vessels will be allowed to enter these marine safety exclusion zones.
- With respect to installation of subsea tie-in infrastructure, a marine safety exclusion zone of 2 nautical miles (3.7 kilometers) will be maintained around the Destiny and Unity FPSOs. No unauthorized vessels will be allowed to enter these marine safety exclusion zones.
- EEPGL will use what is known as a Simultaneous Operations procedure to safely manage Project marine vessels performing work in the same vicinity of each other, which will include considerations for avoiding vessel collisions.
- Marine vessels will have industry-proven station-keeping systems to maintain stations in the offshore environment.
- EEPGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EEPGL will provide active oversight over its contractors to verify that they are complying with its requirements.
- Contractors are required to inspect their vessels regularly. The inspections will address marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability.
- In addition, vessels operating within the Georgetown Harbour or other coastal areas will be required to adhere to speed restrictions and navigation aids.

Multiple automated safety features are designed into offshore supply vessels to minimize the risk of a bunkering system failure (e.g., automated shut-off valves, alarms), and bunkering will be conducted by trained operations and maintenance crews. Additionally, all Project vessels will have robust emergency response plans in place to respond quickly in the event that a fuel release is detected. A release would likely be quickly detected and contained via either an automated and/or manual system.

Oil spill modeling was conducted for two marine fuel spill scenarios (two different volumes at the same location). Results of the modeling indicated that approximately 65 to 90 percent of the spilled fuel evaporated by the end of the 10-day modeling period. For both seasons modeled, the trajectory of the marine spill was northwesterly, generally parallel to the Guyana coastline.

Oil spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). Two spill locations were modeled in the Demerara River: one at the Demerara Harbour Bridge, and one at the temporary MOF. Results of the modeling indicated that approximately 70 percent of the spilled fuel evaporated by the end of the 5-day modeling period, but approximately 20 percent to 30 percent of the spilled fuel came into contact with a shoreline – either on the western bank of the Demerara River or on a portion of the coast immediately west of the mouth of the river. Lengths of shoreline oiled ranged between approximately 4 and 10 kilometers depending on river flow conditions and spill location.

Based on the potential consequence/severity of a marine or riverine fuel spill, and considering that they are unlikely given the suite of preventative measures in place, the assessment assigned a **Moderate** residual risk rating for several biological resources (non-special status and special status marine mammals and marine birds, special status marine fish, and marine turtles [all Guyana species are special status]). The remaining resources that could be impacted by a marine or riverine fuel spill were assigned a **Minor** residual risk rating.

3.2.2. Loss of Integrity of Offshore Pipeline Resulting in a Natural Gas Release

There a number of scenarios that could result in a loss of integrity and resulting release of natural gas from the offshore pipeline, including:

- Corrosion
- Objects striking the pipeline
- A buildup of stress in the pipe wall, causing buckling

If an unplanned release of gas from damaged subsea pipelines occurs, the released gas will generate a gas plume that rises from the seafloor to the sea surface. Fire or explosion accidents can occur when the released gas disperses into the atmosphere and encounters ignition sources, which could have an adverse impact on human life and environment in the immediate vicinity of the fire. The consequences would likely be much less severe offshore than a release from the onshore pipeline because an offshore release would be extremely likely to be free-field[1], thereby negating the chance of an explosion.

To reduce the likelihood of a release, the offshore pipeline design and installation will vary depending on the pipeline depth. At a minimum, the pipeline will be laid in a trench, with sections closer to the nearshore area buried, which will reduce the likelihood of an external impact causing a release. The offshore pipeline will be constructed using international good practices, which will reduce the likelihood of stresses building up in the pipeline walls and thereby reduce the likelihood of buckling. A leak would be quickly detected and isolated using

[1] Free-field is a modeling term used to describe a release that is into open space and not into confined or congested areas.

emergency shut down valves, which will limit inventory loss and therefore the duration of any release event.

Based on the potential consequence/severity of a loss of integrity of the offshore pipeline, and considering that it is unlikely given the suite of preventative measures in place, the assessment assigned a **Minor** residual risk rating for all resources that could be impacted by this unplanned event.

3.2.3. Vessel Collision

A Project vessel collision could occur with a third-party vessel or structure, resulting in a spill of fuel (discussed above). This section addresses the potential for such a collision, but focuses on the potential non-spill related aspects. This section also addresses the potential for a Project vessel to collide with a marine animal, specifically focusing on marine mammals, marine turtles, and riverine mammals.

3.2.3.1. Vessel Collision with a Third-Party Vessel or Structure

A variety of Project vessels will supply construction operations, and these vessels will transit between the Guyana shorebases and either the offshore pipeline corridor or temporary MOF. There is a potential for collisions between these vessels and third-party vessels/structures in the Georgetown Harbour / Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Damage to an impacted structure may require repairs, and in extreme cases, temporary closure of the structure; this has occurred before in Guyana (e.g., damage to and temporary closure of the Demerara Harbour Bridge).

A number of embedded controls will be in place to reduce the potential for a nearshore or offshore collision to occur. Based on the potential consequence/severity of a vessel collision with a third-party vessel, and considering that it is unlikely given the suite of preventative measures in place, the assessment assigned a **Minor** residual risk rating for all resources that could be impacted by this unplanned event.

3.2.3.2. Vessel Strikes of Marine Mammals, Marine Turtles, Riverine Mammals, or Rafting Marine Birds

While marine mammals possess acute senses of hearing that they can use to detect approaching vessels, and they have the necessary swimming speed capability to avoid collisions, they are vulnerable to vessel strikes when they surface to breathe or to feed. This vulnerability increases in shallow nearshore areas where opportunities to maneuver are reduced, however the largest and least maneuverable species have not been documented on the continental shelf throughout EEPGL’s extensive period of collecting Protected Species Observer data offshore Guyana, so their limited ability to avoid oncoming vessels is not anticipated to factor into marine mammals’ susceptibility to vessel strikes during this Project.

Marine turtles tend to spend most of their time at sea at or near the sea surface, and do not possess the acute sense of hearing or the swimming speed that cetaceans use to avoid collisions. Marine turtles are inherently more vulnerable to vessel strikes in the shallow nearshore areas where they congregate prior to coming ashore to nest, than they are in the open ocean. The only sea turtle nesting areas in Guyana are at Shell Beach in Region 1 near the Venezuela border, so any sea turtles encountered in the Project AOI are likely to be moving to or from Shell Beach rather than congregating in the Project AOI.

Riverine mammals in the Demerara River are vulnerable to vessel collision when they surface to breathe or to feed. This vulnerability increases in shallow areas, where there are fewer opportunities to maneuver compared to the open ocean. The American manatee, in particular, would be susceptible to vessel collision within the lower Demerara River. It is well documented that manatees are highly vulnerable to vessel collision, and vessel collision is listed by the International Union for Conservation of Nature (IUCN) as one of the key threats to this subpopulation of manatees. Based on two years of targeted surveys for manatees, the manatee population in the Demerara River appears to be concentrated at the eastern seawall at the river mouth, where they would be well outside the main river channel and the access channel to the temporary MOF and therefore not likely to encounter Project vessels.

Rafting marine birds may suffer injury or mortality from collision with vessels transiting to and from the offshore pipeline corridor. However, rafters are not likely to be present in large aggregations in the offshore pipeline corridor because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for large aggregations of species that favor more calm and sheltered conditions. On the rare occasions that suitable conditions for rafting occur and marine birds are present in high enough concentrations to form rafts, individual marine birds could be susceptible to vessel strike and related injury or mortality. However, large marine bird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path.

Project activities will take place across a range of depths. The species that are most susceptible to vessel strikes are either no common in shallow waters where evasive behavior would be restricted (large whales), are present in the Project AOI only occasionally and congregate elsewhere (marine turtles), or are relatively common in the Project AOI but have been shown through targeted field surveys to favor habitats in the Project AOI that would not be affected by Project vessel traffic (American manatees).

EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface and will issue standing instructions to Project-dedicated vessel masters on what to do if they encounter marine mammals, marine turtles, or riverine mammals while in transit (i.e., reduce vessel speed or deviate from course, when possible, to lower the probability of a collision). While these measures will serve to reduce the residual risk, the risk rating for a vessel collision is considered to be **Moderate** for marine mammals and marine turtles and **Minor** for riverine mammals and rafting marine birds.

3.2.4. Onshore Hydrocarbon Release (from Loss of Integrity of Onshore Pipeline or NGL Plant)

There is the potential for an unplanned release of hydrocarbons from the onshore pipeline or NGL Plant.

3.2.4.1. Loss of Integrity of Onshore Pipeline

The potential unplanned events considered included a full-bore rupture of the onshore pipeline or a leak in the pipeline. Onshore pipeline integrity failures are rare, especially on such relatively short lengths of pipeline as in the case of the Project. If a loss of integrity were to occur, the most likely causes would be a third party striking the line or corrosion of the pipe that ultimately led to a pipe wall failure.

The onshore pipeline will be installed below ground with a minimum cover depth of 1.22 meters. In sections installed using open trenching, a fiber optic cable-based system will be installed in the same trench for communication and to detect leaks and/or third-party intrusion.

A line strike on the buried pipeline could occur as a result of a third party excavating in close proximity to the pipeline without knowing the exact location of the pipeline (e.g., during construction activities in close proximity to the pipeline). A third-party strike typically would present a source of ignition for the released gas, which could result in the immediate ignition of the gas and what is referred to as a jet fire[2]. If the release is not ignited immediately, a flammable gas cloud would be formed and this could ignite, causing either a flash fire[3] or explosion. An explosion would only be likely to occur if the gas is released into a congested space. A congested space can be defined as any space within which there is an obstruction to the free movement of a gas through the space. The most likely places where obstructions would be present near the onshore pipeline would be densely forested areas or thick undergrowth. The strength of the explosion would be correlated to the proportion of the gas cloud within the congested area. The higher the proportion of the gas cloud that is within a congested area, the stronger the resultant explosion would be. Consequently, open areas—such as that characterized by the onshore pipeline corridor—are unlikely to be conducive to an explosion in the case of a hydrocarbon release from the onshore pipeline.

The Project will include a number of embedded controls to reduce the likelihood of a third-party line strike. These include the following:

- While the majority of the onshore pipeline corridor will pass through areas that correspond to Class 1 or Class 2 location classifications, as per American Society of Mechanical Engineers (ASME) B31.8, the onshore pipeline will be designed to a Class 3 location classification—which includes higher design factors, including increased wall thickness.

[2] A jet fire is a combustion of flammable material as it is being released from a pressurized process unit; the duration of the fire can be very long and it is determined by the amount of material available to be released.
[3] A flash fire is a nonexplosive combustion of a flammable vapor cloud, which is diffused in open air; the duration of the fire is very short and depends on the mass of material in the cloud.

- Aboveground pipeline markers installed along the onshore pipeline corridor, indicating the location of the buried pipeline and including standard signage to not excavate in the area prior to contacting EEPGL.
- An fiber optic cable-based system installed along the pipeline at the time the pipeline is buried, to detect leaks and/or third-party intrusion the pipeline.
- For the aboveground valve compound near the shore landing, anti-cut / anti-climb perimeter fencing around the valve, with fiber optic intrusion detection, 24-hour-per-day closed-circuit television monitoring of the compound, and security lighting.

With respect to the potential corrosion causal factor, relevant embedded controls include the above-referenced external corrosion coating for the onshore pipeline, installation and monitoring of an impressed current cathodic protection system, and routine internal inspections for corrosion through the use of pipeline intelligent pigging tools.

3.2.4.2. Loss of Integrity of NGL Plant Facilities

A series of potential scenarios involving a hydrocarbon release from the NGL Plant facilities were screened using consequence modeling software to determine if they had the potential to impact any resources beyond the NGL Plant boundary. There will be numerous layers of protection to prevent a release of natural gas from the NGL Plant; the specifics of these design elements will be developed during the detailed design of the Project. In the unlikely event that multiple layers fail, however, there is the potential that some of the scenarios analyzed have the potential to impact resources outside of the NGL Plant boundary. The types of events assessed for those scenarios with the potential to impact resources outside the NGL Plant boundary included a boiling liquid expanding vapor explosion (BLEVE), a flammable gas cloud, and a jet fire.

A BLEVE can be caused when the contents of a pressurized storage tank are heated by an external heat source such as a fire. The contents of the tank can start to boil, thereby increasing the pressure inside the tank until it exceeds the tank's design pressure, which can ultimately result in a failure of the vessel. At the point of failure, the tank can explode, creating an overpressure[4] and a fireball[5]. The overpressure from a BLEVE typically results in considerably more damage to the surrounding environment than the thermal radiation from a fireball, so the assessment is focused on BLEVEs. Such events are very rare in natural gas processing facilities, and several protection measures will be put in place to prevent such failures, such as pressure relief valves, firefighting systems, and industry-standard separation distances between storage vessels.

The screening assessment identified additional unplanned event scenarios that could result in explosions from other parts of the plant (i.e., other than storage vessels), but the potential extent

[4] Overpressure is the pressure caused by the shockwaves of an explosion.
[5] A fireball occurs when an instantaneous release of flammable material is ignited, resulting in a fire that is spherical and rises through the air due to the buoyancy of the hot combustion products.

of impacts from these scenarios would likely be less significant than a BLEVE; accordingly, these other potential explosion scenarios were not modeled.

Other types of hydrocarbon releases from the NGL Plant could be caused by leaks from flanges or vessels, or operations and maintenance errors. Although significant releases are very rare, there is potential—if they did occur—for this to result in a jet fire or a flammable cloud, both of which could potentially impact resources outside of the NGL Plant boundary.

The potential hydrocarbon releases that could impact resources outside the NGL Plant boundary were modeled using the consequence modeling software. The following events produced the largest potential impacts on resources outside of the NGL Plant boundary:

- Release of gas from the onshore pipeline, a pressurized propane storage bullet, piping upstream of the slug catcher, the deethanizer pump, the residue compressor outlet, or the methanol tank—resulting in a flammable cloud;
- Release and ignition of gas from the onshore pipeline, piping upstream of the slug catcher, the deethanizer pump, the residue compressor outlet, or the methanol tank—resulting in a jet fire; and
- Overpressure from a BLEVE of the pressurized propane storage bullet.

Based on the potential consequence/severity of an onshore hydrocarbon release from a loss of integrity of the onshore pipeline or the NGL Plant, and considering that they are unlikely given the suite of preventative measures in place, the assessment assigned a **Moderate** residual risk rating for two physical resources (sound and vibration, and air quality) and several socioeconomic resources (socioeconomic conditions, community health and wellbeing, social infrastructure and services, cultural heritage, and land use and ownership). The remaining resources that could be impacted by an onshore hydrocarbon release were assigned a **Minor** residual risk rating.

3.2.5. Untreated Wastewater Release at NGL Plant

A sanitary wastewater system will collect all domestic wastes from toilet facilities via manholes located near buildings and underground sloped piping. A modular “package” wastewater treatment plant (WWTP) will provide initial treatment of sanitary wastewater. Treated sanitary wastewater will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant.

A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. Treated wastewater will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant.

An open drain system will collect rainwater from curbed areas of the NGL Plant. This includes the process, loading racks, flare, and substation areas. The water will be collected in an open drain header and drained to an oily water sump that is sized for the first flush (i.e., 15 minutes) of rainfall. The first flush of rainfall will be sent to the process WWTP, while subsequent water will be routed directly to the stormwater pond.

An untreated wastewater release from the NGL Plant could occur if either of the sanitary or process WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted (e.g., because of a high rainfall event or some other prior situation that prevented the stormwater pond contents from being discharged at the design rate). In this situation, the potential exists that the effluent from the stormwater pond could be discharged to the Demerara River (either directly or via a canal adjacent to the NGL Plant) at constituent concentrations above treatment specifications. The key embedded controls that will reduce the likelihood of this situation occurring include the following:

- EEPGL will conduct routine maintenance and monitoring to maintain the performance of the WWTPs.
- The wastewater effluent from the WWTPs will discharge into the stormwater pond, which will contain uncontaminated stormwater runoff. This will dilute the concentrations of constituents present in the wastewater effluents prior to discharge from the stormwater pond into the Demerara River (either directly or via a canal adjacent to the NGL Plant). Water in the stormwater pond will be monitored regularly to confirm compliance with discharge standards prior to discharge to the Demerara River.

If the water flows across unsealed surfaces, some of the water and contaminants will be absorbed by the ground. Water that is not absorbed will continue to flow until it reaches a surrounding water source or is captured by another drain system at the NGL Plant site.

The key embedded controls that will reduce the likelihood of this situation occurring include the following:

- The open drain system will be sized to accommodate a 100-year rainfall event.
- The NGL Plant site will be graded so as to direct stormwater flow across the site into the stormwater pond.

Based on the potential consequence/severity of an untreated wastewater discharge from the NGL Plant, and considering that the low likelihood of this event given the suite of preventative measures in place, the assessment assigned a **Minor** residual risk rating for all resources that could be impacted by this unplanned event.

3.2.6. Onshore Vehicular Accident

The Project will add additional vehicles to the public roadways during the Construction and Operations stages. During the Construction stage, workers will be transported using large-capacity buses, resulting in an estimated additional 30 to 50 round-trip vehicle movements per day at peak construction. During the Operations stage, the number of workers will be significantly reduced, but the estimated additional round-trip vehicle movements could be similar, on the conservative assumption that most employees drive alone to/from the NGL Plant each day.

Based on a baseline traffic study conducted at several intersections along the WBD Public Road in 2021, these estimated additional trips represent an incrementally small change with respect to existing traffic conditions in the vicinity of the Project. Nevertheless, the potential for a vehicular accident involving a Project-related vehicle during the Project life cycle is possible, and the assigned risk residual rating for potential impacts on community health and wellbeing ranges from **Minor** to **Moderate**.

3.3. Cumulative Impacts

The Project's expected contribution to potential cumulative impacts will be limited by the fact that the Project's impacts with higher significance ratings will generally not, with the exception of the Power Plant, overlap spatially with impacts from the other projects considered in the cumulative impact assessment. Other EEPGL offshore Guyana oil and gas exploration and development activities considered in the cumulative impact assessment include the Liza Phase 1 Development Project and Liza Phase 2 Development Project, which are currently operational; the approved Payara Development Project; continued exploration drilling; and future proposed or planned offshore development projects (assumed for the purpose of this assessment to also be in the Stabroek Block). Potential future offshore Guyana oil and gas exploration by other developers and planned shorebase development and replacement of the Demerara Harbour Bridge could, in combination with Project activities in the Demerara River, also potentially contribute to cumulative impacts.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively a number of physical, biological, and socioeconomic resources.

The Project will adopt a number of embedded controls, mitigation measures, and management plans. These are considered sufficient to address the contributions of the Project to cumulative impacts. With respect to the contributions of multiple EEPGL projects/activities to potential cumulative impacts, it is recommended that EEPGL, when designing and undertaking these additional projects/activities, ensure that the same level of potential impact management (i.e., as for the GTE Project) be implemented.

A number of resources were assigned a cumulative impact priority rating of **Medium**, suggesting that additional consideration should be given (i.e., beyond the embedded controls and mitigation measures already proposed for the Project) to address potential cumulative impacts on these resources. The Consultants' recommendations to address these potential cumulative impacts with a **Medium** priority rating include the following:

- To address potential cumulative impacts on sound and vibration during the Project Operations stage, work with the Government of Guyana to confirm that combined noise levels from operations of the NGL Plant and Power Plant are adequately managed, through design and/or operation practices.

- To address potential cumulative impacts on air quality during the Construction stage, work with the Government of Guyana so that dust minimization efforts are implemented consistently for the combined construction activities in this area of the heavy haul road and temporary MOF (the only area with residences in close enough proximity to planned Project construction activities at the NGL Plant to have potential dust impact concerns).
- To address potential cumulative impacts on socioeconomic conditions related to increased competition for local labor, take actions in the medium term to mitigate potential adverse impacts on the local labor workforce, including through continued partnerships (e.g., Centre for Local Business Development), to promote training and development opportunities for local workers and businesses.
- To address potential cumulative impacts on social infrastructure and services related to increased demand on lodging and housing and utilities, monitor the accommodation needs of all contractors working on EEPGL-related projects (including the GTE Project and EEPGL's offshore projects) to assess how the companies anticipate managing those accommodation needs, in particular during the GTE Project Construction stage.
- To address potential cumulative impacts on land use and ownership, consistent with the Project's commitment to support the Government of Guyana in developing a Resettlement and Livelihood Restoration Strategy to implement resettlement (for physical displacement) and livelihood restoration (for economic displacement) through a process that aligns with International Finance Corporation (IFC) Performance Standard 5 (PS 5), identify—for the individuals to be relocated from the area of the temporary MOF—whether these individuals have additional assets that could be impacted by reasonably foreseeable other projects, and consider these impacts with respect to implementation of the above strategy.

3.4. Degree of Irreversible Damage

The planned Project activities will result in irreversible damage to the onshore areas on which permanent aboveground Project infrastructure will be constructed. While portions of the approximately 75-hectare NGL Plant site may be revegetated and allowed to remain in a generally natural state during the Operations stage, it is conservatively assumed for the purpose of this EIA that this entire area will be permanently impacted (noting that some or all of the area may be returned to a natural condition depending on the final decommissioning alternative selected). The temporary portions of the pipeline construction corridor will be restored after construction, but a permanent RoW (covering an area on the order of approximately 23 hectares) will be maintained (i.e., in a height-managed, vegetated state) for the life of the Project. Given the length of the planned operational life cycle, this is considered to be permanently impacted. There will be a permanent loss of benthic habitat offshore as a result of the laying of the offshore pipeline on the seabed for up to 205 kilometers of the offshore pipeline length (amounting to approximately 6.6 hectares), which may be proposed to be left in place upon decommissioning. However, this equipment can ultimately provide the substrate for recolonization of the impacted areas.

In the unlikely event of a fuel spill or fire/explosion resulting from a loss of Project infrastructure integrity, little irreversible damage would be expected, although it could take several years for all resources to fully recover, depending on the nature and extent of the event as well as the time of year.

3.5. MANAGEMENT PLANS

A series of management plans has been developed to manage and mitigate the impacts identified in the EIA. This series includes the following:

- ESMMP
- Comprehensive Waste Management Plan
- Stakeholder Engagement Plan for Guyana Operations
- Preliminary Decommissioning Plan for the Gas to Energy Project
- OSRP for Guyana Operations

EEPGL's Safety, Security, Health, and Environment Policies are provided here as Figures EIS-6 through EIS-9, respectively.

Esso Exploration & Production Guyana Limited
Safety Policy

It is the policy of Esso Exploration & Production Guyana Limited to conduct its business in a manner that protects the safety of employees, others involved in its operations, customers, and the public. The Company will strive to prevent all accidents, injuries, and occupational illnesses through the active participation of every employee. The Corporation is committed to continuous efforts to identify and eliminate or manage safety risks associated with its activities.

Accordingly, the Company's policy is to:

- Design and maintain facilities, establish management systems, provide training and conduct operations in a manner that safeguards people and property;
- Respond quickly, effectively, and with care to emergencies or accidents resulting from its operations, in cooperation with industry organizations and authorized government agencies;
- Comply with all applicable laws and regulations, and apply responsible standards where laws and regulations do not exist;
- Work with government agencies and others to develop responsible laws, regulations, and standards based on sound science and consideration of risk;
- Conduct and support research to extend knowledge about the safety effects of its operations, and promptly apply significant findings and, as appropriate, share them with employees, contractors, government agencies, and others who might be affected;
- Stress to all employees, contractors, and others working on its behalf their responsibility and accountability for safe performance on the job and encourage safe behavior off the job;
- Undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this policy.

Alistair Routledge

General Manager

Date: 1 April 2022

Figure EIS-6: Safety Policy

Esso Exploration & Production Guyana Limited

Security Policy

It is the policy of Esso Exploration & Production Guyana Limited to provide security and safeguards as needed to protect its personnel, assets, operations, facilities, and business information. Security is a line management responsibility. The vigilance and involvement of every employee and contractor is needed, as is a professional and technically competent security organization, Specific activities include:

- Compliance with relevant laws and regulations affecting security in areas where we operate. Where they do not exist, responsible standards based upon our worldwide experience will be applied.
- Systematic assessment of security risks, and ensuring they are managed through the application of protective measures which reflect best cost-effective practices.
- Special emphasis on personnel and protection and security in developing areas.
- Integration of security programs with Operations Integrity Management System (OIMS).
- Monitoring of potential risks through appropriate worldwide information sources and formulation of special steps required.
- Through effective partnerships with the businesses, integration of security measures in the early stages of new plans and projects.
- Prompt investigation of security breaches and irregularities, and provision of sound advice to management concerning steps to be taken.
- Appropriate reviews and evaluations of our security performance to measure effectiveness and drive continuous improvement.

Rod D. Henson

Country Manager

Date: 16 MAR 2018

Figure EIS-7: Security Policy

Esso Exploration & Production Guyana Limited

Health Policy

It is the policy of Esso Exploration & Production Guyana Limited to:

- Identify and evaluate health risks related to its operations that potentially affect its employees, contractors or the public;
- Implement programs and appropriate protective measures to control such risks, including appropriate monitoring of its potentially affected employees;
- Communicate in a reasonable manner to potentially affected individuals or organizations and the scientific community knowledge about health risks gained from its health programs and related studies;
- Determine at the time of employment and thereafter, as appropriate, the medical fitness of employees to do their work without undue risk to themselves or others;
- Provide or arrange for medical services necessary for the treatment of employee occupational illnesses or injuries and for the handling of medical emergencies;
- Comply with all applicable laws and regulations, and apply responsible standards where laws and regulations do not exist;
- Work with government agencies and others to develop responsible laws, regulations, and standards based on sound science and consideration of risk;
- Conduct and support research to extend knowledge about the health effects of its operations;
- Undertake appropriate reviews and evaluations of its operations to measure progress and to foster compliance with this health policy.

Provide voluntary health promotion programs designed to enhance employees' wellbeing, productivity, and personal safety. These programs should supplement, but not interfere with, the responsibility of employees for their own health care and their relationships with personal physicians.

Information about employees obtained through the implementation of these programs should be considered confidential and should not be revealed to non-medical personnel except: at the request of the employee concerned, when required by law, when dictated by overriding public health considerations, or when necessary to implement the Alcohol and Drug Use policy.

Alistair Routledge

General Manager

Routledge

Date: 1 April 2022

Figure EIS-8: Health Policy

Esso Exploration & Production Guyana Limited

Environment Policy

It is the Policy Esso Exploration & Production Guyana Limited to conduct its business in a manner that is compatible with the balanced environmental and economic needs of the communities in which it operates, Further, It is the Company's policy to comply with all applicable environmental laws and regulations and apply responsible standards where laws or regulations do not exist. The Company is committed to continuous efforts to improve environmental performance throughout its activities. It will encourage concern and respect for the environment, emphasize every employee's responsibility in environmental performance, and ensure appropriate operating and training. The Company will communicate with the public on environmental matters and share its experience with others to facilitate improvements in industry performance.

Accordingly, the Company's policy is to:

- Work with government and industry groups to foster timely development of effective environmental laws and regulations based on sound science and considering risk, costs and benefits, including effects on energy and product supply;
- Manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels and design, operate, and maintain facilities to this end;
- Respond quickly and effectively to incidents resulting from its operations, cooperating with industry organizations and authorized agencies;
- Conduct and support research to improve understanding of the impact of its business on the environment, to improve methods of environmental protections and to enhance its capability to make operations and products compatible with the environment;
- Undertake appropriate reviews and evaluations of its operations to measure progress and to ensure compliance with his environmental policy.

Rod D. Henson

Country Manager

Rod D. Henson

Date: 16 MAR 2018

Figure EIS-9: Environment Policy

A number of environmental and socioeconomic performance criteria will be used by the Project. These performance criteria are consistent with good international oilfield practice. Table EIS-4 presents a summary of those key environmental and socioeconomic performance criteria the Project will utilize which have a specific quantitative standard.

Table EIS-4: Summary of Key Environmental and Socioeconomic Performance Criteria with Specific Quantitative Standards to be used by the Project

Aspect	Performance Criteria to be Applied	International Standard That References Applied Performance Criteria
Air Quality	Modeled concentrations of air pollutants at potential onshore receptor locations have been compared to guideline concentrations from the WHO and USEPA.	WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide – Global Update 2005 (WHO 2005); WHO Air Quality Guidelines for Europe, 2nd Edition, 2000; WHO Global Air Quality Guidelines (WHO 2021); USEPA National Ambient Air Quality Standards (USEPA 2021)
Air Quality	Construction-related dust impacts have been assessed with reference to guidance from the United Kingdom Institute of Air Quality Management.	*Guidance on the Assessment of Dust from Demolition and Construction by the United Kingdom Institute of Air Quality Management* (IAQM 2014)
Ballast Water	Comply with requirements.	International Convention for the Control and Management of Ships' Ballast Water and Sediments
Bilge Water	Comply with requirements.	MARPOL 73/78
Cumulative Impacts	The cumulative impact assessment for the Project has been conducted in general accordance with international best practice guidance of the IFC.	IFC's Good Practice Handbook - Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets (IFC 2013)
Deck Drainage	Comply with requirements.	MARPOL 73/78
Ecosystem Services	An ecosystem services prioritization has been conducted in general accordance with international best practice described in the 2012 IFC Performance Standards.	IFC Performance Standards 2012 (IFC 2012)
Food Waste	Comminute to 25 millimeters diameter particle size or less and comply with requirements.	MARPOL 73/78
GHG Emissions	Evaluate options for energy efficiency.	World Bank General EHS Guidelines (2007a)
GHG Emissions	Quantify GHG emissions annually in accordance with internationally recognized methodologies and good practice.	IPIECA's Petroleum Industry Guidelines for Reporting Greenhouse Gas Emissions (IPIECA 2011)
Process Wastewater—NGL Plant	Treat select process wastewater streams with process WWTP and comply with discharge requirements.	World Bank EHS Guidelines for Natural Gas Processing (2007b)

Aspect	Performance Criteria to be Applied	International Standard That References Applied Performance Criteria
Resettlement and Livelihood Restoration	A Resettlement and Livelihood Restoration strategy was developed in alignment with internationally recognized good practice for resettlement as defined by IFC PS 5: Land Acquisition and Involuntary Resettlement.	IFC PS 5: Land Acquisition and Involuntary Resettlement (IFC 2012)
Sediment Quality	Existing concentrations of constituents in sediment samples have been compared to U.S. NOAA “Effects Ranges.”	NOAA (“Development and evaluation of sediment quality guidelines for Florida coastal waters” [Macdonald et al. 1996])
Sanitary sewage and domestic wastewater—offshore	Treat sewage and wastewater and comply with discharge requirements.	MARPOL 73/78 IMO’s 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (IMO 2012)
Sanitary wastewater—NGL Plant	Treat wastewater with a package wastewater treatment system and comply with discharge requirements.	World Bank General EHS General Guidelines (2007a)
Water Quality	Existing concentrations of constituents in water samples have been compared to guideline concentrations in the USEPA water quality guidelines.	USEPA Water Quality Guidelines; (Burgess et al. 2013); USEPA Saltwater Quality Standards
Water Quality—Pipeline Trenching, Dredging	Modeled total suspended solids concentrations from discharge of drill cuttings have been compared to the MARPOL 73/78 recommended total suspended solids threshold of 35 milligrams per liter.	MARPOL 73/78

IMO = International Maritime Organization; IPIECA = International Petroleum Industry Environmental Conservation Association; NOAA = National Oceanic and Atmospheric Administration

4. CONCLUSIONS AND RECOMMENDATIONS

4.1. CONCLUSIONS

The planned Project activities are predicted to have **Negligible** to **Moderate** impacts on physical resources, **Negligible** to **Moderate** impacts on biological resources, and **Negligible** to **Moderate** impacts on socioeconomic resources—with a number of positive impacts on socioeconomic conditions.

In the case of physical resources, the higher significance ratings stem from potential Construction-stage impacts related to potential noise and dust impacts on residential properties in the portions of the onshore pipeline construction corridor that will be in close proximity to existing communities or isolated residences (approximately 3.5 kilometers of the approximately 25-kilometer onshore pipeline corridor).

In the case of biological resources, the higher significance ratings stem from potential Construction-stage impacts related to mortality and injury of marine benthic organisms from offshore pipeline installation.

In the case of socioeconomic resources, the higher significance ratings stem from potential impacts from infrequent and short-term periods of noise during Construction and Operations stages, potentially leading to increased stress-related mental health impacts for nearby residents. For cultural heritage resources, the higher significance rating will only apply if the Project is unable to avoid removal of the silk cotton tree identified in the temporary pipeline RoW at Kilometer Point 4.1. Higher significance ratings are also associated with physical displacement and change in access to land used for agricultural livelihoods (i.e., potential economic displacement), which could affect a limited number of residents and land users in proximity to the onshore pipeline or NGL Plant, heavy haul road, and temporary MOF.

The significance ratings of these potential impacts are reduced through the suite of embedded controls that will be incorporated into the Project design and execution. These same embedded controls contribution to the lower significance ratings for the other potential impacts assessed for planned Project activities. Additionally, the Consultants have recommended a suite of mitigation measures to reduce potential impact significance to as low as reasonably practicable.

Unplanned events, such as a vessel fuel spill or a loss of integrity of Project infrastructure resulting in a fire or explosion, are considered unlikely to occur due to the extensive preventive measures employed by EEPGL; nevertheless, events such as these are considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the nature and location of an unplanned event, as well as the ambient conditions (e.g., wind speed/direction, river flow conditions). The EIA describes (1) modeling of fuel spill scenarios to evaluate a range of possible spill trajectories and rates of travel, and (2) modeling of loss of process infrastructure integrity scenarios to evaluate a range of potential consequences from such an event.

Based on the limited volume of fuel that would likely be released to the environment in the unlikely event of a marine fuel spill from one of the offshore pipeline installation vessels or a support vessel, and the fact that marine diesel would weather (i.e., evaporate, degrade, and partition to the water column) very rapidly once in the ambient environment, the impacts from this type of an event would be expected to be short-term and limited in extent. Socioeconomic resources (e.g., to fisheries or shorelines) would only be expected if the spill occurred in the nearshore/shore crossing segments of the offshore pipeline.

In the case of a riverine spill, the same limited spill volume and rapid weathering would reduce the level and extent of potential impact. However, the constrained geography within the Demerara River would lead to a high likelihood of shoreline impact, with the length of shoreline oiled being a function of spill location and ambient river conditions (i.e., flow volume and tidal stage) at the time of the spill. This event, assuming a spill of the nature reflected in the modeled scenario, would therefore have a high likelihood of affecting biological and socioeconomic resources in the Demerara River and potentially along the shoreline adjacent to the river.

The magnitude of impact for either a marine or riverine fuel spill would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when biological resources are more abundant in the area affected by the spill). Effective implementation of EEPGL's OSRP (Volume III of the EIA) would reduce the risk to resources primarily by efforts to protect shorelines from oiling.

With respect to a potential loss of integrity of Project infrastructure leading to a release of hydrocarbons—and potentially a fire or explosion—the EIA included a preliminary analysis of the potential consequences of such an event, including evaluation of multiple scenarios that could lead to an accidental release of hydrocarbons. The highest risk associated with this type of event would be associated with the portions of the onshore pipeline segment located in close proximity to communities (i.e., where human receptors would have the highest likelihood of being affected by the event). As with a potential fuel spill, EEPGL's primary focus is on prevention of such an event through the rigorous design, construction, and operations procedures that will be put in place. However, in the unlikely situation that such an event occurs, EEPGL will have an Emergency Response Plan (see the ESMMP in Volume III of the EIA) in place prior to introduction of natural gas into Project infrastructure, and EEPGL will conduct regular training and drills to facilitate Project readiness to address an emergency event of this nature.

Additional unplanned events, which are also considered unlikely to occur due to the preventive measures employed by EEPGL, could include a loss of integrity of the offshore pipeline; collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting marine birds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the NGL Plant. The impact extent from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL will put in place if such an event were to occur (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) would also serve to reduce the likely extent of impact.

Table EIS-5 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for impacts on each of the resources that may potentially result from the planned Project activities in each Project stage (i.e., Construction, Operations, and Decommissioning). For each resource, the table shows the highest residual impact significance rating among the potential impacts relevant to each Project stage, as well as positive impacts. The table also summarizes, for each resource, the highest residual risk rating for potential risks to resources from unplanned events (e.g., fuel spill, vessel strike, etc.) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

Table EIS-5: Summary of Residual Impact Significance Ratings, Residual Risk Ratings, and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Construction	Operations	Decommissioning		
Geology and Groundwater	Negligible	Negligible	---	Minor	NA
Soils	Negligible	Negligible	Negligible	Minor	NA
Sediments:					
• Marine Sediments	Negligible	---	---	Minor	NA
• Riverine Sediments	Negligible	Negligible	Negligible	Minor	NA
Water Quality:					
• Marine Water Quality	Negligible	---	---	Minor	NA
• Riverine Water Quality	Negligible	Negligible	---	Minor	NA
Sound and Vibration [c]	Negligible to Moderate	Negligible to Moderate	Negligible	Moderate	Medium
Air Quality, Climate, and Climate Change:					
• Air Quality	Negligible to Moderate	Negligible	Negligible to Moderate	Minor to Moderate	Medium
• Climate / Climate Change	Negligible	Minor	Negligible	Minor	
Waste Management Infrastructure Capacity	Negligible	Negligible	NR	Minor	NA
Protected Areas	---	---	---	---	NA
Marine and Coastal Biodiversity	Moderate	---	Negligible		Low
Terrestrial Biodiversity	Minor	Negligible	Negligible	Minor	Low
Freshwater Biodiversity	Minor	Negligible	Negligible		Low
Ecological Balance and Ecosystems	Minor	Negligible	Negligible		Low
Special Status Species	Moderate	Negligible	Negligible	Moderate	Low
Socioeconomic Conditions:					
• Economic Development	Positive	Positive	---	---	Low
• Employment and Business Growth	Minor [a]	Positive [b]	Positive [b]	---	Medium

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Construction	Operations	Decommissioning		
• Existing Livelihoods	Minor	Minor	---	Moderate	Low
Community Health and Wellbeing:					
• Individual and Social Determinants of Health	Negligible to Minor	Minor	---	---	Low
• Physical Determinants of Health	Moderate	Moderate	Negligible	Minor to Moderate	Low
• Institutional Determinants of Health	Minor	---	---	---	Low
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Medium
• Housing and Utilities	Minor	Negligible	Negligible	Moderate	Medium
• Water and Sanitation	Minor	Negligible	Negligible	Moderate	
Transportation:					
• Marine Transportation	Moderate	Negligible	---	Minor	Low
• River Transportation	Minor	Negligible	Minor	Minor	Low
• Road Transportation	Minor	Minor	Minor	Minor to Moderate	Low
Cultural Heritage	Minor to Moderate	Negligible	---	Minor to Moderate	Low
Land Use and Ownership	Moderate	Minor	---	Moderate	Medium
Landscape, Visual Resources, and Light:					
• Landscape and Visual Resources	Minor	Minor	---	---	Low
• Light	Minor	Minor	---	---	Low
Ecosystem Services	Minor	Negligible	---	Negligible	Low
Indigenous Peoples	Minor	Minor	---	Minor	NA

”---“ = no potential impacts identified for this stage; NR = not rated; NA = not applicable (not assessed in cumulative impact assessment; scoped out as potentially eligible [see Chapter 11, Cumulative Impacts])
[a] This stage also has a potential Positive impact(s).
[b] This stage also has potential impact(s) rated as Negligible.
[c] Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.

The Project will generate benefits for the citizens of Guyana in several ways:

- Project purchasing of in-country goods and services from Guyanese businesses in alignment with the EEPGL Local Content Plan approved by the Ministry of Natural Resources in June 2021.
- Hiring Guyanese nationals, either directly by EEPGL or indirectly by Project contractors, in alignment with the EEPGL Local Content Plan.
- Efforts to enhance the Guyana labor force (i.e., to increase experience, capacity, and skills of local workers) through efforts such as the Greater Guyana Initiative, (a decade-long program funded by the Stabroek Block co-venturers), which provides $20 billion GYD ($100 million USD) in support of sustainable economic diversification and capacity development programs across Guyana. Guyana is known for having a large percentage of the tertiary-educated population emigrate from the country primarily to Organisation for Economic Co-operation and Development nations (World Bank 2016, 2000; Guyana Chronicle 2015). Provided that a more robust employment environment can be demonstrated, an increase in high-skilled, high-paying jobs associated with the oil and gas sector should contribute to the attenuation of this phenomenon, creating a larger pool of advanced workers for all areas of the economy
- Through provision of natural gas to the Government of Guyana's proposed Power Plant, by enabling improved energy independence for Guyana as well as more reliable and less carbon-intensive power generation (as compared to the current fuel oil-fired power sources). Improved electrification at a national scale is typically linked to improvement of economic growth and overall growth in gross domestic product.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits could result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government. These beneficial "multiplier" impacts are expected to occur throughout the Project life.

4.2. Recommendations

The Consultants recommend the following measures be considered by the EPA, the Environmental Advisory Board, and other relevant Government of Guyana agencies as conditions of issuance of an environmental authorization for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see EIA Chapter 15, Commitment Register).
- Mitigation Measures—adopt the recommended mitigation measures (see EIA Chapter 15, Commitment Register).
- Management Plans—implement the proposed ESMMP to manage and mitigate the potential impacts identified in the EIA.

- Oil Spill Preparedness—EEPGL has proactively embedded multiple controls into the Project design to prevent a spill from occurring, and we agree that a fuel spill is unlikely. But given the sensitivity of many of the resources that could potentially be impacted by a spill, we believe it is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises—and involve appropriate Guyanese authorities and stakeholders in these activities, document the availability of appropriate response equipment, and demonstrate that offsite equipment could be mobilized for a timely response.

With the adoption of such controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the GTE Project is expected to pose manageable risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana. In addition, the Project will provide a source of fuel for electric power generation that is less carbon-intensive than the fuel sources currently used by the national utility for generation of power. Thus, the Project will support Guyana's Low Carbon Development Strategy, which outlines a plan to replace heavy fuel oil with natural gas as the main energy source as a bridge to an energy system sourced largely from hydropower, solar, and wind power.

ENVIRONMENTAL IMPACT ASSESSMENT

1. INTRODUCTION

Esso Exploration and Production Guyana Limited (EEPGL) is seeking environmental authorization for the Gas to Energy Project (GTE or Project), which will be located in Region 3 of Guyana (Essequibo Islands and West Demerara). EEPGL is the designated Operator[1] of the Stabroek Block and is acting on behalf of itself and its co-venturers (Hess Guyana Exploration Limited and CNOOC Petroleum Guyana Limited) under the Petroleum Agreement and the Petroleum Prospecting License for the Stabroek Block. The Project includes the construction and operation of a natural gas pipeline from the Liza Phase 1 and Liza Phase 2 Floating, Production, Storage, and Offloading (FPSO) vessels to an onshore natural gas liquids (NGL) processing plant (NGL Plant). The pipeline will transport up to approximately 50 million standard cubic feet per day of dry gas to the NGL Plant. The NGL Plant will drop the pressure of the gas; dehydrate the gas; separate out the natural gas liquids (i.e., propane, butane, and pentanes+); and treat the remaining "dry" gas to the specifications appropriate for use as fuel or raw materials by third parties.

The Government of Guyana is planning a Power Plant that would use dry gas from the NGL Plant to generate electricity for the benefit of Guyana, reducing the country's dependence on foreign imports of diesel fuel (heavy fuel oil), which is the fuel currently used to generate electricity. The Power Plant will likely be owned and operated by the Government of Guyana, although the government may also consider alternative options for Power Plant ownership and/or operation. For these reasons, the Power Plant, and any associated electric substations and transmission lines, are not included in the scope of this Environmental Impact Assessment (EIA), except for its consideration when addressing cumulative impacts for the Project. Figure 1 provides a schematic of the Project and the government's proposed facilities.

EEPGL has not yet made a Final Investment Decision on the Project, and is continuing to evaluate cost considerations during the Project development process. The current Project cost estimate is approximately $260 billion GYD ($1.3 billion USD).[2] A higher certainty cost estimate will be developed after receiving and negotiating all major contracts.

[1] EEPGL will be the Operator of the Project, and is used in this Environmental Impact Assessment to represent the co-venturers.

[2] $1 U.S. dollar (USD) = $200 Guyanese dollars (GYD)

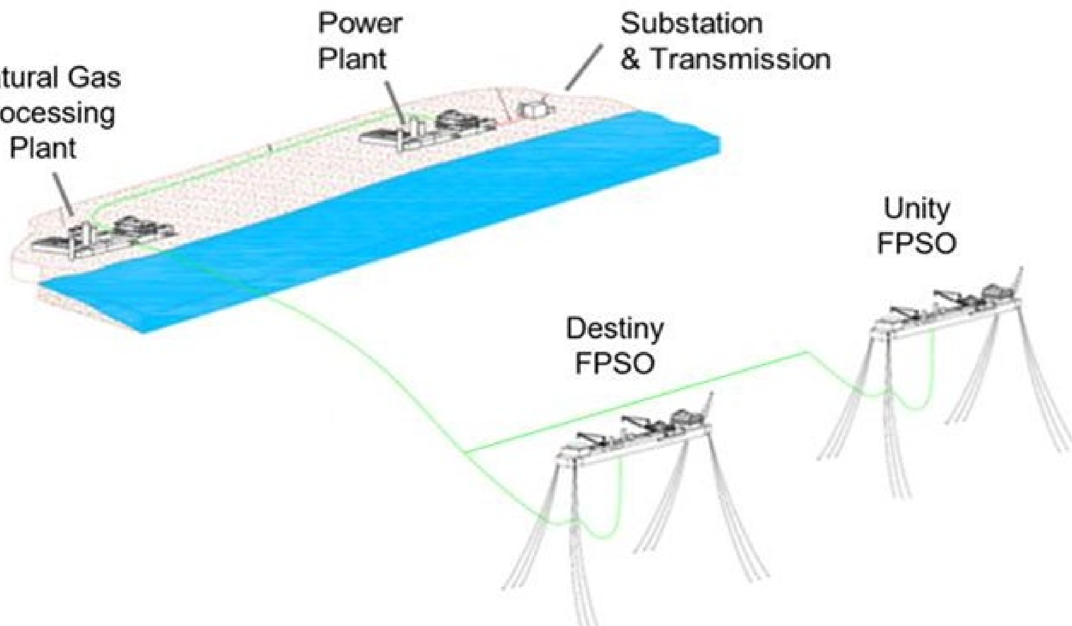

Figure 1: Schematic of the GTE Project and Planned Government of Guyana Facilities

1.1. Project Regulatory Context

Guyanese law requires EEPGL to obtain an environmental authorization from the Guyana Environmental Protection Agency (EPA) to undertake the Project. The EPA oversees the effective management, conservation, protection, and improvement of the environment in Guyana. In this role, the EPA is responsible for managing the environmental authorization process.

EEPGL filed an Application for Environmental Authorisation (Application) for the Project in early 2021, which was subsequently amended. The EPA conducted a review of the application, in accordance with Part IV 11 (2) (b) of the Environmental Protection Act (EP Act) Cap. 20:05, and determined that the Project may significantly affect the environment and will require preparation of an EIA. The EPA consequently, and in accordance with Part IV 11 (6), of the EP Act Cap. 20:05, published a notice of the Project and made a Project summary available to members of the public. Taking into consideration public comments, the EPA approved the Final Terms and Scope for the conduct of the EIA for the Project on 21 September 2021 (EPA 2021).

In accordance with Part IV 11 (4) of the EP Act Cap. 20:05, the EPA required EEPGL to hire a qualified independent environmental consultant to conduct the EIA for the Project. In the final Project Terms and Scope (EPA 2021), Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in preparing EIAs for various oil and gas and power sector projects, was approved by the EPA as the consultant, along with several local subconsultants, to conduct the EIA.

This EIA was prepared by ERM, in association with the Guyanese consultancies E&A Consultants, Inc. (E&A), Caribbean Engineering & Management Consultants Inc. (CEMCO), the University of Guyana Centre for the Study of Biological Diversity (CSBD), and Leon Moore Nature Experience (LMNE); Trinidadian consultant Caribbean Transportation Consultancy Services Company Limited (CARITRANS); and U.S.-based consultant SLR International Corporation (SLR), which are collectively referred to herein as "the Consultants."

This EIA has been prepared in compliance with the EP Act Cap. 20:05, the Environmental Protection Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), international good practice, and EEPGL's corporate standards, and in accordance with the Consultants' standard practices.

1.2. Purpose and Required Contents of the Environmental Impact Assessment

The purpose of the EIA is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL's Application.

In accordance with Part IV (11) (5) of the EP Act Cap.20:05, every EIA shall contain the following information:

- A detailed description of the Project;
- An outline of the main alternatives studied by the developer and an indication of the main reasons for the developer's choice, taking into account the environmental factors;
- Direct, indirect, and cumulative impacts/effects of the proposed Project on the environment including but not limited to:
  - Human beings;
  - Flora and fauna and species habitats;
  - Water;
  - Marine sediments and terrestrial soil;
  - Air and climatic factors;
  - Material assets, the cultural heritage and the seascape;
  - Natural resources, including how much of a particular resource is degraded or eliminated, and how quickly the natural system may deteriorate;
  - The ecological balance and ecosystems;
  - The interaction between the factors listed above; and
  - Any other environmental factor which needs to be taken into account.

- In accordance with Part IV, 11 (4) (b) of the EP Act Cap. 20:05, the EIA must assess the Project with a view to the need to protect and improve human health and living conditions and the need to preserve the stability of ecosystems as well as the diversity of species.
- An indication of any difficulties (technical deficiencies or lack of knowledge or expertise) encountered by the developer in compiling the required information;
- A description of the best available technology;
- A description of any hazards or dangers which may arise from the Project and an assessment of the risk to the environment, socioeconomics, and cultural heritage;
- A description of the measures that the proposed developer intends to use to mitigate any adverse effects and a statement of reasonable alternatives (if any) and reasons for their rejection;
- A statement of the degree of irreversible damage, if any, and an explanation of how it is assessed;
- An Emergency Response Plan summary addressing the procedures for containing and cleaning up any pollution or spill of any contaminant;
- The developer's program for rehabilitation and restoration of the environment; and;
- A non-technical summary of the information provided under the preceding bullets.

After submission of this EIA, the EPA will take into account the review of other government agencies, public comments, EPA's own review (including support from technical experts), and recommendations from the Environmental Assessment Board (EAB) when deciding whether and under what conditions to grant EEPGL an environmental authorization[3] for the Project.

The EAB is an independent body that contributes to the development and review of the EIA and makes recommendations to the EPA on whether an EIA should be accepted, amended, or rejected; whether the environmental authorization should be granted; and if so, under what terms and conditions.

1.2.1. Components of the EIA

This EIA has been prepared as one document presented in three volumes and organized as follows:

Volume I

- Environmental Impact Statement
- Chapter 1, Introduction
- Chapter 2, Policy, Regulatory, and Administrative Framework
- Chapter 3, EIA Approach and Impact Assessment Methodology

[3] The environmental authorization granted by the EPA is also commonly referred to as an environmental permit, and the two terms may be used interchangeably.

- Chapter 4, Alternatives
- Chapter 5, Project Description
- Chapter 6, Stakeholder Engagement
- Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources
- Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources
- Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
- Chapter 10, Unplanned Events
- Chapter 11, Cumulative Impacts
- Chapter 12, Transboundary Impacts
- Chapter 13, Environmental and Socioeconomic Management Plan Framework
- Chapter 14, Residual Impacts and Conclusions
- Chapter 15, Commitment Register
- Chapter 16, References

Volume II

- Appendices

Volume III

- Environmental and Socioeconomic Management and Monitoring Plan (ESMMP)
- Comprehensive Waste Management Plan
- Stakeholder Engagement Plan for Guyana Operations
- Preliminary Decommissioning Plan for the Gas to Energy Project
- Oil Spill Response Plan (OSRP) for Guyana Operations

1.3. EIA REVIEW CHECKLIST

The Environmental Impact Assessment Guidelines Volume 1—Rules and Procedures for Conducting and Reviewing EIAs, Version 5 (EPA 2004) includes an EIA Review Checklist. Table 1.3-1 provides an EIA “roadmap” that shows where in the submittal the checklist items can be found.

Table 1.3-1: EIA Review Checklist Roadmap

EIA Review Checklist Items	Corresponding EIA Reference
1. Adherence to the Terms of Reference (ToR) *Adherence to the ToR must be verified simply by checking that all items and information requested in the ToR have been presented, regardless of the content or quality of such information.*	• Adherence to the approved Terms and Scope issued by EPA on 21 September 2021 confirmed
2. Multidisciplinary Team *The accuracy of the EIA depends on the qualifications of the multidisciplinary team not only regarding the EIA process and methods but also regarding their knowledge of the several stages of the specific type of project. Therefore, individual CVs should be submitted as part of the EIA Annexes. Signatures of each member of the team must be affixed.*	• Appendix A provides core team signatures and curricula vitae
3. Inter-disciplinary Achievement *An EIA must present information regarding the interactions and integration between the physical, biological and socio-economic aspects of the environment in that particular area of the study.*	• Chapter 7 assesses impacts on physical resources/receptors • Chapter 8 assesses impacts on biological resources/receptors • Chapter 9 assesses impacts on socioeconomic resources/receptors[4]
4. Executive Summary *The Executive Summary, also referred to as the non-technical summary, should provide a brief description of the project and information regarding the potential impacts of the project, arranged in order of significance, along with the proposed mitigation/compensatory measures for each impact. The summary should end with the consultants' recommendations.*	• The Executive Summary is included as the Environmental Impact Statement
5. Project Description *The process of environmental impact assessment depends on the full understanding of the project proposal and accurate identification of the project actions. If actions are unclear, sufficiently detailed impacts are not likely to be identified with the accuracy and specificity needed to enable the development of appropriate mitigation measures.*	
5.01 Is the project proposal fully understood?	• Chapter 5, Description of the Project
5.02 Are all phases identified (e.g. planning, construction, operation and decommissioning)?	• Section 5.4.1, Construction Stage • Section 5.4.2, Operations Stage • Section 5.4.3, Decommissioning Stage
5.03 Is the geographical area for each phase identified?	• Section 5.1, Project Area (all stages occur within this same area)
5.04 Are the land use requirements for each phase identified?	• Section 5.1, Project Location and Land Requirements

[4] Findings in the one section that are pertinent to resources in another section (e.g., changes in physical habitat conditions that result in potential impacts to biological resources, changes in biological resources that are socioeconomically important, etc.) are integrated into the discussion of potential impacts to the other section.

EIA Review Checklist Items	Corresponding EIA Reference
5.05 Is there an inventory of the nature and quantity of materials used in the production process?	• Section 5.5.1, Project Materials
5.06 Are there inventories of the type and quantity of products, by-products and effluents expected to be produced by the project?	• Section 5.5, Project Materials, Emissions, Discharges, Wastes, Noise, and Traffic
5.07 Is there an inventory of the type and quantity of residues?	• Section 5.5, Project Materials, Emissions, Discharges, Wastes, Noise, and Traffic
5.08 Are the levels of emissions expected detailed with respect to - Noise? - Vibration? - Light? - Heat? - Radiation? - Gases? - Liquids? Are the types and levels of any other emissions included?	• Section 5.5, Project Materials, Emissions, Discharges, Wastes, Noise, and Traffic
5.09 Is information on employment provided?	• Section 5.2, Project Workforce
6. Identification and Description of Alternatives *The assessment of sound alternatives is necessary to validate the EIA process. Therefore reasonable alternatives have to be fully and comprehensively considered. As a minimum, one of the following alternatives must be considered: location, project layout, technology, scheduling, project scale.*	• Chapter 4, Alternatives
6.01 Did the developer consider alternatives?	• Chapter 4, Alternatives
6.02 Was the "no-project" scenario considered?	• Chapter 4, Alternatives
6.03 Were the environmental factors adequately presented for each alternative?	• Chapter 4, Alternatives
6.04 Is the final choice adequate?	• Chapter 4, Alternatives
7. Definition and Justification of Physical Boundaries (Direct and Indirect Area of Influence) *Inconsistency in identifying the correct areas of influence will inevitably lead to inconsistency in the baseline data and the impact analysis. The indirect area of influence is the area likely to be affected by indirect, secondary and/or long term impacts.*	• Section 3.2, Defining the Project Area of Influence
8. Analysis of the Legal Aspects Involved *The analysis of the legal framework involves more than a list of legal Acts. It involves assessing the consequences for the project of enforcing all the environmental legislation and regulations regarding the proposed site and sectoral requirements related to the proposed activity.*	• Chapter 2, Policy, Regulatory, and Administrative Framework
9. Identification of Other Existing Planned Activities or Projects in the Area of Influence *This information is of utmost importance to ensure that land-use and other types of conflicts do not arise later during the project implementation.*	• Section 11.3.2, Identification of Other Projects • Chapter 11, Cumulative Impacts

EIA Review Checklist Items	**Corresponding EIA Reference**
9.01 Has the compatibility between the proposal and the identified existing activities been analysed?	• Chapter 11, Cumulative Impacts
9.02 Are the activities compatible?	• Chapter 11, Cumulative Impacts
9.03 Does the inventory of existing activities match what is observed?	• Chapter 11, Cumulative Impacts
10. Adequacy and Completeness of Relevant Baseline Data *Baseline data must be specific and relevant to the area of influence. General and superficial information does not allow for the use of adequate impact prediction techniques.*	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.01 Is the information presented specific and relevant?	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.02 Were difficulties in attaining information (if any) documented?	• Chapter 3, EIA Approach and Impact Assessment Methodology
10.03 Have the impact indicators identified been adequately covered (see Section 13)	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
11. Appropriateness of EA Methods *The use of appropriate EA methods is necessary to ensure reliability of the results of the EIA study. Each type of EA method has different strengths and vulnerabilities regarding its appropriateness to perform each step of the EIA study. Some EA methods are unable to provide the means of identification of cause-effect relationships; others do not enable the identification of indirect, secondary and/or long-term impacts. Scientific and technical accuracy of the EIA methods used must therefore be evaluated to ensure the reliability of the conclusions drawn from the impact assessment.*	• Chapter 3, EIA Approach and Impact Assessment Methodology

EIA Review Checklist Items	Corresponding EIA Reference
12.1. Physical Impacts *- Have all the identified impacts on air, water, soil, noise, landscape and natural resources been checked against the relevant impacts defined in the ToR?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?*	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources
12.2. Biological Impacts *- Have all the identified impacts on flora, fauna, rare / endangered species, sensitive ecosystems, species habitats and ecological balance been checked against the relevant impacts in the ToR.* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources
12.3. Social and Health Impacts *- Have all the identified impacts on the social and health context been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to human health, demographic and household characteristics, employment opportunities, size and distinguishing characteristics of resident population, the provision of social services and infrastructure?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- To what extent does the project protect/improve human health?* *- To what extent does the project protect/improve human living conditions?*	• Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
12.4. Cultural, Historical and/or Archeological Impacts *- Have all the identified impacts related to cultural, historical and/or archeological sites and heritage been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to cultural heritage?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Section 9.5, Cultural Heritage
12.5. Economic Impacts *- Have all the identified impacts on the economy (local, regional, national) been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to economic assets and activities?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- Are impacts identified with respect to income generation for the community and at the National Level?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
12.6. Other impacts *- Have all other impacts been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to _____________?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Has the social distribution of the impacts been identified?* *- Have cause/effect relations been properly identified?*	• Chapter 3, EIA Approach and Impact Assessment Methodology
13. Cumulative Impacts *There may be cases where an activity/project will contribute to a cumulative impact on the environment although individually it may not have a significant environmental impact. This may be as a result of the presence of similar activities within the vicinity of the project.*	• Chapter 11, Cumulative Impacts
13.01 Have cumulative impacts been adequately identified and characterized?	• Chapter 11, Cumulative Impacts
13.02 Have the magnitudes been estimated?	• Chapter 11, Cumulative Impacts
13.03 Have the impacts been assigned a significance?	• Chapter 11, Cumulative Impacts
13.04 Has the social distribution of the impacts been identified?	• Chapter 11, Cumulative Impacts
13.05 Have cause/effect relations been properly identified?	• Chapter 11, Cumulative Impacts
14. Impact Indicators *Impact indicators are the parameters used to estimate the magnitude of the impacts.*	• Chapter 3, EIA Approach and Impact Assessment Methodology
14.01 Were the impact indicators used adequate for all the impacts identified?	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15. Prediction Techniques *Impact prediction techniques are necessary to enable the estimation of the magnitude of the impacts. Without the use of adequate impact prediction techniques, accurate impact analysis is not possible.*	• Chapter 3, EIA Approach and Impact Assessment Methodology

EIA Review Checklist Items	Corresponding EIA Reference
15.01 Have the impact prediction techniques used been described? *Are they adequate?*	• Chapter 3, EIA Approach and Impact Assessment Methodology • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15.02 Are they adequate?	• Chapter 3, EIA Approach and Impact Assessment Methodology
16. Magnitude of Impacts *Magnitude is the estimate of the absolute measure/value/dimension of the difference between the environmental situation of a given parameter before and after the project is implemented. In the majority of cases – physical, biological and economic impacts – it must be expressed in **quantitative** values. The estimation of the magnitude of each relevant impact is one of the most important steps in impact analysis. It ensures the accuracy of the EIA and allows for the identification of appropriate and cost-effective mitigation measures. Have the magnitude of all the relevant impacts been adequately estimated (refer to impact indicators – Section 14)?*	• Chapter 3, EIA Approach and Impact Assessment Methodology • Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources • Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
17.0 Importance/Significance of Impacts *Usual methods involve objective criteria regarding the ecological and social relevance of the project*	• Chapter 3, EIA Approach and Impact Assessment Methodology
17.01 Is the relative importance/significance of each impact with regard to the environmental factor affected, and with regard to the other impacts given?	• Chapter 3, EIA Approach and Impact Assessment Methodology
17.02 Is the significance based on objective criteria in order to minimize subjectivity of judgments?	• Chapter 3, EIA Approach and Impact Assessment Methodology
18 Social Distribution of Impacts *Identifies which social groups will be affected by the positive and the negative impacts. These groups are often not the same. The balance between positive and negative impacts cannot be done without the correct identification of the social distribution of the impacts, because it would not have scientific and technical relevance.*	• Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
19 Stakeholder Participation	
19.01 Are the results of stakeholder participation, such as the results of interviews, hearings etc. clearly documented?	• Chapter 6, Stakeholder Engagement
19.02 Have questionnaires used been included?	• Chapter 6, Stakeholder Engagement
19.03 Are the extent and method of stakeholder participation adequate?	• Chapter 6, Stakeholder Engagement

EIA Review Checklist Items	**Corresponding EIA Reference**
19.04 Are the conclusions drawn valid, based on available data?	• Chapter 6, Stakeholder Engagement
20 Analysis and Selection of Best Alternative *Selection must be based on criteria derived from the impact assessment, and appropriate analysis and decision-making methods must be used.*	• Chapter 4, Alternatives
21 Environmental Management Plan (EMP) *An EMP is sometimes called an Impact Management Plan. It is a necessary step to ensure that the developer is effectively committed to the implementation of the mitigation measures. It is also a useful corporate management tool. Does the EMP, as a minimum, present* *- The set of mitigation, remedial or compensatory measures?* *- A detailed description of each one, with indication and criteria for their effectiveness?* *- Detailed budgets for each one?* *- Timetables for implementation?* *- Assignment of responsibilities, including an Environmental Manager?* *- The Environmental Policy*	• Chapter 13, Environmental and Socioeconomic Management Plan Framework • ESMMP (Volume III of the EIA)
22 Monitoring *Monitoring is a necessary step to ensure cost-effectiveness of the EMP. It is usually addressed under the EMP (see Section 20) Does the monitoring plan, as a minimum, address* *- What is going to be monitored (impact indicators)?* *- Where will samples be taken?* *- How the samples will be analysed (method/technique)?* *- Criteria used to evaluate the results?* *- Financial and human resources required?*	• Chapter 13, Environmental and Socioeconomic Management and Monitoring Plan Framework
23 Implementation Plan for the Mitigation Measures and the Environmental Management Plan *Implementation mechanisms must be in place to ensure effective implementation of the mitigation measures and all other recommendations that might arise from the EIA study. It usually involves the assignment of a person responsible for environmental management and an approved timetable for implementation of measures.*	• Chapter 13, Environmental and Socioeconomic Management and Monitoring Plan Framework • ESMMP (Volume III of the EIA)

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2. POLICY, REGULATORY, AND ADMINISTRATIVE FRAMEWORK

This chapter reviews the laws and regulations in Guyana that are relevant to the assessment of potential environmental and social impacts arising from the Project; the chapter is separated into five sections:

- Section 2.1, National Legal Framework, describes the laws and regulations that apply to environmental issues in a general context, such as the Constitution of Guyana, as well as national laws that focus specifically on environmental issues, such as the Environmental Protection Act as amended in 2005. This section also identifies several resource-specific environmental laws that are more narrowly focused and have either direct or indirect relevance to the Project.
- Section 2.2, Environmental Permits and Licenses, describes the major environmental-related permits and licenses EEPGL will be required to obtain to execute the Project.
- Section 2.3, National Policy Framework, describes the Government of Guyana's strategies and policies that apply to the Project. These strategies and policies articulate the government's management goals with respect to various environmental and social issues that could arise based on the Project's design and implementation.
- Section 2.4, International Conventions and Protocols, describes the international and regional conventions and protocols to which Guyana is a signatory and which are relevant to the Project.
- Section 2.5, EEPGL's Operations Integrity Management System, describes EEPGL's framework for addressing risks inherent in its business that can potentially have an impact on personnel and process safety, security, health, and environmental performance.

Additionally, Section 2.5 of the Environmental and Socioeconomic Management and Monitoring Plan for the Project (Volume III, Management Plans) includes a number of environmental and socioeconomic performance criteria that, although not required pursuant to the applicable laws, regulations, and conventions discussed in this chapter, EEPGL will apply to the Project, consistent with good international oil and gas industry practice.

2.1. NATIONAL LEGAL FRAMEWORK

This section provides an overview of the key legislation currently in force in Guyana that pertains to resources that could be affected by the Project.

2.1.1. National Constitution of Guyana

Guyana is governed according to the Constitution of the Co-operative Republic of Guyana, as amended (the Constitution). The Constitution took effect in 1980 and expressly provides for protection of the environment. Article 25 establishes "improvement of the environment" as a general duty of the citizenry.

In addition, Article 36 reads as follows:

> "In the interests of the present and future generations, the State will protect and make rational use of its land, mineral and water resources, as well as its fauna and flora, and will take all appropriate measures to conserve and improve the environment."

2.1.2. The Environmental Protection Act

In 1996, the Environmental Protection Act (EP Act) was enacted to implement the environmental provisions of the Constitution. The EP Act is Guyana's single most significant piece of environmental legislation because it articulates national policy on important environmental topics such as pollution control and the requirements for environmental review of projects that could potentially affect the environment. It also provides for the establishment of an environmental trust fund. Most importantly, the EP Act authorized the formation of the EPA, and established the EPA as the lead agency on environmental matters in Guyana, including the issuance of environmental authorizations with appropriate conditions. The EP Act mandates the EPA to oversee the effective management, conservation, protection, and improvement of the environment (EPA 2021). It also requires the EPA to take the necessary measures to ensure the prevention and control of pollution, assessment of the impact of economic development on the environment, and sustainable use of natural resources.

Regulations on hazardous waste management, water quality, air quality, and noise management were established in 2000 pursuant to the EP Act. These pollution management regulations were developed to regulate the activities of development projects during Construction and Operations stages. The following are regulations applicable to the Project under the EP Act.

2.1.2.1. Water Quality Regulations

According to these regulations, any entity with a facility that discharges effluent is required to register and apply for environmental authorization. These regulations cover effluent discharge limits; new sources of effluent discharges; fees for registration and environmental authorization; sampling points, records and reports; and general provisions for the registration of water effluent, biological integrity, spills or accidental discharges, and standard methods of analysis. Guidelines on effluent discharges and sludge disposal are detailed in these regulations. The Guyana National Bureau of Standards (GNBS) has established Interim Effluent Discharge Standards that have been adopted by the EPA.

2.1.2.2. Air Quality Regulations

According to these regulations, persons with facilities that emit air pollution from any process into the atmosphere are required to register and apply for environmental authorization. The regulations include elements related to regulated air contaminants and emission sampling, fees associated with registration, requirements for new and altered sources of air emissions, requirements and approval of plans, and emission controls. Under these regulations, it is necessary to register with the EPA and submit an application for environmental authorization at least 90 days prior to the commencement of releasing emissions. The regulations include a list the parameters, but do not specify parameter limits.

2.1.2.3. Noise Management Regulations

Under these regulations, operations that emit noise are required to apply to the EPA for an environmental authorization. The regulations include the general requirements to apply for an authorization, the permissible noise levels, factors involved in the determination of the point of noise emissions, applications for variance, requirements related to new and altered sources of noise pollution, requirements and approval of plans, and restrictions on construction activities and power to waive restrictions. The GNBS is responsible for the establishment of standards for permissible noise levels in industry, construction and other areas.

The EPA has developed the following interim noise standards—established according to categories of activities—in collaboration with the GNBS:

- Industrial: 75 decibels (dB) during the day, 70 dB during the night
- Commercial: 65 dB during the day, 55 dB during the night
- Construction: 86 dB during the day, 75 dB during the night
- Transportation: 110 dB during the day, 70 dB during the night

2.1.3. The Public Utilities Commission Act

The Public Utilities Commission Act of 1997 (updated 2016) makes provisions for the establishment, function, and procedure of the Public Utilities Commission (PUC) and related matters. The Act addresses the functions of the PUC and the duties of other utilities in complying with the Act. Under the Act, development and expansion by other public utilities should obtain approval from the PUC.

Section 21 of the Act states that in carrying out its responsibilities, the PUC is bound by the provisions of the Guyana Energy Agency Act and Electricity Sector Reform Act, the terms of any license issued by the government to a public utility, and the terms of agreement between the government and a public utility—or between the government and an investor. The PUC is responsible for economic research in support of assessing rates and efficiency for public utility services, and monitoring regulatory trends in Guyana and other countries to inform its decisions on standards, quality of service, pricing, and evaluation development and expansion programs.

2.1.4. The Guyana Geology and Mines Commission Act

The Guyana Geology and Mines Commission Act was enacted in 1979 and authorized the government to establish the Guyana Geology and Mines Commission (GGMC), which is one of four agencies within the Ministry of Natural Resources. The GGMC promotes and regulates the exploration and development of the country′s mineral and petroleum resources. The GGMC has a dedicated Petroleum Unit charged specifically with regulatory supervision of the oil and gas sector; however, regulation of petroleum-related activities also occurs in other divisions, such as the Geological Services Division and the Environment Division. Prior to 2020, the GGMC worked closely with the Department of Energy on matters related to the oil and gas industry.

After 2020, the Department of Energy was absorbed into the Ministry of Natural Resources where the Petroleum Management Program regulates, manages, and monitors the exploration, development, and use of Guyana's petroleum resources.

2.1.5. Protected Areas Act

The Protected Areas Act was enacted in 2011. It provides for protection and conservation of Guyana's natural heritage and natural capital through a national network of protected areas. The Act also allowed for the creation of the Protected Areas Commission to oversee the management of this network. It highlights the importance of maintaining ecosystem services of national and global importance and public participation in the conservation of protected areas. It establishes a protected areas trust fund to ensure adequate financial support for maintenance of the network. Other functions of the Act include promoting national pride in, and encouraging stewardship of, Guyana's natural heritage; recognizing the conservation efforts and achievements of Amerindian villages and Amerindian communities; and promoting the recovery and rehabilitation of vulnerable, threatened, and endangered species.

2.1.6. The Petroleum Act

The Petroleum (Exploration and Production) Act was enacted in 1986 to regulate the prospecting for and production of petroleum in Guyana, which covers the territorial sea, continental shelf, and Exclusive Economic Zone. The Act and the regulations promulgated thereunder identify persons allowed to hold prospecting licenses, establish the process for obtaining prospecting licenses, and specify requirements for further resource development in the event petroleum resources are discovered.

2.1.7. Amerindian Act

The Amerindian Act was enacted in 2006. It provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities. The Ministry of Indigenous Peoples' Affairs oversees implementation of the Act. Key aspects of the Act include the following:

- The Act includes a process for the granting of land. A community can apply for land once they can prove that they have been living on it for at least 25 years.
- The Ministry is not required to approve leasing of titled Amerindian land. The communities are only required to seek the advice of the Minister.
- With respect to the use of scientific research related to Amerindian issues, the researcher must, among other things, submit a copy of any publication containing material derived from the research to the Village Council.
- The Act supports the need for the communities to use their natural resources in a way that lends support to the concept of sustainability. Impact assessments are required in accordance with the EP Act.

- Amerindians have a legal right to traditional mining with the consent of the Village Council and they must comply with the relevant legislation. Regarding forestry, the Village Council plays an integral role in determining who is allowed to use their land and on what terms.
- The Village Council is empowered to establish rules for their community and set fines within the legal confines of the law. Money received due to the non-adherence of the rules goes into the Village Council's account, not the government's account.

2.1.8. Natural Resource Fund Act

The Natural Resource Fund Act was enacted in 2019 to establish the National Resource Fund (Fund) to manage Guyana's natural resource wealth in an efficient and effective manner for the present and future benefit of the people and for financing national development priorities, including initiatives aimed at achieving an inclusive green economy. The Act provides the legal basis for the establishment of the Fund that will manage the natural resource wealth to ensure intergenerational equity. The Act aims to ensure proper management as well as accountability of the finances garnered from the use of Guyana's natural resources. The Act empowers the Minister of Finance with the overall management of the Fund, including preparing the Fund's Investment Mandate. The Act establishes an Investment Committee, a Macroeconomic Committee, and a Senior Investment Adviser and Analyst to support the Minister in management of the Fund.

The Bank of Guyana is responsible for operational management of the Fund. A Public Accountability and Oversight Committee was established to ensure that the Fund is managed transparently and to provide an independent assessment of withdrawals from the Fund.

2.1.9. Occupational Safety and Health Act

Established in 1997, the Occupational Safety and Health Act governs the regulation of industrial establishments as it relates to the safety and health of workers. The Act is the primary legislation governing workplace health and safety and it applies to different types of work places. It details the rights and duties of all parties in the workplace and it also details procedures for addressing health and safety non-conformities at the work place. While the Act governs and guides self-employed individuals, employers, and employees, the Occupational Safety and Health Department holds the mandate for conducting regular workplace inspections to ensure compliance with the Act.

2.1.10. Town and Country Planning Act

The Town and County Planning Act of Guyana makes provision for the planning and orderly development of land, cities, towns and other rural and urban areas to maintain and improve their amenities, ensuring the existence of fair sanitary conditions, and planning of road infrastructure and public services.

The Act also serves to guide the conservation and development of areas under its mandate. Execution and enforcement are vested under the Central Housing and Planning Authority (CH&PA). The CH&PA is responsible for preparing spatial development and land-use plans in collaboration with local authorities of each geographic area, and these plans guide all future development, including housing development and regulated land use through the planning permission process.

2.1.11. Acquisition of Lands for Public Purposes Act

The Acquisition of Lands for Public Purposes Act governs the land acquisition process and provides the framework under which the government handles valuation, compensation, engagement, and grievances. The Act empowers the Government of Guyana to acquire any area for proposed construction of public infrastructure by declaring works as "public works" and land as "land required for public works" (Sections 3 and 6 of the Act). The Minister of Public Works can also authorize the Commissioner of Lands and Surveys and the Commissioner's agents to enter the land declared, provided that at least 7 days' notice is given to the occupier in writing prior to entering any property, to conduct surveys, take levels, dig or bore into the subsoil, or examine the area with a view to the acquisition of the whole or a part of it for the construction of a public work (Sections 4 and 5 of the Act).

The Ministry of Public Works, pursuant to the Act, issued "Order No. 18 of 2021—The Acquisition of Lands for Public Purposes (Gas Pipeline Route)" on 7 August 2021. This order designates as a public work the proposed construction of the Project's gas pipeline from Novelle Flanders to Canal No. 1 Public Road on the West Bank of the Demerara River, passing through lands described in the order.

2.1.12. Local Content Act 2021

In December 2021, the Local Content Act 2021 was enacted with the following stated objectives:

- Provide for the implementation of local content obligations on persons engaged in petroleum operations or related activities in the petroleum sector;
- Prioritize Guyanese nationals and Guyanese companies in the procurement of goods and services for the enhancement of the value chain of the petroleum sector;
- Enable local capacity development;
- Provide for the investigation, supervision, coordination, monitoring and evaluation of, and participation in, local content in Guyana; and
- Promote competitiveness and encourage the creation of related industries that will sustain the social and economic development of Guyana.

The Act applies to local content in relation to all operations and activities in the petroleum sector for Guyana.

2.2. ENVIRONMENTAL PERMITS AND LICENSES

As part of Project implementation, the Project will be required to obtain the following key environmental-related permits.

2.2.1. Environmental Protection Agency

2.2.1.1. Environmental Permit

In order to undertake the Project, EEPGL is required to obtain an environmental authorization (also commonly referred to as an Environmental Permit) from the EPA. The Application for Environmental Authorisation filed with the EPA on 1 April 2021 initiated this regulatory process. After submission and review of this EIA, the EPA will take into account comments from other agencies, the public′s comments, and EPA′s own review, which includes support from technical experts and recommendations from the Environmental Assessment Board in deciding whether and under what conditions to grant EEPGL an environmental authorization for the Project.

2.2.1.2. Hazardous Waste Permit

Regarding onshore waste management, an Application for Environmental Authorisation must be submitted to the EPA by the proposed operator of any facility that will generate, transport, treat, store, or dispose of hazardous waste. The Application for Environmental Authorisation must be prepared in accordance with the provisions of regulation 17 of the Environmental Protection (Authorisations) Regulations 2000. As such, the vessel owners and operators supporting the Project will be required to obtain authorization for any marine vessels used to transport hazardous wastes to onshore facilities. In addition, vehicle owners and operators will be required to obtain authorization for any vehicles used to transport hazardous waste from Project facilities to off-site waste management facilities. For any third-party owned or operated marine vessels or vehicles used to transport hazardous waste from the Project, the environmental authorization will need to be obtained by the third party. Similarly, any environmental authorizations for third-party operated facilities used to manage hazardous waste will be obtained by the owner/operators of such facilities.

2.2.2. Guyana Lands and Surveys Commission

The Guyana Lands and Surveys Commission (GLSC) facilitates land administration in fulfilment of the needs of its clients and for national development. The GLSC is a governmental institution that is responsible for, among other things, advising the government on the management of state lands, land-use policies, issuance of land titles and leases, and provision of governmental support for land use development and collection of rents from leased lands. As a result, the GLSC acts as the custodian for state lands, including rivers and creeks. In addition, it facilitates the execution of surveys; publishes maps and charts for different localities; approves, records, and clarifies all land surveys; and accounts for all financial transactions payable concerning the sale of public lands as prescribed by law.

With respect to the Project, GLSC is the administrative body in Guyana with the sole responsibility for administration and issuance of state lands approvals for national development projects. The GLSC granted EEPGL access to a 30-meter-wide corridor for the Project's proposed natural gas pipeline right-of-way (RoW).[1] In addition, the GLSC will conduct all cadastral surveys for the Project and formulate easement or purchase agreements with private landowners whose lands fall within the construction RoW or operational Project Footprint, respectively. Further, the GLSC will formulate any additional agreements required for the temporary material offloading facility (MOF) and shore landing location of the Project pipeline.

2.2.3. Ministry of Public Works

The Ministry of Public Works is a government agency responsible for the planning, creation, and maintenance of major public civil works infrastructure throughout Guyana. The Ministry's portfolio includes sea and river defenses, roads and bridges construction/maintenance, ferry services and ferry terminal facilities management, civil aviation development, and electrical safety. The following Ministry of Public Works divisions are applicable to the Project.

2.2.3.1. Works Services Group

The Works Services Group (WSG) was established in 2002 by merging various project implementation units that manage donor-funded roads and bridges. The Sea and River Defences Division was merged with the WSG in 2008 to improve the efficiency of sea defense management and share the regional operational facilities of the WSG. With WSG responsible for the management and maintenance of roads and bridges, the Sea and River Defences Division is charged with implementing protective measures to prevent inundation along coastal and riverine areas throughout Guyana.

As part of Project implementation, EEPGL will be required to consult with the WSG on the necessary approvals for the Project pipeline crossing under road networks.

2.2.3.2. Sea Defence Board

The Sea Defence Board (SDB) was mandated under the Sea Defence Act to manage the construction, rehabilitation, and protection of sea defense works. The SDB members are charged to be the "gatekeepers of the nation" as they serve in their respective designations for the development and protection of Guyana through the management of critical flood protection systems. The SDB also has authority over the clearing of mangroves within the boundaries of the sea defense reserve.

As it relates to the Project, a No Objection letter from the SDB will need to be obtained for the development of the foreshore as part of the installation of the temporary MOF and the shore crossing of the Project pipeline, both of which will cross sea/river defenses. The SDB will also need to be consulted on approvals required for any clearing of mangroves, as needed, along the Demerara River as part of the temporary MOF installation.

[1] The 30-meter onshore pipeline RoW is for study purposes only. The construction RoW will be 22.9 meters wide and the permanent RoW will be 12.2 meters wide.

2.2.3.3. Maritime Administration Department

The Maritime Administration Department (MARAD) is a department under the Ministry of Public Works that operates in accordance with the International Maritime Organization (IMO). It was established in 2003 under the 1997 Merchant Shipping Act. MARAD is responsible for registering and licensing ships, pilotage hydrographic surveys, marine/riverine accident investigation, and marine/riverine search and rescue recovery. MARAD is the lead government entity with respect to Guyana's accession to various IMO conventions, including the International Convention for the Safety of Life at Sea and the International Convention for the Prevention of Pollution from Ships.

Vessel owners/operators supporting the Project will be required to obtain from MARAD a Permit to Operate within the Exclusive Economic Zone of Guyana prior to commencing any offshore activities. For any third-party owned/operated marine vessels, permission will have to be sought by the third party. EEPGL will be required to inform MARAD of vessel schedules in order for any Notices to Mariners to be published.

2.2.3.4. Guyana Energy Agency

The Guyana Energy Agency is mandated by the Guyana Energy Agency Act of 1997, Guyana Energy Agency (Amendment) Act of 2004 and 2005, and the Petroleum and Petroleum Products Regulations of 2004 to advise and to make recommendations to the Minister regarding any measures necessary to secure the efficient management of energy and the source of energy in the public interest. As it relates to the Project, the Agency has the authority to grant and issue licenses relating to petroleum and petroleum products.

2.2.4. Ministry of Agriculture

The Project will interface with various sub-agencies under the mandate of the Ministry of Agriculture, as discussed below.

2.2.4.1. Fisheries Department

The Fisheries Department holds responsibility for managing, regulating, and promoting the sustainable development of Guyana's fishery resources to ensure that all participants benefit while contributing to the national economy. The Department provides support services necessary for the development and maintenance of marine, aquaculture, and inland fisheries. EEPGL will consult with the Department and seek approvals as needed.

2.2.4.2. Guyana Rice Development Board

Under the Rice Development Act of 1994, the Guyana Rice Development Board was established as a policy-making regulatory body for the rice industry. The Board's main functions are to develop the rice industry, propel research, and disseminate knowledge to rice farmers. Should the Project involve the crossing of the pipeline through rice producing areas in Region 3, EEPGL will consult with the Board and seek approvals as needed.

2.2.4.3. National Drainage and Irrigation Authority

Established in 2006 under the Drainage and Irrigation Act of 2004, the National Drainage and Irrigation Authority is the government agency with responsibility for the management, improvement, extension, and provision of drainage, irrigation, and flood-protection services across Guyana. With the Project expected to result in temporary and/or permanent changes to the configuration of drains and canals within portions of the Project Footprint, EEPGL will consult with the Authority and seek approvals as needed.

2.2.4.4. National Agricultural Research and Extension Institute

Established in 1984 and amended in 2010, the National Agricultural Research and Extension Institute (NAREI) has the mandate for promoting efficiency in the production of crops and other agriculture products, regulating trade in agricultural products, and disseminating knowledge to farmers across Guyana through extension services. Further, NAREI holds responsibility for the Guyana Mangrove Restoration Project, which became its permanent responsibility. The Project will consult with NAREI in relation to proposed mangrove removal, including implementation of mitigation measures in support of any infrastructure installation in areas near mangrove stands.

2.2.5. Local Authorities

Governed by the Ministry of Local Government and Regional Development, Regional Democratic Council #3 is the supreme local government body in Region 3, and has responsibility for the overall management and administration of Region 3 and the coordination of the activities of all Neighbourhood Democratic Councils (NDCs) within its boundaries. The NDCs cover defined geographic areas within the region and are responsible for the management and administration of the communities within these areas. With respect to the Project, EEPGL will request permissions, as needed, from Regional Democratic Council #3 and the NDCs crossed by the Project.

2.2.6. Central Housing and Planning Authority

Established under the 1948 Housing Act, the CH&PA has the mandate to address the housing needs of the citizens of Guyana. The CH&PA has several responsibilities, including the mandate to develop housing schemes and regularize and upgrade squatter settlements. Since the Project Footprint will cross within or near several housing areas, the CH&PA will be consulted, and approvals will be obtained as required.

2.3. NATIONAL POLICY FRAMEWORK

Guyana's government has articulated national policies on several environmental and social topics relevant to the Project. This section provides an overview of the key government environmental and social policies applicable to the Project.

2.3.1. Low Carbon Development Strategy

In June 2009, the Government of Guyana announced the Low Carbon Development Strategy (LCDS). Initially, the LCDS focused on protecting and maintaining forests in an effort to reduce global carbon emissions and at the same time attract payments from participating developed countries for the climate services that Guyana's forests provide. In 2013, the LCDS was updated to focus on two main goals: (1) transforming the national economy to deliver greater economic and social development by following a low-carbon development path while simultaneously combating climate change; and (2) providing a model for how climate change can be addressed through low-carbon development in developing countries (Office of the President 2016). The LCDS identifies Reducing Deforestation and Forest Degradation Plus as the primary mechanism for achieving the goals of the strategy.

In November 2021, a draft update to the policy titled *Guyana's Low Carbon Development Strategy 2030* was circulated for national consultation. This draft update adds a new objective of aligning with global climate goals, especially as the nation develops its oil and gas sector, and a plan to "…grow the economy up to five-fold while keeping greenhouse gas emissions from energy generation at around 2019 levels" (Government of Guyana 2021). It includes a plan to replace heavy fuel oil with natural gas as the main energy source as a bridge to an energy system sourced largely from hydropower, solar, and wind power.

2.3.2. The National Development Strategy 2001–2010

The National Development Strategy sets out the primary development policy framework for Guyana. It provides a framework for national planning and captures a number of cross-sectoral issues such as the environment, forestry, agriculture, mining, tourism, and fisheries, among others. The Strategy proposes a program of diversification focusing on the production of non-traditional commodities, for both the domestic and exports markets, with a view to broaden the base of Guyana's economy while consolidating and expanding performance of traditional sectors. Chapter 16 of the Strategy places emphasis on actions to mitigate harmful consequences to the environment through increased monitoring and enforcement, and using the most appropriate and up-to-date environmentally friendly methods.

2.3.3. The National Land Use Plan

In 2013, the National Land Use Plan (NLUP) was developed by the GLSC to provide a strategic framework to guide land development in Guyana; it is supported by a number of national policies and strategies that have relevance for land use and land management. The NLUP promotes multiple land uses and aims to enable financial resources to be targeted at optimal land uses at the regional level. The NLUP is expected to provide support to decision-making by the GLSC when considering development options and constraints throughout the country. The NLUP is also intended to be included in land lease decision processes to encourage decisions that optimize the use of Guyana's resources for the benefit of its people. Among many topics, the NLUP addresses petroleum and natural gas, but the content for this topic pre-dates the petroleum reserve discoveries that have occurred since 2015. In 2018, the Government of

Guyana began preparing a National Land Policy with support from the Food and Agriculture Organisation.

2.3.4. Guyana Sea and River Defence Policy

The Sea and River Defence Policy focuses on alternative solutions to traditional sea defense structures and includes the re-establishment of mangroves for flood protection and for safeguarding environmental resources. With the Policy's framework and with support from the European Union, a national mangrove management project was implemented with the aim of managing and restoring mangrove ecosystems.

2.3.5. The National Mangrove Management Action Plan

In recognition that mangroves are known for their ability to strengthen sea defenses, provide habitats for a variety of biodiversity, trap sediments, and breakdown pollutants, the National Mangrove Management Action Plan 2010–2012 (Mangrove Action Project 2010) was developed to mitigate the impacts of climate change by protecting, rehabilitating, and ensuring the use of mangroves in a sustainable manner to maintain their environmental, social, and socioeconomic functions. It aims to support mangrove research and development of protection and rehabilitation measures. The Plan also aims to increase public awareness of the advantages of mangrove forests, present a legal framework for mangrove ecosystem management, promote community-based mangrove management, and develop the administrative capacity for managing Guyana's mangrove resources.

2.3.6. National Environmental Action Plan

Guyana's National Environmental Action Plan (NEAP) articulates the government's approach to managing the environment from the perspective of economic development. The NEAP outlines several policy objectives, one of which calls for the government to ensure that environmental assessments of proposed development activities that may significantly affect the environment are undertaken. In keeping with this environmental policy objective, the EP Act was introduced in June 1996 and the legal framework for authorizing development activities was established.

The NEAP considers the issues of environmental management, economic development, social justice, and public health to be inextricably linked. It identifies deforestation, pollution, and unregulated gold mining as growing environmental concerns, and identifies private-sector investment as one of the primary opportunities to generate the necessary capacity within Guyana to (1) provide an appropriate level of public services to its citizens; (2) reduce and/or eliminate the avoidable environmental degradation from resource development that occurs in a regulatory vacuum; and (3) reduce unsustainable uses of natural resources due to the socioeconomic pressures of widespread poverty.

The NEAP relates to the Project in several ways. It identifies the coastal zone—within which Project activities will occur—as an area in need of focused management action due to the concentrated human population along the coast and the susceptibility of the coastal environment to both natural and human-induced degradation. Additionally, it identifies private-sector-led development projects as a mechanism to build capacity and ultimately support more responsible environmental management. Finally, it identifies petroleum resources as a potential target for development.

2.3.7. Integrated Coastal Zone Management Action Plan

Guyana's Integrated Coastal Zone Management (ICZM) process is an ongoing initiative to promote the wise use, development, and protection of coastal and marine resources; enhance collaboration among sectorial agencies; and promote economic development. In 2000, after 2 years of study, the ICZM committee produced an ICZM Action Plan, which was approved by the Cabinet in 2001.

The Plan addresses policy development, analysis and planning, coordination, public awareness and education, control and compliance, monitoring and measurement, and information management (EPA 2000). Other coastal zone–related tasks currently undertaken by the government include strengthening the institutional setup for ICZM, conducting a public awareness campaign to increase public understanding of the vulnerability of the coastal zone to sea-level rise and climate change, and creating a database of coastal resources to facilitate improved ICZM. Currently, the EPA is mandated to coordinate the ICZM program and coordinate the development of the Plan through the ICZM Committee.

Under the Caribbean Planning for Adaptation to Climate Change project (CARICOM 2015), Guyana has also conducted a socioeconomic assessment of sea-level rise as part of a wider vulnerability assessment and developed a Climate Change Action Plan, with subsequent draft action plans under development (Government of Guyana 2001; Ministry of the Presidency 2015; Shah 2019).

2.4. International Conventions and Protocols

Guyana is signatory to a number of international agreements and conventions relating to environmental management and community rights, although not all of these agreements have been translated into national legislation. Guyana is a member state of two organizations that administer multiple international treaties and conventions: the International Labour Organization (ILO) and the IMO. The ILO has established eight fundamental conventions that provide certain general protections to workers in signatory states, such as the right to organize, standards for remuneration, restrictions on child labor (including minimum ages to work), and protection from forced labor. In addition to these fundamental agreements, Guyana is signatory to several specific agreements that will govern certain specific aspects of the Project as they relate to labor.

The IMO is a similar organization whose member states have agreed to one or more conventions related to maritime activities. These include three key conventions (the International Convention for the Safety of Life at Sea, the International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978, and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) as well as several other agreements concerning more specific aspects of maritime activity, such as safety and security at sea, maritime pollution, and liability for maritime casualties. One of these other agreements administered by the IMO is the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992, often referred to as FUND92 or FUND. Guyana is an observer nation under the 1992 FUND Convention, which established the International Oil Pollution Compensation Fund and the protocol for the International Oil Pollution Supplementary Fund. MARAD manages compliance with the requirements of the IMO agreements to which Guyana is a signatory, with technical assistance from the IMO's Regional Maritime Advisory Office in Port of Spain, Trinidad.

Guyana also belongs to other international organizations such as the Organization of American States, the International Monetary Fund, and the Caribbean Community.

To highlight Guyana's application of international standards and guidelines relevant to the oil and gas sector, in May 2010, the country announced its commitment to the implementation of the Extractive Industries Transparency Initiative (EITI), and in September 2015, the country recommitted its support to the ILO.

In October 2017, Guyana became the 53rd candidate country in the EITI. EITI is a global standard to promote the open and accountable management of extractives resources; it seeks to strengthen government and company systems, inform the public, and promote industry understanding. It was founded in 2003 to protect the interests of developing or frontier countries such as Guyana (EITI 2021).

To gain membership status, Guyana was required to assemble a multi-stakeholder group, which included equal representation from the government, civil society, and industry. The goal is to develop a consensus reporting system that applies to all extractive companies operating in the country and to make that report public every year. These reports will be audited by a third party and distributed publicly for review. Guyana's most recent report and a workplan for calendar years 2021 and 2022 were published in April 2021.

In December 2017, EEPGL was the first energy company to agree to release of its Petroleum Agreement with the Government of Guyana. The Stabroek Block Petroleum Agreement provides transparent information on revenue share, cost recovery, royalties, taxes, signing bonus, and other topics of interest to the public.

2.4.1. Protocol Concerning Pollution from Land-Based Sources and Activities

The Protocol Concerning Pollution from Land-Based Sources and Activities is one of the three protocols of the Cartagena Convention. It consists of obligations to reduce the negative environmental and human health impacts of land-based pollution in the wider Caribbean region. The Protocol was adopted in Oranjestad, Aruba, on 6 October 1999 and entered into force on 13 August 2010.

The Protocol provides the legal framework for addressing pollution based on national and regional needs and priorities. It is intended to reduce the impacts of priority pollutants by establishing sewage and emissions limits and implementing best management practices, and to exchange scientific and technical information on land-based pollution through regional cooperation in monitoring and research.

Parties are required to address the source categories, activities, and pollutants of concern listed in Annex I to the Convention.

2.4.2. Basel Convention on the Transboundary Movement of Hazardous Wastes and their Disposal

The Basel Convention aims to protect human health and the environment against the adverse impacts resulting from the generation, management, and transboundary movements and disposal of hazardous and other wastes. Guyana is a party to the Convention, which came into force in 1992. It was designed specifically to prevent transferring hazardous wastes from developed to less developed countries and to promote environmentally sound management of hazardous waste.

2.4.3. The Specially Protected Areas and Wildlife Protocol

The Protocol for Specially Protected Areas and Wildlife—commonly referred to as the SPAW Protocol—is one of three sub-protocols of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (also known as the Cartagena Convention). It is a regional agreement for the protection and sustainable use of coastal and marine biodiversity in the wider Caribbean region. Under the SPAW Protocol, which was adopted in 1990, nations in the wider Caribbean region work together to conserve biodiversity. Specifically, the SPAW Protocol is used as a means of regionalizing global conventions such as the United Nations Convention on Biological Diversity; it uses an ecosystem approach to conservation by protecting rare and fragile ecosystems and the endangered species within these ecosystems.

2.5. EEPGL's Operations Integrity Management System

ExxonMobil Corporation (hereinafter "ExxonMobil", which is EEPGL's ultimate parent company) and its affiliates (including EEPGL) are committed to conducting business in a manner that is compatible with the environmental and socioeconomic needs of the communities in which they operate; and that protects the safety, security, and health of employees, those involved with affiliates' operations, their customers, and the public. These commitments are documented in EEPGL's Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (OIMS).

ExxonMobil's OIMS Framework establishes common expectations used by ExxonMobil affiliates worldwide for addressing risks inherent in their businesses. The term "Operations Integrity" is used to address all aspects of its business that can affect personnel and process safety, occupational safety, security, occupational health, and environmental performance.

Application of the OIMS Framework is required across all ExxonMobil affiliates, with particular emphasis on design, construction, and operations. Management is responsible for ensuring that management systems that satisfy the OIMS Framework are in place. Implementation is consistent with the risks associated with the business activities being planned and performed. Figure 2.5-1 provides a high-level description of the OIMS Framework and its 11 essential elements.

Figure 2.5-1: The OIMS Framework

Section 2.3 of the Project's Environmental and Socioeconomic Management and Monitoring Plan (Volume III) includes a discussion of the key elements of EEPGL's occupational safety and health programs that will be used during the Project life cycle. These key elements stem from the expectations and requirements established by OIMS to identify and manage occupational safety and health risks associated with the Project's operations.

3. EIA APPROACH AND IMPACT ASSESSMENT METHODOLOGY

The purpose of this EIA is to assess the potential physical, biological, and socioeconomic (including social, economic, community health, and cultural) impacts of the Project. This chapter provides a summary of the approach and methodology used to assess the potential impacts associated with the Project. The EIA has been prepared in compliance with the Guyana Environmental Protection Act (EP Act) (as amended in 2005), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines—Volume 1, Version 5 (EPA 2004), the Environmental Impact Assessment Guidelines—Volume 2, Version 4 (EPA/EAB 2000), good international industry practice as defined in the World Bank Group's Environmental, Health, and Safety Guidelines (IFC Undated), and in accordance with the Consultants' standard practices. In addition to these overarching guidelines and practices, the EIA fully aligns with the EPA's *Final Terms and Scope for the Conduct of the Environmental Impact Assessment (EIA): Gas to Energy Project* (referred to herein as the "Terms and Scope") (EPA 2021).

The EIA was prepared to provide an independent, science-based evaluation of the potential impacts associated with construction, installation, operations, maintenance, and decommissioning of the Project. The EIA is also the primary mechanism for sharing the findings of this evaluation with stakeholders and decision-makers, so they can make informed decisions regarding the potential benefits and impacts of the Project, as well as the measures proposed to enhance these benefits and mitigate these impacts.

3.1. Types of Potential Impacts

The EIA has been undertaken following a systematic process that evaluates the potential impacts the Project could have on physical, biological, and socioeconomic resources, and that identifies measures EEPGL will take to avoid, reduce, and/or remedy those impacts.[1] For the purposes of the EIA, an impact is defined as an alteration of existing conditions (adverse or beneficial) caused directly or indirectly by the Project. Under the provisions of the EP Act (as amended in 2005), potential adverse impacts could include the following:

"(i) impairment of the quality of the natural environment or any use that can be made of it;
(ii) injury or damage to property or to plant or animal life;
(iii) harm or material discomfort to any person;
(iv) an adverse effect on the health of any person;
(v) impairment of the safety of any person;
(vi) rendering any property or plant or animal life unfit for use by human or unfit for its role in the ecosystem;
(vii) loss of enjoyment of normal use of property; and
(viii) interference with the normal conduct of business."

[1] EEPGL will also establish measures to enhance and/or support access to Project-related benefits.

Although the EP Act does not define positive impacts (i.e., Project benefits), examples of potential positive impacts could include increased economic and community development, employment and livelihood opportunities.

The EIA considers the possibility of direct, indirect, and cumulative impacts of the Project during all three Project stages (i.e., Construction, Operations, and Decommissioning), including those associated with planned activities and those that could be associated with potential unplanned events. Potential unplanned events are defined and identified in Chapter 5, Project Description, and evaluated in Chapter 10, Unplanned Events.

3.2. Defining the Project Area of Influence

The area with the potential to be impacted by a project is referred to as its Area of Influence (AOI). For this EIA, a Direct AOI and an Indirect AOI were defined, as described below:

- Direct AOI, within which the Project is expected to have potential direct impacts. This area includes:
  - Offshore pipeline—the area potentially impacted by the construction of the offshore pipeline extends from tie-in points on the topsides of each of the Floating Production, Storage, and Offloading vessels, to subsea tie-in infrastructure on the seabed, through to the tie-in with the onshore pipeline. This area is conservatively assumed to be a 30-meter-wide corridor centered on the tie-in infrastructure and offshore pipeline (approximately 220 kilometers in length).
  - Onshore pipeline—the area potentially impacted by the construction of the onshore pipeline extends from the tie-in with the offshore pipeline to the tie-in with the natural gas liquids (NGL) processing plant (NGL Plant); this area is conservatively assumed to be a 23-meter-wide by 27-kilometer-long construction corridor, plus additional areas that will be used as additional temporary work spaces along the construction corridor and areas in which access roads and bridges will be developed or improved.
  - NGL Plant—the area potentially impacted by the construction of the NGL Plant will be approximately 50 hectares, including construction laydown areas.
  - Temporary materials offloading facility (MOF) and Lower Demerara River (from the temporary MOF to the mouth of the river)—the area potentially impacted by the construction of the temporary MOF will be located on the west bank of the Demerara River. This component of the Direct AOI includes both the in-water area of impact and the onshore area that will be temporarily impacted and/or used to facilitate transport of materials from the temporary MOF to the NGL Plant site. This also includes portions of the lower Demerara River that will be used to transport heavy equipment and facility modules to the temporary MOF (conservatively assumed to include the full width of the Demerara River from its mouth to the temporary MOF).

  The offshore and onshore/riverine components of the Direct AOI are depicted on Figures 3.2-1 and 3.2-2, respectively.

- Indirect AOI, within which the Project could have potential indirect impacts, including impacts from an unplanned event (Figure 3.2-3). This area includes:
  - Offshore Indirect AOI—there will be the potential for indirect impacts from unplanned events associated with the offshore pipeline (e.g., fuel spills from construction vessels). The EIA assesses the area that could potentially be affected by such an unplanned event.
  - Onshore Indirect AOI—this is defined as Regions 2, 3, and 4 (Figure 3.2-3) on the basis that portions of these regions could be meaningfully impacted from indirect adverse environmental and social impacts (e.g., interference with fisheries activities during offshore pipeline installation), and/or positive socioeconomic benefits (e.g., job creation, purchasing of services and goods).

As described in Chapter 11, Cumulative Impacts, cumulative impacts on environmental and socioeconomic resources could potentially result from incremental impacts of the Project, when combined with other past, present, and reasonably foreseeable future projects/developments within the Project AOI. The geographic extent considered for the cumulative impact analysis includes resources within the Project AOI.

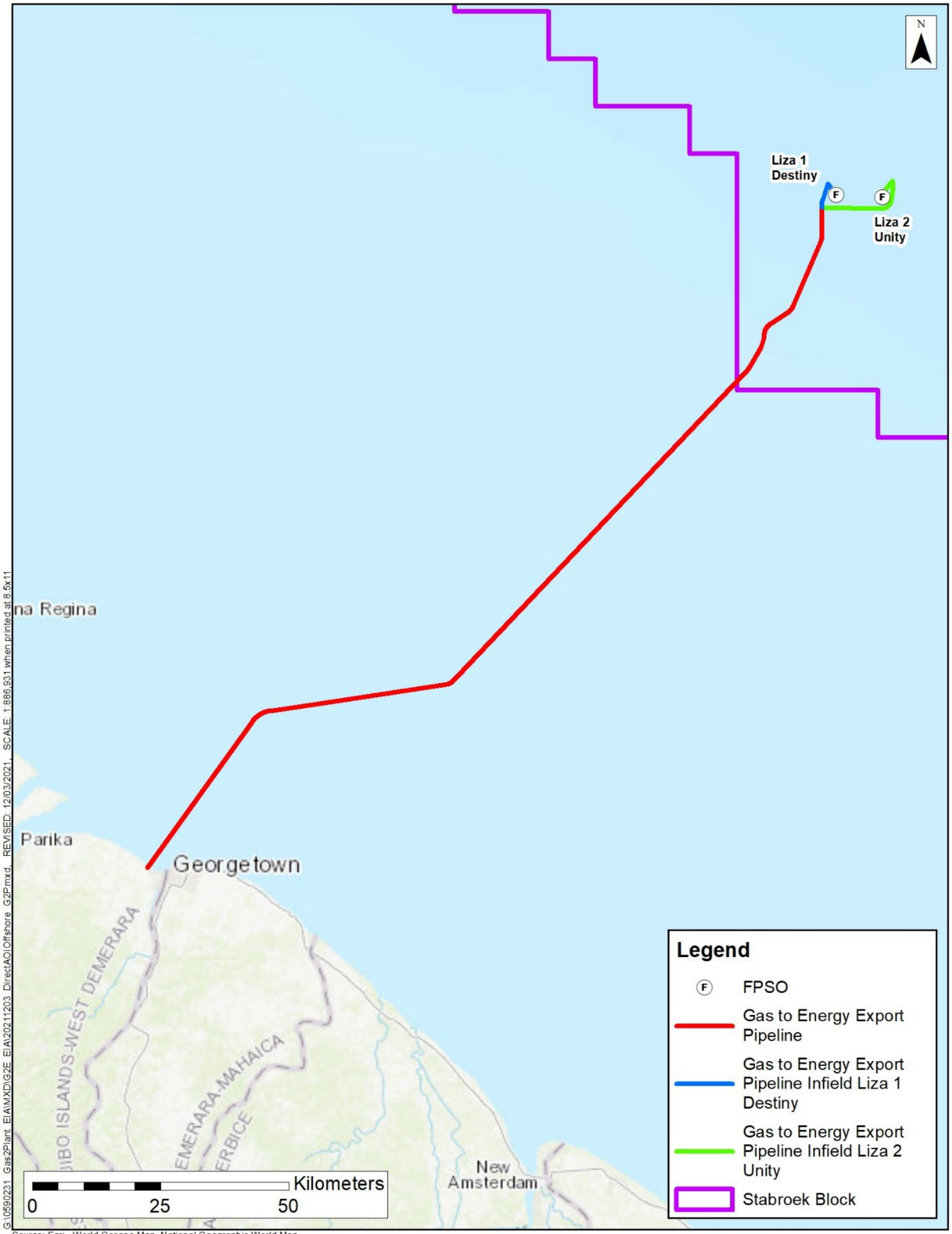
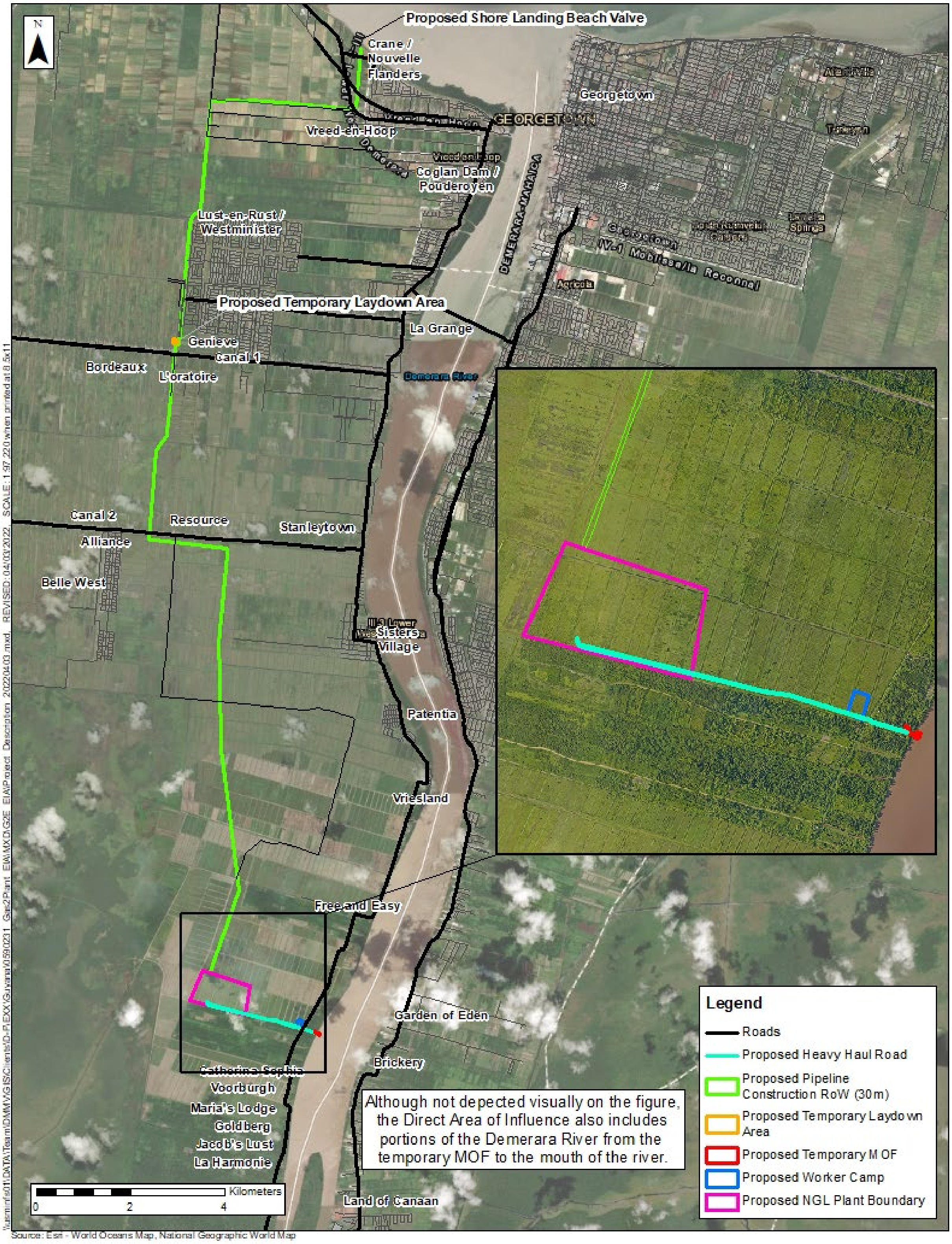
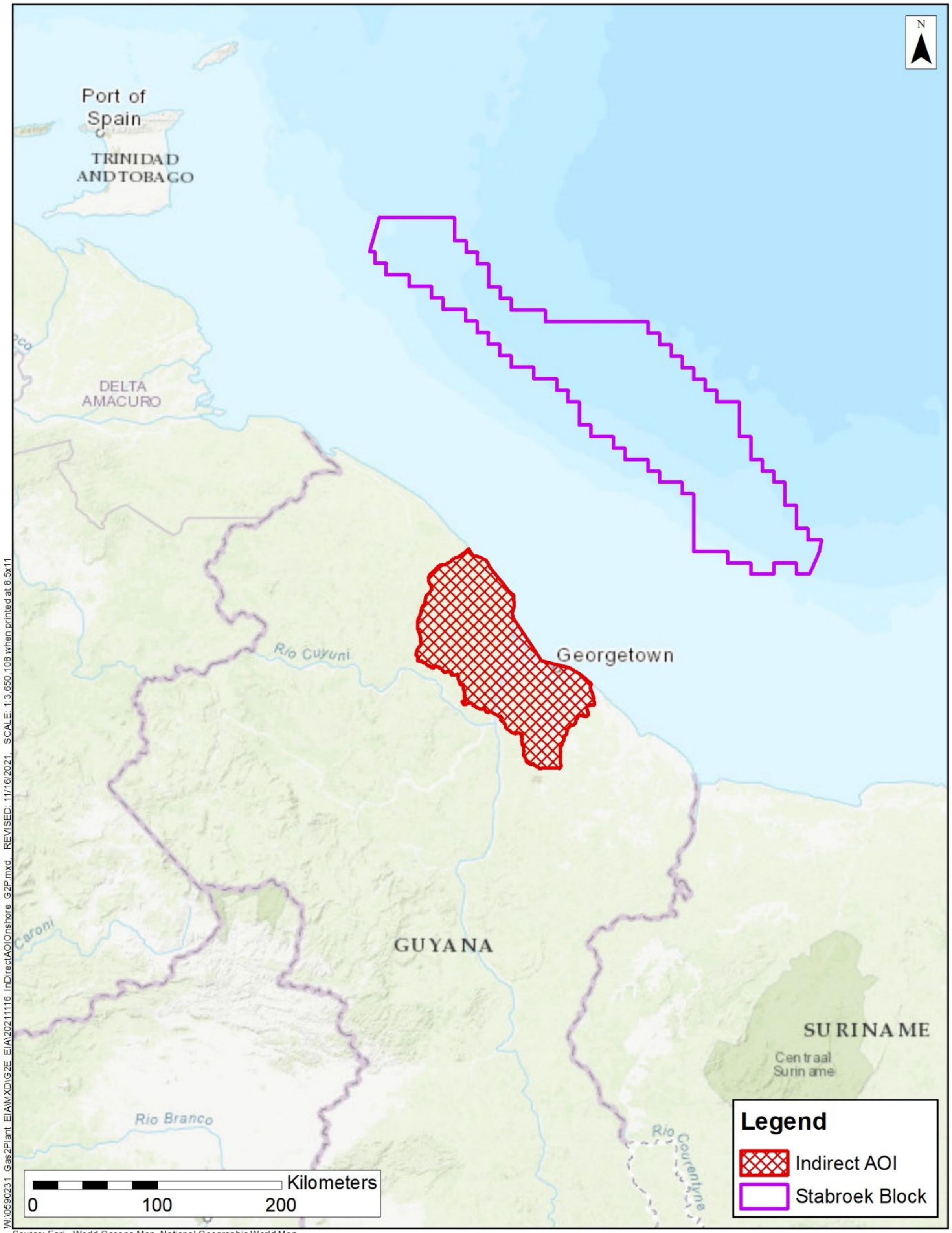


Figure 3.2-1: Offshore Component of Direct Area of Influence



m = meter; RoW = right-of-way

Figure 3.2-2: Onshore/Riverine Components of Direct Area of Influence



Source: Esri - World Oceans Map, National Geographic World Map

Offshore Component of Indirect AOI not shown

Figure 3.2-3: Onshore Component of Indirect Area of Influence

3.3. Approach to Conducting the EIA

This section describes the approach the Consultants used in conducting the EIA. The Consultants used information from various primary and secondary sources, including consultations with government entities and other stakeholders (see Section 3.3.5, Stakeholder Engagement); field and desktop studies; environmental impact assessments for other projects in Guyana and worldwide; and the scientific literature.

The key activities in the EIA approach are:

- Screening
- Scoping
- Assessment of Existing Conditions
- Project Description and Interaction with Project Design Process
- Stakeholder Engagement
- Assessment of Impacts and Identification of Mitigation and Management Measures

Figure 3.3-1: Impact Assessment Process

3.3.1. Screening

The first stage of the EIA process involved the EPA screening the Project to determine the appropriate level of analysis to support the Application for Environmental Authorisation

(Application) submitted by EEPGL on 25 June 2021. The EPA screens projects based on the information provided in the Application and determines the level of detail of the environmental assessment or type of document required to support the review of the Application.

Based on the results of its screening assessment, the EPA can determine that the information included in the Application is sufficient to support a permitting decision, or it can require one of several types of assessments (e.g., Environmental Assessment and Management Plan, EIA) to support the decision. In this case, the EPA determined that the Project could result in potentially significant impacts and, in accordance with the EP Act (as amended in 2005), indicated in a public notice dated 27 June 2021 that an EIA would be required before an environmental authorization can be granted. In a letter dated 26 July 2021, the EPA approved the Consultants as the team to undertake the EIA.

3.3.2. Scoping

The key objectives of scoping are to:

- Identify the Project's planned activities and unplanned events with the potential to result in significant impacts on physical, biological, and/or socioeconomic resources;
- Gather stakeholder input on potential impacts to these resources or other concerns regarding the Project; and
- Help inform the development of a Terms and Scope for the EIA that outlines the scope and technical approach to be used to conduct the EIA.

Following EEPGL's submittal of the Application, a notice of the Application was published by the EPA on 27 June 2021. This initiated a 28-day period during which the public had the opportunity to provide written submissions to the EPA, setting out those questions and matters to be answered and or considered in the EIA. A series of public scoping consultation meetings were conducted during the 28-day period to provide opportunities to further describe the proposed Project and to provide opportunities for stakeholders to ask questions about the proposed Project.

The EPA and the Consultants jointly considered the comments received during the scoping period. Chapter 6, Stakeholder Engagement, provides details related to the public scoping consultation meetings, and includes a summary of the comments received during the 28-day period and how they are addressed in the EIA. Appendix B, Final EPA Terms and Scope Comments, contains EPA's compilation of the comments received during the 28-day period. On 21 September 2021, the EPA issued the Terms and Scope to guide the undertaking of the EIA (EPA 2021).

As noted above, one of the objectives of the scoping process is to identify which resources could have the potential to be significantly impacted by the Project. Based on consideration of the Project's planned activities, potential unplanned events, the understanding of existing conditions at the time of scoping, and input received during the 28-day period, the following resources were identified during the scoping phase as having the potential to be significantly impacted by the Project and were included in the Terms and Scope:

- Physical Resources
  - Marine Geology and Sediments
  - Onshore Geology and Riverine Sediments
  - Soils
  - Air Quality, Climate, and Climate Change
  - Sound, Vibration, and Light
  - Water Quality (marine, riverine, and onshore surface waters; groundwater)
  - Wastes
- Biological Resources
  - Protected Areas and Special Status Species
  - Marine and Coastal Biodiversity
  - Terrestrial Biodiversity
  - Freshwater Biodiversity (Demerara River, streams, and canals)
  - Ecological Balance and Ecosystems
- Socioeconomic Resources
  - Socioeconomic Conditions
  - Community Health and Wellbeing
  - Social Infrastructure and Services
  - Transportation
  - Cultural Heritage
  - Land Use and Ownership
  - Landscape and Visual
  - Ecosystem Services
  - Indigenous Peoples

3.3.3. Assessment of Existing Conditions

The assessment of existing conditions is aimed at providing sufficient detail to meet the following objectives for the physical, biological, and socioeconomic resources identified during scoping as having the potential to be significantly impacted by the Project:

- Identify the key conditions and sensitivities in the Project AOI;
- Provide a basis for extrapolation of current conditions, taking into consideration natural variability and changes due to factors external to the Project;
- Further understand stakeholder concerns, perceptions, and expectations regarding the Project;
- Provide data to aid in the prediction and evaluation of potential impacts of the Project;
- Inform development of appropriate mitigation measures; and
- Provide a baseline to inform assessments of future changes and of the effectiveness of mitigation measures.

Desktop and field studies conducted to assess existing conditions for the resources assessed in the EIA are described in Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

3.3.4. Project Description and Interaction with Project Design

The interaction between the EIA team and the Project design process was one of the key areas in which the EIA influenced how the Project will be developed. It included involvement in identifying those Project components or activities with the potential to cause physical, biological, or socioeconomic impacts and refinement of these components and activities based on consideration of these potential impacts. Additionally, based on the results of the EIA process, the EIA team provided the Project Design team with recommended measures to avoid, reduce, and/or mitigate potential impacts.

3.3.5. Stakeholder Engagement

Consistent with EEPGL's Stakeholder Engagement Plan (provided in Volume III, Management Plans), the key objectives of stakeholder engagement with respect to the EIA are to:

- Identify stakeholders and understand their interests, concerns, and influence in relation to the Project;
- Provide stakeholders with information about the Project in ways that are appropriate to their interests and needs;
- Gather information from stakeholders to inform the understanding of existing conditions, the assessment of potential Project impacts, and the development of management and monitoring measures for the Project;
- Document feedback from stakeholders related to the EIA and address this feedback; and
- Support alignment with the government of Guyana requirements for stakeholder engagement.

As detailed in the Terms and Scope, consultations conducted in support of the EIA included public scoping consultation meetings prior to finalizing the Terms and Scope; consultations during the conduct of the EIA; and public disclosure meetings after the EIA was submitted to the EPA and published for public review. Details pertaining to these stakeholder engagement activities can be found in Chapter 6, Stakeholder Engagement.

3.3.6. Assessment of Impacts and Identification of Mitigation and Management Measures

The primary purpose of an EIA is to assess the potential impacts resulting from a proposed project and identify measures to avoid, reduce, or remedy these potential impacts. The

Consultants used a standardized impact assessment methodology to identify potential impacts and assess their significance.

Potential impacts include impacts on physical, biological, and socioeconomic resources and can be "direct," "indirect," or "induced," as defined below:

- Direct—impacts that result from a direct interaction between a project and a resource (e.g., disturbance of a benthic community habitat on the seabed, increase in employment);
- Indirect—impacts that follow from direct interactions between a project and other resources (e.g., impacts on marine fishes that feed off a directly impacted benthic community, increased opportunities for supporting industries); and
- Induced—impacts that result from other non-Project activities that occur as a consequence of a project (e.g., impacts from an influx of job seekers, increased economic activity).

The assessment of impacts proceeded through an iterative four-step process, as illustrated on Figure 3.3-2.

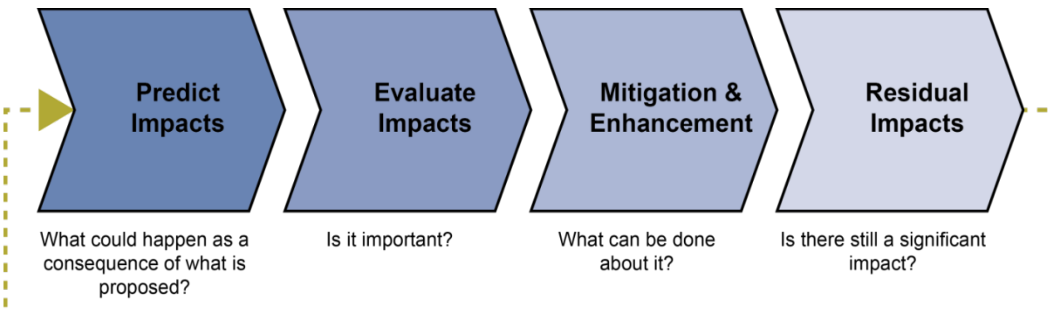


Figure 3.3-2: Impact Prediction and Evaluation Process

3.3.6.1. Step 1: Predict Impacts

The EIA evaluates potential Project impacts by predicting and quantifying, to the extent possible, the magnitude of those impacts on resources and the sensitivity of the impacted resources.

Predicting Magnitude of Impacts

Magnitude essentially describes the nature and degree of change that the potential impact is likely to impart upon the resource. Depending on the impact, magnitude is a function of some or all of the following impact characteristics:

- Intensity (including geographic/spatial extent)
- Frequency
- Duration

The magnitude of an impact takes into account the various dimensions of a particular impact to determine where the impact falls on the spectrum (in the case of adverse impacts) from

Negligible to **Large**. Some impacts will result in changes to the resource that may be immeasurable or undetectable, which are characterized as having a **Negligible** magnitude.

Taking into account the impact characteristics identified above, the magnitude of each potential impact is assigned one of the following five ratings:

- Negligible
- Small
- Medium
- Large

In the case of positive impacts, the EIA does not characterize the magnitude or significance of such impacts. Rather, they are simply reported as positive.

The definitions for intensity, duration, and frequency designations used throughout the EIA are provided in Tables 3.3-1, 3.3-2, and 3.3-3, respectively. Recognizing that impacts could be experienced differently by different resources, the definitions for intensity designations are defined in more detail, where appropriate, in the resource-specific sections of the EIA (Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).

Table 3.3-1: Definitions for Intensity Designations

Intensity Designation	Definition
Negligible	Immeasurable or undetectable change from baseline conditions and/or minute spatial extent
Low	Minor but measureable change from baseline conditions and/or affects a small area within or near the Project Footprint
Medium	Noticeable and readily measurable change from baseline conditions and/or affects a larger area beyond the Project Footprint
High	Substantial change from baseline conditions and/or extends over a larger regional area and may cross international boundaries

Table 3.3-2: Definitions for Duration Designations

Duration Designation	Definition
Short-term	Instantaneous to less than an week in aggregate
Medium-term	More than a week but less than a year in aggregate
Long-term	More than 1 year in aggregate

Table 3.3-3: Definitions for Frequency Designations

Frequency Designation	Definition
Episodic	Occurring occasionally and at irregular intervals
Continuous	Occurring more than occasionally or at regular intervals

To establish a consistent basis for assigning magnitude ratings based on the various impact characteristics (i.e., intensity, frequency, and duration), each of the possible combinations of characteristic designations was assigned a magnitude rating. Figure 3.3-3 lists the various combinations of impact characteristics and the corresponding magnitude ratings that were assigned for each combination.

Intensity	Frequency	Duration	Overall Magnitude Rating
Negligible	Episodic	Short-term Medium-term	Negligible
Low	Episodic	Short-term	Negligible
		Medium-term	Small
Medium	Episodic	Short-term	Negligible
		Medium-term	Small
High	Episodic	Short-term	Negligible
		Medium-term	Small
Negligible	Episodic	Long-term	Negligible
Low	Episodic	Long-term	Small
Medium	Episodic	Long-term	Small
High	Episodic	Long-term	Medium
Negligible	Continuous	Short-term Medium-term	Negligible
Low	Continuous	Short-term	Small
		Medium-term	Small
Medium	Continuous	Short-term	Small
		Medium-term	Medium
High	Continuous	Short-term	Medium
		Medium-term	Medium
Negligible	Continuous	Long-term	Negligible
Low	Continuous	Long-term	Small
Medium	Continuous	Long-term	Medium
High	Continuous	Long-term	Large

Figure 3.3-3: Impact Characteristics and Magnitude Ratings

Predicting Sensitivity

Multiple factors are taken into account when defining the sensitivity of a resource. Not all resources can be assessed according to the same criteria, so the sensitivity ratings for specific resources may be determined differently according to the resource (or the type of impact) being assessed. For physical resources (e.g., air quality), the resource's sensitivity to change (sometimes assessed factoring in the sensitivities of other resources that make use of the physical resource) is typically considered. For biological or cultural resources (e.g., a mangrove forest), the importance (e.g., local, regional, national, or international importance) of the resource or the vulnerability of the resource to the specific type of impact is typically considered. For socioeconomic resources, the vulnerability of the potentially impacted individual, community, or wider societal group to changes in the resource is generally considered. Other factors may also be considered when characterizing sensitivity, such as legal protection, government policy, stakeholder views, and economic value.

The specific criteria used to assign sensitivity ratings are therefore discussed in the resource-specific sections (Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).

While the approach for designating sensitivity ratings varies on a resource-by-resource basis, the following sensitivity designations are consistently used for all resources:

- Low
- Medium
- High

3.3.6.2. Step 2: Evaluate Impacts

The process of impact evaluation considers predicted impacts with the potential to occur due to planned activities of the Project, and impacts that could potentially occur due to unplanned events (e.g., hazardous materials spills), but would not otherwise be expected to occur as a result of planned Project activities.

Evaluating Potential Impacts from Planned Activities

For potential impacts associated with planned activities of the Project, the significance of each potential impact is assigned based on evaluation of the magnitude of the impact and the sensitivity of the resource. The matrix depicted on Figure 3.3-4 is used for assigning impact significance ratings. The assignment of a significance rating enables decision-makers and stakeholders to understand and prioritize key potential Project impacts and consider what mitigation measures may be warranted.

		Sensitivity/Vulnerability/Importance of Resource		
		Low	Medium	High
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major

Figure 3.3-4: Impact Significance Rating Matrix for Planned Activities

Evaluating Potential Impacts from Unplanned Events

Potential risks from unplanned events related to the Project (e.g., hazardous material spills, traffic accidents, or other events with a less-than-certain chance of occurrence) do not lend themselves readily to the analysis described above for planned Project activities. Rather than assigning significance ratings (as is done for potential impacts from planned activities), the EIA assigns risk ratings for potential risks from unplanned events. Assessing risk requires understanding:

- Potential consequence/severity of the unplanned event if it were to occur; and
- Likelihood of the unplanned event occurring.

Consequence/Severity

The consequence/severity element of the risk rating is assigned based on the sensitivity of the resource and the magnitude of the impact (determined as if it were an impact from a planned activity)—essentially equivalent to the manner in which a significance rating is assigned for an impact from a planned activity—and then using Figure 3.3-5 to determine the assigned consequence/severity.

		Sensitivity of Resource		
		Low	**Medium**	**High**
Magnitude of Impact	**Negligible**	Small	Small	Small
	Small	Small	Small	Medium
	Medium	Small	Medium	Large
	Large	Medium	Large	Large

Small Consequence/ Severity

Medium Consequence/ Severity

Large Consequence/ Severity

Figure 3.3-5: Consequence/Severity Determination for Unplanned Events

Likelihood

Likelihood reflects the probability of occurrence of the unplanned event, and is defined as follows:

- Unlikely—considered a rare event; there is a small likelihood that such an event would occur during the Project life cycle;
- Possible—the event has a reasonable chance to occur at some time during normal operations of the Project; and
- Likely—the event is expected to occur at some point during the Project life cycle.

Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred. It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, not the degree to which an impact is expected to occur as a result of the unplanned event. The latter concept is referred to as uncertainty, and this is typically dealt with in a contextual discussion in the impact assessment, rather than in the risk rating process.

Once consequence/severity and likelihood are determined for a given risk to a resource from an unplanned event, the following risk matrix (Figure 3.3-6) is used to rate the risk to resources associated with unplanned events.

		Consequence/Severity		
		Small	Medium	Large
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

Figure 3.3-6: Risk Rating Matrix for Unplanned Events

3.3.6.3. Step 3: Mitigation and Management

The next step in the process is the identification of measures that can be taken to mitigate, as far as reasonably practicable, the identified potential impacts of the Project. A mitigation hierarchy is used, where the preference is always to avoid the impact before considering other types of mitigation. The following is the preferred hierarchy of measures followed in this EIA:

- Avoid—remove the source of the impact by employing alternative designs or operations to avoid potential adverse interactions with environmental and socioeconomic resources;
- Reduce—lessen the chance of adverse interaction between the Project and resources and/or lessen the consequence of adverse interactions that cannot be avoided (e.g., reduce the size of the Project Footprint[2]); and
- Remedy—if adverse interactions between the Project and resources cannot be avoided or their consequences reduced, then "repair" the consequences of the impact after it has occurred through rehabilitation, reclamation, restoration, compensation, and/or other measures.

In support of the EIA process, the Consultants and EEPGL developed an adaptive management strategy to aid in tracking whether committed mitigation measures are implemented as planned and produce the desired outcomes. This adaptive management strategy provides EEPGL, in consultation with the EPA and other stakeholders, the opportunity to:

- Address unanticipated adverse impacts that are encountered—by identifying and implementing new or different mitigation measures (following the same avoid/reduce/ remedy hierarchy);
- Adjust or replace existing mitigation measures when appropriate during the Project life cycle—to address evolving impacts; and
- Retire existing mitigation measures that no longer demonstrate value.

Mitigation and management measures were developed where appropriate to address potential impacts identified in the EIA process. These measures are described in each resource-specific discussion in Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources. Mitigation and

[2] The Project Footprint includes areas used for the Project on a long-term basis (i.e., for the life of the Project) as well as areas used on a temporary basis such as onshore construction laydown areas and marine and aerial routes transited by support vessels and aircraft during drilling, installation, and hook-up/commissioning stages.

management measures are generally not developed for potential adverse impacts that are assessed as having a significance rating of **Negligible**.

In addition, an Environmental and Socioeconomic Management and Monitoring Plan was prepared that describes all the mitigation and management measures incorporated into the EIA, summarizes how each measure will be implemented, and identifies a monitoring strategy to evaluate the effectiveness of each measure. The Environmental and Socioeconomic Management and Monitoring Plan is included in Volume III, Management Plans.

3.3.6.4. Step 4: Determine and Manage Residual Impacts

The final step in the iterative impact evaluation process for this EIA is the assessment of "residual impacts/risks" (i.e., impacts/risks that are predicted to remain after both embedded controls and committed mitigation measures have been taken into consideration). This typically involves repeating the process described in Step 1 and Step 2 to re-evaluate the potential impact significance or risk rating, considering the implementation of proposed mitigation and management measures.

In cases where the residual impact significance rating or the residual risk rating is **Moderate** or **Major**, the management emphasis is on reducing the impact/risk to a level that is as low as reasonably practicable. This does not necessarily mean, for example, that residual impacts/risks of **Moderate** or higher have to be reduced to **Minor**, but rather that these impacts/risks are being managed as effectively and efficiently as practicable.

Although a standard goal of an impact assessment is to eliminate residual impacts/risks of a **Major** significance, for some resources, there may be residual impacts/risks rated as **Major** even after all practicable mitigation options have been exhausted. In these situations, decision-makers must weigh potential negative factors against positive ones, in reaching a decision on the Project.

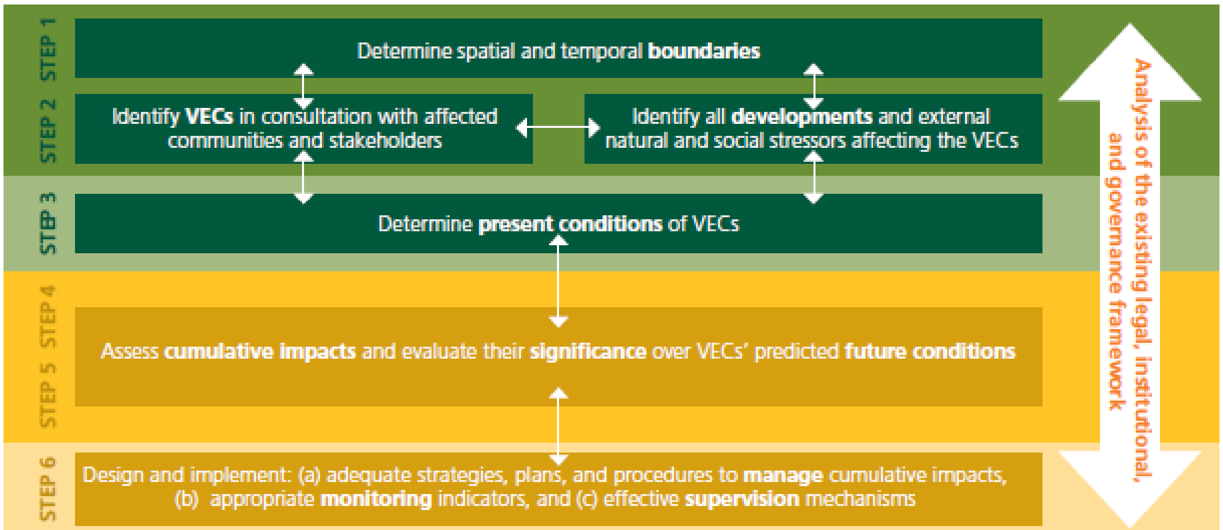
3.3.7. Evaluating Cumulative Impacts

The EIA assesses cumulative impacts using an approach that follows the International Finance Corporation's *Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* ("the Handbook") (IFC 2013). This methodology focuses on environmental and social resources that are considered as important by stakeholders, referred to in the Handbook as valued environmental and social components (VECs), which are: (1) rated as "highly valued/sensitive" by Project-Affected Communities[3] and/or the scientific community; and (2) cumulatively impacted by the Project under evaluation, by other projects, and/or by natural environmental and social external drivers (IFC 2013).

The assessment of cumulative impacts in the EIA considers the interactions between potential impacts from the Project and potential impacts from non-Project activities (including, but not limited to, other EEPGL activities). The cumulative impact assessment considers relevant past,

[3] Project-Affected Communities are defined as local communities potentially directly affected by the Project (consistent with IFC Performance Standard 1, paragraph 1 [IFC 2012]).

existing, or approved/planned activities that are considered reasonably foreseeable, informed by information provided by EEPGL, existing conditions discussed in the EIA, information available in the public domain, and information gathered during the stakeholder consultation process. Figure 3.3-7 summarizes the key steps in the cumulative impact assessment process. Chapter 11, Cumulative Impacts, provides additional details on the methodology for this assessment.



Source: IFC 2013

Figure 3.3-7: Cumulative Impact Assessment Process

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4. ALTERNATIVES

This section describes the alternatives to the proposed Project that were considered, including the following:

- System alternatives
- Location alternatives
- Construction alternatives
- Operations/process/technology alternatives
- No Project alternative

4.1. SYSTEM ALTERNATIVES

The system alternatives under consideration are different ways of meeting the purpose of the Project, including alternative energy sources, alternative methods for transporting natural gas, and alternative means of accessing Project locations.

4.1.1. Energy Source Alternatives

EEPGL and the Government of Guyana have considered alternative sources of energy, including alternative fuel sources for supplying the government's planned Power Plant. A thermoelectric power plant could be fueled by natural gas, biomass (e.g., wood residuals), or bagasse (sugar cane residuals). Power could also be generated by solar, wind, or hydropower generation facilities.

The potential power generation via solar, wind, and biomass sources has been estimated at 88 megawatts (MW) over the next 5 to 10 years, compared to 204 MW via natural gas (K&M Advisors 2019). Of the potential 88 MW via solar, wind, and biomass, only 10 MW is expected to come from wind energy (K&M Advisors 2019). Guyana has the potential to generate 165 MW via hydropower, although construction and commissioning of a new hydropower plant would likely extend through 2025 or 2026 (K&M Advisors 2019; Government of Guyana 2021a, 2021b). The capacity to meet peak demand also differs among energy sources, with gas and hydropower constituting readily available firm capacity, as opposed to intermittent sources like solar and wind, or sources constrained by seasonal availability of fuel like biomass or bagasse (K&M Advisors 2019).

Natural gas is produced offshore Guyana, and the equipment necessary to access this resource is already in place: the Liza Phase 1 and Liza Phase 2 Floating Production, Storage, and Offloading (FPSO) vessels. Natural gas is a well-established fuel source for power plants, and the technology necessary to process the raw natural resource into the grade of fuel needed for efficient power plant operation is well proven.

Natural gas aligns with Guyana's proposed regional integration plans for the electricity sector. While hydropower is an opportunity in the long-term, and other renewable energy sources are available in the interim, natural gas presents a transition fuel opportunity that could reduce electricity costs and promote economic growth (Energy Narrative 2017). Investing in power plants using natural gas does not prevent future hydropower and renewable energy development. Rather, gas-fired power generation offers a bridge for Guyana's energy sector away from heavy fuel oil while renewable energy sources are gradually developed over the next 10 years, as envisioned in Guyana's *Draft Low Carbon Development Strategy 2030* (Government of Guyana 2021a). In this way, gas-fired power generation can reduce greenhouse gas (GHG) emissions associated with electricity generation in the Demerara Berbice Interconnected System by approximately half by the year 2025 (Government of Guyana 2021a).

Forecasts of electricity demand growth predict that the Project's natural gas supply alone would not be sufficient to meet peak electricity demand past the year 2035, thus providing space for alternative energy supplies such as hydropower (Energy Narrative 2017). Natural gas and hydropower can together provide Guyana's baseload generation. The flexibility of gas generation can also buffer seasonal variations in hydropower availability. Natural gas also has the advantage of being feasibly used for power generation near existing transmission lines along the Guyana's coast, where most of the electricity demand is based. In contrast, existing transmission infrastructure is limited or absent near potential sources of hydropower, requiring significant transmission line construction from the potential points of generation in the interior to the coast. If solar power generation capacity were to increase rapidly in Guyana, this would likely not impact power generation by a gas-fired power plant, but rather reduce the use of heavy fuel oil (K&M Advisors 2019). Therefore, natural gas is the preferred energy source for the Project.

4.1.2. Natural Gas Transport Alternatives

Natural gas could be transported from the Liza Phase 1 and Liza Phase 2 FPSOs to shore either via pipeline or a Liquefied Natural Gas (LNG) vessel. Transporting natural gas in the form of LNG would require the construction of additional infrastructure offshore and onshore, including an offshore liquefaction vessel and a coastal regasification plant, in addition to one or more specialized LNG vessels. The LNG vessel(s) may be limited in size and capacity by the limited draft (water depths) near shore and in Guyana's major rivers. Considering the distance to shore is approximately 200 kilometers, the fixed costs of LNG infrastructure would form the majority of the total cost of transporting LNG and would be costlier than transporting natural gas via pipeline (Energy Narrative 2017). LNG vessels are typically used to transport natural gas long distances (e.g., between countries or between continents).

The potential GHG emissions from a pipeline system are expected to be less than those of an LNG liquefaction, transport, and regasification system. The primary reasons for this are the energy needed to liquefy and re-gasify LNG and the releases of methane associated with venting, leakage, and fugitive emissions in the LNG process. Consequently, LNG projects typically have significantly higher emissions intensities than gas pipeline projects, often over three-fold more per equivalent unit of gas (Wood Mackenzie 2017; Shaton et al. 2020).

The Government of Guyana commissioned a study that evaluated the costs, benefits, and risks of a pipeline versus LNG vessel(s) (Energy Narrative 2017). This study concluded that a pipeline is the better option to bring natural gas to shore. Therefore, the preferred alternative includes a pipeline to bring natural gas ashore.

4.1.3. Access Alternatives

Some degree of construction access road development and/or improvement will be required for the Project. This will likely comprise a combination of soil stabilization and temporary hard surfacing, with restoration following completion of construction. The most significant aspect of the Project with respect to access alternatives is the transport of oversize loads related to the construction of the natural gas liquids (NGL) processing plant (NGL Plant).

Construction equipment and materials could be shipped to Georgetown and off-loaded at Guyana Shore Base Inc. (GYSBI) for further delivery to the NGL Plant site. Land routes from GYSBI to the NGL Plant site present challenges, as there is limited seasonal road access to the proposed NGL Plant site, as well as size and weight restrictions and the potential to increase traffic congestion on already busy roads. The proposed NGL Plant site is located close to navigable water (approximately 1.5 kilometers), so another access alternative for transporting oversize loads between GYSBI and the NGL Plant site includes constructing a temporary Materials Offloading Facility (MOF) along the Demerara River near the NGL Plant.

A temporary MOF would allow construction equipment and materials from Georgetown to be loaded onto shallow-draft barges for transport up the Demerara River. A temporary MOF would provide a safe and convenient place to unload barges close to the NGL Plant site, minimizing the need for overland transport. Dredging, backfilling, and concrete work are required to build a temporary MOF, as is construction of a heavy-haul road from the temporary MOF to the NGL Plant location; these activities would have some environmental impacts on lands and waters at the locations of these activities (see Chapters 7 through 9). A temporary MOF would facilitate construction of the NGL Plant by allowing the transport of loads too large to move along the public road network, as well as by avoiding existing traffic congestion. Furthermore, a temporary MOF would reduce the potential impact of the Project on existing road users.

The two alternatives to a temporary MOF are to improve existing roads and/or construct new roads. The existing road route between Georgetown and the proposed NGL Plant location follows the East Bank of Demerara Public Road south from the GYSBI shorebase through the neighborhoods of Houston and McDoom to the Demerara Harbour Bridge, west across the bridge, through the community of La Grange via the west Demerara Harbour Bridge access road, and to the West Bank of Demerara Public Road. The East Bank of Demerara Public Road is the only connection for vehicular traffic between the east and west banks of the Demerara River and is the primary vehicular route between Georgetown and several large residential areas to the south including Agricola, Republic Park, and Providence; this creates severe congestion during the morning and evening commutes. Parking on the shoulder is common, so the shoulders should not be relied upon for oversized loads.

The main potential “pinch point” or potentially challenging section in this segment is the Demerara Harbour Bridge. The Demerara Harbour Bridge has one travel lane in each direction, totaling approximately 9 meters of available roadway on the bridge. The lanes narrow to approximately 3.5 meters in some locations. The bridge has weight limits of 18 metric tons for general traffic and 22 metric tons for special crossings. In addition to overweight vehicles, vehicles wider than 2.3 meters or towing a trailer require prior permission from the Demerara Harbour Bridge Corporation. Vehicular traffic is also subjected to daily closures to allow vessel traffic to pass through the bridge’s central section into and out of the Demerara Harbour. The daily closures typically last 90 minutes and can create significant congestion on either side of the bridge, particularly when they coincide with regular commuting periods. A new bridge across the Demerara River has been proposed to replace the Demerara Harbour Bridge, but construction of the replacement bridge will likely require at least 2 years (Global Construction Review 2021).

From the West Bank of Demerara Public Road, the route to the NGL Plant site follows the West Bank of Demerara Public Road for its entirety. The West Bank of Demerara Public Road is the only connection for vehicular traffic between the southern West Bank Demerara communities (e.g., La Grange, Westminster, Nismes) and the Demerara Harbour Bridge. Similar to the first segment of the route on the East Bank of the Demerara River, it is subject to morning and evening congestion from commuter traffic. The entire road is slightly more than 7 meters wide in most locations, with each traffic lane occupying between 3 and 4 meters of paved surface. Shoulders on both sides of the road are narrow and generally unpaved. Parking on the shoulder or along the side of the road is common along this entire segment. The most significant “pinch points” or potentially problematic sections along this route are three bridges over canals. All of these bridges have low concrete walls approximately 1 meter high on both sides and little to no shoulder. The third and southernmost bridge has the potential to be more challenging for large vehicles. Large trailers are likely to exceed the width of one lane, and oversized loads may not fit, depending on their widths.

If the Project were to use existing roads as the primary means of transporting heavy loads to the proposed NGL Plant location, this would increase traffic congestion during the construction phase of the Project. Existing patterns of traffic congestion could also hinder transportation of Project materials on existing roads, and narrow bridges may limit the width of loads that can be transported.

Constructing new roads from Georgetown to the NGL Plant site on the Wales Estate is only feasible from the west side of the Demerara River, otherwise a new bridge across the Demerara River or a deepwater docking facility on the west bank would be needed; such additional facilities are beyond the scope of the Project. From the point where the Demerara Harbour Bridge connects to the West Bank Main Public Road, new roads could be constructed leading west, south, and then southeast toward the Wales Estate. However, this distance is over 16 kilometers, and any logical route would likely displace homes and intersect at least 12 existing roads and at least 20 canals. A road construction campaign of this magnitude would be costly and disruptive, and could jeopardize the feasibility of the Project, in addition to causing additional environmental impacts beyond those described in Chapters 7 through 9. In any case, a major “pinch point” would remain at the Demerara Harbour Bridge.

The Demerara Harbour Bridge presents a major issue under either access alternative that would use existing roads and/or construct new roads. The size and weight limits on this bridge, in addition to the existing traffic and daily closures, present serious obstacles to transporting the oversize loads involved in constructing the NGL Plant, and certain loads (e.g., heavy equipment) may be too heavy to receive the required approval to cross the bridge. Considering this along with the risk of Project delays and the potentially significant impact of Project traffic on existing bridge traffic, any alternative that requires oversize loads to cross the Demerara Harbour Bridge is unfavorable and potentially infeasible.

Therefore, the preferred alternative is to use a temporary MOF, which will enable the transport of oversize loads, minimize the effects of existing traffic congestion on the Project, minimize the environmental impacts associated with the construction of new roads and bridges and the improvement of existing roads and bridges, and reduce the impact of the Project on other road users in the community.

4.2. LOCATION ALTERNATIVES

The Project has certain requirements regarding location. As discussed in Chapter 1, Introduction, the purpose of the Project is to transport natural gas from the Liza Phase 1 and Liza Phase 2 FPSOs offshore Guyana to the shore, extract NGL for sale, and treat remaining dry gas for use as a fuel source for a Power Plant owned and operated by the Government of Guyana. Thus, the Project requires a pipeline from the Liza Phase 1 and Liza Phase 2 FPSOs to an onshore location suitable for a natural gas and NGL Plant. Construction and operation of the Project will also require a temporary MOF; associated infrastructure upgrades and logistics support facilities (locations to be determined); a temporary pipeline construction right-of-way (RoW) preliminarily estimated to be approximately 30 meters wide; a permanent pipeline RoW preliminarily estimated to be approximately 12 meters wide; access road and bridge development/improvements along the onshore pipeline route; and pipe yards, fabrication facilities, fuel supply facilities, and waste management facilities (locations to be determined).

The primary elements of the Project for which location alternatives are available and meaningfully different are the NGL Plant, the pipeline corridor, and the temporary MOF.

4.2.1. NGL Plant Location Alternatives

EEPGL commissioned a desktop and field survey to evaluate environmental, socioeconomic, and engineering/project development conditions for multiple sites identified by the Government of Guyana for potentially siting the shoreward portion of the Project, which includes the onshore pipeline(s), NGL treatment plant, and gas-fired Power Plant. Potential road transit routes from GYSBI to each site were also assessed.

An initial desktop-based screening evaluated several sites identified by the Government of Guyana as potential locations for supporting the shoreward components of the Project (Figure 4.2-1). This screening included 11 broad screening criteria related to environmental, socioeconomic, constructability, and feasibility issues, as summarized below:

- Pipeline—length, potential routing issues, safety, constructability, other conditions that could affect the practicability of constructing the pipeline;
- Site Constructability—road/equipment access to site, road conditions (width and condition if known), need for new or upgraded bridges, site topography;
- Geotechnical—soil and land conditions;
- Marine/Riverine Accessibility—site accessibility via water (navigability), marine traffic;
- Dredging and Water Quality—construction and maintenance dredging requirements, discharge issues;
- Environmental—habitat type, habitat contiguity/connectivity with off-site natural habitats, biodiversity and protected species information (where available), mangrove quality (where available), data from coastal sensitivity mapping (where available);
- Land—size of site (100 acres minimum), surrounding land use, distance to landmarks (this criterion was subsumed under socioeconomic for rating purposes);
- Socioeconomic—traditional uses/ecosystem services, presence of important fishing and/or cultural sites, distance to communities and indigenous lands, distance to service/supply areas;
- Site Resilience—elevation, flood risk (greater than 5 meters above sea level preferred), presence of seawall;
- Health and Safety—distance to homes or communities, which could be negatively impacted in case of flaring, venting, or explosion at the NGL Plant; and
- Access to Power Infrastructure—proximity to power demand and transmission infrastructure.

The criteria of marine/riverine access and access to power infrastructure were considered essential feasibility considerations for construction and operation of the Project.

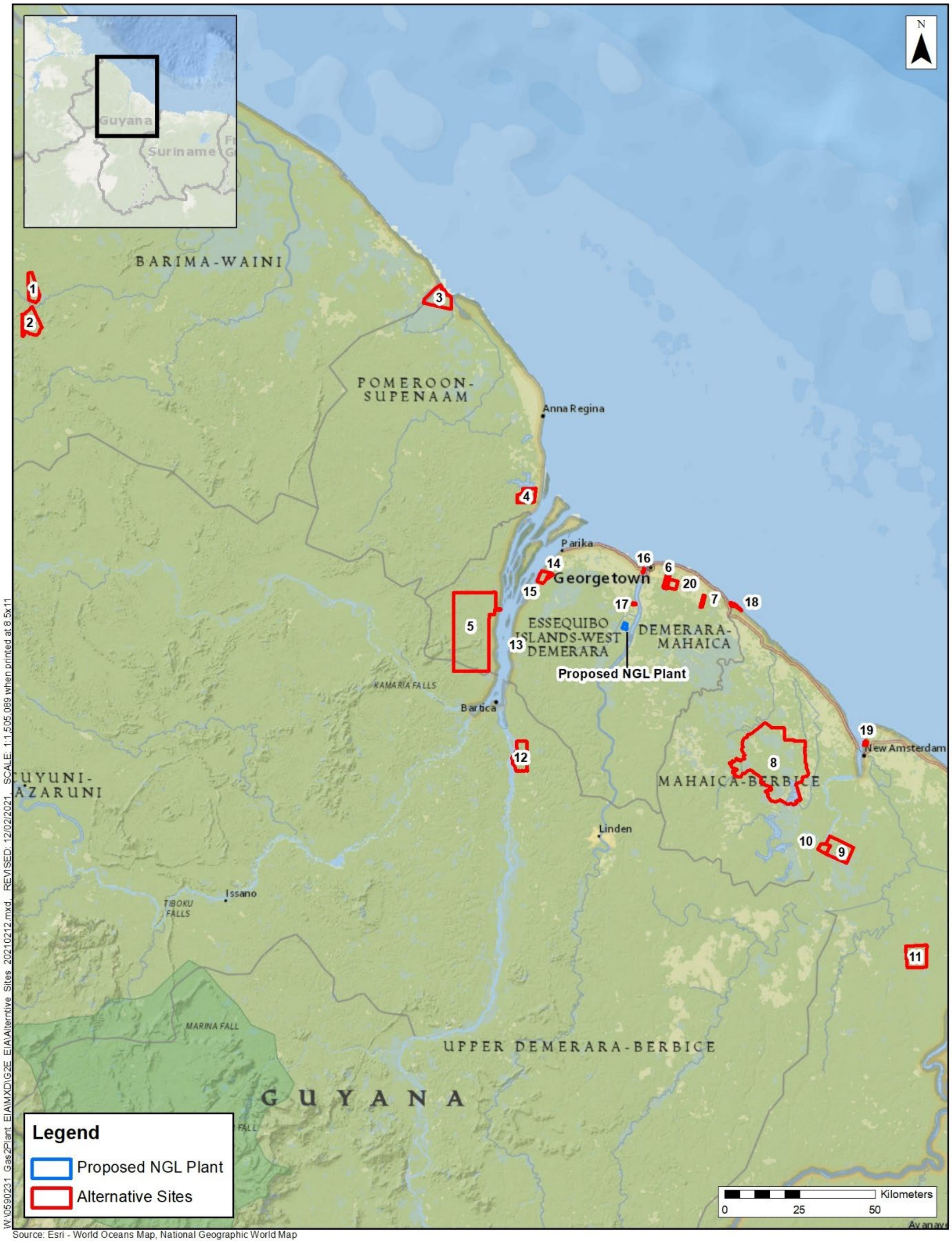


Figure 4.2-1: NGL Plant Location Alternatives

The results of the initial screening indicated that many of the sites presented potential issues that would make the Project infeasible at those sites. Three potentially useable sites were identified—Sites 6, 14, and 15. Subsequent assessments examined six additional sites (Figure 4.2-1):

- Site 16—Vreed-en-Hoop
- Site 16b—Vreed-en-Hoop Power Station
- Site 17—Wales
- Site 18—Mahaica Rivermouth
- Site 19—New Amsterdam
- Site 20—Ogle

The three initially assessed sites plus the six additional sites are discussed below.

4.2.1.1. Site 6—Region 4 Ogle

This site is located near Georgetown and an existing power transmission network. The closest point of approach to an existing neighborhood (i.e., South Ruimveldt) is approximately 0.75 kilometer from the site; this proximity is unfavorable, as distances of at least 1 kilometer are preferred for health and safety reasons. This site is currently recovering from long-term use in agriculture (i.e., sugar cane); active management of this site appears to have ended approximately 5 years ago. It could use a short onshore pipeline heading directly to the coast along existing road/canal RoW. However, the site is far from existing or possible new ports, and ease of access along existing roads would be challenging.

4.2.1.2. Site 14—Region 3 Essequibo River

Site 14 is located along the eastern bank of the Essequibo River, 7 kilometers south of Parika. The site encompasses 147 hectares of cropland, much of which appears to be in active cultivation based on recent satellite imagery. There are fewer than five buildings, which could be homes or farmsteads, on the site. Therefore, there is a moderate potential that physical and economic displacement would be necessary.

The site has good constructability features including flat topography, cleared and drained land, stable soils, and few required bridge crossings. In addition, the proximity of the site to the coast enables an onshore pipeline of moderate length and provides good access to power infrastructure at nearby Parika.

There is no direct road access to the site; however, the Delcante Road lies 2.5 kilometers west of the site and a Government of Guyana RoW connects the site with the road, offering a potential future road corridor. River access is very good, with the Essequibo River located 3 kilometers west of the site, and the Government of Guyana has a RoW that connects the site to the river.

Based on Site 14's likely need for physical and economic displacement, and the lack of direct road access, Site 14 was not chosen for the NGL Plant location.

4.2.1.3. Site 15—Region 3 Essequibo River

Site 15 is located along the eastern bank of the Essequibo River immediately west of Site 14 and 8 kilometers south of Parika. The site consists mostly of cropland, although remnants of forest and shrubland remain scattered throughout. The site has direct road access via the Delcante Road and marine/riverine access via the Essequibo River, which is located immediately west of the site. Similar to conditions described for Site 14, the site has good constructability features including relatively flat topography, suitable land use, stable soils, few required bridge crossings, the potential for an onshore pipeline of moderate length, and good access to power infrastructure at Parika.

According to satellite imagery, the site appears to contain some human habitation in addition to active agriculture. Based on this, the potential for physical and/or economic resettlement is considered high. Furthermore, the site consists of private lands that would require compulsory acquisition. Compulsory acquisition could pose substantial social and schedule challenges for developing the site. Based on these criteria, Site 15 was not chosen for the NGL Plant location.

4.2.1.4. Site 16—Vreed-en-Hoop

The Vreed-en-Hoop site poses significant development challenges related to low elevation (flooding), soft soils, proximity to communities, very limited access, and presence of dense mangrove forest. Development of this site would very likely require some acquisition of private property to provide adequate access to the site. Legal protections for mangrove forest, and the ecological impacts that may occur if the mangrove forest were removed, further complicate the potential development of this site.

4.2.1.5. Site 16b—Vreed-en-Hoop Power Station

The Vreed-en-Hoop Power Station site is adjacent to the Vreed-en-Hoop site and consists of two properties separated from one another by a road. Both properties are currently developed: one contains the active Vreed-en-Hoop Power Station, and the other contains the associated switchyard. Even if these facilities were removed, the cleared portion of this site is too small to support the Project facility. Undeveloped land to the north and east could accommodate the additional footprint needs, but this would involve mangrove removal and would likely bring geotechnical constraints similar to those found on the Vreed-en-Hoop site.

4.2.1.6. Site 17—Wales

Site 17 lies approximately 19 kilometers upriver on the west bank of the Demerara River. Site 17 is part of the larger Wales Estate, a sugarcane plantation owned by the Guyana Sugar Corporation that has largely been removed from production.

There is one access road within the site that provides access to the eastern portion of the site. Road access is via the West Bank of Demerara Public Road, the main arterial road between Georgetown and the west bank of the Demerara River. A defunct Guyana Sugar Corporation sugar factory is located directly east of Site 17 and includes a conveyor apparatus that overpasses the West Bank of Demerara Public Road. The site is drained by a system of canals.

Of the sites assessed, the Wales site was assessed to be the most favorable for development from constructability (e.g., site access, soil conditions), environmental, socioeconomic, and biodiversity perspectives. This site is farther from the coast than most of the other promising sites, thus requiring a longer onshore pipeline and possibly more acquisition of private land (see Section 4.2.2, Pipeline Corridor Alternatives). The same technical constraints related to site access that affect the Vreed-en-Hoop site also affect the Wales site, although acquisition of land near the Wales site would likely be easier than Vreed-en-Hoop, because the site and much of its surroundings consist of government-owned land.

4.2.1.7. Site 18—Mahaica River Mouth

The Mahaica River mouth site poses significant development challenges related to low elevation (flooding), soft soils, proximity to communities, very limited access, and presence of dense mangrove forest covering most of the site. Legal protections for mangrove forest, and the ecological impacts that may occur if the mangrove forest were removed, further complicate the potential development of this site.

4.2.1.8. Site 19—New Amsterdam

The New Amsterdam site, like the Vreed-en-Hoop and Mahaica River Mouth sites, consists mostly of dense mangrove forest at low elevations. Likewise, it poses significant development challenges related to flooding, soft soils, proximity to communities, and limited access. As mentioned above, the abundance of dense mangrove forest, in addition to other constructability challenges, renders this site unfavorable for development.

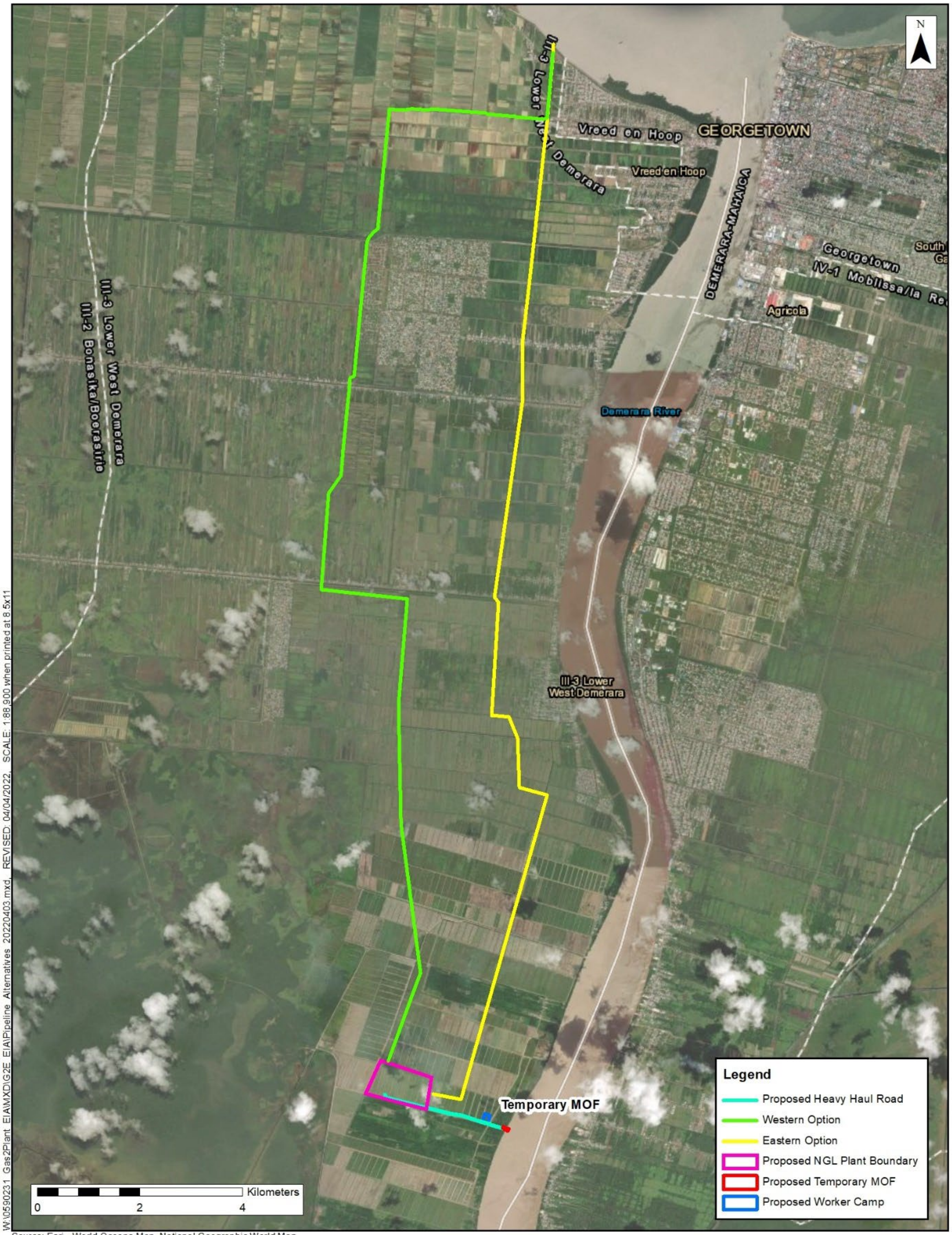
4.2.1.9. Site 20—Ogle

Recent satellite imagery indicates that the site is very similar to the Wales site, although more natural/wild due to the longer period that this site has been abandoned (more than 20 years). The average tree height is expected to be greater than 10 meters. The site is within 2 kilometers of populated areas surrounding the Ogle airport and Georgetown. The East Demerara Water Conservancy, the source of the local water supply, lies just south of the site. Scattered squatter presence appears to occur near the site, and some isolated structures appear to occur on the site. Minimal subsistence farming by squatters may occur on site. This site could use a short onshore pipeline, similar to Site 6.

The Ogle site is expected to be similar to the Wales site in terms of development potential, aside from the considerable constraint of site access, which makes this site less favorable than the Wales site, at least until suitable access is constructed. A new road that is proposed immediately west of this site would improve site access and make it more feasible for development, but the site’s proximity to new developments in Georgetown could produce a degree of community opposition.

4.2.1.10. Conclusion Regarding NGL Plant Location Alternatives

Site 17 on the Wales Estate was identified as the preferred location for the NGL Plant among the sites evaluated above. The Wales Estate is large (approximately 80 square kilometers, see Figure 4.2-2) and the specific site considered above (Site 17) is located at the northern end of the estate, near a large residential community. At a later stage in the NGL Plant site location assessment process, an alternative site within the Wales Estate was identified about 6 kilometers south of Site 17. This alternative site is located in an area of abandoned cane fields with low biodiversity. Compared to Site 17, the proposed location is farther from established neighborhoods (approximately 6 kilometers, versus approximately 0.5 kilometer for Site 17). Although this requires a longer onshore pipeline, the proposed location is preferred over Site 17 for social and health and safety reasons. Further, areas farther south, east, or west of the proposed location have more biodiversity value than the proposed location. Considering feasibility and environmental and social impacts, the preferred alternative for the NGL Plant is the site further east of Site 17, as shown in Figure 4.2-2.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 4.2-2: Proposed NGL Plant Location

4.2.2. Pipeline Corridor Alternatives

The location of the offshore starting point for Project infrastructure is dictated by the location of the existing Liza Phase 1 and Liza Phase 2 FPSOs. Accordingly, there are no feasible alternative starting points. However, there is some flexibility in routing the pipeline corridor. This section discusses the drivers for selecting the pipeline route and the alternatives that were considered.

The following factors were among those used to evaluate potential pipeline routes:

- Total length;
- Width available for RoW;
- Availability of existing RoW(s);
- Pipeline curvature constraints;
- Manmade features or debris;
- Environmentally sensitive locations (e.g., reefs, hard seafloor features, rivers, protected habitats);
- Marine geotechnical challenges (e.g., boulders, sediment waves, steep slopes, canyons, faults, scours, channels, mass transport deposits, and other features that could significantly increase the complexity and risk of pipeline routing, laying, and/or burial;
- Existing marine uses;
- Onshore population density and current land uses;
- Roads, railways, and other infrastructure;
- Onshore geotechnical challenges (e.g., soil and rock characteristics, floodplains, areas of instability); and
- Other constructability considerations.

The proposed route for the offshore segment of the pipeline is approximately 220 kilometers long. This route is reasonably short, minimizes geotechnical and constructability challenges, and does not conflict with existing subsea infrastructure, including cables belonging to GT&T and fiber optic cables belonging to EEPGL. In addition to that, the offshore pipeline follows the same general corridor of the EEPGL Fiber Optic Cable for approximately half of the route to minimize overall footprint and optimize use of the seafloor. The offshore pipeline will initiate at shutdown valves on both the Liza *Destiny* and *Unity* FPSO topsides. From this point, a new riser will be installed, leading to a pipeline end termination (PLET) situated on the seabed near the Liza *Destiny* FPSO (the *Destiny* PLET). The offshore pipeline will be installed from the *Destiny* PLET to a shore landing point with an intra-field pipeline from the Liza *Unity* FPSO tying into the main export pipeline to shore in the vicinity of the *Destiny* FPSO at a location to be further assessed and finalized in future Project phases. The proposed shore landing point is located west of the Demerara River. The preliminary location of this point is approximately 4 kilometers northwest of the mouth of the Demerara River.

4.2.2.1. Onshore Pipeline Corridor

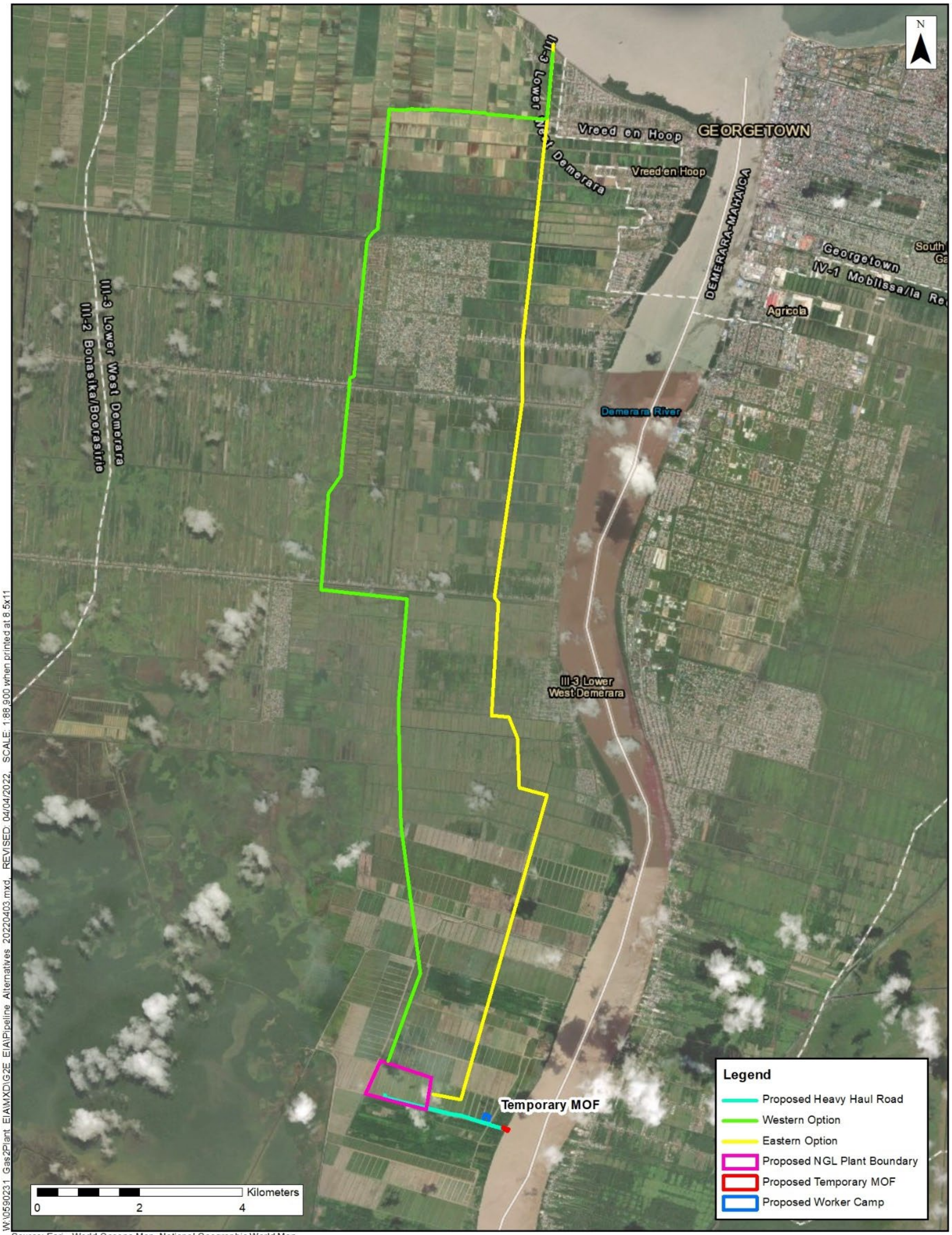
For the onshore portion of the pipeline, EEPGL commissioned studies on engineering/constructability, soils and geotechnical, biodiversity, socioeconomic, land use, and other factors. Field teams assessed the pipeline route options from potential shore landing locations to Vreed-en-Hoop, Wales, and Ogle, and potential road transport routes from GYSBI to Vreed-en-Hoop, Wales, and Ogle. In addition, specialists acquired and reviewed high-resolution satellite imagery of the sites and pipeline routes to supplement the field survey efforts and support desktop analysis of inaccessible portions of the pipeline routes. After considering the findings of these studies, including the selection of a site in the Wales Estate for the NGL Plant location (Section 4.2.1, NGL Plant Location Alternatives), two onshore pipeline routes were considered. The two onshore pipeline route alternatives are shown on Figure 4.2-3.

Western Option—The Western Option would be approximately 27 kilometers long, but uses existing easements under the control of the Government of Guyana along canals and associated access roads. Therefore, this option would affect fewer private landowners.

Eastern Option—The Eastern Option for the onshore pipeline route would be approximately 22 kilometers long, but would affect more private land and require more extensive use of advanced construction methods such as Horizontal Directional Drilling (HDD) (described in Section 4.3.1, Pipeline Construction Alternatives) to cross under canals and existing roads.

Figure 4.2-3 reflects two 200-meter corridors that will allow for future pipeline micro-optimizations during detailed design. The construction RoW width is approximately 23 meters, although it may be narrowed in certain locations to avoid or minimize impacts on sensitive features. The width of the construction RoW was determined based on industry standards for the diameter of pipeline to be installed. The permanent RoW is assumed to be approximately 12 meters in width. These preliminary estimates will be further assessed and finalized in future Project designs.

The preferred route is the Western Option because it allows the predominant use of open-cut construction (see Section 4.3.1, Pipeline Construction Alternatives), reduces impacts on private land, and uses available easements under the government's control along canals and associated access roads.



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Source: Esri - World Oceans Map, National Geographic World Map

Figure 4.2-3: Onshore Pipeline Route Alternatives

4.2.3. Temporary MOF Location Alternatives

The Project includes a temporary MOF to serve as a primary means of transporting construction equipment and materials close to the NGL Plant location. The temporary MOF will consist of a wharf on the west bank of the Demerara River for offloading heavy modules and other imported site construction materials (piles, rebar, etc.). The offloading facility potentially could include a vessel-based crane, an offloading barge with riverside mooring points, and a ramp connection to a riverside laydown area. Dredging and other in-water construction may be required as part of the temporary MOF construction. EEPGL will also continue to leverage existing Guyana marine shorebases, fabrication facilities, warehouses, and storage yards operated by third parties, which could require expansions including additional berths and waste facilities or the siting of new facilities.

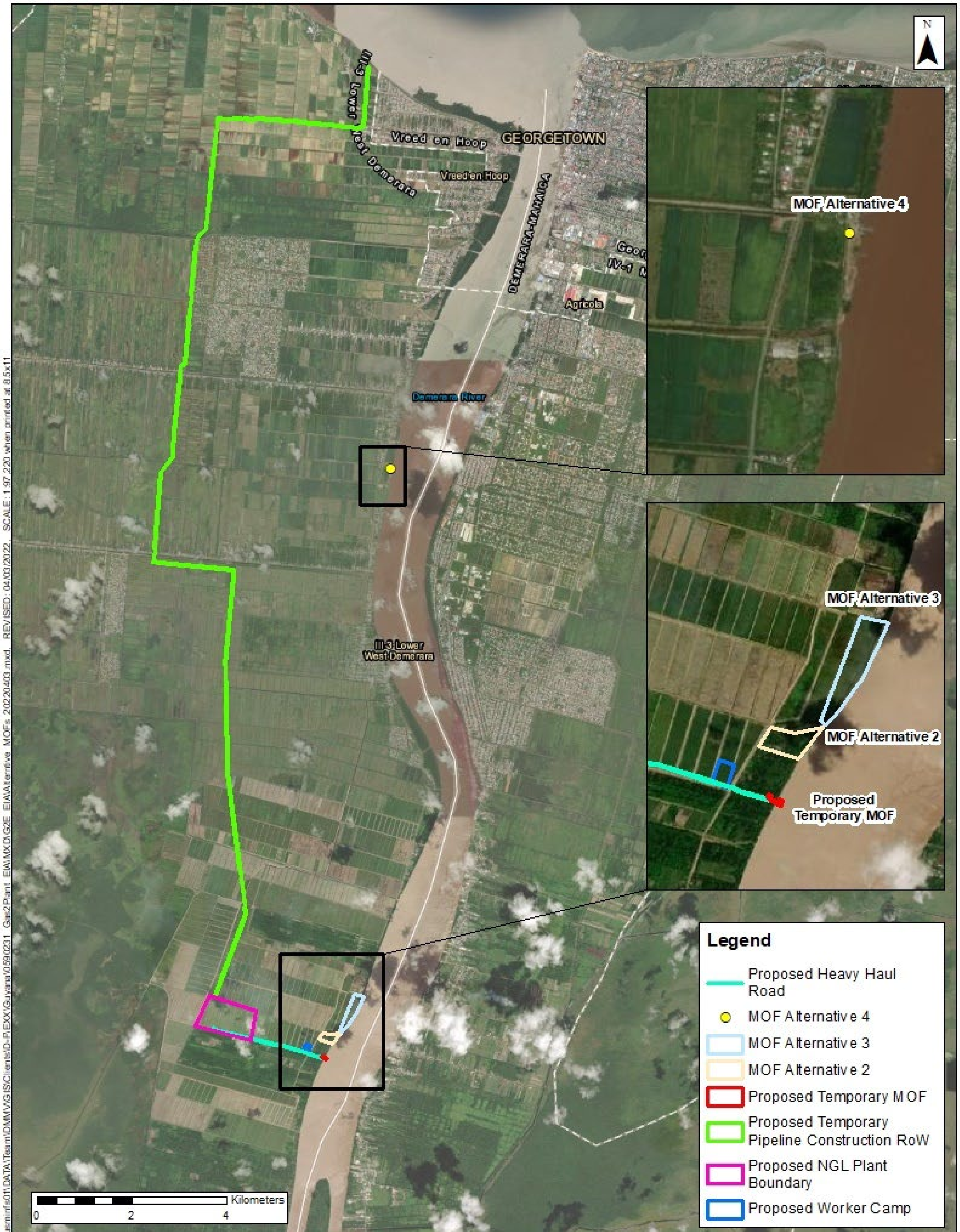
Four temporary MOF location alternatives were considered: three closely situated sites on the west bank of the Demerara River at the Wales Estate, and a separate site downstream of the Wales Estate, but upstream of the Demerara Harbour Bridge (Figure 4.2-4). For the purpose of this alternative evaluation, the sites will be numbered from upstream to downstream.

Site #1 is adjacent to a portion of the Wales Estate, separated only by a dirt/clay road and a canal approximately 5 meters wide. Site #1 includes an occupied residence. This site is very densely vegetated with mid-late successional swamp forest and a narrow band of mangrove forest along the riverbank.

Site #2 is located approximately 220 meters downstream of Site #1 and adjacent to the Wales Estate. Site #2 includes one home that appears to be abandoned. This site exhibits conditions similar to Site #1, although Site #2 exhibits more disturbed, slightly less dense vegetation.

Site #3 is located approximately 30 meters downstream of Site #2 and is separated from Site #2 by a canal approximately 20 meters wide where it reaches the Demerara River. Site #3 is uninhabited and primarily consists of an overgrown sugarcane field. The riverbank exhibits a narrow band of disturbed, young mangrove trees. Just inland of the mangrove trees is early successional grassland/sugarcane/shrub habitat.

Site #4 is located approximately 11.5 kilometers downstream of Site #3 and approximately 3.5 kilometers upstream of the Demerara Harbour Bridge. This site is currently used as a wharf or dock, although modifications may be required to render it usable for the Project. The route from Site #4 to the proposed NGL Plant location following existing roads is approximately 11.9 kilometers. Existing roads and bridges would require substantial improvement in order to allow transit of the large loads of materials for constructing the NGL Plant (see Section 4.1.3, Access Alternatives).



Source: Esri - World Oceans Map, National Geographic World Map

Figure 4.2-4: Temporary MOF Location Alternatives

The criteria used to evaluate the temporary MOF location alternatives are:

- Proximity to the NGL Plant location;
- Minimize impacts on mangroves;
- Minimize physical displacement of persons/homes; and
- Minimize the length of new roads and improvement of existing roads.

Using these criteria, Sites #1, #2, and #3 appear to be viable options. Site #4 would require significant road, bridge, and wharf improvements, which would undermine the purpose and benefits of a temporary MOF (see Section 4.1.3, Access Alternatives). Site #1 is the closest to the NGL site, would require the least existing road improvements, and would require the least environmental impact, so it is the preferred site, although it will require physical resettlement of one household.

4.3. CONSTRUCTION ALTERNATIVES

4.3.1. Pipeline Construction Alternatives

4.3.1.1. Offshore Pipeline Construction Alternatives

Several offshore pipeline construction alternatives were considered as part of the development process. The primary alternatives considered for the offshore pipeline construction include laying on bottom (J-lay, S-lay), trenching and burying, and HDD methods. Installation methods for the offshore pipeline may vary depending on the water depth. In order to meet the needs of the Project and apply industry standard best practices, a combination of installation methods was selected as the preferred alternative for pipeline installation.

J-lay methods are typically employed in deeper water because of the method’s ability to reduce the tension on the suspended pipeline (Herdiyanti 2013). Additionally, the J-lay method allows for increased accuracy when laying the pipeline because the location of the touchdown point is near the vessel. Utilizing the J-lay method also reduces the pipelines exposure to weather conditions and wave motions. Typical disadvantages of the J-lay method can include a slower welding process because J-lay methods do not allow more than one welding and non-destructive testing station on the vessel (Herdiyanti 2013). Additionally, this method cannot be applied in shallow water since the pipe must bend at the seafloor, and shallow depths may cause the pipe to bend too sharply and cause pipeline damage. However, when comparing the advantages, including the Project’s availability of a Dynamic Positioning (DP) vessel, to the disadvantages of the J-lay method, the J-lay method is an attractive installation method for deepwater. Therefore, the preferred alternative for pipeline installation in deepwater (greater than approximately 500 meters water depth) is to use a DP J-lay installation vessel.

At shallower depths (approximately 20 to 30 meters water depth), S-lay methods may be more suitable than J-lay methods. Employing the S-lay method in shallower depths is advantageous because this method has a high production and pipe-laying rate (Herdiyanti 2013). However, the S-lay method is limited to shallower depths and requires additional equipment (i.e., stringers and tensioners) in order to be properly installed (Herdiyanti 2013). Considering the advantages of the S-lay method, it is the preferred installation method for the pipeline in depths between 20 to 30 meters, with a transition from a DP to an anchor-moored, pipeline-laying vessel in the nearshore area.

In some locations in the shallow-water nearshore area, it may be advantageous to lay the pipeline in a trench and bury it for protection purposes. Advantages to burying the pipeline include protection from environmental issues such as wave scouring, severe weather events, and human activities, and also to reduce the potential for fouling of fishing nets. The additional cost and environmental impact of this method can be justified by these advantages. Therefore, starting from the 20-meter bathymetric contour, the preferred alternative for pipeline installation would be to lay the pipeline in a trench and bury the pipeline to greatly reduce the possible impacts on the pipeline if left exposed.

Additional burial requirements beyond the 20-meter bathymetric contour will be further assessed and finalized in future Project phases. For example, multiple trenching techniques are being considered, including suction dredging and jet plowing methods. The trench would generally be naturally backfilled with the same type of excavated soil. In the immediate approach to shore, the Project plans to install the pipeline using HDD, subject to the completion of engineering design. The environmental and social impacts of pipeline installation in the nearshore and shore landing zones would be minimal and similar regardless of the technique used.

Under the preferred alternative, the pipeline will be welded offshore using an installation vessel and then laid on the seabed from the offshore connection point with the FPSOs up to the approximately 20-meter bathymetric contour where the “nearshore area” begins. In the nearshore area, a trench would be excavated and the pipeline will be laid in the trench, which will then be backfilled. In the last few kilometers near shore, the pipeline may be installed using HDD. If the HDD method is used, drilling fluids would be used in order to lubricate the drilling tools and maintain the borehole while drilling. Drilling fluids are formulated using seawater and typically a mixture of barite, clay, and other chemical additives (Energy API 2019).

Prior to commencing operations, the pipeline will be subjected to a pre-commissioning process including hydrostatic testing (hydrotesting) to confirm its integrity. Based on the location of the FSPO and availability of water, two feasible alternatives for source water were determined. Hydrotesting water could be drawn from the ocean (seawater) or alternatively from the Demerara River (freshwater). If hydrotesting water is sourced from the Demerara River, the physical and chemical characteristics of the water, including the high amount of suspended sediment, may require additional treatment to render the water suitable for use in hydrotesting. If seawater is used for hydrotesting, it would likely be treated with oxygen scavengers, corrosion inhibitors, biocides, and/or dyes to prevent internal pipeline corrosion and prevent biofouling. If the water were to be left untreated, it could degrade the integrity of the pipeline.

Water should be sourced from a waterbody where withdrawals would not exceed 10 percent of the flow or volume of the water source and would not adversely affect the water level or flow rate the waterbody. A high-quality source of water is preferred in order to minimize the need for biocides. The preferred alternative for hydrotesting source water is the Demerara River.

After the completion of the testing, the hydrostatic test water will be discharged in accordance with best management practices and applicable regulatory requirements at either an offshore deepwater location near the seafloor (the primary option) or at a combination of a deepwater location and the Demerara River. Other discharge alternatives such as discharging to the Demerara River, to canals, or on land would have additional environmental impacts. For example, the ability of a canal or the Demerara River to dilute the discharge would be much less than in the sea. There is currently no onshore wastewater treatment facility available in Guyana as an alternative to direct discharge of hydrostatic test water. Under the preferred alternative, the discharge would be a single short-term event, and the discharged water would be quickly diluted within the water column. See Section 7.4, Water Quality, for an evaluation of potential impacts on water quality from the discharge of hydrotest water.

4.3.1.2. Onshore Pipeline Construction Alternatives

Two alternative construction methods, open-cut trenching and HDD, were considered for the installation of the pipeline below ground from the shore landing point to the NGL Plant site. Whereas open trenching involves excavation of a trench, installation of the pipeline, and burying the pipeline using the excavated material, HDD involves drilling a horizontal or curved borehole from an entry pit to an exit pit and then pulling a pipe segment through the borehole, thus avoiding impacts at the land surface by passing under sensitive areas. For sections that will be constructed with open-cut methods, a trench will be excavated in segments along the RoW. Depending on the height of the water table, construction activities in the trench may require dewatering using pumps. Pipeline segments will be strung and welded alongside the excavated trench. These welded segments will then be lowered in the trench for final tie-in welding. HDD portions will be constructed by first drilling a directional bore from an entry to a target exit point using drilling fluids. Drilling fluids for this process will be similar to drilling fluids described in Section 4.3.1.1, Offshore Pipeline Construction Alternatives. The pipeline will then be welded from one side of the bore and pulled from the other using a pulling head and a winch. The HDD method is particularly likely to be used for road and water crossings to avoid impacts on those features. In order to meet the needs of the Project, a combination of conventional open-cut construction techniques and HDD was selected as the preferred alternative.

The preferred onshore pipeline route (see Section 4.2.2, Pipeline Corridor Alternatives) allows the predominant use of open-cut construction methods by leveraging available easements under the state's control along canals and associated access roads. Utilizing open-cut methods in these sections allows for a cost-effective installation of the pipeline and ease of restoration once the trench has been backfilled. However, open-cut methods typically occupy a large site footprint and may cause damage in environmentally sensitive areas. In order to avoid the negative impacts associated with open-cut methods, HDD methods will be used in environmentally sensitive areas or areas where open-cut construction would be difficult (i.e., road crossings). Because HDD is a minimally invasive construction technique that does not require trenching, HDD would greatly reduce environmental impact within the Project footprint (Energy API 2019). However, the risks associated with HDD, such as inadvertent fluid returns or borehole collapse, increase with the length of the borehole. In order to minimize negative impacts associated with the construction alternatives, the preferred alternative uses a combination of both open-cut trenching and HDD methods.

Pre-commissioning will include activities similar to those described in Section 4.3.1.1, Offshore Pipeline Construction Alternatives, for the offshore pipeline. Pre-commissioning of the offshore and onshore sections may be done concurrently or in separate stages, depending on design and execution considerations to be further assessed.

4.3.2. MOF Construction Alternatives

In order to accommodate the offloading of heavy modules and other imported materials and equipment, two alternatives were considered for the construction of a MOF. Under these two alternatives, the MOF could be constructed as either a permanent or temporary facility.

Considering that the purpose of the MOF is for offloading construction equipment and materials, the MOF will be operated primarily during the construction phase of the Project. Once the construction of the NGL Plant is completed, the MOF could be removed.

A permanent MOF could serve the Project for future or unforeseen material offloading activities; however, there are currently no Project plans that would require a permanent facility. Additionally, a temporary MOF would reduce the duration of impacts associated with this facility by allowing remediation efforts to take place once the MOF is removed. Therefore, the preferred alternative uses a temporary MOF.

Although the MOF design is still in development, the facility potentially could include a vessel-based crane, an offloading barge with riverside mooring points, and a ramp connection to a riverside laydown area. The main dock or quay may be constructed as a floating structure or a fixed structure. Fixed docks are built on pile-based platforms or concrete foundations located directly on the riverbed, while floating docks sit on the water’s surface and are installed using anchoring systems or by attaching the dock to existing structures. Both designs would allow docking and unloading of ships for delivery to onshore facilities. Floating docks are advantageous where water levels fluctuate. However, fixed docks have the ability to withstand wakes created by frequent boat traffic and are best built in areas with shallow water. A floating dock would have an easier removal process during decommissioning and reclamation of the MOF as compared to a fixed dock. However, the lower stability of a floating dock may cause problems when offloading heavy equipment and materials. Based on current conditions at the proposed MOF site, the floating dock is the preferred alternative.

For any dredged material that could result from the construction process, the material could be disposed of offshore (i.e., the ocean), in a portion of the Demerara River, or onshore in a dredge material disposal facility. Dredged material may contain contaminants that make it unsuitable for disposal within a waterbody such as the Demerara River or the ocean. If dredged material is determined to be suitable for disposal within the ocean, it can only be disposed of at pre-determined sites chosen by the Maritime Administration Department (MARAD 1996). If dredged material contains high levels of environmental contaminants and is not suitable for disposal within the ocean, the material would be disposed of within an engineered dredge material disposal site, as determined by the EPA. Further analysis of existing conditions at the proposed temporary MOF site will determine which dredged material disposal alternatives are appropriate.

4.3.3. NGL Plant Construction Alternatives

Two feasible alternatives were considered for the NGL Plant construction. The first alternative is modular construction, a process of constructing equipment packages off site for later assembly at the NGL Plant site. Skid-mounted equipment packages (modules) will be fabricated outside Guyana and offloaded at a riverside offloading facility. The modules will subsequently be transported on land to the final site location where they will be installed on previously constructed foundations. This process benefits the construction timeline by allowing multiple components to be assembled simultaneously in an off-site factory. Additionally, this alternative saves space within the NGL Plant site by bringing in completed equipment packages rather than storing all construction materials and additional equipment on site.

The second alternative considered was on-site construction, or “stick build,” meaning the NGL Plant would be built on site from more standard construction materials. This process would involve delivering equipment to the NGL Plant site, storing materials on site, and constructing the NGL Plant on site. This alternative has several disadvantages when compared to the modular build alternative. The stick build alternative would be constrained due to the location and size of the site, and storing materials while simultaneously building the NGL Plant could require additional workspace. Additionally, due to the geographic location of the site, the availability of skilled workers may be limited (Whitfield 2016). When considering the advantages and disadvantages of the alternatives, the modular build alternative is highly desirable for the Project.

Under the modular construction alternative, the site would require earthworks including clearing, cutting, filling, and soil improvement and site preparation, such as piling. Temporary construction facilities such as temporary office spaces, eating areas, bathrooms, and rest areas will also be constructed. In comparison to the stick build alternative, the modular construction alternative greatly reduces the amount of site clearing and preparation needed. The stick build alternative requires a laydown area of approximately 100 acres to accommodate materials storage and construction tools and equipment. Under the modular construction alternative, the majority of Project infrastructure would be built off site, thus reducing the number of temporary structures, facilities, and storage areas required when compared to the stick build alternative.

The preferred alternative includes a combination of modular construction and stick build approaches. Modular construction will be used as the primary approach wherever possible, but some stick build construction will be necessary for certain portions of the NGL Plant. This combination of approaches will minimize the size of the necessary workspace and the environmental and social impacts associated with NGL Plant construction.

4.4. Operations/Process/Technology Alternatives

4.4.1. Introduction

EEPGL is using the most appropriate industry-proven technologies for developing the Project, in terms of drilling fluids, equipment selection, development concepts, and environmental management. EEPGL's ultimate parent company, Exxon Mobil Corporation, and its contractors have extensive experience in delivering pipeline and refinery projects around the world, and EEPGL is applying that knowledge, experience, and technology in the development of this Project. EEPGL has also considered experiences in design, construction, and operation of its other development projects in Guyana and applied learnings to technology choices for the Project.

There are no substantive operations/process/technology alternatives with regard to the pipeline(s) or the temporary MOF. The pipeline will be operated within design parameters to be determined at a later stage, dependent on the gas production of the Liza *Destiny* and *Unity* FPSOs. Considering that the purpose of the temporary MOF is for offloading equipment and construction materials, the MOF will be operated primarily during the construction phase of the Project and may be removed upon completion of NGL Plant construction.

Operations/process/technology alternatives are under consideration for NGL Plant operations, specifically with regard to potable and utility water systems, flaring technology, water discharge control, noise control, and waste management.

4.4.2. NGL Plant Operations

4.4.2.1. Water System

The NGL Plant requires water for a variety of potable and utility purposes. Three options were evaluated:

- Option 1—Connect to the public water system. The public water system is not located within a reasonable distance of the proposed NGL Plant, so this was not considered a viable option
- Option 2—Truck water to the NGL Plant. This would require the use of water tanker trucks to haul water to the NGL Plant site. This could be a reasonable alternative for Project operations given the relatively small number of employees (i.e., approximately 40), but would be very difficult to meet construction phase demands given existing road conditions. Trucking would result in an increase in truck traffic along the West Bank Road and adjoining residential areas to provide water for the much larger construction workforce (i.e., approximately 300 workers).
- Option 3—Develop onsite groundwater wells. This option would also require the development of a water treatment system at the site. This option would provide a more reliable source of water, at least for meeting Project utility water demands.

Option 3 is considered the preferred alternative for meeting the Project's utility water demand. Depending on the quality of groundwater and the extent of water treatment required, Project potable water demand may be met by trucking commercially available water (e.g., 20-liter water bottles).

4.4.2.2. Flaring Technology

The facility will be provided with flare systems to safely combust excess gas during start-up, commissioning, emergencies, upset conditions, and depressurization for maintenance, inspection, and troubleshooting. Flaring in normal operation will be minimized. Two flare systems are currently anticipated to be needed for the facility: one wet flare system (for streams containing water) and one cold flare system (for remaining streams). Pilot gas will be supplied by the natural gas processed at the facility. Both elevated and enclosed ground flare technologies are being considered. An elevated flare would have a visible open flame that generates heat and some noise. An enclosed ground flare would not emit noticeable light, heat, or noise beyond the confines of the enclosure, but the exhaust gases would be released close to the ground. An enclosed ground flare was selected to avoid a visible flame and any community impact.

4.4.2.3. Water Discharge Control Technology

The original basis for water discharge control was to truck out all wastewater at the NGL Plant. However, due to the frequency of heavy rainfall and trucking operational challenges at the location of the NGL Plant, this is not feasible. Instead, the facility will include wastewater treatment facilities to handle both oily water collected from process operations as well as stormwater collected from curbed areas of the NGL Plant. The system will remove contaminants from wastewater to meet regulatory discharge limits. Expected components of the facilities include oil separation facilities, flocculants injection system, clarifier, and nutshell filter or dissolved air filtration package. The treated water from the wastewater treatment facilities will be routed to a stormwater pond, analyzed, and discharged to surface water.

A sanitary sewage system will also be provided. No municipal sewer system is available nearby, so onsite sewage treatment is required. The alternatives considered were aseptic system with leach field and an aboveground modular sewage treatment plant. Given the high water table at the site, a septic system with leach field was not considered technically feasible. Therefore, the modular sewage treatment plant was selected.

4.5. NO PROJECT ALTERNATIVE

The "no Project" alternative means that the Project would not be executed. In this scenario, Guyana would continue to obtain electric power in the manner it currently does (i.e., mostly from thermoelectric generation fueled by imported heavy fuel oil / diesel fuel).

4.5.1. Project Impacts

The Project, if implemented, would likely have both positive and negative impacts on physical resources, biological resources, and socioeconomic resources, which are detailed in Chapters 7, 8, and 9, respectively. The potential impacts could be directly and/or indirectly generated by the Project during construction, operations, and/or decommissioning, including air emissions, water discharges, waste generation, disturbance of natural habitat and cultural sites, physical resettlement, and economic displacement (see Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources for additional details). The potential for cumulative impacts exists where impacts from the Project overlap with impacts from other activities affecting the same resources, including EEPGL's other ongoing or reasonably foreseeable activities and other reasonably foreseeable third-party activities, including the Power Plant that will be supplied gas by the Project. As such, a cumulative impact assessment is included in Chapter 11. The Project, however, is generally anticipated to reduce GHG emissions associated with power generation and have a positive impact on the economy of Guyana as a result of more affordable and reliable electricity, as well as increased local employment and procurement opportunities. Potential adverse impacts may include potential short-term increases in the cost of living as a result of increased demand for certain goods and services. Potential adverse impacts on income from agriculture and fisheries could also occur as a result of presence of Project working spreads during installation and construction, or as a result of permanent land use/access changes.

4.5.2. No Project Impacts

If the No Project alternative is selected, the existing conditions described in Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, would remain unaffected by the Project and the potential positive and negative impacts assessed in these chapters would not be realized.

It is reasonable to expect that some environmental and socioeconomic conditions would likely change over time in the absence of the Project. In particular, without the Project's generation of electric power, the associated potential for benefits to physical, biological, and socioeconomic resources would be reduced. The Government of Guyana would also not be able to take advantage of the Project to fulfill its objectives to create more job opportunities, address poverty, reduce GHG emissions associated with power generation, and improve the overall quality of life (IDB 2017; Government of Guyana 2021a).

Opportunities to boost economic growth through increased availability of electric power would be reduced. Additional impacts on the economy if the Project were not enacted would likely include a reduction, relative to implementing the Project, in demand for goods and services from

Guyanese businesses and employment opportunities for Guyanese nationals who would have benefited from the Project. The absence of the Project would also eliminate associated induced economic benefits resulting from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefit other non-Project-related businesses and generate more local tax for the government.

While a No Project alternative would decrease opportunities for the country to grow its economy and diversify production and trade, it would also avoid the potential negative impacts of the Project. Therefore, evaluating the No Project alternative means evaluating the tradeoff between positive and negative impacts.

4.5.3. Comparison of Project and No Project Impacts

The Project would provide a reliable source of fuel for the Government of Guyana's planned gas-fired Power Plant. This fuel also results in less air emissions per unit of electric power and is less carbon-intensive than fuel sources currently in use. Thus, the Project would support Guyana's Low Carbon Development Strategy. The Project would have a positive impact on the economy of Guyana by contributing to the provision of more affordable and reliable electricity, as well as increased local employment and procurement opportunities. However, there would also be temporary and permanent impacts in the immediate vicinity of the offshore and onshore pipelines, the NGL Plant, and the temporary MOF.

Under the No Project alternative, the positive and negative impacts of the Project would not occur.

4.6. Summary of Alternatives

EEPGL and the Government of Guyana considered a range of alternatives for the various aspects of the Project, along with the potential environmental and socioeconomic impacts associated with these alternatives. The preferred alternatives, which comprise the Project Description (Chapter 5), reflect EEPGL's identification of the preferred alternatives from the standpoint of environmental performance and technical and economic feasibility. This selection is supported by the fact that a pipeline and NGL Plant system is a proven development concept for gas purification and downstream electric power generation and it would leverage both operator- and industry-proven technologies and experience.

5. PROJECT DESCRIPTION

The Project will use an offshore resource (associated natural gas) produced from the Liza field in the Stabroek Block. The plan for each of EEPGL's EPA-approved Floating Production, Storage, and Offloading (FPSO) facilities in Guyana has been to re-inject this gas into the underground oil formations to maintain reservoir pressures and enhance oil recovery. The Government of Guyana is pursuing a separate project to construct a power plant (the Power Plant) that would use a portion of this associated natural gas as a fuel source.

Accordingly, EEPGL, at the request of the Government of Guyana, is proposing the Project to provide fuel for the Power Plant. The Project will involve capturing associated gas produced from crude oil production operations on the Destiny and Unity FPSOs, transporting approximately 50 million standard cubic feet per day (MMscfd; 1.4 million standard cubic meters per day [MMsm^3/d]) of rich gas via a subsea pipeline and then an onshore pipeline to a natural gas liquids (NGL) processing plant (NGL Plant), treating the gas to remove NGLs for sale to third parties, and ultimately delivering dry gas meeting government specifications for use at the Power Plant.

The Power Plant will not be owned and operated by EEPGL and is being proposed by a separate proponent under a separate Environmental Authorisation process. The Power Plant thus is not included in the Project decribed in this chapter or assessed in the other sections of the EIA (with the exception that the Power Plant is considered as part of the cumulative impact assessment in Chapter 11, Cumulative Impacts).

Also separate from the Project's Environmental Authorisation process, the EPA has issued a no-objection letter authorizing selected early works activities that will support the proposed construction activities for the Project (EPA 2021). The approved early works relate primarily to the upgrading, rehabilitation, and repair of approximately six bridges and approximately 11 kilometers of roads along the West Bank Road from the village of Patentia south toward the NGL processing plant (NGL Plant) site to provide improved access to the site. The early works activities will also include the establishment of an approximately 5-hectare laydown area to stockpile aggregate, which is needed for site preparation and early works road improvements. The preferred location for this laydown area is near the temporary material offloading facility (MOF) proposed as part of the Project, but the final location will be determined by access conditions. All road and bridge improvements are expected to generally remain within the existing road right-of-way (RoW). These early works activities are essentially maintenance of existing facilities and are described here simply to present a full description of other activities that will be conducted to support the proposed Project-related activities. In addition to supporting the needs of the Project, these improvements are expected to result in improved vehicular access and enhanced safety for residents in this area, who currently only have dry-season vehicular access in some areas because of poor existing road conditions. Since these early works activities are subject to a separate EPA approval—and will not result in any significant adverse environmental or social impacts, they are not included in the Project decribed in this chapter or assessed in the other sections of the EIA (with the exception that they are considered as part of the cumulative impact assessment in Chapter 11, Cumulative Impacts).

As part of the onshore pipeline route selection process, EEPGL has been working with the Government of Guyana to finalize the onshore pipeline corridor proposed in this EIA.

The remainder of this chapter describes the following elements of the Project:

- Project Location and Land Requirements (Section 5.1)
- Project Workforce (Section 5.2)
- Project Components (Section 5.3)
- Project Stages (Section 5.4)
  - Construction Stage (Section 5.4.1)
  - Operations Stage (Section 5.4.2)
  - Decommissioning Stage (Section 5.4.3)
- EEPGL Quality Control Process Overview (Section 5.4.4)
- Project Equipment, Materials, Emissions, Discharges, Wastes, Noise, and Traffic (Section 5.5)
- Proposed Best Available Technology and Embedded Controls (Section 5.6)

5.1. PROJECT LOCATION AND LAND REQUIREMENTS

This section describes the proposed Project location and land requirements.

5.1.1. Project Location

The proposed Project facilities will be comprised of the following primary components, located as follows (Figure 5.1-1):

- Offshore pipeline—an offshore component that involves approximately 220 kilometers of a subsea pipeline extending from new subsea tie-ins at the Destiny and Unity FPSOs in the Stabroek Block to a proposed shore landing, located approximately 3.5 kilometers west of the mouth of the Demerara River.
- Onshore pipeline—an onshore pipeline, which is a continuation of the offshore pipeline, that extends linearly approximately 25 kilometers from the shore landing to a proposed Natural Gas and Natural Gas Liquids (NGL) Processing Plant (NGL Plant). The onshore pipeline corridor extends south from the shore landing, crosses a road and a pair of canals, and continues south through agricultural fields. The corridor then turns west and crosses the West Demerara Highway west of the Vreed-en-Hoop urban area and proceeds west for approximately 3.1 kilometers to a point west of the housing development of Onderneeming. From this point, the corridor proceeds generally south through agricultural fields and west of the housing developments of Onderneeming, Westminster, and La Parfaite Harmonie for approximately 5.8 kilometers, and crosses Canal 1 through an area of residences. The

corridor then follows agricultural fields for approximately 3.9 kilometers and crosses a smaller canal. The corridor then crosses Canal 2 through an area with residences along Canal 2 and turns east. Next, the corridor follows Canal 2 east for 1.7 kilometers. From this point, the corridor heads south for 7.4 kilometers and then southwest for 1.8 kilometers to the NGL Plant site.

- NGL Plant—the NGL Plant and associated infrastructure (e.g., heavy haul road, temporary MOF, and worker camp) located approximately 23 kilometers upstream from the mouth of the Demerara River on the west bank.

All of these facilities are located within Region 3 of Guyana. Some existing facilities within Region 4 (e.g., shorebases, heliport, roads) will also be used to support Project activities, principally related to transporting equipment, supplies, products, and workers to and from the Georgetown area to the above locations of the Project components.

These various Project components are located in proximity to other planned and proposed projects. These other projects and their locations are described in more detail in Chapter 11, Cumulative Impacts.

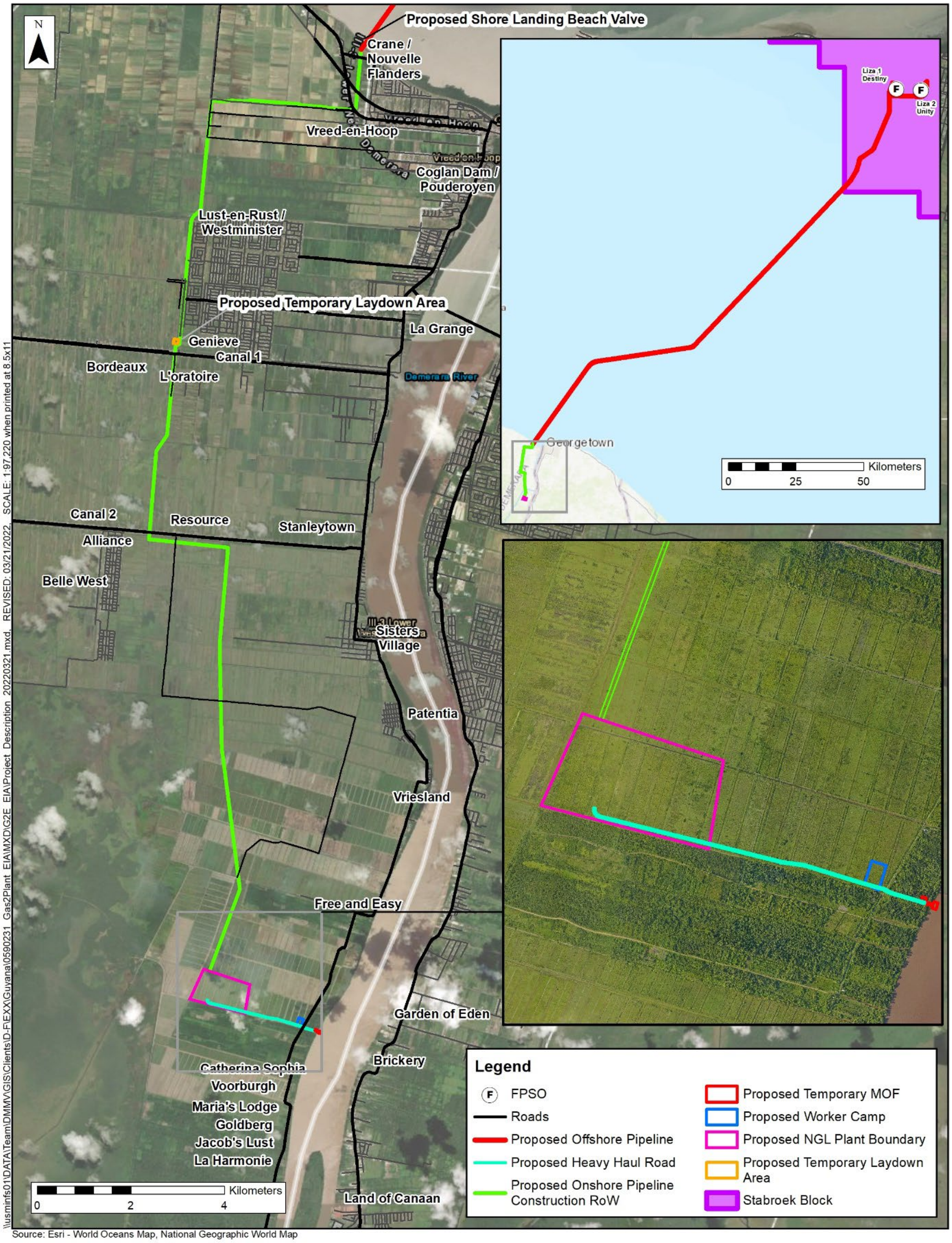
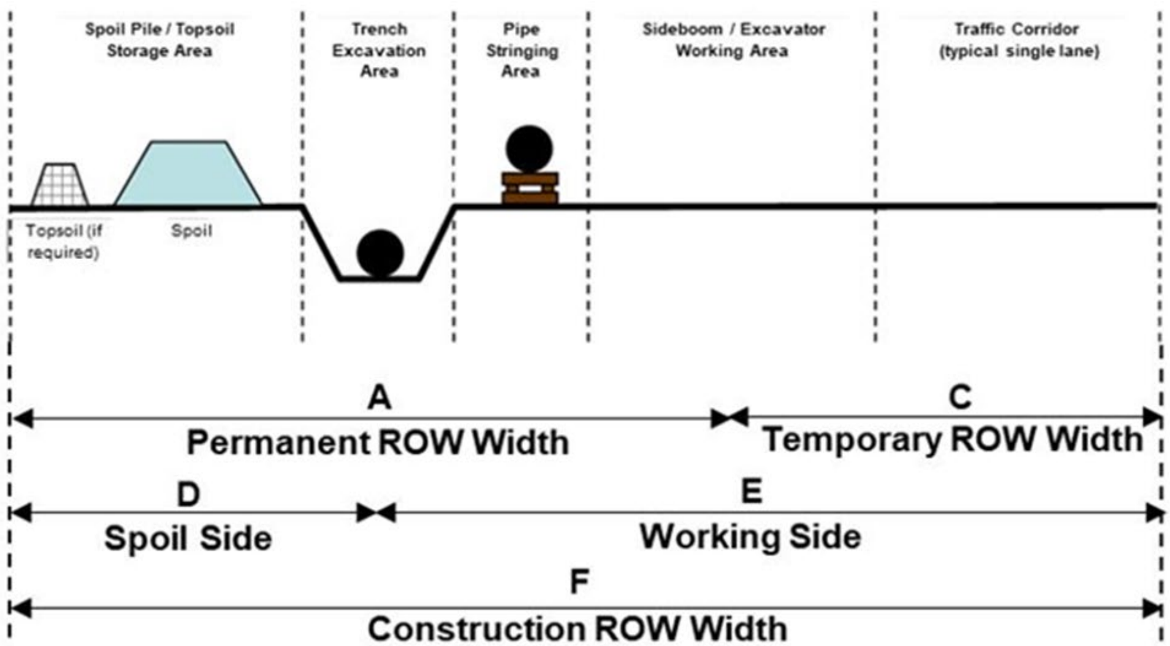


Figure 5.1-1: Project Location

5.1.2. Project Land Requirements and Use

Table 5.1-1 shows the Project's estimated onshore land area required for construction and operations. The onshore pipeline will require an approximately 23-meter-wide temporary construction RoW, which will be expanded in certain designated areas—primarily to accommodate the additional area needed for horizontal directional drilling (HDD) of the pipeline beneath some features such as roads and canals. Typically, HDD entry and exit locations each require an area of 50 meters by 100 meters (see Section 5.3.3, Onshore Pipeline, for more details). The onshore pipeline permanent operational RoW will be approximately 12 meters wide (Figure 5.1-2).

There is no designated RoW for the offshore pipeline. The area of disturbance for the offshore pipeline installation will be a function of the equipment selected to install the pipeline in the portions of the offshore pipeline where the pipeline will be buried. For the purpose of the EIA, it is envisioned that the width of the offshore pipeline trench will be on the order of 3 to 4 meters at the top of the trench.



A	C	D	E	F
12.2m	10.7m	6.1m	16.8m	22.9m

Figure 5.1-2: Notional Temporary and Permanent Onshore Pipeline Rights-of-Way

As Table 5.1-1 indicates, several of the Project features that will involve land use / disturbance are temporary and will only be used during construction, including the portion of the temporary onshore pipeline construction RoW outside of the permanent RoW, as well as temporary laydown areas and HDD work areas along the onshore pipeline corridor, the worker camp, and the temporary MOF.

Table 5.1-1: Estimated Project Onshore Land Requirements

Project Component	Temporary (Construction Stage) (hectares)	Permanent (Operations Stage) (hectares)
NGL Plant	75.0	75.0
Onshore Pipeline [a]	57.9	24.3
Heavy Haul Road	1.6	1.3
Temporary MOF	0.2	—
Worker Camp	1.9	—-
Onshore Pipeline Temporary Laydown Area	1.0	—
Total [b]	137.5	100.6

[a] Temporary area includes construction RoW (23 meters) and HDD areas in the RoW.
[b] Totals may not match sum of components due to rounding for each component.

Figure 5.1-3 shows the land cover types that will be disturbed by Project construction. As the data show, approximately half of the Project land disturbance, including the majority of the NGL Plant site, is currently shrubland/swamp. The NGL Plant site, as well as most of the onshore pipeline RoW, is land that was formerly used for sugarcane cultivation by the Guyana Sugar Corporation (GuySuCo), a state-owned corporation. GuySuCo has stopped its sugarcane operation within the area, and much of the land now supports various pioneer plant species, which are generally 1 to 4 meters in height.

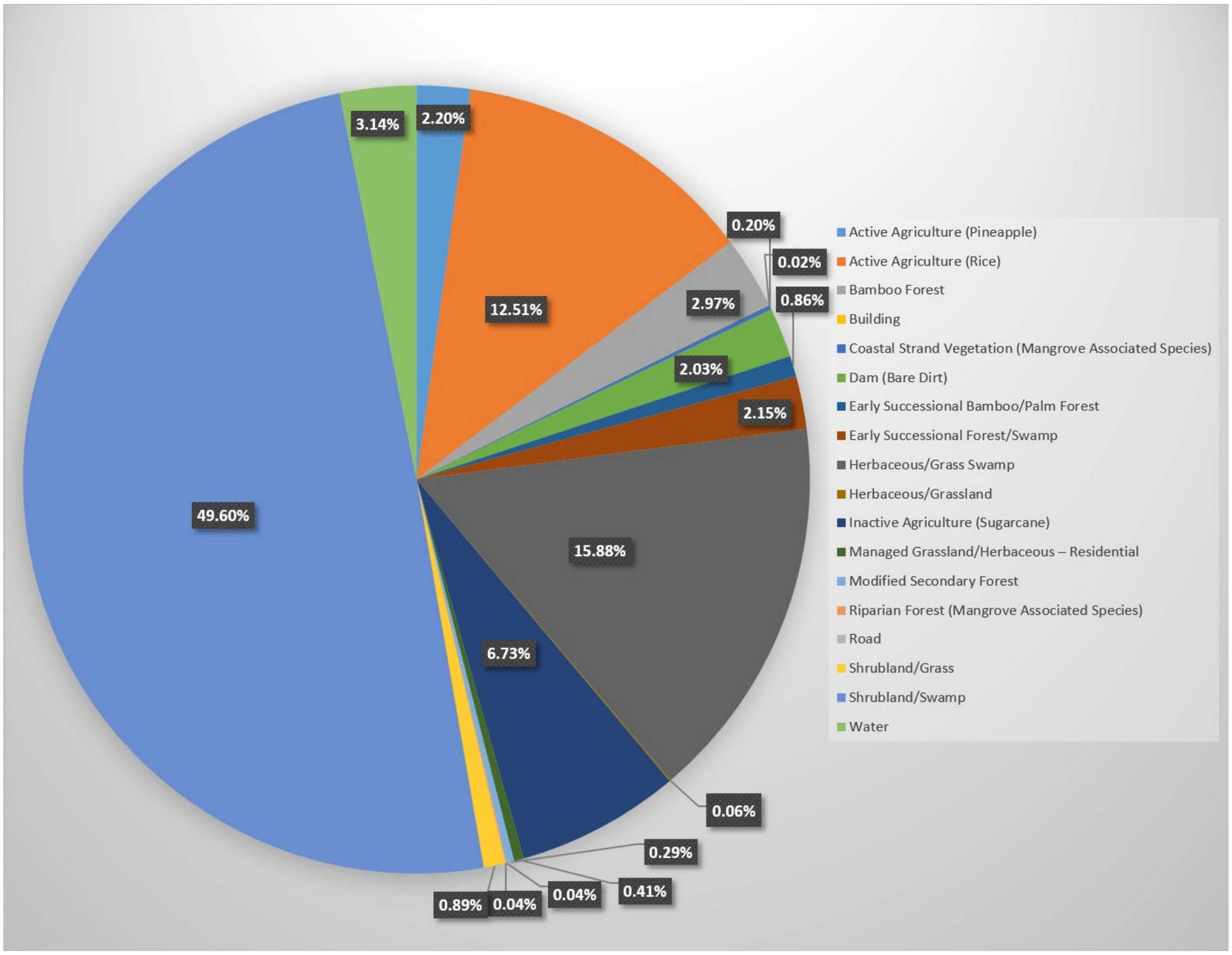


Figure 5.1-3: Project Onshore Existing Land Cover

The onshore pipeline corridor traverses primarily active and inactive agricultural lands and herbaceous/grass swamp. Although the onshore pipeline route selection process was conducted to reduce routing through existing communities, the pipeline route is in proximity to several communities, as identified below in Table 5.1-2 and shown on Figure 5.1-1. There are no known residences within the NGL Plant site, but there is some subsistence sugarcane farming and cattle rearing occurring on and/or near the NGL Plant site.

Table 5.1-2: Communities Located near the Onshore Pipeline Route

Community Name	Approximate Distance from Proposed Pipeline Route to Nearest Community Residence
Crane	0 meters
Vreed-en-Hoop	200 meters
Onderneeming / Westminster/ La Parfaite Harmonie/ Lust-en-Rust	25 meters
Canal 1 Village (Bordeaux)	0 meter
Canal 2 Village (Resource / Alliance)	0 meter
Belle West Housing Scheme, Nismes	510 meters
Free and Easy	2,400 meters

5.2. Project Workforce

The Project will employ up to 800 workers at peak during the Construction stage and approximately 40 full-time equivalent (FTE) workers during the Operations stage. The preliminary workforce estimates are characterized below in terms of Project stages, components, and domestic versus foreign. In addition to dedicated workers, a comparatively smaller number of non-dedicated personnel will provide shorebase and logistical support to the Project, as well as other ongoing projects. The workforce will be expected to ramp up gradually through the mobilization for the Construction stage until reaching a peak during construction activities, and then diminishing to a steady state during the Operations stage. The workforce is expected to increase again briefly during the Decommissioning stage.

Workforce by Project Stage

- Construction—varies by schedule of activities from approximately 25 workers to a peak of approximately 800 workers
- Operations—approximately 40 FTE workers
- Decommissioning—approximately 50 workers at peak

Construction Workforce by Project Component

- Offshore Pipeline Construction—approximately 300 workers at peak
- Onshore Pipeline Construction—approximately 100 workers at peak
- NGL Plant Construction—approximately 400 workers at peak

Anticipated Worker Composition

The anticipated workforce will be targeted at approximately 50 to 75 percent Guyanese for the onshore component of the Construction stage. The offshore component of the Construction stage will have a lower percentage of Guyanese (approximately 5 percent), as this component will require a specialty contractor with its own crew. During the Operations stage, the percentage of Guyanese will increase over time as Guyanese workers are trained and can assume more responsibilities.

EEPGL has prepared a preliminary early version of a Local Content Plan, which focuses on three key strategies:

- Workforce development—hiring personnel and equipping them with the technical and professional skills they need to support existing and future operations, as well as the broader economy;
- Supplier development—investing time, people, and resources to develop local companies to form a competitive industrial base and provider of local goods and services;
- Strategic community investments—supporting education and infrastructure initiatives and programs that contribute to the development of local capabilities while improving the socio-economic environment.

The Local Content Plan will be updated as the Project progresses, in alignment with the 2021 Local Content Act, and will be reflected in EEPGL's submittals to the Government of Guyana, as required pursuant to the 2021 Local Content Act. EEPGL will support the objectives of the Local Content Plan by requiring the primary contractors for the Project to optimize use of local content, including training of local providers and use and development of local suppliers during the Project's Construction and Operations stages. Each primary contractor will be required to prepare its own Local Content Plan, including staffing outlooks, anticipated positions, and forecasted training and other capacity building.

5.3. PROJECT COMPONENTS

The primary components of the Project include new connections to the existing Destiny and Unity FPSOs, an offshore pipeline, an onshore pipeline, an NGL Plant, and various ancillary facilities. These ancillary facilities include a temporary worker camp, a temporary MOF, and a heavy haul road. The Project will use existing third-party support facilities such as shorebases, fabrication facilities, fuel supply facilities, and waste management facilities. The Project will also use ground-based vehicles, marine and riverine vessels, and helicopters to provide logistics support throughout all Project stages. This section discusses these components, as well as certain existing third-party facilities that are not part of the Project, but will be used by the Project.

5.3.1. New Connections to FPSOs

The existing Destiny and Unity FPSOs have pre-installed facilities to allow for gas export. These export facilities include the required piping, equipment (e.g., drains, pig launcher, associated instrumentation), and flow control elements (e.g., orifice flowmeter, flow control valves, associated control instrumentation) to support the Project. The FPSO balconies have open slots allocated to a potential gas export riser and a potential subsea control umbilical. The existing FPSO gas export facilities have been designed to meet the specifications in Table 5.3-1.

Table 5.3-1: Existing Destiny and Unity FPSO Gas Export Riser Specifications

Parameter	Limitations
Operating pressure at top of riser	131 to 196.5 barg (1,900 to 2,850 psig)
Maximum temperature at top of riser	65.6 °C
Destiny FPSO flow rate	10 to 145 MMscfd [a] (0.28 to 4.1 MMsm^3/d)
Unity FPSO flow rate	10 to 152 MMscfd [a] (0.28 to 4.3 MMsm^3/d)

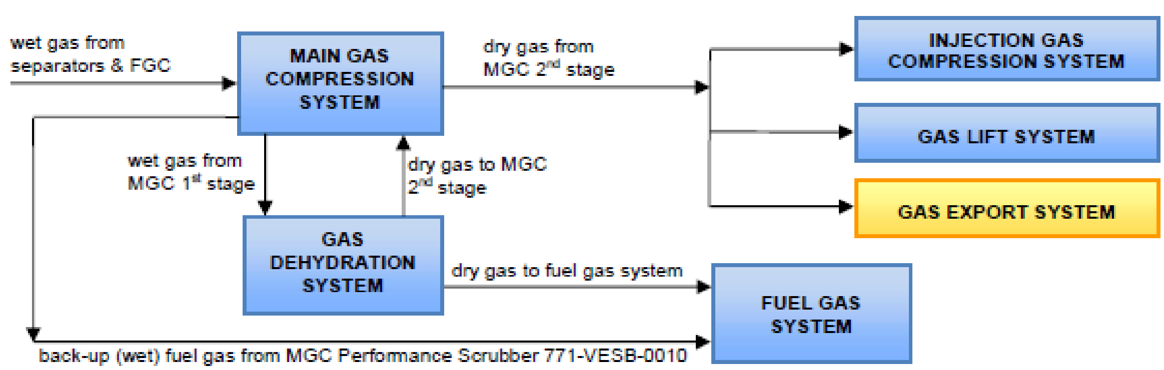
°C = degrees Celsius; barg = bars-gauge; psig = pounds per square inch-gauge
[a] The gas export facilities are sized for up to 145 to 152 MMscfd (4.1 to 4.3 MMsm^3/d), but the gas export control valves can control the flowrate to as little as 10 MMscfd (0.28 MMsm^3/d).

Based on reservoir studies, the export gas is expected to contain no more than 1 pound of water per million standard cubic feet (16 kilograms per million standard cubic meters) and less than 80 parts per million of hydrogen sulfide (H_2S). The gas export facilities are designed to accommodate these expected conditions.

Each FPSO will have the capability of exporting the full 50 MMscfd (1.4 MMsm^3/d) design gas flow for the Project, and will be able to control export rates to as low as 10 MMscfd (0.28 MMsm^3/d). This ability for either FPSO to supply the full design gas flow for the Project will increase the reliability of gas supply during outages at either FPSO and enable optimization of export in line with reservoir management requirements. The current plan is for the Destiny FPSO to typically provide approximately 30 MMscfd (0.85 MMsm^3/d) and the Unity FPSO to typically provide approximately 20 MMscfd (0.57 MMsm^3/d) of natural gas.

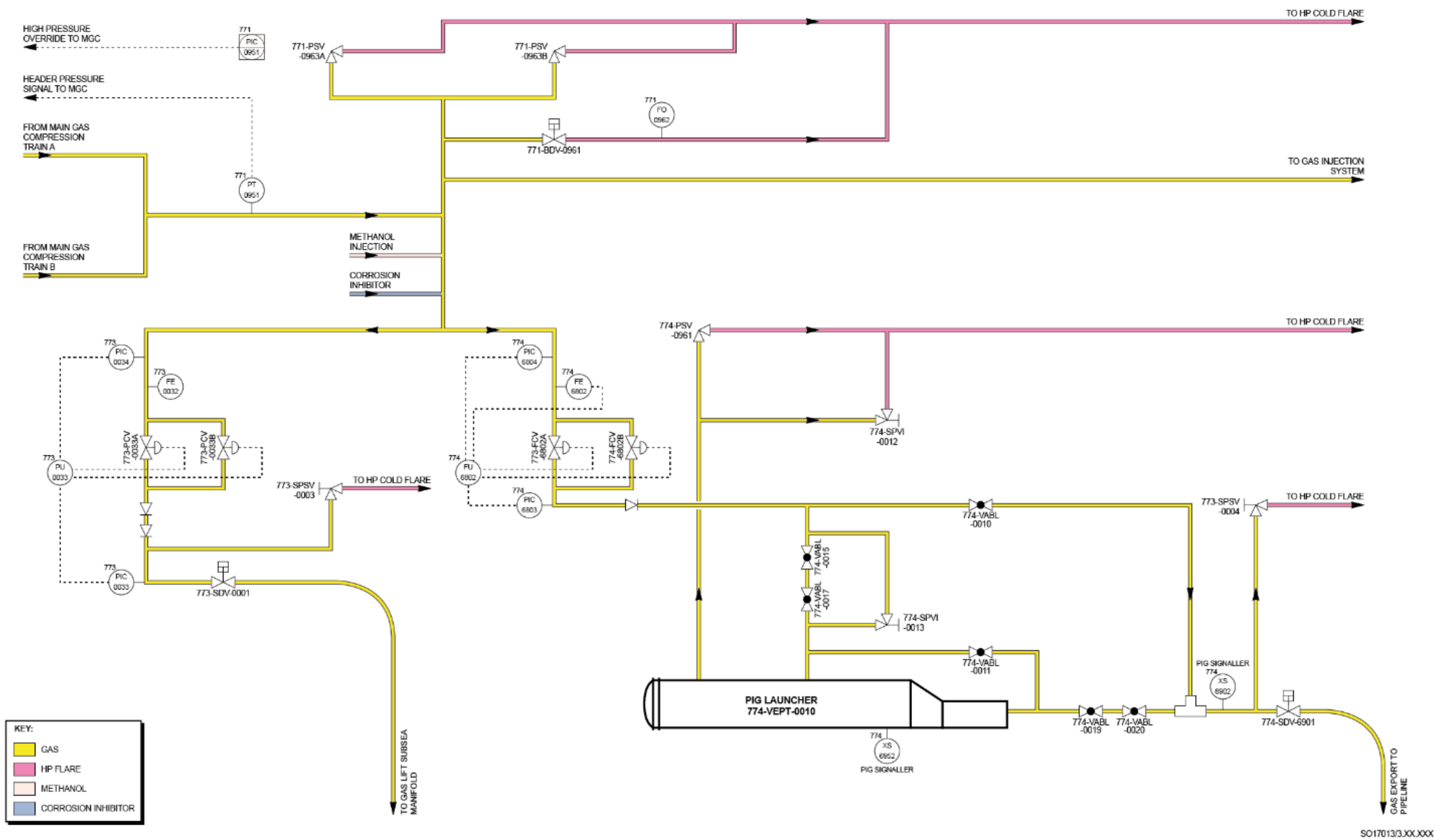
5.3.1.1. Destiny FPSO Gas Export System

The gas export facilities on the Destiny FPSO use a main gas compression system and gas dehydration system to condition produced associated gas for export (Figure 5.3-1). From the main gas compression system, gas can be used for injection, lift, flaring, or export (Figure 5.3-2).



FGC = flash gas compression; MGC = main gas compression

Figure 5.3-1: Destiny FPSO Gas Export Facilities—Simplified Overview



HP = high pressure; MGC = main gas compression

Figure 5.3-2: Existing Destiny FPSO Gas Export System—Simplified Flow Scheme

The existing gas export system includes split-range flow control valves that have a total modulating range of 15 to 145 MMscfd (0.52 to 4.1 $MMsm^3/d$) (Figure 5.3-3). One of the two valves modulates over the lower flow rate range of 15 to 50 MMscfd (0.52 to 1.4 $MMsm^3/d$), and the other modulates over the upper flow rate range of 50 to 145 MMscfd (1.4 to 4.1 $MMsm^3/d$). With the currently proposed gas export rates, it is expected that the higher-flow valve will not be used during typical operation. There is a potential for the higher-flow valve to be used during initial system pressurization.

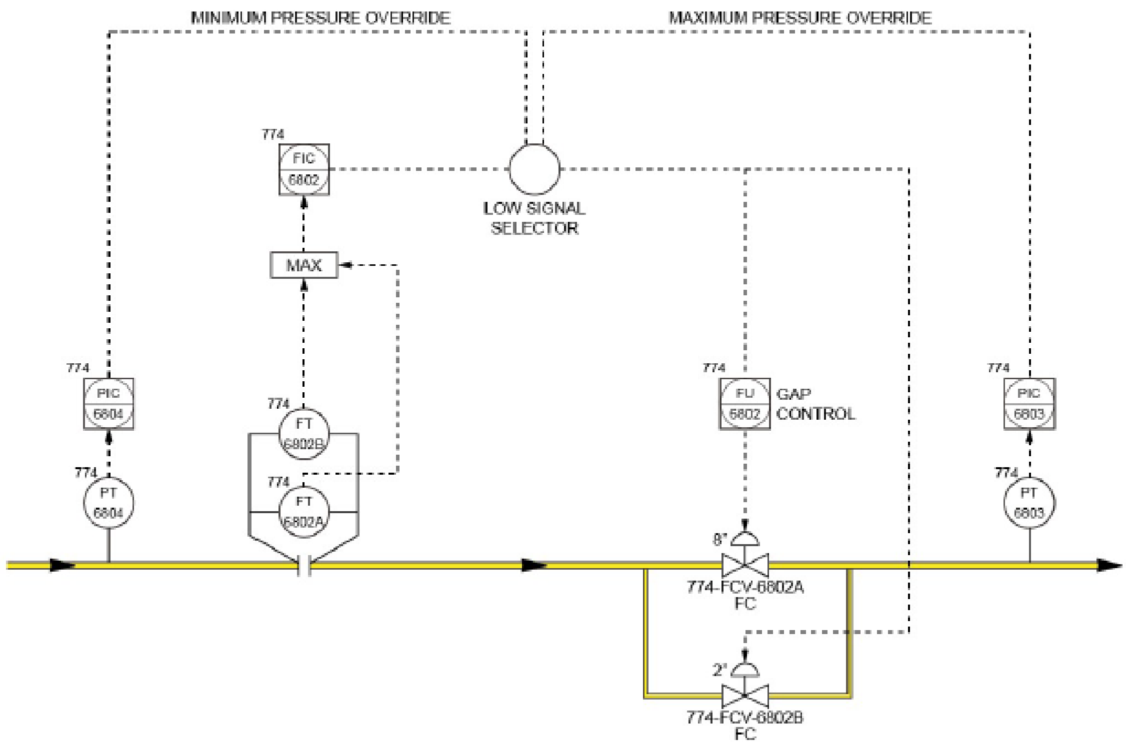
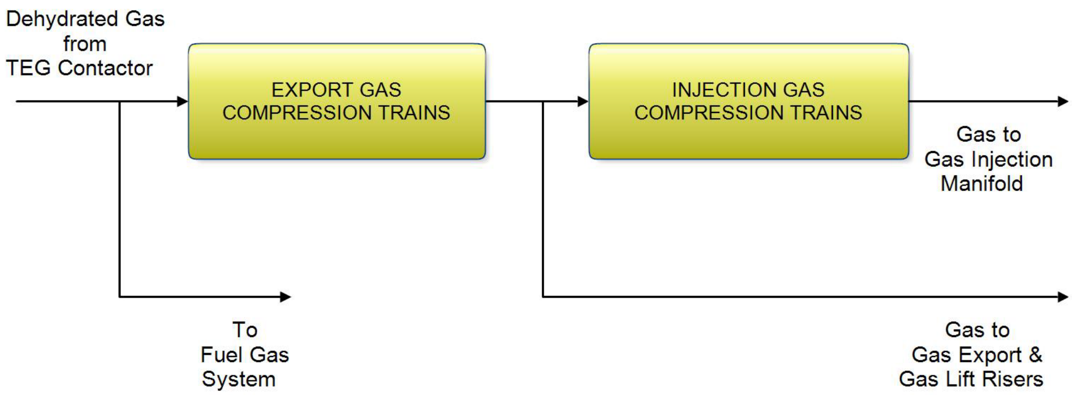


Figure 5.3-3: **Destiny FPSO Existing Gas Export Flow Control Scheme**

5.3.1.2. *Unity FPSO Gas Export System*

The gas export facilities on the Unity FPSO use a gas dehydration system upstream of export gas compression trains (Figure 5.3-4). Gas from the main gas compressor second-stage discharge coolers, Trains A and B, combine and flow into a header that serves the following:

- Inlet to an integrally geared compression suction scrubber
- Inlet to a gas export manifold
- Inlet to gas lift risers (to be installed in the future)



TEG =triethylene glycol

Figure 5.3-4: Unity FPSO Gas Export Facilities—Simplified Overview

The function of the gas export system is to pressurize produced associated gas to the required pressure so it can be exported via a gas export pipeline. From the discharge shutdown valves (Train A) the gas flows to the export manifold, where it combines with export compressor (Train B) discharge. From the export gas compression trains, gas can be used for injection, lift, flaring, or export (Figure 5.3-5).

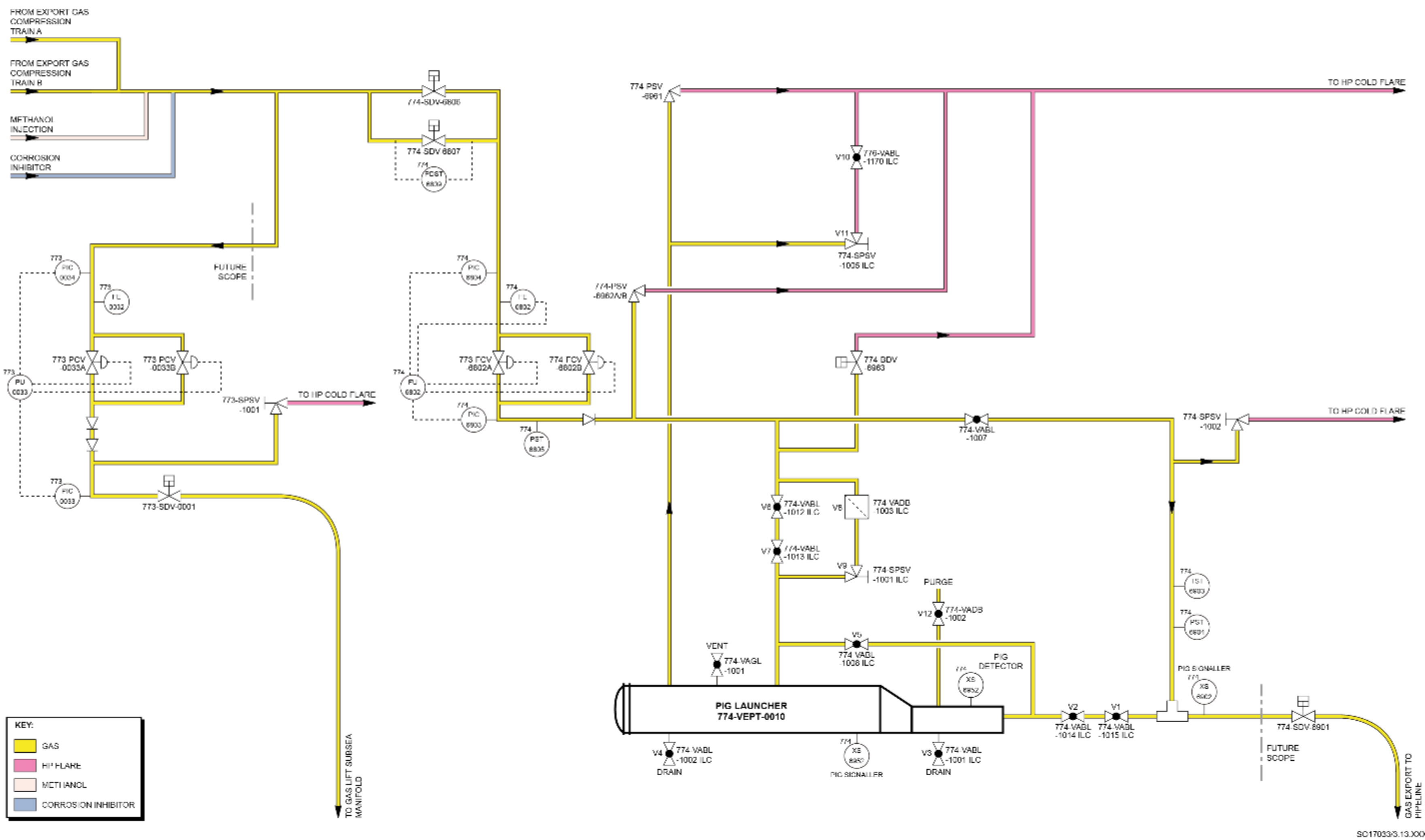


Figure 5.3-5: Existing Unity FPSO Gas Export System—Simplified Flow Scheme

5.3.1.3. Subsea, Umbilicals, Risers, and Flowlines

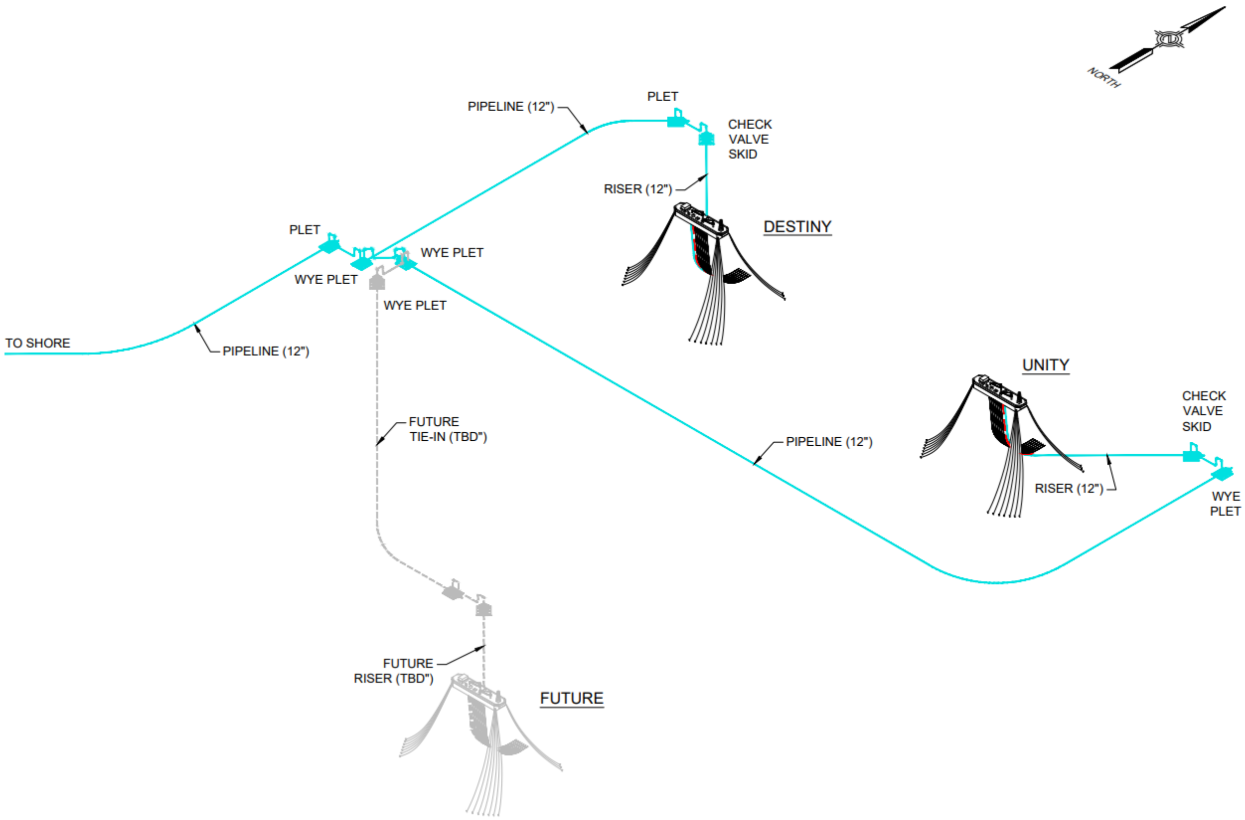
The Project Subsea, Umbilicals, Risers, and Flowlines (SURF) infrastructure will initiate at shutdown valves on each of the Destiny and Unity FPSO topsides. From each of these points, a new riser will be installed, leading to a pipeline end termination (PLET) situated on the seabed near the two FPSOs.

In addition to the FPSO equipment upgrades, the following SURF components will need to be implemented:

- Two gas export steel lazy-wave risers with a total length of approximately 8.2 kilometers, including both suspended length and estimated required anchoring length on seabed (buoyancy modules will be used to form the lazy-wave shape of the riser);
- Infield pipelines connecting the risers to the gathering center location, with a total combined length of approximately 23 kilometers; and
- Two flexible joints to be installed at the top of the risers.
- Two backflow prevention devices consisting of a Subsea Check Valve (SSCV) incorporated in the riser base PLET.
- Five PLETs, one to terminate the gas export line (i.e., the offshore pipeline) and four to terminate the infield lines. Four of the PLETs will have two hubs, each incorporating a "WYE[1]". One "WYE" will be used for the initial tie-in and the other will be a spare for a future tie-in. An additional "WYE" for a potential future tie-in will also be incorporated in the starting PLET for the Unity FPSO infield pipeline. All PLETs will include connection points for dewatering and chemical injection branches.
- Four rigid jumpers to connect the different PLETs.

In summary, there will be a single header line that starts at the riser base of the Destiny FPSO. This header line will connect to the backflow preventer riser base PLET, which will then connect to a second single-valve PLET that will then connect to a piggable "WYE" assembly PLET that is a tie-in for the Unity FPSO. The tie-in will combine the export gas from the Unity FPSO into the main header from the Destiny FPSO (i.e., the offshore pipeline) that then extends to shore. Similarly, the Unity FPSO will be connected at the riser base to a riser base PLET that will then be connected to a "WYE" assembly PLET, which will be connected to another "WYE" assembly PLET. One of the ends will be connected to the "WYE" assembly PLET in the header line of the Destiny FPSO and the other will act as a potential future export gas and future FPSO tie-in. Figure 5.3-6 shows the proposed subsea SURF architecture to be installed as part of the Project.

[1] A "WYE" connection is a used to combine two different branch lines into a single line. One of the branch lines typically enters at a 45-degree angle.



Note: blue indicates new Project components

Figure 5.3-6: Project SURF Architecture

5.3.2. Offshore Pipeline

The offshore pipeline will extend from the Destiny PLET to a shore landing point. As discussed above, an infield pipeline from the Unity FPSO, approximately 18 kilometers in length, will tie into the Destiny PLET (Figure 5.3-7). The offshore pipeline from the Destiny PLET to the shore landing will have a total length of approximately 195 kilometers (Figure 5.3-8). A description of the proposed offshore pipeline segments (including the infield pipelines) at different water depths is provided in Table 5.3-2.

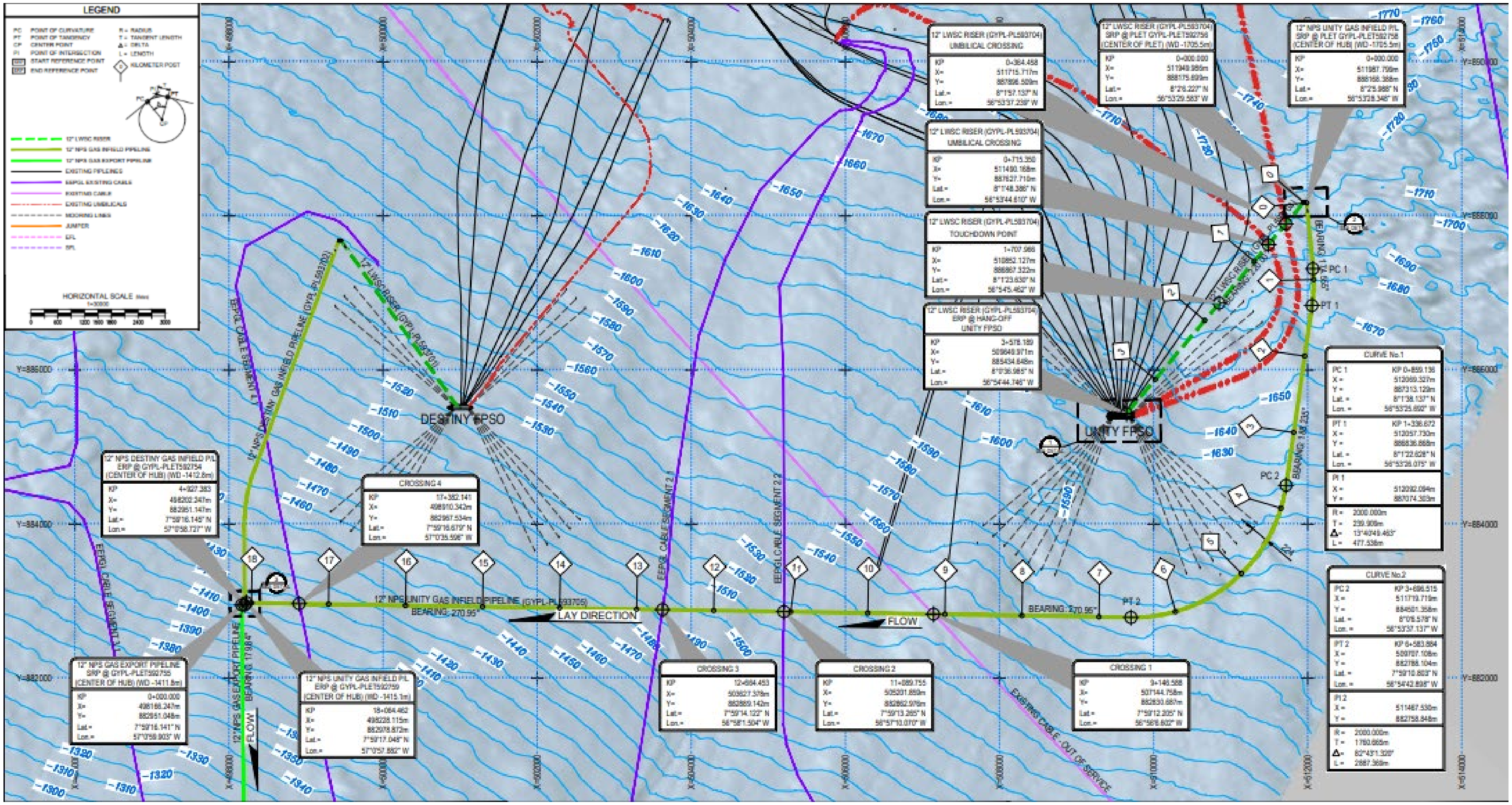


Figure 5.3-7: Infield Pipeline Layout between FPSOs

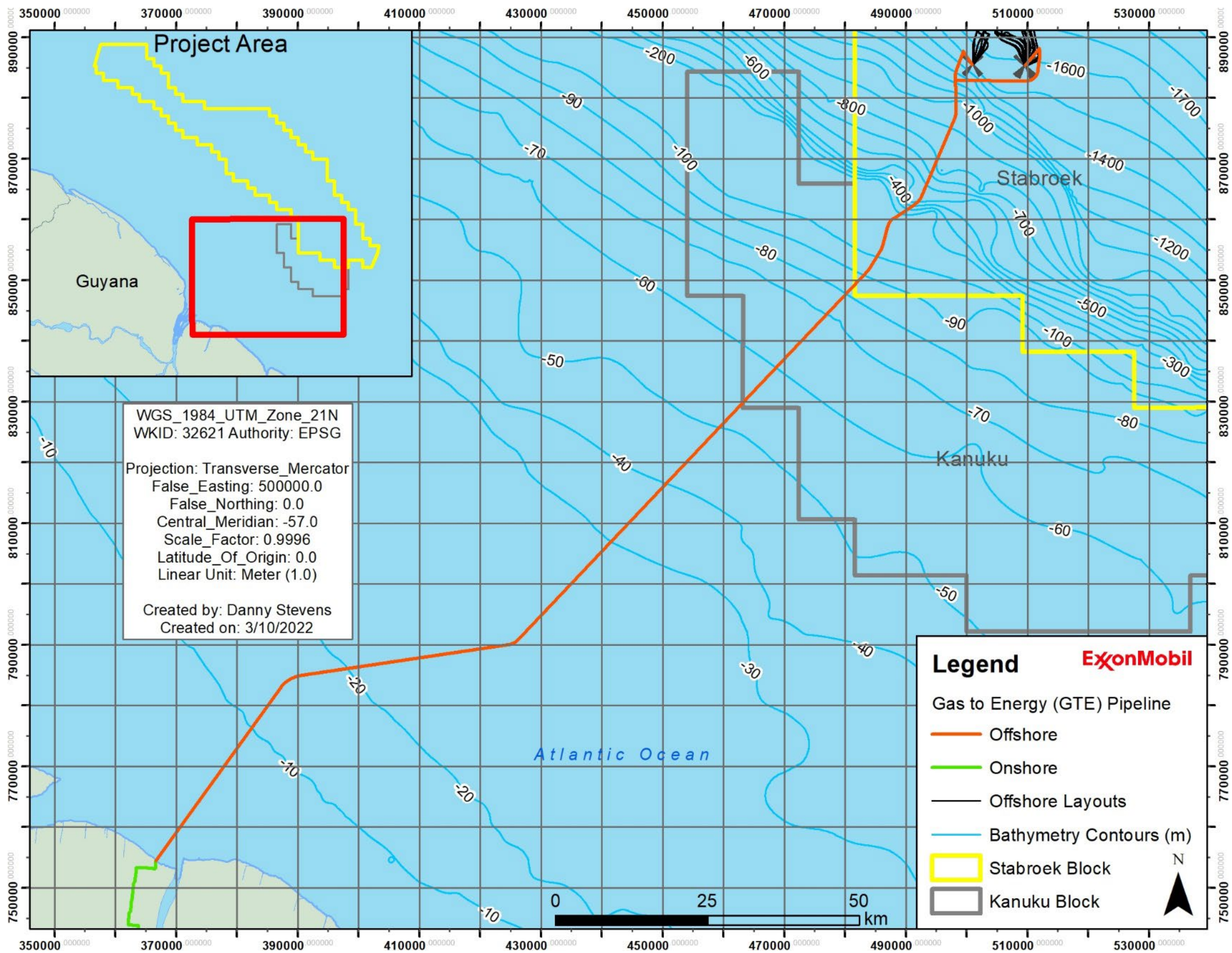


Figure 5.3-8: Offshore Pipeline Route

Table 5.3-2: Overview of Offshore Pipeline Segments

Segment	Approximate Water Depth (meters)	Approximate Length (kilometers)
Infield Pipelines (Deep)	1,400–1,700	23
Offshore Pipeline (Deep)	600–1,400	18
Offshore Pipeline (Intermediate)	20–600	130
Offshore Pipeline (Shallow)	1.6–20	34
Offshore Pipeline (Nearshore)	0–1.6	12
Shore Crossing	0	0.5
Total	—	217.5

In water depths greater than 600 meters (i.e., deep segments), the offshore pipeline will be laid directly on the seabed. At water depths between 20 and 600 meters (i.e., intermediate segment), the offshore pipeline may be laid on the bottom or buried, depending on local conditions. In water depths less than 20 meters up to the approximately 1.6-meter depth (i.e., the shallow segment), the pipeline will be laid in a trench for protection purposes (e.g., damage from vessels, potential for net fouling), at a depth sufficient to achieve a minimum cover of 1.2 meters. For the nearshore segment, the offshore pipeline will be installed by pulling in on the seabed or through a drilled bore. For the shore crossing segment, the pipeline may be installed using either HDD or open-cut trenching techniques. Key design parameters for the offshore pipeline system are provided in Table 5.3-3.

Table 5.3-3: Key Offshore Pipeline System Design Parameters

Parameter	Units	Design Specification
Pipeline Outer Diameter	mm	323.9
Wall Thickness (water depths greater than 600 meters)	mm	25.4
Wall Thickness (water depths less than 600 meters and greater than 24.5 meters)	mm	15.9
Wall Thickness (water depths less than 24.5 meters)	mm	17.5
Design Pressure at Topside Inlet	barg (psig)	220.6 (3,200)
Operating Pressure at Topside Inlet	barg (psig)	196.5 (2,850)
Maximum Temperature	°C	76.7
Minimum Temperature	°C	3.6
Operating Temperature	°C	40
Product Density	kg/m^3	210–240

°C = degrees Celsius; barg = bars-gauge; kg/m3 = kilograms per cubic meter; mm = millimeters; psig = pounds per square inch-gauge

Offshore pipeline stability on the seabed will be achieved through trenching, and/or additional wall thickness, as needed. Concrete weight coating is not required to achieve stability requirements. The offshore pipeline will be designed to be hydrodynamically stable on the seabed considering ocean currents and waves. Pipeline spans will be designed to meet the requirements of installation, hydrotesting, and operations. The offshore pipeline will be designed to minimize stresses, buckling, walking, instability, and fatigue due to wave action, vortexinduced vibrations, flow-induced vibrations, and other natural forces. Thermal end expansion will be kept within appropriate limits.

The offshore pipeline and risers will have a corrosion-resistant coating of either fusion-bonded epoxy or three-layer polyethylene / polypropylene. For the shore crossing segment, where the pipeline may be installed by HDD, a fusion-bonded epoxy with an abrasion-resistant overcoat may be used.

The offshore pipeline corridor will require nine crossings of existing active infrastructure:

- Two of Liza Phase 2 FPSO umbilicals
- Five of the EEPGL Fiber Optic Cable (FOC) system
- One of a Guyana Telephone and Telegraph telecommunication cable
- One of an E-Networks telecommunication cable

All of the crossings are located in water depths greater than 20 meters. The following crossing strategy has been developed as part of SURF / Pipeline Front-End Engineering Design (FEED):

- For umbilicals, the pipeline crossing will have an elevated configuration with concrete mattresses on both sides of the crossing.
- For the FOC system, assuming that cable is sufficiently buried at the crossing location, the pipeline will be laid on concrete mattresses placed on top of the buried cable. If the cable is found to not be sufficiently buried, localized jetting may be required to achieve target spacing between cable and pipeline.
- For the third-party telecommunication cables, a similar approach used for the FOC system cables is proposed, subject to confirmation and final agreement with the third-party operators.

5.3.3. Onshore Pipeline

The onshore pipeline, with a capacity of 120 MMscfd (3.4 MMsm^3/day), will transport the natural gas approximately 25 kilometers from the offshore pipeline shore landing to the NGL Plant site (Figure 5.1-1). An aboveground valve will be located within the onshore pipeline RoW near the shore landing; this will demarcate the boundary between the offshore and onshore pipelines. It will be used to shut down the pipeline for inspection and maintenance. The aboveground valve compound will be equipped with anti-cut / anti-climb perimeter fencing around the valve, with fiber optic intrusion detection, 24-hour-per-day closed-circuit television monitoring of the compound, and security lighting.

The onshore pipeline will be installed below ground with a minimum cover depth of 1.22 meters. An FOC-based system will be installed in the same trench for communication and to detect leaks and/or third-party intrusion. The onshore pipeline will be protected from corrosion using an impressed current system. A monolithic isolation joint will be included at the pipeline shore landing area to isolate the offshore and onshore cathodic protection systems.

Key design parameters for the onshore pipeline system are provided in Table 5.3-4.

Table 5.3-4: Key Onshore Pipeline System Design Parameters

Parameter	Units	Design Specification
Pipeline Outer Diameter	mm (inches)	323.9 (12.75)
Wall Thickness	mm (inches)	19.05 (0.75) [a]
Design Pressure at Inlet	barg (psig)	220.6 (3,200)
Operating Pressure at inlet	barg (psig)	196.5 (2,850)
Maximum Temperature	°C	76.7
Minimum Temperature	°C	3.6
Operating Temperature	°C	40
Product Density	kg/m^3	210–240
Internal Coating	—	None
External Corrosion Coating	—	Three-layer Polyethylene and Dual-layer Fusion-bonded Epoxy
Cathodic Protection System	—	Impressed Current

°C = degrees Celsius; barg = bars-gauge; kg/m3 = kilograms per cubic meter; mm = millimeter; psig = pounds per square inch-gauge
[a] Induction bends will be 20.6 millimeters wall thickness.

Buoyancy control, if needed, will be effected using concrete weight coating and/or additional wall thickness. Where the bend radius required exceeds the natural bend radius, hot induction bends will be used. Induction bends will conform to the requirements of the American Society of Mechanical Engineers (ASME) B16.49 supplemented by relevant EEPGL protocols, and will be manufactured from Project linepipe only. The minimum bend radius for factory-made hot bends will be 60 inches (152 centimeters) (i.e., five times the pipe diameter). The effect of wall thinning on the outer curve of each bend will be considered such that the post-bend wall thickness will meet the minimum specified wall thickness required for pressure containment as per ASME B31.8. The pipeline will be designed to lie within appropriate stress limits.

Aboveground facilities associated with the onshore pipeline will include a cathodic protection system; no compressor stations will be required. The cathodic protection system will help prevent corrosion of the underground pipeline facilities. These systems typically include a small, aboveground transformer-rectifier unit and an associated anode ground bed located underground. The ground bed will be installed at the NGL Plant. Rectifiers and test stations will be installed along the onshore pipeline corridor at distances ranging from 160 to 320 meters from the pipeline. These facilities generally include wires buried approximately 76 centimeters below the ground surface.

A receiving facility just upstream of the NGL Plant will include the following:

- A below-ground to aboveground transition with an associated monolithic isolation joint;
- An emergency shutdown valve;
- A pig receiver with associated valves and instrumentation; and
- A slug catcher designed to accommodate the maximum anticipated slug size.

Another short segment of piping will extend from the NGL Plant to the planned third-party Power Plant site, to deliver dry gas to the Power Plant. Since the location of the Power Plant has not been finalized, the route for and length of this length of piping is not yet known; however, it is assumed for the purpose of this EIA that the Power Plant will be located within less than 1 kilometer of the NGL Plant. The diameter of the piping from the NGL Plant to the Power Plant is expected to be 8 inches (203.2 millimeters).

5.3.4. Natural Gas Liquids Processing Plant

The purpose of the NGL Plant is to process the natural gas from the FPSOs into “dry gas” (methane [C1] and ethane [C2]) to be sent to the Power Plant, by removing impurities and extracting the heavier NGLs (i.e., butane [C3], propane [C4], and pentanes+ [C5+]) for sale to third parties. The NGL Plant facilities, processes, and utility systems are described below.

5.3.4.1. NGL Plant Facilities

The NGL Plant will include the following key facilities:

- Metering skid, located at an inlet receiving section, to measure the volume of gas delivered to the NGL Plant, a slug catcher / liquid separation, and a heated pressure letdown station to reduce the incoming pressure of the gas to plant operating pressure;
- Mercury and H_2S removal facilities;
- An NGL Recovery Unit to extract NGLs and dehydrate the gas to the specifications required for use as fuel for the Power Plant;
- Various utility systems necessary to support plant operation;
- A flare system to accommodate safety, operational, and non-routine flaring, as needed;
- NGL storage and truck loading facilities; and
- An additional metering skid on the Power Plant delivery pipeline, which will serve as the point of custody for transfer of natural gas to the Power Plant.

The NGL Plant will include the following buildings:

- Control Room, including meeting and office space
- Warehouse/Maintenance Shop
- Motor Control Center
- Loading Control Room
- Guard Shack
- Residue Compressor Shed
- Essential Generator Shed
- Emergency Generator Shed

The exact locations of the above facilities and buildings within the NGL Plant will be finalized during detailed design. Figure 5.3-9 provides a generalized block plot plan pending this future detailed design.

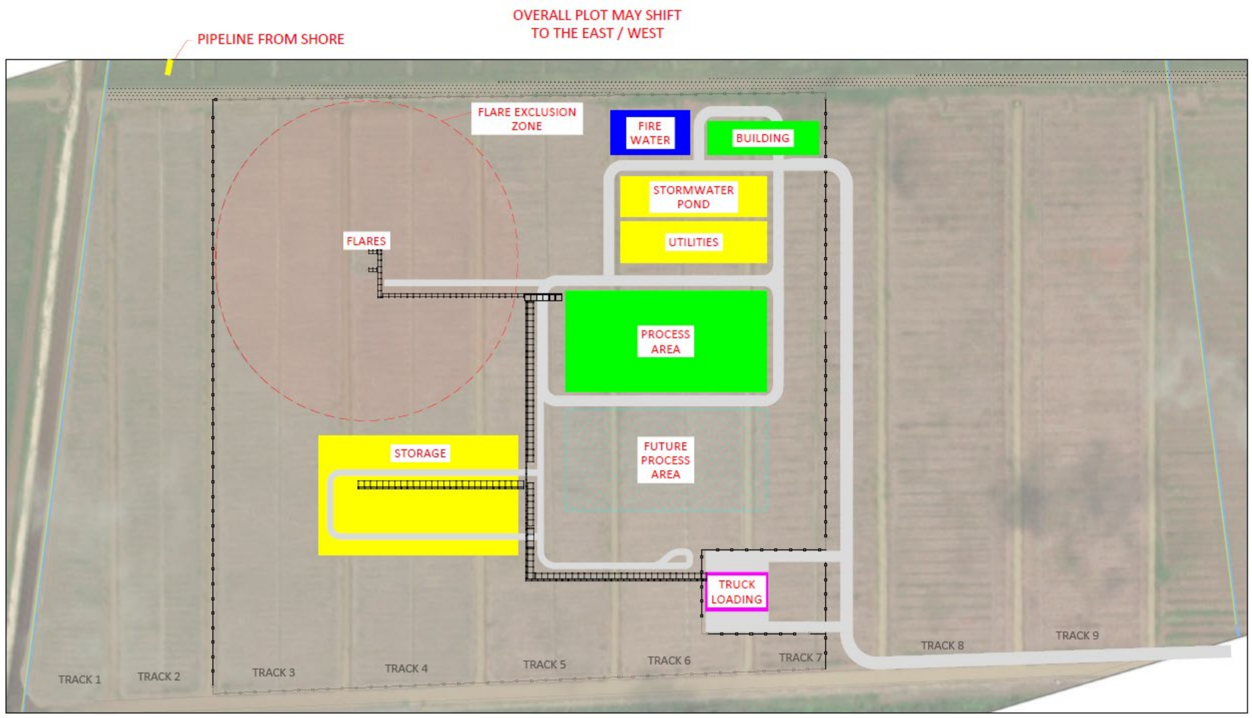


Figure 5.3-9: Preliminary NGL Plant Site Layout

The NGL Plant site layout includes space for the buildings and components listed above, as well as reserve space for future expansion to accommodate a flow rate of 120 MMscfd (3.4 MMsm^3/d)[2]. Major considerations for the NGL Plant site layout include the following:

- The prevailing wind direction is from northeast to southwest.
- Manned areas, such as the control room, office building, and warehouse will be located away from high-pressure units and upwind of the process area. Accordingly, main access to the facility will be provided on the northeast corner with a security gate.
- The heavy haul road will run east-west at the south end of the plot to optimize connectivity between the temporary MOF and the NGL Plant site.
- The flare will be located crosswind of the process area.
- Utilities will be kept at the boundary of the process area.
- The water/sewage treatment unit and storm water pond will be located so as to act as a buffer between occupied buildings and the process area.
- Firewater tanks and pumps will be located upwind of the process area and near occupied buildings.
- The storage area for produced NGLs will be located downwind of occupied buildings.

[2] Assessments in the EIA are based on an average flow rate of 50 MMscfd (1.4 MM sm^3/d).

- The truck loading rack will be located crosswind of the process area, distant from occupied buildings, and outside of the main fence.

5.3.4.2. NGL Plant Systems

The NGL Plant includes systems to process gas from the onshore pipeline by removing C3, C4, and C5+. These NGLs will be sold to third-party users, and the remaining gas (C1 and C2) will be treated to the specifications required for the Power Plant.

Inlet Facilities

The inlet facilities of the NGL Plant will include a pig receiver, an emergency shutdown valve, a slug catcher, a metering skid, and a pressure letdown system with inlet heating to avoid liquid dropout. The inlet gas pressure will be approximately 197 bars-gauge (barg) (2,850 pounds per square inch gauge [psig]). Any liquids that may be present during transitional operation are separated from the incoming gas by a slug catcher, although there will be no free water in the gas stream coming from offshore during normal operations. The slug catcher will include double isolation and bleed valves to allow isolation of 50 percent of the slug catcher for cleaning purposes. The gas from the slug catcher will be sent to the pressure letdown station to reduce outlet pressure to the NGL Plant working pressure of 62 to 83 barg (900 to 1,200 psig). The pressure letdown system will include heating to prevent hydrate formation downstream of the pressure control valve. The pig receiver, slug catcher, anti-hydrate heaters, and the pressure letdown control valves will be rated for the same design pressure as the onshore pipeline. Full-flow pressure relief to the flare system will be available to protect downstream low-pressure equipment in the event of inadvertent opening of the letdown control valves. Table 5.3-5 provides the key design parameters for the NGL Plant inlet system.

Table 5.3-5: NGL Plant Inlet Facilities Key Design Parameters

Parameter	Value
Gas arrival temperature	17.8–32.2 °C
Gas pipeline design temperature	77.2 °C
Gas pipeline operating pressure	127.6–196.5 barg (1,850–2,850 psig)
Gas pipeline design pressure	221 barg (3,205 psig)
Gas flow rate	0–60 MMscfd (0 to 1.7 MMsm^3/d)
Maximum design gas flow rate	121 MMscfd (3.4 MMsm^3/d)

°C = degrees Celsius

Mercury Removal

The NGL Plant will include a mercury removal unit to remove mercury from the inlet gas stream—to prevent damage to any aluminum equipment in the downstream NGL Recovery Unit. The mercury removal vessel will contain sulfur-impregnated activated carbon or a copper sulfide medium and will be equipped with mercury removal effluent dust filters through which the gas will pass prior to entering an Acid Gas Removal Unit. A support structure with a pulley arrangement for handling of H_2S and mercury absorption beds will be included, as well as a roller platform for offloading of spent absorption beds into drums.

Acid Gas Removal

The Acid Gas Removal Unit will remove H_2S in the presence of carbon dioxide (CO_2)—to meet the sales gas and NGL H_2S specifications. The Acid Gas Removal Unit will consist of two treating vessels containing solid beds of iron-or copper-based media. A dust filter will be used downstream of the two treating vessels. The NGL Plant will include space for an additional acid gas removal system, as well as additional dehydration facilities, if needed based on an unexpected increase in H_2S concentrations.

Gas Dehydration

The gas processing train will have a Gas Dehydration Unit to remove water from the gas to avoid freezing in the NGL Recovery Unit. The Gas Dehydration Unit will consist of two vessels, each containing a molecular sieve-bed system to remove water and a regeneration system that periodically removes water that has been adsorbed onto the molecular sieve beds.

NGL Recovery Unit

An NGL Recovery Unit downstream of the Gas Dehydration Unit will include a turbo-expander to reduce pressure and cool the gas stream. The cooled gas stream containing the NGLs will be fed to a de-ethanizer, where C1 and C2 will be removed by fractionation as an overhead product. The bottoms product, consisting of C4 and heavier compounds, will be fed to the depropanizer. In the depropanizer, C4 will be removed as an overhead product and C3 and heavier components will leave the unit as the bottoms product to be fed to a debutanizer tower. In the debutanizer tower, isobutane and normal C3 will be removed as an overhead product and C5+material will leave the unit as the bottoms product.

Residue gas compression may be required to transport treated gas to the Power Plant and for recycle at turndown. For this purpose, compressor sparing will be provided for facility reliability.

NGL Storage and Loading Facilities

The NGL Plant will include a variety of carbon steel storage tanks. One type of tank, known as a "bullet" will be used for storing produced NGLs until they are offloaded to trucks and transported for sale to third parties. Preliminary sizes and design parameters for these storage bullets are summarized in Table 5.3-6.

Table 5.3-6: Preliminary NGL Storage Bullet Design Parameters

NGL Contained	Number of Bullets	Volume (cubic meters)	Width x Length (meters)	Design Pressure (barg)	Design Temperature
C3—Butane	5	465	6 x 16.4	19	79 °C
C4—Propane	3	465	6 x 16.4	19	79 °C
C5—Pentane	2	345	5.5 x 13	10	129 °C

°C = degrees Celsius; barg = bars-gauge

To prevent pooling of any potential hydrocarbon spill from NGL storage area bullets, a remote containment area for spill containment will be provided at least 15 meters away and downwind from the storage area.

It is currently anticipated that the truck loading bay will be able to simultaneously load two trucks per NGL product. The loading racks will include piping, instrumentation, metering, drainage, and required safety measures.

5.3.4.3. NGL Plant Utility Systems

This section discusses the utility systems that will be included in the NGL Plant:

- Power Supply System
- Hot Oil System
- Flare and Blowdown System
- Chemical Injection System
- Nitrogen System
- Instrument / Utility Air System
- Fuel Gas System
- Diesel System
- Fire and Gas Protection System
- Potable / Utility Water System
- Drainage System
- Wastewater System

Power Supply System

The NGL Plant will be equipped with the following power supply systems:

- Normal Power—a utility supply will extend either directly from the Power Plant or from the national utility distribution system.
- Essential Power—essential power will be provided to supply the minimum operating conditions during startup or when the normal power supply is not available due to shutdown. Essential power will be provided by a diesel generator with black start capability.
- Emergency Power—emergency power will be provided to supply power to electric firewater pumps; emergency/egress lighting; control room heating, ventilation, and air conditioning; and supply to uninterruptible power supplies. Emergency power will be provided by a diesel generator with black start capabilities, connected directly to an emergency motor control center.
- Alternating Current (AC) Uninterruptible Power Supplies—dual-input 220 volt AC uninterruptible power supply systems will be provided to power equipment such as fire and gas detection systems, safe shutdown systems, and annunciation systems with backup battery power during emergency situations. Primary input will come from the normal supply 480V system and backup input will come from the 480V emergency motor control center. Battery systems will be sized for the following autonomy periods:

  - Safe shutdown systems—1 hour
  - Fire and Gas Detection systems and Annunciation Systems—8 hours

- Direct Current (DC) Uninterruptible Power Supplies—a single-input with bypass 110V DC uninterruptible power supply system will be provided for switchgear and electrical distribution equipment, with 8-hour autonomy.

Diesel fuel will be supplied by trucks and stored in a diesel storage tank. The preliminary size of the diesel storage tank is 63 cubic meters (m^3). Two redundant diesel pumps will provide diesel to the emergency generator, essential generator, and diesel firewater pump.

Hot Oil System

A Hot Oil System will provide the heat required by the NGL Plant facility and the inlet facilities. The Hot Oil System will be a closed system. Oil will be delivered by trucks and stored in a Hot Oil Storage Tank with a preliminary size of 34 m^3, from which it will be pumped to a Hot Oil Expansion Tank by two Hot Oil Transfer Pumps. The hot oil will be heated by fired heater(s) supplied by fuel gas and pumped to equipment (so called "hot oil users") via two Hot Oil Circulation Pumps. Hot oil users will include anti-hydrate heaters, an inlet vaporizer, a solid bed superheater, a de-ethanizer reboiler, an export superheater, a depropanizer reboiler, a debutanizer reboiler, a Cold Drain Drum, and a Fuel Gas Heater. A Hot Oil Trim Cooler will provide cooling to the Hot Oil System when the heat demand of the hot oil users is less than the heat generated from the Hot Oil Heater. Water blasters will be installed for heat exchanger cleaning.

Flare and Blowdown System

The flare system will be designed to safely accommodate flaring of all emergency pressure relieving scenarios, including facility blowdown. Flares will be sized for flaring during pigging of the pipeline to handle any excess gas that would not be used by the Power Plant, but is required to meet the minimum flow for the pigging activity. The size of the pipeline (12-inch [304.8-millimeter] diameter) requires a higher gas flow rate for pigging operations than would be required by a smaller-diameter pipeline. Because of this higher flow rate requirement (greater than 50 MMscfd [1.4 MMsm^3/d]), incremental volume flaring is likely to be required during pigging.

The NGL Plant will have a wet flare and a cold flare. The wet flare is intended to serve facilities upstream of the molecular sieve and regeneration processes, while the cold flare is intended for the remainder of the plant downstream of the molecular sieve and regeneration processes. Both flares are expected to be enclosed ground flares, although the possible use of an elevated flare will be evaluated in FEED.

Hydrocarbons from the flare header will discharge into a Flare Knockout Drum. Liquids collected in the Flare Knockout Drum will be pumped by a Flare Knockout Liquid Pump to a Closed Drain. The vapor from the Flare Knockout Drum will be routed to the wet flare. Pilot gas for the wet flare will be supplied from the fuel gas header.

A Cold Drain Header will collect extracted liquids. The liquids will flow by gravity to the Cold Drain Drum where they will be heated by hot oil to vaporize the light ends; these vaporized light ends will be sent to the cold flare. The heavier liquids will be pumped to the Closed Drain Drum. Pilot gas for the cold flare will be supplied from the fuel gas header.

The combustion of flare pilot and purge gas will be required to maintain the flares in a safe operational state. The purpose of the flare pilot and purge gas is to prevent oxygen from potentially entering the flare if there is not a constant supply of gas. Non-routine emission sources include flaring from initial start-up; storage bullets venting; loading rack venting; maintenance purging; maintenance pigging; gas-freeing of process equipment during maintenance events, Power Plant turbine trips, power demand swings; and blowdown events. Prior to performing process equipment maintanence, gas inventory in the process equipment will be routed to the flare. Maintenance events will include the catayst change-outs required for the mercury, H_2S, and molecular sieve beds.

Chemical Injection System

The following chemical injection systems may be used in the NGL Plant:

- Methanol for anti-hydrate purposes—Methanol will be stored in a Methanol Tank and supplied by a Methanol Injection Pump to facilities that will use methanol (so called “methanol users”). Methanol users include the Regeneration Gas System, Fuel Gas Inlet, Inlet Gas to NGL Train, Expander Inlet Drum liquid line, feed gas to cold and wet flare, HP liquid drains, and NGL expander recompressor inlet.
- Lubricating oils for rotating equipment.
- Flocculants for the Wastewater Treatment System—flocculants will be injected into the Wastewater Treatment System to bind solid particles prior to removal.

Nitrogen System

Nitrogen will be required in the NGL Plant for tank blanketing and as an inert purge gas to evacuate hydrocarbons from process equipment. Nitrogen will be supplied from a Nitrogen Supply System. Nitrogen may be generated on site using membranes downstream of the instrument air system or from an external supply of liquid nitrogen. Nitrogen will be stored in a nitrogen receiver vessel (approximately 1.2 x 3 meters), and nitrogen supply will be routed to nitrogen users as needed.

Instrument / Utility Air System

An Instrument / Utility Air System will provide air compression and remove water from atmospheric air to meet requirements of instrument/utility air users. This system will be comprised of air compressors, filters, dryers, receivers, and distribution piping. Atmospheric air will flow through an Inlet Air Filter to remove particulates. The filtered air will then be compressed and cooled before splitting into instrument and utility air. Utility air will be sent directly from the cooler to a receiver to provide surge capacity before flowing to utility air users. Instrument air will enter additional filtration and will be dried before sending to the receiver for infiltration air users. Instrument air will then flow to a heaterless, dual-tower, pressure-swing, desiccant-type dryer designed for continuous operation.

Fuel Gas System

A Fuel Gas System, which will be a slipstream of residue gas, will be used to blanket some of the drums in the NGL Plant and as fuel for Hot Oil Heater burners and the Molecular Sieve Regenerator. Low-NO_x (nitrogen oxides) burners are anticipated, and this will be confirmed in FEED. In the event the Power Plant does not supply power to the NGL Plant, a rich gas bypass will be used as fuel for the fired heaters. The rich fuel gas will be superheated in a Fuel Gas Heater, followed by a Fuel Gas Scrubber. The vapor from the scrubber will be filtered to remove any entrained liquid before sending to the fuel gas users.

Diesel System

Diesel will be supplied by trucks and stored in the Diesel Storage Tank. The Diesel Pump (2 x 100 percent) will route diesel to the Emergency Generator, Essential Generator, and Diesel Firewater Pump. Based on the connected load of 3.15 megawatts for the Essential Generator, the Diesel Tank size will have a diesel capacity for 2 days (to be confirmed in FEED). This will cover the period required to start up the NGL Plant, send gas to the Power Plant, and receive power from the Power Plant. Considering a heating value of 46 megajoules per kilogram and a density of 0.85 kilograms per liter, a preliminary estimate based on 2 days storage capacity corresponds to 63 m^3 of required volume.

Fire and Gas Protection System / Fire Water System

The NGL Plant will be protected with strategically placed flammable gas, toxic gas, smoke, and fire detection equipment. The Fire and Gas Protection System will be an independent system with the following basic functions:

- Continuous monitoring of all areas of the installation where either a fire hazard may exist or an accumulation of flammable gas may occur;
- Automatic initiation of appropriate protective actions to isolate the source of a leak, to minimize source of ignition, and to activate fire suppression systems and fire pumps; and
- Annunciation of alarms to alert personnel and identify the general location of the hazard, including interface using the facility's Public Address / General Alarm system.

Fire and gas detection will be employed throughout the facility and will generally consist of the following:

- Smoke detectors will be installed in inside areas with a potential for ordinary combustible-type fires or electrical fires. Smoke detection systems will be installed in all electrical and switch rooms.
- Flame detectors will be used to provide rapid detection of a fire in areas handling hydrocarbons, and a number of flame detectors, such as two out of three, will be networked to provide a confirmed fire alarm.

- An Integrated Control and Safety System will provide an integrated monitoring, control, protection, and safety system for the entire production facility. The safety system will be separate from the Process Control System.
- Gas detectors will be installed in strategic locations in the process and utility areas and in air intakes to buildings and turbine hoods. Open path- (i.e., beam-) type gas detectors will be installed in hydrocarbon processing areas in conjunction with point-type gas detectors. The use of point-type, beam-type, or a combination of point-type and beam-type detectors will help to avoid false alarms. Supplementary ultrasonic detection may be installed for modules where high-leak-potential equipment is located, or where ventilation rates reduce the probability of successful detection by other methods.
- The fire and gas detection system will be supplied with a stand-alone redundant uninterruptible power supply.

Blast protection will be provided where necessary, as determined by a FEED fire and explosion hazard assessment and passive fire protection study. Where necessary, firewalls will also be designed for blast protection.

The NGL Plant will include an active fire protection system, or firewater system. The firewater system will be a pressurized wet ring main. The ring main will be routed underground to required locations where firewater is required. Water (either from groundwater wells or from canals near the NGL Plant) will be the primary source for firefighting. Firewater will be stored in two on-site dedicated 13-meter-high Firewater Storage Tanks, each with a capacity of 6,381 m3. The available firewater capacity will be sufficient to provide a minimum of 4 hours of continuous operation of the fire pumps at maximum firewater demand or such time as it would take to extinguish the longest-duration fire event based on fire risk analysis if that time is greater than 4 hours.

Sparing of firewater pumps will be provided. A Firewater Jockey Pump will operate continuously to maintain pressure in the firewater loop. The main firewater pumps may be powered by diesel or electricity, and the total diesel-driven capacity will be sufficient to handle 100 percent of the requirements. A Firewater Pump-Electric (1 x 50 percent) and two Firewater Pumps-Diesel (2 x 50 percent) will be available on standby to provide a high flowrate of water in the event of a fire. The firewater pump drivers will be segregated from process hazards by distance or barriers and located such that no single event can prevent supply of adequate firewater to the largest potential fire area.

The firewater system will include a freshwater mist system for appropriate locations identified by the fire and explosion hazard assessment that will be conducted during FEED, such as machinery enclosures (e.g., gas turbines). Foam deluge systems will be provided for areas with potential for hydrocarbon fires. High-expansion and low-expansion foam will be used as required. Automatic sprinkler systems will be provided in buildings (e.g., workshop, storage). Sprinkler systems will not be provided in rooms with electrical equipment (e.g., Control Room within Operations Center, Switchgear room). The initial charge in the sprinkler system will be fresh water. The electrical/switchgear room and the Control Room will be provided with a gaseous fire extinguishing system, to be confirmed by the fire and explosion hazard assessment that will be conducted during FEED.

Potable / Utility Water System

Potable/utility water will be supplied from groundwater wells drilled within the NGL Plant site. A Water Treatment System will be used to treat raw water coming from the wells, and water sampling will be conducted to analyze for contaminants and design/operate appropriate treatment facilities. Filtration and chlorination prior to storage will be performed. A potable water tank will supply water for the control room, bathrooms, eyewash stations, and safety showers. Utility water will be supplied from a utility water tank, and this will be used for flushing equipment. Drinking water will be purchased (e.g., in 20-liter water bottles).

The estimated daily water demands are as follows:

- Drinking water—1.5 liters per person per day to be supplied by delivered bottles
- Utility water—up to 15 m^3 per hour
- Domestic water—up to 0.75 m^3 per hour[3]
- Firewater—up to 1,253.5 m^3 per hour, to be confirmed based on the results of a Fire Water Demand Study based on the maximum firewater demand or such time as it would take to extinguish the longest-duration fire event.

The NGL Plant will have no continuous process water needs during normal operations.

Drainage System

The NGL Plant will be equipped with the following drainage systems:

- Closed Drain System—The drains from process vessels and equipment on the NGL Plant will be collected in a closed drain header and routed to a Closed Drain Drum. Vapor from the Closed Drain Drum will be routed to the Flare Knockout Drum and the liquid will be routed to a slop tank and sent back to the process.
- Open Drain System—The open drain system will collect water (i.e., rainwater and firewater) from curbed areas of the NGL Plant. This includes the process, loading racks, flare, and substation areas. The water will be collected in an open drain header and drained to an oily water sump that is sized for the first flush (i.e., 15 minutes) of rainfall. The first flush of rainfall will be sent to the wastewater treatment plant (WWTP), while subsequent water will be routed to the stormwater pond.
- Stormwater Pond—The site will be constructed in such a manner that rainfall falling within the curbed areas after the first flush period of 15 minutes will flow to the stormwater pond. The treated water from the WWTP will also discharge to the stormwater pond. Water from the stormwater pond will be analyzed before it is discharged to the Demerara River, potentially via a canal adjacent to the NGL Plant.

[3] Based on an anticipated maximum of 50 persons on site and a water use rate of 360 liters per person per day

Sanitary Wastewater System

The sanitary wastewater system will collect all domestic wastes from toilet facilities and kitchens via manholes located near buildings and underground sloped piping. A modular "package" WWTP will provide initial treatment of sanitary wastewater. The solids that settle to the bottom of the tank will be vacuumed out on a periodic basis by a local provider. The local provider will characterize the waste and verify it is suitable for disposal at the Haags Bosch Landfill (HBL). Treated sanitary wastewater will be routed to the stormwater pond prior to analysis and discharged to the Demerara River (either directly or via a canal adjacent to the NGL Plant).

Process Wastewater System

A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. The preliminary design calls for injection of flocculants into the oily water streams prior to routing them to a Clarifier Tank. A skimmer will then send separated oil from the Clarifier Tank back to the process. The sludge that settles to the bottom of the Clarifier Tank will then be sent to a Clarifier Sludge Pit, where it will be collected periodically and transported for off-site management. Sludge will be treated as a hazardous waste by an approved and permitted hazardous waste management facility. The de-oiled water from the Clarifier Tank will then be sent to a Nutshell Filter or Dissolved Air Flotation Package for further treatment. Treated wastewater will be routed to the stormwater pond prior to analysis and discharge to the Demerara River (either directly or via a canal adjacent to the NGL Plant).

5.3.5. Ancillary Facilities

The Project will require a variety of other temporary and permanent ancillary facilities to provide access to, or to support, construction activities, including a worker camp, infrastructure upgrades, a temporary MOF, and various support facilities and logistics support. Some of these facilities will be temporary (i.e., only needed during construction), and some—such as infrastructure upgrades—will remain in place after Project construction is complete. These ancillary facilities are described below.

5.3.5.1. Worker Camp

The Project is considering alternatives for accommodating non-local workers during construction. One alternative is to house the workers in existing lodging (likely in the Georgetown area) and another alternative is to establish a worker camp near the proposed temporary MOF (Figure 5.1-1). If this alternative is selected, the worker camp would have the capacity to accommodate 150 workers. In addition to providing housing, the worker camp would also provide a cafeteria, medical clinic, recreation center, and office facilities. These structures would be prefabricated and placed on a concrete pad. The worker camp would be designed to comply with international worker accommodation standards (IFC and EBRD 2009). Table 5.3-7 summarizes the facilities that would be provided at the worker camp.

Table 5.3-7: **Worker Camp Facilities**

Work Camp Element	**Facility Requirements**
Total Area	Approximately 1.87 hectares
Camp Capacity	Approximately 150 workers
Accommodations	Comply with the Workers' Accommodation: Processes and Standards (IFC and EBRD 2009)
Sanitation Facilities	Comply with the Workers' Accommodation: Processes and Standards (IFC and EBRD 2009)
Canteen/Cooking/Laundry Facilities	Comply with the Workers' Accommodation: Processes and Standards (IFC and EBRD 2009)
Medical Facilities	On-site first aid room to address non-emergency incidents to comply with the Workers' Accommodation: Processes and Standards (IFC and EBRD 2009)
Security	Unarmed security to comply with Workers' Accommodation: Processes and Standards (IFC and EBRD 2009) and Assessing and Managing the Risks and Impacts of the Use of Security Personnel (World Bank 2018). Perimeter fencing to be installed around camp.
Access	Access from the heavy haul road via west bank access road and/or temporary MOF
Power	Three 500-kilowatt diesel generators
Water	Source: on-site groundwater well Treatment: water treatment system Capacity: 51,000 liters/day
Wastewater	Temporary, packaged sanitary WWTP (separate from permanent sanitary WWTP discussed above for NGL Plant)
Internet	Internet access will be provided

5.3.5.2. Temporary Materials Offloading Facility

A temporary MOF will be constructed on the west bank of the Demerara River near the NGL Plant site for offloading of heavy modules and imported material or equipment from barges and vessels (Figure 5.1-1).

A schematic of the temporary MOF is shown on Figure 5.3-10. The temporary MOF is expected to consist of the following:

- Unloading area (approximately 48 meters by 30 meters);
- Trestle (approximately 11 meters by 60 meters) extending from the unloading area to a heavy haul road;
- Two winch platforms (approximately 10 meters by 8.5 meters each); and
- Four mooring dolphins (two extending from each side of the rear of the unloading area).

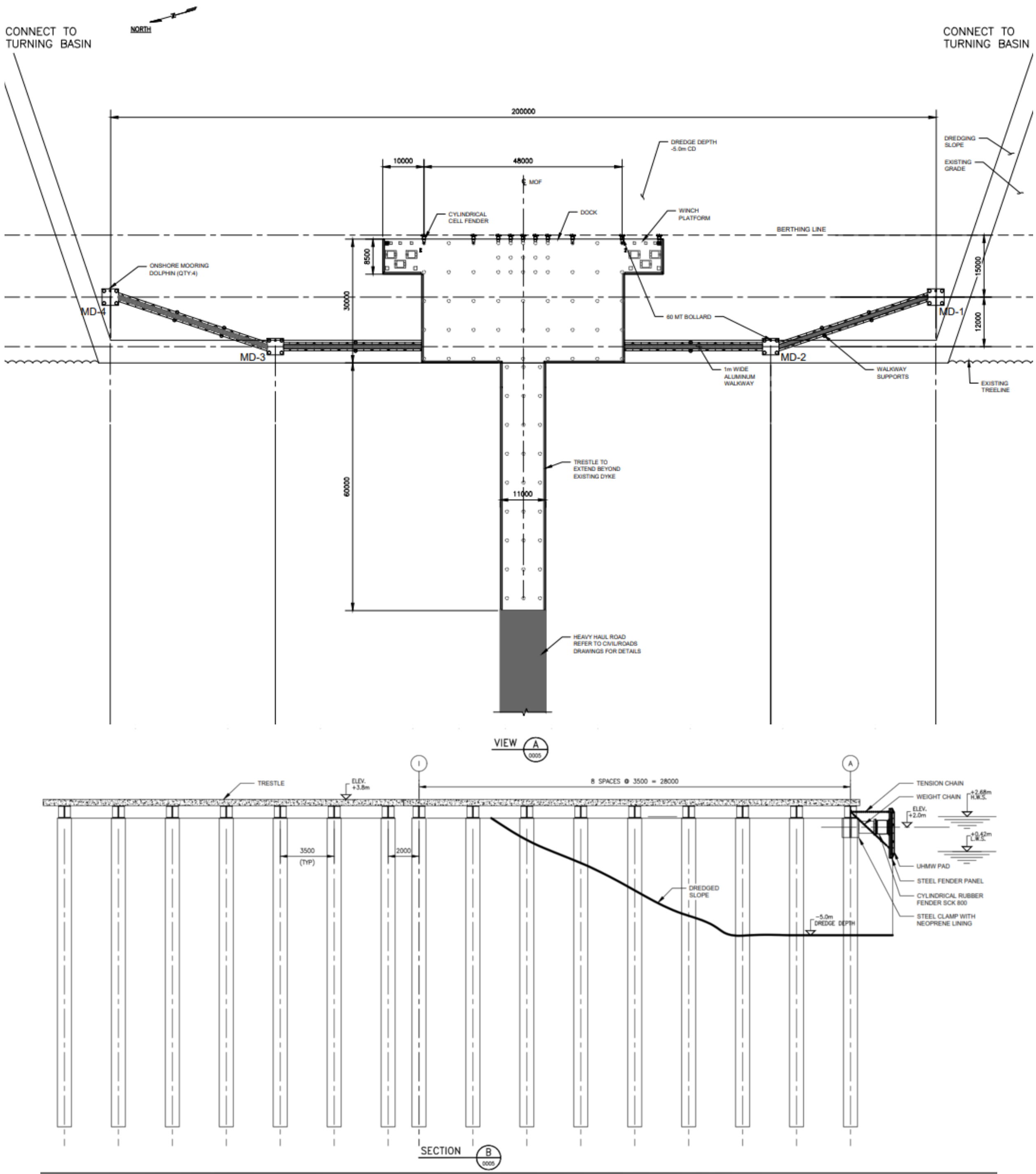


Figure 5.3-10: Proposed Temporary MOF Schematic

The structure will be designed as a steel-pipe pier with pre-cast concrete decking. The mooring dolphins will be connected and accessed via aluminum walkways, supported by piles. The unloading area and mooring dolphins will be installed in front of the existing vegetation line, resulting in a significant decrease in the clearing as compared to an orientation that would place the unloading area entirely behind the vegetation line. The trestle component is proposed in order to connect the unloading area to the heavy haul road without impacting the existing dike in this area.

This arrangement is designed with the intention to allowing docking of a range of vessels (e.g., cargo barges, ferries, etc.), with maximum delivery loads of up to 200 tonnes. Equipment and material will be unloaded on a roll-on-roll-off or lift-on-lift-off basis, dependent on size and weight. For a roll-on-roll-off basis, a ramp will extend from the vessel to the unloading area. The ramp on the unloading area will support a stress of 10 tonnes per square meter, with all other areas of unloading area and trestle designed to support 8 tonnes per square meter.

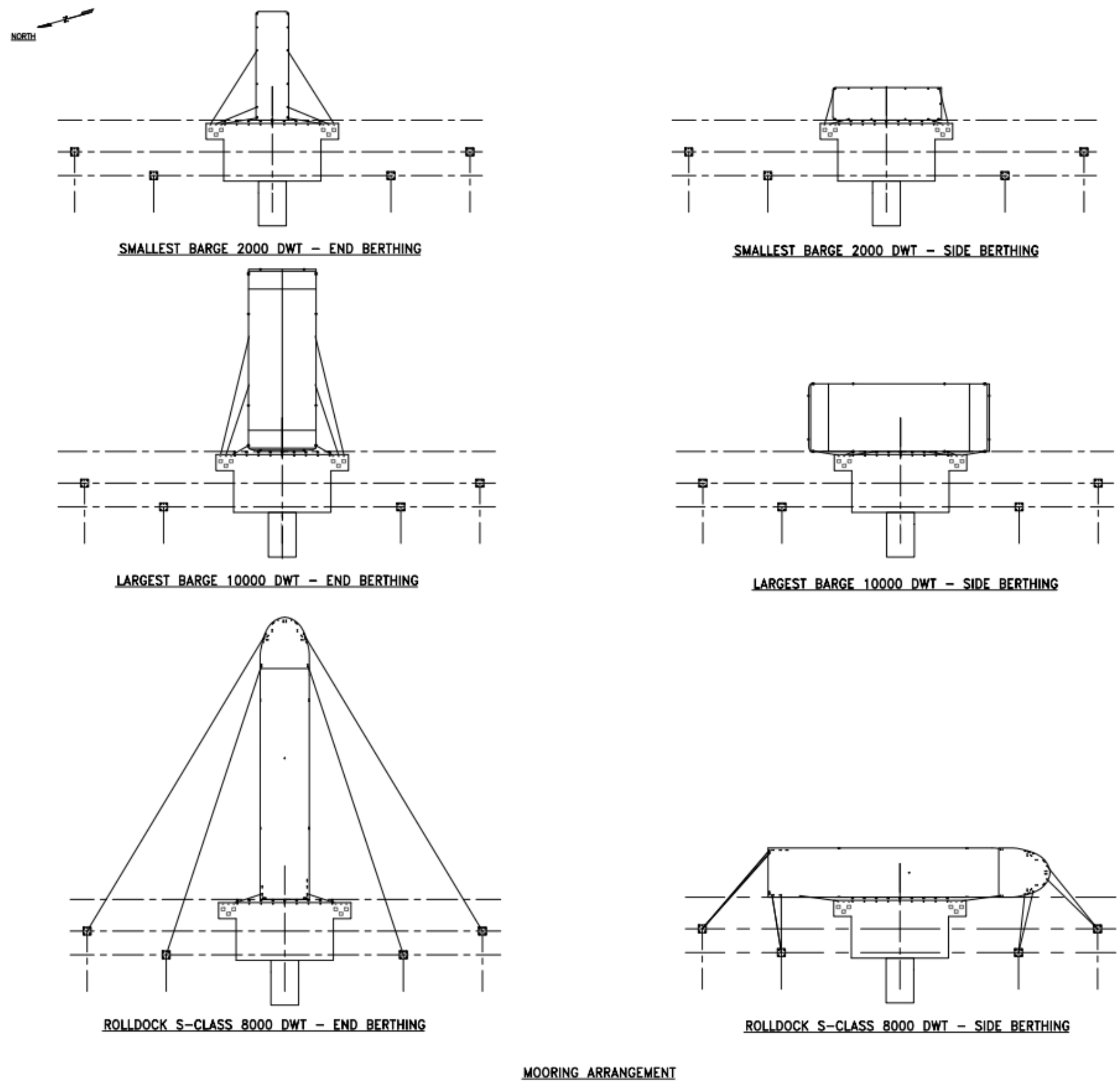
The detailed specifications for mooring arrangements at the temporary MOF will be finalized during detailed design; however, it is currently anticipated that the mooring arrangements may include the following (Figure 5.3-11):

- Six self-contained hydraulic-powered mooring winches of approximately 80-tonne holding capacity, arranged three per side: one each roughly just aft of the bow, amidships and near the stern of the docked vessel or barge.
- Mooring winches fitted with synthetic mooring lines and attached to four to six dockside bollards or dolphins of approximately 60-tonne ton holding capacity.

In addition to the temporary MOF features described above, a temporary conveyor system is anticipated to be installed on the unloading area to support delivery of aggregate materials for site preparation. The operation of the conveyor system will require an additional approximately 3-meter-wide area along the northern edge of the trestle, on which the conveyor support structure will be situated, and an approximately 30-meter x 30-meter footprint on the land-side of the conveyor, where material will be stockpiled and loaded onto trucks traversing the heavy haul road.

A 10-year design life was used for the temporary MOF design. Plans are to remove the temporary MOF prior to design life being met.

Approximately 1,500,000 m^3 of dredging will be required for the construction and operation of the temporary MOF. This quantity accounts for temporary MOF construction, connecting the existing ship channel to the temporary MOF, and providing a turning basin for the range of vessels anticipated for the Project. It is expected that dredging will be performed with locally available equipment, using locally approved methods (e.g., trailing suction hopper barge, with spoils to be disposed upstream of the Project location).



DWT = dead weight tonnage

Figure 5.3-11: Proposed Mooring Plans

5.3.5.3. Infrastructure Upgrades

A heavy haul road with a width of approximately 11 meters and a length of approximately 3 kilometers will be installed between the temporary MOF and the NGL Plant to support Project traffic and equipment delivery (Figure 5.1-1). Sand for construction of the heavy haul road will be obtained from existing borrow pits in Guyana; aggregate for the heaby haul road subbase will be obtained from outside of Guyana.

5.3.5.4. Existing Support Facilities

The Project will use existing onshore infrastructure, which may include shorebases, warehouses, storage and pipe yards, fabrication facilities, fuel supply facilities, and waste management facilities in Guyana. Such infrastructure will be used to support the Construction, Operations, and Decommissioning stages.

Shorebases

The Project will require the use of existing onshore storage facilities and laydown areas in Guyana for Project materials (e.g., pipe) and may also use existing onshore facilities in Guyana for pre-fabrication or assembly of Project equipment. At this time, EEPGL plans to use existing Guyana shorebases to support the Project, although new third-party onshore facilities in Guyana may also be used by the Project (these would be developed by third parties as separate projects). All onshore support facilities that will be used by the Project will be owned/operated by third parties. Should any new or expanded shorebases or onshore support facilities be used, the construction/expansion of such facilities, as well as the associated environmental authorizations, would be the responsibility of the owner/operator and such work scope is therefore not included in the scope of the EIA for the Project.

A typical shorebase quay is shown on Figure 5.3-12, and a typical laydown yard is shown on Figure 5.3-13. Additional logistical support may be provided by other regional suppliers outside of Guyana, as informed by inputs from EEPGL contractors after contract award, to address Project needs (e.g., deepwater port access in Trinidad).

Figure 5.3-12: Typical Shorebase Quay

Figure 5.3-13: Typical Laydown Yard

Onshore facilities will include pier/port/quayside space with sufficient draft for receipt of cargo vessels bringing materials to and from the shorebase; marine support vessels will be used to service the offshore pipeline installation activities. A marine berth and secure warehousing space for indoor and outdoor storage of materials and goods, trucking, stevedoring, freight forwarding, customs logistics, receiving, inspection, and associated container handling and storage operations will also be used.

Daily activities and operations to be performed at the shorebases will generally include the following:

- Storage of pipe, equipment, and spares;
- Loading and unloading cargo from trucks and marine vessels;
- Use of cranes and other lifting equipment;
- Pre-fabrication and assembly of pipeline components;
- Bulk storage of chemicals, fuels, and industrial consumables; and
- Secure handling, storage, and treatment of wastes pending final recycling, treatment, or disposal.

Warehouses, Storage and Pipe Yards, and Fabrication Facilities

In addition to the shorebases, which primarily will be supporting offshore pipeline installation, other onshore warehouses, storage and pipe yards, and fabrication facilities may be needed to support onshore pipeline installation. These facilities have not been specifically identified, but would be existing third-party facilities. Any new EEPGL-owned facilities required to support construction of the NGL Plant would be located at the NGL Plant site or at the temporary MOF site.

Fuel Supply Facilities

As mentioned above, vessel refueling will be coordinated through the shorebases. The Project will also require diesel fuel to support onshore construction activities, on-site generators, vehicles, and other equipment at the NGL Plant and along the onshore pipeline. Bulk deliveries of diesel and possibly other fuels to the NGL Plant and other locations along the pipeline will be provided by third-party suppliers. Diesel fuel deliveries will be by truck. Bunded fuel storage for construction will be located at the laydown area or the NGL Plant site.

Waste Management Facilities

Project wastes will be reduced, recycled, and reused where practicable, with the remainder being treated as needed and properly disposed. There are a limited number of facilities for the treatment of hazardous and industrial waste in Guyana, although the construction and proposal of additional such facilities are growing commensurate with the planned expansion of oil and gas activities. Tiger Rentals Guyana Inc. (TRG) and Sustainable Environmental Solutions (SES), both located at the Guyana Shorebase Inc. facility, are currently the primary providers of hazardous and non-hazardous waste treatment services in Guyana. TRG employs a variety of waste treatment technologies (sorting/segregation of recyclables, physical/chemical/thermal treatment of hazardous and non-hazardous wastes), discharges its treated fluids as permitted effluent to the Demerara River. In addition to TRG, several additional private waste management facilities have recently come online or are expected to come online in the near-term for hazardous (and non-hazardous) waste treatment. SES employs various hazardous and non-hazardous waste management technologies, including hot oil thermal desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing operations.

The HBL is government-owned and is operated by a third-party contractor. The HBL is the only engineered sanitary landfill in Guyana, and started operations in early 2011. The HBL is the current destination for most municipal and commercial solid non-hazardous waste generated from the greater Georgetown area, including wastes generated from the 25-plus Neighborhood Democratic Councils between Mahaica, the Seawall, Timehri, and Parika. Treated non-hazardous solid waste from the TRG facility—as well as other non-hazardous wastes received at TRG (including general waste, paper/cardboard, and scrap wood)—are disposed in the HBL. All non-hazardous solid wastes generated to date from EEPGL's projects have been disposed at the HBL.

Waste streams generated by the Project will be managed in accordance with the EEPGL Comprehensive Waste Management Plan (CWMP), which has been approved by the EPA (Volume III of the EIA).

Aggregate Quarries

A variety of aggregate materials (sand, loam, and various sizes of crushed stone) will be required for onshore construction activities. Large quantities of sand and loam are readily available in Guyana, and therefore, the Project will attempt to maximize the use of sand and/or loam for bulk backfill material, as these materials are expected to be readily available in Guyana. The remaining quantities of required aggregate that may not be readily available in Guyana (e.g., crushed stone) are expected to be brought in via barge from other countries in the Caribbean Community (CARICOM) region.

5.3.5.5. Logistics Support

The Project will use helicopters and marine and riverine vessels to provide logistics support throughout all Project stages. Logistical support will be optimized and shared among other EEPGL-operated facilities (e.g., Liza Phase 1, Liza Phase 2, Payara, and Yellowtail), as well as exploration drilling operations. Helicopters required for crew changes (e.g., to/from offshore pipeline installation vessels) are planned to be operated out of the Eugene F. Correia International Airport, as is currently being done for EEPGL's drilling and offshore operation activities. These flights will be routed directly offshore, avoiding flight paths over sensitive onshore areas such as schools and medical facilities. It is estimated that during offshore pipe installation, helicopter flights for the Project will be on the order of approximately two round-trip flights per week. In some cases, crew transfers may occur by marine vessel.

It is estimated that the Project will generate a variety of marine and riverine support vessel trips during construction. Support vessel activities will consist of the following:

- Multi-purpose vessels supporting subsea installation and maintenance activities;
- Multiple supply vessels conducting re-supply trips to the pipelaying vessel;
- Multiple vessels transporting material and equipment to the temporary MOF; and
- Vessels conducting vessel-to-vessel fuel bunkering.

The number of Project-related vessel trips between an overseas port and a Guyana shorebase is estimated at approximately 50 trips during the Construction stage to support importation of line pipe, equipment modules, and materials for construction. The frequency of Project-related vessel trips between a Guyana shorebase and an offshore pipelay vessel is estimated as approximately twice per week during the offshore portion of the Construction stage. The frequency of Project-related vessel trips between a Guyana shorebase and the temporary MOF is estimated as approximately eight to ten per week during the onshore portion of the Construction stage for site preparation, civil, and infrastructure (2023). During the equipment installation and hookup portions of the onshore Construction stage (2024), Project-related vessel trips between a Guyana shorebase and the temporary MOF are estimated to decrease to two to three per week. Use of support vessels during the Operations stage will be rare, as the only offshore facility will be the offshore pipeline, which requires little vessel support other than periodic inspection and maintenance, and the temporary MOF will ultimately be removed.

5.3.6. Associated Facilities

Associated facilities include facilities or activities that will not be operated by EEPGL and are not a component of the Project subject to the EIA, but are directly related to the Project; carried out or planned to be carried out contemporaneously with the Project; and are necessary for the Project to be viable and would not have been constructed, expanded or conducted if the Project did not exist (IFC 2012). Two facilities, both of which are related to the Power Plant, have been identified as meeting the definition of an associated facility and are described below and evaluated in Chapter 11, Cumulative Impacts.

5.3.6.1. Government of Guyana Power Plant

The Power Plant meets the definition of an associated facility as it is directly and significantly related to the Project, will be constructed contemporaneously with the Project, and is a facility without which the Project would not be viable at this time. The Power Plant would be built somewhere in the vicinity of the NGL Plant—presumed for the purpose of this EIA to be within 1 kilometer of the NGL Plant, although the exact location and design have not yet been finalized.

5.3.6.2. Substation and Transmission Line

The government's Power Plant will require electrical substation(s) and transmission lines to transmit power from the Power Plant to the Guyana electrical grid. At this time, the transmission line alignment, capacity, number of towers, and interconnection location with the grid are not known.

5.3.7. Design Codes and Standards

The following main design codes and standards will be used for the SURF and pipeline design supplemented by EEPGL Global Practices and Det Norske Veritas (DNV) Recommended Practices, as required:

- Risers:
  - American Petroleum Institute (API) Recommended Practice (RP) 1111
  - API RP 2RD
  - API STD 2RD
- Subsea structures:
  - API RP 2A
- Infield pipelines and offshore pipeline:
  - API RP 1111
- Onshore pipeline:
  - ASME B31.8

The NGL Plant will be designed to comply with all Guyanese codes, standards, and regulations, as well as applicable international design codes and standards. The design will be supplemented by EEPGL and contractor design specifications, as required. The following main design codes and standards will be used:

- ASME boiler and pressure vessel code
- API Standards 620, 650, 660, 661, 668, 662, 560, 534, 651
- ISO 16812, 13706, 15547, 9001, 14000
- ASME
- American National Standards Institute
- American Welding Society
- National Electrical Code
- ASTM International

Additional codes and standards may apply.

5.4. PROJECT STAGES

The Project life cycle will involve three primary stages:

- Construction
- Operations
- Decommissioning

Figure 5.4-1 shows the preliminary construction schedule, subject to receipt of environmental authorization. Construction will begin as soon as possible after receiving all necessary authorizations (with a target date of August 2022 for start of NGL Plant site preparation) and will take approximately 3 years. The combined offshore and onshore pipeline system is targeted to be ready to deliver rich gas by end of 2024, and the NGL Plant is targeted to be operational by mid-2025. The Project has a planned life cycle of at least 25 years.

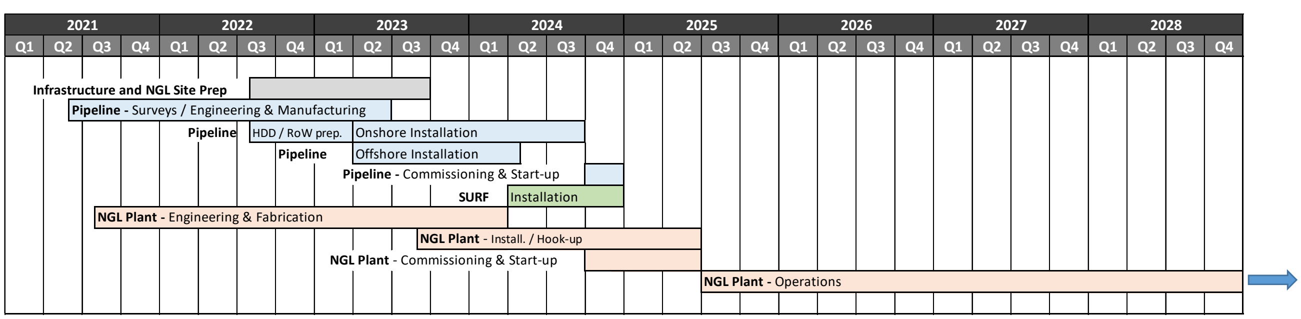


Figure 5.4-1: Preliminary Project Schedule

The three primary stages are described below.

5.4.1. Construction Stage

This section describes the proposed methods for the construction and installation of the new FPSO SURF facilities, offshore pipeline, onshore pipeline, and NGL Plant.

5.4.1.1. Subsea, Umbilicals, Risers, and Flowlines

The new SURF proposed as part of the Project will include the following components:

- PLETs and foundations
- SSCV structure and foundations
- Flow path isolation valves in the subsea system

All pipeline segments that tie into a subsea structure will be connected by a rigid or flexible jumper to a PLET structure (single or dual hub incorporating a "WYE"). These structures will provide a suitable connection hub for the jumper connections. The base case for the jumper connection system will be conventional rigid (steel pipe) with vertical facing hubs. However, horizontal jumper connections may be considered. All PLETs will have either suction pile or folded mud mat foundations suitably sized for local seabed conditions.

Holdback systems are often used to control the movement of the structures under environmental and operational loads and to control/mitigate the pipeline movements (thermal expansions and/or walking). However, based on the SURF / offshore pipeline FEED, holdback systems are not anticipated to be required for the Project's subsea structures due to the low thermal gradient. This will be further evaluated and confirmed during detailed design. If found to be required during detailed design, multiple types of holdback systems may be considered, including suction piles and pipe clamping mattresses.

5.4.1.2. Offshore Pipeline Construction Methods

The offshore pipeline will start at the single-hub PLET and will terminate at the shore landing, extending for a total length of approximately 195 kilometers. The water depths across which the offshore pipeline will traverse vary from approximately 1,400 meters to the shore. Table 5.3-2 lists the approximate offshore pipeline segment lengths relative to water depths.

Installation methods for the offshore pipeline will vary depending on the water depth. In deep water (greater than approximately 500-meter water depth), installation is likely to use a dynamically positioned (DP) J-lay installation vessel. At shallower depths, the S-lay installation method is likely to be employed, with a transition from a DP vessel to an anchor-moored pipeline lay vessel in the nearshore area (at the approximately 20-meter water depth). In water depths up to at least 20 meters, the offshore pipeline will be laid in a trench for protection purposes. Additional burial requirements beyond the 20-meter bathymetric contour will be further assessed and finalized in the detailed design phase. Multiple trenching techniques for pipeline burial will be evaluated, including both suction dredging and jet plowing methods. The trench will generally be allowed to backfill naturally, although bedding and rock protection layers may be required for the bottom and top portions of the trench, respectively. For the shore crossing segment, the pipeline may be installed using either HDD or open-cut trenching techniques. The extent of the HDD bore at the shore crossing is not anticipated to exceed 2 kilometers.

Marine Construction Vessels

Construction of the offshore pipeline and ancillary structures (PLETs and jumpers) will require a variety of types and sizes of vessels ranging from small day-use work boats to large supply and construction vessels. The primary vessels that will be used for offshore construction activities are described below:

- Pipelay Barge—a pipelay barge is a large (approximately 122 meters long by 37 meters wide) construction vessel that includes the facilities necessary to fabricate and lay the offshore pipeline either in previously excavated trenches or directly on the seafloor. An assembly line of welding, coating, and inspection stations will be set up on the pipelay barge deck. A near-horizontal ramp on the pipelay barge deck allows space for the welding stations, tensioners, a nondestructive examination station, and a field joint-coating station.
- Crane Barge—cranes mounted on barges will be used to lower and lift various facilities and equipment to and from the seafloor, including protective covers over ancillary facilities, as needed. Crane barges will be moored using anchors with mid-line buoys to keep the anchor cables from impacting the seafloor.

Logistical Support

It is estimated that during offshore construction and installation of the SURF and offshore pipeline, helicopter flights for the Project will be on the order of approximately two round-trip flights per week during the offshore portion of the Construction stage. The helicopters will be flown out of Ogle Airport and routed directly offshore, avoiding flight paths over sensitive onshore areas such as schools and medical facilities.

The offshore pipeline installation will generate a variety of marine support vessel trips during construction. Support vessel activities will consist of the following, and will average approximately two trips per week between a Guyana shorebase and the offshore construction spread:

- Multiple supply vessels conducting re-supply trips with pipe, equipment, and other materials to the marine construction vessels;
- Crew boats and barges to transport workers;
- Dive-support boats;
- Vessels to refuel the marine construction vessels; and
- Tug vessels to handle anchors and supporting marine construction vessels.

Offshore Pipeline Installation Methods

The offshore pipeline will be welded offshore using an installation vessel and then laid on the seabed from the offshore connection point with the FPSOs up to the approximately 20-meter bathymetric contour, where the nearshore segment begins. In the nearshore segment, the offshore pipeline will be trenched (either pre- or post-placement). In the last few kilometers near shore (the shore crossing segment), the offshore pipeline may be installed using HDD or open-cut techniques. The proposed offshore pipeline installation methods are described in further detail below.

Pipe Delivery

The offshore pipeline will be fabricated from 12.2-meter-long pipe joints. The pipe joints will be shipped by sea from a pipe mill manufacturer to an existing third-party shorebase in Georgetown. The pipe joints for HDD segments will include an abrasive-resistant exterior coating to protect the pipe during pull-back. After temporary storage at the shorebase, the pipe joints will be transported by barge from the shorebase to the offshore pipelay barge for fabrication and pipelay.

Pipe Bending, Stringing, Assembly, and Welding

The pipe typically will be delivered in straight sections. Pipe joints that require bending (e.g., to follow the natural grade of the seafloor in steeper sections or directional changes in the pipeline alignment) will be bent in the factory; no pipeline joints will be bent in the field or on the pipelay barge. Manufactured bends and prefabricated elbow fittings may be used in certain circumstances as needed.

After the pipe joints are brought to the pipelay barge, the ends of the pipe joints will be aligned end-to-end, or “strung” together, and then welded together using multiple passes, resulting in a full-penetration weld that produces continuous lengths known as “strings.” All welding will be performed according to applicable international standards and only qualified welders will be used during construction. Every completed weld will be examined by a welding inspector using radiographic or other approved methods to determine its quality. Radiographic examination is a nondestructive method of inspecting the inner structure of welds and determining the presence of defects. Welds that do not meet specifications will be repaired or the affected pipe section replaced. Following welding, the previously uncoated ends of the pipe joints will be treated in the field with a company- and industry-approved anti-corrosion coating. Before lowering the pipe, the pipe will be inspected electronically for faults or voids in the coating and will be visually inspected for scratches and/or other defects and any damaged areas will be repaired.

After several sections of the pipe are welded together and tested on the pipelay barge, the leading end of the pipeline will be lowered down to the seabed. As the pipeline is lowered, more joints will be welded on to the end as described above until the entire pipeline is fabricated and resting on the seafloor or in a seafloor trench.

General Pipelay Procedures

Installation methods for the offshore pipeline will vary depending on the water depth. In general, the pipelay barge will be moved via a tug to set up at pre-determined locations using conventional mooring or DP and will act as a platform for the welding and stringing of the pipe. Once the pipelay barge is positioned, winch wire from the crane barge will be attached to the pipe pull head on the pipelay barge. As the pipeline is fabricated, it will be slowly lowered over a ramp equipped with a pipe guide along the winch wire and into the water. The crane barge will use a winch wire to maintain tension on the pipeline profile in the water column, along with flotation buoys to prevent the pipeline from touching the seafloor until the entire pipeline segment is completed. Once the pipeline segment has been welded and properly located above the seafloor, the winch wire will be released to allow the pipeline segment to be lowered into place by the crane barge and tug assist. The crane barge will then be moved to the next position, and the pipelay barge will start fabricating the pipe string for the next section of pipeline. This process will be repeated for each offshore pipeline section. Specialized procedures for deep water, intermediate-depth water, shallow water, and nearshore pipelay are described below.

Specialized Deep-Water Pipelay Procedures

In deep water (greater than approximately 300-meter water depth), installation may use a DP J-lay installation vessel, which will lay the pipeline directly on the seafloor. In these depths, the pipeline will not be buried.

The term "DP" or "dynamically positioned" means that the location or position of the lay barge is maintained by the vessel's specialized propulsion and station-keeping system, which, instead of or in addition to the conventional propeller-rudder system at the stern, employs a system of hull-mounted thrusters near the bow, at midship, and at the stern. When in the station-keeping mode, these thrusters, which have the capability to rotate 360 degrees in a horizontal plane, are controlled by a shipboard computer system that usually interfaces with a satellite-based geographic positioning system.

The method is referred to as a J-lay because the configuration of the pipe as it is being assembled resembles a "J." Lengths of pipe are joined to each other by welding or other means while supported in a vertical or near vertical position by a tower and, as more pipe lengths are added to the string, the string is lowered to the ocean floor.

The pipelay barge includes a stinger, a structure that is attached to the deck that supports the pipe when it leaves the barge deck and helps support the pipe as it transitions from the barge deck to the seabed. The purpose of a stinger in the J-lay configurations is to change the angle at the top of the pipe to a vertical orientation. The orientation of the pipe at the surface does not have a large over-bend region and thus results in relatively small horizontal and vertical reactions on the stinger. The method is attractive as the bending stresses are low, the horizontal force required for station-keeping is within the capability of DP systems, and the use of modular towers allows derrick barges and moderately sized support vessels to be equipped for pipeline installations. Figure 5.4-2 provides a schematic of a J-lay arrangement.

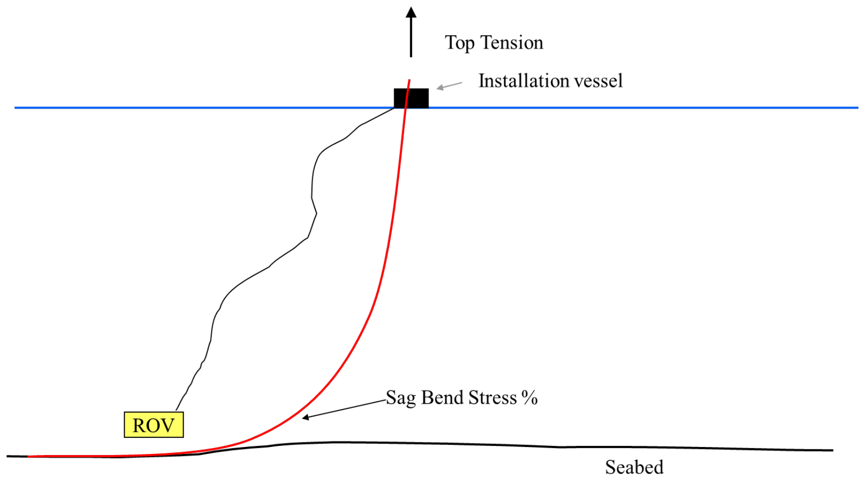


Figure 5.4-2: Schematic of J-Lay Arrangement

Specialized Intermediate-Depth Water Pipelay Procedures

In intermediate-depth water (water depths of approximately 300 to 20 meters), installation will use a conventional DP S-lay installation vessel. The base case in this water depth area is to lay the pipeline directly on the seafloor, without trenching. Figure 5.4-3 provides a schematic of an S-lay arrangement.

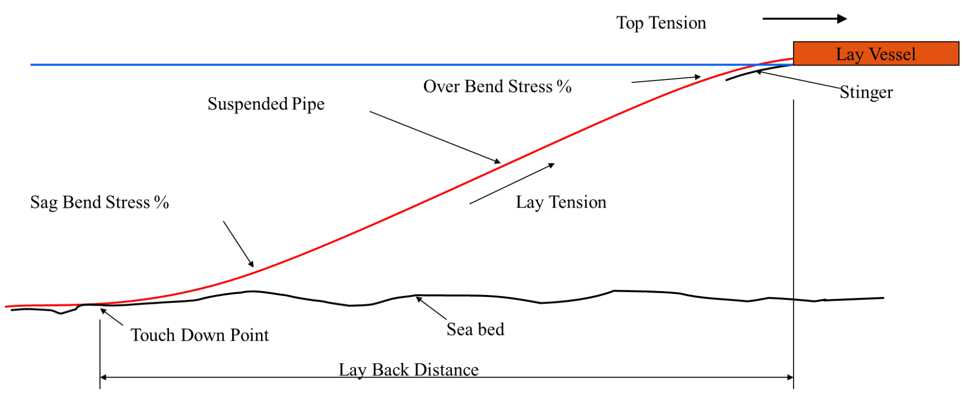


Figure 5.4-3: Schematic of S-Lay Arrangement

The method is referred to as the S-lay method because the profile of the pipe as it moves in a horizontal plane from the welding and inspection stations on the lay barge across the stern of the lay barge and onto the ocean floor forms an elongated "S." As the pipe moves across the stern of the lay barge and before it reaches the ocean floor, the pipe is supported by a truss-like circular structure equipped with rollers (the stinger). The purpose of the stinger in the S-lay configuration is to control the deflection of the pipe in the over-bend region above the pipe inflection point to return the angle of the pipe at the surface to the horizontal. The curvature radius of the stinger corresponds to at least the maximum bending stress. To avoid a bending moment peak at the last roller, the pipe must lift off smoothly from the stinger well ahead of the lower end of the stinger.

Specialized Shallow-Water Pipelay Procedures

Shallow-water construction (water depths between 20 and 1.6 meters) will be performed by an S-lay ultra-shallow water anchor-moored lay barge. For this segment, rather than using DP vessels, the installation vessel will be "conventionally moored," meaning that the location or position of the installation vessel (lay barge) will be maintained through anchors, associated anchor chains, and/or cables. In general, the larger the vessel, that is, the greater the target area presented to wind, wave, and current forces, and the heavier the vessel, the higher the holding requirements will be for the mooring system. The rated holding capacity of an anchor system is a function of the weight and size of the anchor and the tensile strength of the chain or cable that secures the anchor to the vessel.

For this segment, the pipeline will be laid in a trench with sufficient depth to have a minimum cover of 1.2 meters—to protect it from potential damage from vessels and anchors, and to reduce the potential for the pipeline to snag fishing nets and/or fishing lines. Typical trenching techniques are described below.

Specialized Nearshore Pipelay Procedures

Pulling/towing/floating pipeline strings using above-water tie-in welds will be used for the nearshore segment, in water depths less than 1.6 meters. As with the shallow water segment, the pipeline will be laid in a backfilled trench for protection purposes with sufficient depth to achieve a minimum cover of 1.2 meters.

Specialized Shore Crossing Pipelay Procedures

The shore crossing segment will be conducted using either HDD (base case) or open trenching. An HDD involves drilling a hole under a physical feature and installing a prefabricated pipe segment through the hole. The first step in an HDD is to drill a small-diameter pilot hole from one side of the crossing to the other using a drill rig. As the pilot hole progresses, segments of drill pipe are inserted into the hole to extend the length of the drill. The drill bit is steered and monitored throughout the process until the desired pilot hole had been completed. The pilot hole is then enlarged using several passes of successively larger reaming tools. Once reamed to a sufficient size, a prefabricated segment of pipe is attached to the drill string on the exit side of the hole and pulled back through the drill hole toward the drill rig.

Under the base case, HDD methodology will be used to install the offshore pipeline beneath the land-water interface at the shoreline and beneath shore protection features, with the drilling spread located onshore and a drilling exit pit located offshore, where the pipe will be welded on a shallow water installation barge in preparation for pull-back through the hole. At the HDD exit point on the seaward side of the bore, the contractor will typically excavate a transition pit to assist in the pipe-string "punch-out," so as to not have a sharp inclination of the pipe-string as it transitions from the bore to the seabed/trench. A water-based drilling mud will be used to complete the HDD boring. The drilling mud will be composed of approximately 65 percent water and 30 bentonite, a naturally occurring clay mineral that can absorb up to 10 times its weight in water. The remaining 5 percent will consist of additives such as barium sulfate (barite) and calcium carbonate (chalk), or hematite. The majority of the HDD tailings/cuttings and drilling mud will be returned to the onshore entry point area in the slurry containment and cutting settlement pit. An offshore exit pit is generally excavated to capture any potential residual material released during punch out.

Offshore Pipeline Burial Techniques

From a water depth of 20 meters to the shoreline, the offshore pipeline will be buried with at least 1.2 meters of cover through the use of plowing, jetting, and/or dredging methodologies, as follows:

- Jetting—jetting is a term used to describe a system that employs water jets to displace the sediments around and in front of a pipeline. The sediments are removed by air lifts, water eductors, or submersible pumps. The jetting device can be stabilized by skids that slide on the seabed or by buoyancy tanks on a machine that rolls along the pipeline. Water jetting involves either pulling a jet sled along the top of a pipeline after it has been laid on the seafloor or moving a jetting remotely operated vehicle through the water column along the specified route before or after laying the pipeline.
- Hydraulic Suction Dredging—hydraulic suction dredging works by suctioning up a mixture of sediment and water (known as slurry) from the seabed and then transferring the mixture through a pipeline to another location. This methodology essentially acts like a floating vacuum, removing sediment from the pipeline alignment. The two most common forms of hydraulic dredging used for pipeline trenching are cutter suction dredgers and trailing suction hopper dredges. Cutter suction dredgers use a rotating cutting head connected to a hydraulic suction to break up the soil on the seabed and then suction it up onto a spoils barge for discharge at adjacent locations. The cutter suction dredger excavates the trench with a rotating cutter head on the end of a ladder extended to the seabed. As the cutter head breaks the soil, it pumps the soil/water slurry through the pipe and through a discharge pipe. The end of the discharge pipe is typically located within a couple hundred meters from the dredge and is moved often to prevent excessive dredged spoil from accumulating in one area.

Both pre-trench and post-trench burial approaches are currently being considered. In the case of a pre-trench approach (or equivalent technique with trenching in parallel to pipelay), the seabed would be restored to the approximate preconstruction profile after pipeline installation through active backfilling by the construction team. In a post-trench approach, the pipeline cover and seabed restoration would be effected through natural backfilling.

Hydrostatic Testing

Once the offshore pipeline is in place, it will be subjected to hydrostatic testing to confirm its integrity. Hydrostatic testing involves filling the pipeline with water and pressurizing the water in the pipeline for several hours to confirm the pipeline's integrity. Due to lack of equipment and space available on the FPSO, hydrotesting equipment required to flood the pipeline is likely to be placed on another vessel alongside the FPSO. To enable hydrostatic testing, the vessel will tie into the pipeline by running hoses to the FPSO. Freshwater from the Demerara River or from one of the canals in the vicinity of the Direct AOI will be used for hydrotesting; this water may be treated with oxygen scavengers, corrosion inhibitors, and biocides prior to hydrotesting.

After hydrostatic testing is completed, the hydrotest water for the offshore pipeline will be discharged to the ocean at one of the PLETs (i.e., in water depth of approximately 1,400 meters). Additional drying of the pipeline may be needed after the hydrotest water is discharged. This process would involve running pigs with batch treatment to absorb the remaining water in the pipeline.

Commissioning

During commissioning, the offshore pipeline will be inerted by introducing low-pressure nitrogen gas, which will then be vented to the atmosphere. Associated natural gas will then be introduced from the FPSOs in preparation for startup activities. Once operational, the offshore pipeline will operate at a maximum operating pressure of 2,850 psig (196.5 barg).

5.4.1.3. Onshore Pipeline Construction Methods

This section describes the proposed methods for installing the onshore pipeline, which will extend approximately 25 kilometers from the shore landing beach valve at the shore crossing point.

Installing the onshore pipeline will generally be completed using sequential pipeline construction techniques, which include survey and staking; clearing and grading; trenching; pipe stringing, bending, and welding; lowering-in and backfilling; hydrostatic testing; commissioning; and cleanup and restoration. These construction techniques will generally proceed in an assembly-line fashion, and construction crews will move down the construction RoW as work progresses. Specialized construction methods, such as HDD, will be used to cross under certain areas, and specialized residential- and road-crossing methods will also be employed where appropriate.

The Project has identified six onshore pipeline access points and two primary temporary laydown areas; these areas will be used for storing pipe and other construction materials.

The subsections that follow describe typical onshore pipeline construction procedures.

Survey and Staking

After the Government of Guyana completes land or easement acquisition and before the start of construction, civil survey crews will stake the limits of the construction RoW, the centerline of the proposed trench, and other approved work areas. Property owners will be notified prior to surveying and staking activities. Survey crews will mark approved access roads using temporary signs or flagging and the limits of approved disturbance on any access roads. Other environmentally sensitive areas will also be marked where appropriate.

Clearing and Grading

Grading across the onshore pipeline RoW will be conducted to promote adequate drainage away from the pipeline. Prior to beginning ground-disturbing activities, the construction contractors will locate, identify, and flag existing underground utilities to prevent accidental damage during pipeline construction. Once this process is complete, the clearing crew will mobilize to the construction areas. Clearing will remove trees, shrubs, brush, roots, and large rocks from the construction work area and will level the RoW surface to allow operation of construction equipment. Vegetation will generally be cut or scraped flush with the surface of the ground, leaving rootstock in place where possible. Cleared vegetation and stumps will either be burned, chipped, or hauled off site for disposal at the HBL. Grading will be conducted where necessary to provide a reasonably level work surface.

During backfilling, subsoil will be returned to the trench first. Topsoil will follow such that spoil will be returned to its approximate original horizon. If the ground is relatively flat and does not require topsoil segregation or grading, the existing vegetation mat may be "peeled" and removed similar to topsoil and stockpiled along the RoW for use in restoration.

Temporary erosion controls will be installed along the construction RoW prior to initial disturbance of the soil and will be maintained in place until permanent erosion controls are installed or restoration is completed.

Trenching

For pipeline sections that will be constructed using open-cut methods, a trench will be excavated in segments along the RoW. Soil will be removed to create a trench, into which the pipeline will be placed. A rotary trenching machine, track-mounted excavator, backhoe, or similar equipment will be used to excavate the pipeline trench. The trench will be excavated to a depth that will provide space for sufficient cover over the pipeline. Typically, the trench will be deep enough to provide a minimum of 1.22 meters of cover over the top of the pipeline after backfilling. Excavations could be deeper in certain locations, such as at road and waterway crossings. Spoil material excavated from the trench will be temporarily piled within the RoW to one side of the trench.

Due to the shallow water table, the need for trench dewatering along the RoW is anticipated. Diesel-fueled pumps will be used to dewater the trench to allow safe and effective construction activity. All trench water will be discharged into upland areas or properly constructed dewatering structures to allow the water to infiltrate back into the ground. If trench dewatering is necessary in or near a waterbody, the removed trench water will be discharged into an energy dissipation/ sediment filtration device, such as a geotextile filter bag or straw bale structure, located away from the waterbody's edge—to prevent heavily silt-laden water from flowing into the waterbody.

Pipe Stringing, Bending, Welding, and Coating

Prior to the trench being excavated, the pipe will be strung along the trench. Stringing involves initially hauling the pipe by truck, generally in 12.2-meter lengths (referred to as "joints"), from laydown areas to the construction RoW. The Project has identified an approximately 10,000 square meter (m^2) laydown area located just north of Canal 1, which will be used for storing pipe and other construction materials (Figure 5.1-1). The shore crossing location and the NGL Plant site may also be used for laydown purposes.

The pipe will be offloaded from trucks and placed next to the trench using a side-boom tractor. The pipe will be delivered to the job site with a protective coating that will inhibit corrosion by preventing moisture from coming into direct contact with the steel.

Typically, several pipe joints are lined up end-to-end, or “strung,” to allow for welding into continuous lengths known as strings. Individual joints will be placed on temporary supports or wooden skids and staggered to allow room for work on the exposed ends. The pipe will be delivered to the laydown areas in straight sections. Some bending of the pipe may be required to enable the pipeline to follow the natural grade of the trench and to accommodate direction changes of the RoW. Selected joints will be bent by track-mounted hydraulic bending machines as necessary prior to line-up and welding. Manufacturer supplied induction bends may be used in certain circumstances as needed.

Following stringing and bending, the individual joints of pipe will be aligned and welded together. Every completed weld will be examined by a welding inspector to determine its quality using a radiographic or other approved method. Radiographic examination is a nondestructive method of inspecting the inner structure of welds and determining the presence of defects. Welds that do not meet the regulatory standards and the Project’s established specifications will be repaired or replaced.

Once the welds are completed, a coating crew will coat the area around the weld with additional epoxy or other coating before the pipeline is lowered into the trench. Prior to application, the coating crew will thoroughly clean the bare pipe with a power wire brush or sandblast machine to remove dirt, mill scale, and other debris. The crew will then apply the coating and allow it to dry.

The pipeline will be inspected electronically for faults or voids in the coating and will be visually inspected for scratches and other defects. The construction contractor will repair any damage to the coating before the pipeline is lowered into the trench.

Specialized tie-in crews will be used at some locations, such as at waterbody and road crossings and at other selected locations as needed. A tie-in is typically a relatively small segment of pipeline specifically used to cross certain features. Once the tie-in segment is installed across the feature, the segment is then welded to the rest of the pipeline.

Lowering and Backfilling

Before the pipeline is lowered-in, the trench will be inspected in an effort to remove rocks and other debris that could damage the pipe or protective coating. The pipeline will then be lowered into the trench by a series of side-boom tractors (tracked vehicles with hoists on one side and counterweights on the other) or backhoes, which will carefully lift the pipe and place it on the bottom of the trench. After the pipe is lowered into the trench, final tie-in welds will be made and inspected.

In rocky areas, padding material such as sand, approved foam, or other protective materials will be placed in the bottom of the trench to protect the pipeline. A padding machine may be used to reduce the likelihood that rocks mixed with subsoil do not damage the pipe. The padding will consist of subsoil free from rocks and will surround the pipe along the bottom, both sides, and at the top. Topsoil will not be used as padding material.

The trench will then be backfilled using the excavated material. All suitable material excavated during trenching will be re-deposited into the trench using bladed equipment or backhoes. A crown of soil about the width of the trench and up to 0.3-meter-high may be left over the trench to compensate for settling. Appropriately spaced breaks may be left in the crown to prevent interference with stormwater runoff. The soil will be inspected for compaction and scarified, as necessary. It is anticipated that no excess soils are to be generated from onshore construction of the pipeline.

Horizontal Directional Drilling Construction Method

The onshore HDD method will require an expanded construction RoW, nominally about 50 meters by 100 meters that will typically be centered on the existing construction RoW (typical 23 meters wide). Along straight pipeline sections, no additional pull areas are required as the pull area can remain within the RoW. Where the RoW changes direction, additional temporary pull areas may be required, depending on the length of the HDD crossing.

Depending on the substrate and HDD crossing length, drilling and pull-back can last anywhere from a few days to a few weeks. As described above, the HDD method uses a slurry referred to as drilling mud. The drilling mud will be pumped under pressure through the inside of the drill pipe and flow back to the drill entry point along the outside of the drill pipe. The purpose of the drilling mud is to lubricate the drill bit and convey the drill cuttings back to the drill entry point where the mud is reconditioned and reused in a closed circulating process. Drilling mud also forms a cake on the rock surface of the borehole, which helps to keep the drill hole open and maintain circulation of the drilling mud system. Because the drilling mud is pressurized, it can be lost, resulting in an inadvertent release or “hydrofracture,” if the drill path encounters fractures or fissures that offer a path of least resistance or near the drill entry and exit points where the drill path has the least amount of ground cover.

The potential for an inadvertent release is typically greatest during drilling of the initial pilot hole and decreases once the pilot hole has been completed. The volume of mud lost in such an instance would depend on several factors, including the size of the fault, the permeability of the geologic material, the viscosity of the drilling mud, and the pressure of the drilling system. A drop in drilling pressure (or loss of returns to the drilling rig altogether) will indicate that a release may be occurring, and the release may not be evident from the ground surface if the mud moves laterally. For a release to be evident, there must be a fault or pathway extending vertically to the surface. The migration of fluids could also occur horizontally, for instance in folded or fractured formations or in proximity to shallow groundwater such as perched aquifers/ seeps/springs. A release underground is typically more difficult to contain and is often addressed by thickening the drilling mud, stopping drilling all together, or continuing to drill past the fault or blockage to re-establish the borehole as the path of least resistance.

A total of 11 HDDs are expected, including two temporary pull areas, as summarized in Table 5.4-1 and illustrated on Figure 5.4-4.

Table 5.4-1: Summary of Proposed HDD Locations

Number	Purpose	Length (meters)	Temporary Pull Area or Access Area Required?
1	Crosses West Coast Demerara Public Road and Canal	20.6	Temporary Pull Area
2	Crosses Cogland Dam canal and another unnamed canal	485.1	No
3	Crosses 1 unnamed canal	766.9	No
4	Crosses 2 unnamed canals	426.2	Temporary Pull Area
5	Crosses 3 unnamed canals	266	No
6	Crosses Canal 1 and two unnamed roads	267.2	No
7	Crosses 3 unnamed canals	412.8	No
8	Crosses Canal 2 and Stanleytown Road and one unnamed road	265.6	No
9	Crosses 4 unnamed canals and two unnamed roads	669.3	No
10	Crosses 4 unnamed canals and two unnamed roads	556.2	No
11	Crosses 4 unnamed canals and three unnamed roads	803.9	No

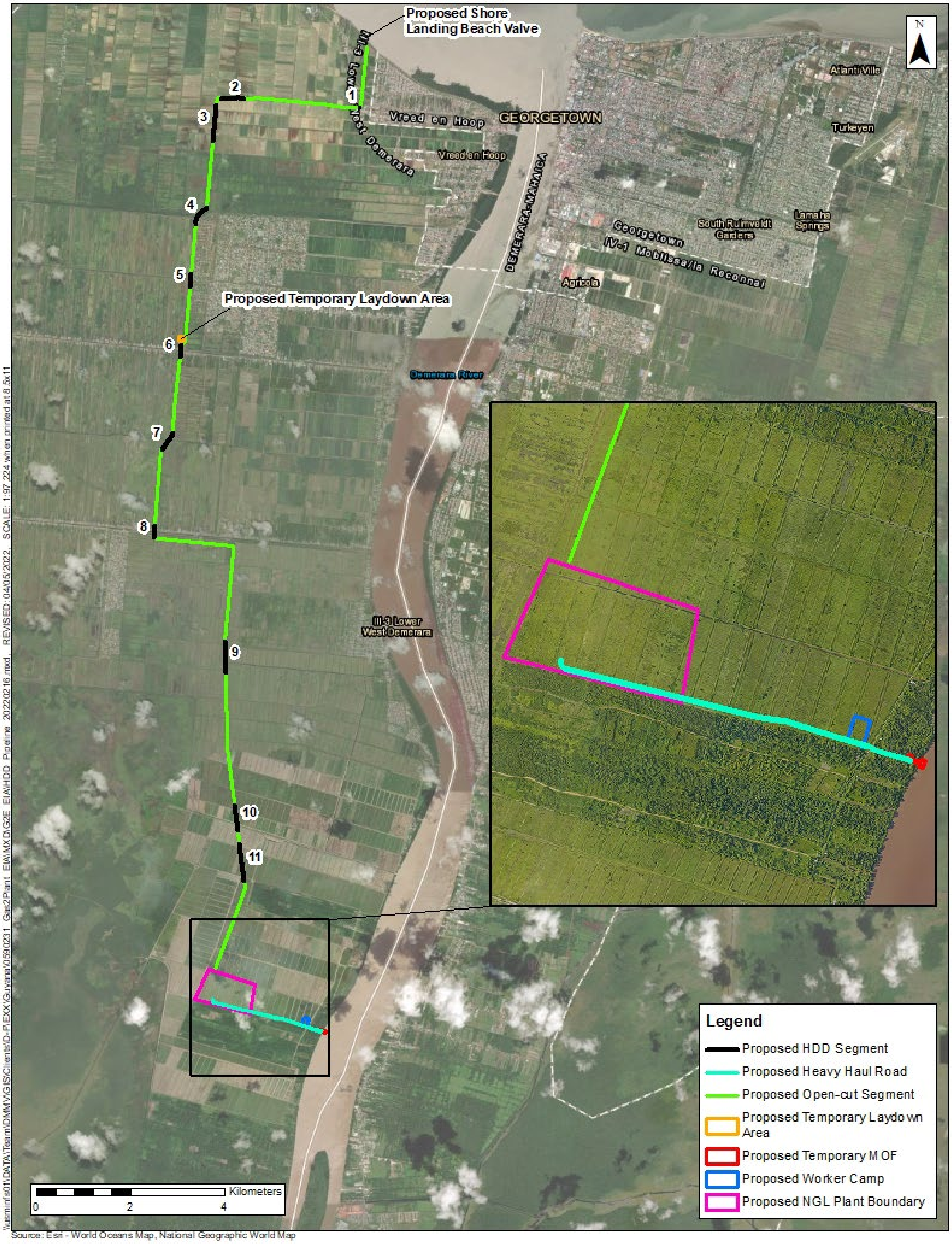


Figure 5.4-4: Location of Proposed HDDs along Onshore Pipeline Corridor

Residential Area Construction

Construction through or near residential areas will be done in a manner that reduces adverse impacts to the extent practicable and facilitates a prompt and thorough cleanup. Access to homes will be maintained, except for the brief periods when access limitations are needed to lay the pipeline.

Road Crossings

The construction contractor will use HDD techniques to install the pipeline under most public roads. This crossing method will allow uninterrupted use of the road throughout construction. Most private roads will be crossed by the open-cut method, which will require temporary closure of the road and the establishment of detours. Most open-cut road crossings require only a few days to complete.

Internal Pipe Cleaning and Hydrostatic Testing

After burial, the inside of the pipeline will be cleaned to remove any dirt, water, or debris inadvertently collected in the pipe during installation. A manifold will be installed on one end of the pipeline section and a cleaning pig (typically a large, soft, plug used to swab the inside of the pipeline) will be propelled by compressed air through the pipeline. After cleaning, the pipeline will be hydrostatically tested to confirm that the system is capable of withstanding the operating pressure for which it was designed. The testing will be done in segments. Any leaks will be repaired and the section of pipe retested until the required specifications were met. At the completion of the hydrostatic test, the pressure will be removed from the test section and the water will be released from the test section. A dewatering pig will be run to remove remaining moisture and condition the pipeline for commissioning.

Water for hydrostatic testing will be obtained from the Demerara River or from a canal. A screened intake will be used to prevent debris and limit entrainment of aquatic life. Water will be filtered prior to use for hydrostatic testing. Biocides may be added to the hydrostatic test water to prevent algal growth. The hydrostatic test water from the onshore pipeline will be discharged either to the ocean through the offshore pipeline (see above) or to the stormwater pond at the NGL Plant, pending ultimate discharge through the stormwater discharge structure.

Cathodic Protection

Cathodic protection is a technique to reduce corrosion (rust) of the pipeline through the use of an induced current or a sacrificial anode (such as zinc) that corrodes at a faster rate. The use of both an external protective coating and a cathodic protection system significantly reduces the corrosion rate compared to unprotected or partially protected pipe.

Commissioning

Commissioning involves verifying that equipment has been properly installed and is working to design specifications, verifying that controls and communications systems are functioning, and confirming that the pipeline is ready for service. In the final step, the pipeline will be hydrotested and dried, as discussed above, before introducing natural gas.

5.4.1.4. NGL Plant Construction Methods

Construction of the NGL Plant will require typical civil construction activities, including site preparation (e.g., clearing, grading), drainage and utility work (e.g., installing storm drain, water, sewer, communication lines), foundations, aboveground construction (e.g., vertical construction, electrical, mechanical, plumbing), and installation of security facilities, as described in more detail below.

Site Preparation

The initial step in NGL Plant construction will be installing appropriate erosion and sediment control facilities in and around the area of planned disturbance. With these facilities in place, the construction team will clear the site of vegetation, roots, and rock. This material will be used for soil stabilization, chipped, or hauled to the HBL for disposal.

The NGL Plant is located in a low-lying area that may be subject to localized flooding. The overall NGL Plant site will be raised approximately 2 meters by bringing in fill material and additional soil improvements. The Project will seek to maximize the use of sand and/or loam for bulk fill material, as these materials are expected to be readily available in Guyana. Remaining aggregate that is not readily available in Guyana (e.g., crushed stone) is expected to be brought in via barge from other countries in the CARICOM region.

Rough grading at the site will be performed to provide a level (surface-draining) working surface with sufficient bearing capacity for construction activities. Grading across the site will be conducted to promote adequate drainage (minimum 1 percent for permanent facilities; 1 to 2 percent for construction laydowns). The specific geotechnical design across the site will differ between areas intended to support building foundations and those without buildings, as described below.

NGL Plant foundation areas will be constructed following the steps below:

- Step 1: Dewatering secondary drainage canals into primary drainage canals and low-lying site areas, while installing temporary drainage (e.g., grading, swales, ditches) that will prevent the collection of water during remainder of rough grading;
- Step 2: Stripping unsuitable soil materials (assumed to be to depth of 0.3 meter below ground surface;
- Step 3: Installing geocell mattress with crushed rock to an elevation of 2 meters above ground surface; and
- Step 4: Installing wick drains, to induce settlement, and crushed rock to an elevation of 2.8 meters above ground surface.

NGL Plant non-foundation areas will be constructed following the steps below:

- Step 1: Dewatering by installing temporary drainage;
- Step 2: Stripping unsuitable material (assumed to be to depth of 0.3 meter below ground surface and backfilling with soil mix (i.e., soil mixed with 3 percent quicklime and 12 percent cement) and rock geocell to an elevation of 2 meters above ground surface; and
- Step 3: Backfilling with fill to an elevation of 2.8 meters above ground surface.

Drainage and Utility Work

During construction, stormwater will be managed to minimize potential erosion from the site that could impact drainage canals near the site. Stormwater will be collected and routed to a stormwater pond. The stormwater pond will have an outfall that discharges to existing irrigation canals to the north and south of site that empty into the Demerara River.

Construction power will be provided by diesel generators, which will be fueled from a 2,000-gallon diesel storage tank on the NGL Plant site. Temporary diesel generator power will be used until hook-up to power from the national grid is established.

Laying Foundations

NGL Plant components and buildings will be modularized to the extent possible and placed on pile cap foundations. These foundations will be constructed using piles that will be driven into the ground using vibratory or driving equipment from a crane or excavator. The formwork and steel rebar placement before concrete pours will be completed on site. Concrete for pile caps and building foundations will come from a temporary concrete batch plant that will be operated at the site, or from mobile batch plant trucks sourcing from a local concrete plant. During pile driving activities, underground ducts and plumbing piping for water and sewage will be laid out and installed.

Aboveground Vertical Construction

Most of the NGL Plant buildings will be modularized. The prefabricated modules will be shipped to Guyana by sea, and transferred to barges that will transport the modules to the temporary MOF. The modules will be offloaded at the temporary MOF onto trucks and transported along the heavy haul road to the NGL Plant site. The modules will be self-contained with base frame or other supporting structure composed of built-up plate girders and rolled sections. The base frame will provide support for equipment and piping. Once at the NGL Plant site, the modules will be lifted and placed onto the pile cap foundations.

Occupied and/or critical buildings will be designed with blast resistant materials.

Security Measures

Security measures, including but not limited to anti-cut/anti-climb security fencing, a Genetec-based access control and video monitoring system, hardened shelters within certain buildings, appropriate lighting, camera coverage and the use of security personnel, will be installed to prevent unauthorized access to the site.

Commissioning

Commissioning activities will follow construction, including static and dynamic NGL Plant equipment testing, instrumentation and electrical connection testing, inerting, function tests, and introduction of the natural gas stream in preparation for facility startup.

5.4.1.5. Temporary Material Offloading Facility Construction Methods

The temporary MOF will be installed to support the receipt of NGL Plant modules, heavy equipment, and large quantities of bulk aggregate required for NGL Plant site construction activities. The temporary MOF will include a conveyor system to support the receipt and stockpiling of aggregate.

Construction will consist of driving steel-pipe piles to design depths, connecting piling system with a series of steel beams, and installing pre-cast concrete decking on top of steel structure. Mooring dolphins and connecting aluminum walkways will also be supported by steel-pipe pile structures. Concrete for the temporary MOF pier structure will be sourced from the on-site batch plant or from local sources. Foundations installed in the same manner discussed above may be installed at the temporary MOF site.

Operation of the temporary MOF will require some dredging to allow the barges to travel from the main river channel to the pier, and to allow for barge maneuvering while at the temporary MOF (i.e., a turning basis). Dredging at the temporary MOF is estimated to require the removal of approximately 40,000 to 50,000 m^3 of dredged material.

5.4.1.6. Post-Construction Cleanup and Restoration

After the completion of construction for each of the Project components (i.e., offshore and onshore pipelines, NGL Plant, temporary MOF), each construction contractor will clean up and restore their affected areas as follows:

- Dismantle and remove all remaining contractor equipment, surplus materials, rubbish, debris, waste, and all temporary facilities from the site for reuse, recycling, or disposal at a company-approved disposal facility;
- Repair any infrastructure damaged during the work (e.g., roads, fences);
- Complete re-grading, slope stabilization, and revegetation of disturbed areas and restore natural drainage patterns;
- Restore disturbed areas to their preconstruction condition;
- Test topsoil and subsoil for compaction at regular intervals in agricultural areas disturbed by construction activities, and plow any severely compacted agricultural areas;
- Spread stockpiled vegetation and mulch back across the RoW;

- Spread large shrubs and trees cut during clearing across the RoW to impede vehicular traffic and other unauthorized access, or haul away for disposal;
- Install markers showing the location of the pipeline along the RoW to identify the owner of the pipeline, warn against unauthorized disturbance, and provide emergency contact information;
- Remove access improvements after construction, and restore affected roads to their preconstruction condition unless the landowner requests that the improvements be left in place;
- Engage with property owners, repair any damage to personal property, and address any claims for settlement; and
- Return land used for temporary access to its owner.

Following construction, EEPGL will inspect the restoration and revegetation of all areas disturbed during construction.

5.4.2. Operations Stage

Operation and maintenance considerations for the proposed facilities are described below.

5.4.2.1. Pipeline Operations and Maintenance

Once in operation, the offshore and onshore pipelines will require inspection, maintenance, and (as necessary) repair. EEPGL has designed the offshore pipeline to operate in the marine environment and to accommodate potential stresses associated with tropical storm events. Periodic inspections will be conducted to verify that adequate burial depth is maintained over the buried portion of the pipeline. EEPGL will use the results of post-construction surveys to develop an offshore pipeline inspection schedule for the operating life of the Project.

For the onshore pipeline, periodic ground inspections by pipeline personnel will be conducted to assess for soil erosion that may expose the pipe, dead vegetation that may indicate a leak in the line, conditions of the vegetative cover, unauthorized encroachment on the RoW (e.g., buildings and other substantial structures), and other conditions that could present a safety hazard or require preventive maintenance or repairs.

The offshore and onshore pipelines will be designed and constructed to accommodate inspection using in-line inspection tools known as “pigs.” These internal inspections will be capable of detecting internal and external damage to the pipeline. Each FPSO has one pre-installed pig launcher and the NGL Plant receiving facility will have one pig receiver.

Maintenance pigging and intelligent pigging[4] will be conducted for the pipeline for both corrosion control and flow assurance. The gas will be dehydrated at the FPSOs to prevent hydrate formation and corrosion. Formation water is thus not expected to be present in the gas

[4] Intelligent pigging is an inspection technique whereby an inspection probe, often referred to as a "smart" pig, is propelled through a pipeline while gathering data, such as the presence and location of corrosion or other irregularities on the inner walls of the pipeline.

stream. In normal operations, no hydrate blockage, corrosion, or scale deposition is expected. Maintenance pigging of the main export line will likely be conducted once per year to clean the line. Maintenance pigging of the minor branches (Unity FPSO to subsea PLET or Destiny FPSO to subsea PLET) will be conducted in the instance where an operational upset resulting in water drop-out occurs. Intelligent pigging will be conducted on regular intervals to assess and confirm the integrity of the pipeline.

EEPGL will also periodically monitor and inspect the cathodic protection systems to provide adequate corrosion protection of the facilities. Supervisory Control and Data Acquisition systems will be employed to monitor operations. The offshore pipeline will be equipped with automatic and manual shutdown systems that will be activated in the event of a pipeline leak or equipment failure. In addition, there will be Atmos Pipe leak detection system technology integrated with the onshore instrumentation, control, and safety systems by monitoring pipeline flow and pressure measurements across the offshore and onshore facilities to indicate leaks along the pipeline.

So that the public is aware of the location of the pipeline RoW and to facilitate inspections and emergency response, if necessary, EEPGL will maintain the vegetation within the permanent RoW as herbaceous cover. Maintenance will include selectively cutting and remove trees within the permanent RoW to maintain pipeline integrity.

5.4.2.2. NGL Plant Operations and Maintenance

The NGL Plant will receive a rich gas feed from the FPSOs via the offshore and onshore pipelines. The rich gas will be treated to remove mercury. Next, the gas will be fed to a dehydration unit to remove water. The gas will then be processed in an NGL Recovery Unit to cool the stream and separate the C1 and C2 from C3, C4, and C5+. The NGL Recovery Unit will consist of a turboexpander, de-ethanizer, depropanizer, and debutanizer. The resulting C1/C2 gas stream will be sent to the Power Plant, while the NGLs will be fractionated into saleable C4, C3, and C5+ and sent to temporary on-site storage tanks. Truck loading facilities will be provided to allow for the sale of the NGL products to market. Figure 5.4-5 summarizes the NGL Plant gas processing system.

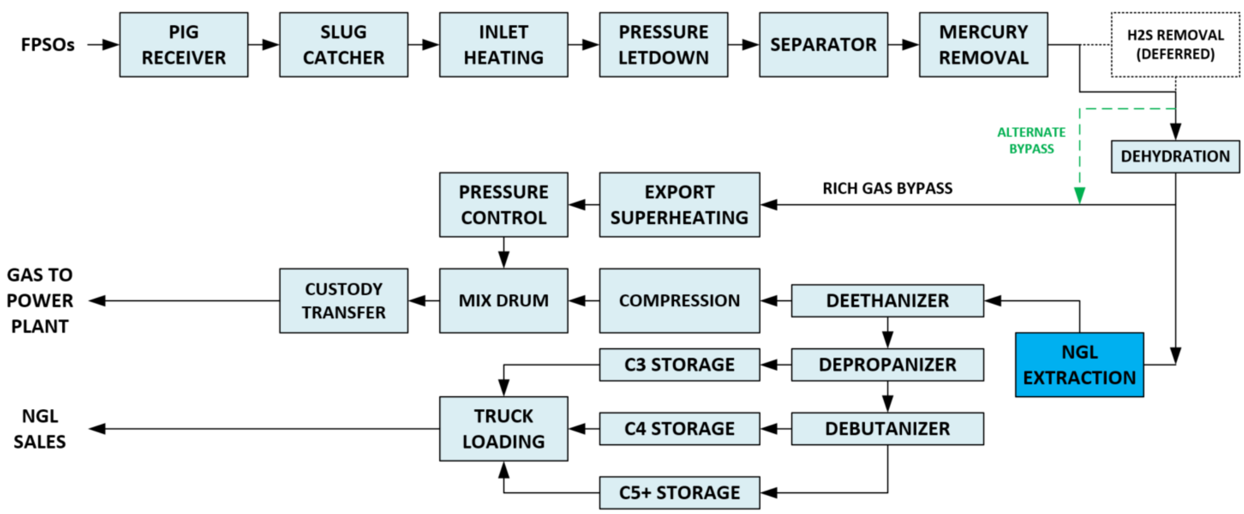


Figure 5.4-5: Overview of the NGL Gas Processing System

The NGL Plant will process approximately 50 MMscfd (1.4 MMsm^3/d) of natural gas and separate approximately 617 m^3 [5] per day of NGLs from the gas stream for sale to third parties, as follows:

- C3—326 m^3 per day
- C4—194 m^3 per day
- C5+—97 m^3 per day

A communication and controls network will be established between the NGL Plant and the Integrated Operations Center at the EEPGL Guyana Office Complex to enable high-bandwidth, low-latency connectivity between the NGL Plant and offshore FPSOs, and provide remote real-time surveillance.

The NGL Plant will be a continuous operation staffed 24 hours per day with two 12-hour operations shifts and one 8-hour maintenance day shift. Facility staffing is estimated to be around 40 FTE employees and contractors working at the facility.

The NGL Plant will have a dedicated maintenance crew for routine maintenance. A maintenance program will be established to manage preventive and corrective maintenance activities to minimize facility downtime. A facility integrity management system will be established; this is a primary driver for inspections of vessels, piping, and equipment that cannot be completed while the facility is online.

5.4.3. Decommissioning Stage

The NGL Plant is expected to have a life expectancy of at least 25 years. This life expectancy could be extended with appropriate maintenance and necessary equipment replacement/rehabilitation. A Preliminary Decommissioning Plan is included in Volume III of the EIA. As the time of decommissioning approaches, EEPGL will develop a more detailed

[5] Subtotals are based on 50 MMscfd (1.4 MMsm^3/d) gas production.

decommissioning plan, in consultation with appropriate Guyanese regulators. EEPGL will perform inspections, surveys, and testing to assess the then-current facility conditions, which will provide the basis and required information to prepare a more detailed decommissioning plan. As part of that planning process, EEPGL will perform comparative assessments of decommissioning options for the various facility components. Where there may be multiple decommissioning options, including facility components left in situ, the assessments will assist in arriving at the final decommissioning recommendation.

5.4.4. EEPGL Quality Control Process Overview

The objective of EEPGL's quality control process is to provide quality assurance oversight of the engineering, procurement, and construction contractors who will support the Project. The contractors themselves are responsible for the quality of the components and equipment. EEPGL processes will be used to oversee contractor activities and monitor that they are following the Project-approved procedures. Audits, assessments, and verifications are the main processes used for oversight.

5.4.4.1. Project Quality Management System

The Project Quality Management System consists of four main documents:

- Project Quality Plan
- Engineering Surveillance Plan
- Procurement Surveillance Plan
- Construction Surveillance Plan (CSP)

Additionally, there will be a focus on quality assurance / quality control activities in the following areas:

- Inspections at suppliers' facilities during equipment fabrication
- Surveillance during equipment preservation
- Internal assessments during fabrication

Additional detail on the four above-referenced documents is provided below.

5.4.4.2. Project Quality Plan

Each EEPGL project has a project-specific Project Quality Plan that outlines the requirements and expectations of the Project team. This document outlines the plans and procedures to be used on the Project. The detailed activities are listed in the plans themselves.

5.4.4.3. Engineering Surveillance Plan

The Engineering Surveillance Plan is the document used by the engineering team to conduct assessment and verification of contractors' engineering activities. Periodic assessments are carried out by the package engineers of the design and quality control processes and the suitability of contractor's design tools. Engineering verification includes review of engineering products to confirm that engineering deliverables, including supplier designs, adhere to specifications, regulations, codes, and good international industry practice. In some cases, such as milestone design reviews and independent design verification, the contractor may have assigned responsibility and the Project team can reference the contractor's program.

5.4.4.4. Procurement Surveillance Plan

The Project Surveillance Plan outlines the oversight activities to be conducted by the quality team over all procured equipment. Workshops are held by contractors and EEPGL to determine the criticality of each component; this determines the amount of inspection oversight carried out by EEPGL. Each individual engineering/procurement site will prepare a site-specific or contract-specific Project Surveillance Plan that incorporates program requirements. Assessment activities, which will be used to monitor contractors and suppliers and associated work products, will include the following:

- Review Non-Conformance and Corrective Action Reports;
- Confirm contractor internal processes are followed;
- Confirm adequate quality and regulatory certification requirements;
- Confirm adherence to inspection/testing requirements; and
- Confirm adherence to access and notification requirements.

Verification activities are product-based activities that are carried out at supplier/fabrication facilities. This includes oversight of the supplier and the contractors' inspection teams. Deviations from specifications are documented and dispositions are tracked to completion.

The results of assessments and verifications will be documented in a manner that identifies any deficiencies or quality issues, assigns action, and resolves the deficiencies/issues.

5.4.4.5. Construction Surveillance Plan

A CSP is designed to assess contractor and subcontractor processes and activities and to verify their work products. Each individual construction site will prepare a site-specific or contract-specific CSP that incorporates program requirements. Assessment activities will include the following:

- Initial assessment of contractor plans, procedures, and Inspection and Test Plans to determine if they convey suitable work processes, include all necessary components, and comply with contract requirements; and
- Periodic assessments to determine if the contractor is complying with the plans and procedures. These may be performed with the contractor or independently and may use various methods such as surveillance checklists or formal audits.

Verifications of work products will confirm that deliverables are in accordance with construction drawings and instructions. The Project team is also responsible for witnessing fabrication and testing to the degree necessary to assure that the final product is in compliance with Project specifications.

5.4.4.6. Internal and External Auditing

The Project will implement an integrated audit program by combining resources with the contractors and participating in their respective audit programs. This approach will eliminate the redundancy of two separate audit programs. All audit schedules will be submitted to EEPGL for approval. Project audit participants will review and/or participate in the development of all audit checklists and questionnaires. This integrated approach does not eliminate EEPGL's ability to conduct audits independently.

5.5. PROJECT MATERIALS, EMISSIONS, DISCHARGES, WASTES, NOISE, AND TRAFFIC

The Project will require various materials to operate and will result in the release of various air emissions, effluent discharges, waste generation, noise emissions, and increases in traffic. These aspects of the Project are described below and their associated impacts evaluated in the EIA.

5.5.1. Project Materials

5.5.1.1. Construction Stage

Construction stage activities will require various chemicals, as described below:

- Diesel fuel—will be used to fuel onshore construction equipment. A diesel fuel tank will be installed at the NGL Plant site to support construction at the site. Mobile fueling units will be used to support construction along the onshore pipeline corridor.
- Marine gas oil—will be used to offshore construction equipment.
- Pipe coating materials—polyethylene and dual-layer fusion-bonded epoxy will be applied to the onshore pipeline during installation.
- Drilling mud—will be used to complete HDD borings.
- Hydrotesting chemicals—corrosion inhibitor, biocide, and oxygen scavengers, and hydrate inhibitors will be applied to hydrotest water.
- Solvents—will be used to remove pipe coating.
- Welding gases—will be used for pipeline joint welding.
- Nitrogen—will be used for pipeline inerting and packing.

5.5.1.2. Operations Stage

Operations of the NGL Plant will require various liquid and solid chemicals, as described below:

- Diesel fuel—diesel fuel will be needed during operations for the startup of the NGL Plant and to power the backup generator. A diesel fuel tank will be installed at the NGL Plant and this will be sufficient to meet the power requirements of the NGL Plant for up to 2 days.
- Hot oil—will be used as a heating medium for NGL Plant processes.

- Lube oil—will be used a lubricant for moving equipment in the NGL Plant.
- Methanol—will be used as an anti-hydrate in the NGL process.
- Miscellaneous materials—include engine coolants, lubricating oils, direct current batteries, CO2, nitrogen, various chemical additives, standard gases for chemical lab and gas chromatograph, and welding gas.

As described in more detail in Section 5.5.3, Effluent Discharges, the NGL Plant will have a wastewater treatment facility. This facility will require the following chemicals:

- Chlorine—will be used as part of the disinfection process for domestic wastewater treatment; and
- Flocculants—will be injected into the process wastewater stream prior to routing oily water to the Clarifier Tank to bind solid particles and facilitate removal.

All liquid chemicals will be stored in tanks in a secure area and each tank will have secondary containment equal to 100 percent of the storage volume of the tanks within the enclosure (Table 5.5-1).

Table 5.5-1: Liquid Chemical Storage Characteristics

Chemical	Preliminary Storage Tank Volume	Storage Tank Materials	Storage Tank Pressure
Diesel	1 x 63 m^3	Carbon steel	Atmospheric
Hot oil	1 x 34 m^3	Carbon steel	Atmospheric
Lube oil	Multiple storage drums	Drum material	Atmospheric
Methanol	1 x 38 m^3	Carbon steel	Atmospheric
Chlorine (Hyprochlorite)	Multiple storage drums	Drum material	Atmospheric
Flocculants (Polyaluminum chloride)	Multiple storage bags	Bag material	Atmospheric

Dry chemicals to be used at the NGL Plant will include various catalysts used for natural gas processing, including the following (Table 5.5-2):

- H_2S Removal Media—a fixed-bed absorbent containing mixed metal oxide in engineered granules to remove H_2S from the natural gas to meet Power Plant delivery specifications;
- Mercury Removal Media—a fixed-bed absorbent containing mixed metal oxide in engineered granules to remove mercury from the natural gas to meet Power Plant delivery specifications; and
- 3A Molecular Sieve—a synthetic crystalline aluminosilicate, which comes in the form of a dry bead, used for the drying of gases.

Table 5.5-2: Preliminary Catalyst Bed Characteristics

Catalyst/Solid Media	Bed Volume	Catalyst Life @ Max Concentration	Function	Details
H_2S Removal Bed (Puraspect 1039 or 1065)	77.59 m^3/bed	6 months	Prevents corrosion	Current site data indicate that the H_2S inlet concentration will not reach the maximum concentration until later in the life of the Project. The catalyst will not need to be replaced until completely spent. Beds will be arranged in a configuration such that one is ready to be used and one is a spare, so that the switch can be made when outlet concentrations limits are not being met.
Mercury Removal Bed (Puraspec 1194)	1.47 m^3	>10 years	Prevents corrosion	Single bed configuration due to the life expectancy of the bed (expected to be more than 10 years). When changeout is required, the stream will bypass the beds during the catalyst loading and unloading operations.
3A Molecular Sieve	80.88 m^3/bed	4–5 years	Dehydration	Under normal operation, one of the adsorbers is treating the wet gas, and one adsorber is being thermally regenerated to desorb the compounds that were loaded during the adsorption steps.

5.5.2. Air Emissions

5.5.2.1. Construction Stage

A summary of the estimated emissions to air from activities during the Construction stage is provided in Table 5.5-3.

Table 5.5-3: Summary of Estimated Construction Stage Emissions from Fuel Combustion

Pollutant	Project Component	Estimated Emissions (tonnes)
Nitrogen oxides (NO_x)	Offshore Pipeline	3.81
	Onshore Pipeline	0.33
	NGL Plant, Heavy Haul Road, Temporary MOF	1.28
	Total	5.42
Sulfur dioxide (SO_2)	Offshore Pipeline	39.63
	Onshore Pipeline	21.43
	NGL Plant, Heavy Haul Road, Temporary MOF	72.68
	Total	133.73

Pollutant	Project Component	Estimated Emissions (tonnes)
Particulate matter (PM)	Offshore Pipeline	15.89
	Onshore Pipeline	2.21
	NGL Plant, Heavy Haul Road, Temporary MOF	11.94
	Total	30.05
Carbon monoxide (CO)	Offshore Pipeline	1.95
	Onshore Pipeline	0.47
	NGL Plant, Heavy Haul Road, Temporary MOF	1.46
	Total	3.88
Non-methane volatile organic compounds (VOCs)	Offshore Pipeline	47.75
	Onshore Pipeline	25.82
	NGL Plant, Heavy Haul Road, Temporary MOF	87.57
	Total	161.13
GHGs (kilotonnes carbon dioxide-equivalents)	Offshore Pipeline	45.46
	Onshore Pipeline	1.62
	NGL Plant, Heavy Haul Road, Temporary MOF	10.17
	Total	57.25

5.5.2.2. Operations Stage

The Project will generate air emissions during operations from the following sources:

- Routine Sources
  - Various fugitive emissions
  - Hot Oil Heater
  - Molecular Sieve Regeneration Heater
  - Flare purge/pilot
- Non-routine Sources
  - Flaring from temporary upsets and maintenance (e.g., pigging, blowdown)
  - Gas-freeing of process equipment during maintenance (e.g., during catalyst change-outs for mercury, H_2S, and molecular sieve beds)
  - Storage bullets venting
  - Loading rack venting
- All other vents (diesel, slop system, chemical storage, etc.)
- Diesel engine (essential and emergency generators)

Table 5.5-4 provides estimates of Operations stage emissions from the above sources.

Table 5.5-4: Summary of Estimated Project Operations Stage Emissions

Pollutant	Source Category	Hours of Operation per Year	Lower-end Scenario	Higher-end Scenario
			Estimated Maximum Annual Emissions (tonnes)	
Nitrogen oxides (NO_x)	Hot Oil Heater	8,760	1.02E+01	1.02E+01
	Molecular Sieve Regeneration Gas Heater	8,760	6.70E-01	6.70E-01
	Flaring (safety and non-routine from cold and wet flare)	8,760	2.03E+01	2.03E+01
	Blowdown Event Flaring [b]	132	NA	7.23E+00
	Essential Generator [b]	72	7.17E+00	7.17E+00
	Emergency Generator [b]	72	6.59E-01	6.59E-01
	Total		3.90E+01	4.62E+01
Sulfur dioxide (SO_2)	Hot Oil Heater	8,760	1.55E-01	1.55E-01
	Molecular Sieve Regeneration Gas Heater	8,760	1.28E-02	1.28E-02
	Flaring (safety and non-routine from cold and wet flare)	8,760	2.25E+00	2.25E+00
	Blowdown Event Flaring [b]	132	NA	1.56E+00
	Essential Generator [b]	72	2.41E-01	2.41E-01
	Emergency Generator [b]	72	1.60E-02	1.60E-02
	Total		2.67E-00	4.23E+00
Particulate matter (PM) [a]	Hot Oil Heater	8,760	1.56E+00	1.56E+00
	Molecular Sieve Regeneration Gas Heater	8,760	1.00E-01	1.00E-01
	Flaring (safety and non-routine from cold and wet flare)	8,760	0.00E+00	0.00E+00
	Blowdown Event Flaring [b]	132	NA	0.00E+00
	Essential Generator [b]	72	1.35E-01	1.35E-01
	Emergency Generator [b]	72	4.87E-02	4.87E-02
	Total		1.84E+00	1.84E+00
Carbon monoxide (CO)	Hot Oil Heater	8,760	1.71E+01	1.71E+01
	Molecular Sieve Regeneration Gas Heater	8,760	1.12E+00	1.12E+00
	Flaring (safety and non-routine from cold and wet flare)	8,760	8.42E+01	8.42E+01
	Blowdown Event Flaring [b]	132	NA	2.99E+01
	Essential Generator [b]	72	1.91E+00	1.91E+00
	Emergency Generator [b]	72	1.42E-01	1.42E-01
	Total		1.04E+02	1.34E+02

Pollutant	Source Category	Hours of Operation per Year	Lower-end Scenario	Higher-end Scenario
			Estimated Maximum Annual Emissions (tonnes)	
Greenhouse gases (GHGs) (kilotonnes carbon dioxide-equivalents)	Hot Oil Heater	8,760	2.46E+01	2.46E+01
	Molecular Sieve Regeneration Gas Heater	8,760	1.62E+00	1.62E+00
	Flaring (safety and non-routine from cold and wet flare)	8,760	3.95E+01	3.95E+01
	Blowdown Event Flaring [b]	132	NA	1.44E+01
	Essential Generator [b]	72	8.20E-04	8.20E-04
	Emergency Generator [b]	72	1.50E-07	1.50E-07
	Total		6.57E+01	8.00E+01
Non-methane volatile organic compounds (VOCs)	All Sources	8,760	1.53E+02	1.91E+02

NA = not applicable;
[a] PM emissions represent total PM.
[b] The emission rates in this table reflect estimated annual totals based on the assumed number of operating hours shown.

5.5.3. Effluent Discharges

The Project will have the various effluent discharges, including:

- Sanitary wastewater
- Process wastewater
- Stormwater
- Hydrotest water

These are discussed below by Project stage.

5.5.3.1. Construction Stage

Construction-stage effluent discharges are described below for each of the primary Project components.

Offshore Pipeline Installation

For the offshore pipeline, the construction activity will generate several types of effluent discharges including sanitary sewage (blackwater), other domestic wastewater (grey water), food wastes, and hydrotest water. Black and grey wastewater will be treated with a combination of digesters, biological treatment, and/or chemical treatment according to regulatory requirements and the specific treatment facilities available onboard the installation and support vessels. These wastewaters are estimated to total approximately 54 m3 per day (estimated 300 offshore workers x 180 liters/day/worker). These effluents will be discharged to the sea according to applicable standard international practices (i.e., International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 [MARPOL 73/78]).

Food wastes will be comminuted (i.e., ground) before discharge in accordance with MARPOL 73/78 requirements.

As a base case, the Project proposes to discharge hydrostatic test water from the offshore pipeline testing at the seaward end of the offshore pipeline, approximately 200 kilometers offshore. The Project will generate approximately 16,050 m^3 of hydrostatic test water for the offshore pipeline segment.

Onshore Pipeline Installation

For onshore pipeline installation, effluent discharges will involve sanitary wastewater, trench dewatering water, and hydrostatic test water.

Portable toilets will be placed along the pipeline work areas to collect sanitary wastewater. The estimated 100 workers along the onshore pipeline are estimated to generate approximately 10 liters of domestic wastewater/day, for a total of approximately 1 m^3 per day. This wastewater will be removed via truck and managed in accordance with applicable regulatory requirements.

Water from pipeline trench dewatering will be discharged to the ground within the construction RoW. Depending on required volumes and/or proximity of nearby waterbodies, straw bales or silt fencing will be used to filter discharges.

Hydrostatic test water for the onshore pipeline segment (approximately 1,820 m^3) will be discharged either offshore (at the same location as the offshore pipeline hydrostatic test water) or into the stormwater settling basin at the NGL Plant, from which it will ultimately be discharged through the stormwater settling basin's discharge structure.

NGL Plant Construction

NGL Plant construction will result in sanitary wastewater and stormwater effluent discharges, as described below.

Sanitary wastewater will be generated by the approximately 300 workers at the NGL Plant during construction, 150 of which could reside at the worker camp. Based on an estimated sanitary wastewater generation rate of 230 liters per day per person for workers not residing in the worker camp and 340 liters per day per person for workers residing in the worker camp, the Project will generate approximately 85,500 liters per day of sanitary wastewater.

The Project will provide a sanitary wastewater collection and package wastewater treatment system at the worker camp, which will treat sanitary wastewater, grey water from showers and sinks, as well as wastewater from the kitchen area. Additionally, the Project will include portable toilets at the NGL Plant construction site. Vacuum trucks will remove the wastewater from the portable toilets and discharge it to the package WWTP at the worker camp. The package WWTP will be designed to meet the World Bank Group values for treated sanitary sewage discharges (Table 5.5-5), disinfected with chlorine, and discharged to the Demerara River (either directly or via a canal adjacent to the NGL Plant).

Table 5.5-5: Indicative Values for Treated Sanitary Sewage Discharges

Pollutants	Units	Guideline Value
pH	pH	6–9
BOD	mg/L	30
COD	mg/L	125
Total nitrogen	mg/L	10
Total phosphorus	mg/L	2
Oil and grease	mg/L	10
Total suspended solids	mg/L	50
Total coliform bacteria	Most Probable Number / 100 milliliters	400

Source: World Bank 2007a

BOD = biochemical oxygen demand; COD = chemical oxygen demand; mg/L = milligrams per liter

5.5.3.2. Operations Stage

All discharges during the Operations stage will be from the NGL Plant; there will be no operational discharges from the offshore or onshore pipelines. The NGL Plant will discharge treated sanitary wastewater, treated process wastewater, and stormwater, as described below.

Sanitary Wastewater

Sanitary wastewater will be generated by the approximately 40 FTE employees and contractors working at the NGL Plant during operations. Based on an estimated water use of 340 liters per day, the Project will generate approximately 13,600 liters per day of domestic wastewater. The Project will construct a sanitary wastewater system to collect and treat all sanitary wastewater from toilet facilities and kitchen areas. This sanitary wastewater will be routed by pipes to an on-site package WWTP, which will be designed to meet the World Bank Group values for treated sanitary sewage discharges (Table 5.5-5), disinfected with chlorine, and discharged to the Demerara River (either directly or via a canal adjacent to the NGL Plant).

Process Wastewater

Process wastewater from the NGL Plant operations will include:

- Potentially oil-contaminated stormwater from process area stormwater drainage, including loading racks, flares, compressor drains, and substation areas. Water from the process area drains will be routed to an oily water sump that is sized for 15 minutes of rainfall (i.e., the first flush). This first flush period of rainfall will be sent to the process WWTP while the subsequent rainfall will be routed to the stormwater pond. Based on rainfall statistics, this first flush of process area drainage that is routed to the process WWTP will be up to 119,720 m^3 per year.
- Molecular sieve water from the gas processing plant; this is estimated at approximately 25 m^3 per year. The current design routes the molecular sieve water to the closed drain header before it is collected in the slop oil tank;
- Water from the dehydrators;

- Cooling water; and
- Process fluids.

With the exception of the post-first-flush process area drainage and the molecular sieve water (as noted above), all process wastewater will be routed to the process WWTP, which will be configured to include oil separation facilities. Flocculants will be injected into the wastewater stream prior to routing the wastewater to a Clarifier Tank. A skimmer will send separated oil in the Clarifier Tank back to the process area for reuse. The sludge that settles to the bottom of the Clarifier Tank will be sent to the Clarifier Sludge Pit, where it will be collected periodically and transported for off-site treatment and disposal. The de-oiled water from the Clarifier Tank will be sent to a Nutshell Filter or Dissolved Air Flotation Package for further treatment and then will be discharged to the stormwater pond. The process WWTP will be designed so that the discharge to the stormwater pond will meet World Bank Group effluent levels for a natural gas processing facility (Table 5.5-6).

Table 5.5-6: Effluents Levels for Natural Gas Processing Facilities

Pollutant	Units	Guideline Value
pH	—	6–9
BOD_5	mg/L	50
COD	mg/L	150
Total suspended solids	mg/L	50
Oil and grease	mg/L	10
Cadmium	mg/L	0.1
Total residual chlorine	mg/L	0.2
Chromium	mg/L	0.5
Copper	mg/L	0.5
Iron	mg/L	3
Zinc	mg/L	1
Cyanide free/total	mg/L	0.1/1.0
Lead	mg/L	0.1
Nickel	mg/L	1.5
Heavy metals total	mg/L	5
Phenol	mg/L	0.5
Nitrogen	mg/L	40
Phosphorous	mg/L	3

Source: World Bank 2007b

BOD_5 = biochemical oxygen demand after 5 days; mg/L = milligrams per liter

Stormwater

Stormwater runoff from the NGL Plant will be managed at a stormwater management facility, which will include a pond that will hold non-process area stormwater runoff (approximately an average of 430,689 m^3 per year), process area stormwater runoff (i.e., rainwater after the initial

15-minute “first flush”), and treated (i.e., de-oiled) process wastewater (preliminary WWTP capacity of 15 m^3 per hour).

The surface area of the stormwater pond will be approximately 4,200 m^2, with a total storage volume of approximately 13,000 m^3. Water in the stormwater management facility will be monitored regularly to confirm compliance with discharge standards prior to discharge to the Demerara River (either directly or via a canal adjacent to the NGL Plant).

5.5.4. Waste Generation

Several types of non-hazardous and hazardous wastes will be generated during Project construction and operation, as described below and summarized in Table 5.5-7.

Table 5.5-7: Summary of Estimated Project Solid and Hazardous Waste Generation by Stage

Project Stage	**Solid Waste (tonnes annually)**	**Hazardous Waste (tonnes annually)**
Construction	420	55
Operations	50	10

5.5.4.1. Construction Stage

The Project will generate various wastes during construction of the offshore pipeline, onshore pipeline, and the NGL Plant, as described below.

Offshore Pipeline Installation

For the offshore pipeline installation, waste collection, storage, and processing will be implemented onboard vessels supporting pipeline installation and hook-up according to the waste management plans for the vessels and EEPGL’s CWMP (Volume III of the EIA). At a minimum, these plans include the following waste management procedures:

- Designation of general waste collection areas on deck, in the accommodation block, and the engine room;
- Segregation of waste by category into containers prominently labeled and color-coded according to waste type; and
- If wastes are discharged overboard, such discharges will be conducted according to the applicable provisions of MARPOL 73/78 Annexes IV and V, which prohibit disposal of solid waste overboard with the exception of comminuted or ground food waste and treated sanitary waste and grey water.

In addition to the minimum requirements listed above, and as required by MARPOL 73/78, all vessels which have a gross tonnage of 400 or more and every vessel certified to carry 15 persons or more will maintain a Garbage Record Book for recording all disposal and incineration operations and a Garbage Management Plan. Any excess sediments generated from offshore trenching will be discharged on the seabed adjacent to the offshore pipeline trench or placed as a small berm on top of the pipeline trench following pipeline placement.

Onshore Pipeline Installation and NGL Plant Construction

The construction of the onshore pipeline, NGL Plant, temporary MOF, and other early works activities will generate a variety of non-hazardous solid waste, including domestic waste from the workers, as well as some construction debris / building materials. These materials will be transported by an approved waste hauler and disposed of in the HBL. A limited amount of hazardous waste will be generated, generally limited to waste oils, solvents, paints, and contaminated rags. These hazardous materials will be transported by an approved waste hauler to an approved hazardous waste treatment facility in Guyana (see Section 7.7, Waste Management Infrastructure Capacity).

Temporary MOF Construction

As described above, operation of the temporary MOF will require some dredging to allow the barges to travel from the main river channel to the pier, and to allow for barge maneuvering while at the temporary MOF (i.e., a turning basis). Dredging at the temporary MOF is estimated to require the removal of approximately 1,500,000 m^3 of dredged material. Dredge spoils from this activity will be placed at a location to be designated by the Maritime Administration Department (MARAD). The current expectation based on discussed with MARAD is that this material will be placed upstream of the temporary MOF.

5.5.4.2. Operations Stage

During the Operations stage, solid and hazardous wastes will be generated only at the NGL Plant. The sources of these solid and hazardous wastes are described below:

- Domestic Waste—the Project will generate small quantities of domestic waste (e.g., trash, food wastes, packaging) from the 40 FTE workers and various deliveries to the NGL Plant. This waste will be hauled periodically by an approved waste transporter to the HBL for disposal (see Section 7.7.2, Existing Conditions and Baseline Studies [Waste Management and Infrastructure Capacity]).
- Various Scrap Metals—replaced equipment and other scrap metals will be transported to a scrap metal consolidation and exporting facility for recycling/reuse to the extent possible.
- WWTP Sludge—the NGL Plant will have WWTPs (see Section 5.5.3, Effluent Discharges) to treat sanitary and process wastewaters. These WWTPs will generate sludge, which will be periodically removed, transported by an approved waste hauler, and treated and disposed at approved waste treatment and disposal facilities. Scrap metals that cannot be recycled/ reused will be hauled by an approved waste transporter to the HBL for disposal.
- Process Wastes—the natural gas will be processed to remove various impurities and NGLs to produce a gas meeting the Power Plant specifications. The NGL Plant operations will generate various waste oils/solvents, spent molecular sieve media, and spent H_2S and mercury absorbent beds. Table 5.5-8 summarizes these waste types and quantities.

- Waste Oils/Solvents—lubricating oil for mechanical rotating equipments (e.g., compressors, pumps) is required to prevent corrosion and friction that could impact the equipment's efficiency and life. Lubricating oil will be drained to containers during oil changes and transported to an approved waste treatment and disposal facility.
- Spent Molecular Sieve Media—the molecular sieve media is regenerative, but has a life expectancy of 4 to 5 years and then needs to be replaced. Spent molecular sieve media will be transported to approved media/catalyst vendors or local waste management facilities for treatment.
- Spent Catalyst Absorbent Beds—the absorbent beds remove impurities in the gas (i.e., H_2S, mercury). The H_2S absorbent bed will require change out approximately every 2 months to 4 years, depending on the actual average concentration of H_2S in the natural gas. The mercury absorbent bed will require less frequent change out (approximately every 10 years) because of the lower mercury concentrations in the gas. H_2S absorbent beds will be transported by an approved waste hauler, and treated and disposed at approved local waste treatment and disposal facilities. The current expectation is that mercury absorbent beds will be shipped out of Guyana for treatment. Local waste management facilities' capacity to treat spent mercury catalyst beds will be assessed at the time the treatment is needed.

Table 5.5-8: Summary of Estimated Project Operations Stage Process Wastes

Waste Type	Estimated Quantity	Comments
Waste Oil/Solvents	1.69 m^3 per year	Includes lubricating oil used for machinery during oil change
Spent Molecular Sieve Media	162 m^3 every 4–5 years	Total amount of solid media used for both beds.
Spent H_2S Absorbent Beds	156 m^3 every 1 year	Total amount of solid media used for both beds at maximum projected H_2S concentration.
Spent Mercury Absorbent Beds	1.5 m^3 every 10 years	Total amount of solid media used at maximum projected mercury concentration.

5.5.5. Noise Emissions

Noise emissions from Project construction and operation are described below.

5.5.5.1. Construction Stage

The key sources of noise during the Construction stage will include:

- Ground-based mobile construction equipment operating along the onshore pipeline corridor, at the NGL Plant site, along the heavy haul road, and at the temporary MOF;
- HDD operations along the onshore pipeline corridor;
- Marine vessel operations along the offshore pipeline corridor, at the temporary MOF, between Guyana shorebases and the offshore pipeline corridor, and between Guyana shorebases and the temporary MOF;

- Berthing and offloading operations (e.g., winches, conveyors, truck loading equipment) at the temporary MOF.

5.5.5.2. Operations Stage

The key continuous and intermittent sources of Operations stage noise at the NGL Plant will include the following:

- Continuous NGL Plant process equipment (maximum external sound level of 85 A-weighted decibels [dBA]):
  - Pressure letdown station
  - Aerial coolers
  - Turboexpander module
  - Compressor modules
- Intermittent noise sources:
  - Flaring (maximum external sound level of 115 dBA), with the following estimated durations and frequencies:
    - Pigging (duration of 2 to 3 days; frequency of quarterly during first 1 to 2 years of operation)
    - Pipeline depressurizing (duration of 9 days; not reasonably anticipated to occur)
  - High-pressure drop valves (e.g., pressure safety valve, flare vent control valves, etc.; maximum external sound level of 115 dBA)
  - Power generation modules (maximum external sound level of 85 dBA)

5.5.6. Traffic Generation

The Project will generate additional ground vehicle movements during both the Construction and Operations stages.

5.5.6.1. Construction Stage

Project traffic on public roads during construction will vary by location as indicated in Table 5.5 9. Please note that this does not include traffic on the heavy haul road between the temporary MOF and the NGL Plant, as this will occur on a private road, other than the crossing of the West Bank Road. Most of the traffic moving to and from the NGL Plant site will be concentrated along the West Bank Road.

Table 5.5-9: Estimated Project Traffic Generation during Construction Stage

Component	Average Daily Round-Trips	Vehicle Type	Notes
Offshore Pipeline	None	Not applicable	Limited to occasional vessel crew changes
Onshore Pipeline	8 to 15	40% cars / 60% buses	Assume two pipeline crews, with transport of workers by high-capacity buses
NGL Plant	14 to 22 (2023) 19 to 32 (2024)	50% cars / 50%buses	Assumes no worker camp, with transport of workers by high-capacity buses

5.5.6.2. Operations Stage

Project traffic to and from the NGL Plant during operations will consist of the estimated 40 FTEs commuting, visitors (e.g., vendors, repair-persons), chemical/water/waste transport, and product (i.e., various NGLs) transport (Table 5.5-10). Most of this traffic will be concentrated along the West Bank Road.

Table 5.5-10: Estimated Project Traffic Generation during Operations Stage

Traffic Types	Average Daily Trips	Vehicle Type	Origin/Destination
Employees	60 round trips per day	100% cars	Home
Visitors	20 round trips per day	50% cars / 50% trucks	Offices (Georgetown area)
Chemical transport	20 round trips per day	100% trucks	—
Product transport	40 round trips per day	100% trucks	Georgetown industrial/port area
Total	140 round trips per day	50% cars/50% trucks	—

5.6. Proposed Best Available Technology and Embedded Controls

5.6.1. Application of Best Available Technology

The following sections summarize the best available technology applied as part of the Project design.

5.6.1.1. NGL Recovery Unit

For NGL recovery, a turboexpander with a Joule-Thomson bypass valve (used in the event the turboexpander must be bypassed for maintenance or low flow rate) will be installed. As the pressure is reduced, the stream is cooled to low temperatures, allowing for separation of the liquids (C4, C3, C5+) from the C1 and C2 in a de-ethanizer fractionation column. A depropanizer column and a debutanizer column will be used to separate the liquids into higher purity products.

The turboexpander with a Joule-Thomson bypass valve is a proven and reliable technology for NGL recovery, and was, therefore, selected for this application. The specific column configuration will be optimized in the next engineering stage, in consideration of liquid recovery, operating complexity, and required gas compression / energy usage.

5.6.1.2. Acid Gas Removal

Solid bed technology will be used to remove H_2S from the natural gas. A solid bed with either an iron-based or copper-based catalyst will be considered. The system includes a lead and lag configuration to allow full use of the lead bed catalyst and provide a means to perform bed change-outs while the plant remains in operation. This option does not include any rotating or heat-exchanging equipment, and only requires nitrogen as a utility requirement for purging during bed change-outs. The solid bed can be installed at early life and not require frequent change-outs until the H_2S concentration in the inlet gas increases.

An amine unit was considered but not chosen for this application. An amine unit sweetens the gas through countercurrent absorption with a lean amine stream in the absorber column. The rich amine exits the bottom of the absorber and is regenerated in the regenerator column where it is heated with a heating medium to strip out the acid gas. The acid gas exits the overhead of the regenerator and is sent to an incinerator. The lean amine is cooled and stored before being pumped to the absorber. Among the options considered, an amine unit with an incinerator entails the greatest utility requirements. Furthermore, the sulfur dioxide emissions associated with operating an amine unit will exceed the alternative options.

Liquid scavengers were another option considered. This system includes a continuous stream of spent liquids while in operation. Liquid scavengers are water-based and saturate the gas, requiring a dehydration unit. Since the system requires additional equipment and may cause operational challenges in foaming and carryover, liquid scavengers were not selected for the removal of H_2S.

5.6.1.3. Dehydration Unit

A dehydration unit is required to prevent hydrates and freezing during the cooling process at the NGL Plant. Water removal can be performed using a triethylene glycol unit, ethylene glycol or methanol injection, or a molecular sieve unit. Due to the high NGL recovery and low temperatures required, molecular sieve dehydration to low water dew points was selected for the Project.

5.6.1.4. Flare Technology

Two flare technologies are currently being considered: enclosed ground flares and elevated flares. Advantages of the enclosed ground flare technology include reduced noise and flame visibility. This technology decision will be further evaluated in the next engineering stage. The flares will be located in a manner considering the distance of nearby equipment and the direction of the wind. A flare dispersion study for flame-out scenarios will be performed to confirm the flare design allows for the plume to disperse adequately without posing a threat to personnel within the facility and outside the property fence line.

5.6.1.5. Utility Technology

Utilities to support the NGL Plant will be self-sustaining to the extent possible because of the remote location of the site. The design of the utility systems considers the in-country availability of chemicals and waste treatment facilities. Diesel generators were selected as an emergency/ essential power source due to the availability of diesel in country. Methanol will be used for anti-hydrate purposes due to the existing supply of the chemical to the Destiny FPSO. The NGL Plant will include a WWTP since it is uncertain that nearby treatment facilities can treat the quantities of wastewater that will be generated from the NGL Plant and provide sufficient treatment for discharge. Without a WWTP, the wastewater would need to be transported out of the facility on a periodic basis, which could lead to trucking operational challenges. The spent H_2S and mercury beds will require change-outs once the discharge specification exceeds the minimum requirements. The current plan is to use existing treatment facilities in country for the H_2S beds and mercury beds. Freshwater supplies from a groundwater well installed at the NGL Plant were selected since there is no nearby connection to the municipal water system.

5.6.1.6. Construction Concept

Construction of the NGL Plant will use two methods:

- Stick-Build: Ship components (such as vessels, piping, instrumentation, and support steel) to the site and assemble components at the site; and
- Modularization: Assemble components off site into larger modules and ship the modules to the site; modules are put in place and hooked-up to other equipment at the site.

Due to the remote location of the site, pre-fabrication and use of modules will be maximized. Vendor packages/modules are expected to be used for the NGL Plant and Balance of Plant (including piperacks) as much as practical. It is expected that the NGL recovery and fractionation sections of the NGL Plant will be modularized. Other sections of the NGL Plant will be further evaluated for modularization. A temporary MOF on the Demerara River is planned to be installed nearby to the NGL Plant site as a means for transporting the modules/equipment.

5.6.2. Proposed Embedded Controls

Embedded controls are physical or procedural measures which avoid or reduce Project environmental and social impacts that are proposed by EEPGL and incorporated as part of the Project design. These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance ratings. EEPGL has incorporated the embedded controls provided in Table 5.6-1 into the Project.

Table 5.6-1: Proposed Embedded Controls

EIA Section	Commitment: Embedded Controls
Section 7.1	Design horizontal directional drilling (HDD) fluid composition based on consideration of the characteristics of the soils through which HDD bores will be completed and adjust drilling fluids as needed during HDD operations based on the results of HDD fluids/cuttings returns.
Section 7.1	Conduct dewatering along work segments and only for durations required to implement the construction activity for the work segment; cease dewatering as soon as reasonably practicable after completing pipeline installation in a work segment.
Section 7.1	To the extent reasonably practicable, return extracted waters from dewatering to an adjacent segment of the same canal to minimize/avoid long term decreases in water level in the canal.
Section 7.1	Use industry standard filtration techniques to reduce solids content in dewatering discharges to surface water features.
Section 7.1	Install groundwater extraction well(s) at the natural gas liquids processing plant (NGL Plant) using standard well construction techniques, including features to prevent downward migration of contaminants to the groundwater bearing unit.
Section 7.1	Use only non-petrochemical-based, non-hazardous additives that comply with permit requirements, and environmental regulations, such as NSF International/ANSI 60 Drinking Water Treatment Chemicals—Health Effects compliant in the drilling fluids.
Sections 7.2, 8.4, 8.6, and 9.3	Implement soil erosion, stormwater runoff, and sedimentation control measures during soil disturbance (e.g., use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from construction areas, use of sediment basins and check dams to control water runoff).
Sections 7.2, 8.3, 8.4, 8.6, and 9.3	Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable, and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Sections 7.2 and 9.3	Outside of the permanent RoW and within temporarily disturbance areas, restore active agricultural areas to their preconstruction conditions to support continued agricultural use.
Sections 7.3, 8.2, and 8.6	Monitor and manage suction dredging or jet plowing and burial rates to improve efficiency and reduce turbidity.
Sections 7.3, 8.2, and 8.6	To the extent practicable, avoid suction/jetting any deeper than what is required for protection of the pipeline.
Sections 7.3, 7.4, 8.3, 8.4, and 8.6	Monitor and manage excess overflow from hopper on dredging facility to improve efficiency and reduce turbidity in dredging supernatant.
Sections 7.3, 7.4, 8.3, and 8.4	Monitor and manage suction rate to enhance efficiency and reduce turbidity in the water column during dredging.
Sections 7.4, 8.2, and 8.6	Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and use the Offshore Chemical Notification Scheme (CEFAS 2019) as a resource for chemical selection in its production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of material safety data sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Using the minimum safety risk relative to flammability and volatility;

EIA Section	Commitment: Embedded Controls
	• Risk evaluation of residual chemical releases into the environment.
Sections 7.5, 8.3, 8.5, 8.6 and 9.2	Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD drilling activity).
Sections 7.5, 8.2, and 8.3	Maintain marine and onshore construction equipment, power generators, and vehicles in accordance with manufacturer's specifications to reduce noise generation to the extent practicable.
Sections 7.5, 8.3, and 8.6	Design continuously operating process equipment at the NGL Plant to generate noise emissions of no more than 85 A-weighted decibel (dBA) at a distance of 3 meters from the source.
Sections 7.5, 8.3, and 8.6	Design intermittently operating process equipment at the NGL Plant (e.g., flare and high-pressure drop valve) to generate noise emissions of no more than 115 dBA at a distance of 3 meters from the source.
Section 7.5	Subject NGL Plant operational equipment to routine maintenance in accordance with manufacturer's specifications.
Sections 7.6, 8.3, and 8.6	Plan the construction schedule of the Project to enable early paving of permanent roads and re-vegetating of earthworks and exposed areas to the extent practicable.
Sections 7.6, 8.3, and 8.6	Minimize dust-emitting activities such as cutting, grinding, and sawing by employing alternative methods or technologies, such as the use of pre-fabricated material wherever possible.
Sections 7.6 and 8.6	Review construction plan and confirm availability of water for dust suppression on site for dust suppression.
Sections 7.6 and 8.6	Keep uncovered stockpiles moist using non-toxic chemical suppressants.
Sections 7.6 and 8.6	Apply water to unpaved haul roads to minimize dust generation.
Sections 7.6 and 8.6	Train workers to employ material handling methods that will minimize dust emissions. These include minimizing drop heights to control the fall of materials and minimizing exposure of stockpiles to wind by removal of earth from small areas of secure covers when needed.
Sections 7.6, 8.3, 8.6, and 9.6	Use appropriate control measures to minimize dust arising from construction works (e.g., watering of roads or exposed surfaces during dry conditions).
Sections 7.6, 8.3, and 8.6	Require construction equipment and other workforce vehicle drivers to adhere to Project-established speed limits within the construction worksites.
Section 7.6	With respect to non-routine flaring of gas at the NGL Plant, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low NO_x emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Install high-reliability instrument pressure protection systems, as appropriate, to reduce overpressure events and avoid or reduce flaring situations;

EIA Section	Commitment: Embedded Controls
	• Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; • Minimize flaring from purges and pilots without compromising safety through measures such as installation of purge gas reduction devices, vapor recovery units, inert purge gas, and soft seat-valve technology where appropriate, and installation of pilot flares; and • Minimize flame lift off and/or flame lick.
Sections 7.6, 8.3, and 8.6	Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and NGL Plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Sections 7.6, 8.3, and 8.6	Implement inspection, maintenance, and surveillance programs (including Leak Detection and Repair systems) to identify and prevent unplanned emissions to atmosphere from the NGL Plant.
Section 7.6	Avoid routine venting (excludes tank flashing emissions, standing / working / breathing losses) except during safety and emergency conditions.
Sections 7.6, 8.2, 8.3, 8.4, 8.5, and 8.6	Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers’ guidance and/or good international industry practices (GIIP), as applicable, and at their optimal levels to minimize atmospheric emissions to the extent reasonably practicable.
Sections 7.6, 8.3, and 8.6	Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Section 7.7	For transport of hazardous wastes off site for treatment or disposal, confirm that the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.
Section 7.7	Provide for adequate onshore waste management equipment and facilities for the proper management of waste in accordance with local regulation and good international industry practice.
Section 7.7	For wastes generated offshore that cannot be reused, treated, or discharged/disposed on marine vessels, properly manifest and transfer such wastes to appropriate onshore facilities for management.
Section 7.7	Periodically audit waste contractors to verify that appropriate waste management practices are being used.
Section 7.7	Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with the waste management hierarchy.
Sections 8.2, 8.4, 8.5, and 8.6	For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization and International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Sections 8.2, 8.4, 8.5, and 8.6	Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plants, and oil-water separators) in accordance with manufacturers’ guidelines to maximize efficiency and minimize malfunctions and unnecessary discharges into the environment.
Sections 8.3 and 8.6	Conduct paced, sequential clearing to allow for mobile wildlife to move away from work zones.
Sections 8.3, 8.6, and 9.7	Restore and revegetate the temporary onshore pipeline corridor following construction.

EIA Section	Commitment: Embedded Controls
Sections 8.4, 8.6, and 9.3	Dewater any trenches by first installing temporary drainage and use methods to prevent excessive transport of sediments into existing canals.
Sections 8.4, 8.6, and 9.3	Manage stormwater to minimize potential erosion and excessive sediment transport into canals adjacent to the onshore pipeline corridor.
Sections 8.4 and 8.5	Use procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.
Sections 8.3, 8.4, 8.5, and 8.6	Provide domestic WWTP that complies with World Bank Indicative Values for Treated Sanitary Sewage Discharges (World Bank 2007a) and Effluents Levels for Natural Gas Processing Facilities (World Bank 2007b).
Section 8.5	For effluent released from the STPs on board Project marine vessels, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Section 8.5	Implement engineering controls, administrative controls, and training to protect offshore workforce from high noise levels in the offshore work environment.
Section 8.5	Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Section 8.5	Provide a stormwater management facility at the NGL Plant site.
Section 8.5	For Project marine vessels necessitating ballast water exchanges, abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard), and abide with MARPOL 73/78.
Section 9.1	Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable.
Section 9.1	Work with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities in alignment with Guyana's Local Content policy.
Section 9.1	Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.
Section 9.2	Provide health-screening procedures for Project workers to reduce risks of transmitting communicable diseases.
Section 9.2	Project dedicated medical resources will be available on the west side of the Demerara River to support project related activities and treat workers for minor medical issues.
Sections 9.2, 9.6, 9.8, and 9.9	Develop and implement a Stakeholder Engagement Plan (SEP) that includes measures for continued engagement with communities, including informal settlements, potentially affected residents, landowners and Indigenous Peoples, aimed at increasing awareness of the nature of the Project and the measures in place to prevent accidents.
Sections 9.2, 9.6, 9.8, and 9.9	Implement a transparent, accessible, and consistent CGM prior to onset of Project activities. Take measures to promote the CGM being well publicized and understood by the public, including residents of informal settlements and Indigenous Peoples—in particular in the Santa Aratak community.
Section 9.3	Require construction contractors to locate, identify, and flag existing underground utilities to prevent accidental damage during onshore pipeline construction.
Section 9.3	Collect stormwater and route, if feasible, to existing canals.
Section 9.4	Restore all roads to their pre-construction condition or better following completion of each contractor's component of the construction process (potentially including retention

EIA Section	Commitment: Embedded Controls
	and handover of temporary bridge spans to the Government of Guyana, where appropriate).
Section 9.4	Complete pipeline road crossings using trenchless methods where practicable. Where open-trench crossings are used, minimize the time of road closure to the extent practicable, and provide adequate detours.
Section 9.5	Prior to initiation of seabed disturbance, conduct a seabed survey to assess the presence of potential underwater cultural heritage resources. If any potential cultural heritage resources are found, adjust the layout of Project features to avoid such resources or subject the resources to assessment by a cultural resources specialist and, as warranted, consult with the National Trust of Guyana prior to disturbing such resources.
Section 9.5	Use HDD techniques or adjust onshore pipeline corridor construction area to avoid physical disturbance of silk cotton trees where reasonably practicable.
Section 9.5	Where HDD techniques are used for a segment where a silk cotton tree falls within the permanent RoW, avoid removal of the tree from the permanent RoW.
Section 9.5	Use HDD techniques for onshore pipeline crossings at Canal 1 and Canal 2.
Section 9.7	Use HDD techniques at major road and waterway crossings to help minimize visual impacts on key viewpoints during construction activities.
Section 9.7	Subject to direction from the Government of Guyana regarding its desire to continue to use the temporary material offloading facility (MOF) after the Project Construction stage is complete, remove temporary MOF infrastructure as soon as feasible following completion of Project construction and attainment of stable operations, (the temporary MOF will be removed prior to the 10-year design life of the structure being met) and revegetate disturbed areas in consultation with appropriate Guyanese authorities (e.g., National Agricultural Research and Extension Institute).
Section 9.7	Design and locate aboveground structures associated with the onshore pipeline (e.g., beach valve station) so as to minimize their visual profile and the degree to which they impact views of sensitive visual resources.
Section 9.7	Implement industry-standard lighting practices, including (but not limited to): • Use the minimum lighting intensity necessary for health and safety. • Use directional lighting with full-cutoff features that direct light only to locations where it is necessary, while minimizing leakage into surrounding areas. • Use timers, motion sensors, or other features that activate lights only when necessary. • Use lights with lower color temperatures (i.e., closer to the yellow end of the spectrum).
Sections 9.8 and 9.9	During dredging activities associated with the temporary MOF, conduct the dredging operation so as to maintain the ability for passenger vessels to pass up- and down-river of the temporary MOF, between the Santa Aratak community and downriver locations.

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6. STAKEHOLDER ENGAGEMENT

As introduced in Chapter 3, EIA Approach and Impact Assessment Methodology, stakeholder engagement has been (and continues to be) conducted to provide information about the Project to the public and interested stakeholders, and to support the development of the EIA and associated Environmental and Socioeconomic Management and Monitoring Plan. The objectives of the Project's stakeholder engagement activities are to:

- Identify Project stakeholders and understand their interests, concerns, and influence in relation to the Project;
- Promote the development of respectful and open relationships between stakeholders and EEPGL throughout the Project life cycle;
- Provide stakeholders with information about the Project in ways that are appropriate to their interests and needs and also appropriate to the level of expected risks and potential adverse impacts;
- Gather information from stakeholders to inform the understanding of existing conditions, the assessment of potential Project impacts, and the development of management and monitoring measures for the Project;
- Document feedback from stakeholders and address any grievances that may arise from Project-related activities through a formal feedback mechanism; and
- Support alignment with the Government of Guyana requirements for stakeholder engagement.

This chapter describes EEPGL's overall engagement strategy and stakeholder engagement activities conducted to date, as well as the GTE Project-specific stakeholder program that has supported the development of the EIA and the planned engagement to support disclosure. This chapter also provides a summary of stakeholder comments and how they were addressed in the EIA.

6.1. STAKEHOLDER ENGAGEMENT STRATEGY

6.1.1. Context

The EIA is occurring alongside other EEPGL activities in Guyana and, as such, the stakeholder engagement process for the Project has benefited from the knowledge and understanding gained through EEPGL's past and ongoing engagement activities, including engagement related to EIAs for other offshore development projects conducted since 2016 (Section 6.2, Engagement to Date). Engagement for the Project builds upon existing relationships and uses the methods described in Section 6.1.3, Engagement Methods, to provide all relevant stakeholders with the opportunity to receive information and/or be consulted on the Project.

6.1.2. Stakeholder Engagement Plan

EEPGL's Stakeholder Engagement Plan for Guyana Operations (the SEP) guides Project stakeholder engagement activities (see Volume III of the EIA, Management Plans). The SEP is a document that is updated periodically as EEPGL meets milestones and as new projects, like the GTE Project, come onboard. The SEP is updated to reflect new information, changing conditions (e.g., COVID-19), and additional stakeholders. The SEP describes the following:

- Stakeholders identified for engagement;
- A program of engagement and communications activities throughout a Project life cycle;
- Formal stakeholder feedback mechanisms through which stakeholders can contact EEPGL to voice concerns, provide information, or ask questions about a Project and its activities; and
- Mechanisms through which EEPGL will monitor and report on external engagement and communications.

The SEP, including its various attachments, provides an account of the multiple years of engagement that have taken place by EEPGL and its consultants, including engagement with vulnerable populations. Attachments include non-technical materials used to share information during engagement and templates used for engagements related to ecosystem services studies, participatory fishing studies, social infrastructure studies, and one-on-one meetings.

6.1.3. Engagement Methods

Supporting the SEP, EEPGL's stakeholder engagement strategy identifies mechanisms and tools to facilitate information sharing and stakeholder consultation. EEPGL also has a community grievance mechanism (CGM) that allows stakeholders to provide feedback and share concerns.

6.1.3.1. Information Sharing

EEPGL provides information about a project to stakeholders to support their understanding of what is proposed to occur. EEPGL may disseminate information through print and online publications and media releases, as well as presentations (virtual and in-person) and open houses. The intent of these types of activities is to provide information to a broad audience or group of stakeholders as efficiently as possible.

The Project Consultants work with the relevant government authorities, such as the EPA, so that the Terms and Scope development and EIA for a project can be informed by stakeholder comments.

To support stakeholder understanding of the technically complex EIA submittal, the GTE Project engagement program includes development and distribution of a non-technical summary of the EIA, as well as development and distribution of other materials (brochures, handout materials, photo books) to help clearly explain the Project's potential impacts and benefits with simple communication tools that are inclusive and tailored to different audiences. Materials developed to support engagement to date are attached to the SEP (Volume III of the EIA, Management Plans).

6.1.3.2. Stakeholder Consultation

The stakeholder engagement program seeks to support open dialogue and receive stakeholder feedback, opinions, concerns, and knowledge regarding the way the Project may interact with the natural and social environment.

Consultation or dialogue activities involve a two-way flow or exchange of information between stakeholders and EEPGL or the Consultants, and may include one-on-one and small-group meetings, public meetings, and feedback mechanisms—including a formal CGM (described in the SEP), which has a dedicated email address (gteinquiries@exxonmobil.com) and phone line (+592 623 1137). EEPGL also communicates regularly with stakeholders through its Facebook page.[1]

The intent of these activities is to allow for not only a two-way exchange of information, but also a means to gather information concerning topics that are important to stakeholders. These activities also help facilitate stakeholder comments and opinions being heard and legitimate concerns addressed.

Engagement has been and continues to be conducted in accordance with applicable coronavirus disease 2019 (COVID-19) regulations and precautions, including physical distancing, use of personal protective equipment (e.g., masks), limits to gathering size, vaccination requirements, etc. As pandemic conditions and control measures frequently change, EEPGL will continue to work with relevant authorities including the National COVID-19 Task Force to determine and comply with the appropriate precautions at each stage of engagement.

6.2. ENGAGEMENT TO DATE

Since 2016, EEPGL and its consultants have held hundreds of stakeholder engagement events in coastal Regions 1, 2, 3, 5, and 6, and have held more than 1,000 engagement events and individual stakeholder meetings in Region 4. Engagements have included key informant interviews, EIA public scoping consultation and disclosure meetings, coastal mapping efforts, fisherfolk engagement, oil spill response demonstrations and training, community outreach events (e.g., informational booths, school fairs, job fairs), open houses, and capacity-building efforts. EEPGL and the Consultants document these activities in an engagement database and within the SEP to promote follow-up of legitimate concerns.

As noted above, EEPGL and its consultants have conducted extensive engagement efforts in specific support of the environmental authorization processes for the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail development projects. These engagements have provided a range of opportunities for community members, special interest groups, fisherfolk, businesses, conservation groups, Indigenous Peoples, and other stakeholders to learn about the offshore

[1] https://www.facebook.com/exxonmobilguyana/

development projects, discuss concerns and potential impacts, and provide input into the EIAs. The following such engagements have provided information used for EIA development:

- Continuous engagements with government and agencies that have oversight of EEPGL's projects, such as those listed below, as well as other local decision-making bodies as outlined in Section 3.4 of Appendix 2 of the Terms and Scope (EPA 2021):
  - EPA
  - Ministry of Natural Resources
  - Ministry of Agriculture
  - Fisheries Department
  - National Agricultural Research Education Institute
  - National Trust Guyana
  - Ministry of Social Protection
  - Civil Defence Commission
  - Guyana Geology and Mines Commission
  - Guyana Tourism Authority
  - Conservation International
- Ongoing engagement with fishing communities with the objective of answering questions and sharing information with fisherfolk about offshore activities and potential impacts in the marine environment. These activities also relate to the participatory fishing study contracted by EEPGL between 2019 and 2020, for which a second phase of study began in 2021.
- Follow-on discussions with many of the 61 coastal Neighborhood Democratic Councils (NDCs), Regional Democratic Councils (RDCs), town councils, and Village Councils (VCs) in Regions 1 through 6 that participated in the Ecosystem Services Study conducted from 2017 to 2019.
- Updates from government agencies, communities and other stakeholders related to socioeconomic baseline data and related studies that were collected between 2017 and 2021.

Engagement with fishing cooperatives in all six regions, covering 16 landing sites, occurred on at least a monthly basis as part of an EEPGL-commissioned Participatory Fishing Study between January 2019 and March 2020. The study resumed in March 2021 with the goal of re-engaging with fisherfolk to collect data and build on the knowledge base established by the original study and examining emerging trends related to artisanal and industrial fisheries in Guyana.

EEPGL has continually engaged with vulnerable groups, as defined in the GTE Project Terms and Scope as "Indigenous Peoples in Regions 1 to 6; women; persons with disabilities; Civil Society Organizations; the elderly and migrants" (EPA 2021). Specific focus throughout the years has been given to Region 1 and Indigenous Peoples representatives' groups and communities. EEPGL and its consultants also take specific care during public engagements to understand the opinions of women, the elderly, and youth—by ensuring all participants are provided with the opportunity to speak. One-on-one engagement with key informants also helps identify and understand the needs of vulnerable individuals who may be less likely to speak in public consultation forums. Details can be found in the SEP.

6.3. GTE Project Engagement Process

6.3.1. Stakeholder Identification

In accordance with the SEP and as outlined in the Terms and Scope, the Consultants evaluated a long list of potential Project stakeholders based on their anticipated interest in and influence on the Project. Stakeholders included those with perceived positive, negative, and neutral positions related to the Project. In total, more than 100 stakeholder groups/individuals were identified from the following categories:

- Government ministries, departments, and other agencies
- Non-governmental organizations (NGOs)
- Communities and Indigenous Peoples in Regions 1 through 6, including RDCs, NDCs, and Toshaos
- Fisherfolk
- Businesses and industry groups
- Associations and cooperatives
- Chambers of commerce and economic development organizations
- Other local groups including women, elders, disability advocates
- Academic institutions

These stakeholders were identified, and their interests considered, through a combination of desktop research, internal workshops with EEPGL and Guyana community experts, and in-country assessment and engagement. The stakeholders identified in Section 5.6 of the Terms and Scope (EPA 2021) for consultation were included in the identification mapping and analysis. The understanding of stakeholders and their potential interests and concerns related to the Project have directly informed the engagement program to-date and plans for engagement through the EIA disclosure period.

6.3.2. EIA Scoping

6.3.2.1. Information Distribution

After EEPGL submitted the Application for Environmental Authorisation for the Project, the EPA published a public notice in the Stabroek News and Guyana Chronicle on 27 June 2021 and posted on the EPA's website on the same day (Figure 6.3-1). The public notice marked the start of the 28-day public comment period for the scoping stage and provided information about where and how the public could access information about the EPA process and the Project. EEPGL also placed advertisements in the newspaper and used "howlers" to help increase awareness of upcoming public scoping consultation meetings (Figure 6.3-2).

EPA

Environmental Protection Agency
Ganges Street, Sophia, Georgetown- Head Office

NOTICE TO THE PUBLIC

Esso Exploration and Production Guyana Limited (EEPGL) has submitted an application to the Environmental Protection Agency (EPA) for an Environmental Authorisation for the following project:

Gas to Energy Project *Onshore and Offshore Guyana - including the construction, commissioning and operation of:*

1. Onshore Natural Gas Liquids and Natural Gas Processing Plant (NGL Plant) proposed to be located at the Amsterdam (Demerara River)/Vriesland Area, West Bank Demerara;
2. Offshore 12-inch pipeline (approximately 220km long) from the Liza Phase 1 and Liza Phase 2 Floating, Production, Storage and Offloading (FPSO) vessels situated within the Stabroek Block, Offshore Guyana to La Jalousie/Nouvelle Flanders, West Coast Demerara;
3. Onshore 12-inch pipeline (approximately 27km long) commencing North from the proposed NGL Plant Site, then West and North again towards Canal No.2, where it turns West travelling along the Canal, before proceeding North across Canal No. 2, through agricultural fields, an additional smaller canal, Canal No.1 and residences of Canal No.1, and additional agricultural fields to a point West of La Parfaite Harmonie, Westminster and Onderneeming. The route then moves East through agricultural fields and across the West Coast Demerara Highway at a point West of Vreed-en-Hoop/Crane, and northward through agricultural fields, and across a road and a pair of canals until reaching the seawall; and
4. Temporary Materials Offloading Facility (MOF) at Amsterdam/Vriesland on the West Bank of the Demerara River, inclusive of other support works such as associated dredging, in-water construction activities, road construction, road improvements and post-construction restorative works around the entire proposed project area.

As a result of the intended developmental activities, possible effects on the environment may include impacts to marine water quality, air quality, marine and terrestrial flora and fauna, socio-economic resources, among others.

As such, in keeping with the Environmental Protection Act, Cap. 20:05, the EPA has determined that the proposed project may significantly affect the environment and therefore will require an Environmental Impact Assessment (EIA). The EIA will include but not be limited to all possible alternatives studied, effects on the environment, and assessment of risks, and may lead to further optimization of the proposed project.

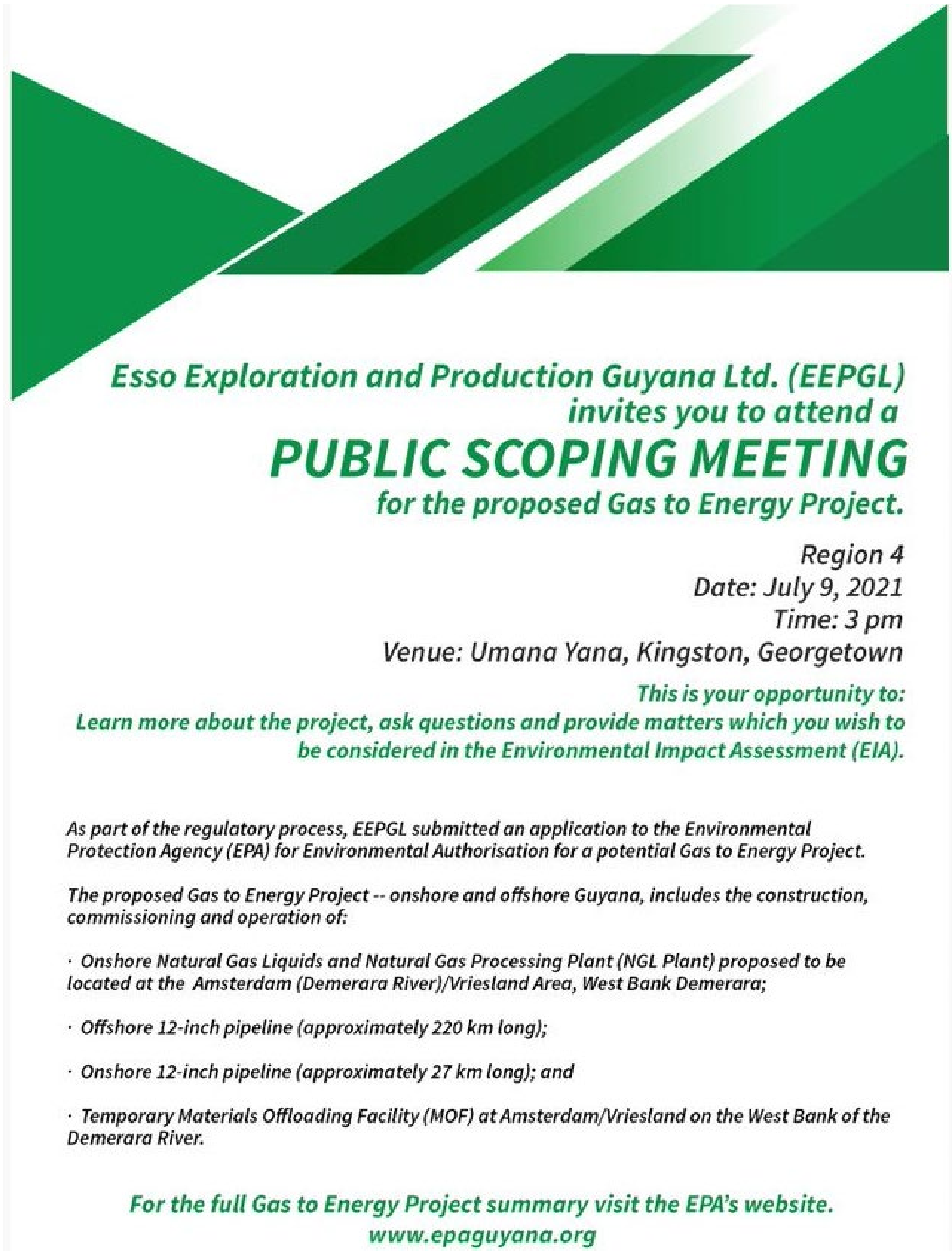
Members of the public are hereby invited, **within twenty-eight (28) days** of this Notice, to make written submissions to the Agency, setting out those questions and matters which they require to be answered or considered in the EIA.

A summary of the project can be viewed on the EPA's website or uplifted at the EPA's Offices in Linden (Region 10), Whim (Region 6) or Sophia, Georgetown, at the reasonable cost of photocopying.

***Comments should be addressed to*:**

The Environmental Protection Agency
Executive Director
Ganges Street, Sophia, Georgetown.
Phone: 225-0506 / 225-5467-8 / 225-5471-2
Fax: 225-5481
E-mail epa@epaguyana.org
Website: www.epaguyana.org

Figure 6.3-1: EPA Notice to the Public Initiating 28-Day Public Comment Period (27 June 2021)



Esso Exploration and Production Guyana Ltd. (EEPGL)
invites you to attend a

PUBLIC SCOPING MEETING

for the proposed Gas to Energy Project.

Region 4
Date: July 9, 2021
Time: 3 pm
Venue: Umana Yana, Kingston, Georgetown

This is your opportunity to:
Learn more about the project, ask questions and provide matters which you wish to be considered in the Environmental Impact Assessment (EIA).

As part of the regulatory process, EEPGL submitted an application to the Environmental Protection Agency (EPA) for Environmental Authorisation for a potential Gas to Energy Project.

The proposed Gas to Energy Project -- onshore and offshore Guyana, includes the construction, commissioning and operation of:

- *Onshore Natural Gas Liquids and Natural Gas Processing Plant (NGL Plant) proposed to be located at the Amsterdam (Demerara River)/Vriesland Area, West Bank Demerara;*
- *Offshore 12-inch pipeline (approximately 220 km long);*
- *Onshore 12-inch pipeline (approximately 27 km long); and*
- *Temporary Materials Offloading Facility (MOF) at Amsterdam/Vriesland on the West Bank of the Demerara River.*

For the full Gas to Energy Project summary visit the EPA's website.
www.epaguyana.org

Figure 6.3-2: Example of Public Notices Advertising Public Scoping Consultation Meetings

EEPGL distributed meeting notices and Project summary flyers for the public scoping consultation meetings to communities throughout Guyana. Materials were prepared for the RDCs of Regions 1, 2, 3, 5, and 6, as well as 81 NDCs, Community Councils, and VCs in these regions. Materials were sent by courier and included USB flash-drives and printed copies of the Project summary and excerpts from the Project scoping meeting presentation. Howlers were also dispatched in various communities to announce upcoming public meetings.

6.3.2.2. Public Scoping Consultation Meetings

Public scoping consultation meetings for the Project were hosted by the EPA and EEPGL in July 2021. A mix of virtual and in-person meetings was held, as summarized in Table 6.3-1. All meetings included an overview of the environmental review process by the EPA, an overview of the proposed Project by EEPGL, and an opportunity for stakeholders to identify issues and concerns to be considered in the development of the Terms and Scope for the Project EIA. EEPGL and the Consultants took specific care during public engagements to understand the opinions of women, the elderly, and youth by ensuring all participants were provided with the opportunity to speak, if they so desired.

Table 6.3-1: GTE Project Public Scoping Consultation Meetings, 2021

Date	Region	Venue	Number of Participants
July 6	5	Latchmansingh Primary School, West Coast Berbice	20
July 7	6	#66 Fishport Complex, Corentyne, Berbice	45
July 7	6	St. Francis Building / Portuguese Quarters, Port Mourant, Berbice	59
July 8	All	Virtual Meeting #1	Not available
July 9	4	Umana Yana, Kingston, Georgetown	43
July 12	4	Diamond Primary School, East Bank Demerara	39
July 13	3	Leonora Technical Institute, West Coast Demerara	28
July 14	3	West Demerara Secondary School, West Bank Demerara	55
July 15	All	Virtual Meeting #2	Not available
July 16	1	Mabaruma Primary School, Mabaruma	57
July 19	1	Flavio’s Hall, Santa Rosa	59
July 22	3	Patentia Primary School, West Bank Demerara	51
July 23	2	Townhall, Anna Regina	16

The physical distancing requirements of COVID-19 added a layer of complication for in-person engagement, although the in-person meetings were well attended. Virtual meetings were also conducted so that individuals not wishing or able to attend in person could still be informed and provide their input.

Issues and concerns raised during the scoping stage informed the Terms and Scope and development of this EIA, including the understanding of the baseline socioeconomic and biophysical environment, potential impacts, and the development of mitigation and management measures. In addition to comments raised during the public scoping consultation meetings, members of the public and other stakeholders could also provide comments directly to the EPA. Consolidated comments from the scoping stage are summarized in Section 6.3.2.3, Scoping Consultation Comments.

6.3.2.3. Scoping Consultation Comments

The public scoping consultation meetings (Section 6.3.2.2) served to inform stakeholders about the Project and to afford stakeholders the opportunity to provide verbal input regarding the issues and concerns to be addressed in the EIA. Stakeholders were also informed that comments could be submitted directly to the EPA. More than 180 individual comments were recorded from attendees of the scoping meetings. All comments, including those received verbally and in writing, were reviewed and considered by the EPA in developing the Terms and Scope for the EIA, and by the Consultants in developing the EIA. Comments were received from a range of stakeholders including public, government agency, and NGO stakeholders over the course of Project scoping.

Comments received through the EPA or directly from stakeholders during the scoping period are included in their entirety in the EIA (Appendix B, Final EPA Terms and Scope Comments). Table 6.3-2 summarizes the broad themes of these comments and how they have been addressed in the EIA.

Table 6.3-2: Scoping Comments by Theme

Key Theme	Consideration in EIA
Socioeconomic impacts	• Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, describes the assessment of potential socioeconomic impacts from planned Project activities. • Chapter 10, Unplanned Events, describes the assessment of potential risks to socioeconomic resources from unplanned events (e.g., natural gas leak).
Environmental impacts	• Each resource-specific discussion in Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources, and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, describes the assessment of potential impacts on environmental resources from planned Project activities and the management measures recommended to address those potential impacts. • Chapter 10, Unplanned Events, describes the assessment of potential risks to environmental resources from unplanned events (e.g., natural gas leak).
Water quality impacts	• Chapter 5, Project Description, provides a summary of planned Project effluent discharges and various discharge management systems. • Section 7.4, Water Quality, and the Water Quality Modeling Report (Appendix C) provide an assessment of potential Project impacts on water quality.
Regulatory process	• Chapter 2, Policy, Regulatory, and Administrative Framework, describes the administrative framework applicable to the Project, including the regulatory process for the EIA. • Chapter 3, EIA Approach and Impact Assessment Methodology, provides additional detail on the EIA process.

Key Theme	Consideration in EIA
Unplanned events	• Chapter 10, Unplanned Events, assesses potential risks to resources from unplanned events. • The Emergency Response Plan and an updated Oil Spill Response Plan, which are included in Volume III of the EIA, describe EEPGL's approach for managing the impacts of unplanned events, should one occur.
Project design, location, and schedule	• Chapter 5, Project Description, includes a description of the proposed Project and a schedule describing anticipated timing for the major stages of the Project, assuming receipt of regulatory approval to proceed.
Cumulative impacts	• Chapter 11, Cumulative Impacts, assesses the potential cumulative impacts of the Project, when combined with the potential effects of other reasonably foreseeable activities with the potential to impact the same resources as the Project.
Waste management	• Section 7.7, Waste Management Infrastructure Capacity, assesses potential impacts of planned Project activities on waste management infrastructure capacity. • Chapter 11, Cumulative Impacts, assesses the potential cumulative impacts on waste management infrastructure capacity as a result of planned Project activities and other EEPGL activities. • A Comprehensive Waste Management Plan, provided in Volume III of the EIA, describes EEPGL's strategy for addressing Project-generated wastes.
Stakeholder engagement	• Stakeholder engagement activities, including those with indigenous communities, are discussed in this chapter; a SEP is included in Volume III of the EIA.

6.3.3. EIA Development

EEPGL and the Consultants engaged with various stakeholders (Table 6.3-3) to request new or updated information in support of the EIA. In an effort to reduce stakeholder fatigue, the engagement plan for the Project prioritized key stakeholders based on the Project's specific needs and data gaps, with a focus on the Project Area of Influence (AOI). Engagement during the EIA development stage included emails, phone calls, focus groups, and key informant interviews with a variety of stakeholders, including local community members, NDCs, RDCs, and Toshaos in Regions 1 through 6.

A mix of in-person meetings, virtual meetings, emails, and phone calls was used based on the objectives of engagement and stakeholder preferences.

Table 6.3-3: Engagement Objectives: EIA Development

Stakeholder Group or Category	Description of EIA Development Engagement Objectives
EPA	• Consult with the EPA to align on EIA content and methods
Government of Guyana: Ministries and Departments	• Engage with Bureau of Statistics, Ministry of Agriculture, Ministry of Health, and other relevant government offices to request updated socioeconomic statistics and validate information collected from local communities
NGOs	• Engage with NGOs to understand concerns related to the Project, in addition to those identified during the Project scoping period; specific focus was on those NGOs representing vulnerable populations

Stakeholder Group or Category	Description of EIA Development Engagement Objectives
Fisherfolk	• Align with EEPGL's ongoing fisherfolk engagement program, including the Participatory Fishing Study, to provide Project updates and gather EIA inputs within the Project AOI.
Communities and Businesses in Regions 3 and 4	• Update community-level baseline information to inform the Project EIA, with a focus on socioeconomic conditions and ecosystem services data, in and around Regions 3 and 4, especially near the Project's Direct AOI

As part of the baseline data collection efforts, ERM also conducted a quantitative socioeconomic survey within and around the Direct AOI. The socioeconomic survey is discussed in detail in Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

As part of the stakeholder engagement process for the Project EIA, the Consultants connected with a wide range of stakeholders, including:

- 18 stakeholders from national, regional, and local government; NGOs; and other entities that agreed to meet through one-on-one engagement (out of the 40 entities invited for engagement);
- 34 representatives of NDCs in the Project AOI in Region 3 during targeted focus groups;
- 150 businesses in Regions 3 and 4 during the socioeconomic surveys; and
- 370 individuals in Region 3 during the socioeconomic surveys, including 122 individuals categorized as members of vulnerable groups.

This engagement provided the Consultants the opportunity to obtain new baseline data and request updated information, and complemented information obtained through similar engagements conducted in relation to the Yellowtail project in August and September 2021. Information received during this period has been incorporated into relevant sections of the EIA.

Table 6.3-4 summarizes the stakeholder engagement activities, including meetings and surveys, conducted with respect to the Project during the EIA development stage including engagements between November 2021 and March 2022.

Table 6.3-4: Stakeholder Engagement during EIA Development

Stakeholder Group or Category	Engagement
Best-Klien-Pouderoyen NDC	Meeting with NDC representatives in the Best-Klien-Pouderoyen NDC about the GTE Project and any concerns they may have.
Toevlugt/Patentia NDC	Meeting with NDC representatives about the ecosystem services in the communities and related studies and impacts relating to the Project. Provided an opportunity for NDC members to voice concerns, suggestions, and questions, as well as provide pertinent information about the ecosystem services in the area.
Goed Fortuin NDC	Meeting with NDC representatives about the ecosystem services in the communities and related studies and impacts relating to the Project. Provided an opportunity for NDC members to voice concerns, suggestions, and questions, as well as provide pertinent information about the ecosystem services in the area.

Stakeholder Group or Category	Engagement
Canal Polder NDC	Meeting with NDC representatives about the ecosystem services in the communities and related studies and impacts relating to the Project. Provided an opportunity for NDC members to voice concerns, suggestions, and questions, as well as provide pertinent information about the ecosystem services in the area.
Department of Fisheries	Meeting to discuss Project details, fishing activities, and impacts on fishing in Project areas.
Guyana Geology and Mines Commission (GGMC)	Meeting to get GGMC's input into the review of the EIA and discuss any project concerns the Commission may have.
Guyana Tourism Authority	Meeting to discuss the Project's impacts on the social, accommodation, and tourism/hospitality sectors
Maritime Administration Department (MARAD)	Meeting to discuss vessel traffic and marine safety/exclusion zones in the river, as well as address MARAD's concerns, input, and feedback about the GTE Project.
National Toshaos Council	Meeting to provide information about the GTE Project, discuss the social impacts of the work, and discuss the impacts the Project may have on Amerindian villages/people in the Project's AOI.
Sea and River Defense Board	Meeting to discuss the GTE Project and receive the Sea and River Defense Board's concerns, questions, and suggestions about the Project.
Pakuri (St. Cuthbert's Mission)	Meeting to discuss the Amerindian village's concern about the Project, receive recommendations and questions, and gain an understanding of the socioeconomic conditions in the village.
Santa Aratak	Meeting to discuss the Amerindian village's concern about the Project, receive recommendations and questions, and gain an understanding of the socioeconomic conditions in the village.
Traffic Chief Team	Meeting to discuss the possible impacts of the GTE project on traffic and learn more about data, the department's Road Safety Program, and possible mitigation strategies.
Socioeconomic Survey	Interviewed 440 households in the Project AOIs to learn more about the socioeconomic conditions in the areas and among households.
Commercial Survey	Interviewed 150 businesses in the Project AOIs to learn more about the economic and business activities in the areas.

6.3.4. EIA Disclosure

Following submission of the EIA to the EPA, the Consultants will facilitate engagement to share the results of the EIA with and solicit feedback from the public and other stakeholders. Similar to the scoping stage, this will include a combination of information distribution and public disclosure meetings intended to provide stakeholders with an opportunity to ask questions and provide comments on the EIA.

6.3.4.1. Information Distribution

Notification of the EIA submission and dissemination of information about the EIA and its findings will include:

- Public notice of availability announcing the EIA and where the public can access further information, to be published in local newspaper(s) and on EEPGL's website/social media;
- Distribution of a non-technical summary of the EIA, in printed and digital formats; and
- Use of traditional media and social media to share information about the Project and EIA.

6.3.4.2. Disclosure Meetings

After submittal of the EIA, and in collaboration with the EPA, ERM plans to host a series of public informational disclosure meetings, including at least one meeting in each of the six coastal regions. These meetings will provide the opportunity for stakeholders to learn about the EIA findings from the Consultants (including the potential environmental and socioeconomic impacts of the Project), and allow stakeholders to provide feedback on key issues addressed as part of the EIA.

6.3.5. Post-EIA Engagement

Once the EIA process is complete, and if EEPGL obtains an environmental authorization from the EPA and other required approvals, the Project would transition into execution. Plans for stakeholder engagement during Project execution are described in the SEP, and engagement activities would be adjusted to reflect evolving Project status and activity level, as well as stakeholder concerns over the life of the Project.

During Project execution, the emphasis of engagement shifts from input gathering to disclosure about planned activities, receiving feedback from members of the public and other stakeholders, and consultation about ongoing and planned activities. EEPGL would keep the public informed about the general progress of the Project (e.g., completion of Project stages such as construction and installation) and respond to grievances (i.e., specific complaints) filed under the Project's CGM which is described in the SEP. The Project's CGM is maintained throughout Project permitting and construction, after which the overall EEPGL CGM will be used.

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7. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—PHYSICAL RESOURCES

7.1. GEOLOGY AND GROUNDWATER

This section presents a discussion of the existing onshore geology and hydrogeology (inclusive of groundwater) in the Project Area of Influence (AOI), and an assessment of potential impacts to these resources from planned activities of the Project.

7.1.1. Baseline Methodology

The study of the area's geology, marine stratigraphy, and onshore hydrogeologic conditions was divided into two main phases: a desktop phase and a field data collection phase. The desktop phase included a review of geologic mapping and studies available in the published literature. The field data collection phase included the completion of soil borings and installation of piezometers (water level monitoring wells) within the Direct AOI.

7.1.2. Existing Conditions and Baseline Studies

7.1.2.1. Coastal Geology

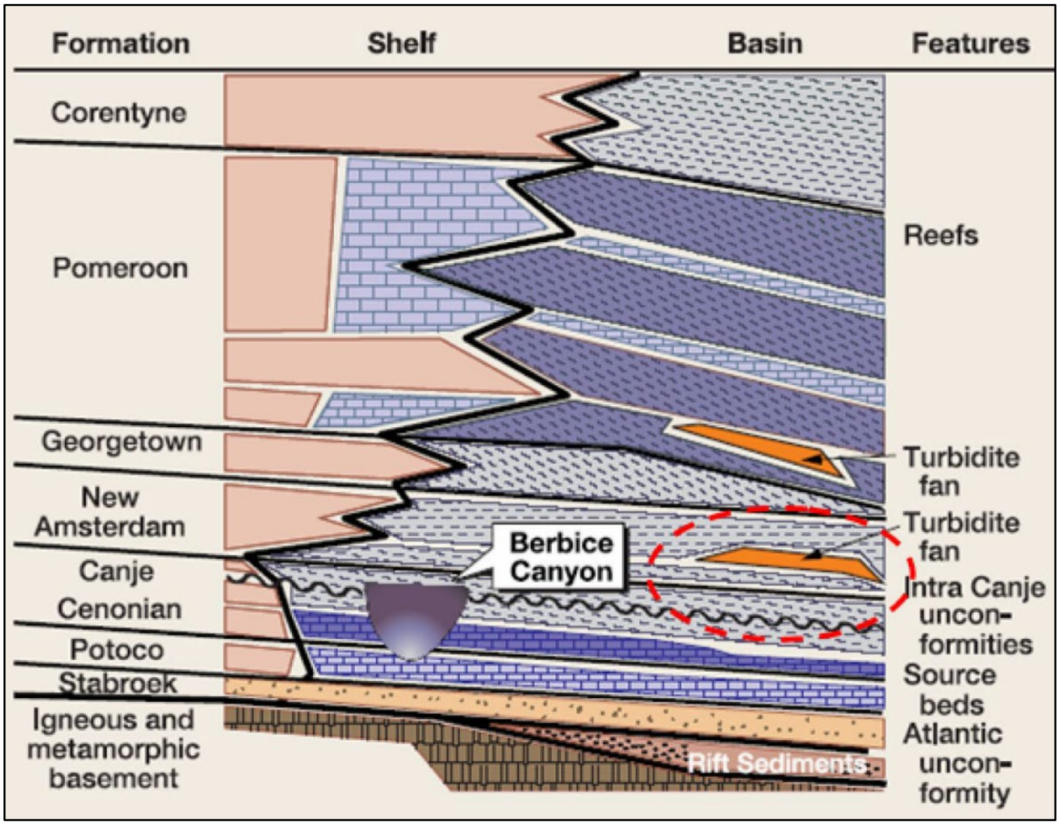
Guyana's continental shelf occupies an area of 48,665 square kilometers (km^2), with an average width of approximately 113 kilometers (NDS 1997). The shelf is widest near the borders of Suriname and Venezuela, and slightly narrower near the center of Guyana's coastline. Guyana's coastline is approximately 432 kilometers long (NDS 1997).

7.1.2.2. Marine Stratigraphy

The Guyana-Suriname Basin has been described as a passive margin basin[1] associated with the rifting and opening of the equatorial Atlantic Ocean. Part of the Guyana-Suriname Basin is onshore, but most of it occurs offshore. Figure 7.1-1 depicts the basin stratigraphy and Table 7.1-1 summarizes the age and composition of the major geologic formations (listed in descending order from ground/seabed surface) that comprise the Guyana-Suriname Basin (Workman 2000; CGX 2009). The uppermost Corentyne and underlying Pomeroon formations comprise the shallow bedrock beneath the seafloor. The formations are of Pleistocene-Pliocene and Miocene-Eocene age and dominated by shales and sandstones. Underlying the Pomeroon formation are sandstones of the Lower Tertiary to Maastrichtian age. The Georgetown and New Amsterdam formations are dominated by sandstones with subordinate layers of shales and carbonates. The underlying Santonian- to Turonian-aged interval contains the Canje and Cenonian formations, which are comprised primarily of organic and non-organic shales and sandstones. Underlying the Canje Cenonian formation is the Aptian-aged Potoco formation, which is dominated by carbonates. The deeper Stabroek formation is Cretaceous-Barremian in age and is dominated by continental shales and sands. The sedimentary rock sequence rests

[1] A passive margin is an area where continents have drifted apart to become separated by an ocean. Passive margins are found at every ocean and continent boundary that is not marked by a strike-slip fault or a subduction zone.

atop the igneous and metamorphic Precambrian Basement Complex of Proterozoic-Hadean age.



Source: From Workman and Birnie 2015; modified by the Consultants

Figure 7.1-1: Stratigraphic Chart of Guyana-Suriname Basin

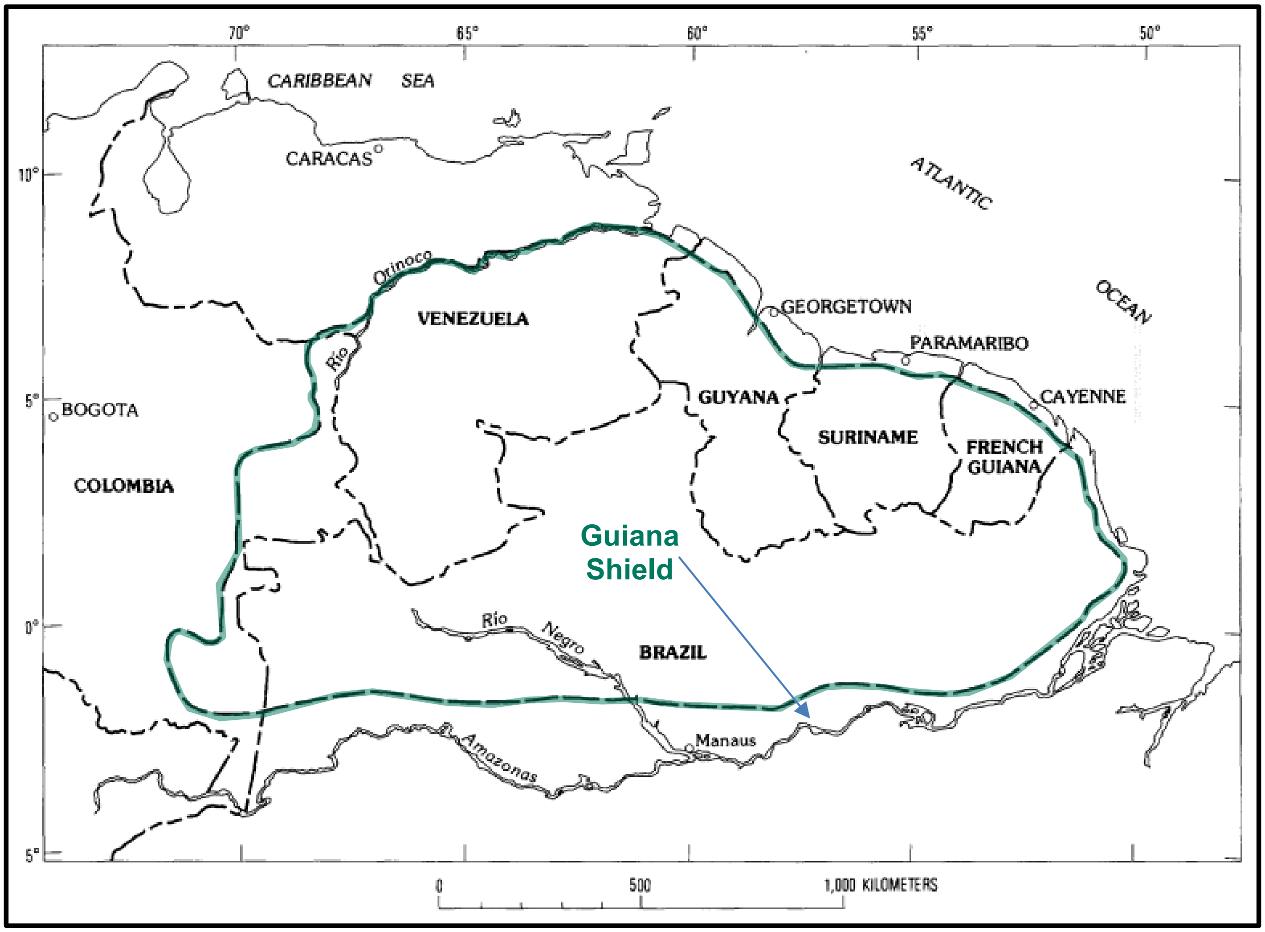
Table 7.1-1: Major Geologic Formations of the Guyana-Suriname Basin

Formation	Age	Composition
Corentyne	Pleistocene-Pliocene	Sandstone and shale
Pomeroon	Miocene-Eocene	Carbonate sandstone and shale
Georgetown	Maastrichtian	Sandstone, shale and carbonate
New Amsterdam	Lower Tertiary to Maastrichtian	Sandstone and shale
Canje and Cenonian	Santonian to Turonian	Organic shale, non-organic shale, and sandstone
Potoco Formation	Aptian	Carbonates
Stabroek Formation	Cretaceous–Barremian	Basal shales and sandstones of continental origin
Precambrian Basement	Proterozoic-Hadean	Igneous/Metamorphic rocks [a]

[a] The igneous/metamorphic basement on Figure 7.1-1 is of Precambrian age.

7.1.2.3. Geology

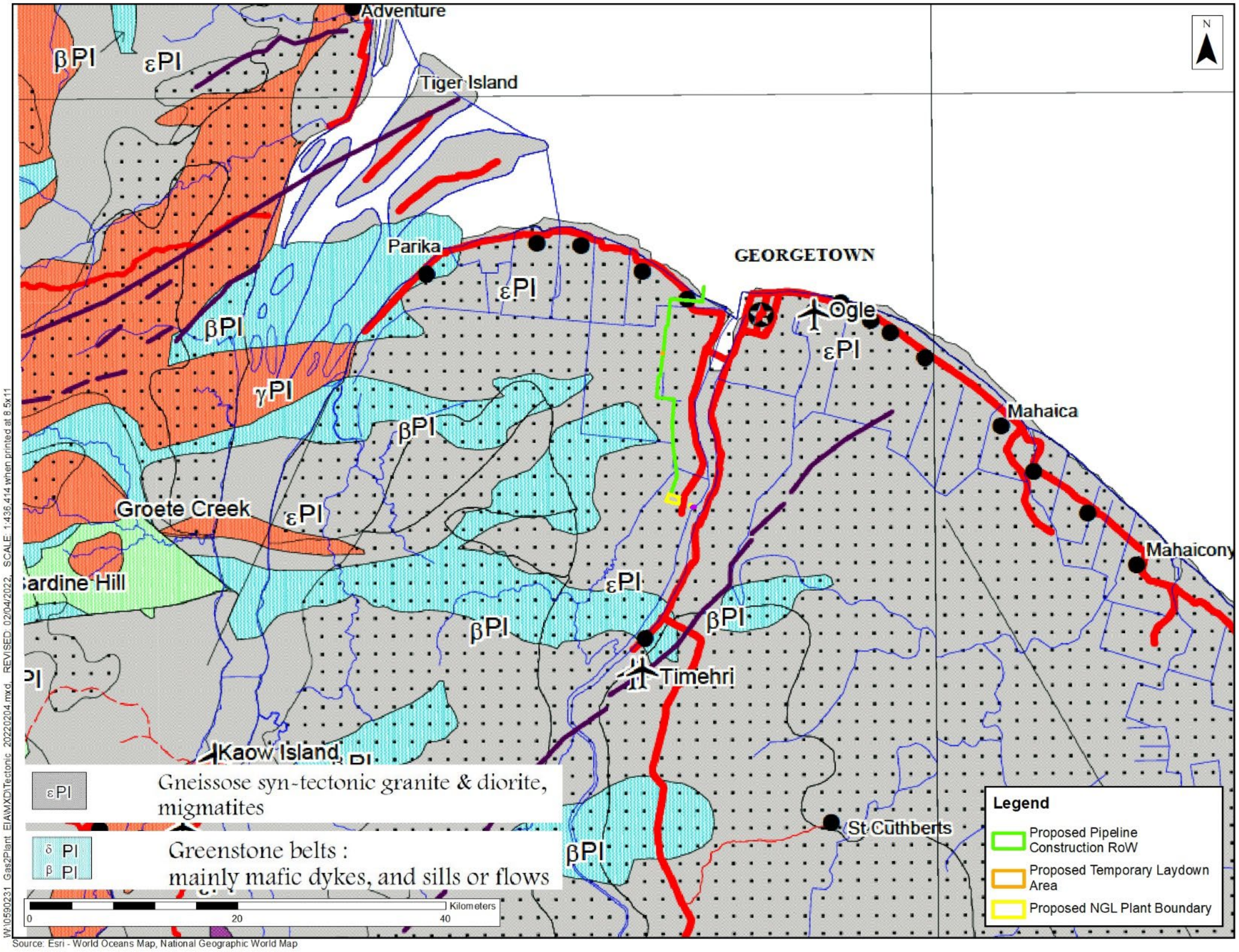
Guyana's landmass is situated at the southern portion of the Guyana-Suriname Basin and the northern edge of the Guiana Shield, which is in the northernmost portion of the South American continent (Figure 7.1-2). The basement complex of the Guiana Shield is composed of metamorphic, magmatic, and volcanic rocks of Precambrian age. The Guri Fault, located approximately 350 kilometers west-northwest of Georgetown, marks the southern boundary of the Archean Imataca Complex, separating the oldest rocks in the shield from Early Proterozoic metavolcanic rocks of the Pastora Supergroup and the granitic plutonic Supamo Complex (USGS 1993).



Source: USGS 1993

Figure 7.1-2: Location of the Precambrian Guiana Shield of Northern South America

Figure 7.1-3 presents a detailed map of the basement complex of the northern portion of Guyana, consisting primarily of Palaeoproterozoic Orosirian greenstone belts (Barama-Mazaruni Supergroup), intruded by granites, and overlain unconformably by sandstones and igneous rock of the Statherian Burro-Burro Group. Some folding occurred before these were overlain by the locally unconformable and almost flat-lying Roraima Group (Gibbs 1993). Within the Project AOI, bedrock is primarily composed of Gneissose syn-tectonic granite and diorites facies with younger greenstone belts occurring in the southern and western regions. The exposed contacts between the basement rock and the overlying White Sand Series delineate the boundary of the coastal artesian basin.



Source: GGMC 2010

Figure 7.1-3: Onshore Geologic Map of Project Area of Influence

7.1.2.4. Onshore Stratigraphy

Guyana is generally subdivided into four regions that describe the country's geologic stratigraphy:

1. Mountainous country of Precambrian basement complex of the Guiana Shield in the south;
2. Plateau country of the western central portion of Guyana of Paleozoic to Precambrian sediments;
3. Interior savannah with elevations between the Plateau country and the Atlantic Coastal Plain; and
4. Atlantic Coastal Plain, which extends inland from the coastline nearly 100 kilometers.

The onshore portion of the Direct AOI lies within the Atlantic Coastal Plain, a narrow strip extending about 100 kilometers inland. Figure 7.1-4 illustrates a geologic cross section between Georgetown (to the north) and Linden (to the south) (Arad 1983). The Atlantic Coastal Plain is subdivided into the Young Coastal Plain, 0.5 to 3.5 meters above mean sea level (amsl), and the Old Coastal Plain, up to 7.5 meters amsl. The former is covered by the Demerara Clay and the latter by the Coropina Formation. Together, these are commonly referred to as the uppermost clay and have a combined average thickness of 45 meters.

Approximately 40 kilometers inland from the coastline, there is a region of low hills with elevations up to 130 meters amsl where the White Sand Series outcrops. The Atlantic Coastal Plain is underlain with alternating layers of low-permeability clays and higher-permeability sands, as described below:

- The Upper Sands Series is composed primarily of loose quartz sand 15 to 55 meters thick, and is the uppermost confined coastal aquifer.
- The Intermediate Clay and Sand Formation is a highly heterogeneous unit about 150 meters thick that underlies the Upper Sands Series. It is very irregular in composition and thickness, and is considered as an aquitard between the Upper Sands and deeper aquifers (Arad 1974).
- The Lower Sand Series ("A Sand") consists of a thick unit of quartz sand and gravels and forms the major uppermost coastal aquifer. Although found at about 90 meters deep at its perimeter (Essequibo River), it is estimated at about 150 to 220 meters deep in the Direct AOI and more than 300 meters deep in the central part of the coastal artesian basin.
- A series of alternating beds of sand and clay approximately 50 meters thick separate the A sands from the underlying B Sand.
- The B Sand, characterized by alternating cemented sand and hard shale, is up to about 50 meters thick in the Georgetown area, but becomes less distinguishable in the central part of the coastal plain. The potentiometric water levels within this unit are the highest in the coastal plain, often resulting in artesian conditions.

Within the Direct AOI, the Precambrian basement complex is present at depths of about 550 to 600 meters below mean sea level (bmsl).

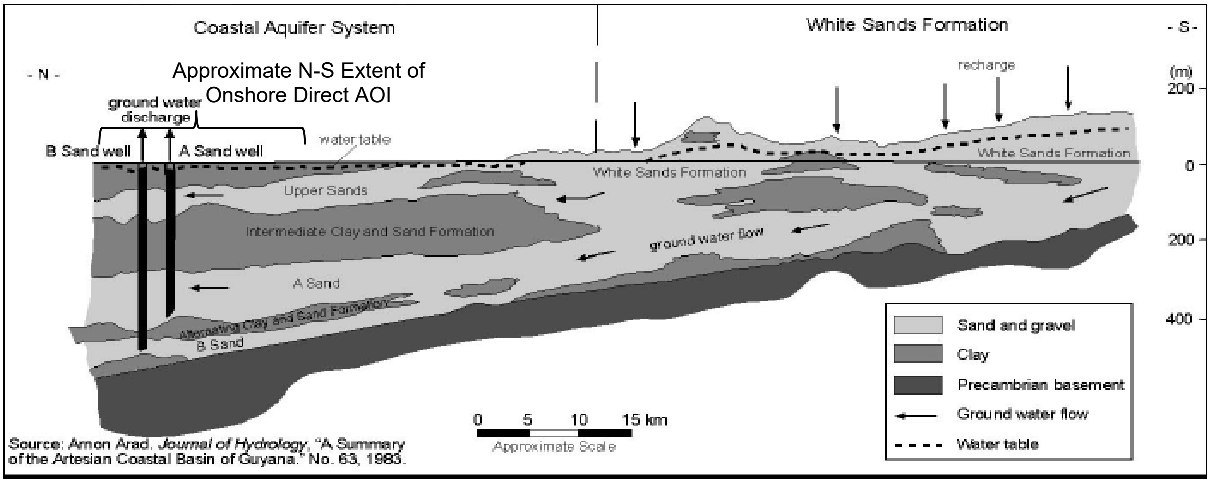


Figure 7.1-4: Geologic Cross Section between Georgetown (north) and Linden (south)

7.1.2.5. Seismic Activity

The Guiana Shield and Guyana-Suriname Basin are within the interior of the South American continental plate. Since 1900, fewer than 100 earthquakes have been reported either in Guyana (in the southern portion of the country) or in portions of Venezuela or Brazil near a Guyana border. The majority of these earthquakes have been recorded in the 3.0 to 4.0 magnitude range (VolcanoDiscovery.com Undated). Of these, the highest magnitude earthquake was reported at 5.6 on 31 January 2021, and occurred in the southern portion of the country in the Upper Takutu-Upper Essequibo Region, approximately 450 kilometers south of Georgetown. Table 7.1-2 summarizes the reported earthquakes in or near the borders of Guyana and their recorded magnitudes.

Table 7.1-2: Summary of Earthquakes Reported in Guyana Since 1900

Magnitude	Frequency
< 2.0	9
2.0 – 3.0	12
3.0 – 4.0	46
4.0 – 5.0	21
> 5.0	3

The majority of the seismic activity reported in or near the borders of Guyana is due to fault activity between the Caribbean and South American plates off the coast of Venezuela, where stresses are built up along and between rock layers. Off the coast of Venezuela is a subduction zone, where the North and South American plates are subducting under the oceanic Caribbean plate. At the southern boundary, the Caribbean plate interacts with the South American plate, forming the island of Trinidad on the South American plate and Tobago on the Caribbean plate. This boundary is associated with a transform-plate margin.

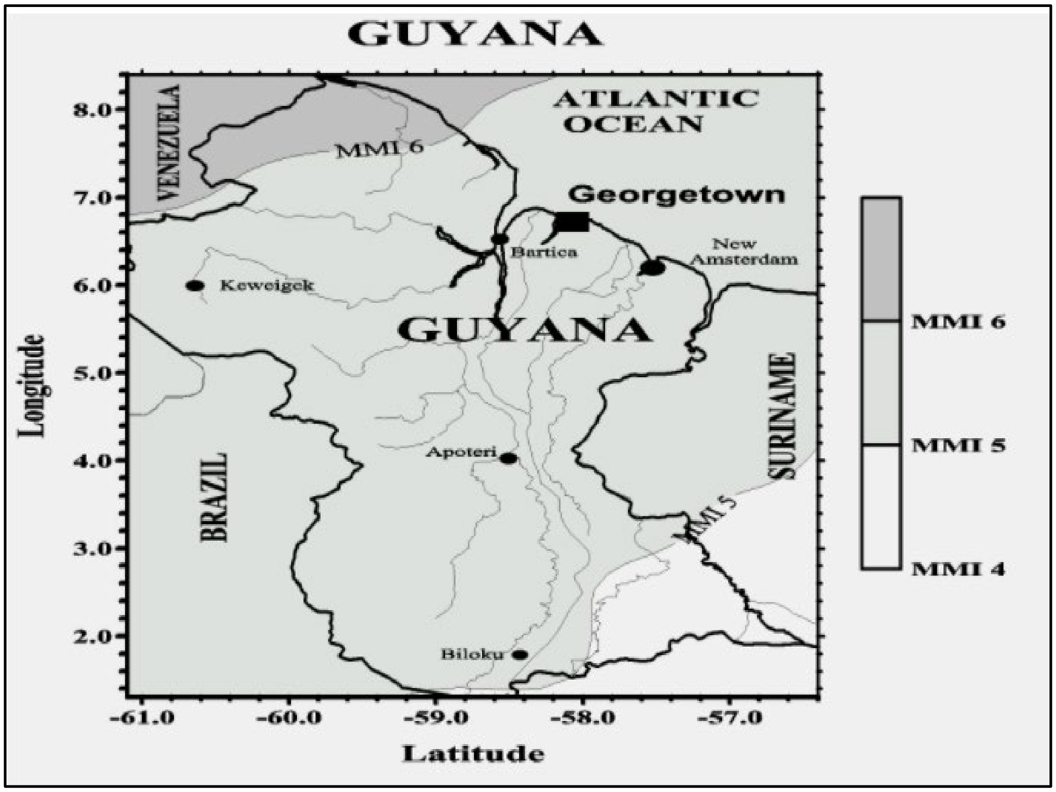
Guyana is classified as very-low probability for an earthquake hazard, indicating that there is less than a 2 percent chance of a potentially damaging earthquake in any 50 years (ThinkHazard.org Undated). Intensity scales, like the Modified Mercalli Intensity, measure the amount of shaking at a particular location. The lower numbers of the intensity scale generally correspond to the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage.

Intensity	Shaking	Description/Damage
I	Not felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest,especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Source: Public Domain

Figure 7.1-5: The Modified Mercalli Intensity Scale

The majority of Guyana, and specifically the region in which the Direct AOI is located, is classified as having a 10 percent probability of an earthquake's Modified Mercalli Intensity exceeding V in any 50-year period (CDMP 2001; Figure 7.1-6).



Source: CDMP 2001

Figure 7.1-6: Expected Maximum Mercalli Intensity with a 10 Percent Probability of Exceedance in Any 50-year Period

7.1.2.6. Hydrogeology

The coastal aquifer system is the source of most of Region 3's groundwater resources, with most wells concentrated near the population centers of the Atlantic coast and only scattered wells in the interior. While abundant forest resources and forest utilization have minimal direct impact on water resources, over-harvesting of forests in the White Sands area could affect the recharge of the aquifer that provides most of the potable water for the country (USACE 1998).

Three separate, but hydrogeologically connected, aquifers within the coastal aquifer system have provided water for the coastal residents of Guyana for the last century (Figure 7.1-4). Domestic water supply accounts for nearly 90 percent of the groundwater produced from wells in the coastal lowlands region (USACE 1998). With a growing demand on surface water for agricultural and industrial needs, groundwater is becoming an increasingly important water source.

The White Sand Series, which outcrops approximately 40 kilometers inland from the coastline in the Project AOI, is the main intake area of the coastal artesian basin and a source of water for many streams and wetlands in the lower coastal plain. In the coastal region, a shallow water table is present within the low-permeability silts and clays that comprise the upper geologic stratum in this area. The Upper Sands aquifer is the shallowest of the three aquifers of the coastal aquifer system (USACE 1998). Initially developed for water supply, this aquifer was never fully utilized and withdrawals ultimately ceased due to a high iron and salinity content.

The A Sand aquifer serves as the principal water source for Georgetown and the coastal lowlands region. A typical water well completed in this aquifer yields between 4,000 and 40,000 liters per minute (USACE 1998) of good quality water with a low chloride content; however, its high iron content typically requires treatment. The Intermediate Clay Formation, composed of clay and shale, acts as an impermeable barrier between the Upper Sands aquifer and the A Sand aquifer, minimizing intrusion of seawater into the A Sand aquifer. Since its initial development, increased demand has decreased the potentiometric levels in the A Sand aquifer by several tens of meters (USACE 1998).

The deeper B Sand aquifer, separated from the A sand by the overlying Alternating Clay and Sand Formation, provides a secondary source of groundwater supply. While the B Sand is not exploited to the extent of the A Sand aquifer because it is deeper and requires more pumping and more treatment to remove hydrogen sulfide, it also has yields of 4,000 to 40,000 liters per minute year-round (USACE 1998).

Groundwater Quality Assessment

In late 2021, the Consultants conducted studies to characterize groundwater quality and levels at the proposed natural gas liquids (NGL) processing plant (NGL Plant) site and along the onshore pipeline route. Temporary shallow piezometers were installed in the low-permeability silts and clays that comprise the upper geologic stratum to facilitate collection of groundwater samples. In early 2022, piezometers were installed in the Upper Sands aquifer and groundwater samples were collected from these piezometers. The locations of the shallow groundwater sampling locations (P2 through P5, NGL1, NGL4, and NGL5) and the deeper groundwater sampling locations (Piez-105 and Piez-106) are shown on Figure 7.1-7. Piezometer Piez-105 was installed to a depth of 30.5 meters below ground surface (bgs) and piezometer Piez-106 was installed to a depth of 19.8 meters bgs.

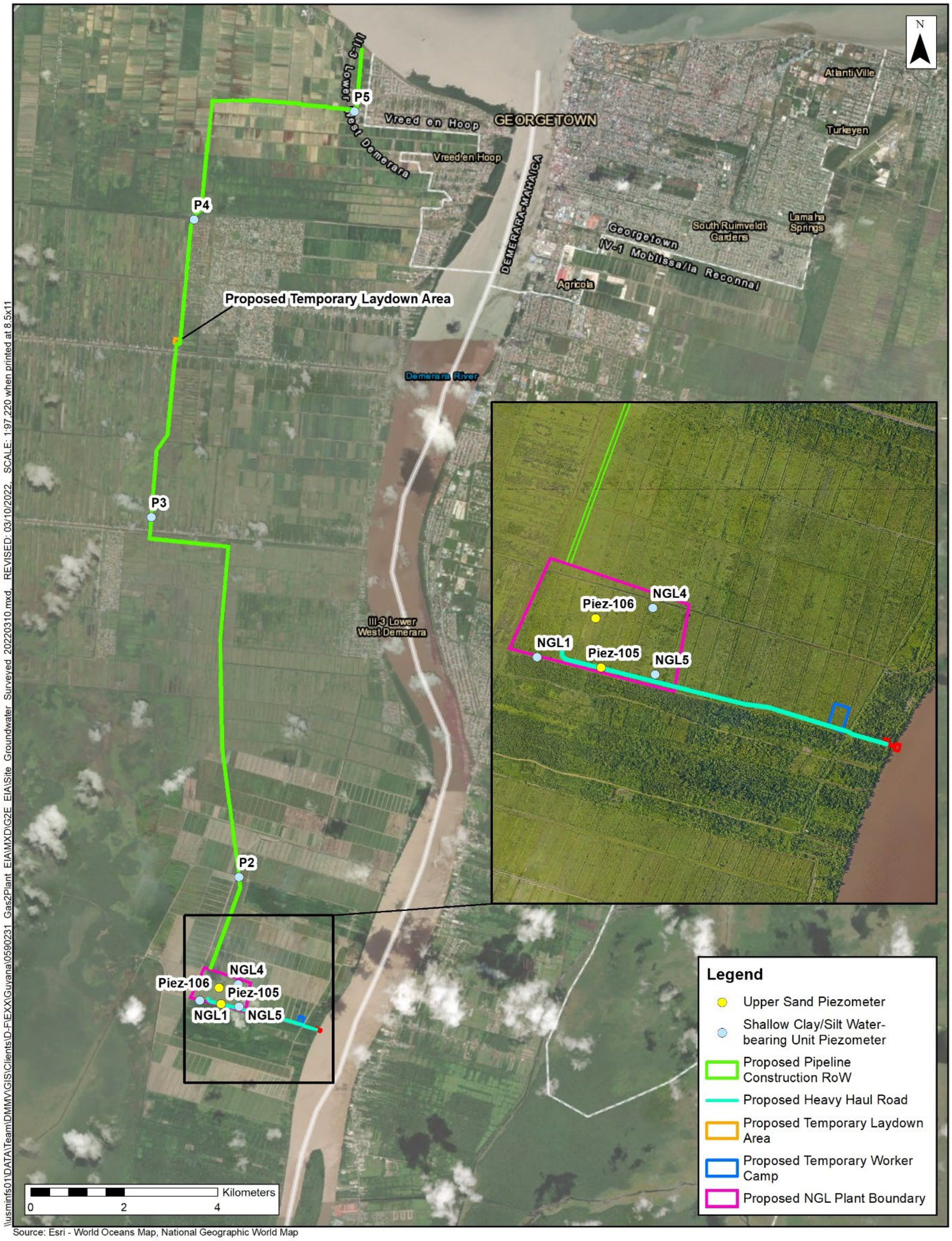


Figure 7.1-7: Groundwater Quality Sample Locations

Additional groundwater study details, including field-sampling methodology, water quality monitoring data logs, and laboratory reports, are provided in Appendix D, Geology and Hydrogeology Reports. Water quality parameters measured on site included temperature, pH, conductivity, and turbidity. All other water quality parameters were analyzed by ALS Environmental laboratory in Houston, Texas, including:

- Metals by United States Environmental Protection Agency (USEPA) Method 6020
- Volatiles organic compounds by USEPA Method 8260
- Polynuclear aromatic hydrocarbons (PAHs) by USEPA Method 8270
- Pesticides and polychlorinated biphenyls (PCBs) by USEPA Methods 8081 and 8082
- Herbicides by USEPA Method 8151

While the study was not intended to assess the suitability of groundwater for consumption purposes, analytical results were compared to the USEPA National Primary Drinking Water standards as a basis for establishing existing water quality conditions (USEPA 2009). For most constituents, these standards are the Maximum Contaminant Levels (MCLs), which are determined by the USEPA to be the highest levels that are allowed in drinking water. In the absence of a published USEPA MCL, results for some constituents were compared to secondary MCLs (e.g., iron and manganese), where available. These secondary MCL values are related to aesthetic qualities of water (i.e., taste, odor, appearance) and are not based on health-based considerations. The groundwater-bearing zones sampled as part of this study are not proposed for use as a water supply for the Project. Groundwater quality results and the reference standards to which they were compared are summarized in Tables 7.1-3 and 7.1-4 and discussed below.

Table 7.1-3: Summary of Groundwater Analytical Results for Piezometers in Shallow Water-bearing Zone along Onshore Pipeline Right-of-Way

Parameter	Unit	Reference Standard [a]	Onshore Pipeline			
			P2	P3	P4	P5
General Water Quality Parameters						
Nitrate, Nitrogen	mg/L	10	0.0824 JH	0.076 JH	0.105 H	0.908 H
Nitrogen, Nitrate-Nitrite	Mg/L	NA	2.60 J	2.68 J	2.58 J	1.76 J
Phosphorus	mg/L	NA	BDL	0.41 J	3.86	9.35
Potassium	mg/L	NA	7.48	8.59	14.7	50.7
Iron	mg/L	0.3 *	283	280	386	419
Manganese	mg/L	0.05 *	8.33	0.632	2.85	13.3
pH (field)	Std. Units	6.5 - 8.5	6.84	3.82	5.60	6.75
Temperature (field)	°C	NA	28.2	29.4	31.4	30.4
Total Organic Carbon	mg/L	NA	21.1	19.9	20.8	33.8
Specific Conductivity	mmhos/cm	NA	1.68	1.08	0.367	14.6
Pesticides						
4,4-DDD	mg/L	NA	BDL	BDL	BDL	BDL
4,4-DDE	mg/L	NA	BDL	BDL	BDL	BDL
4,4-DDT	mg/L	NA	BDL	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	Onshore Pipeline			
			P2	P3	P4	P5
Aldrin	mg/L	NA	BDL	BDL	BDL	BDL
alpha-BHC	mg/L	NA	BDL	BDL	0.000008 H	0.000011
Alpha-Chlordane	mg/L	NA	BDL	BDL	BDL	BDL
beta-BHC	mg/L	NA	BDL	BDL	0.0000013 HP	0.0000069
delta-BHC	mg/L	NA	BDL	BDL	BDL	BDL
Dieldrin	mg/L	NA	BDL	BDL	BDL	BDL
Endosulfan I	mg/L	NA	BDL	BDL	BDL	BDL
Endosulfan II	mg/L	NA	BDL	BDL	BDL	BDL
Endosulfan Sulfate	mg/L	NA	BDL	BDL	BDL	BDL
Endrin	mg/L	0.002	BDL	BDL	BDL	BDL
Endrin Aldehyde	mg/L	NA	BDL	BDL	BDL	BDL
Endrin Ketone	mg/L	NA	BDL	BDL	BDL	BDL
Gamma-BHC (Lindane)	mg/L	0.0002	BDL	BDL	BDL	BDL
Gamma-Chlordane	mg/L	NA	BDL	BDL	BDL	BDL
Heptachlor	mg/L	0.0004	BDL	BDL	0.000002 HP	0.0000017 P
Heptachlor Epoxide	mg/L	0.0002	BDL	BDL	BDL	0.0000038
Methoxychlor	mg/L	0.04	BDL	BDL	BDL	BDL
Toxaphene	mg/L	0.003	BDL	BDL	BDL	BDL
Polychlorinated biphenyls						
Aroclor 1016	mg/L	0.0005	BDL	BDL	BDL	BDL
Aroclor 1221	mg/L	0.0005	BDL	BDL	BDL	BDL
Aroclor 1232	mg/L	0.0005	BDL	BDL	BDL	BDL
Aroclor 1242	mg/L	0.0005	BDL	BDL	BDL	BDL
Aroclor 1248	mg/L	0.0005	BDL	BDL	BDL	BDL
Aroclor 1254	mg/L	0.0005	BDL	BDL	BDL	BDL
Aroclor 1260	mg/L	0.0005	BDL	BDL	BDL	BDL
Herbicides						
2,4,5-T	mg/L	NA	BDL	BDL	BDL	BDL
2,4,5-TP (Silvex)	mg/L	0.05	BDL	BDL	BDL	BDL
2,4-D	mg/L	0.07	BDL	BDL	BDL	BDL
2,4-DB	mg/L	NA	BDL	BDL	BDL	BDL
Dalapon	mg/L	0.2	0.000102 JHP	BDL	BDL	BDL
Dicamba	mg/L	NA	BDL	BDL	BDL	BDL
Dichloroprop	mg/L	NA	BDL	BDL	BDL	BDL
Dinoseb	mg/L	0.007	BDL	BDL	BDL	BDL
MCPA	mg/L	NA	BDL	BDL	BDL	BDL
MCPP	mg/L	NA	BDL	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	Onshore Pipeline			
			P2	P3	P4	P5
Metals						
Antimony	mg/L	0.006	BDL	BDL	BDL	BDL
Arsenic	mg/L	0.01	0.032	0.119	0.0254	0.127
Beryllium	mg/L	0.004	0.0111	0.00394	0.0203	0.0143
Cadmium	mg/L	0.005	BDL	0.00055 J	0.000284 J	0.000434 J
Chromium	mg/L	0.1	0.0226	0.0431	0.0229	0.0615
Copper	mg/L	1.3 [TT]	0.0367	BDL	0.0016 J	0.0478
Lead	mg/L	0.015 [TT]	0.0973	0.104	0.0291	0.323
Mercury	mg/L	0.002	0.000033 J	0.00007 J	0.000067 J	BDL
Nickel	mg/L	NA	0.138	0.0981	0.0855	0.126
Selenium	mg/L	0.05	BDL	0.00347	0.00479	0.00765
Silver	mg/L	0.1 *	BDL	BDL	BDL	BDL
Thallium	mg/L	0.002	BDL	0.000200 J	BDL	BDL
Zinc	mg/L	5 *	0.925	0.594	1.52	0.626
Volatile Organic Compounds						
1,1,1-Trichloroethane	mg/L	0.2	BDL	BDL	BDL	BDL
1,1,2,2-Tetrachloroethane	mg/L	NA	BDL	BDL	BDL	BDL
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	mg/L	NA	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	mg/L	0.005	BDL	BDL	BDL	BDL
1,1-Dichloroethane	mg/L	NA	BDL	BDL	BDL	BDL
1,1-Dichloroethene	mg/L	0.007	BDL	BDL	BDL	BDL
1,2,3-Trichlorobenzene	mg/L	NA	BDL	BDL	BDL	BDL
1,2,4-Trichlorobenzene	mg/L	0.07	BDL	BDL	BDL	BDL
1,2-Dibromo-3-chloropropane	mg/L	0.0002	BDL	BDL	BDL	BDL
1,2-Dibromoethane (EDB)	mg/L	NA	BDL	BDL	BDL	BDL
1,2-Dichlorobenzene	mg/L	NA	BDL	BDL	BDL	BDL
1,2-Dichloroethane (EDC)	mg/L	0.005	BDL	BDL	BDL	BDL
1,2-Dichloropropane	mg/L	0.005	BDL	BDL	BDL	BDL
1,3-Dichlorobenzene	mg/L	NA	BDL	BDL	BDL	BDL
1,4-Dichlorobenzene	mg/L	0.075	BDL	BDL	BDL	BDL
2-Butanone (MEK)	mg/L	NA	BDL	BDL	0.0044 H	BDL
2-Hexanone	mg/L	NA	BDL	BDL	BDL	BDL
4-Methyl-2-pentanone (MIBK)	mg/L	NA	BDL	BDL	BDL	BDL
Acetone	mg/L	NA	0.013	0.0047 H	0.013 H	0.0065
Benzene	mg/L	0.005	BDL	BDL	BDL	BDL
Bromochloromethane	mg/L	NA	BDL	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	Onshore Pipeline			
			P2	P3	P4	P5
Bromodichloromethane	mg/L	0.08 #	BDL	BDL	BDL	BDL
Bromoform	mg/L	NA	BDL	BDL	BDL	BDL
Bromomethane	mg/L	NA	BDL	BDL	BDL	BDL
Carbon Disulfide	mg/L	NA	BDL	0.0012 JH	BDL	BDL
Carbon Tetrachloride	mg/L	0.005	BDL	BDL	BDL	BDL
Chlorobenzene	mg/L	0.1	BDL	BDL	BDL	BDL
Chloroethane	mg/L	NA	BDL	BDL	BDL	BDL
Chloroform	mg/L	NA	BDL	BDL	BDL	BDL
Chloromethane	mg/L	NA	BDL	BDL	BDL	BDL
cis-1,2-Dichloroethene	mg/L	0.07	BDL	BDL	BDL	BDL
cis-1,3-Dichloropropene	mg/L	NA	BDL	BDL	BDL	BDL
Cyclohexane	mg/L	NA	BDL	BDL	BDL	BDL
Dibromochloromethane	mg/L	0.08 #	BDL	BDL	BDL	BDL
Dichlorodifluoromethane (Freon 12)	mg/L	NA	BDL	BDL	BDL	BDL
Ethylbenzene	mg/L	0.7	BDL	BDL	BDL	BDL
Isopropylbenzene (Cumene)	mg/L	NA	BDL	BDL	BDL	BDL
m/p-xylene	mg/L	10	BDL	BDL	BDL	BDL
Methyl acetate	mg/L	NA	BDL	BDL	BDL	BDL
Methyl t-Butyl Ether	mg/L	NA	BDL	BDL	BDL	BDL
Methylcyclohexane	mg/L	NA	BDL	BDL	BDL	BDL
Methylene Chloride	mg/L	0.005	BDL	BDL	BDL	BDL
o-Xylene	mg/L	10	BDL	BDL	BDL	BDL
Styrene	mg/L	0.1	BDL	BDL	BDL	BDL
Tetrachloroethene	mg/L	0.005	BDL	BDL	BDL	BDL
Toluene	mg/L	1	BDL	BDL	BDL	0.00071 J
trans-1,2-Dichloroethene	mg/L	0.1	BDL	BDL	BDL	BDL
trans-1,3-Dichloropropene	mg/L	NA	BDL	BDL	BDL	BDL
Trichloroethene	mg/L	0.005	BDL	BDL	BDL	BDL
Trichlorofluoromethane (Freon 11)	mg/L	NA	BDL	BDL	BDL	BDL
Vinyl Chloride	mg/L	0.002	BDL	BDL	BDL	BDL
Semivolatile Organic Compounds						
1-Methylnaphthalene	mg/L	NA	BDL	BDL	BDL	BDL
2-Methylnaphthalene	mg/L	NA	BDL	0.00004 JH	BDL	BDL
Acenaphthene	mg/L	NA	BDL	BDL	BDL	BDL
Acenaphthylene	mg/L	NA	BDL	BDL	BDL	BDL
Anthracene	mg/L	NA	BDL	BDL	BDL	BDL
Benzo(a)Anthracene	mg/L	NA	BDL	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	Onshore Pipeline			
			P2	P3	P4	P5
Benzo(a)Pyrene	mg/L	0.0002	BDL	BDL	BDL	BDL
Benzo(b)Fluoranthene	mg/L	NA	BDL	BDL	BDL	BDL
Benzo(g,h,i)Perylene	mg/L	NA	BDL	BDL	BDL	BDL
Benzo(k)Fluoranthene	mg/L	NA	BDL	BDL	BDL	BDL
Chrysene	mg/L	NA	BDL	BDL	BDL	BDL
Dibenzo(a,h)anthracene	mg/L	NA	BDL	BDL	BDL	BDL
Fluoranthene	mg/L	NA	BDL	0.000029 JH	BDL	BDL
Fluorene	mg/L	NA	BDL	BDL	BDL	BDL
Indeno(1,2,3-cd)Pyrene	mg/L	NA	BDL	BDL	BDL	BDL
Isophorone	mg/L	NA	BDL	BDL	BDL	BDL
Naphthalene	mg/L	NA	BDL	BDL	BDL	BDL
Phenanthrene	mg/L	NA	BDL	0.000056 JH	BDL	BDL
Pyrene	mg/L	NA	BDL	0.000026 JH	BDL	BDL

°C = degrees Celsius; BDL = below detection limit; H = analyzed outside of holding time; J = analyte detected below quantitation limit; mg/L = milligrams per liter; mmhos/cm = millimhos per centimeter; NA = not available (no USEPA Primary Drinking Water Standard); P = dual column relative percent difference > 40%; P2–P5 = piezometer sample IDs
[a] National Primary Drinking Water Standards, May 2009, USEPA 816-F-09-004 (USEPA 2009). Unless otherwise indicated, the listed reference standards are MCLs, determined by the USEPA to be the highest levels that are allowed in drinking water.
* Secondary MCLs related to aesthetic qualities of water (e.g., taste, odor, appearance).
[TT] Lead and copper are regulated by the USEPA by a treatment technique that requires water systems to control the corrosiveness of their water. For copper, the action level is 1.3 mg/L and for lead the action level is 0.015 mg/L.
[#] National Primary Drinking Water Standards for total trihalomethanes (USEPA 2009).

Onshore Pipeline Right-of-Way Piezometers (Shallow Clay/Silt Water-bearing Zone)

Groundwater was encountered in the four shallow piezometers completed along the onshore pipeline route (see Figure 7.1-7) between 0.76 and 2.9 meters bgs. Water samples were collected from each of these piezometers to characterize the water quality, as described above. Below are some of the key findings from the water quality data:

- Field pH values ranged from 3.82 to 6.84, indicating generally acidic conditions, consistent with the low buffering capacity of the surrounding sediments.
- Iron and manganese are common within natural aquifer systems and their presence at concentrations above the reference standards is not atypical.
- Nitrate nitrogen, cadmium, chromium, copper, selenium, and zinc were detected, but at concentrations below reference standards.
- Concentrations of beryllium at three locations and arsenic and lead at all four locations were detected above, but generally within about one order of magnitude of their respective reference standard concentrations. Acidic conditions will tend to mobilize metals in the environment and the presence of these metals in groundwater is not atypical; accordingly,

this should not be interpreted as necessarily indicative of anthropogenic contamination. The groundwater in the zone in which these piezometers were completed is not known to be used for potable supply and the concentrations reported do not suggest an elevated risk due to acute contact exposure scenarios such as would be involved in Project construction activities (USEPA 2021).

- Trace levels of pesticide and herbicides were detected in samples P2, P4, and P5 at concentrations below their reference standards.
- Several volatile and semivolatile organic compounds were detected at concentrations below their respective reference standards.
- PCBs were not detected in any of the samples.

NGL Plant Site Piezometers (Shallow Clay/Silt Water-bearing Zone)

Groundwater was encountered in the three shallow piezometers completed at the NGL Plant site between 1.0 and 1.6 meters (3.2 and 5.3 feet) bgs (Figure 7.1-7). Water samples were collected from each of the three piezometers to characterize water quality. Below are observations from the water quality data:

- Field pH values ranged from 6.07 to 6.48, indicating slightly acidic conditions, consistent with the low buffering capacity of the surrounding sediments.
- Iron and manganese are common within natural aquifer systems and their presence at concentrations above the reference standards is not atypical. Manganese concentrations exceeded the reference standards at all three piezometers by up to two to three orders of magnitude. Iron concentrations also exceeded the reference standard at piezometers NGL4 and NGL5 by about three orders of magnitude, but this parameter was not detected in the sample from NGL1.
- Nitrate nitrogen, cadmium, chromium, copper, mercury, selenium, and zinc were also detected, but at concentrations below reference standards.
- Concentrations of arsenic, beryllium, and lead were detected at all three locations above their respective reference standard concentrations. Acidic conditions will tend to mobilize metals in the environment and the presence of these metals in groundwater is not atypical; accordingly, this should not be interpreted as necessarily indicative of anthropogenic contamination. The groundwater in the zone in which these piezometers were completed is not known to be used for potable supply and the concentrations reported do not suggest an elevated risk due acute contact exposure scenarios such as would be involved in Project construction activities (USEPA 2021).
- Trace levels of 4,4-DDT, a pesticide, and Dalapon, a herbicide, were detected in samples from NGL1 and NGL4, respectively, but at concentrations below their reference standards.
- Other than acetone, which does not have a USEPA reference standard, volatile and semivolatile organic compound and polychlorinated biphenyls were not detected in the

samples. The trace levels of acetone detected in the samples would not present an exposure risk due to direct contact (USEPA 2021).

Table 7.1-4: Summary of Groundwater Analytical Results for Piezometers in Shallow Water-bearing Zone within NGL Plant Site

Parameter	Unit	Reference Standard [a]	NGL Plant		
			NGL1	NGL4	NGL5
General Water Quality Parameters					
Nitrate, Nitrogen	mg/L	10	0.0971 JH	BDL	0.0923 JH
Nitrogen, Nitrate-Nitrite	mg/L	NA	0.836 J	2.76 J	2.72 J
Phosphorus	mg/L	NA	BDL	BDL	BDL
Potassium	mg/L	NA	9.38	9.74	5.25
Iron	mg/L	0.3 *	BDL	379	125
Manganese	mg/L	0.05 *	25	16.6	11.5
pH (field)	Std. Units	6.5–8.5	6.43	6.07	6.48
Temperature (field)	°C	NA	23.6	22.2	22.4
Total Organic Carbon	mg/L	NA	34.0	20.0	9.08
Specific Conductivity	mmhos/cm	NA	2.06	1.22	1.79
Pesticides					
4,4-DDD	mg/L	NA	BDL	BDL	BDL
4,4-DDE	mg/L	NA	BDL	BDL	BDL
4,4-DDT	mg/L	NA	BDL	0.000007 HP	BDL
Aldrin	mg/L	NA	BDL	BDL	BDL
alpha-BHC	mg/L	NA	BDL	BDL	BDL
Alpha-Chlordane	mg/L	NA	BDL	BDL	BDL
beta-BHC	mg/L	NA	BDL	BDL	BDL
delta-BHC	mg/L	NA	BDL	BDL	BDL
Dieldrin	mg/L	NA	BDL	BDL	BDL
Endosulfan I	mg/L	NA	BDL	BDL	BDL
Endosulfan II	mg/L	NA	BDL	BDL	BDL
Endosulfan Sulfate	mg/L	NA	BDL	BDL	BDL
Endrin	mg/L	0.002	BDL	BDL	BDL
Endrin Aldehyde	mg/L	NA	BDL	BDL	BDL
Endrin Ketone	mg/L	NA	BDL	BDL	BDL
Gamma-BHC (Lindane)	mg/L	0.0002	BDL	BDL	BDL
Gamma-Chlordane	mg/L	NA	BDL	BDL	BDL
Heptachlor	mg/L	0.0004	BDL	BDL	BDL
Heptachlor Epoxide	mg/L	0.0002	BDL	BDL	BDL
Methoxychlor	mg/L	0.04	BDL	BDL	BDL
Toxaphene	mg/L	0.003	BDL	BDL	BDL
Polychlorinated biphenyls					
Aroclor 1016	mg/L	0.0005	BDL	BDL	BDL
Aroclor 1221	mg/L	0.0005	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	NGL Plant		
			NGL1	NGL4	NGL5
Aroclor 1232	mg/L	0.0005	BDL	BDL	BDL
Aroclor 1242	mg/L	0.0005	BDL	BDL	BDL
Aroclor 1248	mg/L	0.0005	BDL	BDL	BDL
Aroclor 1254	mg/L	0.0005	BDL	BDL	BDL
Aroclor 1260	mg/L	0.0005	BDL	BDL	BDL
Herbicides					
2,4,5-T	mg/L	NA	BDL	BDL	BDL
2,4,5-TP (Silvex)	mg/L	0.05	BDL	BDL	BDL
2,4-D	mg/L	0.07	BDL	BDL	BDL
2,4-DB	mg/L	NA	BDL	BDL	BDL
Dalapon	mg/L	0.2	0.000118	BDL	BDL
Dicamba	mg/L	NA	BDL	BDL	BDL
Dichloroprop	mg/L	NA	BDL	BDL	BDL
Dinoseb	mg/L	0.007	BDL	BDL	BDL
MCPA	mg/L	NA	BDL	BDL	BDL
MCPP	mg/L	NA	BDL	BDL	BDL
Metals					
Antimony	mg/L	0.006	BDL	BDL	BDL
Arsenic	mg/L	0.01	0.0724	0.0553	0.0186
Beryllium	mg/L	0.004	0.0255	0.014	0.00694
Cadmium	mg/L	0.005	0.000628 J	0.000625 J	0.000297 J
Chromium	mg/L	0.1	0.0442	0.069	0.0248
Copper	mg/L	1.3 [TT]	0.0318	0.0485	0.0409
Lead	mg/L	0.015 [TT]	0.177	0.178	0.0942
Mercury	mg/L	0.002	0.000033 J	BDL	BDL
Nickel	mg/L	NA	0.244	0.208	0.117
Selenium	mg/L	0.05	0.0071	0.00763	0.00352
Silver	mg/L	0.1 *	BDL	BDL	BDL
Thallium	mg/L	0.002	BDL	BDL	BDL
Zinc	mg/L	5 *	1.67	1.18	0.492
Volatile Organic Compounds					
1,1,1-Trichloroethane	mg/L	0.2	BDL	BDL	BDL
1,1,2,2-Tetrachloroethane	mg/L	NA	BDL	BDL	BDL
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	mg/L	NA	BDL	BDL	BDL
1,1,2-Trichloroethane	mg/L	0.005	BDL	BDL	BDL
1,1-Dichloroethane	mg/L	NA	BDL	BDL	BDL
1,1-Dichloroethene	mg/L	0.007	BDL	BDL	BDL
1,2,3-Trichlorobenzene	mg/L	NA	BDL	BDL	BDL
1,2,4-Trichlorobenzene	mg/L	0.07	BDL	BDL	BDL
1,2-Dibromo-3-chloropropane	mg/L	0.0002	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	NGL Plant		
			NGL1	NGL4	NGL5
1,2-Dibromoethane (EDB)	mg/L	NA	BDL	BDL	BDL
1,2-Dichlorobenzene	mg/L	NA	BDL	BDL	BDL
1,2-Dichloroethane (EDC)	mg/L	0.005	BDL	BDL	BDL
1,2-Dichloropropane	mg/L	0.005	BDL	BDL	BDL
1,3-Dichlorobenzene	mg/L	NA	BDL	BDL	BDL
1,4-Dichlorobenzene	mg/L	0.075	BDL	BDL	BDL
2-Butanone (MEK)	mg/L	NA	BDL	BDL	BDL
2-Hexanone	mg/L	NA	BDL	BDL	BDL
4-Methyl-2-pentanone (MIBK)	mg/L	NA	BDL	BDL	BDL
Acetone	mg/L	NA	0.0056	0.0061	0.0044
Benzene	mg/L	0.005	BDL	BDL	BDL
Bromochloromethane	mg/L	NA	BDL	BDL	BDL
Bromodichloromethane	mg/L	0.08 [#]	BDL	BDL	BDL
Bromoform	mg/L	NA	BDL	BDL	BDL
Bromomethane	mg/L	NA	BDL	BDL	BDL
Carbon Disulfide	mg/L	NA	BDL	BDL	BDL
Carbon Tetrachloride	mg/L	0.005	BDL	BDL	BDL
Chlorobenzene	mg/L	0.1	BDL	BDL	BDL
Chloroethane	mg/L	NA	BDL	BDL	BDL
Chloroform	mg/L	NA	BDL	BDL	BDL
Chloromethane	mg/L	NA	BDL	BDL	BDL
cis-1,2-Dichloroethene	mg/L	0.07	BDL	BDL	BDL
cis-1,3-Dichloropropene	mg/L	NA	BDL	BDL	BDL
Cyclohexane	mg/L	NA	BDL	BDL	BDL
Dibromochloromethane	mg/L	0.08 [#]	BDL	BDL	BDL
Dichlorodifluoromethane (Freon 12)	mg/L	NA	BDL	BDL	BDL
Ethylbenzene	mg/L	0.7	BDL	BDL	BDL
Isopropylbenzene(Cumene)	mg/L	NA	BDL	BDL	BDL
m/p-xylene	mg/L	10	BDL	BDL	BDL
Methyl acetate	mg/L	NA	BDL	BDL	BDL
Methyl t-Butyl Ether	mg/L	NA	BDL	BDL	BDL
Methylcyclohexane	mg/L	NA	BDL	BDL	BDL
Methylene Chloride	mg/L	0.005	BDL	BDL	BDL
o-Xylene	mg/L	10	BDL	BDL	BDL
Styrene	mg/L	0.1	BDL	BDL	BDL
Tetrachloroethene	mg/L	0.005	BDL	BDL	BDL
Toluene	mg/L	1	BDL	BDL	BDL
trans-1,2-Dichloroethene	mg/L	0.1	BDL	BDL	BDL
trans-1,3-Dichloropropene	mg/L	NA	BDL	BDL	BDL
Trichloroethene	mg/L	0.005	BDL	BDL	BDL

Parameter	Unit	Reference Standard [a]	NGL Plant		
			NGL1	NGL4	NGL5
Trichlorofluoromethane (Freon 11)	mg/L	NA	BDL	BDL	BDL
Vinyl Chloride	mg/L	0.002	BDL	BDL	BDL
Semi-Volatile Organic Compounds					
1-Methylnaphthalene	mg/L	NA	BDL	BDL	BDL
2-Methylnaphthalene	mg/L	NA	BDL	BDL	BDL
Acenaphthene	mg/L	NA	BDL	BDL	BDL
Acenaphthylene	mg/L	NA	BDL	BDL	BDL
Anthracene	mg/L	NA	BDL	BDL	BDL
Benzo(a)Anthracene	mg/L	NA	BDL	BDL	BDL
Benzo(a)Pyrene	mg/L	0.0002	BDL	BDL	BDL
Benzo(b)Fluoranthene	mg/L	NA	BDL	BDL	BDL
Benzo(g,h,i)Perylene	mg/L	NA	BDL	BDL	BDL
Benzo(k)Fluoranthene	mg/L	NA	BDL	BDL	BDL
Chrysene	mg/L	NA	BDL	BDL	BDL
Dibenzo(a,h)anthracene	mg/L	NA	BDL	BDL	BDL
Fluoranthene	mg/L	NA	BDL	BDL	BDL
Fluorene	mg/L	NA	BDL	BDL	BDL
Indeno(1,2,3-cd)Pyrene	mg/L	NA	BDL	BDL	BDL
Isophorone	mg/L	NA	BDL	BDL	BDL
Naphthalene	mg/L	NA	BDL	BDL	BDL
Phenanthrene	mg/L	NA	BDL	BDL	BDL
Pyrene	mg/L	NA	BDL	BDL	BDL

°C = degrees Celsius; BDL = below detection limit; H = analyzed outside of holding time; J = analyte detected below quantitation limit; mg/L = milligrams per liter; mmhos/cm = millimhos per centimeter; NA = not applicable (no USEPA Primary Drinking Water Standard); NGL 1,4,5 = piezometer sample IDs; P = dual column relative percent difference > 40%

[a] National Primary Drinking Water Standards, May 2009, USEPA 816-F-09-004 (USEPA 2009). Unless otherwise indicated, the listed reference standards are MCLs, determined by the USEPA to be the highest levels that are allowed in drinking water.

* Secondary MCLs are related to aesthetic qualities of water (i.e., taste, odor, appearance).

[TT] Lead and copper are regulated by the USEPA by a treatment technique that requires water systems to control the corrosiveness of their water. For copper, the action level is 1.3 mg/L and for lead the action level is 0.015 mg/L.

[#] National Primary Drinking Water Standards for total trihalomethanes (USEPA 2009).

Upper Sands Aquifer

Groundwater is present in the Upper Sands Aquifer under artesian[2] conditions. Depth to groundwater was measured at 0.88 and 0.85 meter bgs, respectively, at the two deep piezometers completed at the NGL Plant site: Piez-105 and Piez-106 (Figure 7.1-7). Water samples were collected from each of the two piezometers to characterize water quality. Pesticides, PCBs, and herbicides were not able to be analyzed due to excessive sediment in the samples. Below are observations from the water quality data:

[2] Artesian refers to situations where the groundwater is confined under pressure below low-permeability layers.

- Field pH values ranged from 6.74 to 7.92 during purging, indicating circumneutral conditions, consistent with pH values of other samples taken at the NGL Plant site.
- Iron and manganese are common within natural aquifer systems and their presence at concentrations above the reference standards is not atypical. Manganese concentrations exceeded the reference standards at both piezometers by more than an order of magnitude. Iron concentrations also exceeded the reference standard at both deep piezometers by about two orders of magnitude. It is important to note that these reference standards are related to aesthetic qualities of water (i.e., taste, odor, appearance) and do not represent a concern for health risk or contamination.
- Nitrate nitrogen, chromium, copper, mercury, selenium, and zinc were also detected, but at concentrations below reference standards.
- Concentrations of arsenic, beryllium, and lead were detected at both locations above their respective reference standard concentrations. The groundwater in the zone in which these piezometers were completed is not known to be used for potable supply and the concentrations reported do not suggest an elevated risk due acute contact exposure scenarios such as could be involved in Project construction activities (USEPA 2021).
- Methylene chloride was detected in both deep piezometer samples at concentrations one to three orders of magnitude above drinking water reference standards. Methylene chloride is a solvent used in a variety of industries and applications, such as adhesives, paint, and coating products. Its presence in the groundwater suggests the possibility of past anthropogenic impacts. It is noted that methylene chloride is a common laboratory contaminant. Review of the laboratory analytical reports for the two deep piezometer samples confirmed that methylene chloride was not detected in either of the method blanks analyzed by the laboratory. This indicates no evidence of laboratory contamination.

Table 7.1-5: Summary of Groundwater Analytical Results for Piezometers in Upper Sands within NGL Plant Site

Parameter	Unit	Reference Standard[1]	NGL-Piez-105	NGL-Piez-106
Metals				
Antimony	mg/L	0.006	BDL	BDL
Arsenic	mg/L	0.01	0.0159	0.0185
Beryllium	mg/L	0.004	0.00718	0.00191 J
Cadmium	mg/L	0.005	BDL	BDL
Chromium	mg/L	0.1	0.0849	0.0305
Copper	mg/L	1.3 [TT]	0.0198	0.00828
Iron	mg/L	0.3 *	39.1	17.1
Lead	mg/L	0.015 [TT]	0.0563	0.0165
Manganese	mg/L	0.05 *	0.747	0.373
Mercury	mg/L	0.002	0.000520 J	BDL
Nickel	mg/L	0.1	0.0271	0.0156

Parameter	Unit	Reference Standard[1]	NGL-Piez-105	NGL-Piez-106
Potassium	mg/L	NA	8.03	9.07
Selenium	mg/L	0.05	0.00349 J	0.00152 J
Silver	mg/L	0.1	BDL	BDL
Thallium	mg/L	0.002	BDL	BDL
Zinc	mg/L	5	0.275	0.0558
Groundwater Quality Parameters				
Nitrogen, Nitrate-Nitrite	mg/L	10	0.397 J	0.382 J
Volatile Organic Compounds				
1,1,1-Trichloroethane	mg/L	0.2	BDL	BDL
1,1,2,2-Tetrachloroethane	mg/L	NA	BDL	BDL
1,1,2-Trichlor-1,2,2-trifluoroethane	mg/L	NA	BDL	BDL
1,1,2-Trichloroethane	mg/L	0.005	BDL	BDL
1,1-Dichloroethane	mg/L	NA	BDL	BDL
1,1-Dichloroethene	mg/L	0.007	BDL	BDL
1,2,3-Trichlorobenzene	mg/L	NA	BDL	BDL
1,2,4-Trichlorobenzene	mg/L	0.07	BDL	BDL
1,2-Dibromo-3-chloropropane	mg/L	0.0002	BDL	BDL
1,2-Dibromoethane	mg/L	NA	BDL	BDL
1,2-Dichlorobenzene	mg/L	NA	BDL	BDL
1,2-Dichloroethane	mg/L	0.005	BDL	BDL
1,2-Dichloropropane	mg/L	0.005	BDL	BDL
1,3-Dichlorobenzene	mg/L	NA	BDL	BDL
1,4-Dichlorobenzene	mg/L	0.075	BDL	BDL
2-Butanone	mg/L	NA	BDL	BDL
2-Hexanone	mg/L	NA	BDL	BDL
4-Methyl-2-pentanone	mg/L	NA	BDL	BDL
Acetone	mg/L	NA	BDL	0.011 H
Benzene	mg/L	0.005	BDL	BDL
Bromochloromethane	mg/L	NA	BDL	0.0054 H
Bromodichloromethane	mg/L	0.08 [#]	BDL	BDL
Bromoform	mg/L	NA	BDL	BDL
Bromomethane	mg/L	NA	BDL	BDL
Carbon disulfide	mg/L	NA	BDL	BDL
Carbon tetrachloride	mg/L	0.005	BDL	BDL
Chlorobenzene	mg/L	0.1	BDL	BDL
Chloroethane	mg/L	NA	BDL	BDL
Chloroform	mg/L	NA	BDL	BDL
Chloromethane	mg/L	NA	BDL	BDL
Ethylbenzene	mg/L	0.7	BDL	BDL
Isopropylbenzene	mg/L	NA	BDL	BDL
m,p-Xylene	mg/L	10	BDL	BDL

Parameter	Unit	Reference Standard[1]	NGL-Piez-105	NGL-Piez-106
Methyl acetate	mg/L	NA	BDL	BDL
Methyl tert-butyl ether	mg/L	NA	BDL	BDL
Methylcyclohexane	mg/L	NA	BDL	BDL
Methylene chloride	mg/L	0.005	0.055 H	3 H
o-Xylene	mg/L	10	BDL	BDL
Styrene	mg/L	0.1	BDL	BDL
Tetrachloroethene	mg/L	0.005	BDL	BDL
Toluene	mg/L	1	BDL	BDL
trans-1,2-Dichloroethene	mg/L	0.1	BDL	BDL
trans-1,3-Dichloropropene	mg/L	NA	BDL	BDL
Trichloroethene	mg/L	0.005	BDL	BDL
Trichlorofluoromethane	mg/L	NA	BDL	BDL
Vinyl chloride	mg/L	0.002	BDL	BDL
Xylenes, Total	mg/L	10	BDL	BDL
Semi-Volatile Organic Compounds				
1-Methylnaphthalene	mg/L	NA	BDL	BDL
2-Methylnaphthalene	mg/L	NA	BDL	BDL
Acenaphthene	mg/L	NA	BDL	BDL
Acenaphthylene	mg/L	NA	BDL	BDL
Anthracene	mg/L	NA	BDL	BDL
Benz(a)anthracene	mg/L	NA	BDL	BDL
Benzo(a)pyrene	mg/L	0.0002	BDL	BDL
Benzo(b)fluoranthene	mg/L	NA	BDL	BDL
Benzo(g,h,i)perylene	mg/L	NA	BDL	BDL
Benzo(k)fluoranthene	mg/L	NA	BDL	BDL
Chrysene	mg/L	NA	BDL	BDL
Dibenz(a,h)anthracene	mg/L	NA	BDL	BDL
Dibenzofuran	mg/L	NA	BDL	BDL
Fluoranthene	mg/L	NA	BDL	BDL
Fluorene	mg/L	NA	BDL	BDL
Indeno(1,2,3-cd)pyrene	mg/L	NA	BDL	BDL
Naphthalene	mg/L	NA	BDL	BDL
Phenanthrene	mg/L	NA	BDL	BDL
Pyrene	mg/L	NA	BDL	BDL

BDL = below detection limit; H = analyzed outside of holding time; J = analyte detected below quantitation limit; mg/L = milligrams per liter; NA = not available (no USEPA Primary Drinking Water Standard); NGL-Piez-105, 106 = piezometer sample IDs;

[1] National Primary Drinking Water Standards, May 2009, USEPA 816-F-09-004 (USEPA 2009). Unless otherwise indicated, the listed reference standards are MCLs, determined by the USEPA to be the highest levels that are allowed in drinking water.

* Secondary MCLs are related to aesthetic qualities of water (i.e., taste, odor, appearance).

[TT] Lead and copper are regulated by the USEPA by a treatment technique that requires water systems to control the corrosiveness of their water. For copper, the action level is 1.3 mg/L and for lead the action level is 0.015 mg/L.

[#] National Primary Drinking Water Standards for total trihalomethanes (USEPA 2009)

7.1.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on geology and groundwater. The relevant planned Project activities and the associated potential impacts of these activities on geology and groundwater resources are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

Planned Project activities will not impact geological resources in Guyana. Specifically, the Project will not involve any activities with the potential to influence seismic activity, or impact geomorphology or mineral resources. Accordingly, this section focuses on potential impacts on groundwater resources as a result of planned activities of the Project.

7.1.3.1. Relevant Project Activities and Potential Impacts

Various activities during the Construction and Operations stages of the Project (i.e., horizontal directional drilling [HDD], onshore pipeline trench excavation, excavation dewatering, and groundwater withdrawals) could potentially impact groundwater resources in the Direct AOI. The key potential impacts assessed include changes in shallow groundwater quality and drawdown of the shallow groundwater table or the potentiometric surface of deeper aquifers.

Table 7.1-6 summarizes the planned Project activities that could result in potential impacts on groundwater.

Table 7.1-6: Summary of Relevant Project Activities and Key Potential Impacts—Groundwater

Stage	Project Activity	Key Potential Impacts
Construction	Completion of HDD borings; Dewatering to facilitate excavation below shallow groundwater table during onshore pipeline installation trenching.	• Changes in groundwater quality from loss of drilling fluids to surrounding groundwater • Shallow groundwater table drawdown, potentially resulting in reduction in water quantity/level in adjacent canals • Dewatering discharge to adjacent canals, potentially resulting in changes in water quality in canals
Operations	Withdrawal of groundwater from A Sand aquifer for process and domestic use at NGL Plant	• Potentiometric surface drawdown in A Sand aquifer, potentially resulting in reduction of groundwater availability for other users • Changes to groundwater quality as a result of installation or operation of the groundwater pumping well

7.1.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity) and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for groundwater (Tables 7.1-7 and 7.1-8). Sensitivity is defined on a resource -specific basis for all resources, and the definitions for groundwater sensitivity are provided in Table 7.1-9). Because the potential impacts discussed in this section cover both direct impacts on groundwater and indirect impacts on surface water (i.e., canal water) that is hydrologically connected to groundwater, the definitions in Tables 7.1-6 through 7.1-8 refer to “water availability” and “water quality” to cover both types of impacts.

For the purpose of assessing the significance of potential impacts with respect to reduction in groundwater availability and changes in groundwater quality, separate discussions are provided for the following Project activities:

- HDD
- Dewatering during open-cut trenching for onshore pipeline installation
- Withdrawal of groundwater from the A Sand aquifer

Table 7.1-7: Definitions for Intensity Ratings for Potential Impacts on Groundwater (Reduction in Water Availability)

Criterion	Definition
Intensity	**Negligible**: The projected water-level drawdown at nearby canals is within the reasonably expected variation, OR the projected long-term groundwater level (potentiometric surface) drawdown is less than 10 percent of the available drawdown of the transmissive zone.
	Low: The projected water-level drawdown at nearby canals is greater than the reasonably expected variation, but not to the extent that it significantly affects the functionality of the canal to serve water users, OR the projected long-term groundwater level (potentiometric surface) drawdown is greater than 10 percent of the available drawdown of the transmissive zone, but limited to a localized area (i.e., within the Direct AOI).
	Medium: The projected water-level drawdown at nearby canals is greater than the reasonably expected variation to the extent that it affects the functionality of the canal to serve water users temporarily, OR the projected long-term groundwater level (potentiometric surface) drawdown is greater than 10 percent of the available drawdown of the transmissive zone over a moderately sized area (i.e., up to 0.5 kilometer beyond the Direct AOI).
	High: The projected water-level drawdown at nearby canals is greater than the reasonably expected variation to the extent that it affects the functionality of the canal to serve water users over an extended time period, OR the projected long-term groundwater level (potentiometric surface) drawdown is greater than 10 percent of the available drawdown of the transmissive zone over a widespread area (i.e., more than 0.5 kilometer beyond the Direct AOI).

Table 7.1-8: Definitions for Intensity Ratings for Potential Impacts on Groundwater (Changes in Water Quality)

Criterion	Definition
Intensity	**Negligible:** No increase in constituent concentrations above levels with potential to contribute to human health impacts
	Low: Increases in constituent concentrations to above levels with potential to contribute to human health impacts, but limited to a localized area (i.e., within the Direct AOI)
	Medium: Increases in constituent concentrations to above levels with potential to contribute to human health impacts over a moderately sized area (i.e., up to 0.5 kilometer beyond the Direct AOI)
	High: Increases in constituent concentrations to above levels with potential to contribute to human health impacts, affecting a widespread area (i.e., more than 0.5 kilometer beyond the Direct AOI)

Table 7.1-9: Definitions for Resource Sensitivity Ratings for Potential Impacts on Groundwater (Reduction in Water Availability or Quality)

Criterion	Definition
Sensitivity	**Low**: Affected groundwater resources are not a direct source of water for communities living nearby and do not discharge to canals that support diverse habitats and/or are a source of water for communities living nearby.
	Medium: Affected groundwater resources are a direct source of water for communities living nearby and/or are a significant discharge to canals that support diverse habitats, and/or are a non-critical source of water for communities living nearby.
	High: Affected groundwater resources are a significant direct source of water for communities living nearby and/or are a significant discharge to canals that support economically significant or biologically unique species or provide essential habitat for those species, and/or are a critical source of water for communities living nearby.

7.1.3.3. Impact Magnitude Ratings—Groundwater

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to groundwater is provided in Table 7.1-10.

Horizontal Directional Drilling

The HDD method will be used to install several segments of the onshore pipeline so as to avoid surface disturbance in specific areas (e.g., road crossings, major canal crossings). The HDD rig is designed to drill at shallow angles, curves, or horizontal / flat elevation and generally involves a three-step process: (1) drilling a pilot hole along the designated pipeline centerline; (2) enlarging the pilot hole to a larger diameter suitable to accommodate the pipeline (often called pre-reaming); and (3) pulling the pipe back through the enlarged / reamed borehole.

Initially, the drilling stem, drill rod, and bit will be advanced into the ground in a pilot borehole at a shallow angle until the desired depth is reached. The drill head can then be leveled out to continue drilling at the desired depth and grade until it reaches the targeted exit point.

Depending upon the pipeline design and HDD equipment, rather than leveling out, the pilot hole can be advanced along a gentle arc beneath the ground surface, exiting into a shallow excavation or receiving pit. Current construction plans include use of HDD installation methods at 11 separate segments of the pipeline, comprising approximately 5 kilometers (20 percent) of the onshore pipeline length (Figure 7.1-8).

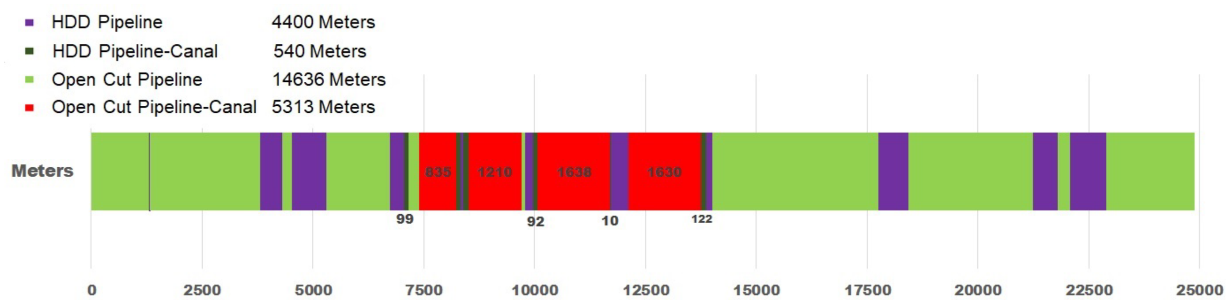


Figure 7.1-8: Pipeline Installation Methods along Alignment

HDD is a trenchless construction method that uses drilling fluids under pressure. The potential impacts on groundwater resources from HDD operations are related to the potential loss of these drilling fluids from the HDD bore to the surrounding formation. With proper drilling fluid design and management, these losses are expected to be infrequent and—where they do occur—limited in areal extent (NJDEP 2021). Potential losses are more likely to occur in the presence of loose, sandy soils and poorly compacted fill (NJDEP 2021)—neither of which characterize the surficial soils along the onshore pipeline corridor in which HDD bores will be completed. In some cases, unforeseen circumstances can lead to an excessive loss of drilling fluid from the HDD bore to surrounding groundwater or to the ground surface; as a loss of this magnitude is a situation that is not reasonably expected to occur as part of planned Project activities, the risk of this type of event is evaluated in Chapter 10, Unplanned Events. Under expected circumstances, the drilling fluid will remain within the HDD bore and returned to the HDD drilling fluid management pits at the bore entrance or exit. In summary, the HDD bores that will be completed in the soils along the onshore pipeline corridor are not reasonably anticipated to result in effects to water quality in the shallow groundwater zones through which the HDD bores will pass. Further, the HDD operation will not involve withdrawal of groundwater, so there will not be any effect on groundwater availability associated with this Project activity.

The intensity of this potential impact relative to degradation of groundwater quality is therefore rated as **Negligible** during the Construction stage. Any potential impacts will occur on an essentially continuous basis while HDD activities are occurring, so the frequency of this impact is considered **Continuous** during these stages. HDD activities will last less than a week along each segment, so the duration is considered **Short-term**.

Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact relative to change in groundwater quality is rated as **Negligible** during the Construction stage.

Dewatering During Open-Cut Trenching for Onshore Pipeline Installation

Dewatering of saturated soils during the Construction stage may be required due to the shallow groundwater table across portions of the onshore pipeline corridor. Depending on the connectivity of the shallow groundwater zone to nearby canals, dewatering could reduce contributions of shallow groundwater to these surrounding waterbodies and have an indirect effect on the water levels in the canals.

Because dewatering during the Construction stage will be conducted primarily along the onshore pipeline corridor, the assessment of potential dewatering impacts was focused on this component of the Project. The information considered when evaluating the dewatering of open-cut trenches, in particular in areas adjacent to canals, includes the following:

5. The estimated lengths of onshore pipeline segments that will be installed using open-cut trenching beneath the groundwater table;
6. An estimate of the depth that the trenches will extend below the groundwater table (i.e., the saturated zone thickness affected), based on depth-to-water measurements made at four temporary piezometers installed along the onshore pipeline corridor; and
7. The duration of pipeline construction and the average amount of time dewatering will need to be conducted for a pipeline segment.

The onshore pipeline extends approximately 25 kilometers from the shore landing to the proposed NGL Plant. Current construction plans indicate that open-cut trench excavation methods will be used for approximately 20 kilometers (80 percent) of the onshore pipeline extent (Figure 7.1-8).

The potential need for dewatering open-cut trench segments, which excludes the portions that will be completed using HDD, was evaluated using the methodology described above. The estimated total length of open-cut trenching that will be below the groundwater table (assuming a water table depth at 0.75 meter to 3 meters bgs; see Section 7.1.2, Existing Conditions and Baseline Studies) is approximately 8.3 kilometers (42 percent of the extent of the pipeline that will be installed using open-cut trenching).

As an embedded control, where the onshore pipeline route crosses a canal and open-cut trench methods are to be used, temporary flow-diversion structures will be installed to limit flow of water from the upstream and downstream segments of the canal into the trench. The isolated portion of the canal will then be dewatered to facilitate pipeline installation. Dewatering of the segment will thus be limited to the immediate area of the trench crossing and any water removed will be discharged to the canal downstream of the temporary flow-diversion structure. Further, surface water upstream of the trench crossing will be diverted around the trench crossing and discharged into the canal downstream of the temporary flow-diversion structure, essentially maintaining the natural flow and water level in the canal during construction activities.

The Project will open trench segments of between approximately 200 and 3,750 meters in length at any given time to complete the onshore pipeline. Where these segments run adjacent to / parallel to a canal, dewatering required to keep the excavation dry may result in a lowering of the potentiometric surface beneath the canal (i.e., as a result of removal of shallow groundwater that is hydrologically connected to the canal). However, it is unlikely that the water levels in the canal will be impacted during dewatering for the following reasons:

1. Surface water in the canal upstream of the open trench segment will continue to flow downstream within the canal to the segment of the canal alongside the trench dewatering.
2. Dewatering of the open trench will occur on one side of the canal. The surface water in the canal will serve as a constant-head boundary to which the dewatering cone of depression will extend. Shallow groundwater on the opposite side of the canal will continue to discharge to the canal.
3. Where a canal is present adjacent to a segment where dewatering will occur, the water removed from dewatering will be discharged into the adjacent canal, effectively recharging the water in the canal faster than it will be removed from the canal via drainage through the soil formation.

Dewatering for a segment will stop once the pipeline in the segment is installed in the trench and the trench is backfilled. Accordingly, dewatering of the entire corridor length will not occur at any one time.

For the reasons stated above, the projected water-level drawdown in nearby canals is expected to be within the reasonably expected variation. Accordingly, the intensity of this potential impact relative to reduction in water availability in the canals is rated as **Negligible**. There will be no chemicals used in open trenching, but the groundwater removed from the dewatering operation and discharged into canals, where they are adjacent to the dewatering segment, has the potential to introduce an elevated particulate concentration into the canals. As an embedded control, the Project will use filtration techniques to reduce the solids content of the dewatering discharge to an acceptable level. On this basis, no increase in constituent or solids concentrations above levels currently present in the canals is expected, and the intensity of the potential impact relative to changes in water quality in the canals is rated as **Negligible**.

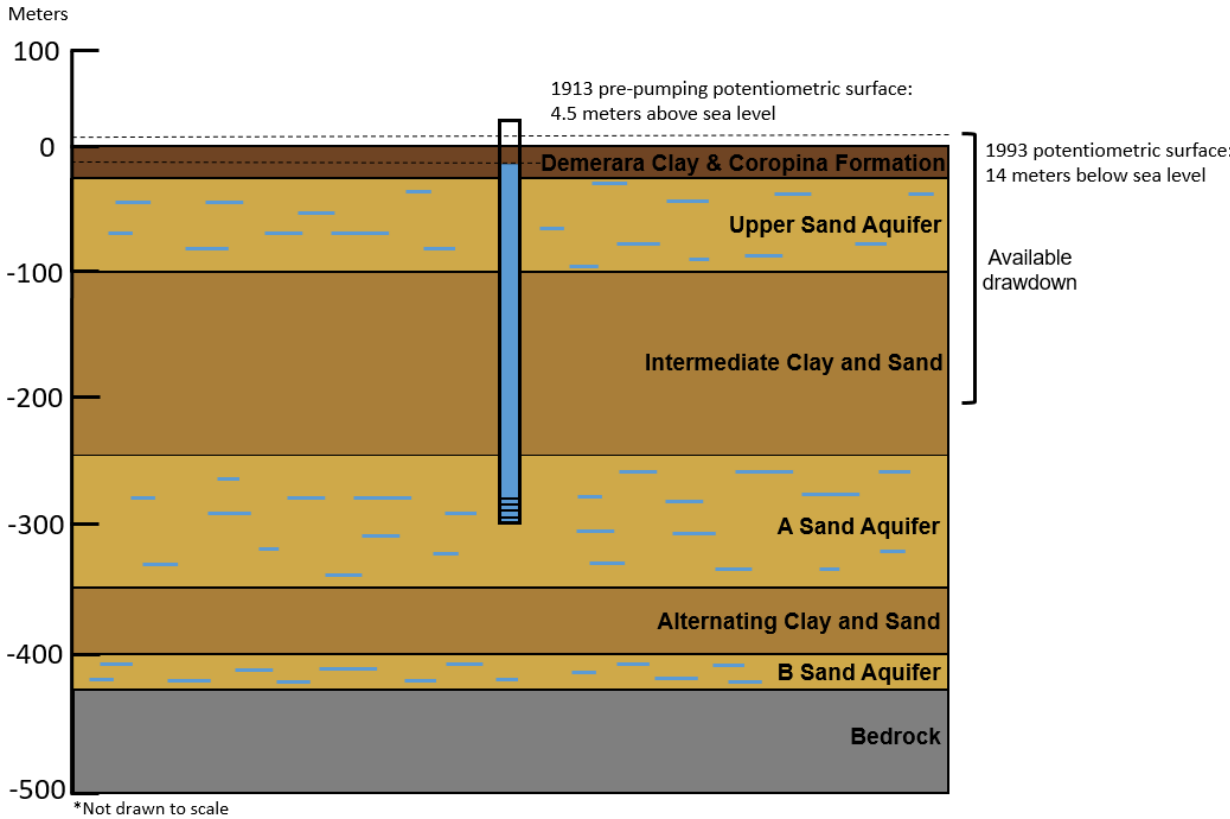
Dewatering during the Construction stage will essentially occur on a **Continuous** basis from prior to the initiation of trenching for a segment until the pipeline is installed and connected with the adjacent segment. Dewatering for each individual segment could last more than a week, but less than a year, so the duration is considered **Medium-term**. No dewatering is planned during the Operations and Decommissioning stages. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of the potential impact relative to water availability during the Construction stage is rated as **Negligible** and the magnitude of the potential impact relative to changes in water quality during the Construction stage is rated as **Negligible.**

Withdrawal of Groundwater from the A Sand Aquifer

As described in Section 5.3.4.3, NGL Plant Utility Systems, on-site water for the operation of the NGL Plant for domestic and process/utility water will be supplied from groundwater well(s) drilled within the NGL Plant site. The anticipated source of groundwater for the NGL Plant site is the A Sand aquifer. The estimated daily water demands to be obtained from groundwater sources are as follows:

- Utility water: up to 15 cubic meters (m^3) per hour (m^3/hr)
- Domestic water: up to 0.75 m^3/hr

Long-term monitoring in the past has indicated a steady decline in water levels in the A Sand aquifer and the B Sand aquifer, which together historically provided about 90 percent of the domestic water for the country (Arad 1983; USACE 1998). The A Sand aquifer provides the highest-quality water in the area, and its use for domestic water use over the years resulted in a decline of the potentiometric surface of 18.5 meters from 1913 to 1993 (USACE 1998). However, these declines are considered acceptable when compared with the amount of water available in the aquifer. The amount of water available is expressed as percent of the aquifer's "available drawdown," which is commonly calculated as 80 percent of the distance from the historic pre-pumping potentiometric surface to the top of the pumped aquifer formation. Potential impact on groundwater users is typically assessed by estimating drawdown in the aquifer at some distance from the pumping well, where other groundwater users could be located. The available drawdown of the A Sand aquifer is estimated to be on the order of 208 meters, as displayed on Figure 7.1-9, of which about 91 percent was remaining as of the latest information identified.



Depths of the stratigraphic units are approximated from a figure presented in Arad (1983).

Figure 7.1-9: Configuration of Guyana's Coastal Aquifer System and Estimated Available Drawdown in A Sand Aquifer

Analysis using the Theis (1935) equation was performed to assess the potential drawdown of the potentiometric surface of the A Sand as a result of planned groundwater withdrawals by the Project and the potential impacts this could have on availability of groundwater to other potential users. It was assumed for the purpose of this analysis that the well at the NGL Plant site will be completed in the A Sand aquifer at a screen depth of approximately 300 meters. The analysis assumed a continuous withdrawal rate of 15.75 m^3/hr (4,700 liters per minute) to supply water for the NGL Plant's process and domestic needs.

Assuming a maximum withdrawal rate of 15.75 m^3/hr (378 m^3 per day) from the A Sand aquifer, it is estimated that the withdrawal of groundwater for use at the NGL Plant—after 50 years (well beyond the Project's anticipated operational life cycle)—will be expected to result in an additional drawdown of approximately 0.22 meter at a distance of 500 meters from the pumping well (Figure 7.1-10). Appendix D, Geology and Hydrogeology Reports, provides the analysis and input values used for this method, as well as the calculation results. This estimated drawdown at 500 meters from the well would account for approximately 0.12 percent of the remaining available drawdown of the A Sand aquifer at this distance from the well.

There are no residents or other users of groundwater within 1 kilometer of the NGL Plant site based on the 2021 socioeconomic survey conducted by the Consultants.

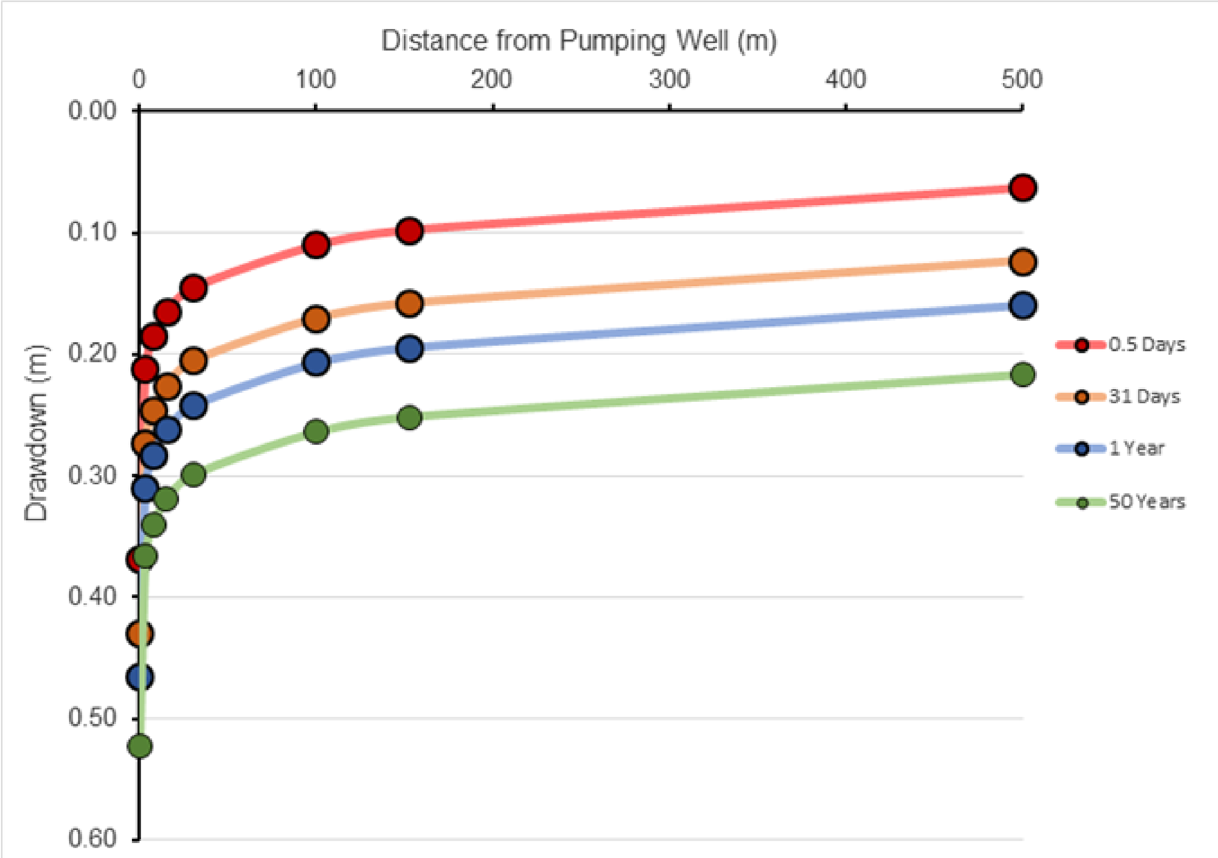


Figure 7.1-10: Theis Drawdown Analysis Graph for a Pumping Well Completed in the A Sand Aquifer

The Project is expected to withdraw up to 378 m^3 per day on essentially a **Continuous** basis for the duration of the Operations stage (**Long-term** duration). Even after 50 years of pumping, the withdrawal is expected to result in less than a 0.22-meter drawdown at a distance of 500 meters from the well, representing a 0.12 percent reduction in the theoretical available drawdown of the A Sand aquifer at this distance. No groundwater users are present within this distance from the proposed well, and even if a groundwater well were established within this distance, the projected drawdown would not result in a significant effect on groundwater yield from such as well. On this basis, the intensity of the potential impact on water availability is rated as **Negligible**.

The groundwater extraction well(s) will be completed using standard groundwater well installation and completion techniques to prevent downward migration of surface contaminants. Accordingly, no effects to groundwater quality are expected as a result of installation or operation of the pumping well. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact relative to groundwater quantity and quality during the Operations stage is rated as **Negligible.**

7.1.3.4. Sensitivity of Resource—Groundwater

Horizontal Directional Drilling

The resource sensitivity associated with potential groundwater impacts related to HDD operations is characterized based on consideration of the shallow groundwater zones through/under which HDD bores will be completed. The shallow groundwater zones through which the HDD bores will be completed are not known to be a source of water for communities. The canals under which the HDD bores will be completed are in some cases used as a non-critical source of water for communities; these canals do support biological habitats, but none that are economically significant or key for biologically unique species. On this basis, the resource sensitivity for water in the canals could be as much as **Medium**, recognizing the potential for hydrologic connectivity between the canals and the shallow groundwater zones through which HDD bores will pass.

Dewatering During Open-Cut Trenching for Onshore Pipeline Installation

The resource sensitivity associated with potential reduction in the availability of water or change in water quality is characterized based on consideration of the canals and shallow groundwater zones that are within or adjacent to the areas that will be affected by dewatering during open trench installation of the onshore pipeline. None of the canals adjacent to the onshore pipeline corridor are characterized as supporting diverse biological habitats. The canals adjacent to dewatering segments are in some cases used as a non-critical source of water for communities; these canals do support biological habitats, but none that are economically significant or key for biologically unique species. On this basis, the resource sensitivity for water in the canals could be as much as **Medium**.

Withdrawal of Groundwater from the A Sand Aquifer

The resource sensitivity associated with a reduction in the availability of groundwater in the A Sand aquifer is characterized based on the potential impact on current or future users of the aquifer. Although the A Sand aquifer is an important source of water to Guyana, there are no groundwater users within at least 1 kilometer of the NGL Plant site. A resource sensitivity of **Low** is therefore assigned for potential impacts on groundwater availability or quality.

7.1.3.5. Pre-mitigation Impact Significance—Groundwater

Assuming implementation of the embedded controls listed in Table 7.1-10, the intensity ratings for each of the potential Project impacts considered for groundwater resources will be **Negligible**. This results in pre-mitigation magnitude ratings of **Negligible** for impacts considered. Coupled with sensitivity ratings of **Medium** for HDD and dewatering of open trenches and **Low** for extraction of water from the A Sand aquifer, the pre-mitigation impact significance for groundwater resources is rated as **Negligible**.

7.1.4. Impact Management and Monitoring Measures

Based on the **Negligible** significance of potential impacts on groundwater resources, no mitigation measures are proposed. It is noted, however, that the limited significance of potential impacts on groundwater resources is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings. Table 7.1-9 summarizes the management and monitoring measures relevant to groundwater.

Table 7.1-10: List of Management and Monitoring Measures

Embedded Controls
Design HDD drilling fluid composition based on consideration of the characteristics of the soils through which HDD bores will be completed and adjust drilling fluids as needed during HDD operations based on the results of HDD fluids/cuttings returns.
Conduct dewatering along work segments and only for durations required to implement the construction activity for the work segment; cease dewatering as soon as reasonably practicable after completing pipeline installation in a work segment.
To the extent reasonably practicable, return extracted waters from dewatering to an adjacent segment of the same canal to minimize/avoid long-term decreases in water level in the canal.
Use industry standard filtration techniques to reduce solids content in dewatering discharges to surface water features.
Install groundwater extraction well(s) at the NGL Plant using standard well construction techniques, including features to prevent downward migration of contaminants to the groundwater bearing unit.
Use only non-petrochemical-based, non-hazardous additives that comply with permit requirements, and environmental regulations, such as NSF International/ANSI 60 Drinking Water Treatment Chemicals—Health Effects compliant in the drilling fluids.
Monitoring Measures
Visually monitor the ground surface and nearby surface waterbodies (e.g., canals) during advancement of HDD borings for any evidence of fluid release.
Monitor HDD fluid/cuttings returns to assess for potential excessive fluid loss to formation.
Monitor solids content of dewatering discharges.

ANSI = American National Standards Institute

7.1.5. Assessment of Residual Impacts

As described above, no mitigation measures are proposed to address potential impacts on groundwater resources. Accordingly, the residual impact significance ratings remain unchanged at **Negligible**.

Table 7.1-11 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on groundwater resources.

Table 7.1-11: Summary of Potential Pre-Mitigation and Residual Impacts—Groundwater

Stage	Potential Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Changes in groundwater quality from loss of drilling fluids to surrounding groundwater	Negligible	Medium	Negligible	None	Negligible
	Shallow groundwater table drawdown, potentially resulting in reduction in water quantity/level in adjacent canals	Negligible	Medium	Negligible	None	Negligible
	Dewatering discharge to adjacent canals, potentially resulting in changes in water quality in canals	Negligible	Medium	Negligible	None	Negligible
Operations	Potentiometric surface drawdown in A Sand aquifer, potentially resulting in reduction of groundwater availability for other users	Negligible	Low	Negligible	None	Negligible
	Changes to groundwater quality as a result of installation or operation of the groundwater pumping well	Negligible	Low	Negligible	None	Negligible

7.2. SOILS

7.2.1. Baseline Methodology

The study of the Project area's soils was divided into two phases: a desktop phase and a field phase. These phases were supported by satellite and geographic data analysis of the AOI.

7.2.1.1. Desktop Phase

To characterize existing conditions for and assess the Project's potential impacts on soil resources, the physical-chemical characteristics and properties of the soil types mapped in the Direct AOI were reviewed and evaluated using information from the National Agriculture Research and Extension Institute (NAREI) of Guyana, the Guyana Lands and Surveys Commission, the Food and Agriculture Organization, and the U.S. Department of Agriculture. The information reviewed included soil type map units and percent coverage, physical-chemical characteristics, and land use capability.

7.2.1.2. Field Phase

The field phase of the existing conditions study for soils included data collection along the pipeline corridor and at the NGL Plant site.

Soil Sampling

Onshore Pipeline

To characterize existing soil productivity and soil quality, eight soil samples (designated P2 and P4 through P10) were collected along the onshore pipeline route. Samples were collected from soil borings completed approximately every 3 kilometers along the route (Figure 7.2-1). A composite soil sample was collected from each sampling location from a depth of 0 to 50 centimeters using a hand-held soil probe/auger.

NGL Plant and Associated Facilities

To characterize existing soil productivity and soil quality, three soil samples (designated NGL B1 through NGL B3) were collected within the NGL Plant site (Figure 7.2 1). A composite soil sample was collected from each sampling location from a depth of 0 to 50 centimeters using a hand-held soil probe/auger.

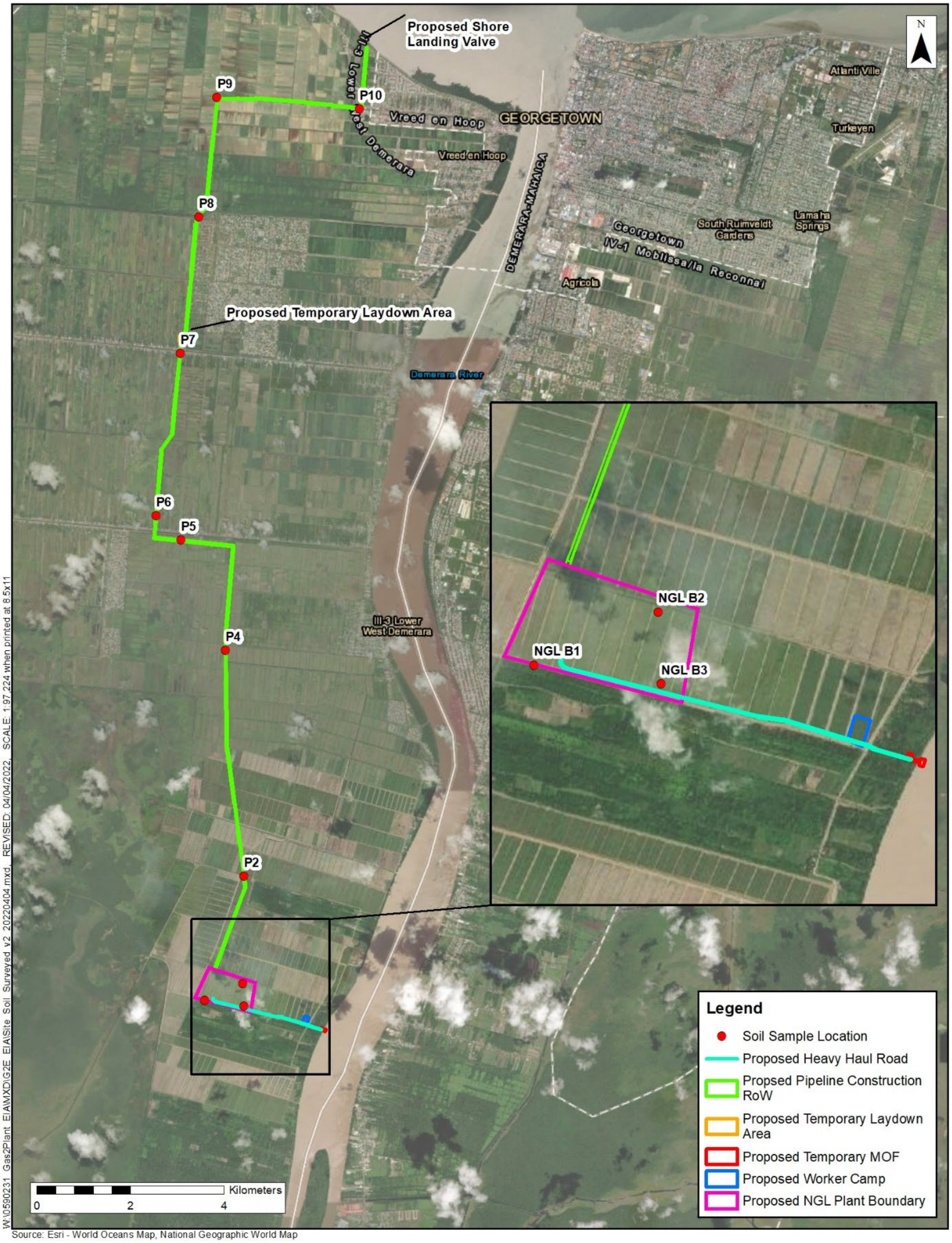


Figure 7.2-1: Soil Sampling Locations

7.2.2. Existing Conditions and Baseline Studies

7.2.2.1. Soil Characteristics

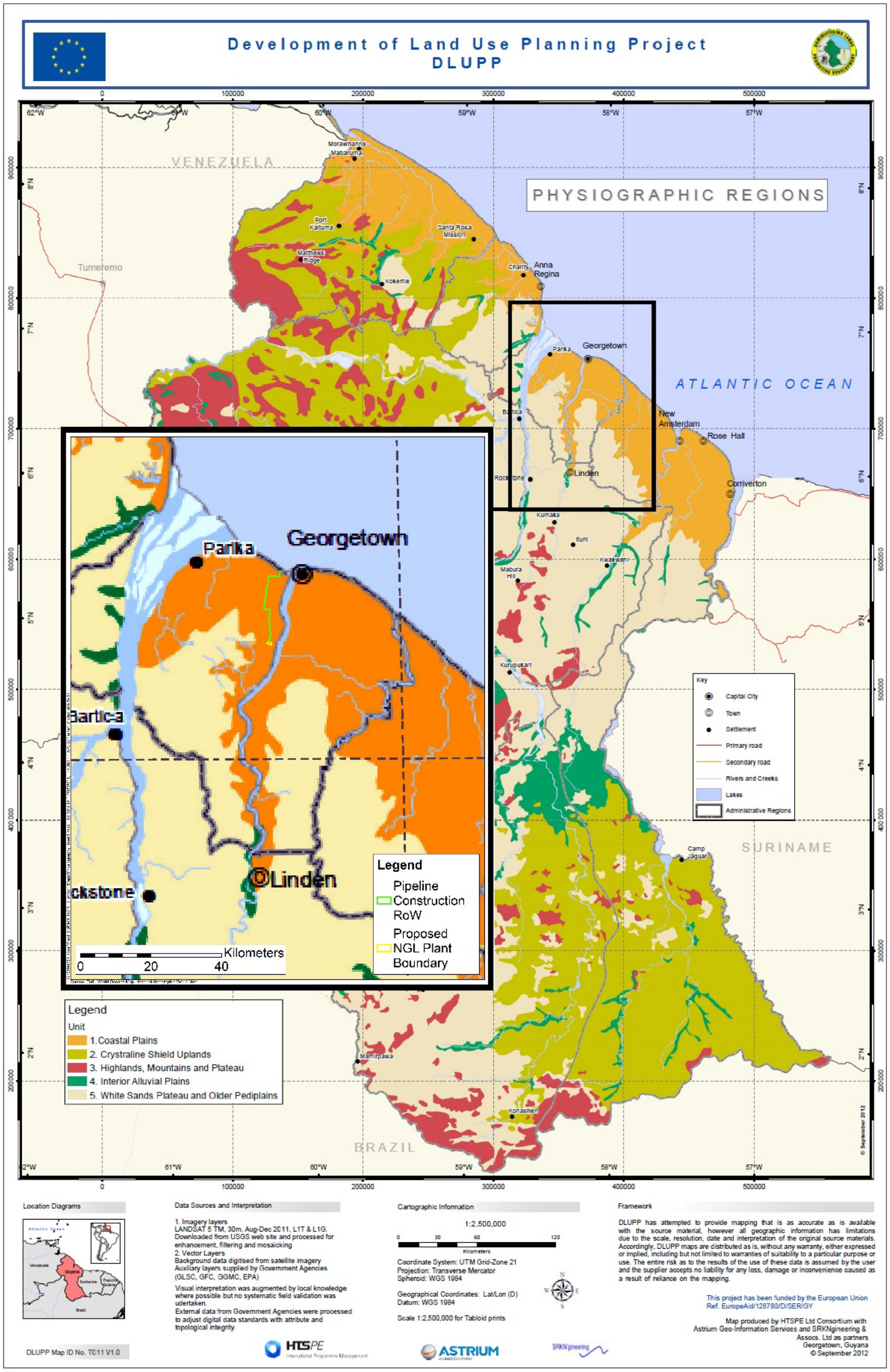
Five major physiographical regions can be distinguished in Guyana (GLSC 2013). These include the following regions (Figure 7.2-2):

- Coastal Plain
- Crystalline Shield Uplands
- Highlands, Mountains, and Plateau
- Interior Alluvial Plains
- White Sands Plateau and Older Pediplains

The onshore portion of the Project AOI is entirely situated within the Coastal Plain physiographic region. The Coastal Plain region is a narrow belt stretching from the Corentyne River in the east to Waini Point in the west and supports most of the agricultural production in the country. East of the Essequibo River, the Coastal Plain region is subdivided into the Young Coastal Plain, 0.5 to 3.5 meters amsl, and the Old Coastal Plain, up to 7.5 meters amsl. The Coastal Plain consists of recent and old sediments with recent deltaic and fluvio-marine clays and silts occurring along the coast and older with silty clays and sands farther inland. The former is covered by the Demerara Clay and the latter by the Coropina Formation. Commonly referred to as the uppermost clay, this layer has an average thickness of approximately 45 meters. The normal tidal range along the Guyana coast is about 3 meters, resulting in periodic flooding (sea invasion) within portions of the Young Coastal Plain, especially during the wet seasons from April to August and November to January, as well as during high tides. Many areas of the Coastal Plain are below sea level, while other areas have been filled to raise them above the typical flooding elevation. An elaborate system of sea defenses, along with irrigation and drainage canals, is required to protect much of the Coastal Plain from flooding (GLSC 2013).

The Coastal Plain region is composed of a variety of soils developed from a variety of parent materials, such as marine and fluvio-marine deposits with back-swamp organic soils. In general, the soils closer to the ocean and along rivers are more fertile than the soils further inland, which can have very low fertility in some instances (GLSC 2013).

Information on the soil types in the onshore portion of the Project AOI was retrieved from the Reconnaissance Soil Map for Guyana developed by the Food and Agriculture Organization and reclassified by NAREI using the U.S. Department of Agriculture taxonomic classification system (NAREI 2021). Additionally, data were gathered from the above-referenced soil sampling. Based on consideration of these data, the onshore portion of the Project AOI can be mapped as two soil map units (Table 7.2-1 and Figure 7.2-3).



Source: GLSC 2013

Figure 7.2-2 :Guyana Physiographic Regions

Table 7.2-1 :Characteristics of Soil Map Units within the Onshore Portion of the Project AOI

Soil Map Unit	Soil Description	Soil Texture	Depth to Bedrock	Drained Class	Fertility	Erosion Potential	Land Capability Class [a]	Limitation for Construction
Hydraquents	• Wet, primarily clayey soils of tidal marshes that are permanently saturated with water • Hydraquents have never been dry and, consequently, their bulk densities are low and water contents high • Sulfaquents and Fluvaquents soil types are associated with the Hydroaquents soils	Clay; silt loam	Deep	Poorly drained	Medium to high	Low	I, II	Poor drainage; presence of acid clays containing sulfates, which can promote steel corrosion
Medihemists	• Wet, organic soils that consists of thick, continuous hemic materials, which normally is 30 centimeters thick derived from woody or herbaceous plant material • Sulfohemists and Medisaprists soils types are associated with Medihemists soils	Mainly organic material	Deep	Very poorly drained	Low	Low	III	Poor drainage; presence of acid clays containing sulfates, which can promote steel corrosion

Source: GLSC 2013

[a] Class I contains soils have few limitations for cultivation; Class II soils have some limitations for cultivation; Class III soils have severe limitations for cultivation.

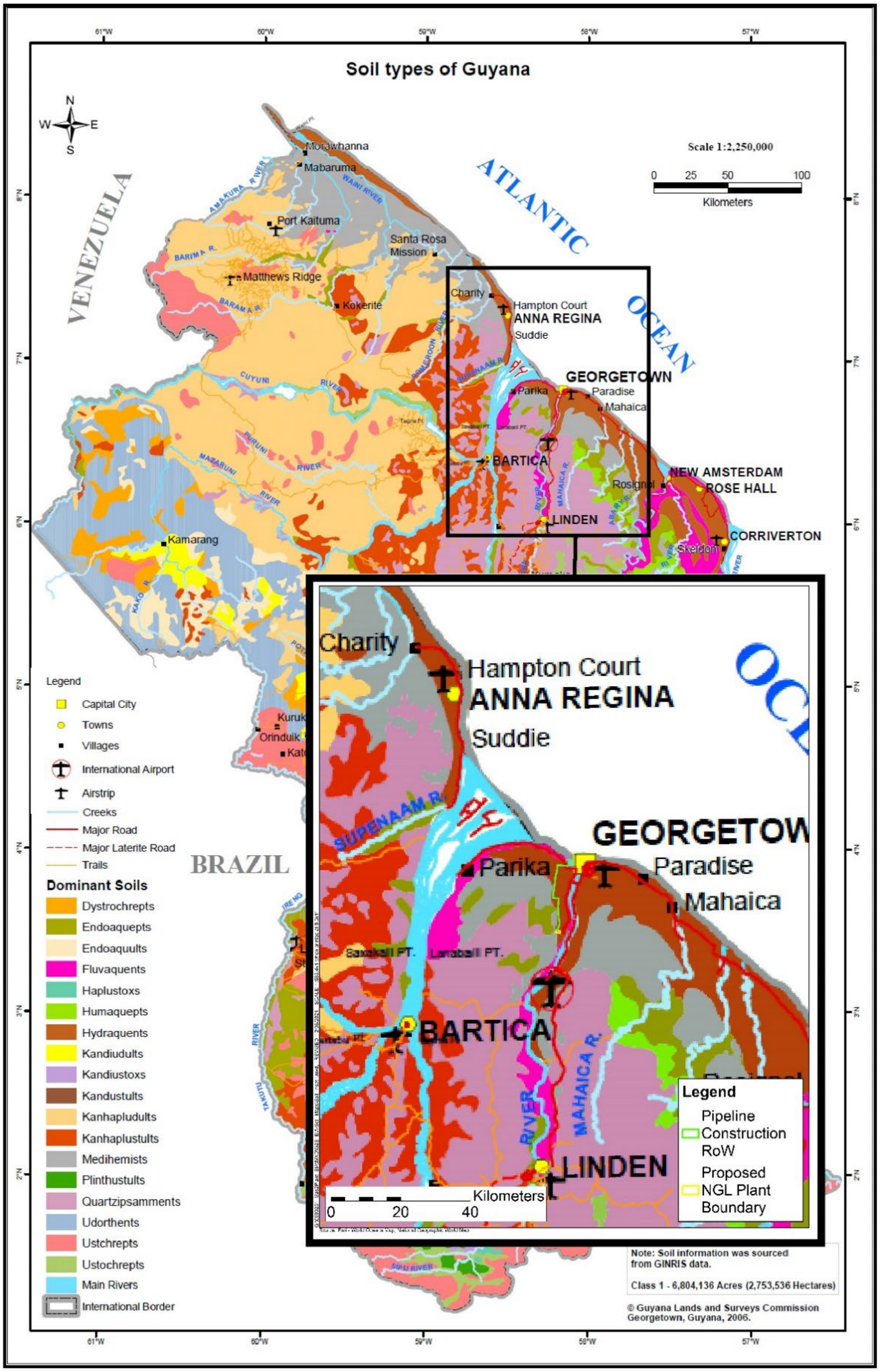


Figure 7.2-3 :Soils Map of the Project Area

7.2.2.2. Soil Quality

Existing soil information from NAREI does not include data on soil productivity and environmental quality for the Project area (NAREI 2021). Therefore, soil samples to assess the chemical characteristics of the soils were collected from within the NGL Plant site and along the pipeline route (Figure 7.2-1) and submitted for laboratory analysis. The results of the chemical characterization are included in Appendix E, Soils Quality Reports.

As shown in Tables 7.2-1 and 7.2-2, the sampled soils generally exhibit characteristics that are unfavorable from a productivity standpoint (e.g., the soil texture is generally high in clays and organic matter, poorly drained, and often require drainage improvements to be suitable for agriculture), variable soil fertility, and low pH (acidic) condition.

As indicated in Table 7.2-2, the nitrate nitrogen, phosphorus, and potassium concentrations are generally relatively low in the soils sampled, as compared with typical ranges in soils. The specific conductivity of the soils is below 2 millimhos per centimeter, indicating non-saline soil conditions.

Similarly, the concentrations of other soil micronutrients (copper, iron, manganese, and zinc) are generally in the low range in the soils sampled, as compared with typical ranges in soils (Table 7.2-2).

To assess for the presence of potential environmental quality concerns, the samples collected were analyzed for a suite of parameters, including pesticides, polychlorinated biphenyls (PCBs), herbicides, metals, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) (Table 7.2-3). As shown in Table 7.2-3, the reported concentrations for most of the pesticides, herbicides, metals, PCBs, VOCs, and SVOCs were below the method detection limits. In the few cases where parameters were detected, the reported concentrations were below the USEPA screening levels for residential and industrial reference benchmarks, except for arsenic, for which reported concentrations exceeded residential screening levels for all samples and industrial screening levels for most samples (USEPA 2021).

Historically, the primary land use in the onshore portion of the Project AOI has been agriculture production (sugarcane plantations), so the soil contaminants detected above the method detection limits and the reference benchmarks for residential or industrial land uses could be related to the past use of herbicides and pesticides during agricultural practices (Defarge et al. 2018).

Table 7.2-2: Summary of Soil Productivity Chemical Characteristics and Comparison with Benchmark or Background Values

Parameter	Unit	Concentration in Background or Benchmark Criteria	Onshore Pipeline			NGL Plant		
			Minimum	Mean	Maximum	Minimum	Mean	Maximum
Nutrients								
Nitrate nitrogen	mg/kg	5–10 [a]	0.80	1.6	4.0	0.83	3.0	5.7
Phosphorus	mg/kg	40–4,500 [b] 200–5,000 [c]	2.8	78.9	136.0	6.6	43.1	81.2
Potassium	%	0.19–6.3 [b] 0.04–3.0 [c]	0.10	0.13	0.17	0.08	0.10	0.13
Copper	mg/kg	2–300 [b] 2–100 [c]	3.5	6.6	11.4	3.6	6.8	11.3
Iron	%	0.1–>10 [b] 0.7–55 [c]	0.94	2.8	3.8	0.90	1.4	2.6
Manganese	mg/kg	30–5,000 [b] 20–3,000 [c]	12.4	155.7	527.0	24.1	60.1	114.0
Zinc	mg/kg	10–2,100 [b] 10–300 [c]	13.5	57.5	205.0	17.8	29.1	35.7
Other Soil Parameters								
pH	Standard units	6–9 [a]	3.5	4.9	6.4	4.9	5.1	5.4
Total organic carbon	%	NA	0.97	2.0	3.8	0.48	1.4	2.1
Specific conductivity	Millimhos / centimeter	<2 [a]	0.12	0.65	1.6	0.06	0.08	0.12

mg/kg = milligrams per kilogram; NA = not applicable
[a] Bohn et al. 1979: Value for soils used for agricultural production.
[b] Shacklette and Boerngen 1984: Value is the observed range of the expected 95% range for the U.S. soils west of the 96th meridian.
[c] Lindsay 1979: Common range in soils.

Table 7.2-3: Summary of Chemicals of Potential Concern and Comparison with Benchmark Values

Parameter	Unit	Benchmark Value (Residential Soil) [a]	Benchmark Value (Industrial Soil) [a]	Onshore Pipeline			NGL Plant		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Pesticides									
4,4-DDD [a]	mg/kg	1.9	9.6	BDL	BDL	BDL	BDL	BDL	BDL
4,4-DDE	mg/kg	2.0	9.3	BDL	na	0.0024	BDL	BDL	BDL
4,4-DDT	mg/kg	1.9	8.5	BDL	BDL	BDL	BDL	BDL	BDL
Aldrin	mg/kg	0.04	0.18	BDL	BDL	BDL	BDL	BDL	BDL
Alpha-Hexachlorocyclohexane	mg/kg	0.09	0.36	BDL	BDL	BDL	BDL	BDL	BDL
Alpha-chlordane	mg/kg	36.0	500.0	BDL	BDL	BDL	BDL	BDL	BDL
Beta-BHC	mg/kg	0.30	1.3	BDL	BDL	BDL	BDL	BDL	BDL
Delta-BHC	mg/kg	0.30	1.3	BDL	BDL	BDL	BDL	BDL	BDL
Dieldrin	mg/kg	0.03	0.14	BDL	BDL	BDL	BDL	BDL	BDL
Endosulfan I	mg/kg	470.0	7,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Endosulfan II	mg/kg	470.0	7,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Endosulfan sulfate	mg/kg	380.0	4,900.0	BDL	BDL	BDL	BDL	BDL	BDL
Endrin	mg/kg	19.0	250.0	BDL	BDL	BDL	BDL	BDL	BDL
Endrin aldehyde	mg/kg	na	na	BDL	BDL	BDL	BDL	BDL	BDL
Endrin ketone	mg/kg	na	na	BDL	BDL	BDL	BDL	BDL	BDL
Gamma-BHC (lindane)	mg/kg	0.57	2.5	BDL	BDL	BDL	BDL	BDL	BDL
Gamma-chlordane	mg/kg	36.0	500.0	BDL	BDL	BDL	BDL	BDL	BDL
Heptachlor	mg/kg	0.1	0.6	BDL	BDL	BDL	BDL	BDL	BDL
Heptachlor epoxide	mg/kg	0.07	0.3	BDL	BDL	BDL	BDL	BDL	BDL
Methoxychlor	mg/kg	320.0	4,100.0	BDL	BDL	BDL	BDL	BDL	BDL
Toxaphene	mg/kg	0.5	2.1	BDL	BDL	BDL	BDL	BDL	BDL
PCBs									
Aroclor 1016	mg/kg	4.1	27.0	BDL	BDL	BDL	BDL	BDL	BDL
Aroclor 1221	mg/kg	0.20	0.83	BDL	BDL	BDL	BDL	BDL	BDL
Aroclor 1232	mg/kg	0.17	0.72	BDL	BDL	BDL	BDL	BDL	BDL
Aroclor 1242	mg/kg	0.23	0.95	BDL	BDL	BDL	BDL	BDL	BDL
Aroclor 1248	mg/kg	0.23	0.94	ND	BDL	BDL	BDL	BDL	BDL

Parameter	Unit	Benchmark Value (Residential Soil) [a]	Benchmark Value (Industrial Soil) [a]	Onshore Pipeline			NGL Plant		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Aroclor 1254	mg/kg	0.24	0.97	BDL	BDL	BDL	BDL	BDL	BDL
Aroclor 1260	mg/kg	0.24	0.99	BDL	BDL	BDL	BDL	BDL	BDL
Herbicides									
2,4,5-T	mg/kg	630.0	8,200.0	ND	ND	ND	ND	ND	ND
2,4,5-TP (Silvex)	mg/kg	510.0	6,600.0	ND	ND	ND	ND	ND	ND
2,4-D	mg/kg	700.0	9,600.0	ND	ND	ND	ND	ND	ND
2,4-DB	mg/kg	na	na	ND	ND	ND	ND	ND	ND
Dalapon	mg/kg	1,900.0	25,000.0	ND	ND	ND	ND	ND	ND
Dicamba	mg/kg	1,900.0	25,000.0	ND	ND	ND	ND	ND	ND
Dichloroprop	mg/kg	na	na	ND	ND	ND	ND	ND	ND
Dinoseb	mg/kg	63.0	820.0	0.07	0.09	0.12	0.01	0.07	0.10
2-methyl-4-chlorophenoxyacetic acid	mg/kg	32.0	410.0	ND	ND	ND	ND	ND	ND
meta-Chlorophenylpiperazine	mg/kg	63.0	820.0	ND	ND	ND	ND	ND	ND
Metals									
Antimony	mg/kg	31.0	470.0	BDL	BDL	0.24	BDL	BDL	0.00
Arsenic [b]	mg/kg	0.7	3.0	2.8	8.2	18.6	2.7	4.6	6.5
Beryllium	mg/kg	160.0	2,300.0	0.19	0.62	1.2	0.9	1.0	1.2
Cadmium	mg/kg	7.1	100.0	BDL	na	0.08	BDL	na	0.03
Chromium	mg/kg	120,000.0	1,800,000.0 [m]	14.3	20.8	26.0	19.9	21.3	22.6
Lead	mg/kg	400.0	800.0	6.8	14.8	35.0	12.6	14.5	16.4
Mercury	mg/kg	11.0	46.0	0.02	0.04	0.05	0.03	0.05	0.06
Nickel	mg/kg	1,500.0	22,000.0	2.4	9.0	19.1	7.7	10.6	13.5
Selenium	mg/kg	390.0	5,800.0	0.30	0.49	0.73	1.04	1.19	1.3
Silver	mg/kg	390.0	5,800.0	BDL	na	0.03	0.02	0.02	0.02
Thallium	mg/kg	0.8	12.0	BDL	BDL	BDL	BDL	BDL	BDL
Zinc (included in nutrient list)	mg/kg	23,000.0	350,000.0	13.5	57.5	205.0	0.0	17.9	35.7
VOCs									
1,1,1-Trichloroethane	mg/kg	8,100.0	36,000.0	BDL	BDL	BDL	BDL	BDL	BDL

Parameter	Unit	Benchmark Value (Residential Soil) [a]	Benchmark Value (Industrial Soil) [a]	Onshore Pipeline			NGL Plant		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
1,1,2,2-Tetrachloroethane	mg/kg	1.1	5.0	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	mg/kg	6,700.0	28,000.0	BDL	BDL	BDL	BDL	BDL	BDL
1,1,2-Trichloroethane	mg/kg	1.1	5.0	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethane	mg/kg	3.6	16.0	BDL	BDL	BDL	BDL	BDL	BDL
1,1-Dichloroethene	mg/kg	230.0	1,000.0	BDL	BDL	BDL	BDL	BDL	BDL
1,2,3-Trichlorobenzene	mg/kg	63.0	930.0	BDL	BDL	BDL	BDL	BDL	BDL
1,2,4-Trichlorobenzene	mg/kg	24.0	110.0	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dibromo-3-chloropropane	mg/kg	0.0	0.1	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dibromoethane	mg/kg	0.0	0.2	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichlorobenzene	mg/kg	1,800.0	9,300.0	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloroethane	mg/kg	0.46	2.0	BDL	BDL	BDL	BDL	BDL	BDL
1,2-Dichloropropane	mg/kg	2.5	11.0	BDL	BDL	BDL	BDL	BDL	BDL
PCBs	mg/kg	1,800.0	9,300.0	BDL	BDL	BDL	BDL	BDL	BDL
1,4-Dichlorobenzene	mg/kg	2.6	11.0	BDL	BDL	BDL	BDL	BDL	BDL
2-Butanone	mg/kg	27,000.0	190,000.0	BDL	BDL	BDL	BDL	BDL	BDL
2-Hexanone	mg/kg	200.0	1,300.0	BDL	BDL	BDL	BDL	BDL	BDL
4-Methyl-2-pentanone	mg/kg	33,000.0	140,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Acetone	mg/kg	70,000.0	1,100,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Benzene	mg/kg	1.2	5.1	BDL	BDL	BDL	BDL	BDL	BDL
Bromochloromethane	mg/kg	150.0	630.0	BDL	BDL	BDL	BDL	BDL	BDL
Bromodichloromethane	mg/kg	0.29	1.3	BDL	BDL	BDL	BDL	BDL	BDL
Bromoform	mg/kg	19.0	86.0	BDL	BDL	BDL	BDL	BDL	BDL
Bromomethane	mg/kg	6.8	30.0	BDL	BDL	BDL	BDL	BDL	BDL
Carbon disulfide	mg/kg	770.0	3,500.0	BDL	BDL	BDL	BDL	BDL	BDL
Carbon tetrachloride	mg/kg	0.65	2.9	BDL	BDL	BDL	BDL	BDL	BDL
Chlorobenzene	mg/kg	280.0	1,300.0	BDL	BDL	BDL	BDL	BDL	BDL
Chloroethane	mg/kg	5,400.0	23,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Chloroform	mg/kg	0.32	1.4	BDL	BDL	BDL	BDL	BDL	BDL

Parameter	Unit	Benchmark Value (Residential Soil) [a]	Benchmark Value (Industrial Soil) [a]	Onshore Pipeline			NGL Plant		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Chloromethane	mg/kg	110.0	460.0	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,2-Dichloroethene	mg/kg	160.0	2,300.0	BDL	BDL	BDL	BDL	BDL	BDL
cis-1,3-Dichloropropene	mg/kg	1.8	8.2	BDL	BDL	BDL	BDL	BDL	BDL
Cyclohexane	mg/kg	6,500.0	27,000.0	BDL	BDL	BDL	BDL	BDL	0.001
Dibromochloromethane	mg/kg	8.3	39.0	BDL	BDL	BDL	BDL	BDL	BDL
Dichlorodifluoromethane (Freon 12)	mg/kg	87.0	370.0	BDL	BDL	BDL	BDL	BDL	BDL
Ethylbenzene	mg/kg	5.8	25.0	BDL	BDL	BDL	BDL	BDL	BDL
Isopropylbenzene (Cumene)	mg/kg	1,900.0	9,900.0	BDL	BDL	BDL	BDL	BDL	BDL
m/p-xylene	mg/kg	550.0	2,400.0	BDL	BDL	BDL	BDL	BDL	BDL
Methyl acetate	mg/kg	78,000.0	1,200,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Methyl t-Butyl Ether	mg/kg	47.0	210.0	BDL	BDL	BDL	BDL	BDL	BDL
Methylcyclohexane	mg/kg	na	na	BDL	BDL	BDL	BDL	BDL	BDL
Methylene Chloride	mg/kg	57.0	1,000.0	BDL	BDL	BDL	BDL	BDL	BDL
o-Xylene	mg/kg	640.0	2,800.0	BDL	BDL	BDL	BDL	BDL	BDL
Styrene	mg/kg	6,000.0	35,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Tetrachloroethene	mg/kg	24.0	100.0	BDL	BDL	BDL	BDL	BDL	BDL
Toluene	mg/kg	4,900.0	47,000.0	BDL	BDL	BDL	BDL	BDL	BDL
trans-1,2-Dichloroethene	mg/kg	70.0	300.0	BDL	BDL	BDL	BDL	BDL	BDL
trans-1,3-Dichloropropene	mg/kg	1.8	8.2	BDL	BDL	BDL	BDL	BDL	BDL
Trichloroethene	mg/kg	0.94	6.0	BDL	BDL	BDL	BDL	BDL	BDL
Trichlorofluoromethane (Freon 11)	mg/kg	23,000.0	350,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Vinyl chloride	mg/kg	0.06	1.7	BDL	BDL	BDL	BDL	BDL	BDL
SVOCs									
1-Methylnaphthalene	mg/kg	18.0	73.0	BDL	BDL	BDL	BDL	BDL	BDL
2-Methylnaphthalene	mg/kg	240.0	3,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Acenaphthene	mg/kg	3,600.0	45,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Acenaphthylene	mg/kg	3,600.0	45,000.0	BDL	BDL	BDL	BDL	BDL	BDL

Parameter	Unit	Benchmark Value (Residential Soil) [a]	Benchmark Value (Industrial Soil) [a]	Onshore Pipeline			NGL Plant		
				Minimum	Mean	Maximum	Minimum	Mean	Maximum
Anthracene	mg/kg	18,000.0	230,000.0	BDL	na	0.002	BDL	BDL	BDL
Benzo(a)anthracene	mg/kg	1.1	21.0	BDL	BDL	0.11	BDL	BDL	0.03
Benzo(a)pyrene	mg/kg	0.11	2.1	BDL	BDL	0.03	BDL	BDL	0.004
Benzo(b)fluoranthene	mg/kg	1.1	21.0	BDL	BDL	0.11	BDL	na	0.05
Benzo(g,h,i)perylene	mg/kg	na	na	BDL	na	0.03	BDL	BDL	0.01
Benzo(k)fluoranthene	mg/kg	11.0	210.0	BDL	BDL	0.03	BDL	BDL	0.02
Chrysene	mg/kg	110.0	2,100.0	BDL	BDL	0.03	0.004	0.04	0.07
Dibenzo(a,h)anthracene	mg/kg	0.1	2.1	BDL	BDL	0.004	BDL	BDL	0.009
Fluoranthene	mg/kg	2,400.0	30,000.0	BDL	BDL	0.03	0.016	0.14	0.27
Fluorene	mg/kg	2,400.0	30,000.0	BDL	BDL	BDL	BDL	BDL	BDL
Indeno(1,2,3-cd)pyrene	mg/kg	18.0	73.0	BDL	BDL	0.02	BDL	BDL	0.010
Isophorone	mg/kg	570.0	2,400.0	BDL	BDL	BDL	BDL	BDL	BDL
Naphthalene	mg/kg	2.0	8.6	BDL	BDL	0.001	BDL	BDL	BDL
Phenanthrene	mg/kg	na	na	BDL	BDL	0.01	BDL	na	0.16
Pyrene	mg/kg	1,800.0	23,000.0	BDL	na	0.03	0.010	0.04	0.07

BDL = below method detection limit (analyzed but not detected above the method detection limit or sample detection limit); DDD = dichlorodiphenyldichloroethane; DDE = dichlorodiphenyldichloroethylene; na = not available (unable to calculate a mean value, as one or more of the reported concentrations were below the method detection limit / sample detection limit; ND = not detected at the reporting limit; m = regional screening level exceeds ceiling limit

[a] USEPA regional screening levels for residential and industrial soils (USEPA 2021)

[b] Arsenic is a naturally occurring metal and the concentrations detected are within the ranges reported for background soils in the United States, between <0.1 to 97 mg/kg (Shacklette and Boerngen 1984). The concentrations reported for these samples are likely representative of natural conditions, but may be related to historical uses of arsenic-containing pesticides on agricultural fields.

7.2.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on soils. The relevant planned Project activities and the associated potential impacts of these activities on soils are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

7.2.3.1. Relevant Project Activities and Potential Impacts

The construction and operation of the onshore pipeline, the NGL Plant, and the associated onshore Project facilities—including land clearance, grading, land recontouring, and pipeline trenching—could impact the soils in the Direct AOI. During the Construction stage, the onshore pipeline will be connected to the offshore pipeline at the land side of the pipeline shore crossing, which will be installed using HDD methods. Construction stage activities at the NGL Plant site will include land clearance, backfilling, and grading, followed by surface stabilization. From this connection point, the onshore pipeline will be installed below ground to the NGL Plant via either HDD methods or open trenching. During the Operations stage, soil disturbance will generally be limited to maintenance of the onshore pipeline permanent right-of-way (RoW) and the NGL Plant site (i.e., principally to prevent growth of woody vegetation and maintain proper drainage). A number of options may be considered at the time of decommissioning. The base case assessed for the purpose of this EIA is that the onshore pipeline will be left in situ after being purged, cleaned, and sealed, and that the NGL Plant process equipment, building, and civil infrastructure will be removed from the site. The site will be graded to drain and will be vegetated or otherwise armored to prevent erosion. The key potential impacts assessed include soil erosion and loss of, or damage to, agricultural soils.

Table 7.2-4 summarizes the planned Project activities that could result in potential impacts on soils.

Table 7.2-4: Summary of Relevant Project Activities and Key Potential Impacts—Soils

Stage	Project Activity	Key Potential Impacts
Construction	• Construction of onshore pipeline and associated temporary workspaces • Construction of NGL Plant • Construction of ancillary facilities (heavy haul road, temporary MOF, worker camp)	• Potential increase in soil erosion • Loss of or damage to agricultural soils

Stage	Project Activity	Key Potential Impacts
Operations	• Maintenance of permanent onshore pipeline RoW • Maintenance of NGL Plant and permanent ancillary facilities	• Loss of, or damage to, agricultural soils
Decommissioning	• Decommissioning of NGL Plant infrastructure and ancillary facilities	• Potential increase in soil erosion

7.2.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for soils (Tables 7.2-5 and 7.2-6). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for soil sensitivity are provided in Tables 7.2-7 and 7.2-8.

For the purpose of assessing the significance of potential impacts on soils, separate discussions are provided for the two key potential impacts assessed:

- Soil erosion
- Loss of, or damage to, agricultural soils

Table 7.2-5: Definitions for Intensity Ratings for Potential Impacts on Soils (Soil Erosion)

Criterion	Definition
Intensity	**Negligible**: Less than 10 percent of soils disturbed have medium or high erosion potential and/or are on slopes greater than 10 percent.
	Low: More than 10 percent, but less than 50 percent, of soils disturbed have a medium or high erosion potential and/or are on slopes greater than 10 percent, and the total disturbance area represents a small fraction of the regional soil series.
	Medium: More than 10 percent, but less than 50 percent, of soils disturbed have a medium or high erosion potential, and the total disturbance area represents a moderate to large fraction of the regional soil series. OR More than 50 percent of soils disturbed have a medium or high erosion potential and/or are on slopes greater than 10 percent, and the total disturbance area represents a small fraction of the regional soil series.
	High: More than 50 percent of soils disturbed have a medium or high erosion potential and/or are on slopes greater than 10 percent, and the total disturbance area represents a moderate to large fraction of the regional soil series.

Table 7.2-6: Definitions for Intensity Ratings for Potential Impacts on Soils (Loss of, or Damage to, Agricultural Soils)

Criterion	Definition
Intensity	**Negligible**: Area of disturbance of agricultural soils represent a negligible portion (i.e., less than 10 percent) of the total agricultural soils in the area.
	Low: Area of disturbance of agricultural soils represent a small portion (i.e., 10 to 25 percent) of the total agricultural soils in the area.
	Medium: Area of disturbance of agricultural soils represent a moderate portion (i.e., 25 to 50 percent) of the total agricultural soils in the area.
	High: Area of disturbance of agricultural soils in use represent a significant portion (i.e., 50 percent or more) of the total agricultural soils in the area.

Table 7.2-7: Definitions for Resource Sensitivity Ratings for Potential Impacts on Soil (Soil Erosion)

Criterion	Definition
Sensitivity	**Low**: Disturbed soils do not drain to water or land features that support diverse habitats or are a locally important source of water for communities living nearby.
	Medium: Disturbed soils drain to water or land that support diverse habitats or are a locally important source of water for communities living nearby.
	High: Disturbed soils drain to water or land features that support economically important or biologically unique species or provide essential habitat for those species or are an important source of water for communities living nearby.

Table 7.2-8: Definitions for Resource Sensitivity Ratings for Potential Impacts on Soils (Loss of, or Damage to, Agricultural Soils)

Criterion	Definition
Sensitivity	**Low**: Loss of the disturbed agricultural soils would result in only a minimal impact on the user.
	Medium: Loss of the disturbed agricultural soils would result in a moderate impact on the user.
	High: Loss of the disturbed agricultural soils would result in a significant impact on the user.

7.2.3.3. Impact Magnitude Ratings—Soils

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to soils is provided in Table 7.2-11.

Soil Erosion

As described in Section 7.2.2.1, Soil Characteristics, the surficial soils found within the Direct AOI are characterized primarily as poorly drained, clayey-silty clays, and organic soils with low erosion potential.

Project implementation will result in the disturbance of approximately 138 hectares of soil during the Construction stage that will be subject to potential increases in erosion. Table 7.2-9 provides a summary of the approximate area of soils that will be disturbed by the various Project components and associated facilities during the Construction stage. Potential impacts on soils would result from construction activities such as site preparation (vegetation clearance and grubbing, grading, and recontouring for proper drainage), onshore pipeline installation, temporary workspace development, and temporary MOF construction. A reduced amount of land disturbance, as compared to the Construction stage, will occur during the Decommissioning stage (e.g., removal of NGL Plant facilities). By the end of the Construction stage, disturbed areas of the Project footprint will be revegetated or otherwise armored (e.g., hard surfacing) to reduce potential for erosion during the Operations stage. Accordingly, no increase in soil erosion is expected during the Operations stage.

Potential impacts on soils related to erosion are typically of greatest concern in areas where slopes are moderately steep or steep (i.e., more than 10 percent slope) and/or where the soil erosion potential is medium or high. Based on the regional geomorphology and topography characteristics, the Direct AOI can be characterized as relatively flat, with slopes in the range of 0 to 4 percent, and the erosion potential of the soils that will be disturbed in the Direct AOI is low (see Table 7.2-1).

As the Project is not expected to disturb soils with medium or high erosion potential, and the areas to be disturbed are in landscapes with slopes less than 10 percent, an intensity rating of **Negligible** is assigned for both the Construction and Decommissioning stages of the Project. Soil erosion impacts will occur on an essentially continuous basis from the time of initial disturbance until work areas are revegetated or otherwise armored, so the frequency of this impact is considered **Continuous** during these periods. This period at any particular location will be expected to last longer than a week, but less than a year for both Construction and Decommissioning stages, so the duration is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Negligible**.

Table 7.2-9: Summary of Soils Temporarily Disturbed During Project Construction

Project Feature	Approximate Area Disturbed During Project Construction (hectares)	Approximate Area Disturbed with Soils Having Medium or High Erosion Potential and/or on Slopes >10% (hectares)
NGL Plant	75.0	0
Onshore Pipeline [a]	57.9	0
Heavy Haul Road	1.7	0
Temporary MOF	0.3	0
Worker Camp	1.9	0
Onshore Pipeline Temporary Laydown Area	1.0	0
Total [b]	137.8	0

ha = hectare
[a] Includes construction RoW (22.9 meters) and HDD work areas in the RoW.
[b] Total does not match sum of components due to rounding for each component.

Loss of, or Damage to, Agricultural Soils

As described in Section 7.2.2.1, Soil Characteristics, the surficial soils found within the Direct AOI, when drained effectively, can be used for cattle raising or to grow crops. That said, only a portion of the Direct AOI contains soils that are either in active or inactive agricultural use. In the Direct AOI, active agricultural areas include primarily rice production, with some areas cultivated for pineapple production. The Wales Development Area, through which approximately 11 kilometers of the onshore pipeline corridor will traverse, is no longer in active agricultural use; GuySuCo has stopped its operation, and this area is now planned for industrial, not agricultural use. For the purpose of this assessment, the active and inactive agricultural areas are collectively considered agricultural soils. The Project will temporarily disturb and result in the temporary disturbance (i.e., through the same construction activities producing potential soil erosion impacts) and the permanent loss (i.e., through installation of Project infrastructure and subsequent restriction of use in the footprint of such infrastructure) of agricultural soils.

The total areas of active and inactive agricultural soils that will be impacted by the Project are summarized in Table 7.2-10. The onshore pipeline temporary construction RoW and the onshore pipeline temporary laydown area will disturb approximately 19.9 hectares of active agricultural soils and approximately 8.2 hectares of inactive agricultural soils. However, embedded controls for construction includes the restoration of suitable agricultural areas to their pre-construction conditions to support continued agricultural use.

Following construction, the maintained portion of the permanent RoW will result in a loss (in terms of their ability to remain under agricultural use) of 5.9 hectares of active agricultural soils and 2.1 hectares of inactive agricultural soils. Since these areas represent a negligible portion (i.e., less than 10 percent) of the total agricultural soils in the area, the intensity of the impact on agricultural soils is characterized as **Negligible**. This impact will occur on an essentially continuous basis from the time of initial disturbance during the Construction stage and continuing through the Operations stage as the permanent onshore pipeline RoW and NGL Plant footprint are maintained and permanently removed from agricultural use, so the frequency of this impact is considered **Continuous**. The permanent impacts will extend more than a year, so the duration is **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Negligible**.

Table 7.2-10: Summary of Agricultural Soils Disturbed or Lost During Project Construction and Operations

Project Feature	Active Agricultural Soils		Inactive Agricultural Soils	
	Approximate Area Disturbed during Project Construction (hectares)	Approximate Area Maintained as Non-Agricultural during Project Operations (hectares)	Approximate Area Disturbed during Project Construction (hectares)	Approximate Area Maintained as Non-Agricultural during Project Operations (hectares)
NGL Plant	0.0	0.0	0.0	0.0
Onshore Pipeline [a]	18.9	5.9	8.2	2.1
Heavy Haul Road	0.0	0.0	0.0	0.0
Temporary MOF	0.0	0.0	0.0	0.0

Project Feature	Active Agricultural Soils		Inactive Agricultural Soils	
	Approximate Area Disturbed during Project Construction (hectares)	Approximate Area Maintained as Non-Agricultural during Project Operations (hectares)	Approximate Area Disturbed during Project Construction (hectares)	Approximate Area Maintained as Non-Agricultural during Project Operations (hectares)
Worker Camp	0.0	0.0	0.0	0.0
Onshore Pipeline Temporary Laydown Area	1.0	0.0	0.0	0.0
Total [b]	19.9	5.9	8.2	2.1

ha = hectare
[a] Includes construction RoW (22.9 meters) and HDD work areas in the RoW.
[b] Total may not match sum of components due to rounding for each component.

7.2.3.4. Sensitivity of Resource—Soils

In accordance with the sensitivity rating definitions in Table 7.2-7, the resource sensitivity for soils with respect to a potential increase in soil erosion is characterized based on consideration of the areas within the Project construction footprint that are adjacent to canals potentially used by communities for various purposes (on the order of 15 to 20 hectares) as compared to the areas of the Project construction footprint not adjacent to canals (the remaining 117.5 to 112.5 hectares). None of the canals adjacent to the construction footprint are characterized as supporting diverse biological habitats, but the area to be disturbed by the portion of the heavy haul road that extends into shrubland/swamp and the onshore portion of the temporary MOF in the same land cover (together approximately 1.3 hectares) supports a diverse habitat. On the basis of the above, the resource sensitivity for soils ranges from **Low** to **Medium** within the construction footprint, with the majority of the total disturbance area (on the order of 85 percent) is characterized as **Low**. During decommissioning, the entire area that will be disturbed (i.e., the NGL Plant area) will not be adjacent to a canal, so the sensitivity for this stage is characterized as **Low**.

In accordance with the sensitivity rating definitions in Table 7.2-7, the resource sensitivity for soils with respect to loss of, or damage to, agricultural soils is characterized as **Low** based on the limited amount of active agricultural soils that will be permanently removed from agricultural use (5.9 hectares) and the fact that this loss of agricultural soils represents only a minimal fraction of the agricultural soils available to the affected users.

7.2.3.5. Pre-mitigation Impact Significance—Soils

Assuming implementation of the embedded controls listed in Table 7.2-11, the intensity ratings for potential Project impacts on soils will be **Negligible**. This results in pre-mitigation magnitude ratings of **Negligible** for both types of impacts considered. Coupled with sensitivity ratings of **Low** to **Medium** for soil erosion and **Low** for damage to, or loss of, agricultural soils, the pre-mitigation impact significance for soils is rated as **Negligible**.

7.2.4. Impact Management and Monitoring Measures

Based on the **Negligible** significance of potential impacts on soils, no mitigation measures are proposed. It is noted, however, that the limited significance of potential impacts on soils is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings. Table 7.2-11 summarizes the management and monitoring measures relevant to soils.

Table 7.2-11: List of Management and Monitoring Measures

Embedded Controls
Implement soil erosion, storm water runoff, and sedimentation control measures during soil disturbance (e.g., use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from construction areas, use of sediment basins and check dams to control water runoff).
Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable, and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Outside of the permanent RoW and within temporarily disturbance areas, restore active suitable agricultural areas to their pre-construction conditions to support continued agricultural use.
Monitoring Measures
Conduct routine inspections of erosion, storm water runoff, and sedimentation control measures while bare soils are exposed.

7.2.5. Assessment of Residual Impacts

As described above, no mitigation measures are proposed to address potential impacts on soils. Accordingly, the residual impact significance ratings remain unchanged at **Negligible**.

Table 7.2-12 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on soils.

Table 7.2-12: Summary of Potential Pre-Mitigation and Residual Impacts—Soils

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Potential increase in soil erosion	Low to Medium	Negligible	Negligible	None	Negligible
	Loss of or damage to agricultural soils	Low	Negligible	Negligible	None	Negligible
Operations	Loss of or damage to agricultural soils	Low	Negligible	Negligible	None	Negligible
Decommissioning	Potential increase in soil erosion	Low	Negligible	Negligible	None	Negligible

7.3. SEDIMENTS

7.3.1. Baseline Methodology

The baseline conditions of marine and riverine sediments (i.e., the latter referring to sediments in the Demerara River and canals in the vicinity of the Direct AOI) were defined primarily from two different sources of information: a desktop-based review of existing peer-reviewed literature and studies, and a series of field studies conducted to support the Project EIA and other prior EEPGL projects. For marine sediments, the field studies included a 2021 environmental baseline survey (EBS) conducted for the purposes of this EIA (Appendix F, Environmental Baseline Survey: Guyana Gas to Shore Pipeline Project) as well as several EBS campaigns previously commissioned by EEPGL for projects in the vicinity of the offshore pipeline corridor. The 2021 EBS consisted of 10 sediment samples for geotechnical analysis and 15 sediment samples for chemical analysis along the offshore pipeline route. The marine sediment samples from the 2021 EBS campaign were analyzed for the following parameters:

- Total organic carbon (TOC) (in-house method—L023-PL)
- Moisture content (in-house method—L019-UK/PL)
- Oxidation-reduction (redox) potential (in-house method—L084-PL)
- Metals – extractable by aqua regia digestion[1] (in-house method—L038-PL)
- Monoaromatic hydrocarbons (in-house method based on USEPA SW-846 8260)
- Petroleum hydrocarbons (aliphatic and aromatic) (in-house method—L088/76-PL).

For riverine sediments, a field survey was conducted in 2021–2022 by the Consultants to collect samples for chemical characterization at 10 stations, which included 1 coastal station, 6 Demerara River stations (three of which were from the area to be dredged in order to construct the temporary MOF), and 3 stations in the canals in the vicinity of the Direct AOI (Appendix G, Demerara River Baseline Field Study). Sediment samples were collected during the dry season from the surficial layer of the sediments. The only exception was the sediment sample at S11, which was inaccessible during the dry season sampling event. The sediment sample at S11 was collected during the wet season sampling event. The sediment samples were analyzed by a certified laboratory for the following parameters:

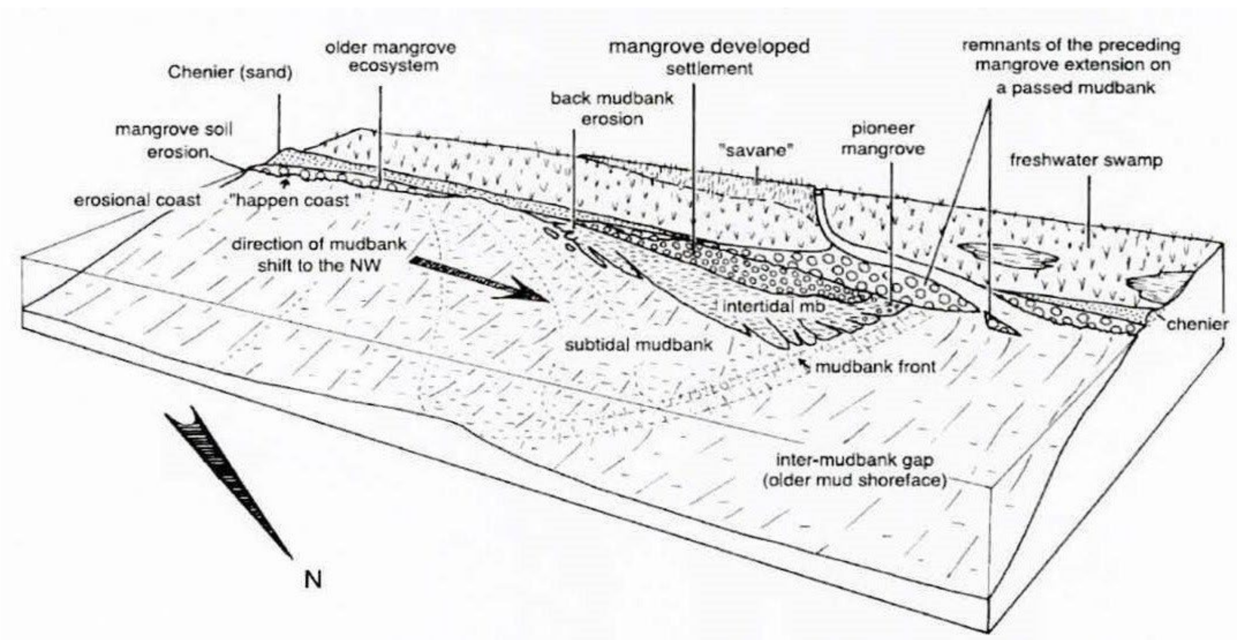
- Total solids (American Society for Testing and Materials [ASTM] 245G)
- Total organic carbon (ASTM 2579D)
- Total sulfide (USEPA SW-846 Method 9030)
- Particle size analysis (ASTM D422-63)
- Mercury (USEPA SW-846 Method 7471B)
- Metals (USEPA SW-846 Method 6020A)
- Organochlorine pesticides (USEPA SW-846 Method 8081A)
- PCBs as arochlors (USEPA SW-846 Method 8082A)
- PAHs (USEPA SW-846 Method 8270-SIM)

[1] Aqua regia digestion provides a strong partial digest, releasing into solution metals associated with the fines fraction within the sediments (but does not extract all trace elements associated with the coarse fraction).

7.3.2. Existing Conditions and Baseline Studies

7.3.2.1. Marine Sediments

Fine clay and mud sediments are transported north from the mouth of the Amazon River and deposited approximately 21 to 60 kilometers from the Guyana coastline, to an average thickness of approximately 20 meters; they form a series of low mud ridges, or mudbanks, along Guyana's continental shelf (CGX 2009). Moving farther out to sea (i.e., toward the edge of the continental shelf), sand gradually becomes the dominant sediment layer. The bathymetric profile of the continental shelf forms a generally smooth, gradual slope from nearshore to shelf edge, except for the low mudbanks (Figure 7.3-1).



Source: Royal Haskoning, Delft Hydraulics 2004

Figure 7.3-1: Typical Distribution of Mudbanks on Guyana's Coast

Although the Essequibo River and several other smaller rivers (e.g., the Demerara, Courantyne, and Berbice rivers) discharge large quantities of fine sediment, which are subsequently transported seaward and westward across the continental shelf, analysis of the humic content, nutrient composition, and ratio of surface area to mass of Guyanese marine sediments indicates that they are nearly identical to Amazonian sediments (Eisma and van der Marel 1971). This evidence strongly indicates that from a sedimentary perspective, the Guyanese continental shelf functions as a marine extension of the Amazonian delta system. At depths greater than 45 meters, calcarenite (coral fragment) substrates become more prevalent (Sætersdal et al.1999). The Stabroek Block occupies the transition area between the Amazonian-influenced zone and the older, deeper calcarenite zones.

Along the proposed offshore pipeline route, the seabed sediments that were sampled primarily consisted of fine silt clays (Figure 7.3-2). There was no significant sand or gravel component to any of the sediments encountered during the 2021 EBS (Appendix F, Environmental Baseline Survey: Guyana Gas to Shore Pipeline Project).

Sediment samples were also collected from the Stabroek Block offshore Guyana in the general vicinity of the pipeline as part of EBSs conducted in 2017 (ESL 2018), 2018 (Maxon et al. 2019; Fugro 2019a), 2019 (Fugro 2019b), and 2020 (CSA Ocean Sciences 2020) (see Figure 7.3-2). As these EBS events were all conducted in the vicinity of the offshore pipeline route, these EBS data help characterize sediment quality in the vicinity of the offshore pipeline.

As discussed above, sediment samples have been collected from the Stabroek Block in the vicinity of the offshore pipeline as follows:

- 10 sampling stations during the 2017 Stabroek Block EBS (ESL 2018)
- 8 sampling stations during the 2018 Stabroek Block EBS (Maxon et al. 2019)
- 8 sampling stations during the 2018 Payara Development EBS (Fugro 2019a)
- 8 sampling stations during the 2019 Hammerhead EBS (Fugro 2019b)
- 8 sampling stations during the 2020 Hammerhead EBS (CSA Ocean Sciences 2020)

Figure 7.3-2 shows the sediment sampling locations for the EBS campaigns described above. Summaries of the EBS sediment sampling results for reported metals and hydrocarbon concentrations are presented in Table 7.3-1 and Table 7.3-2, respectively.

Table 7.3-1 includes the U.S. National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (ERL) and Effects Range Median (ERM) values. These values are bulk sediment benchmarks used to evaluate whether a concentration of a constituent in sediment might have toxicological effects. The ERL value indicates the concentration below which toxic effects are rarely observed or expected; the ERM value indicates the concentration above which effects are generally observed (Long et al. 1995). They are not regulatory criteria, but define a benchmark as a concentration that, when exceeded, has the potential to cause harm or cause significant risk to organisms in the environment.[1] Table 7.3-1 also provides the mean concentration of each metal in the upper continental crust as another reference and for context for those metals without ERL/ERM values. Benchmark values for hydrocarbons are not available and it is noted that the presence of hydrocarbons in a sample does not necessarily indicate contamination from anthropogenic sources. This is discussed further below.

[1] NOAA screening values are commonly used as a reference when other jurisdiction-specific values are not available.

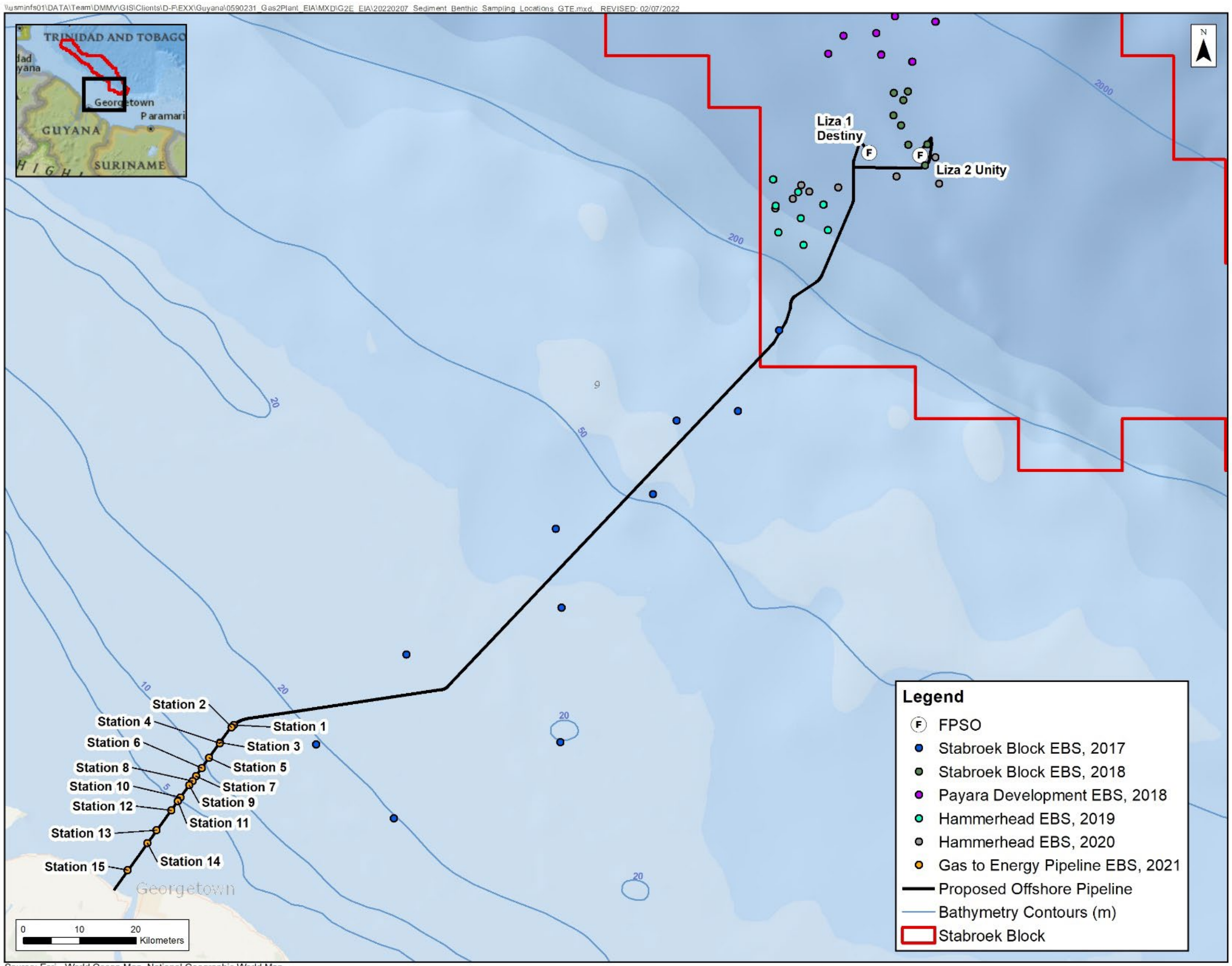


Figure 7.3-2: Proposed Offshore Pipeline Route and Relevant EBS Sampling Locations

Table 7.3-1: Summary of Metal Concentrations Reported for Sediment Samples Collected in Vicinity of Offshore Pipeline Route (mg/kg dry weight)

Parameter	Mean	Minimum	Maximum	Effects Range Low [b]	Effects Range Median [c]	Mean Background Continental Crust Value [a]
2021 EBS (n=15)						
Aluminum	25,267	20,000	30,000	—	—	77,440
Arsenic	17	14	27	8.2	70	2
Barium	34	21	54	—	—	668
Cadmium	BDL	BDL	BDL	1.2	9.6	0.102
Chromium	32	23	39	81	370	35
Copper	12.2	8.1	21.0	34	270	14.3
Iron	39,667	34,000	66,000	—	—	30,890
Mercury	BDL	BDL	BDL	0.15	0.71	0.056
Selenium	BDL	BDL	BDL	—	—	0.083
Lead	21	14	34	46.7	218	17
Nickel	22	16	26	20.9	51.6	18.6
Zinc	92	69	130	150	410	52
2017 Stabroek Block EBS (n=10)						
Aluminum	6,510	2,900	13,000	—	—	77,440
Arsenic	15	3.6	50	8.2	70	2
Barium	7.5	3.5	16	—	—	668
Cadmium	BDL	BDL	BDL	1.2	9.6	0.102
Chromium	15	7.7	24	81	370	35
Copper	3.1	BDL	6.7	34	270	14.3
Iron	20,720	8,900	35,000	—	—	30,890
Mercury	BDL	BDL	BDL	0.15	0.71	0.056
Selenium	BDL	BDL	BDL	—	—	0.083
Lead	7.8	3.8	15	46.7	218	17
Nickel	8.6	3.8	15	20.9	51.6	18.6
Zinc	29	11	55	150	410	52
2018 Stabroek Block EBS (n=8)						
Aluminum	11,550	10,400	12,700	—	—	77,440
Arsenic	9.46	7.76	11.3	8.2	70	2
Barium	206	133	396	—	—	668
Cadmium	0.13	0.11	0.143	1.2	9.6	0.102
Chromium	26.0	22.3	27.8	81	370	35
Copper	21.2	19.3	23.1	34	270	14.3
Iron	20,363	17,900	23,100	—	—	30,890

Parameter	Mean	Minimum	Maximum	Effects Range Low [b]	Effects Range Median [c]	Mean Background Continental Crust Value [a]
Mercury	0.030	0.027	0.034	0.15	0.71	0.056
Selenium	26.8	22.4	32.5	—	—	0.083
Lead	14.8	13.5	16.5	46.7	218	17
Nickel	26.8	22.4	32.5	20.9	51.6	18.6
Zinc	69.3	62.4	77.6	150	410	52
2018 Payara Development EBS (n=8)						
Aluminum	36,400	29,800	45,100	—	—	77,440
Arsenic	37.8	6.62	250	8.2	70	2
Barium	165	132	240	—	—	668
Cadmium	BDL	BDL	BDL	1.2	9.6	0.102
Chromium	30.3	24.5	38.9	81	370	35
Copper	15.1	12.5	17.4	34	270	14.3
Iron	33,700	17,700	122,000	—	—	30,890
Mercury	0.0236	0.0206	0.027	0.15	0.71	0.056
Selenium	0.63	0.50	1.53	—	—	0.083
Lead	12.3	10.4	14.7	46.7	218	17
Nickel	20	16.8	26.1	20.9	51.6	18.6
Zinc	60.5	42.6	112	150	410	52
2019 Hammerhead EBS (n=8)						
Aluminum	52,100	39,000	60,000	—	—	77,440
Arsenic	8.9	5.8	11	8.2	70	2
Barium	199	140	240	—	—	668
Cadmium	0.14	0.11	0.17	1.2	9.6	0.102
Chromium	50	37	57	81	370	35
Copper	17	11	20	34	270	14.3
Iron	32,000	23,000	37,000	—	—	30,890
Mercury	0.038	0.025	0.043	0.15	0.71	0.056
Selenium	19	14	39	—	—	0.083
Lead	33	20	22	46.7	218	17
Nickel	-	<1	<1	20.9	51.6	18.6
Zinc	14	61	97	150	410	52
2020 Hammerhead EBS (n=8)						
Aluminum	72,400	38,500	84,600	—	—	77,44
Arsenic	9.4	7.5	11.5	8.2	70	2
Barium	2644	250	16,200	—	—	668
Cadmium	0.16	0.15	0.18	1.2	9.6	0.102
Chromium	41.1	18.4	52.1	81	370	35
Copper	16.9	10.6	22	34	270	14.3
Iron	33,566	19,200	39,00	—	—	30,890

Parameter	Mean	Minimum	Maximum	Effects Range Low [b]	Effects Range Median [c]	Mean Background Continental Crust Value [a]
Mercury	0.04	0.0286	0.0622	0.15	0.71	0.056
Selenium	BDL	BDL	BDL	—	—	0.083
Lead	19.0	9.6	29.5	46.7	218	17
Nickel	29.4	15.5	35.8	20.9	51.6	18.6
Zinc	80.6	43.2	114	150	410	52

"—" = no Effects Range Low / Effects Range Medium; BDL = below detection limit (analyzed but not detected above the method detection limit or sample detection limit); mg/kg = milligrams per kilogram
Note: One-half of the detection limit was used for non-detect results in all statistical calculations.
[a] Mean concentration in upper continental crust (Wedepohl 1995)
[b] NOAA ERL value (Macdonald et al. 1996)
[c] NOAA ERM value (Macdonald et al. 1996)

Table 7.3-2: Summary of Hydrocarbon Concentrations Reported for Sediment Samples Collected in Vicinity of Offshore Pipeline Route

Parameter		Mean	Minimum	Maximum
2021 EBS (n=15)				
n-alkanes (TPH-CWG - Aromatic)	*nC_{12-16}*	BDL	BDL	2.1
	nC_{21-35}	BDL	BDL	24
	nC_{5-35}	BDL	BDL	33
2017 Stabroek Block EBS (n=10) (detected constituents only)				
n-Dotriacontane (µg/g)		0.213	0.17	0.26
n-Hexatriacontane (µg/g)		0.194	0.14	0.28
n-Octadecane (µg/g)		0.14	BDL	1.4
n-Triacontane (µg/g)		0.22	0.17	0.31
Total extractable hydrocarbons		7.1	4.9	10
2018 Stabroek Block EBS (n=8)				
Total PAH (ng/g)		20.60	17.83	22.59
Total TPH (µg/g)		1.5	<1.4	2,21
Unresolved TPH (µg/g)		—	<1.4	<1.4
Resolved TPH (µg/g)		1.5	<1.4	2.21
2018 Payara Development EBS (n=8)				
THC (µg/g)		0.7	0.6	0.8
UCM (µg/g)		0.4	0.4	0.5
n-alkanes	nC_{12-20} (µg/g)	0.02	0.01	0.02
	nC_{21-36} (µg/g)	0.06	0.05	0.08
	nC_{12-36} (µg/g)	0.08	0.06	0.1
CPI	nC_{12-20}	1.13	1.04	1.2
	nC_{21-36}	2.71	2.45	2.92
	nC_{12-36}	2.22	2.02	2.4
Pristane (µg/g)		0.0007	0.0006	0.0009
Phytane (µg/g)		0.0003	0.0002	0.0004

Parameter		Mean	Minimum	Maximum
Pristane/Phytane Ratio		2.42	2.06	3.17
Total PAHs (Sum of 2-6 Rings) (ng/g) [b]		4	2	7
Sum of 2-3 Rings (NPD) (ng/g)		1	BDL	2
Sum of 4-6 Rings (ng/g)		3	-	5
NPD/4-6 Ring		0.33	BDL	0.40
2019 Hammerhead EBS (n=8)				
THC (µg/g)		2.6	2.0	3.7
UCM (µg/g)		1.3	1.0	1.9
n-alkanes	nC12-20 (µg/g)	0.07	0.03	0.08
	nC21-36 (µg/g)	0.18	0.11	0.25
	nC12-36 (µg/g)	0.25	0.15	0.32
CPI	nC12-20	1.19	0.97	1.47
	nC21-36	2.39	2.04	2.63
	nC12-36	1.95	1.81	2.13
Pristane (µg/g)		0.0018	0.0014	0.0025
Phytane (µg/g)		0.0014	0.0012	0.0021
Pristane/Phytane Ratio		1.25	0.92	1.58
Total PAHs (Sum of 2-6 Rings) (ng/g)[a]		47	34	64
2020 Hammerhead EBS (n=9) (calculated values include results for duplicate at station 2)				
Total TPH (µg/g)		267	3	1,233
Total PAHs (ng/g)		121.44	37.2	319

µg/g = microgram per gram; BDL = below detection limit (analyzed but not detected above the method detection limit or sample detection limit); CPI = carbon preference index (the ratio of odd-number carbon chain n-alkanes to even-numbered carbon chain n-alkanes); NA = not applicable; ng/g = nanograms per gram; NPD = naphthalene, phenanthrene, anthracene, and dibenzothiophene (2-ring and 3-ring PAHs); SHC = saturated and aliphatic hydrocarbons; THC = total hydrocarbons; TPH = total petroleum hydrocarbons; UCM = unresolved complex mixture

Notes:

Petrogenic/Pyrogenic = Ratio of the sum of combustion-related PAHs (fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene) divided by the sum of petrogenic PAHs (naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrene, dibenzothiophenes, chrysenes, and fluoranthenes/pyrenes).

2-6 Ring PAH = Total 2- to 6-ring polycyclic aromatic hydrocarbons

nC_{5-35} = alkanes ranging from carbon numbers 5 to 35

nC_{12-20} = alkanes ranging from carbon numbers 12 to 20

nC_{21-35} = alkanes ranging from carbon numbers 21 to 35

nC_{21-36} = alkanes ranging from carbon numbers 21 to 36

nC_{12-36} = alkanes ranging from carbon numbers 12 to 36

[a] NOAA suggested Effects Range Low and Effects Range Median values for total PAHs of 4.022 µg/g and 44.792 µg/g, respectively (Long et al. 1995)

2021 Environmental Baseline Survey

Total Organic Carbon

TOC concentrations were slightly greater than for prior EBS campaigns, which showed concentrations generally less than 1 percent; concentrations of TOC for the 2021 EBS ranged from 0.6 to 1.6 percent, with a mean of 1.1 percent. TOC concentrations tended to be higher in samples with higher clay content.

Moisture Content

Sediment moisture content is an important fundamental physical property that may be highly variable. Its value is dependent upon particle size and type, organic matter content, as well as physio-chemistry of the sediment. Temporal and spatial changes may occur in sediment porosity that also affect water content (Bennett et al. 1990). Sediment moisture contents ranged from 44 to 62 percent, with a mean moisture content of 56 percent. The highest moisture content was measured at Station 2, while the lowest moisture content was measured at Station 1 itself, located immediately adjacent to Station 2. This suggests a lack of correlation between depth and sediment moisture content.

Redox Potential

The redox potential values in 9 of the 15 samples were positive, indicating mostly oxic conditions (i.e., a habitat in which oxygen is present) within the sediments; the remaining 6 values were negative, indicating anoxic conditions (i.e., a habitat in which oxygen is absent). No discernable correlation was observed between the measured redox potential and the proximity of the sediment samples to the shoreline.

Metals

Twelve metals were analyzed in the sediment samples. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) were used as indicators of anthropogenic sources and 2 metals (aluminum and iron) were used to provide geological source information. Samples were analyzed for concentrations of extractable metals (digested with aqua regia). The average concentrations and ranges of concentrations for all metals were consistent with those observed during the 2017 to 2020 surveys, with the exception of mercury, which was not detected in any of the 2021 samples.

The average (mean) concentrations of two anthropogenic indicator metals (arsenic and nickel) exceeded the NOAA ERL values and the mean background continental crust values. This is consistent with almost all of the above-referenced prior EBS campaigns. As in previous years, comparing total arsenic and iron concentrations for the same sample indicates a strong positive correlation. The observed variation in total arsenic and iron concentrations at different stations can be interpreted as reflecting natural background concentrations associated with variations in sediment geochemistry. However, the presence of mercury in samples for some of the prior EBS campaigns suggests possible influences from mining or other industries transported via direct runoff or through deposition of river sediments.

Monoaromatic Hydrocarbons

Monoaromatic hydrocarbons analyzed in the 2021 survey included benzene, toluene, ethylbenzene, xylenes (BTEX). The BTEX concentrations in all sediment samples were all below detection limit (BDL) levels.

Petroleum Hydrocarbons

All 15 samples were analyzed for a full suite of saturated hydrocarbons ranging from C5 to C35. Results were reported for eight aliphatic hydrocarbon blocks and eight aromatic hydrocarbon blocks, where a block represents a specific carbon range (i.e., aromatic blocks were >C5-C7, >C7-C8, >C8-C10, >C10-C12, >C12-C16, >C16-C21, >C21-C35, and C5-C35). No aliphatic hydrocarbon blocks were detected above a respective detection level at any of the 15 stations. Of the eight aromatic hydrocarbon blocks, only three blocks (>C12-C16, >C21-C35, and C5-C35) were detected in sediments, and only at Station 11 (located approximately 19.4 kilometers offshore). At Station 11, the reported aromatic hydrocarbon concentrations in the >C12-C16, >C21-C35, and C5-C35 blocks were 2.1, 24, and 33 milligrams per kilogram (mg/kg), respectively. The hydrocarbon block concentrations for all other stations were BDL levels.

2017, 2018, 2019, and 2020 Surveys

During the referenced 2017 to 2020 EBS campaigns, sediment samples were analyzed for the following parameters:

- TOC
- Metals
- Hydrocarbons
- Moisture content (only the 2017 EBS campaign)
- Redox potential (only the 2017, 2018 Stabroek, and 2020 EBS campaigns)

Total Organic Carbon

Concentrations of TOC were generally less than 1 percent in the samples collected during the 2017–2020 surveys. The higher concentrations of TOC were found in the samples collected closer to shore, which tend to have a greater proportion of fine sediments, indicating a negative correlation between grain size and organic content (logical given that smaller grain sizes have a greater surface area and thus more ability to adsorb organic matter).

Metals

Seven of the ten anthropogenic-indicator metals had average concentrations (across the five surveys) similar to those reported for the upper continental crust (Wedepohl 1995). One metal, mercury, exhibited concentrations lower than the average upper continental crust concentration. The remaining two metals, arsenic and selenium, had average concentrations that were higher than the upper continental crust mean background concentrations (arsenic average concentration of 17.8 micrograms per gram (µg/g) compared to upper continental crust mean concentration of 2 µg/g and selenium average concentration of 15.5 µg/g compared to upper crust mean concentration of 0.083 µg/g). Nickel and arsenic were the only two metals with an average concentration across some or all of the five prior EBS campaigns higher than the NOAA ERL values. The average nickel concentration of 21.2 µg/g was slightly higher than the ERL value of 20.9 µg/g. The average arsenic value of 17.8 µg/g was about two times higher than the ERL value of 8.2 µg/g. The average concentrations of nickel and arsenic are similar to the 2021 data.

Hydrocarbons

The most common measurements of representative hydrocarbon in the surveys were saturated hydrocarbons (SHC, measured in 2017, 2018, and 2020) and total PAHs (measured in 2018, 2019, and 2020). The SHC measurement represents saturated alkanes with carbon numbers ranging from C12 through C35. In the SHC measurement, there is no aromatic component. The SHC measurements ranged from 0.08 to 0.767 µg/g. PAHs are composed of fused aromatic rings. PAHs analyzed included 20 parent (i.e., unalkylated) compounds and 23 alkylated homologues, consisting of 2- to 6-ring compounds. The total PAH measurements ranged from 4 to 121 nanograms per gram (ng/g).

Several SHC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. These parameters and ratios are listed below, along with a general discussion of their relevance in determining the source of the hydrocarbons:

- Carbon Preference Index (CPI): The total odd-chain hydrocarbons divided by the total even-chain hydrocarbons. A value of 2 to 4 indicates input from plants. As petroleum is added, the value decreases, approaching 1.
- Pristane/Phytane Ratio: The source of phytane is mainly petroleum, whereas pristane is derived from both biological matter and petroleum. In environmental samples with no petroleum contribution, this ratio is greater than 1 and it decreases as petroleum is added.
- Hexadecane (nC_{16}) / (pentadecane [nC_{15}] + heptadecane [nC_{17}]) ratio: At “background” levels, hydrocarbons nC_{15} and nC_{17} can be used as indicators of plankton hydrocarbon inputs. As plankton productivity increases, this ratio decreases. If the ratio were to increase over time or within the data set, the rationale would be that it is related to anthropogenic sources. Hexadecane (nC_{16}) is rarely found in biolipids (Thompson and Eglinton 1978); paraffins of nC_{15}, nC_{17}, or nC_{19} have been found to be predominant in benthic algae (Clark and Blumer 1967; Youngblood et al. 1971).

The results of the sediment samples exhibited a predominance of odd-chain hydrocarbons as compared to even-chain hydrocarbons, with an average CPI value of approximately 2; this indicates a primarily biogenic source of hydrocarbons. This result is reasonable given the volume of land runoff from the Essequibo and Demerara rivers.

The average pristane/phytane ratios reflect a predominance of pristane over phytane in the sediments, also indicating a predominantly biogenic source of hydrocarbons.

The low ratio (less than 1) of nC_{16} over the sum of nC_{15} + nC_{17} for all samples also indicates relatively higher concentrations of plankton-related hydrocarbons, as compared to hydrocarbons from anthropogenic sources.

The ratio of the sum of 2- and 3-ring PAHs (i.e., naphthalene, phenanthrene, anthracene, and dibenzothiophene; petrogenic indicators) divided by the sum of 4- to 6-ring PAHs (i.e., chrysene, benzo(b)fluoranthene; pyrogenic indicators) is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons. The ratio increases as inputs from petroleum increase. In general, samples showed a predominance of 4- to 6-ring PAHs (i.e., 2+3 rings / 4-6-ring ratios of less than 1), indicating predominantly pyrogenic sources of hydrocarbons, as opposed to petrogenic sources. However, high concentrations of perylene relative to other PAHs were also observed. Perylene is a biogenic compound linked to plant pigments from terrestrial runoff and is not indicative of either petrogenic or pyrogenic sources.

Overall, the survey results indicate the low levels of hydrocarbons measured for prior EBS campaigns could have derived from biogenic or natural materials as well as combustion-related compounds. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs, while combustion-related emissions could arise from multiple natural or anthropogenic sources.

Moisture Content

Sediment moisture content for the 2017 EBS campaign ranged from 22.1 to 38.6 percent, with an average value of 27.4 percent (ESL 2018)—about half of what was measured in the nearshore samples from the 2021 EBS campaign. No moisture content values were reported for the 2018 to 2020 EBS surveys.

Redox Potential

The redox potential (Eh) values detected in all samples collected in the prior EBS campaigns—where measured—were positive and within the normal range for oxygenated, fine-grained, low organic carbon sediment, similar to the 2021 data, indicating oxic conditions within the sediment at the time of sampling. No redox potential values were reported for the 2018 Payara or 2019 Hammerhead EBS campaigns.

7.3.2.2. Riverine Sediments

The baseline conditions of sediments in the Demerara River and the canals in the vicinity of the onshore Direct AOI were characterized based on analysis of sediment samples collected during a 2021-2022 survey by the Consultants (Appendix G, Demerara River Baseline Field Study). No historical surveys or other prior characterization information were identified by the Consultants. The various sample locations during the 2021 survey were categorized based on their locations: coastal, river, canals, temporary MOF (in the area that will be dredged as part of the temporary MOF construction). Sediment station locations are summarized in Table 7.3-3 and shown on Figure 7.3-3. The river stations were selected to represent a range of locations relative to the NGL Plant such that R3 is upstream of the NGL Plant, R2 is slightly downstream of the NGL Plant, and R1 is at the mouth of the Demerara River.

Table 7.3-3: Sediment Sampling Station Locations

	Station	Latitude	Longitude
Coastal Station	C1	6°52'53.65"N	58° 8'30.63"W
River Stations	R1	6°48'12.85"N	58°10'30.72"W
	R2	6°38'18.55"N	58°12'23.78"W
	R3	6°34'52.47"N	58°13'28.00"W
Canal Stations	S11 [a]	6°38'31.32"N	58°13'32.85"W
	S13	6°38'1.51"N	58°12'52.60"W
	S14	6°38'20.08"N	58°12'39.97"W
Temporary MOF Stations	D2	6°37'59.78"N	58°12'45.74"W
	D3	6°37'57.48"N	58°12'40.40"W
	D4	6°37'55.60"N	58°12'35.46"W

[a] This station was inaccessible during the dry season sampling event and was sampled during the wet season sampling event.

Particle size and solids content are physical properties of sediments influenced by surrounding water resources and can be highly variable or similar depending on those sources and their interactions with the sediments. A summary of the measured properties for these parameters in riverine sediment samples is provided in Table 7.3-4. All sediments were free of large-gravel-sized particles. River samples collected at R2 and R3 were similar to one another, with more than 90 percent of their composition from sand and the remaining 10 percent from fine silt and clay. These sediment samples also had similar total solids concentrations, ranging from 66 to 67 percent. The river sediment sample collected nearest to the river mouth (R1) was different from sediments collected at R2 and R3, with approximately 87 percent of the R1 sediment composed of clay (67 percent) and fine silt (20 percent). The R1 sediment sample was similar to the sediment collected in the coastal area (C1). The C1 sediment sample was composed of 82 percent clay and 17 percent fine silt. The total solids in sediments collected at C1 and R1 were similar, ranging from 26 to 36 percent.

The similarity in particle size and total solids content in sediments collected at C1 and R1 suggest that the sediments at R1 have a coastal influence. The canal sediments collected at S11, S13, and S14 were similar to one another and largely composed of clays (63 to 89 percent) with some fine silts (9.4 to 33 percent). The total solids for S11 and S13 were similar, at 32 and 34 percent. In contrast, the total solids at S14 were 74 percent. The temporary MOF sediments at D2 and D4 (which were similar to one another) were composed of 15 to 21 percent sand, 29 to 33 percent fine silt, and 47 to 52 percent clay. The temporary MOF sediment at station D3 was 99 percent sand, which was different than the temporary MOF stations D2 and D4, but similar to the river stations R2 and R3.

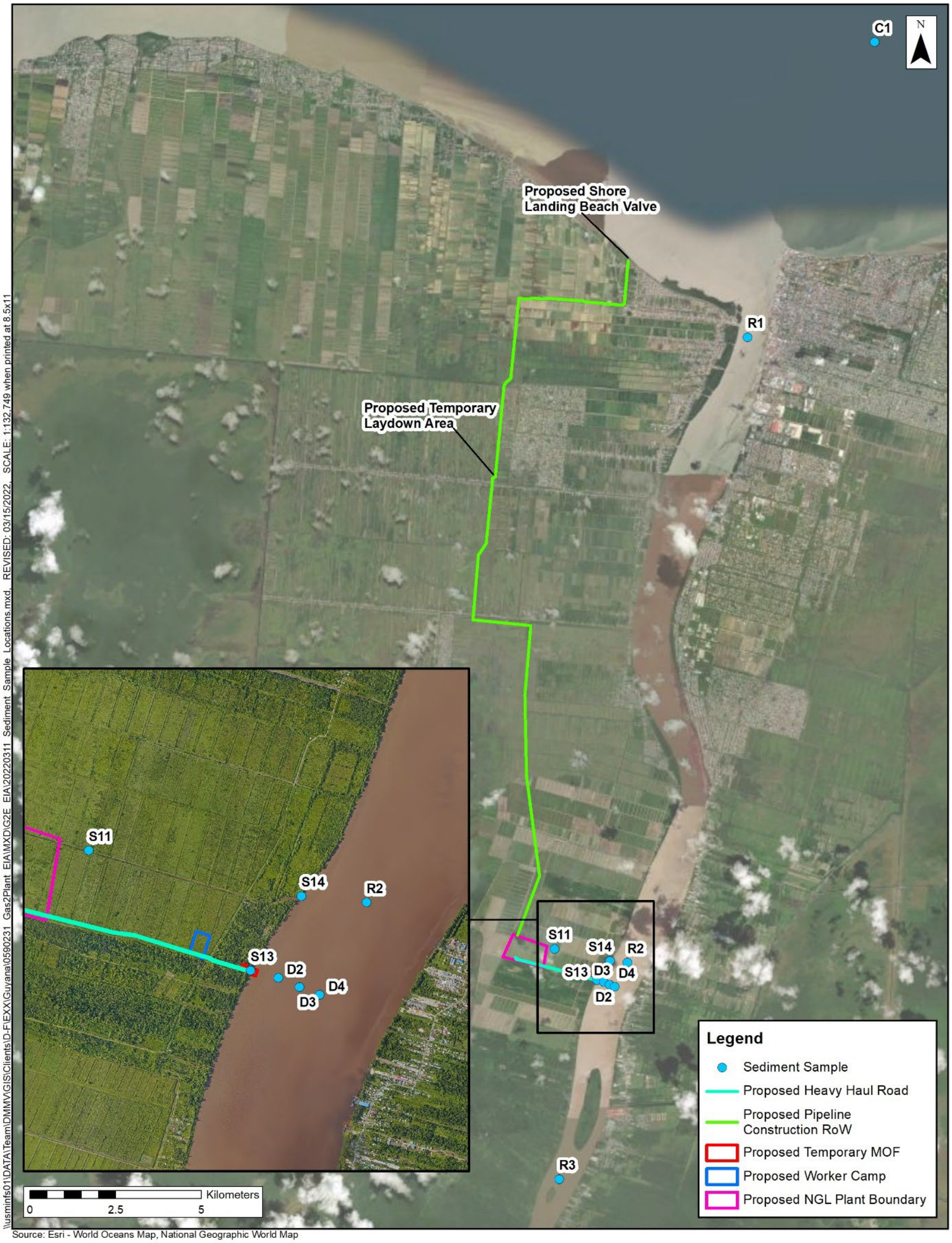


Figure 7.3-3: Location of Sediment Stations for Sample Characterization

Table 7.3-4: Particle Size Distribution and Total Solids for Sediment Samples

Station	Gravel (%)	Sand (%)	Coarse Silt (%)	Fine Silt (%)	Clay (%)	Total Solids (%)
R1	0	11	0.81	20	67	36
R2	0.29	91	0.63	4.0	3.9	67
R3	0.06	96	0.30	0.60	2.6	66
S11	0	2.6	1.2	33	63	34
S13	0.03	2.3	0	9.4	89	32
S14	0.55	1.5	2.6	27	69	73
C1	0	0	1.2	16.9	82	26
D2	0	15	0	33	52	49.4
D3	0	99	0.38	0.7	0	85.2
D4	0	21	3.1	29	47	53.5

Metals

Sixteen metals (antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc) and total sulfide were analyzed for the sediment samples. The measured metal concentration at each location is summarized in Table 7.3-5. The corresponding background concentrations in the upper continental crust are provided for reference. With the exception of a single instance of arsenic (in the sample from S13) and all instances of selenium, reported metals concentrations were below the NOAA ERL reference values (see Section 7.3.2.1, Marine Sediments, for discussion of NOAA ERLs) or the corresponding average concentrations in the continental crust (where no ERL is available).

The metals concentrations in R3 and D3 were similar and generally exhibited the lowest concentrations across all stations, followed by R2. The sediments at S13 and S14 had similar concentrations of all metals. The sediments at S13 and S14 had higher concentrations of seven metals (mercury, arsenic, cobalt, copper, molybdenum, nickel, lead) compared to the sediments at stations D2 and D4. The metals concentrations in sediments at R2, the station downstream of S13, S14, D2, and D4, were lower than the concentrations in the S13/S14/D2/D4 cluster, suggesting some mixing of the sediment is achieved downstream of the points where these canals discharge into the river. Similar to the physical properties, sediments at station R1 demonstrated different (higher in this case) metals concentrations than sediments at upstream location R2, possibly indicating contributions from the heavier industrial activities near the mouth of the river.

Table 7.3-5: Metal Concentration in Coastal, River, and Canal Sediment Samples (mg/kg)

Metal	R1	R2	R3	S11	S14	S13	C1	D2	D3	D4	Effects Range Low	Continental Crust[a]
Mercury	0.0545	0.00998	0.00582	0.0142	0.0162	0.0178	0.0134	0.028	0.00677	0.0201	0.15	0.056
Antimony	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-	0.31
Arsenic	6.71	7.37	1.32	5.2	7.61	8.63	4.92	7.83	2.83	4.88	8.2	2
Beryllium	0.418	0.211	0.0628	0.383	0.576	0.7	0.439	0.594	0.0588	0.722	-	3.1
Cadmium	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.2	0.102
Chromium	11.2	4.24	1.86	8.37	16.1	17.3	11	13.7	0.67	13.8	81	35
Cobalt	4.14	1.49	0.517	3.24	6.57	6.62	4	5.23	0.273	5.97	-	11.6
Copper	5	1.27	0.491	2.86	8.05	6.02	3.69	4.8	0.195	5.27	34	14.3
Lead	7.63	6.53	1.81	5.41	11	11.4	7	10	2.12	9.96	46.7	17
Molybdenum	0.153	0.172	0.0311	0.0794	0.353	0.317	0.127	0.171	0.0566	0.104	-	1.4
Nickel	6.75	3.05	0.895	5.39	11.1	11.8	7.29	8.83	0.286	10.2	20.9	18.6
Selenium	0.365	0.211	BDL	0.232	0.524	0.528	0.288	0.342	BDL	0.382	-	0.083
Silver	BDL	BDL	BDL	BDL	0.0162	BDL	BDL	BDL	BDL	BDL	1	0.055
Thallium	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.222	-	0.75
Vanadium	18.4	11.5	3.16	11.5	22.8	26.1	17.6	22.8	3.21	22.6	-	53
Zinc	29	9.35	3.35	23.4	39.3	44	27.8	35.3	1.17	40.3	150	52

[a] Mean concentration in upper continental crust (Wedepohl 1995)

Polychlorinated Biphenyls and Organochlorine Pesticides

Organochlorine pesticides and PCBs in all riverine sediment samples were reported to be BDL levels. The organochlorine pesticides included analysis of 23 individual chemicals. The PCB analysis included seven congeners.

Polynuclear Aromatic Hydrocarbons

Nineteen individual PAHs were analyzed in the sediment samples. The results are summarized in Table 7.3-6. Also provided is a sum total of the measured PAH concentrations. The total PAH concentrations in the sediments were variable and did not appear to exhibit a pattern with respect to station location. The total PAH concentration ranged from 0.34 micrograms per kilogram (µg/kg) in the coastal sediment sample to 749 µg/kg in the sediment collected at station R1 at the mouth of the river. A potential source of PAHs are petroleum products and it is possible that commercial and industrial activities and/or general vessel traffic in the Georgetown area could have contributed to the PAH concentrations in the sediments near the mouth of the river. All total PAH concentrations were below the NOAA ERL value of 4,022 µg/kg (Long et al. 1995).

Total Organic Carbon

Reported TOC concentrations in the sediment samples are summarized in Table 7.3-6. The TOC concentrations were variable among the sediment sampling locations, with concentrations ranging from 0.065 to 1.66 percent. The sediment at station R1 had the highest TOC concentration of 1.66 percent, which aligns with this station exhibiting the highest total PAH concentration. The lowest TOC concentration was observed in sediment collected at D3.

Table 7.3-6: PAH Concentration in Coastal, River, and Canal Sediment Samples (µg/kg unless otherwise indicated)

PAH	Effects Range Low	R1	R2	R3	S11	S14	S13	C1	D2	D3	D4
Total organic carbon (%)	-	1.66	0.934	0.145	0.72	1.23	1.2	1.2	0.311	0.065	0.287
1-Methylnaphthalene	-	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.42	0.63
2-Methylnaphthalene	70	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.37	0.62	1.2
Acenaphthene	16	BDL	BDL	BDL	BDL	0.34	BDL	BDL	BDL	BDL	BDL
Acenaphthylene	44	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Anthracene	85.3	4.4	BDL	BDL	BDL	0.51	BDL	BDL	BDL	0.48	BDL
Benz(a)anthracene	261	60	1.2	BDL	BDL	5	BDL	BDL	BDL	0.79	BDL
Benzo(a)pyrene	430	100	9.9	3.7	BDL	5.3	4.1	BDL	BDL	0.7	BDL
Benzo(b)fluoranthene	-	150	BDL	BDL	BDL	6.5	BDL	BDL	BDL	1.2	BDL
Benzo(g,h,i)perylene	-	59	2.5	BDL	BDL	4.1	BDL	BDL	BDL	1	BDL
Benzo(k)fluoranthene	-	75	BDL	BDL	BDL	5	BDL	BDL	BDL	0.72	BDL
Chrysene	384	68	1.9	BDL	BDL	5.8	BDL	BDL	BDL	1.5	BDL
Dibenz(a,h)anthracene	63.4	9.1	0.47	BDL	BDL	0.66	BDL	BDL	BDL	BDL	BDL
Dibenzofuran	-	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Fluoranthene	600	68	1.5	BDL	BDL	8.8	BDL	0.34	BDL	3.4	BDL
Fluorene	19	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Indeno(1,2,3-cd)pyrene	-	61	2.3	BDL	BDL	4.2	BDL	BDL	BDL	0.55	BDL
Naphthalene	160	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.4	0.61
Phenanthrene	240	19	0.42	BDL	0.75	1.1	BDL	BDL	0.53	3.5	0.7
Pyrene	665	75	1.7	BDL	BDL	10	BDL	BDL	0.7	2.8	BDL
Total PAHs	4,022	749	21.9	3.7	0.75	57.3	4.1	0.34	1.6	18.08	3.14

7.3.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on marine and riverine sediments. The relevant planned Project activities and the associated potential impacts of these activities on marine and riverine sediments are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

7.3.3.1. Marine Sediments

Relevant Project Activities and Potential Impacts

No impacts on marine sediments are expected as a result of activities associated with the installation of new subsea infrastructure at the seaward end of the offshore pipeline (e.g., risers and pipeline end terminations [PLETs]). In addition, there are no planned Project activities that will disturbed marine sediments during the Operations or Decommissioning stages of the Project. Accordingly, the remainder of this section focuses on potential impacts on marine sediments as a result of offshore pipeline installation during the Construction stage.

The offshore pipeline construction will be buried for protection purposes for the portion of the pipeline corridor from the 20-meter bathymetric contour to shore, using techniques such as suction dredging or jet plowing. Additionally, the shore-crossing segment of the pipeline will be completed using HDD techniques; this will involve excavation of an exit pit at the in-water “punch-out” location of the HDD boring from shore. These activities could impact the marine sediments in the Direct AOI of the Project. The key potential impact assessed includes the deposition of sediments onto the seafloor from the resuspension and transport of sediments during these pipeline installation activities. The base case for decommissioning is to leave the offshore pipeline in place after flushing it and capping it. Accordingly, no additional sediment disturbance is expected during Decommissioning.

Table 7.3-7 summarizes the planned Project activities that could result in potential impacts on marine sediments.

Table 7.3-7: Summary of Relevant Project Activities and Key Potential Impacts—Marine Sediments

Stage	Project Activity	Key Potential Impacts
Construction	Installation of offshore pipeline in shallow water segments using various trenching techniques such as suction dredging or jet plowing	Deposition of sediments onto the seafloor from the resuspension and transport of sediments during burial of the offshore pipeline and completion of the HDD shore crossing.

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for marine sediments (Table 7.3-8). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for marine sediment sensitivity are provided in Table 7.3-9.

Table 7.3-8: Definitions for Intensity Ratings for Potential Impacts on Marine Sediments

Criterion	Definition
Intensity	**Negligible:** No changes to overall functionality with respect to providing a habitat for benthic organisms.
	Low: Changes to overall functionality with respect to providing a habitat for benthic organisms but limited to a localized area.
	Medium: Changes to overall functionality with respect to providing a habitat for benthic organisms over a moderately sized area (i.e., up to 1 km^2 around the pipeline corridor).
	High: Widespread changes to overall functionality with respect to providing a habitat for benthic organisms (i.e., more than 1 km^2 around the pipeline corridor).

Table 7.3-9: Definitions for Sensitivity Ratings for Potential Impacts on Marine Sediments

Criterion	Definition
Sensitivity	**Low:** Affected habitat does not support any unique or otherwise critically important species.
	Medium: Affected habitat supports unique or critically important species but represents only a small portion of the habitat on which these species depend.
	High: Affected habitat supports unique or critically important species and represents a substantial portion of the habitat on which these species depend.

Impact Magnitude Ratings—Marine Sediments

Modeling was performed to estimate the potential environmental impacts related to pipeline burial operations that could influence sediment resuspension and deposition (settlement of sediment onto the seafloor) throughout the portion of the offshore Direct AOI where the pipeline will be buried. The approach required a two-pronged analysis: assessment of sediment impacts and assessment of water quality impacts. Sediments will be disturbed during the pipe-laying activities and will resuspend and eventually resettle, resulting in potential smothering effects on benthic resources in the area of deposition. Similarly, the resuspended sediment will increase total suspended solids (TSS) concentrations in the vicinity of the pipeline burial segment and during subsea infrastructure and offshore pipeline decommissioning, if removal of subsea infrastructure is conducted as part of decommissioning. Predicted increases in TSS concentrations and the associated potential impacts on water quality are described in detail in Section 7.4, Water Quality.

Due to the length of the pipeline and the varied difference in ocean depth along the pipeline route, three locations were selected for assessment: Area 1—Coastal, approximately 11 kilometers long (pipeline burial via jetting near the coastline, at an approximately 1-meter bathymetric contour); Area 2—Shallow, approximately 16 kilometers long (pipeline burial via jetting at the 10-meter bathymetric contour); and Area 3—Offshore, approximately 20 kilometers long (pipeline burial via jetting at the 20-meter bathymetric contour).

Modeling was performed to simulate the transport and settling of sediments suspended into the water column during the process of seabed disturbance. The modeling was performed using Generalized Environmental Modeling System for Surfacewaters (GEMSS®) and its sediment particle and fluids discharge module, Generalized Integrated Fate and Transport (GIFT) (Kolluru and Spaulding 1993; Kolluru et al. 1998; Fichera and Kolluru 2007; Fichera et al. 2013; Prakash and Kolluru 2014). GIFT simulates the fate of dissolved and particulate material of various sizes discharged into a waterbody. This three-dimensional particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values. The modeling methodology is based on a deterministic mode of simulation. In deterministic mode, single-event simulations include the starting date and current speed and direction at each time step, which are chosen from a property database in the selected periods (see Appendix C, Water Quality Modeling Report).

As described previously, impacts related to sediments suspended into the water column and ultimately deposited on the seabed were assessed in terms of two key variables: TSS concentrations in the water column and sediment depositional thickness on the seafloor. Increases in water column TSS concentrations are discussed in Section 7.4, Water Quality.

Sediment suspended during seabed disturbance will settle to the seafloor and create a footprint of deposited material. These deposits may result in habitat loss or disruption to a defined area of the seabed, specifically through potential burial and smothering of existing benthic communities. The severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material, and the duration of the burial.

Thickness thresholds vary by species and sediment impermeability. A suggested threshold of 6.5 millimeters (mm) has been reported (Smit et al. 2006); this is representative of instantaneous burials adversely affecting 5 percent of the studied benthic species (i.e., the more sensitive members of the population). In addition, a maximum threshold deposition rate of 50 mm per month has been reported based on publications by Ellis and Heim (1985) and MarLIN (2011) for gradual releases in the marine environment.

As described in greater detail in the Water Quality Modeling Report (see Appendix C), deposition was modeled for scenarios reflecting minimum and maximum current speeds, as the current speed at the time of sediment suspension and deposition will affect the area over which deposition occurs and the ultimate deposition thickness on the seabed. Table 7.3-10 summarizes the results of the modeling of sediment depositional thickness for the above-referenced assessment areas. Figures 7.3-4 and 7.3-5 depict the maximum depositional thickness at the shallow location under minimum and maximum currents, respectively.

Table 7.3-10: Summary of Modeling Results for Sediment Deposition Thickness Scenarios

Representative Trenching Area	Maximum Predicted Thickness (mm)	Total Area (km^2) with Thickness > 6.5 mm	Total Area (km^2) with Thickness > 50 mm
Minimum Currents			
Area 1—Coastal	3.6	0	0
Area 2—Shallow	13.2	0.021	0
Area 3—Offshore	1.4	0	0
Maximum Currents			
Area 1—Coastal	3.0	0	0
Area 2—Shallow	13.2	0.018	0
Area 3—Offshore	1.0	0	0

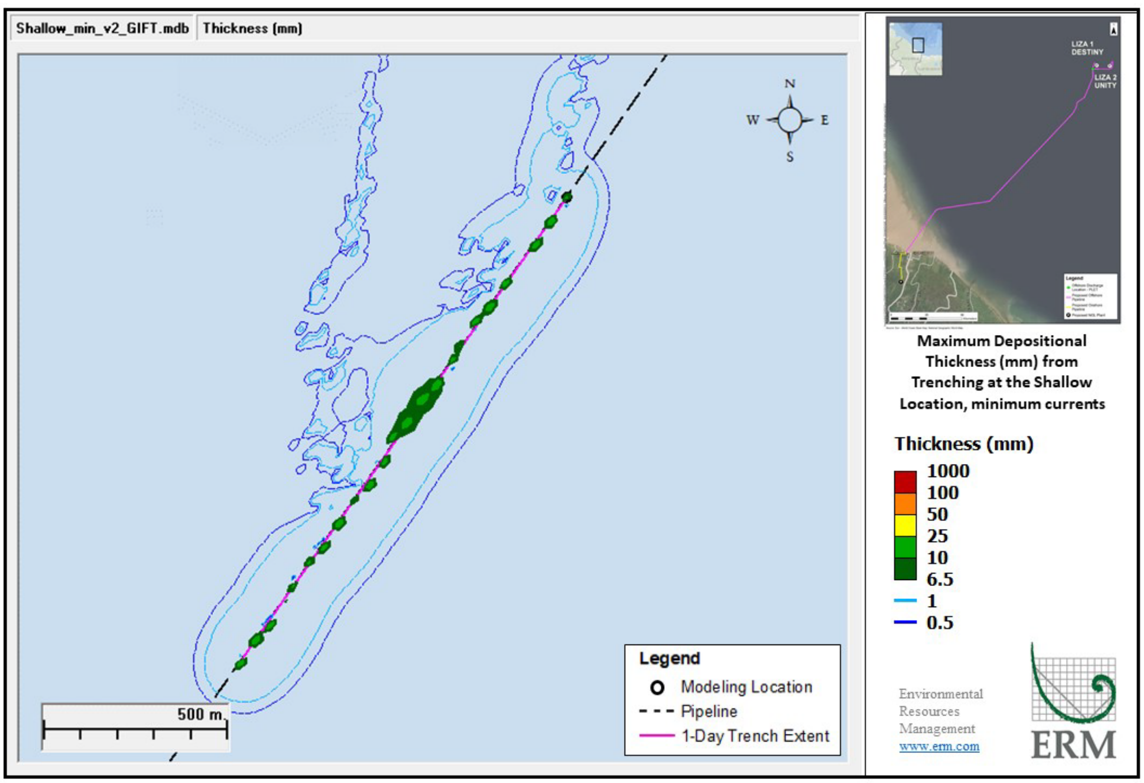


Figure 7.3-4: Maximum Depositional Thickness at Sea Bottom at the Shallow Modeling Location under Minimum Currents after 1 Day of Trenching (Close Up)

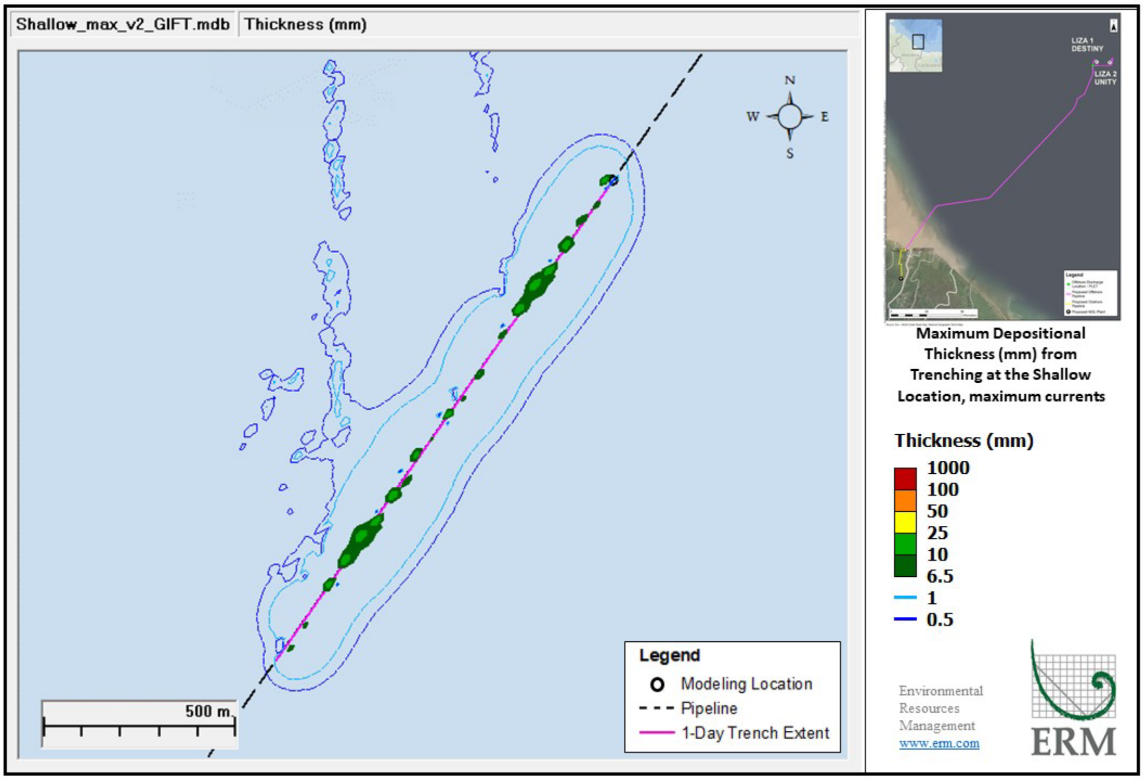


Figure 7.3-5: Maximum Depositional Thickness at Sea Bottom at the Shallow Modeling Location under Maximum Currents after 1 Day of Trenching (Close Up)

For Area 1—Coastal, the maximum predicted seabed accumulation of sediment at the coastal trenching location under minimum current conditions was 3.6 mm. The maximum predicted seabed accumulation of sediment under maximum current conditions was 3 mm. The 6.5-millimeter impact threshold was not exceeded under either current condition.

For Area 2—Shallow, the maximum predicted seabed accumulations of sediment at the jetting location under minimum and maximum current conditions were both 13.2 mm, with the area exceeding the 6.5-millimeter thickness at approximately 0.018 to 0.021 km^2. The maximum distance from the jetted area exceeding the 6.5-millimeter thickness was approximately 38 meters (Table 7.3-10).

For Area 3—Offshore, the maximum predicted seabed accumulation of sediment at the jetting location under minimum current conditions was 1.4 mm (Table 7.3-10). The maximum predicted seabed accumulation of sediment under maximum current conditions was 1 mm. The 6.5-millimeter impact threshold was not exceeded for this area under either current condition.

The 6.5-millimeter threshold was only exceeded at Area 2—Shallow, adjacent to the trench in the immediate vicinity of the pipeline, and covering an area of approximately 0.02 km^2 (Table 7.3-10). On this basis, the intensity of impact associated with sediment deposition on the seafloor is considered **Low**. While there will be periods during the pipeline installation when active sediment deposition will not occur, the impact will be present continuously during jetting, yielding a **Continuous** frequency rating. Pipeline installation in the segments designated for pipeline burial is expected to occur over approximately 3 months, so the duration is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact on sediment morphology from drill cutting deposition is considered **Small**.

Sensitivity of Resource—Marine Sediments

As discussed in Section 8.2, Marine and Coastal Biodiversity, the marine benthic biological resources of Guyana have not been extensively studied, but the data collected to date indicate that the coastal and nearshore areas of Guyana do not support the matrix of shallow coral reefs and seagrass meadows often considered emblematic of coastal, tropical Atlantic environments elsewhere in the world. This is because of the area's highly turbid conditions, which do not promote the growth of warm water corals that rely on symbiotic photosynthetic algae for nourishment.

The 2021 EBS (EAME 2021) describes benthic infauna analysis of 15 samples collected from depths ranging from 1.4 to 18.2 meters along the offshore pipeline corridor. A total of ten specimens in seven taxa were observed in the 2021 benthic nearshore samples. Several factors—including extensive sedimentation from surrounding river systems, absence of coarser sand and gravel, persistent mixing from wind and river, and a high TSS load—are likely contributors to the observations of low total abundance and reduced taxa richness and diversity observed in each of the nearshore benthic samples. Each of the nearshore samples was characterized as soft, silty clay (fines with diameters less than 0.063 mm), with no visible differences in overall sample composition. These findings suggest a nearshore benthic environment that is relatively homogenous and limiting to colonization by benthic infauna.

Based on the sensitivity definitions in Table 7.3-9, the resource sensitivity for marine sediment resource (considering sensitivity of potentially indirectly impacted marine biota) to potential changes in sediment transport and deposition is considered **Low**, as the sediments in the area do not support high densities of unique marine species; this has been corroborated by multiple EBS events conducted in the vicinity of the offshore pipeline corridor.

Pre-mitigation Impact Significance—Marine Sediments

Assuming implementation of the embedded controls listed in Table 7.3-11, the intensity rating for potential Project impacts on marine sediment is **Low**. This results in a pre-mitigation magnitude rating of **Small**. Coupled with sensitivity ratings of **Low**, the pre-mitigation impact significance for marine sediments is rated as **Negligible**.

7.3.3.2. Riverine Sediments

This section discusses the potential impacts of planned activities of the Project on riverine sediments. The relevant planned Project activities and the associated potential impacts of these activities on riverine sediments are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

Relevant Project Activities and Potential Impacts

In general, the planned Project activities that could affect riverine sediments are those that will disturb or change the existing sediment bed profile. The planned dredging activities associated with construction of the temporary MOF will impact the sediments of the Demerara River over a localized area. Sediments will be disturbed within the temporary MOF's dredge prism and redistributed to other areas along the river. The planned treated effluent discharges from the NGL Plant could potentially impact sediment quality if the particulate or dissolved constituents in the discharge settle onto the riverbed sediments. Table 7.3-11 summarizes the planned Project activities that could result in potential impacts on riverine sediments.

Table 7.3-11: Summary of Relevant Project Activities and Key Potential Impacts—Riverine Sediments

Stage	Project Activity	Key Potential Impacts
Construction	Dredging for installation of the turning basin and navigation channel around the temporary MOF	• Deposition of sediments onto the riverbed from the resuspension and transport of sediments
Operations	Operational effluent discharges from NGL Plant; removal of the temporary MOF in-water components during decommissioning	• Sorption of dissolved constituents on to suspended particulate material and subsequent settling onto riverbed sediments • Settling of particulate material onto riverbed sediments • Deposition of sediments or debris onto the riverbed from the resuspension and transport of sediments

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for riverine sediments (Table 7.3-12). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for riverine sediment sensitivity are provided in Table 7.3-13.

To assess the significance of potential impacts on riverine sediments, separate discussions are provided for the following components that may lead to impacts on riverine sediments, with the assessment focusing on the specific potential impacts that are relevant to each of these activities:

- Dredging around the temporary MOF and discharge of dredge spoils
- Effluent discharges from the NGL Plant into the Demerara River
- Decommissioning of the temporary MOF

Table 7.3-12: Definitions for Intensity Ratings for Potential Impacts on Riverine Sediments

Criterion	Definition
Intensity	**Negligible**: No changes to sediment that would be expected to affect benthic organisms.
	Low: Changes are perceptible and could affect benthic organisms over a localized area.
	Medium: Changes are perceptible and could affect benthic organisms over a moderately sized area (i.e., up to 0.5 km^2 of riverbed sediment).
	High: Changes are perceptible and could affect benthic organisms over a widespread area (i.e., more than 0.5 km^2 of riverbed sediment).

Table 7.3-13: Definitions for Resource Sensitivity Ratings for Potential Impacts on Riverine Sediments

Criterion	Definition
Sensitivity	**Low:** Affected habitat does not support any rare or disturbance-sensitive benthic organisms. Benthic community is dominated by non-native and/or habitat generalist species.
	Medium: Affected habitat supports few rare or disturbance-sensitive benthic species but represents only a small portion of the habitat in which these species occur.
	High: Affected habitat supports rare or disturbance-sensitive benthic organisms that have high ecological value (e.g., importance to the food chain) and represents a substantial portion of the habitat in which these species occur.

Impact Magnitude Ratings—Riverine Sediments

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to sediments is provided in Table 7.3-18.

Dredging around the Temporary Material Offloading Facility

The planned sediment dredging activities adjacent to the temporary MOF include excavation of sediments for a turning basin and channel to connect the turning basin to the existing navigation channel along the eastern side of the Demerara River. The turning basin will have a radius of 275 meters and a dredged depth of 6.5 meters. The navigation channel will have a width of 140 meters, a length of 900 meters, and a dredged depth of 6.5 meters. Based on this design information and the existing bathymetry around the area, an estimated 1,500,000 m^3 of sediment will need to be dredged to create the turning basin and the navigation channel. The dredging will be performed with a trailing suction hopper dredger (TSHD), which is a vessel equipped with dredging and storage capabilities. The dredged material (i.e., water and sediment) will be removed from the river bottom by a gas-powered suction pipe and temporarily stored in an onboard hopper pending discharge at an alternate location. As the dredged material fills the hopper, settling will occur such that heavier size particles gravitate to the bottom of the hopper, and the water (i.e., the supernatant) will float to the top of the hopper. To maximize the amount of solids stored within the hopper, the supernatant will be discharged back into the river during the dredging process. This overflow process will continue until the hopper is filled. The overflow water is expected to consist of fine particles that could be transported downstream and potentially settle along the river bottom. Once the hopper is full, the dredge spoils will be transported to another location and discharged. The spoils will be discharged at a location dictated by the Maritime Administration Department (MARAD). It is currently understood that this location will be approximately 3 to 8 kilometers upriver of the temporary MOF site.

As described in Appendix C, Water Quality Modeling Report, to aid in assessing the intensity of the sediment resuspension, transport, and subsequent deposition of dredged sediments on the riverbed, modeling was conducted using GEMSS® and its sediment particle and fluids discharge module, GIFT. Model inputs include information on the dredging schedule, sediment density and particle size distribution, and sediment release rates. In lieu of detailed information on the TSHD system planned for the dredging, some assumptions were sourced from literature. These included information such as sailing speed, overflow losses, hopper dimensions, and sediment suction rate. Assumption basis parameters for the dredging operation and sediment characterization used in the modeling are provided in Appendix C, Water Quality Modeling Report. For the modeling, a dredging cycle of 6 hours was assumed; this includes the time for a full cycle of sediment dredging, transporting the dredged material upstream, discharge of the dredged material to the disposal area, and then travelling back to the Project area. Assuming operations occur 24 hours per day, there will be four dredging cycles per day. During a dredging cycle, the modeling is based on the assumption that the actual dredging will take 90 minutes (1.5 hours). Accordingly, the modeling reflects releases of TSS occurring continuously for 90 minutes every 6 hours (for the four dredge cycles estimated per day). To represent the various locations where dredging may occur, TSS releases were simulated at four locations: two in the turning circle (Cir-W and Cir-E), and two in the navigation channel (Nav-W and Nav-E) (Figure 7.3-6 and Appendix C, Water Quality Modeling Report)—with dredging assumed to occur once at each location during a 1-day (four dredge cycles) period. Modeling of TSS was performed for two flow conditions: the minimum freshwater flow and maximum freshwater flow in the Demerara River, simulated over a 14-day period to reflect a range of conditions across the entire lunar tidal cycle, including the influence of both neap and spring tides.

Using the same approach described above (Section 7.3.3.1, Marine Sediments), impacts related to sediments were assessed through sediment suspension and depositional thickness modeling. Sediment suspended during excavation will settle to the river floor and create a footprint of deposited material. These deposits may result in physical damage and habitat loss or disruption over a defined area of the riverbed through burial and smothering of benthic communities. The specific thickness of burial that may cause an impact can vary depending on the species and the amount of oxygen depletion that may occur, causing anoxic conditions beneath the depositional layer. A suggested threshold of 6.5 mm has been reported (Smit et al. 2006); this is representative of instantaneous burials adversely affecting 5 percent of the studied benthic species (i.e., the more sensitive members of the population).

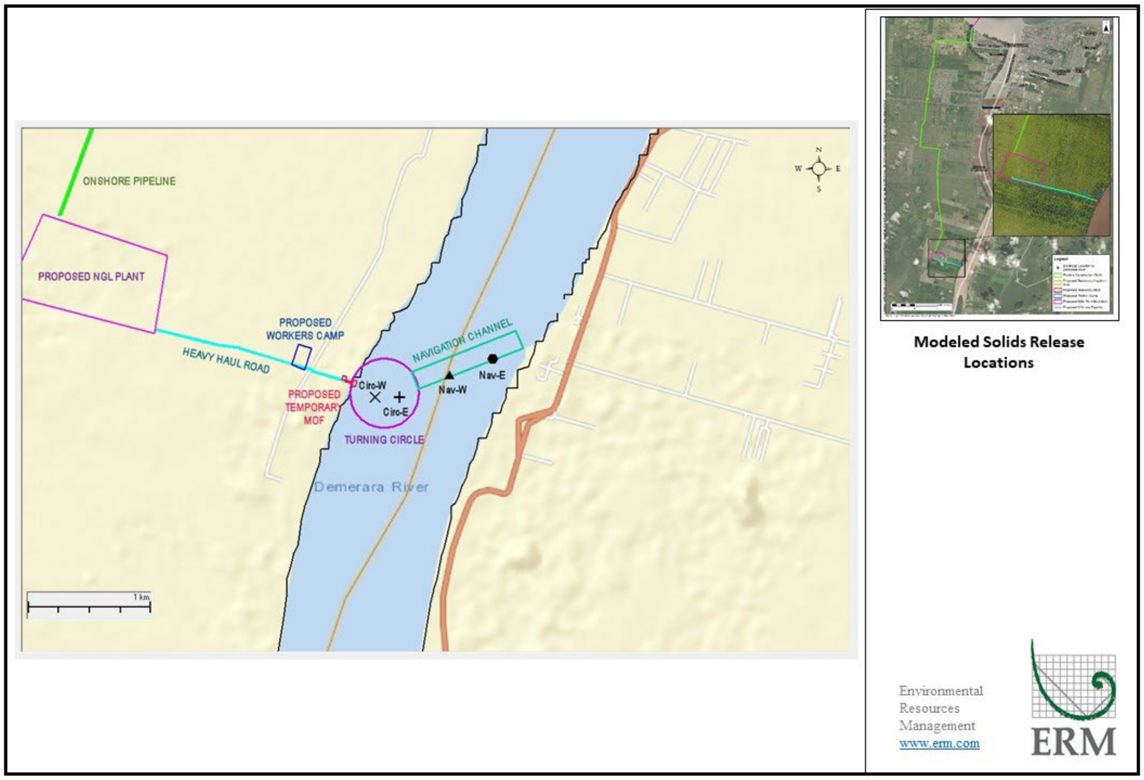


Figure 7.3-6: Modeled Total Suspended Solids Release Areas during Dredging

Modeling was performed for both minimum and maximum flow conditions in the Demerara River. Impacts were examined across three phases of the lunar tidal cycle, resulting in a total of six simulations. The maximum modeled depositional thicknesses are presented in Table 7.3-14. In all scenarios, the threshold of 6.5 mm was exceeded within areas of between 0.22 and 0.60 km². The minimum freshwater flow / spring tide scenario had the highest maximum seabed accumulation of approximately 381.5 mm. However, the maximum area of thickness threshold exceedance occurred for the minimum freshwater blow / between neap and spring tide scenario, with an area of approximately 0.60 km². Figure 7.3-7 shows this maximum area of thickness threshold exceedance.

Table 7.3-14: Result Summary for Temporary Material Offloading Facility Dredging under Different Flows at Time of Maximum Total Suspended Solids Occurrence

Scenario	Maximum Bottom Thickness (mm)	Area (km²) with Thickness > 6.5-millimeter Threshold
MOF_Spring_Min	381.5	0.41
MOF_Spring_Max	104.3	0.27
MOF_Neap_Min	205.5	0.45
MOF_Neap_Max	102.5	0.26
MOF_Between_Min	265.9	0.60
MOF_Between_Max	170.2	0.22

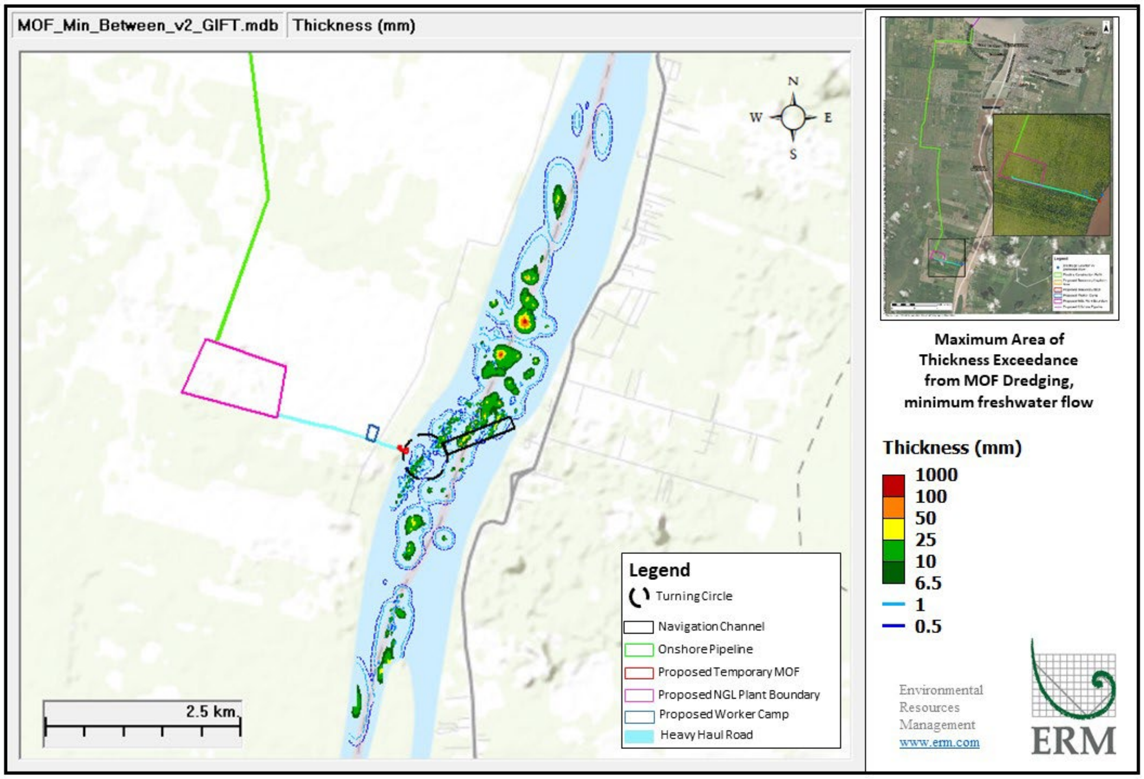


Figure 7.3-7: Maximum Area of Thickness Exceedance at Sea Bottom at the Temporary Material Offloading Facility Modeling Location under Minimum Flow Conditions

For all dredging model scenarios, the maximum sediment accumulation thickness was above the threshold of 6.5 mm. The areas above the thickness threshold ranged from 0.22 to 0.60 km^2. On this basis, the intensity of impacts on sediments from suspension, transport, and deposition are considered **Medium** (for five of the tidal cycle / river flow combinations) to **High** (for one of the tidal cycle / river flow combinations) during the Construction stage. These impacts will occur on a temporary basis only during the relatively short, intermittent periods during which sediments are being dredged, so the frequency of this impact is considered **Episodic** during this stage. Dredging of the temporary MOF area is expected to be completed within 1 month, so the duration is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine sediment is rated as **Small**.

Discharge of the Natural Gas Liquids Processing Plant Effluent into the Demerara River

The NGL Plant will have three effluents: treated process wastewater, treated sanitary wastewater, and stormwater. The treated process wastewater and the treated sanitary wastewater streams will be discharged into a stormwater pond within the NGL Plant site. The process wastewater treatment plant will be designed so that the discharge to the stormwater pond will meet World Bank Group effluent levels for a natural gas processing facility (World Bank 2007a). The sanitary wastewater plant will be designed so that the discharge to the stormwater pond will meet World Bank Group values for treated sanitary sewage discharges

(World Bank 2007b). The stormwater pond effluent will be discharged either directly into the Demerara River or via a canal adjacent to the NGP Plant site. For modeling purposes, a direct discharge to Demerara River approximately 100 meters downstream of the temporary MOF is assumed. A maximum discharge rate of 550 cubic meters per hour (m^3/hr; 0.15 cubic meters per second [m^3/s]) was provided by EEPGL, with an assumption that the entire contents of the stormwater pond will be emptied within a 24-hour period. The maximum TSS concentration that will be discharged into the river is 50 milligrams per liter (mg/L), on the conservative assumption that the TSS concentration in the discharge from the stormwater pond will be no higher than the TSS concentrations of the process and sanitary wastewater streams when entering the stormwater pond (Chapter 5, Project Description [Tables 5.5-5 and 5.5-6]).

The discharge into the Demerara River will have a particulate component and potentially a dissolved constituent component (e.g., metals). Although the effluent will be diluted once it enters the river, the effluent could have particle sizes large enough to settle onto the riverbed sediment. Over time, a gradual buildup of these solids could occur and accumulate on the river bottom in localized areas. Similarly, the dissolved components may be initially at levels below discharge limits, but these dissolved constituents could partition to particulate material in the water column and, depending on particle sizes, settling of the particles could occur in a localized area. Over time, the dissolved component that has partitioned onto the particulate material could therefore accumulate in the sediment to levels that could potentially affect the benthic community.

Sediment impacts from effluent discharges are difficult to predict and dependent on several factors. The effluent TSS concentration and particle size composition will be dependent on the degree of settling in the stormwater pond. An efficient settling system may produce an effluent with a lower TSS concentration and a smaller particle size distribution. Chemical partitioning coefficients are dependent on site-specific characteristics. Sediment load deposits in rivers surge during high flows, resulting in much higher naturally occurring sediment deposition peaks in the Demerara River than will be expected from sediment deposition resulting from the NGL Plant effluent discharge. On this basis, the intensity of impacts on riverine sediments from sediment deposition from NGL Plant effluent discharge is considered **Low** during the Operations stage. The NGL Plant is expected to operate on a continuous basis, discharging to the stormwater pond. The stormwater pond will be discharged intermittently to the river or via an adjacent canal, so the frequency of this impact is considered **Episodic** during this stage. The NGL Plant is expected to have a life expectancy of at least 25 years, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine sediments is rated as **Small.**

Decommissioning of the Temporary Material Offloading Facility

A 10-year design life was used for the temporary MOF design. Plans are to remove the temporary MOF prior to the 10-year design life of the structure being met, so this activity is expected to occur during the Operations stage of the Project. The temporary MOF will be comprised of an approximately 30 meters by 50 meters offloading pier structure / concrete pad extending into the river. Support structures in the river will be removed during decommissioning. These structures will occupy a small area in the river. During decommissioning, sediments around the supports in the river will potentially be disturbed, resuspended, and transported downstream to settle along the river bottom. Additionally, depending on how the support structures are removed, debris from the structure can enter the water and potentially transport downstream and settle along the river bottom. The intensity of impacts on sediment resuspension, transport, and accumulation are considered **Negligible** during the Operations stage, principally based on the limited area of riverbed disturbance. These impacts will occur on an intermittent basis during dismantling, so the frequency of this impact is considered **Episodic** during this stage. The removal of support structures is expected to occur over a period of less than a week, so the duration is considered **Short-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on river sediments is rated as **Negligible.**

Sensitivity of Resource—Riverine Sediments

The riverine benthic biological resources of Guyana have not been extensively studied. River sediment samples were collected during the 2021 to 2022 survey by the Consultants (Appendix G, Demerara River Baseline Field Study). Sediment samples were collected at six stations in the river, including three stations in the temporary MOF dredging area. The stations were representative of conditions along this length of the river, from upstream of the NGL Plant to the mouth of the river. These sediment samples were analyzed for particle size distribution, a physical property of sediments that is influenced by surrounding water resources and their interactions with sediments. Particle size information is a good descriptor of what types of infauna are living in the sediment (Fresi et al. 1983). Species that occupy wavy-sandy environments are likely to withstand environments where sediment scouring occurs. Species found in fine silty-clay environments are likely to survive in low-oxygen conditions (Dernie et al. 2003). The particle size distributions of the sediment samples collected by the Consultants were variable, suggesting a diverse environment in the river. Two sediment samples collected in the MOF were composed of 15 to 21 percent sand with silt and clays accounting for the remaining composition, while the third sediment sample was 99 percent sand.

Based on the sensitivity rating definitions in Table 7.3-9, the resource sensitivity for riverine sediments is characterized based on its diversity, which is likely to support a variety of benthic species rather than a unique species. On this basis, the sensitivity of the riverine sediments is characterized as **Low**.

Pre-mitigation Impact Significance—Riverine Sediments

Assuming implementation of the embedded controls listed in Table 7.3-15, the intensity ratings for potential Project impacts on riverine sediments will range from **Negligible** to **High** (with the **High** rating associated with an **Episodic** frequency and representing only a particular period in the tidal cycle during minimum river flow conditions). This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small**. Coupled with a sensitivity rating of **Low**, the pre-mitigation impact significance for riverine sediments is **Negligible**.

7.3.4. Impact Management and Monitoring Measures

7.3.4.1. Marine Sediments

Based on the **Negligible** significance of potential marine sediment impacts, no mitigation measures are proposed. It is noted, however, that the limited significance of potential marine impacts is supported by a suite of embedded controls (see summary in Chapter 14, Recommendations). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

Table 7.3-15 summarizes the management and monitoring measures relevant to marine sediments.

Table 7.3-15: List of Management and Monitoring Measures—Marine Sediments

Embedded Controls
Monitor and manage suction dredging or jet plowing and burial rates to improve efficiency and reduce turbidity.
To the extent practicable, avoid suction/jetting any deeper than what is required for protection of the pipeline.

7.3.4.2. Riverine Sediments

Based on the **Negligible** significance of potential riverine sediment impacts, no mitigation measures are proposed. It is noted, however, that the limited significance of potential riverine sediments is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

Table 7.3-16 summarizes the management and monitoring measures relevant to riverine sediments

Table 7.3-16: List of Management and Monitoring Measures—Riverine Sediments

Embedded Controls
Monitor and manage excess overflow from hopper on dredging facility to improve efficiency and reduce turbidity in dredging supernatant.
Monitor and manage suction rate to improve efficiency and reduce turbidity in the water column during dredging.

7.3.5. Assessment of Residual Impacts

7.3.5.1. Marine Sediments

As described above, no mitigation measures are proposed to address potential impacts on marine sediments. Accordingly, the residual impact significance ratings remain unchanged at **Negligible.**

Table 7.3-17 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on marine sediments.

7.3.5.2. Riverine Sediments

As described above, no mitigation measures are proposed to address potential impacts on riverine sediments. Accordingly, the residual impact significance ratings remain unchanged at **Negligible**.

Table 7.3-18 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on riverine sediments.

Table 7.3-17: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Sediments

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Deposition of sediments onto the seafloor from the resuspension and transport of sediments during burial of the pipeline	Low	Small	Negligible	None	Negligible

Table 7.3-18: Summary of Potential Pre-Mitigation and Residual Impacts—Riverine Sediments

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Deposition of sediments onto the riverbed from the resuspension and transport of sediments	Low	Small	Negligible	None	Negligible
Operations	Sorption of dissolved constituents on to suspended particulate material and subsequent settling onto riverbed sediments; settling of particulate material in effluent discharges	Low	Small	Negligible	None	Negligible
	Deposition of sediments or debris onto the riverbed from the resuspension and transport of sediments	Low	Negligible	Negligible	None	Negligible

7.4. WATER QUALITY

7.4.1. Baseline Methodology

The baseline conditions for marine and riverine water quality were defined primarily from two different sources of information: a desktop-based review of existing peer-reviewed literature and studies, and a series of field studies conducted to support the Project and other previous EEPGL projects. For marine water quality, field studies considered included a 2021 EBS conducted in support of the Project EIA (see EBS 2021 in Appendix F), as well as prior EEPGL-commissioned EBS campaigns covering areas relevant to the offshore portion of the Direct AOI. The 2021 EBS included ten water quality sampling locations along the offshore pipeline route. The number of samples collected at each location was dependent on water depth. For locations less than 12-meter water depth, two discrete samples were collected at each location: one sample between 0.5 and 1 meter and one sample at 1 meter above the seabed. For locations greater than 12-meter water depth, a third sample was collected at the approximate middle of the water column. A total of 23 water samples were collected and analyzed by a certified laboratory for the following parameters:

- pH (electrometric method)
- TOC (Clesceri et al. 1998)
- TSS (Clesceri et al. 1998)
- Dissolved metals (Acidification followed by inductively coupled plasma-optical emission spectrometry)
- Saturated hydrocarbons (aliphatic and aromatic) (USEPA SW-846 Methods 8260 and 8270)
- PAHs (USEPA SW-846 Method 8270)

For riverine water quality, a 2021-2022 field survey was conducted by the Consultants to collect samples at 18 stations, which included 1 coastal station, 3 Demerara River stations, and 14 stations in the canals along the onshore portion of the Direct AOI (see Appendix G, Demerara River Baseline Field Study). Samples were collected during the dry season (October, November, and December 2021) and during the wet season (January and February 2022). Discrete water samples were collected at the approximate mid-depth in the water column at each station. The water samples were analyzed by a certified laboratory for the following parameters:

- Total solids (TS), total dissolved solids (TDS), TSS (SM 2540 series)
- Dissolved oxygen (DO) (SM500-O)
- Oil and grease (E1664A)
- Phosphorus (E365.3-1978)
- Total Kjeldahl nitrogen (TKN) (SM 4500)
- Nitrate-nitrite nitrogen (E300.0)
- Mercury (USEPA SW 7470A)

- Metals (USEPA SW6020A)
- PAHs (USEPA 8270-D)

At the coastal sampling station and three river sampling locations, continuous data loggers were deployed to monitor conductivity-temperature-depth (CTD) every 15 minutes for a 2-week period. An additional river station was established in the Essequibo River, R4, to assess hydrographic conditions at this location. During the dry season deployment period, the data loggers at the four river stations were lost, and data were only captured at C1. During the wet season, new data loggers were deployed at C1, R3, and R4.

7.4.2. Existing Conditions and Baseline Studies

7.4.2.1. Marine Waters

Oceanographic Conditions

Guyana's marine environment is bounded, and heavily influenced, by the Orinoco and Amazon rivers in Venezuela and Brazil, respectively. During the rainy season, Guyana's coastal marine waters receive large volumes of freshwater discharges from these major rivers, as well as from Guyana's own Essequibo, Demerara, and Berbice Rivers (FAO 2005).

Guyana's surficial marine waters are crossed by the Guiana Current, which is part of the northern limb of the North Atlantic Meridional Overturning Circulation (MOC). The North Atlantic MOC circulates water between the subtropics and polar region. The Guiana Current derives from the North Brazil Current (NBC) flowing north along the northeastern coast of South America from northern Brazil toward the southeastern Caribbean Sea. As it reaches French Guiana, part of the NBC separates from the coast to join the North Equatorial Counter Current (NECC), while the rest continues flowing northwest to form the Guiana Current. Figure 7.4-1 illustrates the proximity of the Guiana Current, NBC, and NECC to the offshore portion of the Direct AOI.

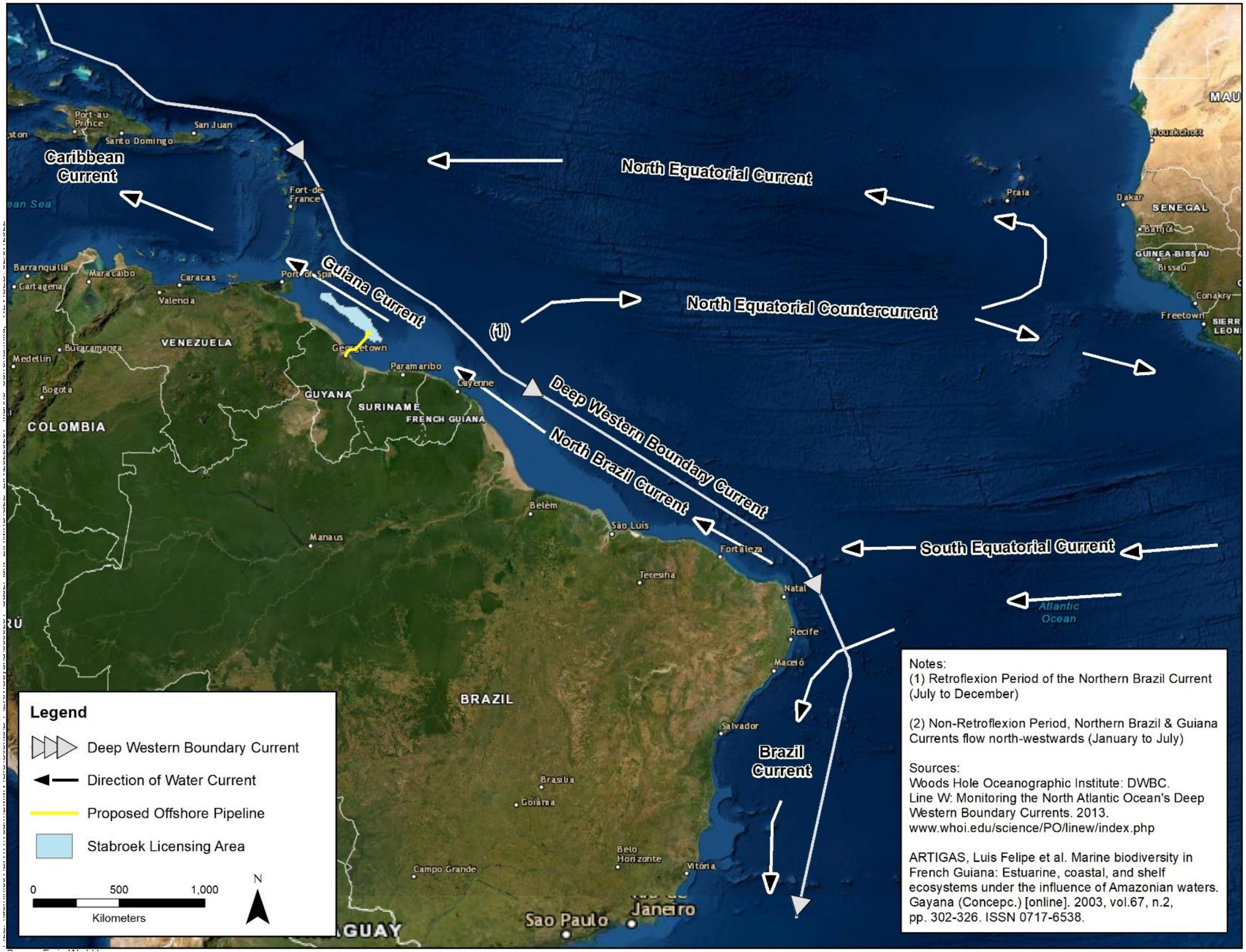


Figure 7.4-1: Marine Currents in the Vicinity of the Offshore Portion of the Direct Area of Influence

Several times a year, the NBC turns back on itself to create closed circulation and form regions of strong eddies (circular currents). These eddies can separate the NBC and NECC and travel northwest along the South American coast. These eddies may range from approximately 145 to 400 kilometers (approximately 90 to 250 miles) in diameter. The current magnitude within the eddies can vary significantly depending on the depth.

During the spring, the Guiana Current can extend as far as 300 nautical miles (550 kilometers) offshore to cover Guyana's entire continental shelf. Its highest velocities tend to occur along the edge of the continental shelf (i.e., in Guyana just shoreward of the Stabroek Block). Fluctuations in the Inter-Tropical Convergence Zone (ITCZ) and the trade winds lead to significant variation in the strength of the Guiana Current and the extent of its influence offshore, but maximum speeds generally occur from April to May, while minimum speeds commonly occur in September (Gyory et al. 2013).

The Guiana Current primarily influences the upper portion[5] of the water column, while the deeper portion of the water column in the Stabroek Block is strongly influenced by the North Atlantic Deep Western Boundary Current (DWBC), which is the southward limb of the North Atlantic MOC. The North Atlantic DWBC returns colder, denser water from polar regions to the subtropics at intermediate and deep levels.

In May 2014, EEPGL commissioned a Lowered Acoustic Doppler Current Profiler (LADCP) survey at four stations along a transect in the central portion of the Stabroek Block. The LADCPs were placed at depths ranging from approximately 970 to 1,100 meters. To supplement the above data, in March 2016, an EEPGL contractor deployed and maintained a series of four deepwater current profile mooring buoys and one surface met station buoy (RPS 2016; 2017a, b, c; 2018b). Two of the mooring buoys were deployed in the Liza field along with a surface met station buoy, and the remaining two mooring buoys were deployed northwest of the Liza field. During the deployment in September 2017, the two Liza field mooring buoys were installed at the same locations, but the met station buoy was relocated. Figure 7.4-2 shows the locations of the LADCPs (shown as "Station 1" through "Station 4"), the two Liza field mooring buoys (shown as "LF" and "LG"), and the surface met station buoy (shown as "LC").

[5] There is limited information documenting the depths at which the Guiana Current and North Atlantic DWBC exert an influence, but metocean data collected by EEPGL (Figure 7.4-1) suggests the Guiana Current exerts an influence in at least the top 200 meters and the North Atlantic DWBC exerts an influence at depths of more than 800 meters. The strength of the Guiana Current will also likely dictate how deep its influence extends at a given time, as it weakens/strengthens depending on the winds and Amazon River flows.

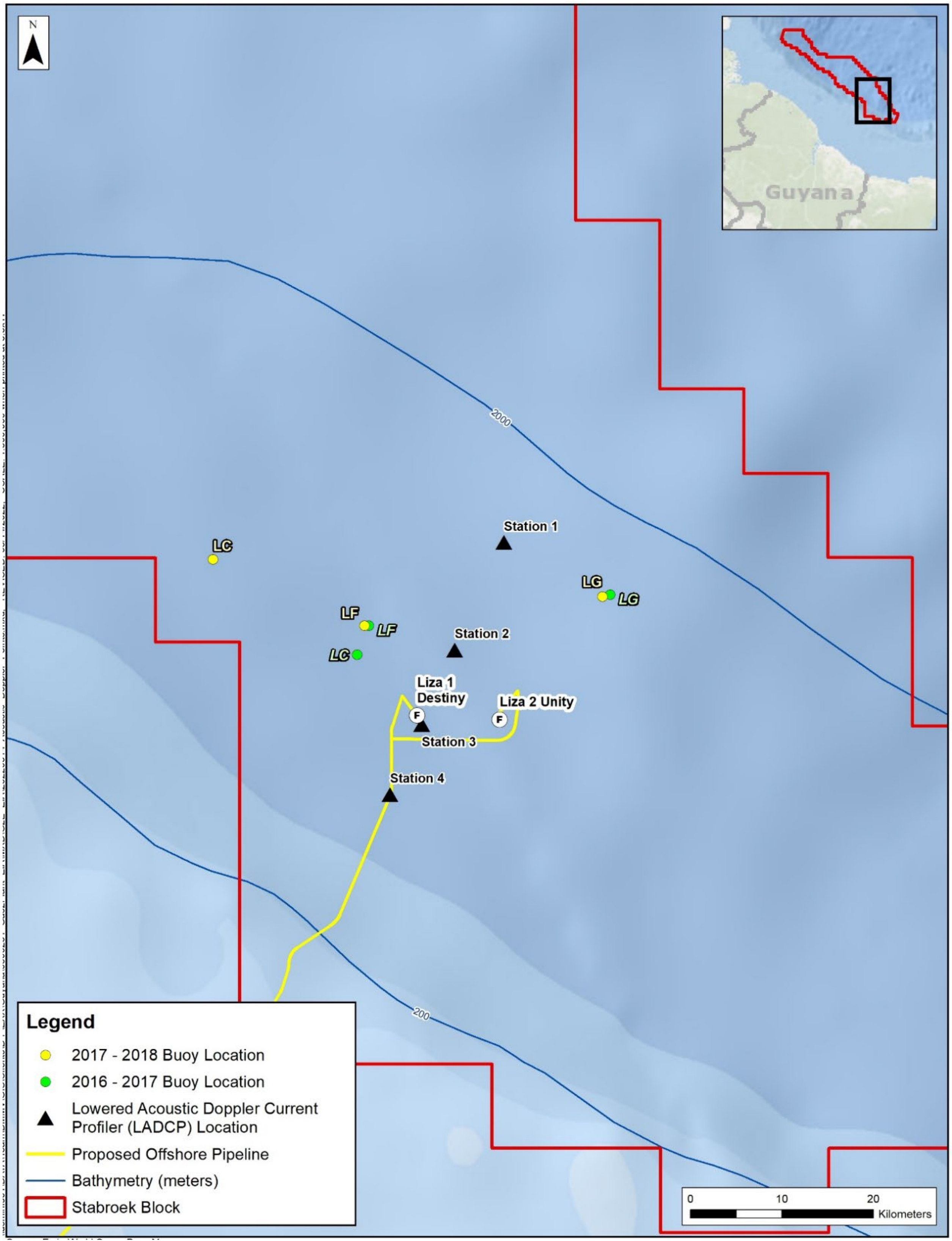
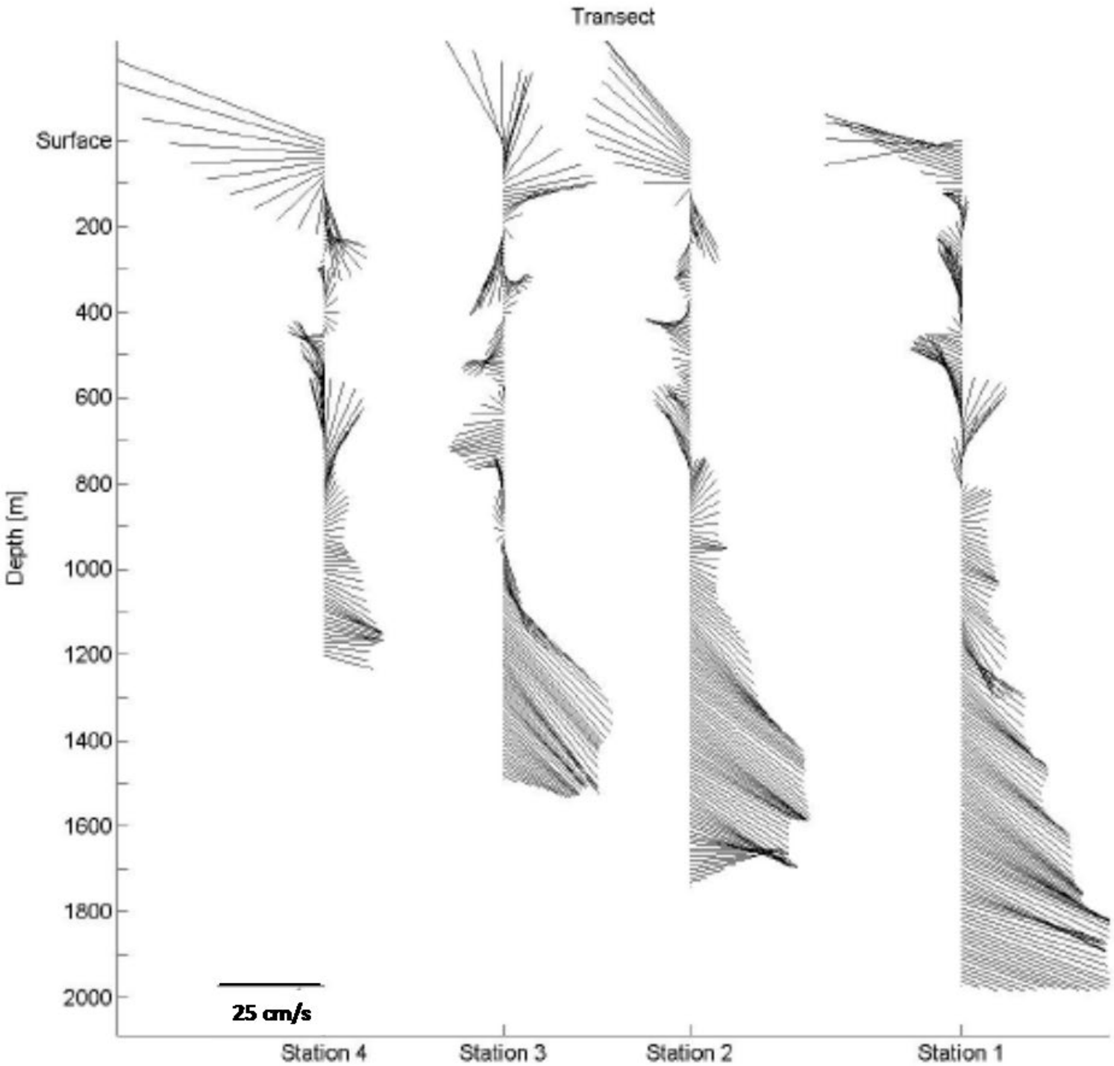


Figure 7.4-2: Lowered Acoustic Doppler Current Profiler and Buoy Locations

The LADCP data indicate the presence of both the Guiana Current and the North Atlantic DWBC. Figure 7.4-3 shows vector stick plots from the four stations along the LADCP transect. The three deepest stations (Stations 1, 2, and 3) showed similar vertical current structure (i.e., a north-westward surface flow influenced by the Guiana Current and a south-eastward deep flow influenced by the North Atlantic DWBC). The shallowest station (Station 4) showed a similar layered structure, but the speed of the north-westward surface current was significantly greater at this station than at the others (TDI-Brooks 2014).

Processed final datasets from the mooring buoys were developed for buoy deployments spanning March 2016 through April 2018, including the fifth deployment that spanned from mid-September 2017 to early April 2018. In addition to confirming the overall circulation pattern off the coast of Guyana as measured in 2014, these moorings also helped identify regional current phenomena. For example, the data showed the existence of a northwest/north-northwest current that is characteristic of the NBC current at this location (see data from “LF” mooring buoy on Figure 7.4-4). The currents shown on the plot are directed toward the northwest/north-northwest with a strong magnitude starting around 19 February 2017. The NBC is an aperiodic current, and Figure 7.4-4 shows the onset of the leading edge of this current reaching the LF mooring buoy location. The vector stick plot (Figure 7.4-3) shows a point in time when the NBC ring was present at the LADCPs. The most recent dataset (RPS 2018b) showed four significant pulses of surface currents during early to mid-October, early to mid-January, late February, and early April. All four of these events were toward the west-northwest, characteristic of the general direction of the Guiana Current. The near-bottom current magnitudes averaged from 18 to 20 centimeters per second at the LF buoy location and from 24 to 28 centimeters per second at the LG buoy location, representative of the south-eastward deep flow influenced by the North Atlantic DWBC.

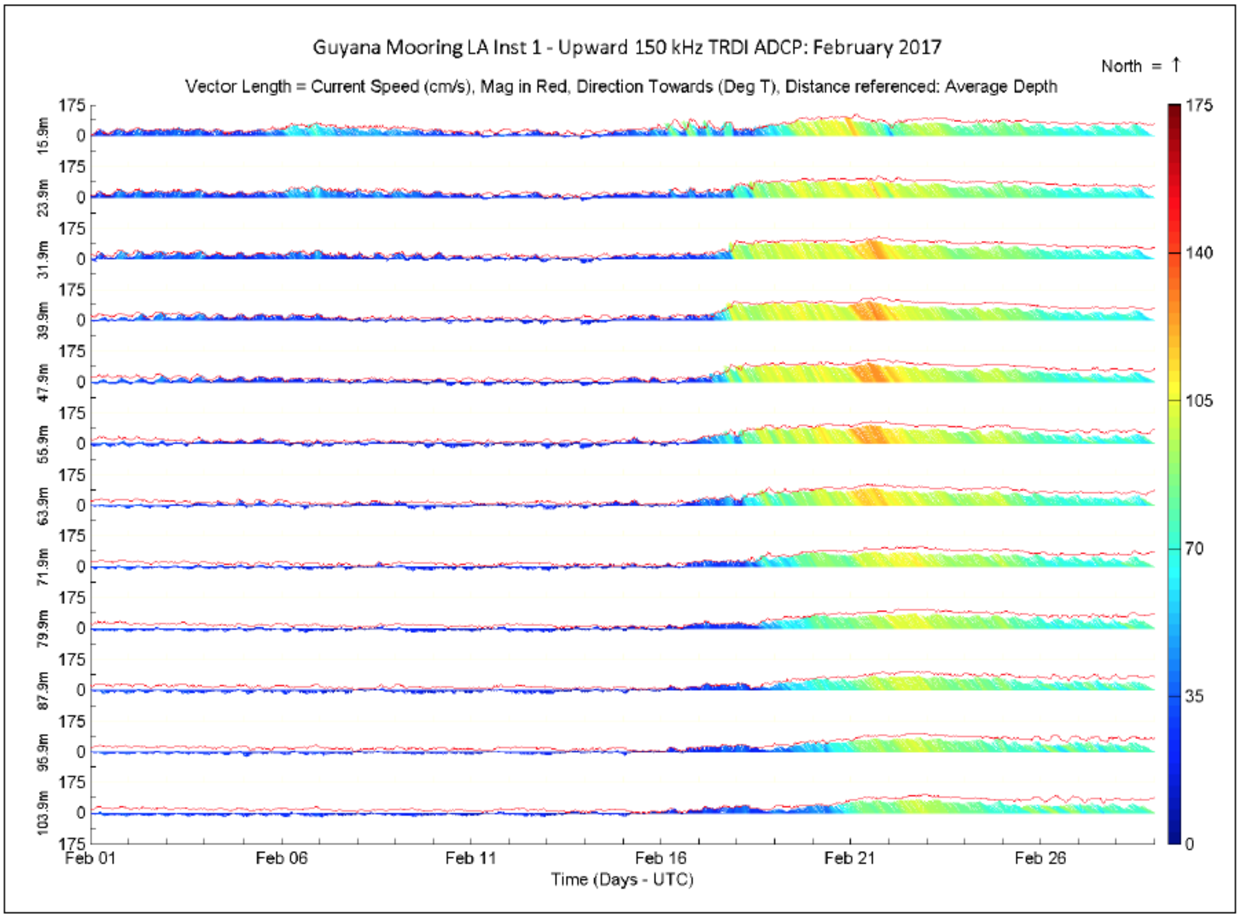


Source: TDI-Brooks 2014

m= meters

Note: Each “stick” (also called a vector) describes the direction, speed, and depth of a discrete measurement. The length of the vector is directly proportional to its speed (a scale is provided at the bottom of the plot). The depth of each measurement is provided on the y-axis. The direction of the vector points in the compass direction of the current flow (north corresponding to “up” on the plot). The horizontal distance between stations on the x-axis is to scale.

Figure 7.4-3: Vector Stick Plot for Stations on the Stabroek Block Lowered Acoustic Doppler Current Profiler Transect



Source: RPS 2018a

ADCP = Acoustic Doppler Current Profile; Deg T = direction degrees towards; kHz = kilohertz; Mag = magnitude; m = meters; UTC = Universal Time Coordinated

Figure 7.4-4: Near-Surface Currents at LF Mooring Buoy, Showing the Onset of the Strong Northwest/North-northwest Currents Related to the North Brazil Current

Marine Water Quality

Regional Water Quality Influences

The hydrographic[6] and isohaline[7] conditions in Guyana's coastal marine waters are greatly impacted by the outflow of the coastal rivers in the region, as described in Section 7.4.2.1, Oceanographic Conditions. The large amount of freshwater discharge affects ocean salinity and temperature. Oceanic water is relatively heavy, cold, and saline compared to the lighter, warmer, and fresher water of the Amazon and Orinoco plumes that converge offshore of Guyana. These convergences form oceanic fronts offshore of Guyana. Freshwater lenses[8] generated by the Amazon and Orinoco rivers are transported across Guyana's continental shelf

[6] Relating to the characteristic features (such as flow or depth) of bodies of water

[7] Isohalines are areas in an aquatic system that have the same salinity.

[8] Freshwater lenses are formed near the surface of a marine environment when fresh (non-saline) water from rivers or rainfall enters a marine/saline waterbody. Freshwater is lighter and floats to the top of the saline water column, creating a layer (lens) of fresh, lower-salinity water.

to points north and west. These lenses persist for months and have been detected as far away as Barbados and Trinidad (Sherman and Hempel 2009).

Of the several coastal rivers that influence the Guyana offshore marine environment, the Amazon River, with an average discharge of 180,000 m^3/s (Nittrouer and De Master 1987), is the most prominent factor in terms of marine water quality. Analysis of the Amazonian plume has shown there is little seasonal variation in the plume's nutrient content (e.g., silicates of 144 micromoles per kilogram [µmol/kg], phosphates of 0.7 µmol/kg, and nitrates of 16 µmol/kg) (De Master and Pope 1996). It has been estimated that 40 to 50 percent of the annual Amazon runoff transits along the coast of Guyana (Nittrouer and De Master 1987).

The entire region offshore of Guyana is considered part of the North Brazil Shelf large marine ecosystem (LME). The ocean temperature in the North Brazil Shelf LME has alternately warmed and cooled over the last few decades. A period of cooling lasted from the mid-1970s through the mid-1990s; since the mid-1990s, the LME has consistently warmed (Sherman and Hempel 2009). The net change in the LME's water temperature since 1957 equates to an average increase of more than 0.22 degrees Celsius (˚C) over 50 years (Sherman and Hempel 2009).

Characterization of Marine Water Quality

Baseline conditions of marine water quality were established using information from four EBS campaigns that collected marine water samples along the offshore pipeline route. A 2021 EBS campaign collected water samples at ten locations along the offshore pipeline route, from near the proposed shore landing to a distance of approximately 35 kilometers from shore (see EBS 2021 in Appendix F). Prior EBS campaigns in 2017 (ESL 2018), 2018 (Maxon et al. 2019; Fugro 2019a), 2019 (Fugro 2019b), and 2020 (CSA Ocean Sciences 2020) collected water samples in deeper waters in the vicinity of the offshore pipeline route. Descriptions of the sampling program for each EBS campaign and summaries of the results are provided below.

<u>2021 Environmental Baseline Survey Campaign</u>

Station locations where water samples were collected are shown on Figure 7.4-5. The stations spanned a distance from approximately 4 kilometers from shore (Station 15) to approximately 35 kilometers offshore (Station 1) - where the water depth was approximately 20 meters. The evaluation of water conditions included profiling of CTD, pH, temperature, DO, turbidity, and oxidation-reduction potential (ORP), and collection of water samples for laboratory analysis. The CTD profiles were generally consistent across stations. At each station, the pH and ORP generally did not change with depth. The temperature and DO decreased slightly with depth, while a large increase in turbidity was observed with depth; the latter finding could be attributed to the contribution of sediments from the seabed, which is mostly comprised of fine silty material that is easily disturbed by currents.

Figure 7.4-5: Water Sampling Locations for the 2021 Environmental Baseline Survey Campaign

Water samples were analyzed for petroleum hydrocarbons, TOC, pH, and dissolved metals. The petroleum hydrocarbons analyzed included BTEX and aliphatic and aromatic hydrocarbon block ranges. The hydrocarbon block ranges covered C5 to C35 hydrocarbons. Petroleum hydrocarbons were BDL levels in all water samples.

For TOC and dissolved metals, no discernible difference was observed with distance from shore. This observation, combined with the previous observation of water chemistry being essentially consistent with depth based in terms of pH and ORP profiles, suggests that average values of these samples can be considered representative of water quality along the sampled portion of the offshore pipeline corridor. However, for TSS, the average values near the surface and at the sea bottom were calculated separately. The results for TSS, TOC, and dissolved metals are summarized in Table 7.4-1. Only two water samples had concentrations of cadmium above detection limits: Station 3 and Station 12, with concentrations of 0.22 and 0.25 micrograms per liter (µg/L), respectively. The maximum of these two cadmium concentrations is shown in Table 7.4-1. The average TOC concentration was 1.8 mg/L. Where available, the USEPA water quality criteria (WQC) for the protection of saltwater organisms from long-term effects are provided in the table as reference values (USEPA 2009). With the exception of copper, the maximum concentrations for all metals are below the chronic WQCs, where available. The copper concentrations in four water samples (S1, S5, S14, and S15) were above the chronic WQC.

Table 7.4-1: Results of Chemical Characterization of Water Samples from 2021 Environmental Baseline Survey Campaign

Parameter	Units	Average	Minimum	Maximum	USEPA Chronic WQC
pH	pH units	7.3	6.7	7.8	6.5-8.5
Total organic carbon	mg/L	1.8	0.4	6.3	-
TSSs (surface)	mg/L	71	46	160	-
TSS (bottom)	mg/L	178	48	510	-
Aluminum (dissolved)	mg/L	0.138	0.020	0.880	-
Arsenic (dissolved)	µg/L	5.109	2.700	8.400	36
Barium (dissolved)	µg/L	16.9	10.0	99.0	-
Cadmium (dissolved)	µg/L	BDL	BDL	0.25	7.9
Chromium (dissolved)	µg/L	0.9	0.4	1.5	74
Copper (dissolved)	µg/L	2.3	BDL	6.5	3.1
Iron (dissolved)	µg/L	141	15.0	880	-
Lead (dissolved)	µg/L	3.6	1.6	5.5	8.1
Mercury (dissolved)	µg/l	BDL	BDL	BDL	0.94
Nickel (dissolved)	µg/L	5.4	4.5	7.0	8.2
Selenium (dissolved)	µg/L	7.9	< 4.0	19.0	71

Prior Environmental Baseline Survey Campaigns

The combined water quality sampling stations for the five prior EBS campaigns conducted in the vicinity the offshore pipeline corridor are shown on Figure 7.4-6. At each sampling location, three water samples representing surface, mid-depth, and bottom were collected for chemical analysis. The water column was profiled at each station with a CTD meter. In all five surveys, chemical analysis included TOC and TSS measurement. Additionally, the 2018 Payara (Fugro 2019a) and 2020 Hammerhead surveys included metals and hydrocarbons (CSA Ocean Sciences 2020).

In the 2017 EBS campaign, depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at the deepwater stations (1,705- to 2,006-meter water depths) and well-mixed conditions at the continental shelf stations (14 to 26 meters water depths) and continental slope stations (134 to 215 meters water depths) (ESL 2018). DO ranged from 6.21 mg/L to 6.86 mg/L at continental shelf stations, 6.23 mg/L to 8.05 mg/L at continental slope stations, and 6.28 mg/L to 10.56 mg/L at deepwater stations. TOC concentrations were similar across stations, but tended to decrease with increasing depth, ranging between 1.3 and 2.1 mg/L at the surface and between 1.1 and 1.9 mg/L at the bottom depths. TSS concentrations also generally decreased with increasing depth, ranging between 2.8 and 28 mg/L near the surface and between 3.3 and 10.6 mg/L at the bottom depths. Total cyanide and all analyzed metals were reported to be not detected in all samples. Saturated hydrocarbons were detected at all of the continental slope and continental shelf locations, but not at the deepwater stations. Reported detections ranged from 210 to 580 µg/L. Ammonia was detected only at continental shelf locations, with reported detections ranging from 0.01 mg/L to 0.02 mg/L (ESL 2018).

The 2018 Payara Development EBS (Fugro 2019a) included sampling at eight locations within the Payara PDA. Depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at these stations that were consistent with data collected at deeper stations. The temperatures observed were around 29.3 ºC near surface and around 3.7 ºC near the seabed. Salinity ranged from 34.6 parts per thousand (ppt) to 36.9 ppt, with a mean of 35 ppt. DO was reported as a percentage of saturation and ranged from 33.2 percent to 105 percent, with a mean of 49.1 percent. The pH showed alkaline conditions throughout the survey area, with a range of 7.60 to 8.43, and a mean of 7.77. TSS did not exhibit any significant variation with depth with concentrations ranging between 22 and 59 mg/L at all sampled depths. All TOC concentrations were below the minimum reporting value of 0.5 mg/L, lower than for previously sampled stations. Reported total hydrocarbon (THC) concentrations were below the minimum reporting value of 10 µg/L at all stations except for one (bottom), which had a reported concentration of 21 µg/L. Arsenic concentrations ranged from 1.42 µg/L to 2.19 µg/L, with a mean concentration of 1.7 µg/L (comparable to previous surveys). All other metals were also found to be generally within the same range as previously sampled.

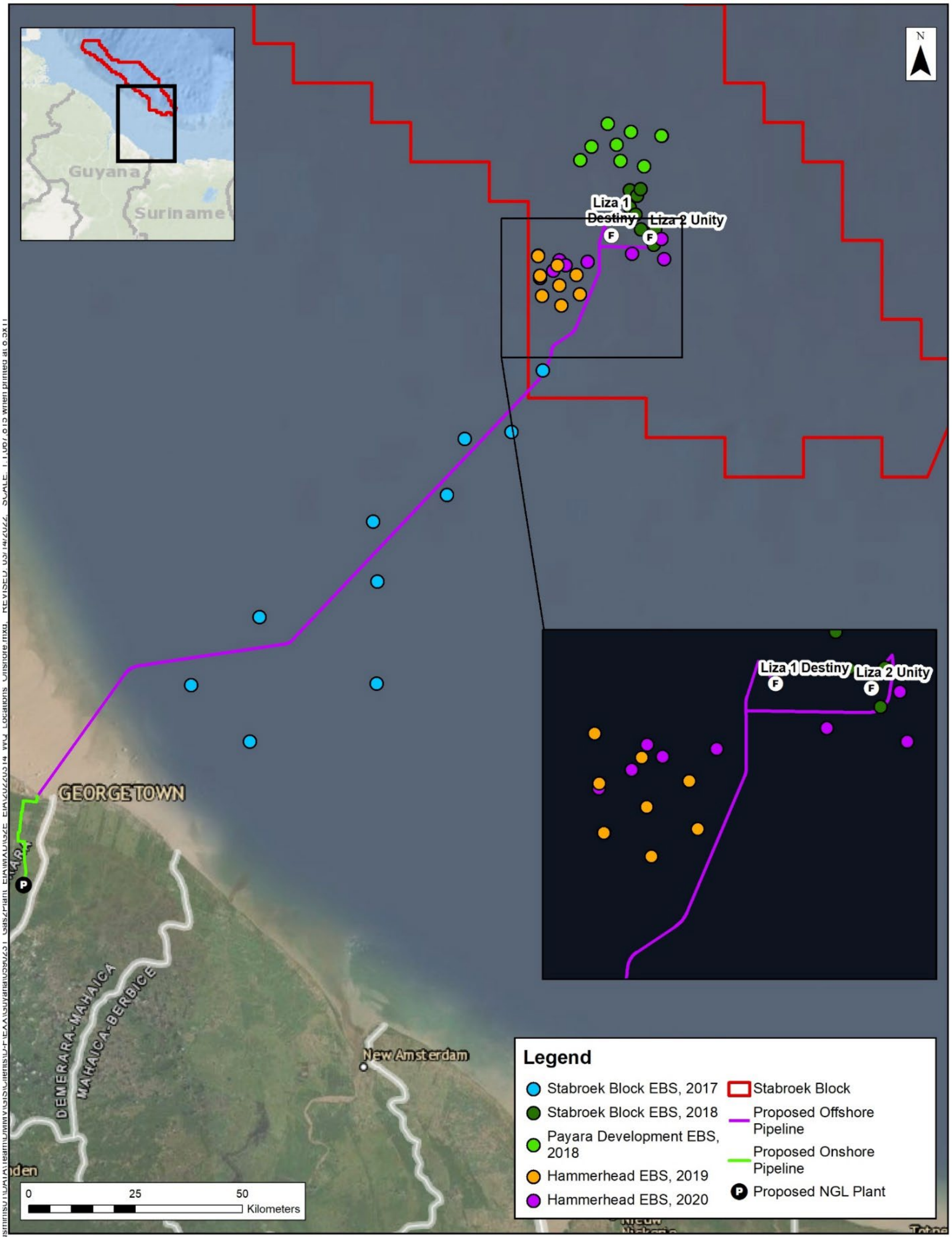


Figure 7.4-6: Combined Water Quality Sampling Locations for 2017, 2018, 2019, and 2020 Environmental Baseline Survey Campaigns

In the 2018 Stabroek Block EBS (Maxon et al. 2019), eight stations were sampled within the Liza Phase 2 Development area. Water column profiling depicted a steep halocline, reaching a maximum salinity of 37 ppt at approximately a 100-meter depth at all stations. A warm water layer (approximately 30 ºC) was detected on top of a prominent thermocline at 40- to 50-meter depth, below which temperature was observed to drop monotonically from 28 to 3 ºC around a depth of 1,600 meters. The resulting density profiles indicated a highly stratified water column, which likely limits nutrient flux into surface waters from below the mixed layer. The permanent (nonseasonal) pycnocline extended down to approximately 200 meters, below which density increased slowly with depth. The water column was relatively clear, with turbidity less than 1 nephelometric turbidity unit (NTU) throughout the water column. DO was consistently high, ranging from roughly 6 mg/L near the surface to greater than 7.5 mg/L below 1,000 meters. TOC concentrations in all samples were less than or equal to 1.2 mg/L and consistent with previous survey results in the area. Values for pH were within the normal, narrow range for seawater with no differences between sampling depths. All 11 metals, including barium, were detected in eight or more samples, well within the natural range for ocean water. Concentrations for the majority (7 of 11) of metals did not vary significantly between depth strata. There were no detectable concentrations of either resolved or unresolved total petroleum hydrocarbon (TPH) (less than 13.3 µg/l).

In the 2019 EBS campaign, the water profiles obtained at all stations were typical of the oceanic water column within the region (Fugro 2019b). There was an upper layer of wave-mixed water, extending to approximately the 20-meter depth, in which all parameters remained relatively constant. Below this depth, there was a distinct thermocline, extending to approximately the 200-meter depth, over which temperature and DO concentration decreased rapidly. Temperatures ranged from 27.9 °C at the sea surface to 5 °C near the seabed. DO saturation ranged from 108 percent near the surface, decreasing to approximately 40 percent by the 300-meter depth at all stations. Mean salinity in near-surface waters was 34.4 practical salinity units (psu), increasing to 36.9 psu and then decreasing to 35 psu below 200 meters to the seabed. Measured pH values were alkaline throughout the survey area and ranged from 7.75 to 8.28, with a mean of 7.33. Turbidity was consistently low throughout the water column, with a mean value of 1.7 formazin turbidity units (FTU). TOC and TSS showed little evidence of stratification with sample depth. TOC concentrations ranged from 0.93 mg/L to 2.16 mg/L. TSS concentrations ranged from 25.6 mg/L to 108 mg/L.

In the 2020 EBS campaign, salinity ranged from 34.54 to 37.2 psu, with similar trends at each station (CSA Ocean Sciences 2020). Temperature ranged from 4.07 °C to 28.19 °C and exhibited a similar trend at each station. Temperature changed very little in the upper 60 to 70 meters of the water column. DO concentration ranged from 3.90 to 8.47 mg/L (mean of 5.17 mg/L). Turbidity within the water column remained reasonably constant throughout the entire length of all water profiles, with mean values equal to or less than 0.25 NTU. pH was generally stable throughout the water column, ranging from 8.07 to 9.62, with a mean of 8.4. TOC concentrations were very low at all EBS stations, with a range from 0.3 mg/L to less than or equal to 0.2 mg/L. TSS concentrations were low in the survey area, with most samples below the laboratory reporting limit of 5 mg/L. TPH concentrations at all sampling stations and depths were below the laboratory reporting limit of 13 µg/L. Total PAH concentrations (for 64 compounds) were extremely low in all samples, ranging from non-detect to 24.1 nanograms per liter (ng/L). Total metal concentrations within the water column were low with the exception of strontium and molybdenum. Strontium, one of the most abundant minerals in seawater, was at expected levels of around 8,000 µg/L. Concentrations of molybdenum ranged from 10.3 to 35 µg/L, which is above the expected range in open ocean systems of 9.3 to 10.4 µg/ L (Smedley and Kinniburgh 2017). Total aluminum and beryllium concentrations were below the laboratory reporting limits of 21 µg/L and 0.02 µg/L, respectively.

7.4.2.2. Riverine Water

Hydrodynamic Conditions

Guyana has four principal rivers: the Courantyne River (bordering Suriname), the Berbice River, the Demerara River, and the Essequibo River. While the Essequibo River forms the country's largest river system, and its drainage basin encompasses most of the country, the Demerara River basin represents 6,500 km^2 of Guyana's drainage basin (U.S. Army Corps of Engineers 1998). The Demerara River is a perennial freshwater source in eastern Guyana beginning in the rainforests in the central part of the country, and flowing north for a length of approximately 346 kilometers until draining into the Atlantic Ocean. MERIT Hydro, a global hydrography dataset, indicates that during the period of 1979 to 2019, the minimum flow recorded in the Demerara River was 0.03 m^3/s and the maximum flow recorded was 2,139 m^3/s, with an average flow of 203 m^3/s (Yamazaki 2019).

The Demerara River meets the Atlantic Ocean near Georgetown. The spring tide range at Georgetown is reported at 2.49 meters, and the neap range is reported at 1.68 meters (JICA 2017).

A network of canals has been developed around Georgetown to irrigate and drain the agricultural plantations in the area. Sluice gates and pumps are present to drain these canals to avoid inland flooding. Since Georgetown lies slightly (less than 1 meter bmsl), gravity drainage facilitates draining these canals during low tides (when sluice gates are opened). During high tides, sluice gates are closed, and pumps are used to drain water and avoid any back-flow from the ocean/river (JICA 2017). No recent data were identified by the Consultants regarding the state of the capacity or connectivity of the existing canals.

Water Quality Conditions

Little information on the water quality of the Demerara River and the canals is available in the published literature. The Great Falls monitoring station (U.S. Army Corps of Engineers 1998) indicates that the water is generally soft, with low levels of TDS and TSS. A study on fish diversity in Kumani Creek, which flows into the Demerara River upstream of the proposed NGL Plant, measured DO, temperature, and pH at six locations (Gonsalves et al. 2016). DO was observed to be relatively high at these locations, ranging from 7 to 9 mg/L. The temperature of the water ranged from 27 to 32 °C. The pH in the water samples was acidic, at 4 to 5 pH units.

Acidic pH levels in the waters of Guyana is not uncommon and has been attributed to acid mine drainage (Williams et al. 2020).

The baseline water quality conditions in the Demerara River and the canals in the vicinity of the onshore portion of the Direct AOI are based on the characterization of water samples collected by the Consultants during a 2021 field survey (see Appendix G, Demerara River Baseline Field Study). The various sampling locations during this survey were categorized based on their locations: coastal, river, or canal. Sampling station locations are summarized in Table 7.4-2 and shown on Figure 7.4-7. The Demerara River stations were selected to represent a range of locations relative to the NGL Plant such that R3 is upstream of the NGL Plant, R2 is slightly downstream of the NGL Plant, and R1 is at the mouth of the river. Data loggers were used to conduct continuous monitoring (i.e., readings every 15 minutes for 2 weeks) for CTD at the C1, R3, and R4 stations, as indicated in Table 7.4-2 (see Appendix G, Demerara River Baseline Field Study). Station R4 was solely used as a hydrographic monitoring point, and a discrete sample was not collected for analysis of water quality characteristics.

Table 7.4-2: Coastal, River, and Canal Water Sampling Locations and Programs

Station		Latitude	Longitude	Continuous	Discrete Water
Coastal Station	C1	6°52'53.65"N	58° 8'30.63"W	X	X
Demerara River Stations	R1	6°48'12.85"N	58°10'30.72"W		X
	R2	6°38'18.55"N	58°12'23.78"W		X
	R3	6°34'52.47"N	58°13'28.00"W	X	X
Essequibo River Station	R4	6°52'31.45"N	58°25'30.02"W	X	
Canal Station	S1	6°49'33.81"N	58°12'23.39"W		X
	S2	6°48'42.36"N	58°12'27.53"W		X
	S3	6°48'32.10"N	58°14'9.86"W		X
	S4	6°46'42.99"N	58°14'25.87"W		X
	S5	6°45'53.53"N	58°14'30.36"W		X
	S6	6°44'52.27"N	58°14'39.23"W		X
	S7	6°43'47.77"N	58°14'49.96"W		X
	S8	6°43'44.99"N	58°14'32.66"W		X
	S9	6°42'13.11"N	58°13'20.78"W		X
	S10	6°40'13.44"N	58°13'18.57"W		X
	S11[a]	6°38'31.32"N	58°13'32.85"W		X
	S13	6°38'1.51"N	58°12'52.60"W		X
	S14	6°38'20.08"N	58°12'39.97"W		X

[a] S11 was not accessible during the dry season and was only sampled during the wet season.

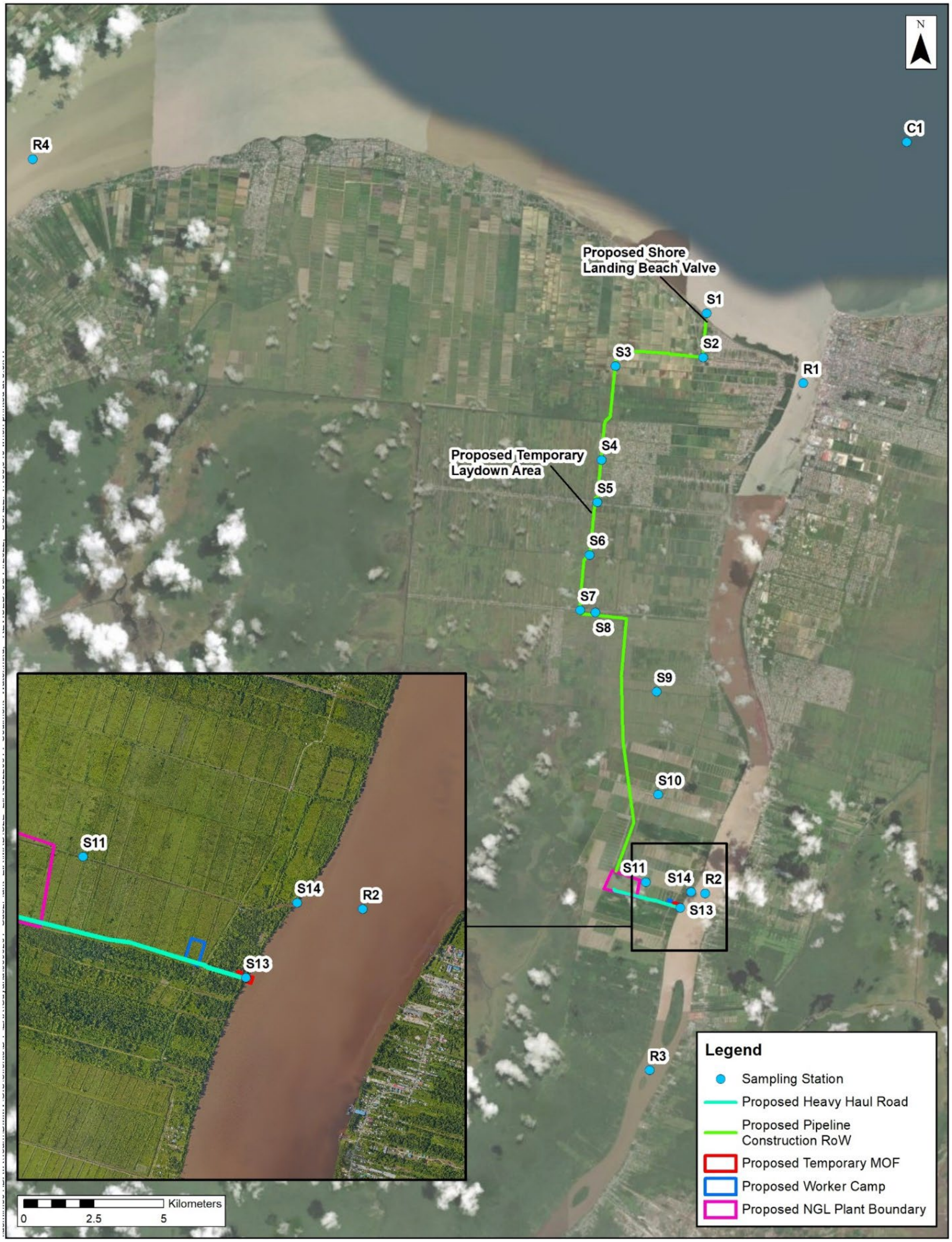


Figure 7.4-7: Locations of Coastal, River, and Canal Water Sampling Stations

The results of water quality characterization for conventional parameters for the discrete water samples collected during the dry and wet seasons sampling events are provided in Table 7.4-3 and Table 7.4-4, respectively. During each of the dry and wet seasons, the initial sampling plan was to collect two discrete samples at each station. However, weather conditions or accessibility issues prevented collection of the second sample from some stations (predominantly in the dry season). In Table 7.4-3 and Table 7.4-4, the station identification (ID) is followed by an "A" or a "B," indicating that these results are from different discrete samples collected during the season. For both dry and wet seasons, the DO concentrations ranged 4.91 to 11.7 mg/L across all stations and were above the lowest WQC for ambient 7-day mean minimum DO concentration of 4.0 mg/L for warm water (USEPA 1986).

The pH values in the river and canal samples ranged from 3.09 to 7.08. Samples collected at R1 and S2 had pH values within the USEPA recommended range of 6.5 to 9.0 for freshwater aquatic life (USEPA 1986). Samples at the other stations had pH levels lower than 6.5, i.e., outside the USEPA recommended pH values. The pH of the coastal water sample collected at C1 was consistent during the dry and wet season at 7.6 to 7.7, within the recommended range for marine aquatic life (USEPA 1986). The nutrient levels were within the USEPA recommended levels for rivers and streams for various ecoregions (USEPA 2021b).

The oil and grease concentrations were higher during the wet season, with average values of 4.0 mg/L and 2.4 mg/L in the wet and dry seasons, respectively. The higher oil and grease concentrations during the wet season are possibly due to runoff from roads containing oils during rain events. The salinity measurements at the upstream river sampling stations (R2 and R3) and at the canal sampling locations confirmed that the waters were characterized as freshwater (i.e., salinity BDL). The salinity at R1, near the mouth of the river, was variable, suggesting a tidal influence. During the wet season, the salinity at R1 was BDL levels most likely as a result of the higher river flows flushing out or preventing coastal waters from entering the river. During the dry season, the salinity at R1 was as high as 5 ppt, suggesting a tidal influence from the coastal waters.

During the dry season, continuous monitoring of CTD over a 2-week period at the coastal station C1 provided information on the variability of these parameters at this location. The water depth ranged from 11.4 to 14.3 meters with an average depth of 12.8 meters. The temperature ranged from 27.4 to 31 °C with an average temperature of 28.6 °C. The largest variation was observed in conductivity, which ranged from 10,200 to 55,035 microsiemens per centimeter (μS/cm); this is likely reflective of the influence of changing tidal conditions and freshwater influences from the Demerara and Essequibo Rivers.

Table 7.4-3: Water Quality Results for Conventional Parameters in Coastal, River, and Canal Water Samples Collected during Dry Season Sampling

Station [a]	DO (mg/L)	Oil and Grease (mg/L)	Salinity (ppt)	pH	TKN (mg/L)	Nitrate/Nitrite (as N mg/L)	Total P (mg/L)	TS (mg/L)	TDS (mg/L)	TSS (mg/L)
R1-A	7.4	BDL	5	-	-	-	BDL	1,030	982	21.4
R1-B	11.7	BDL	BDL	7.08	0.22	0.534	0.055	11,200	10,500	435
R2-A	6.9	1.22	BDL	-	-	-	BDL	1150	1,040	14.8
R2-B	10.4	BDL	BDL	5.68	0.50	0.668	0.183	532	162	319
R3-A	5.6	1.61	BDL	-	-	-	0.021	366	354	16.8
R3-B	11	BDL	BDL	4.87	0.39	0.678	0.103	130	62	44
S1	-	1.22	-	-	0.37	BDL	BDL	13,500	9,080	4,250
S2	-	2.47	-	-	1.1	0.632	0.084	726	512	235
S3	-	BDL	-	-	0.44	0.576	BDL	42	28	8.8
S4	-	6.15	-	-	0.32	0.218	BDL	118	108	BDL
S5	-	BDL	-	-	0.17	0.548	BDL	140	100	BDL
S6	-	4.53	-	-	0.38	0.211	BDL	114	78	11.2
S7	-	1.63	-	-	0.81	0.203	BDL	322	264	BDL
S8	-	1.21	-	-	0.43	0.217	BDL	186	106	2.8
S9	-	2.86	-	-	1.1	0.38	BDL	56	32	22.7
S10	-	0.816	-	-	0.54	0.602	BDL	124	66	44
S11	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S13-A	7.2	BDL	BDL	-	-	-	BDL	622	560	14
S13-B	9.8	2.45	BDL	5.42	0.42	0.688	0.135	420	114	286
S14-A	7.1	BDL	BDL	-	-	-	BDL	1300	1,140	28
S14-B	9.9	BDL	BDL	5.44	1.2	0.668	0.253	290	104	298
C1	10.5	BDL	28.2	7.7	0.44	0.492	0.065	22200	20,800	22.3

"-" = parameter not measured; N = nitrogen; NS = no sample: P = phosphorus

[a] The 'A' and 'B' after the station ID indicate different discrete samples collected at a station during the same seasonal sampling event.

Table 7.4-4: Water Quality Results for Conventional Parameters in Coastal, River, and Canal Water Samples Collected during Wet Season Sampling

Station [a]	DO (mg/L)	Oil and Grease (mg/L)	Salinity (ppt)	pH	TKN (mg/L)	Nitrate/ Nitrite (as N mg/L)	Total P (mg/L)	TS (mg/L)	TDS (mg/L)	TSS (mg/L)
R1-A	10.1	1.22	BDL	6.49	0.29	BDL	0.227	914	888	390
R1-B	10.2	2.10	BDL	6.25	0.35	0.331	0.034	1670	1230	718
R2-A	10.4	BDL	BDL	4.94	0.29	BDL	0.036	76	60	44
R2-B	9.58	2.02	BDL	5.21	0.18	0.273	0.102	228	74	232
R3-A	10.5	7.76	BDL	4.8	0.37	0.367	0.031	48	60	14.8
R3-B	10.7	1.27	BDL	5.08	0.28	0.262	BDL	174	64	98
S1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
S2-A	6.23	13	BDL	6.62	0.46	0.312	0.119	119	112	77
S2-B	10.6	3.28	BDL	6.66	0.32	0.189	BDL	106	104	BDL
S3-A	8.37	1.36	BDL	4.82	0.69	0.345	0.029	54	32	15
S3-B	10.5	BDL	BDL	4.95	0.53	0.191	BDL	42	14	13.6
S4-A	8.56	2.87	BDL	4.60	0.28	0.224	BDL	6	34	9.8
S4-B	10.8	BDL	BDL	4.45	0.55	0.187	BDL	28	14	9.4
S5-A	9.92	2.44	BDL	3.66	0.2	0.244	BDL	90	40	4.3
S5-B	10.5	4.12	BDL	3.56	0.23	0.184	BDL	104	70	2.4
S6-A	9.0	2.51	BDL	4.23	0.29	0.256	BDL	44	26	14.5
S6-B	10.7	1.66	BDL	4.16	0.59	0.188	BDL	56	36	18
S7-A	8.87	5.96	BDL	3.12	0.21	0.20	0.171	82	126	4
S7-B	10.2	2.1	BDL	3.09	0.87	0.36	0.266	114	116	47.5
S8-A	4.91	3.93	BDL	5.79	1.9	0.178	0.096	124	112	74
S8-B	10.3	5.86	BDL	6.38	2.8	0.194	BDL	182	104	22
S9-A	7.19	7.6	BDL	5.54	0.16	0.167	0.096	6	70	10
S9-B	10.8	3.67	BDL	3.92	0.78	0.186	BDL	46	28	12.5
S10-A	8.64	4.58	BDL	4.61	0.22	0.198	BDL	14	48	16
S10-B	8.81	6.64	BDL	4.57	0.22	0.206	BDL	60	48	38
S11-A	6.72	3.70	BDL	5.93	0.22	0.284	0.167	208	88	138
S11-B	11.1	2.02	BDL	5.88	0.97	0.376	0.171	112	58	47
S13-A	7.93	8.09	BDL	4.79	0.19	0.246	0.033	88	58	23
S13-B	9.25	1.61	BDL	5.44	0.16	0.27	0.159	212	48	201
S14-A	8.16	BDL	BDL	5.0	0.23	0.264	BDL	50	86	28
S14-B	8.40	2.02	BDL	6.17	0.14	0.234	0.208	214	10	184
C1-A	10.2	8.98	BDL	6.65	0.40	0.327	0.143	1,130	826	474
C1-B	9.71	2.09	23	7.64	0.38	0.336	0.044	18,000	16,900	83.6

"-" = parameter not measured; N = nitrogen; NS = no sample; P = phosphorus

[a] The 'A' and 'B' after the station ID indicate different discrete samples collected at a station during the same seasonal sampling event.

During the wet season, continuous monitoring of CTD at C1, R3, and R4 was conducted for a 2.5-week period in January 2022. At C1, the CTD results were more variable during the wet weather deployment period than observed during the dry weather deployment period. At C1, the water depth ranged from 10.3 to 16.8 meters with an average depth of 13.9 meters. The temperature ranged from 26 to 28.6 °C with an average temperature of 27.2 °C. A large variation was observed in conductivity ranging from 32 to 56,220 µS/cm with an average of 18,059 µS/cm. At R3, the water depth was variable ranging from 12.7 to 19.2 meters with an average depth of 15.9 meters. The conductivity was also variable ranging from 18.3 to 28.5 µS/cm with an average value of 22 µS/cm. The variability in depth and conductivity is reflective of the tidal influences. At R3, the temperature was relatively consistent, ranging from 26.7 to 28.7 °C. At R4, the water depth was variable, ranging from 12.2 to 19.1 meters with an average depth of 15 meters. The conductivity was also variable ranging from 11.4 to 16.3 µS/cm with an average value of 13 µS/cm. The variability in depth and conductivity is reflective of the tidal influences. At R4, the temperature was consistent, ranging from 27.2 to 28.2 °C.

Polycyclic Aromatic Hydrocarbons

The polycyclic aromatic hydrocarbon (PAH) results for samples collected during the dry and wet seasons are summarized in Table 7.4-5 and Table 7.4-6, respectively. During the dry season, PAHs were above detection levels in four stations (R2, S1, S5, and S9), with total PAH concentrations ranging from 0.03 µg/L to 0.092 µg/L. The individual PAHs that were detected included naphthalene, 1-methylnaphthalene, and 2-methylnaphthelene. During the wet season, PAHs were more prevalent, with naphthalene detected at every station in at least one sample. Several individual PAHs (1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, naphthalene, phenanthrene, fluoranthene, fluorene, pyrene, indeno(1,2,3-cd)pyrene) were measured at R2 and canal stations S2, S3, S8, S10, and S13. The concentrations of PAHs at these stations were higher during the second round of sampling during the wet season (i.e., samples identified with a "B" after the station ID in Table 7.4-6), suggesting that the prevalence of PAHs is variable and may be dependent on rainfall conditions. The sum of the measured PAHs in the different samples ranged from 0.01 µg/L to 0.572 µg/L. For both dry and wet seasons, individual PAH concentrations were below the respective USEPA final chronic values for the protection of aquatic life (USEPA 2003).

PAHs are ubiquitous substances found in air, plants, waters, sediments, and soils globally. Possible PAH sources include naturally occurring combustion processes such as forest fires and volcanoes, and anthropogenic activities such as asphalt production, agricultural operations, and motor vehicle exhaust (Patel et al. 2020). The PAHs present in the Demerara River and canals are most likely from atmospheric deposition, urban runoff, and storm water.

Table 7.4-5: Water Quality Results for Polycyclic Aromatic Hydrocarbons in Coastal, River, and Canal Water Samples Collected during Dry Season Sampling (µg/L)

Station[a]	1MNap	2MNap	Ace	Acy	Ant	BaA	BaP	BbF	BghiP	BkF	Chr	DahA	Flu	Flo	Ind	Nap	Phe	Pyr	TPAH
R1-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
R1-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
R2-A	BDL	0.026	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.057	BDL	BDL	0.083
R2-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
R3-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
R3-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S1	0.011	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.061	BDL	BDL	0.092
S2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S4	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.064	BDL	BDL	0.064
S6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S7	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03	BDL	BDL	0.03
S10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S13-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S13-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S14-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
S14-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
C1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0
USEPA FCV[b]	75.37	72.16	55.85	306.9	20.73	2.227	0.9573	0.6774	0.4391	0.6415	2.042	0.2825	7.109	39.3	0.275	193.5	19.13	10.11	-

1MNap = 1-methylnaphthalene; 2MNap = 2-methylnaphthalene; Ace = acenaphthene; Acy = acenaphthylene; Ant = anthracene; BaA = benzo(a)anthracene; BaP = benzo(a)pyrene; BbF = benzo(b)fluoranthrene; BghiP = benzo(ghi)perylene; BKF = benzo(k)fluoranthene; Chr = chrysene; DahA = dibenz(ah)anthracene; Flu = fluoranthrene; Flo = fluorene; Ind = indeno(123,cd)pyrene; Nap = naphthalene; Phe = phenanthrene; Pyr = pyrene; TPAH = total polycyclic aromatic hydrocarbons

[a] The ‘A’ and ‘B’ after the station ID indicate different discrete samples collected at the same station during the season
[b] USEPA Final Chronic Value (USEPA 2003)
[C] Total PAH assumes a value of zero for BDL measurements.

Table 7.4-6: Water Quality Results for Polycyclic Aromatic Hydrocarbons in Coastal, River, and Canal Water Samples Collected during Wet Season Sampling (µg/L)

Station[a]	1MNap	2MNap	Ace	Acy	Ant	BaA	BaP	BbF	BghiP	BkF	Chr	DahA	Flu	Flo	Ind	Nap	Phe	Pyr	TPAH
R1-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.048	BDL	BDL	0.048
R1-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
R2-A	0.02	0.011	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.047	BDL	BDL	0.078
R2-B	0.02	0.032	0.012	BDL	0.012	BDL	0.011	0.013	0.013	BDL	BDL	BDL	0.013	0.012	0.013	0.068	0.012	BDL	0.231
R3-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
R3-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.045	BDL	BDL	0.045
S1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-
S2-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S2-B	0.036	0.034	0.019	0.012	0.02	0.018	0.046	0.057	0.045	0.043	0.022	0.031	0.025	0.015	0.045	0.049	0.03	0.025	0.572
S3-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S3-B	0.012	0.013	BDL	BDL	0.01	BDL	BDL	BDL	0.011	BDL	BDL	BDL	0.011	BDL	0.011	0.017	0.015	BDL	0.100
S4-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S4-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.014	BDL	BDL	0.014
S5-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.013	BDL	BDL	0.013
S5-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.014	BDL	BDL	0.014
S6-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	BDL	BDL	0.010
S6-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.012	BDL	BDL	0.012
S7-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.041	0.01	BDL	0.051
S7-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S8-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.035	BDL	BDL	0.035
S8-B	BDL	0.011	BDL	BDL	BDL	BDL	0.012	0.011	0.015	0.016	BDL	BDL	BDL	BDL	0.011	0.02	BDL	BDL	0.096
S9-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S9-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	BDL	BDL	0.010
S10-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.025	BDL	BDL	0.025
S10-B	0.028	0.043	0.015	0.01	0.018	0.011	0.016	0.022	0.019	0.012	0.015	0.015	0.018	0.015	0.019	0.097	0.016	0.012	0.401
S11-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.074	BDL	BDL	0.074
S11-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.013	BDL	BDL	0.013
S13-A	0.016	0.019	0.016	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.011	BDL	0.13	0.014	BDL	0.206

Station[a]	1MNap	2MNap	Ace	Acy	Ant	BaA	BaP	BbF	BghiP	BkF	Chr	DahA	Flu	Flo	Ind	Nap	Phe	Pyr	TPAH
S13-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	BDL	BDL	0.01
S14-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
S14-B	0.014	0.014	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.034	BDL	BDL	0.062
C1-A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.028	BDL	BDL	0.028
C1-B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
USEPA FCV[b]	75.37	72.16	55.85	306.9	20.73	2.227	0.9573	0.6774	0.4391	0.6415	2.042	0.2825	7.109	39.3	0.275	193.5	19.13	10.11	-

1MNap = 1-methylnaphthalene; 2MNap = 2-methylnaphthalene; Ace = acenaphthene; Acy = acenaphthylene; Ant = anthracene; BaA = benzo(a)anthracene; BaP = benzo(a)pyrene; BbF = benzo(b)fluoranthrene; BghiP = benzo(ghi)perylene; BkF = benzo(k)fluoranthrene; Chr = chrysene; DahA = dibenz(ah)anthracene; Flu = fluoranthrene; Flo = fluorene; Ind = indeno(123,cd)pyrene; Nap = naphthalene; NS = no sample; Phe = phenanthrene; Pyr = pyrene; TPAH = total polycyclic aromatic hydrocarbons

[a] The ‘A’ and ‘B’ after the station ID indicate different discrete samples collected at the same station during the season

[b] USEPA Final Chronic Value (USEPA 2003)

[C] Total PAH assumes a value of zero for BDL measurements.

Total Metals

Water samples were analyzed for up to 18 metals during the dry and wet seasons (Table 7.4-7 and Table 7.4-8). Six metals were either not detected in any samples (cadmium, molybdenum, and silver) or were only detected in one or two samples at concentrations below 0.5 µg/L (thallium, mercury, and antimony). Iron and manganese—which occur naturally in rocks and soils—were present in every sample. The remaining ten metals (arsenic, beryllium, cobalt, copper, chromium, lead, nickel, selenium, vanadium, and zinc) are anthropogenic indicator metals and were distributed throughout the riverine stations. Historically, the land use around the riverine stations has been under agricultural production (e.g., sugarcane plantations), so the presence of arsenic, chromium, cobalt, lead, and nickel could be related to the past use of herbicides and pesticides during agricultural practices (Defarge et al. 2018). Additionally, gold mining has been occurring in Guyana since the late 1800s (Veiga 1998), and these metals—especially vanadium and beryllium, which are present in the Earth's crust—could be traced back to mining activities.

The USEPA has established WQC for the protection of aquatic life in freshwater systems from chronic effects. Chronic WQC are available for mercury, arsenic, copper, chromium (III), iron, lead, nickel, zinc, and selenium (USEPA 2009, 2021a), and these are shown in Table 7.4-7. An approach is available for establishing a freshwater copper WQC, but it considers site-specific water quality characteristics. In lieu of an applicable freshwater copper WQC, the saltwater WQC is used. Since iron is naturally occurring and the guidance value is not derived from a toxicological basis, iron is excluded from this discussion. There were 22 occurrences where the measured metal concentrations were higher than the WQC. Stations that exhibited metal concentrations higher than WQCs were R1, R2, S1, S2, S9, S13, S14, and C1. Copper (9 samples) and lead (10 samples) had the highest number of samples with concentrations above WQCs. Station S1 had the highest number of metals above the WQCs for a single sample (5 metals in the dry season).

Table 7.4-7: Metal Concentrations in Coastal, River, and Canal Water Samples Collected during Dry Season Sampling Events—October, November, and December 2021 (µg/L)

Station [a]	Hg	Sb	As	Be	Cd	Co	Cr	Cu	Fe	Pb	Mo	Mn	Ni	Se	Ag	Tl	V	Zn
R1-A	BDL	BDL	1.38	BDL	BDL	-	1.69	BDL	1130	BDL	-	83.8	1.28	BDL	BDL	BDL	-	4.29
R1-B	BDL	BDL	1.64	BDL	BDL	-	3.3	4.39	1500	0.831	-	89.3	1.52	1.91	BDL	BDL	-	19.7
R2-A	BDL	BDL	1.05	BDL	BDL	-	1.75	1.24	1330	0.726	-	60.3	1.15	BDL	BDL	BDL	-	4.52
R2-B	BDL	BDL	4.88	0.468	BDL	-	9.4	3.62	11400	7.3	-	292	6.94	BDL	BDL	BDL	-	42.7
R3-A	BDL	0.489	0.955	BDL	BDL	-	1.21	1.17	1180	0.715	-	45.8	1.16	BDL	BDL	BDL	-	8.69
R3-B	BDL	BDL	1.3	BDL	BDL	-	1.55	BDL	2040	1.37	-	72.5	1.41	BDL	BDL	BDL	-	7.5
S1	0.038	BDL	33.6	7.14	BDL	68.3	80.5	41.4	-	117	BDL	-	71.7	6.98	BDL	BDL	179	381
S2	BDL	BDL	5.66	0.597	BDL	3.48	5.04	7.02	-	8.59	BDL	-	5.64	BDL	BDL	0.2	12.3	29.8
S3	BDL	BDL	BDL	BDL	BDL	BDL	0.566	BDL	-	BDL	BDL	-	BDL	BDL	BDL	BDL	BDL	4.16
S4	BDL	BDL	BDL	0.761	BDL	3.31	0.452	-	-	BDL	-	-	7.48	BDL	BDL	BDL	0.601	23.9
S5	BDL	BDL	0.684	0.513	BDL	2.7	0.759	BDL	-	0.788	BDL	-	6.33	BDL	BDL	BDL	2.34	31.5
S6	BDL	BDL	0.59	0.223	BDL	1.15	0.674	BDL	-	1.06	BDL	-	2.71	BDL	BDL	BDL	0.926	14.9
S7	BDL	BDL	0.749	1.02	BDL	1.69	1.69	-	-	0.711	BDL	-	9.57	BDL	BDL	BDL	0.627	56.6
S8	BDL	BDL	0.497	0.207	BDL	2.2	0.742	BDL	-	BDL	BDL	-	4.98	BDL	BDL	BDL	0.691	22.5
S9	BDL	BDL	1.32	BDL	BDL	0.712	1.5	BDL	-	BDL	BDL	-	1.4	BDL	BDL	BDL	1.25	4.28
S10	BDL	BDL	1.98	BDL	BDL	0.387	2.31	1.01	-	1.49	BDL	-	0.882	BDL	BDL	BDL	4.55	10.3
S13-A	BDL	BDL	1.19	BDL	BDL	-	1.6	1.48	1430	0.818	-	60.9	1.14	BDL	BDL	BDL	-	17.5
S13-B	BDL	BDL	3.54	0.311	BDL	-	4.88	2.38	7520	5.4	-	218	3.94	BDL	BDL	BDL	-	22.2
S14-A	BDL	BDL	1.73	BDL	BDL	-	1.41	2.2	2190	0.869	-	87.2	1.3	BDL	BDL	BDL	-	7.67
S14-B	BDL	BDL	3.09	0.28	BDL	-	4.19	2.52	6890	4.76	-	191	3.73	BDL	BDL	BDL	-	49.3
C1	BDL	BDL	1.92	BDL	BDL	-	4	1.01	876	BDL	-	19.8	1.31	1.29	BDL	BDL	-	36.7
USEPA WQC [b,c]	0.77	-	150	-	0.72	-	74	3.1[d]	1000	2.5	-	-	52	3.1	-	-	-	120

"-" = criteria not available; As = arsenic; Ag = silver; Be = beryllium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Fe = iron; Hg = mercury; K = potassium; Mn = manganese; Mo = molybdenum; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Tl = thallium; V = vanadium; Zn = zinc

[a] The 'A' and 'B' after the station ID indicate different discrete samples collected at the same station during the season.

[b] USEPA 2009

[c] USEPA 2021a

[d] WQC for saltwater

Table 7.4-8: Metal Concentrations in Coastal, River, and Canal Water Samples Collected during Wet Season Sampling Event 1—January and February 2022 (µg/L)

Station [a]	Hg	Sb	As	Be	Cd	Co	Cr	Cu	Pb	Mo	Ni	Se	Ag	Tl	V	Zn
R1-A	BDL	BDL	6.7	0.775	BDL	7.33	14.2	6.39	11.8	BDL	10.6	BDL	BDL	BDL	24.8	61.4
R1-B	BDL	BDL	6.67	0.723	BDL	7	9.9	18.3	10.8	BDL	8.69	BDL	BDL	BDL	19.6	51
S4-A	BDL	BDL	0.411	BDL	BDL	0.337	0.965	BDL	BDL	BDL	1	BDL	BDL	BDL	0.622	6.67
S4-B	BDL	BDL	BDL	BDL	BDL	0.294	BDL	BDL	BDL	BDL	0.939	BDL	BDL	BDL	BDL	5.83
S5-A	BDL	BDL	0.724	0.407	BDL	2.04	0.837	BDL	BDL	BDL	4.97	BDL	BDL	BDL	BDL	27.2
S5-B	BDL	BDL	0.525	0.425	BDL	1.93	1.05	BDL	0.671	BDL	4.54	BDL	BDL	BDL	0.612	23.9
S6-A	BDL	BDL	0.501	BDL	BDL	0.285	1.05	BDL	BDL	BDL	0.881	BDL	BDL	BDL	0.72	5.83
S6-B	BDL	BDL	0.646	BDL	BDL	0.254	0.871	BDL	BDL	BDL	1.03	BDL	BDL	BDL	0.677	5.49
S7-A	BDL	BDL	0.467	0.561	BDL	2.48	0.856	BDL	BDL	BDL	5.43	BDL	BDL	BDL	1.51	36.7
S7-B	BDL	BDL	0.444	0.606	BDL	1.78	0.575	BDL	BDL	BDL	4.81	BDL	BDL	BDL	BDL	40
S8-A	BDL	BDL	1.94	BDL	BDL	1	0.993	BDL	BDL	BDL	1.72	BDL	BDL	BDL	BDL	4.72
S8-B	BDL	BDL	1.88	BDL	BDL	0.519	0.56	BDL	BDL	BDL	1.71	BDL	BDL	BDL	BDL	18.5
S9-A	BDL	BDL	0.888	BDL	BDL	0.339	0.905	BDL	BDL	BDL	0.652	BDL	BDL	BDL	BDL	4.81
S9-B	BDL	BDL	0.94	BDL	BDL	0.31	0.685	6.96	BDL	BDL	BDL	BDL	BDL	BDL	BDL	3.74
S10-A	BDL	BDL	1.1	BDL	BDL	0.245	0.892	BDL	BDL	BDL	1.8	BDL	BDL	BDL	1.34	4.63
S10-B	BDL	BDL	0.83	BDL	BDL	0.242	1.78	BDL	BDL	BDL	0.706	BDL	BDL	BDL	2.74	3.95
S11-A	BDL	BDL	2.72	BDL	BDL	1.3	1.59	1.24	1.52	BDL	2.66	BDL	BDL	BDL	3.04	6.91
S11-B	BDL	BDL	2.54	BDL	BDL	1.29	0.637	BDL	BDL	BDL	1.62	BDL	BDL	BDL	1.7	3.5
S13-A	BDL	BDL	0.637	BDL	BDL	0.777	1.94	1	0.865	BDL	1.14	BDL	BDL	BDL	2.28	40.5
S13-B	BDL	BDL	3.64	0.288	BDL	3.32	6.06	3.37	4.62	BDL	5.13	BDL	BDL	BDL	10.8	29.6
S14-A	BDL	BDL	0.898	BDL	BDL	0.879	1.59	1.02	0.894	BDL	1.06	BDL	BDL	BDL	2.5	14.4
S14-B	BDL	BDL	3.3	0.212	BDL	2.28	3.56	2.36	5.71	BDL	3.45	BDL	BDL	BDL	7.41	19
C1-A	BDL	0.469	4.77	0.576	BDL	4.27	10.2	5.26	7.12	BDL	7.1	BDL	BDL	BDL	16.6	49.1
C1-B	BDL	BDL	BDL	BDL	BDL	BDL	5.86	BDL	BDL	BDL	BDL	BDL	BDL	BDL	8.68	BDL
USEPA WQC [b,c]	0.77	-	150	-	0.72	-	74	3.1[d]	2.5	-	52	3.1	-	-	-	120

"-" = criteria not available; As = arsenic; Ag = silver; Be = beryllium; Cd = cadmium; Co = cobalt; Cr = chromium; Cu = copper; Hg = mercury; Mo = molybdenum; Ni = nickel; Pb = lead; Sb = antimony; Se = selenium; Tl = thallium; V = vanadium; Zn = zinc

[a] The 'A' and 'B' after the station ID indicate different discrete samples collected at the same station during the season.

[b] USEPA 2009

[c] USEPA 2021a

[d] WQC for saltwater

7.4.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on marine and riverine water quality. The relevant planned Project activities and the associated potential impacts of these activities on marine and riverine water quality are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

Several modeling studies assisted with the assessment of potential impacts on marine and riverine waters from planned Project activities. These studies included modeling simulations of sediment disturbance from offshore pipeline trenching; discharge of commingled stormwater and treated effluent from the NGL Plant; discharge of pipeline hydrotest water both offshore and to the Demerara; and sediment resuspension from Demerara River dredging to support the construction and operation of the temporary MOF. The treated effluent from the NGL Plant and the effluent from the onshore pipeline hydrotest water will be discharged to the Demerara River either directly or via a canal adjacent to the NGL Plant site. For the modeling purposes, direct discharge to the Demerara River approximately 100 meters downstream of the temporary MOF is assumed. If the discharge is into a canal, the assumption of discharging directly into the Demerara River is conservative as it ignores any dilution effects realized within the canal. Information on the modeling, including model descriptions, model inputs, model outputs, and discussions of results, can be found in Appendix C, Water Quality Modeling Report.

7.4.3.1. Marine Water Quality

Relevant Project Activities and Potential Impacts

In general, the planned Project activities that could affect marine water quality are those that cause potential health impacts on marine biota. The planned trenching activities for the installation of the offshore pipeline will potentially impact marine water quality by temporarily increasing TSS concentrations in the water column. Hydrotesting of the onshore and offshore pipeline will potentially impact marine water quality via discharge of water treatment chemicals to the ocean—resulting in potential impacts on marine biota. The base case for decommissioning is that subsea components will be disconnected from the Floating Production, Storage, and Offloading vessel topsides after flushing and preparation and left *in situ* on the seafloor. On this basis, there will be no potential impacts to marine water quality associated with the Decommissioning stage. Table 7.4-9 summarizes the planned Project activities that could result in potential impacts on marine water quality.

Table 7.4-9: Summary of Relevant Project Activities and Key Potential Impacts—Marine Water Quality

Stage	Project Activity	Key Potential Impacts
Construction	• Installation of offshore pipeline in the shallow segments using various trenching techniques, including suction dredging and jet plowing, HDD, or open-cut techniques • Hydrotesting of onshore and offshore pipelines	• Increase in TSS in the water column from the resuspension and transport of sediments during burial of the offshore pipeline and completion of the HDD shore crossing (potential indirect impact on marine biota) • Offshore release of water treatment chemicals used in hydrotesting (potential indirect impact on marine biota)

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for marine water quality (Table 7.4-10). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for marine water quality sensitivity are provided in Table 7.4-11.

For the purpose of assessing the significance of potential impacts on marine water quality, separate discussions are provided for the following activities that may result in changes to marine water quality, with the assessment focusing on the specific potential impacts that are relevant to each of these activities:

- Trenching for installation of offshore pipeline
- Hydrotesting of onshore and offshore pipeline, with release of hydrotest water to marine waters

Table 7.4-10: Definitions for Intensity Ratings for Potential Impacts on Marine Water Quality

Criterion	Definition
Intensity	**Negligible**: No changes to water quality with the potential to cause health impacts on marine fauna.
	Low: Changes to water quality have the potential to cause health impacts on marine fauna, but limited to a localized area.
	Medium: Changes to water quality have the potential to cause health impacts on marine fauna over a moderately sized area (i.e., up to 1 km^2 around the pipeline corridor).
	High: Changes to water column quality have the potential to cause health impacts on marine fauna, affecting a widespread area (i.e., more than 1 km^2 around the pipeline corridor).

Table 7.4-11: Definitions for Resource Sensitivity Ratings for Potential Impacts on Marine Water Quality

Criterion	Definition
Sensitivity	**Low:** Affected portion of water column does not support high densities of unique, biologically vulnerable, or otherwise critically important species.
	Medium: Affected portion of water column supports high densities of unique, biologically vulnerable, or critically important species, but represents only a small portion of the area on which these species depend.
	High: Affected portion of the water column supports high densities of unique, biologically vulnerable, or critically important species, and represents a substantial portion of the area on which these species depend.

Impact Magnitude Ratings—Marine Water Quality

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to marine water quality is provided in Table 7.4-21.

Trenching for Installation of Offshore Pipeline

Planned offshore pipeline installation activities will potentially impact marine water quality as a result of burial of selected segments of the offshore pipeline. Sediments will be disturbed, resulting in a temporary increase in TSS concentrations in the water column. These temporary increases in TSS may have direct impacts on marine biota through clogging of fish gills or, in the photic zone, through light inhibition for photosynthetic organisms. The highest concentration increases will occur at the point of sediment disturbance (i.e., at the seafloor where the trenching occurs) and concentrations will decrease over time and distance, as the TSS plume dissipates and settles. Larger particles will settle more quickly (within a few hours) than finer particles, such that smaller particles may stay suspended longer and travel further than larger particles. As such, elevated TSS concentrations may form in regions where tiny particles remain suspended and mix with particles from subsequent discharges. To help assess the predicted TSS concentration increase in the water column, modeling was performed using GEMSS® and its sediment particle and fluids discharge module, GIFT, as discussed in Appendix C, Water Quality Modeling Report. This three-dimensional particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values to calculate the fate and transport of particulate in the water column. Model outputs provide estimates of the water column TSS concentrations resulting from the planned trenching activities. A commonly used guidance value for TSS effluent discharges in the marine environment recommended by the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) is 35 mg/L (IMO 2006). Accordingly, for the purpose of modeling, results are presented in terms of the lateral area with TSS concentrations exceeding 35 mg/L.

Modeling was performed at three locations across the pipeline route to represent different depths and sediment particle size distributions: coastal, shallow, and offshore. A map of these locations is shown on Figure 7.4-8. Modeling was performed over a 1-day trenching event for both minimum and maximum current conditions, resulting in six simulations. The maximum predicted TSS concentrations for each simulation are presented in Table 7.4-12. The maximum predicted TSS concentrations were assessed at the bottom of the water column, as that is where the highest concentrations will occur. In all scenarios, the threshold of 35 mg/L is exceeded to a small extent, with maximum TSS concentrations ranging from 35.3 to 47.3 mg/L. Table 7.4-12 also shows the total area within which predicted TSS concentrations exceeded the threshold of 35 mg/L. The maximum exceedance area was predicted for the offshore location, where the predicted area exceeding the 35 mg/L threshold was on the order of approximately 12,000 square meters (m^2) (0.012 km^2) (Figure 7.4-9).

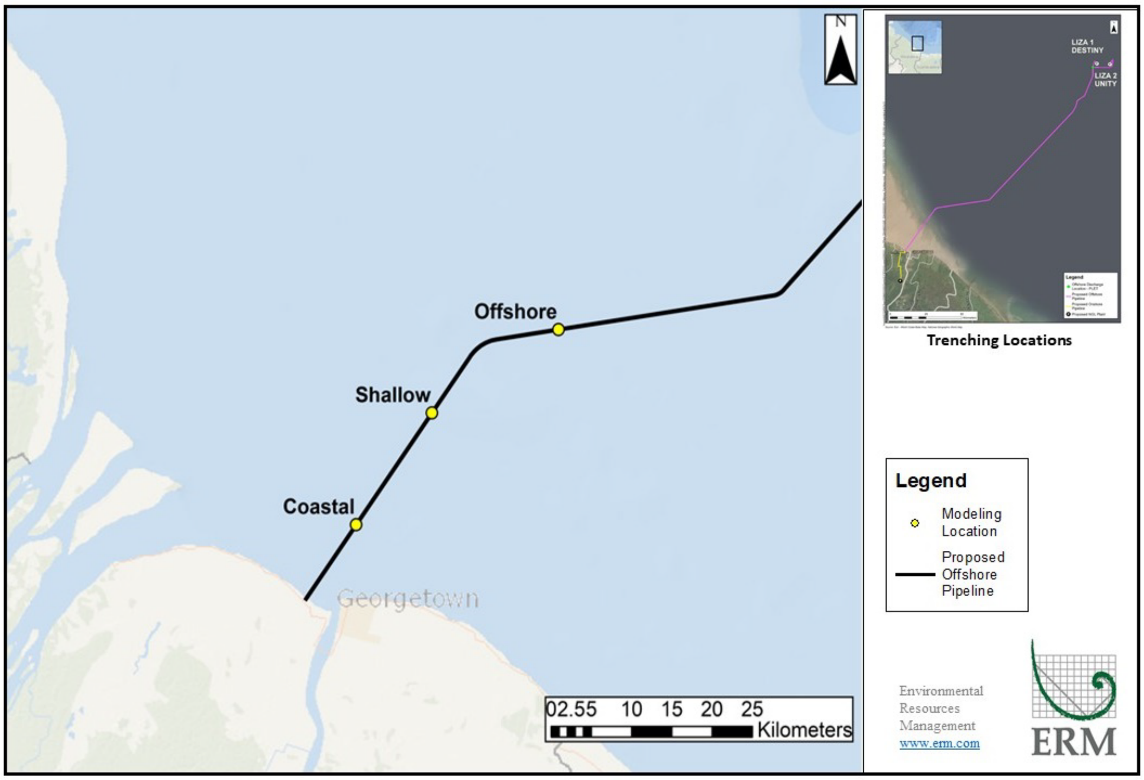


Figure 7.4-8: Three Representative Offshore Locations Selected for Modeling of Trenching Activities

Table 7.4-12: Summary of TSS Modeling Results for Coastal, Shallow, and Offshore Pipeline Burial

Scenario	Maximum Predicted TSS Concentration at Bottom of Water Column (mg/L)	Area (m²) with TSS Concentrations > 35 mg/L Threshold
Coastal minimum currents	36.2	47
Coastal maximum currents	35.3	44
Shallow minimum currents	38.7	3,495
Shallow maximum currents	35.8	598
Offshore minimum currents	47.3	11,932
Offshore maximum currents	40.4	4,669

Based on the above results, the intensity of impacts from increased TSS concentrations in the water column from pipeline trenching are considered **Low** during the Construction stage. While there will be periods during pipeline trenching when sediment resuspension will not occur, the impact will be present throughout trenching, yielding a **Continuous** frequency rating. Pipeline trenching is expected to occur over several months, so the duration is considered **Medium-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact is rated as **Small.**

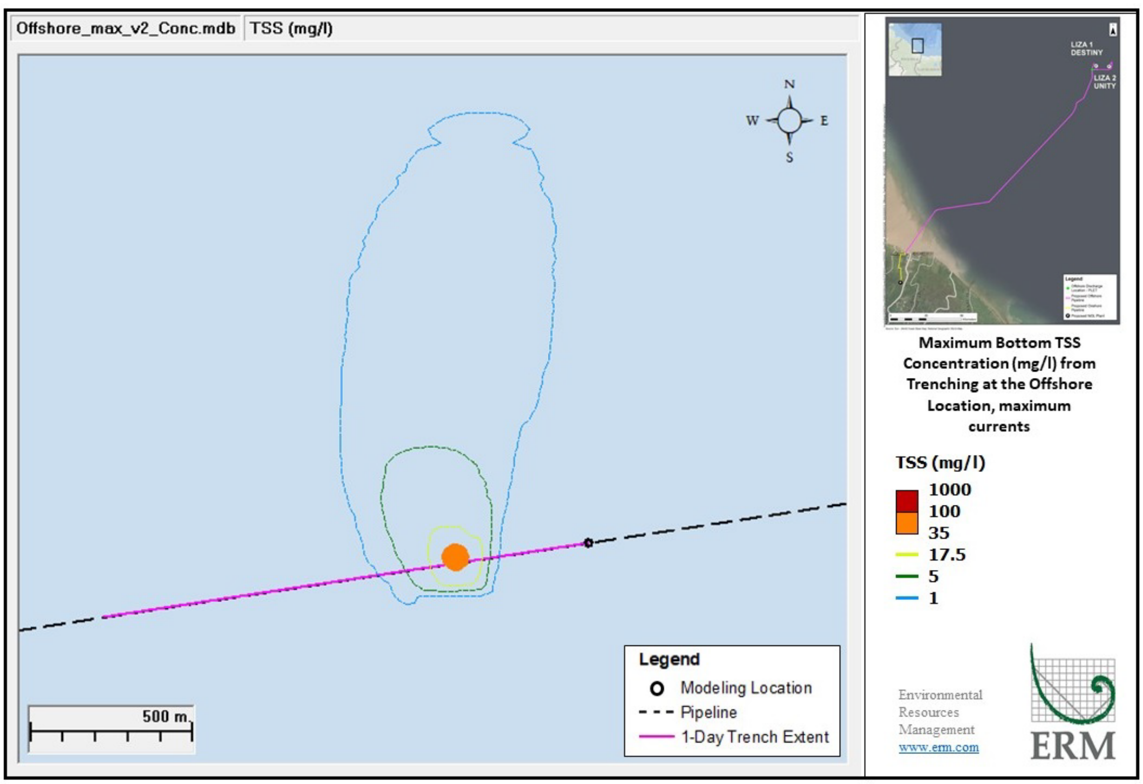


Figure 7.4-9: Maximum Predicted TSS Concentration Gradients at Bottom of Water Column at the Offshore Modeling Location under Maximum Currents

Hydrotesting of Pipelines with Release of Hydrotest Water to Marine Waters

Hydrotesting is performed to test the integrity of the pipelines prior to introducing gas. The Project has planned discharges to water associated with the hydrotesting process. Currently, four alternatives are considered for the discharge of hydrotest water:

4. Alternative 1: Discharge of hydrotest water for the entire pipeline (from the NGL Plant to the PLET) offshore at the PLET location.
5. Alternative 2: Discharge of hydrotest water from the offshore pipeline segment (i.e., from the beach valve to the PLET) at the PLET location and discharge of the hydrotest water for the onshore pipeline segment (i.e., between the beach valve and NGL Plant) to the stormwater pond at the NGL Plant site, from which it would eventually be discharged into the Demerara River (either directly or via a canal adjacent to the NGL Plant site approximately 100 meters downstream of the temporary MOF).
6. Alternative 3: Discharge of hydrotest water from the offshore pipeline segment between the beach valve and an Intermediate Point 1 (located approximately 50 kilometers offshore along the pipeline) to the ocean at Intermediate Point 1; discharge of hydrotest water from the offshore pipeline segment between Intermediate Point 1 and the PLET to the ocean at the PLET; and discharge of hydrotest water for the onshore pipeline segment (between the beach valve and the NGL Plant) to the stormwater pond at the NGL Plant site.
7. Alternative 4: Discharge of hydrotest water from the offshore pipeline segment between the beach valve and an Intermediate Point 2 (located approximately 75 kilometers offshore along the pipeline) to the ocean at Intermediate Point 2; discharge of hydrotest water from the offshore pipeline segment between Intermediate Point 2 and the PLET to the ocean at the PLET; and discharge of hydrotest water for the onshore pipeline segment (between the beach valve and the NGL Plant) to the stormwater pond at the NGL Plant site.

Under all four alternatives, there would be a discharge of hydrotest water to marine waters at the PLET (Figure 7.4-10) and under two alternatives (Alternatives 3 and 4) there would also be a discharge of hydrotest water to marine waters in shallower depths. The lengths, diameters, hydrotest water volumes, and discharge durations for the pipeline segments relevant to the four alternatives (including discharges to marine waters and riverine waters) are provided in Table 7.4-13.

Figure 7.4-10: Locations of Alternative Marine Discharges for Hydrotest Water

Table 7.4-13: Lengths, Diameters, Hydrotest Water Volumes, and Discharge Durations of Pipeline Segments to be Discharged for Assessed Discharge Alternatives

Alternative No.	Discharge Location	Intake Location	Starting and Ending Locations of Pipeline Segment to be Discharged	Pipeline Diameter (inches)	Pipeline Length (kilometers)	Hydrotest Water Volume (m^3)	Discharge Duration (hours)
1	PLET	PLET and/or Demerara River	From NGL Plant to PLET	12	245	17,877	24
2	PLET	Demerara River	From beach valve to PLET	12	220	16,053	24
	Demerara River	Demerara River	From beach valve to NGL Plant	12	25	1,824	24
3	Intermediate Point 1	Intermediate Point 1	From beach valve to Intermediate Point 1	12	50	3,649	6
	PLET	PLET	From Intermediate Point 1 to PLET	12	170	12,405	18
	Demerara River	Demerara River	From beach valve to NGL Plant	12	25	1,824	24
4	Intermediate Point 2	Intermediate Point 2	From beach valve to Intermediate Point 2	12	75	5,473	8
	PLET	PLET	From Intermediate Point 2 to PLET	12	145	10,581	16
	Demerara River	Demerara River	From beach valve to NGL Plant	12	25	1,824	24

To assess the potential magnitude of the hydrotest discharge once it enters the marine waters, the USEPA's Cornell Mixing Zone Expert System (CORMIX) dilution model was used to define the plume characteristics. CORMIX is a design tool routinely used by regulatory agencies to estimate the size and configuration of mixing zones resulting from effluent discharges. Understanding the mixing achieved once released into the marine waters requires an understanding of the properties of the ambient marine water, discharge water, and discharge structures. Relevant properties of the marine waters and hydrotest discharge include velocity, temperature, and salinity. Differences in velocity and density, as well as the properties of the discharge structure, determine the mixing achieved. The input properties for the CORMIX modeling are provided in Appendix C, Water Quality Modeling Report. For each alternative, six scenarios were modeled to represent extreme density differences between the marine and discharge waters, as well as a range of ambient (i.e., marine water) current velocities. The density is computed from temperature and salinity data. The extreme density differences are only realized when the intake water is from the river and is discharged into marine waters (i.e., a low saline water is discharged into a high saline water). The scenarios modeled for each marine discharge alternative are summarized in Table 7.4-14. The low, median, and high densities are computed from the distribution of the salinity and temperature values. For example, the median density was computed using the 50th percentile of both the salinity and temperature values. The low and high densities were computed using varying combinations of the 5th and 95th percentiles of the salinity and temperature values. The range in salinity and temperature had little impact on the modeled density. The density of river water ranged from 995.85 kilograms per cubic meter (kg/m^3) (low) to 996.78 kg/m^3 (high). The density of the marine water at the PLET ranged from 1,027.47 kg/m^3 to 1,027.57 kg/m^3.

The achieved dilution factors (DFs) at 100 and 500 meters from the discharge location for each scenario are provided in Table 7.4-14. When marine waters are used as the source of hydrotest water, the achieved DFs are similar, ranging from 134 to 190 at 100 meters from the discharge location. When river water is used as the source of hydrotest water and discharged into marine water, the density difference between the river water and marine water creates density-driven currents, resulting in an increase in mixing and dilution. At 100 meters from the discharge location, the achieved DFs range from 292 to 352 when river water is used as the source of hydrotest water. Additional detail regarding the CORMIX modeling can be found in Appendix C, Water Quality Modeling Report.

Table 7.4-14: Densities, Currents, and Resulting Dilution Factors for each Alternative Modeled for the Release of Hydrotest Discharge into Marine Waters

Alternative	Intake Location	Discharge Location	Density of Discharge	Density of Receiving Water	Current of Receiving Water	Dilution Factor at 100 Meters from Discharge	Dilution Factor at 500 Meters from Discharge
1	PLET	PLET	Median	Median	5%	133	2298
1	PLET	PLET	Median	Median	50%	136	3410
1	PLET	PLET	Median	Median	95%	137	3607
1	River	PLET	Low	High	5%	292	5531
1	River	PLET	Low	High	50%	320	6915
1	River	PLET	Low	high	95%	352	8431
2	River	PLET	Low	High	5%	323	6007
2	River	PLET	Low	High	50%	355	7619
2	River	PLET	Low	High	95%	394	9281
2	River	PLET	High	Low	5%	319	5950
2	River	PLET	High	Low	50%	351	7580
2	River	PLET	High	Low	95%	390	9224
3	PLET	PLET	Median	Median	5%	134	2627

Alternative	Intake Location	Discharge Location	Density of Discharge	Density of Receiving Water	Current of Receiving Water	Dilution Factor at 100 Meters from Discharge	Dilution Factor at 500 Meters from Discharge
3	PLET	PLET	Median	Median	50%	136	3710
3	PLET	PLET	Median	Median	95%	165	2814
3	Intermediate Point 1	Intermediate Point 1	Median	Median	5%	137	934
3	Intermediate Point 1	Intermediate Point 1	Median	Median	50%	139	599
3	Intermediate Point 1	Intermediate Point 1	median	Median	95%	137	740
4	PLET	PLET	Median	Median	5%	134	2815
4	PLET	PLET	Median	Median	50%	137	3877
4	PLET	PLET	Median	Median	95%	190	4024
4	Intermediate Point 2	Intermediate Point 2	Median	Median	5%	138	661
4	Intermediate Point 2	Intermediate Point 2	Median	Median	50%	144	777
4	Intermediate Point 2	Intermediate Point 2	Median	Median	95%	139	687

The hydrotest water will contain water treatment chemicals to protect the pipeline during hydrotesting. For the purpose of this EIA, the concentration of these chemicals in the hydrotest discharge was assumed to be 500 mg/L, based on preliminary design assumptions provided by EEGPL. The final selection of hydrotest chemicals has not been determined. EEGPL provided material safety data sheets (MSDSs) for two representative water treatment chemicals that may be used: RX-5254 and SLB HydroHib. These chemicals may have different toxicities than the chemicals selected for use in the hydrotesting. For both chemicals, guidance thresholds were developed based on ecological effects data and composition information provided in the MSDSs. Depending on the scenario, the hydrotest water is assumed to be released over no more than a 24-hour period, and peak concentrations will only exist during times when the release is occurring and will quickly dissipate once the discharge is over. Therefore, the exposure to the water treatment chemicals is short-term and a threshold based on acute toxicological data, where the test organisms are exposed for up to 96 hours to a continuous concentration of the chemical, is appropriate.

For each chemical, the component with the lowest guidance threshold was identified. For RX-5254, the component with the lowest guidance threshold was identified as didecyldimethylammonium chloride (DDMAC). Acute (i.e., short-term exposure) toxicity data considered for DDMAC were obtained from the MSDS and from a toxicity assessment report (ECHA 2015). Acute toxicity data were available for freshwater fish, invertebrates, and algae; and saltwater fish and invertebrates. Freshwater species exhibited higher toxicity (i.e., lower toxicity endpoints) to DDMAC than saltwater species. The more conservative guidance threshold is therefore derived based on the toxicity data for the freshwater species. For DDMAC, the lowest acute toxicity value is an algae EC50[9] for growth inhibition of 0.021 mg/L. This value is then adjusted by the percent of DDMAC in RX-5254 to compute an acute guidance threshold for the entire product RX-5254. The highest compositional percent of DDMAC in RX-5254 is 2.8 percent (as provided in the MSDS). The resulting acute guidance threshold for RX-5254 is 0.75 mg/L. For SLB HydroHib, the component with the lowest guidance threshold is a diethylene glycol/morpholine derivative identified as ethanol, 2,2'-oxybis-, reaction products with ammonia, morpholine derivatives residues (CAS Number 68909-77-3). Toxicological information for fish, algae, and invertebrates are provided in a dossier on this substance (EHS Support 2021). MSDS. The lowest acute endpoint was a 72-hour EC50 for algae growth rate with a value of 45 mg/L. The highest compositional percent of this substance in SLB HydroHib was 30 percent. The resulting acute guidance threshold for SLB HydroHib is 150 mg/L.

Assuming an initial concentration of 500 mg/L of the chemical in the hydrotest discharge, a DF of 667 is needed for RX-5254 to be below the acute threshold of 0.75 mg/L. At 100 meters from the discharge, the DFs range from 133 to 394. At 500 mg/L, the diluted concentrations of RX5254 range from 1.27 mg/L to 3.76 mg/L, which are higher than the acute guidance threshold of 0.75 mg/L. However, at 500 meters from the discharge location, the DFs are sufficient to meet the acute guidance threshold under all scenarios except for one scenario for each of Alternatives 3 and 4, at the Intermediate Point 1 and Intermediate Point 2 discharge locations. For SLB HydroHib, the initial concentration of 500 mg/L would have to be diluted by a factor of 3.4 to be below the acute guidance threshold value of 150 mg/L. All modeled DFs at 100 meters were higher than 3.4 and therefore no acute toxicity is expected from SLB HydroHib.

Based on the above results, the intensity of impacts on marine water quality from water treatment chemicals used in the hydrotest water are considered **Negligible** (SLB HydroHib) to **Low** (RX-5254) during the Construction stage. The hydrotesting is a continuous process, yielding a **Continuous** frequency rating. The hydrotesting will be completed over a period of 24 hours or less, so the duration is considered **Short-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact is rated as **Negligible** to **Small.**

Sensitivity of Resource—Marine Water Quality

Based on the sensitivity rating definitions in Table 7.4-11, the resource sensitivity for marine water quality is characterized considering the marine biota community that inhabits the large and ecologically diverse marine area in and around the Direct Offshore AOI, from shallow, turbid, coastal waters to the deep, clear, open ocean. The continental shelf was the most species-rich environment sampled during the EEPGL-commissioned marine fish assessment (compared with nearshore and deepwater environments), accounting for 109 fish species in the first study year of the marine fish study conducted by the Consultants and 92 species in the second study year. The life cycles of many of the fish species present in the community

[9] In ecotoxicity studies with algae, the EC50 (median effective concentration) is the concentration of a test substance that results in a 50 percent reduction in either algae growth or algae growth rate.

exemplify the ecological connectivity among the mangroves, estuaries, and offshore zones because many fish species are dependent on different habitats at specific life stages or occur in more than one habitat type. See Section 8.2, Marine and Coastal Biodiversity, for a more detailed listing of the species present in Guyana's coastal waters. The marine and coastal habitat and biota in the Project AOI are generally comprised of disturbance-tolerant biota that are considered to be of low sensitivity. Therefore, the sensitivity rating for marine waters is rated as **Low.**

Pre-mitigation Impact Significance—Marine Water Quality

Assuming implementation of the embedded controls listed in Table 7.4-21, the intensity ratings for potential Project impacts on marine water quality is **Negligible** to **Low** for both types of impacts considered. This results in pre-mitigation magnitude ratings of **Negligible** to **Small.** Coupled with a sensitivity rating of **Low**, the pre-mitigation impact significance for marine water quality for both types of impacts is **Negligible.**

7.4.3.2. Riverine Water Quality

Relevant Project Activities and Potential Impacts

The planned activities that could potentially impact riverine water quality include dredging activities associated with the temporary MOF, hydrotesting of the onshore pipeline and discharge of hydrotest water from the stormwater pond at the NGL Plant to the Demerara River, and discharge of treated sanitary and treated process wastewater effluents from the NGL Plant into the river. As stated above, the hydrotest discharge and NGL plant discharge are modeled as direct discharges into the river and no dilution from the canal is considered. Table 7.4-15 summarizes the planned Project activities that could result in potential impacts on riverine water quality.

Table 7.4-15: Summary of Relevant Project Activities and Key Potential Impacts—Riverine Water Quality

Stage	Project Activity	Key Potential Impacts
Construction	• Dredging of river for installation of the turning basin and navigation channel to support the temporary MOF • Hydrotesting of onshore pipeline segment, and discharge to river	• Increase in TSS concentrations in the water column from the resuspension and transport of sediments during dredging (potential indirect impact on biota) • Release of chemicals used in hydrotesting into river (potential indirect impact on biota)
Operations	Discharge of NGL Plant wastewater effluents (process and sanitary) and stormwater into the Demerara River	• Release of constituents in NGL Plant effluents into Demerara River (potential indirect impact on biota)

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for riverine water quality (Table 7.4-16). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for riverine water quality sensitivity are provided in Table 7.4-17.

For the purpose of assessing the significance of potential impacts on riverine water quality, separate discussions are provided for the following components that may disturb the water column, with the assessment focusing on the specific potential impacts that are relevant to each of these activities:

- Dredging around the temporary MOF
- Hydrotesting of the onshore pipeline, with release of hydrotest water to the stormwater pond and then to Demerara River
- Discharge of the NGL Plant wastewater effluents into the Demerara River

Table 7.4-16: Definitions for Intensity Ratings for Potential Impacts on Riverine Water Quality

Criterion	Definition
Intensity	**Negligible:** No changes to water quality with the potential to cause health impacts on riverine biota.
	Low: Changes to water quality have the potential to cause health impacts on riverine biota, but limited to a localized area.
	Medium: Changes to water quality have the potential to cause health impacts on riverine biota over a moderately sized area (i.e., up to 0.5 km^2).
	High: Changes to water quality have the potential to cause health impacts on riverine biota (i.e., more than 0.5 km^2).

Table 7.4-17: Definitions for Resource Sensitivity Ratings for Potential Impacts on Riverine Water Quality

Criterion	Definition
Sensitivity	**Low:** Affected portion of water column does not support high densities of unique, biologically vulnerable, or otherwise critically important species.
	Medium: Affected portion of water column supports high densities of unique, biologically vulnerable, or critically important species, but represents only a small portion of the area on which these species depend.
	High: Affected portion of the water column supports high densities of unique, biologically vulnerable, or critically important species, and represents a substantial portion of the area on which these species depend.

Impact Magnitude Ratings—Riverine Water Quality

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to riverine water quality is provided in Table 7.4-22.

Dredging around the Temporary MOF

Modeling was conducted to predicted increases in TSS concentrations in the water column associated with sediment re-suspension during dredging associated with the temporary MOF construction. These water quality impacts are associated with the dredging disturbance of the riverbed and overflow from the dredging hopper. The TSS plume will dissipate with distance from the release as it mixes in the water column and/or settles back to the riverbed.

Impacts on aquatic organisms related to elevated TSS may occur if light penetration is impeded significantly for long periods of time (reducing the ability of plants and phytoplankton to photosynthesize). Increases in TSS may also decrease water clarity and clog fish gills. In the absence of a local TSS freshwater quality criterion, a value of 30 mg/L was obtained from criteria promulgated in the Emirate of Dubai for guidance on development and infrastructure projects (Dubai Municipality 2019).

The model predicts TSS concentrations added to the water from the planned activities. Therefore, to assess the overall predicted TSS concentrations during dredging activities that exceed 30 mg/L, model results were added to measured ambient values. TSS may vary greatly in the Demerara River. In the sampling performed October and November 2021 (Demerara River Baseline Field Study [see Appendix G]), TSS values in the Demerara River by the temporary MOF (Station R2) ranged from 14.8 mg/L to 319 mg/L, indicating that the background conditions in the river can exceed the 30 mg/L water quality threshold by an order of magnitude. Assessing the relative increase of TSS impacts on water quality when the river may already be over the threshold is difficult. In such scenarios when background levels are high, the impact of temporarily increased TSS may be indiscernible. The modeling of TSS from the dredging activity therefore focused on two conditions: when the background TSS was 14.8 mg/L and 319 mg/L.

Modeling was performed for both minimum (dry season) and maximum (wet season) flow conditions in the Demerara River, and results were examined as a composite of the day's dredging activities across the daily high tides, low tides, and slack tides. The TSS concentrations were modeled as background TSS plus the addition of TSS from the dredging. Modeling demonstrates that the area immediately surrounding the location being dredged, where the overflow will be discharged, will experience an increase in TSS above 1,000 mg/L while the dredging activity takes. The plume of TSS will then travel generally downstream.

The maximum predicted TSS concentrations when the background TSS concentrations are low (14.8 mg/L) are presented in Table 7.4-18. The output displays the highest predicted TSS concentration in each model grid cell recorded during the simulation day. While this shows all the locations that may be impacted by elevated TSS, there will be no single moment during the day in which the TSS will be that high at all locations. When considering the lower background TSS concentration of 14.8 mg/L in the Demerara River, 1 day of dredging leads to a composite area of 3.0 km² above the 30 mg/L threshold, extending over 7.3 kilometers along the length of the river. When accounting for a high background concentration of 319 mg/L in the Demerara River, the entirety of the river already exceeds the TSS threshold of 30 mg/L before the addition of TSS due to dredging activities.

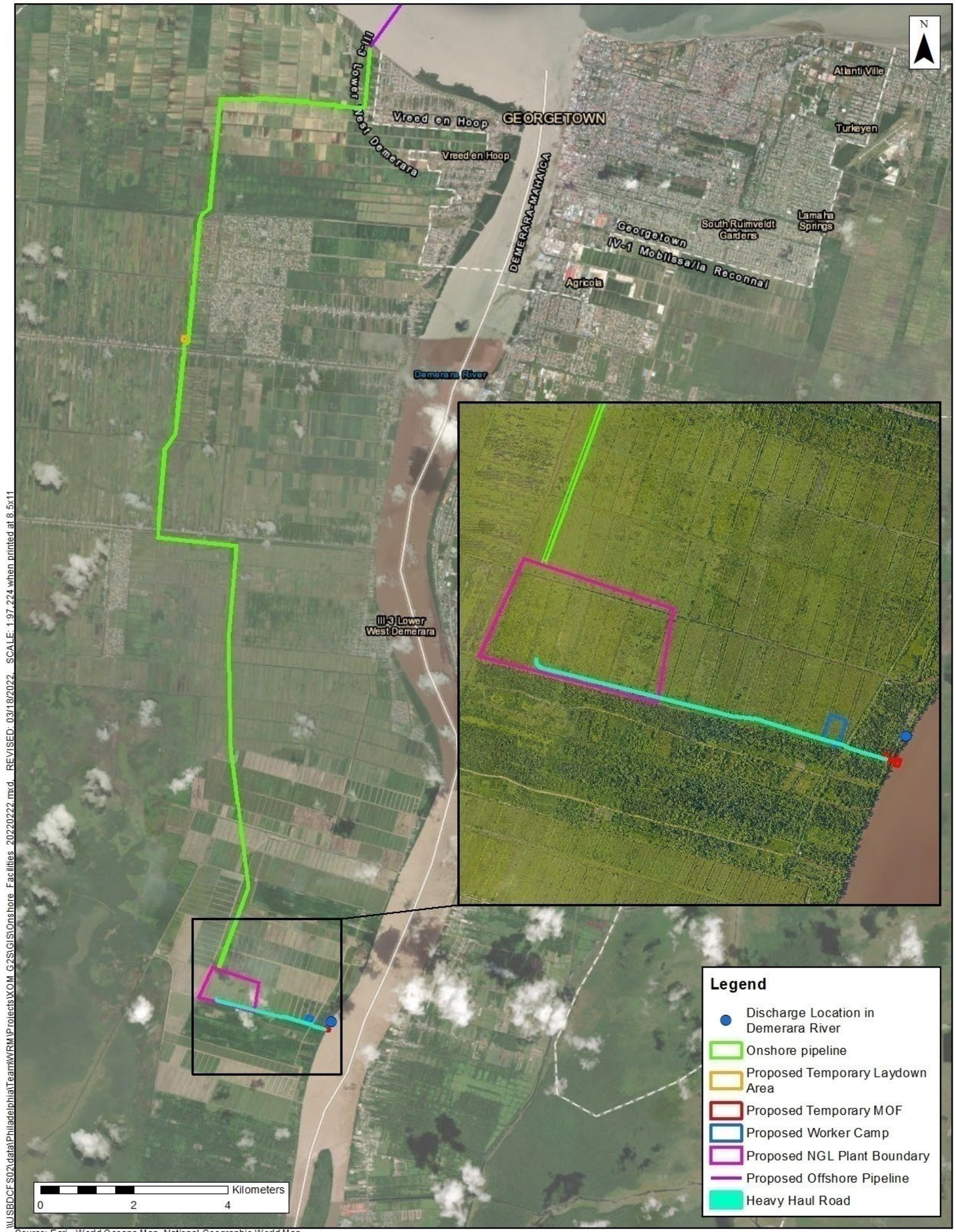
Table 7.4-18: Estimated Maximum Total Areas with TSS above Threshold from 1 Day of Temporary MOF Dredging during Low Background TSS Concentration Conditions (14.8 mg/L)

Scenario	Area (km²) with TSS > 30 mg/L Threshold	Approximate Length of Plume with TSS > 30 mg/L Threshold
Dry season		
Minimum flow: spring tide	3.0	7.3
Minimum flow: mid-cycle tide	2.4	8.3
Minimum flow: neap tide	2.1	3.1
Wet season		
Maximum flow: spring tide	1.8	6.4
Maximum flow: mid-cycle tide	2.3	7.9
Maximum flow: neap tide	2.1	7.7

Based on the above results, the intensity of impacts on sediments resuspension, transport, and accumulation are considered **High** during the Construction stage. These impacts will occur on a temporary basis only during the active dredging portions of each dredge cycle, so the frequency of this impact is considered **Episodic** during this stage. Dredging of the temporary MOF area is expected to be completed within a period of between a week and a year, so the duration is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine water quality is rated as **Small.**

Hydrotesting of Onshore Pipeline with Release of Hydrotest Water to Demerara River

As discussed in Section 7.4.3.1, Marine Water Quality, in the subsection on hydrotesting, Alternatives 2, 3, and 4 include a release of hydrotest water to the Demerara River. In all alternatives, the release is for the 25-kilometer onshore pipeline segment (between the beach valve and the NGL Plant) of hydrotest water that would be released to the onshore stormwater pond at the NGL Plant, and then eventually discharged directly or potentially via an existing canal into the Demerara River. The planned hydrotest effluent volume into the river will be approximately 1,824 m^3 that would be released over a 24-hour period. For modeling purposes, the assumed location of this release is shown on Figure 7.4-11.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 7.4-11: Location of Hydrotest Discharge in the Demerara River

Similar to the modeling of the hydrotest water release into marine waters, CORMIX was used to characterize the discharge plume and estimate the dilution factor at a distance of 100 and 500 meters from the release location. The hydrotest water plume behavior in the Demerara River is not dependent on the density difference, as the source water is expected to be very close to the ambient water (i.e., river) properties. Therefore, median densities were used in all simulations for both the ambient and the hydrotest discharge waters (corresponding to their 50th percentile water temperature and 50th percentile salinity). The median density was 996.3 kg/m^3. The river currents will influence the dispersion of the hydrotest discharge in the river. Therefore, six scenarios for discharging hydrotest water in the Demerara River were represented with a range of current velocities during both dry and wet seasons (Table 7.4-19). Higher DFs were achieved during the wet season due to the higher observed river currents during this season. In the dry season, at 100 meters from the discharge location, the DFs ranged from 75 to 567, compared to DFs ranging from 815 to 1,203 at 100 meters during the wet season.

Since the discharge of the hydrotest water into the river will occur over a 24-hour period, the acute guidance thresholds derived in Section 7.4.3.1, Marine Water Quality, for the two hydrotest chemical RX-5245 and SLB HydroHib of 0.75 mg/L and greater than 150 mg/L, respectively, are applicable to the discharge of hydrotest water in the river. Assuming the initial concentration of 500 mg/L for the chemicals (see Section 7.4.3.1, Marine Water Quality), a DF of 667 is required to be below the acute threshold for RX-5245. Modeling indicates that a DF of 667 is met at 100 meters during the wet season, where DFs range from 815 to 1757. During the dry season, a DF of 667 is met at 500 m from the discharge location under only high current conditions. For SLB HydroHib, all modeled DFs at 100 meters are higher than the DF of 3.4 needed to be below the acute guidance threshold and so no acute toxicity is expected from this substance.

Table 7.4-19: Densities, Currents, and Resulting Dilution Factors for each Alternative Modeled for the Release of Hydrotest Discharge into Riverine Waters

Alternative	Intake Location	Discharge Location	Density of Discharge	Density of Receiving Water	Current of Receiving Water	Dilution Factor at 100 Meters from Discharge	Dilution Factor at 500 Meters from Discharge
2, 3, and 4	River	River - Dry season	Median	Median	5%	75	166
2, 3, and 4	River	River - Dry Season	Median	Median	50%	336	551
2, 3, and 4	River	River - Dry Season	Median	Median	95%	567	836
2, 3, and 4	River	River - Wet Season	Median	Median	5%	815	1196
2, 3, and 4	River	River - Wet Season	Median	Median	50%	1011	1479
2,3, and 4	River	River- Wet Season	Median	Median	95%	1203	1757

Based on the above results, the intensity of the potential impact on riverine water quality from the water treatment chemical in the hydrotest water is considered **Negligible** for SLB HydroHib. For RX-5254, the intensity is considered **Negligible** for wet season conditions and up to **Medium** for dry season conditions. The potential impacts from hydrotesting will be continuous during the discharge, yielding a **Continuous** frequency rating. The hydrotesting will be completed over a relatively short time frame, so the duration is considered **Short-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on is rated as **Negligible** to **Small.**

Discharge of NGL Plant Wastewater Effluents into the Demerara River

The NGL Plant will have two treated wastewater effluents: one from the process wastewater treatment system and one from the sanitary wastewater treatment system. EEPGL plans to consolidate these two streams with site stormwater in a stormwater pond. The comingled waters from the stormwater pond will then be discharged intermittently into the Demerara River either directly or via a canal adjacent to the NGL Plant site. EEPGL provided maximum concentrations for constituents in the treated sanitary and treated process wastewater streams, as referenced from World Bank Group values for treated sanitary sewage discharges and effluent levels for a natural gas processing facility, respectively (see Section 5.5.3, Effluent Discharges). These maximum allowable concentrations are summarized in Table 7.4-20. These concentrations are intended to be the maximum concentrations that can be safely discharged under World Bank Group guidance and do not consider the actual efficiencies achieved from the treatment systems once operational or any removal via biodegradation or settling that may occur in the stormwater holding pond prior to release into the river. The average background concentrations in the Demerara River are also provided in in Table 7.4-20. The background concentrations of iron and TSS in the river are higher than the maximum allowable concentrations.

As stated above, for modeling purposes, a direct discharge to the river is assumed and no dilution from the canal is considered. The only dilution considered is from the Demerara River. A hydrodynamic and water quality model was used to simulate the intermittent discharges from the stormwater pond into the river. The discharge was modeled to determine the extent of the plume and mixing characteristics. The outfall location was assumed to be 100 meters downstream of the temporary MOF (Figure 7.4-12). Two scenarios were modeled: minimum 14-day average flows during dry season (0.84 m^3/s) and maximum 14-day average flows during wet season (1,682 m^3/s). Each flow condition was modeled for the full tidal conditions and included the planned NGL Plant discharge from the stormwater pond at a maximum discharge rate of 550 m^3/hour, as provided by EEPGL.

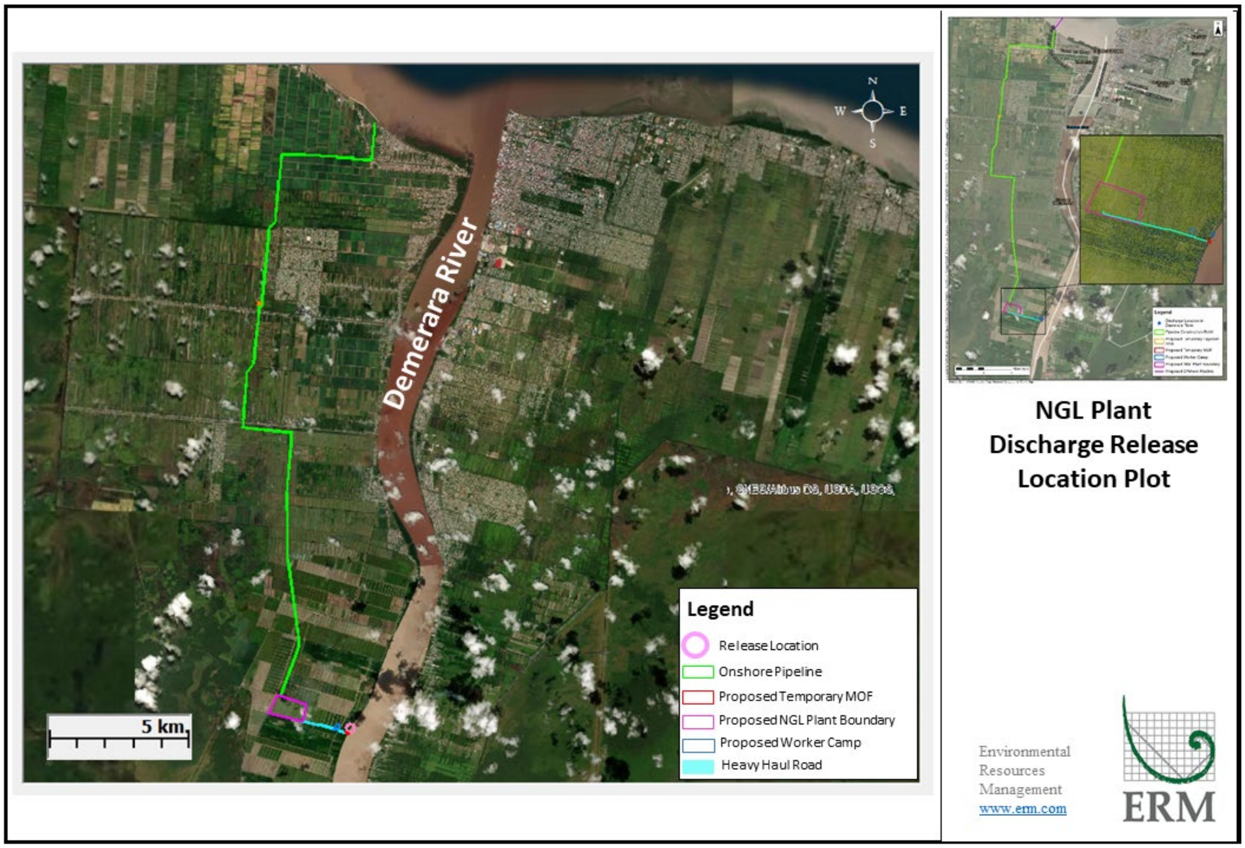


Figure 7.4-12: NGL Plant Stormwater Pond Discharge Location

Modeled output consisted of the DF achieved along the river. To demonstrate the impact river flow has on the achieved DF, two extreme scenarios were modeled: minimum flow, dry season (results in minimum DF) and maximum flow, wet season (results in maximum DF). These results are shown on Figure 7.4-13 and Figure 7.4-14, respectively. The modeled plumes demonstrate that under minimum flow, dry season, DFs of at least 100 are achieved within a short distance of the discharge point. Under maximum flow, wet season, much higher DFs are achieved, and the plume travels downstream along a narrow path along the west side of the river.

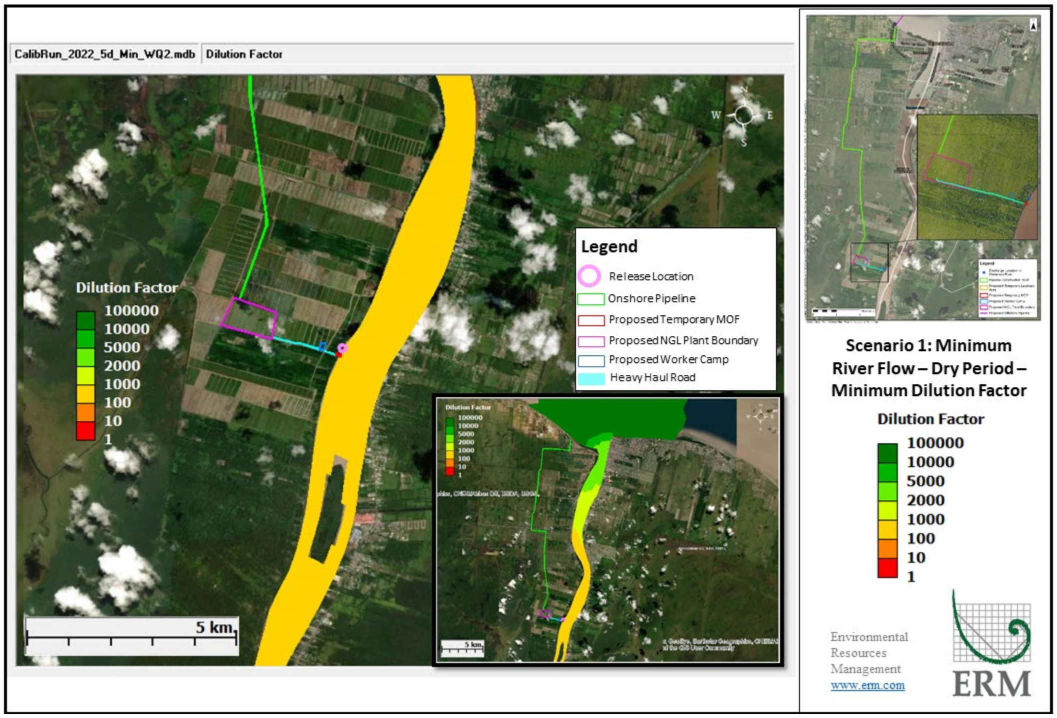


Figure 7.4-13: Minimum, Dry Season River Flow—Surface Minimum Dilution Factor

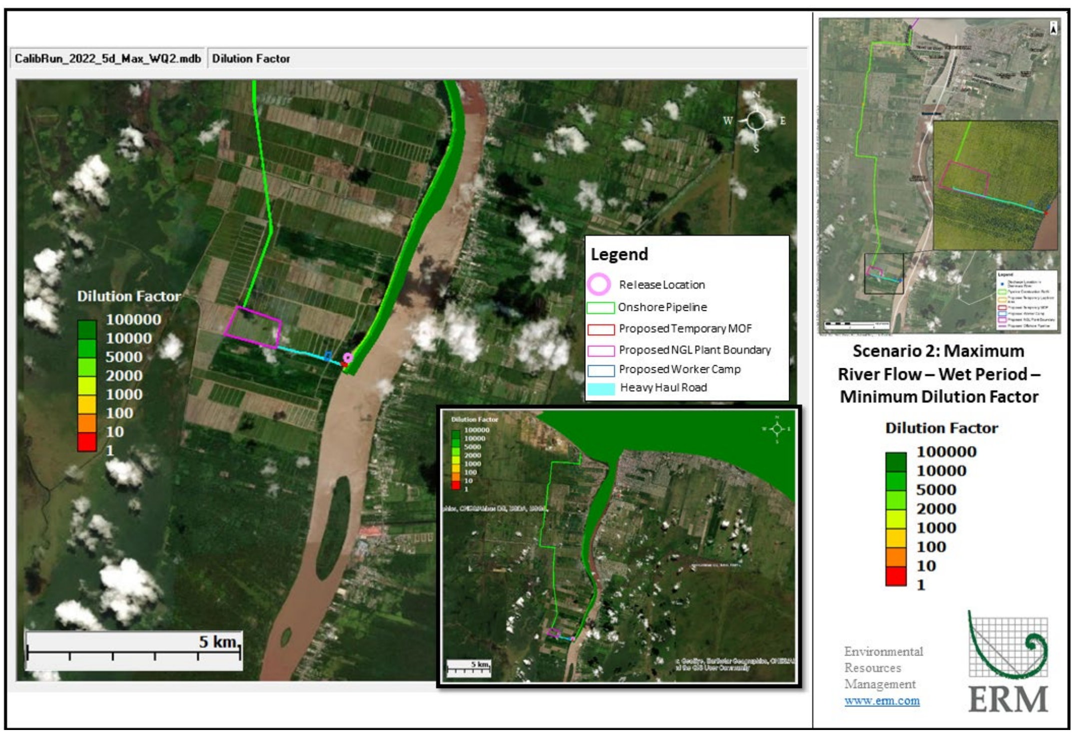


Figure 7.4-14: Maximum, Wet Season River Flow—Surface Minimum Dilution Factor

At a reference point 100 meters downstream of the discharge point, DFs of 154 and 2,475 are achieved under dry and wet seasons, respectively. At a reference point 500 meters downstream, the DFs achieved are 194 and 2,635, respectively.

Table 7.4-20: Maximum Allowable Discharge Concentrations for Natural Gas Facilities and Treated Sanitary Effluents and Measured Demerara River Background Concentration

Constituent	Maximum Allowable Discharge Concentration for Natural Gas Facilities	Maximum Allowable Concentration for Treated Sanitary Effluent	Measured River Background Concentration
TSS, mg/L	50	50	435
Chromium, mg/L	0.5	—	0.0094
Copper, mg/L	0.5	—	0.00439
Zinc, mg/L	1	—	0.0427
Lead, mg/L	0.1	—	0.0073
Nickel, mg/L	1.5	—	0.00694
Iron, mg/L	3		11.4
Oil and grease, mg/L	10	10	1.61
Cadmium, mg/L	0.1	—	BDL
Total nitrogen, mg/L	10	10	1.068
Total phosphorus, mg/L	2	2	0.18
BOD_5, mg/L	50	30	ND
chemical oxygen demand, mg/L	150	125	ND
Total residual chlorine, mg/L	0.2	—	ND
Free/Total cyanide, mg/L	0.1/1	—	ND
Phenol, mg/L	0.5	—	ND

— = no value available; BOD_5 = biochemical oxygen demand after 5 days; ND = no data

Since the NGL Plant discharge will meet the World Bank Group guidelines and will achieve dilution once discharged into the river, the intensity of potential impacts on riverine water quality from discharge of NGL Plant wastewater effluents is considered **Negligible** during the Operations stage. The NGL Plant discharge will be intermittent, yielding an **Episodic** frequency rating. The NGL Plant will be operational for more than 1 year, so the duration is considered **Long-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on is rated as **Negligible.**

Sensitivity of Resource—Riverine Water Quality

Based on the sensitivity rating definitions in Table 7.4-17, the resource sensitivity for riverine waters is based on the aquatic biota community in the Demerara River, the waterbody potentially impacted by the planned activities. A study of the fish in the lower Demerara River (see Appendix H, Ichthyofaunal Assessment of the Gas to Energy Project Sites) concluded that despite the turbid nature of the Demerara River, the river provides suitable habitats for numerous fish species, all of which are considered habitat generalists. See Section 8.4, Freshwater Biodiversity, for a more detailed listing of the species present in Guyana's riverine waters and diversity metrics. None of the species documented are considered rare or disturbance-sensitive. Because a wide variety of generalists and disturbance-tolerant species inhabit the Demerara River, the sensitivity rating for riverine waters is **Low.**

Pre-mitigation Impact Significance—Riverine Water Quality

Assuming implementation of the embedded controls listed in Table 7.4-22, the intensity ratings for potential Project impacts on riverine water quality range from **Negligible** to **High**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small.** Coupled with a sensitivity rating of **Low**, the pre-mitigation impact significance for potential impacts on riverine water quality is **Negligible.**

7.4.4. Impact Management and Monitoring Measures

7.4.4.1. Marine Water Quality

Based on the **Negligible** significance of potential impacts on marine water quality, no mitigation measures are proposed. It is noted, however, that the limited significance of potential impacts on marine water quality are supported by a suite of embedded controls related to discharge management (see summary in Chapter 15, Commitment Register). Table 7.4-21 summarizes the management and monitoring measures relevant to marine waters.

Table 7.4-21: List of Management and Monitoring Measures—Marine Water Quality

Embedded Controls
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. Consider the Offshore Chemical Notification Scheme (CEFAS 2019) as a resource for chemical selection. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of material safety data sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Using the minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.

7.4.4.2. Riverine Water Quality

Based on the **Negligible** significance of potential riverine waters, no mitigation measures are proposed. It is noted, however, that the limited significance of potential impacts on riverine water quality impacts are supported by a suite of embedded controls related to discharge management (see summary in Chapter 15, Commitment Register). Table 7.4-22 summarizes the management and monitoring measures relevant to riverine waters.

Table 7.4-22: List of Management and Monitoring Measures—Riverine Water Quality

Embedded Controls
Monitor and manage excess overflow from dredging hopper to ensure efficiency and reduce turbidity.
Monitor and manage suction rate for dredger to improve efficiency and reduce turbidity.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. Consider the Offshore Chemical Notification Scheme (CEFAS 2019) as a resource for chemical selection. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of Safety Data Sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Using the minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Monitoring Measures
Conduct routine inspections to confirm the sanitary wastewater treatment plant is working according to design specifications and monitor effluent quality regularly.
Conduct routine inspections to confirm that the process wastewater treatment plant is working according to design specifications and monitor effluent quality regularly.

7.4.5. Assessment of Residual Impacts

7.4.5.1. Marine Water Quality

As described above, no mitigation measures are proposed to address potential impacts on marine water quality. Accordingly, the residual impact significance ratings remain unchanged at **Negligible.**

Table 7.4-23 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on marine water quality.

7.4.5.2. Riverine Water Quality

As described above, no mitigation measures are proposed to address potential impacts on riverine water quality. Accordingly, the residual impact significance ratings remain unchanged at **Negligible.**

Table 7.4-24 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on riverine water quality.

Table 7.5-23: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Water Quality

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Increase in TSS in the water column from the resuspension and transport of sediments during burial of the offshore pipeline and completion of the HDD shore crossing (potential indirect impact on marine biota)	Low	Small	Negligible	None	Negligible
	Offshore release of water treatment chemicals used in hydrotesting (potential indirect impact on marine biota)	Low	Negligible to Small	Negligible	None	Negligible

Table 7.4-24: Summary of Potential Pre-Mitigation and Residual Impacts—Riverine Water Quality

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Increase in TSS concentrations in the water column from the resuspension and transport of sediments during dredging (potential indirect impact on biota)	Low	Small	Negligible	None	Negligible
	Release of chemicals used in hydrotesting into river (potential indirect impact on marine biota)	Low	Negligible to Small	Negligible	None	Negligible
Operations	Release of constituents in NGL Plant effluents into river (potential indirect impact on marine biota)	Low	Negligible	Negligible	None	Negligible

7.5. Sound and Vibration

This section presents a discussion of the existing sound and vibration conditions within the Project area, a summary of Guyana and international sound and vibration standards to which the Project will adhere, and an assessment of potential Project impacts relating to sound and vibration.

7.5.1. Baseline Methodology

The terms noise and sound are often used interchangeably. Sound is energy created by vibrations; when an object vibrates, it causes the surrounding air particles to vibrate, resulting in sound waves. An individual within range of the vibrations (i.e., sound waves) hears the sound. Noise is a class of sounds that are generally considered "unwanted," and in some situations, noise can adversely affect the health and/or well-being of exposed individuals.

The standard unit of sound measurement is the decibel (dB). The dB scale is a measure used to quantify sound power or sound pressure. In air, sounds are often weighted to reflect higher hearing sensitivity at particular frequencies (i.e., to reflect how the human ear perceives sound). The A-weighted scale (measured in units of dBA) is a common scale that was developed to allow sound-level meters to simulate the frequency sensitivity of human hearing. Since noise levels can vary over a given period, they are evaluated using various descriptors, such as the equivalent sound level (L_{eq}), which is an average of the time-varying sound energy for a specified period; the day-night sound level (L_{dn}), which is an average of the time-varying sound energy for one 24-hour period, with an artificial 10 dB addition to the sound energy for the time between 10 p.m. and 7 a.m. to account for increased noise sensitivity during nighttime hours; and the maximum sound level (L_{max}), which is the maximum sound level during a measurement period or noise event. The human ear's threshold perception is generally considered to be 3 dBA for noise change; a 5 dBA increase is generally considered to be "readily noticeable"; and a 10 dBA increase is generally perceived as a doubling of noise (USDOT 1995).

The study of the Project area's existing sound and vibration conditions was divided into two main phases: a desktop phase and a field data collection phase. The desktop phase included a review of aerial imagery to determine the locations of noise/vibration-sensitive resources within or near the Direct AOI. The field data collection phase included the collection of baseline noise data at select locations to characterize existing sound levels.

Vibration is defined as regularly repeated movement of a physical object about a fixed point. No existing vibration data were collected because no significant anthropogenic or natural sources of vibration were identified within or near the Direct AOI.

7.5.2. Applicable Standards

This section describes the standards identified for the purpose of assessing the Project's potential sound (noise) and vibration impacts. The standards include those that derive from Guyana regulations as well as those adopted by the Project from international criteria.

7.5.2.1. Noise Standards

Guyana Noise Standard

Guyana's Environmental Protection Noise Management Regulations 2000 establish regulations for noise management from various activities including construction, transport, industry, commerce, and other institutions. Pursuant to these regulations, the EPA, along with the Guyana National Bureau of Standards developed Guidelines for Noise Emissions into the Environment (GNBS 2010). Emissions to the environment must comply with the limits specified in Table 7.5-1. The categories applicable to the Project are construction and industrial activities, during the Construction and Operations stages of the Project, respectively.

Table 7.5-1: Guyana Guideline Values for Noise in Specific Environments

Receptor Categories	Daytime Limits in dBA [a]	Nighttime Limits in dBA [b]
Residential	75	60
Institutional	75	60
Educational	75	60
Industrial	100	80
Commercial	80	65
Construction	90	75
Transportation	100	80
Recreational	100	100 (6:00 p.m. to 1:00 a.m.) 70 (1:00 a.m. to 8:00 a.m.)

Source: GNBS 2010

dBA = A-weighted decibel
[a] Daytime: 6:00 a.m. to 6:00 p.m.
[b] Nighttime: 6:00 p.m. to 6:00 a.m. unless otherwise indicated (i.e., for recreational)

World Health Organization

The World Health Organization's *Guidelines for Community Noise* (WHO 1999) are health-based guidelines that incorporate various noise guidance as part of a framework for noise management. The guidelines recommend internal and external noise levels that will prevent detrimental effects on workers or the public, including:

- To protect the majority of people from serious annoyance during the daytime, the noise level on balconies, terraces, and outdoor living areas should not exceed 55 dB A-weighted equivalent sound level (LA_{eq}) for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor noise level should not exceed 50 dB LA_{eq}.
- At night, noise levels at the outside façades of living spaces should not exceed 45 dB LA_{eq} and 60 dB A-weighted maximum sound level (LA_{max}), so that people can sleep with bedroom windows open.

International Finance Corporation

The International Finance Corporation (IFC) Environmental Health and Safety Guidelines – Noise Management document (IFC 2007) establishes the following noise impact guidelines:

- A source should not exceed a daytime 1-hour equivalent sound level (LA_{eq}) of 55 dBA or nighttime LA_{eq} of 45 dBA at residential, institutional, or educational receptors.
- Noise impacts should not exceed or result in a maximum increase in background levels of 3 dB at the nearest off-site receptor.

The IFC Noise Management document was used to guide field-based noise monitoring. The IFC guidelines suggest that noise monitoring programs be conducted over a 48-hour period using continuous data logging, or hourly covering different periods within several days, including weekend and workdays; however, these recommendations may be adapted based on local conditions and the type of noise being monitored. The IFC guidelines further suggest that noise monitors be located approximately 1.5 meters above the ground and no closer than 3 meters to any reflecting surface (e.g., walls). The document recommends that highly intrusive noises, such as noise from aircraft flyovers and passing trains, should not be included when establishing background noise levels (IFC 2007).

7.5.2.2. Vibration Standards

No applicable international standards for assessment of vibration impacts were identified. The IFC Performance Standards include vibration in their definition of "pollution"; however, no vibration standards have been established by the IFC.

7.5.3. Existing Conditions and Baseline Studies

7.5.3.1. Characterization of Baseline Noise Conditions

Some of the Project's onshore components (e.g., the onshore pipeline and the NGL Plant) are near populated areas, so these areas have the potential to be affected by Project construction and operation noise. The onshore pipeline will pass near the communities of Vreed-en-Hoop, Onderneeming, Westminster, La Parfaite Harmonie, Best Village, Bordeaux, Resource, and Nismes; the NGL Plant is near the village of Free and Easy and some other areas with residences (see Table 5.1-2, Communities Located near the Onshore Pipeline). Other land uses within or near the Direct AOI include undeveloped land, agriculture, residential, and transportation corridors.

Noise measurements were taken to establish baseline conditions. The goal of this exercise was to identify the existing baseline sound levels at selected onshore locations in the vicinity of proposed Project components or activities. Offshore noise concerns for human receptors are generally limited to potential occupational health and safety impacts on workers—which are addressed through EEPGL's occupational health and safety management system and are outside of the scope of the EIA. No other fixed-location offshore human receptors were identified in proximity to the offshore pipeline; accordingly, no offshore baseline noise measurements were collected. Offshore pipeline construction activities in the nearshore segment of the pipeline (i.e., at the seaward end of the shore crossing) will generate offshore noise that could result in onshore noise impacts. However, the nearest residence to an offshore construction vessel at the shore landing will be on the order of 1 kilometer away, so a baseline noise monitoring location was not established near the shore landing.

Existing ambient noise sources were anticipated to be vehicular traffic along roadways, human activity in residential areas, noise from agricultural activities, and natural sources such as wind and wildlife.

Baseline Noise Monitoring Locations

To identify potential noise-sensitive areas relevant to the Project, a desktop assessment involving review of aerial imagery was conducted. Potential noise-sensitive receptors were mapped within 0.8 kilometer of the onshore pipeline corridor and within 1.6 kilometers of the proposed aboveground facilities (NGL Plant, worker camp, temporary MOF site, and along the primary access road to the NGL Plant). Monitoring locations were determined based on proximity to the planned construction and operational noise-generating areas, representative locations for residential areas in proximity to the Project, and field accessibility. An overview of the Project area and proposed baseline noise monitoring locations is presented on Figure 7.5-1.

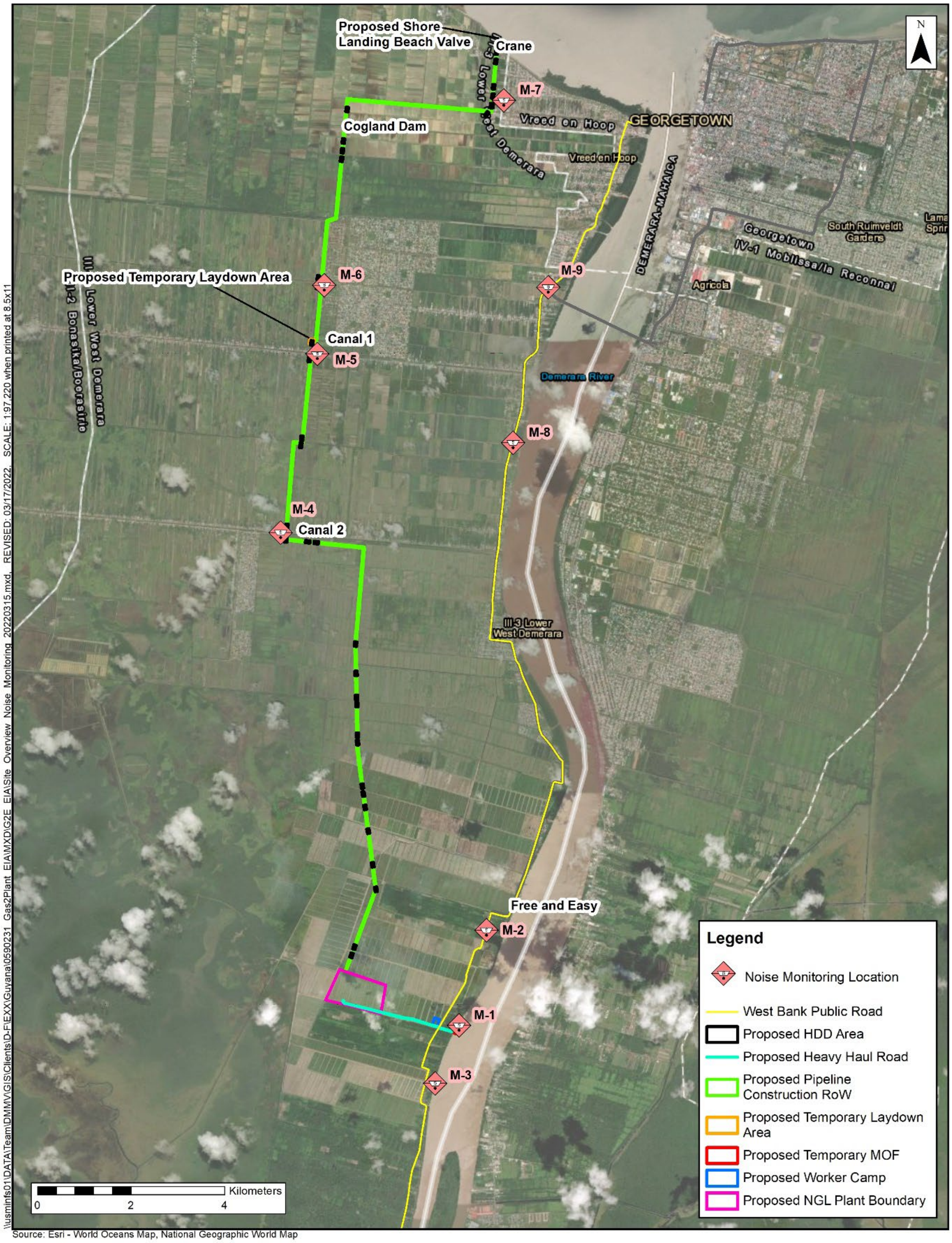


Figure 7.5-1: Baseline Noise Monitoring Locations

Table 7.5-2 presents the coordinates for the baseline noise monitoring locations presented on Figure 7.5-1 along with a description of the location and its relationship to the areas of Project components or activities. The monitoring locations were divided into short-term monitoring locations and long-term monitoring locations.

Table 7.5-2: Proposed Baseline Noise Monitoring Locations

Location ID	Description	Latitude	Longitude
Long-term Monitoring Location			
M-1	Residences near main camp/temporary MOF	6.634867	-58.217230
M-2	Free and Easy village residences along West Bank of Demerara Public Road	6.656710	-58.207210
M-3	Other residences near NGL Plant boundary	6.623939	-58.219916
Short-term Monitoring Locations			
M-4	Canal 2, residences along canal near onshore pipeline	6.729899	-58.248433
M-5	Canal 1, residences along canal near onshore pipeline	6.764683	-58.241159
M-6	Parfaite Harmonie Backlands residences near onshore pipeline	6.778178	-58.239957
M-7	Best Village residences near onshore pipeline	6.813888	-58.205403
M-8	West Bank of Demerara Public Road (along primary public road to be used for access to NGL Plant)	6.747726	-58.203725
M-9	Demerara Harbour Bridge (along primary public road to be used for access to NGL Plant)	6.777849	-58.196734

Measurement Schedule/Duration

With the exception of M-1 and M-3, which could not be accessed to during the field data collection effort, baseline noise measurements were collected at each of the above-referenced measurement locations on the following schedules/durations:

Long-term Monitoring Locations

- One 48-hour measurement

Short-term Monitoring Locations

Four 1-hour monitoring periods:

- One daytime hour on a weekday
- One nighttime hour on a weekday
- One daytime hour on a weekend
- One nighttime hour on a weekend

Measurements were not conducted during periods of rain or when average winds exceeded 20 kilometers per hour, as this can generate misleading data. Long-term monitoring locations were selected to include areas near Project components that will result in operational noise or longer-term construction activities in proximity to noise-sensitive areas (e.g., NGL Plant, temporary MOF). Short-term monitoring locations were selected to include areas near Project components where primarily short-term construction activities will occur in proximity to noise sensitive areas (e.g., onshore pipeline).

Results

The results below summarize the findings of the baseline noise study. A detailed baseline noise report is included in Appendix I, Baseline Noise Monitoring Report.

Average daytime, nighttime, and day-night sound levels calculated from measurements collected during the baseline noise monitoring event are presented in Table 7.5-3. Baseline average daytime sound levels ranged from 35.4 to 67.5 dBA at the monitoring locations. Baseline average nighttime sound levels ranged from 44.7 to 64.9 dBA at these locations. The ambient day-night sound levels (L_{dn})—which include an artificial 10 dB addition to nighttime sound levels to account for greater sensitivity to noise at night—ranged from 50.4 to 70.1 dBA at these locations. Sound levels were higher during the day than at night at most of the monitoring locations, with the exception of M-2, M-4, and M-6. The highest average daytime sound level (67.5 dBA) occurred at M-9—near the Demerara Harbour Bridge—driven by the high traffic volume on the bridge throughout the day (Table 7.5-3).

Table 7.5-3: Day, Night, and Day-Night (L_{dn}) Average Sound Levels at Noise Monitoring Locations

		Sound Levels (dB)		
Location ID	Measurement Type	Day Average Sound Level	Night Average Sound Level	L_{dn}
M-1	48-hour	NM	NM	NM
M-2	48-hour	62.4	64.9	69.0
M-3	48-hour	NM	NM	NM
M-4	Weekday	61.1	63.0	61.9
	Weekend	61.6	61.1	61.4
	Average	61.4	62.0	61.6
M-5	Weekday	63.3	59.7	62.3
	Weekend	61.8	61.1	61.4
	Average	62.6	60.4	61.8
M-6	Weekday	35.4	56.2	52.0
	Weekend	55.1	55.5	55.3
	Average	45.2	55.8	53.6
M-7	Weekday	56.5	54.3	55.8
	Weekend	65.0	64.7	64.9
	Average	60.8	59.5	60.4
M-8	Weekday	57.7	52.8	56.4
	Weekend	52.0	44.7	50.4
	Average	54.8	48.8	53.4
M-9	Weekday	67.5	64.3	70.1

NM = Not measured; measurement location was not accessible during field activities

Additional details for the baseline noise monitoring event are presented in Appendix I, Baseline Noise Monitoring Report, including minimum and maximum sound levels observed during each monitoring period. The baseline data summarized in this section were used to assess the potential noise-related impacts Project construction and operation could have on human receptors in proximity to the Project area.

7.5.4. Impact Prediction and Assessment

This section discusses the potential sound and vibration impacts of planned activities of the Project. The relevant planned Project activities and the associated potential sound and vibration impacts of these activities are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

7.5.4.1. Relevant Project Activities and Potential Impacts

The Project will generate sound (noise)[10] and vibration during the Construction, Operations, and Decommissioning stages. Impacts to biological resources related to underwater noise (i.e., from construction and vessel activity in the marine and riverine environment) are addressed in Section 8.2, Marine and Coastal Biodiversity (marine resources) and Section 8.4, Freshwater Biodiversity (riverine resources). Accordingly, this section is focused on potential impacts related only to airborne noise. There will be no overwater human receptors (other than individuals on passing vessels) located in proximity to marine or riverine construction activities; accordingly, potential impacts from airborne noise on overwater human receptors associated with in-water activities in the marine and riverine environments are not further assessed in this section. Airborne noise from marine or riverine construction activities may be perceptible at the shoreline as a result of in-water construction activities conducted near the coastal or riverine shoreline (i.e., at the temporary MOF or shore crossing); however, there are no residences located in close proximity to these locations, so potential impacts from these nearshore in-water activities are not discussed further herein.

Further, this section focuses on potential noise-related impacts to non-Project receptors (i.e., community receptors). Noise-related occupational health aspects applicable to Project workers are outside of the scope of the EIA, and will be addressed by the occupational health and safety protocols that will be put in place by EEPGL and its contractors.

With respect to vibration, no blasting is planned associated with construction of the Project. Operation of construction equipment may generate a small amount of ground-borne vibration in close proximity to the construction area; however, due to the temporary nature of construction activities, no perceptible ground-borne vibration is anticipated beyond the immediate construction area. Operation of the onshore pipeline will result in no ground-borne vibration. Operation of the NGL Plant may generate a small amount of ground-borne vibration in close proximity to the process equipment units; however, no perceptible ground-borne vibration is anticipated beyond the NGL Plant boundaries. Because the Project will not be a source of

[10] GYS 263:2010 defines noise as unwanted sound which may cause or tend to cause an adverse psychological effect on human beings. For the purpose of this section, the term “noise” is therefore used with respect to potential impacts of changes in sounds levels as a result of the Project.

significant ground-borne vibration outside the Project footprint, potential vibration-related impacts are not further assessed.

Table 7.5-4 summarizes the planned Project activities that could result in potential airborne sound (noise) impacts.

Table 7.5-4: Summary of Relevant Project Activities and Key Potential Impacts—Airborne Sound

Stage	Project Activity	Key Potential Impacts
Construction	Installation of the onshore pipeline; construction of the NGL Plant, heavy haul road, and temporary MOF	Increases in noise levels at sensitive receptor locations
Operations	Operations of NGL Plant and associated generation of noise from continuously operating and intermittently operating equipment	Increases in noise levels at noise sensitive receptor locations
Decommissioning	Decommissioning of NGL Plant facilities	Increases in noise levels at noise sensitive receptor locations

7.5.4.2. Impact Assessment Methodology—Airborne Noise

For most resources assessed in the EIA, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource.

For noise, however, the approach taken is to predict noise levels quantitatively and compare them against standards that inherently take into account resource sensitivity. Rather than applying a two-dimensional matrix for noise impact significance, the process for noise instead considers the type of receptor (e.g., residential), and draws on the relevant standards to directly determine impact significance.

Guyana noise standards are presented in Table 7.5-1. Because the receptors with the potential to be impacted by Project-related noise are of a residential nature, the residential receptor category was used to establish the basis by which significance is rated. Table 7.5-5 includes the significance criteria applied to construction-related Project noise based on these standards. The duration of construction noise is accounted for by applying variable noise thresholds to assess impact significance.

For short-term to medium-term Construction stage exposure, significance criteria are established such that:

- **Negligible** significance corresponds to a predicted noise level 5 dBA below the residential receptor criteria;
- **Minor** significance corresponds to a predicted noise level up to the residential receptor criteria;
- **Moderate** significance corresponds to a predicted noise level up to 5 dBA higher than the residential receptor criteria; and

- **Major** significance corresponds to a predicted noise level more than 5 dBA higher than the residential receptor criteria.

For long-term Construction stage exposure, significance criteria are reduced by 5 dBA for each level of significance, such that a **Negligible** significance corresponds to a level 10 dBA below the residential receptor criteria and a **Major** significance corresponds to a level at the residential receptor criteria.

Table 7.5-5: Significance Criteria for Construction Stage Noise

Construction	Daytime Noise Levels $L_{eq,\ 1hour}$ (dBA)				Nighttime Noise Levels $L_{eq,\ 1hour}$ (dBA)			
Significance Rating:	**Negligible**	**Minor**	**Moderate**	**Major**	**Negligible**	**Minor**	**Moderate**	**Major**
Short term exposure <1 month	<70	70-75	75-80	>80	<55	55-60	60-65	>65
Medium term exposure 1–6 months	<70	70-75	75-80	>80	<55	55-60	60-65	>65
Long term exposure > 6 months	<65	65-70	70-75	>75	<50	50-55	55-60	>60

Leq, 1 hour = statistical noise descriptor that represents the equivalent continuous sound pressure level over a 1-hour period; < = less than; > = greater than

For Operations stage activities, a similar matrix for impact significance has been developed (Table 7.5-6) that is also based on Guyana noise standards as presented in Table 7.5-1. The significance levels used for Operations stage exposure are set equal to the levels associated with long-term exposure for the Construction stage. Additionally, to address situations where ambient levels are low or open space areas have high amenity value, an additional criterion is applied to assess noise impact based on increase above existing baseline. The World Health Organization (WHO) states that a 3 dB increase in sound level is just perceptible to the human ear, a 5 dB increase is clearly noticeable, and a 10 dB increase is perceived as a doubling of the sound level (WHO 1999). These sound increases were used to develop additional significance criteria for projected Operations stage noise increases above baseline levels.

Table 7.5-6: Significance Criteria for Operations Stage Noise

Operations	Daytime Noise Levels $L_{eq,\ 1hour}$ dBA				Nighttime Noise Levels $L_{eq,1hour}$ dBA			
Significance Rating:	**Negligible**	**Minor**	**Moderate**	**Major**	**Negligible**	**Minor**	**Moderate**	**Major**
Project-contributed Noise Level	<65	65-70	70-75	>75	<50	50-55	55-60	>60
Incremental Increase above Background Levels (Leq, 1-hour)	<3	3-5	5-10	>10	<3	3-5	5-10	>10

$L_{eq,\ 1\ hour}$ = statistical noise descriptor that represents the equivalent continuous sound pressure level over a 1-hour period; < = less than; > = greater than

7.5.4.3. Airborne Noise Modeling

Construction Stage Airborne Noise Modeling

The U.S. Federal Highway Administration (FHWA) *Roadway Construction Noise Model* [RCNM] *User's Guide*, Final Report (FHWA 2006) was used to estimate noise emissions from construction equipment and activities using information from its construction noise database. The noise levels listed in the database represent the L_{max}, measured at a distance of 15.2 meters from the construction equipment. The RCNM also uses an "acoustical usage factor" to estimate the fraction of time each piece of construction equipment is operating at full power (i.e., its loudest condition) during a construction activity. The RCNM provides a construction noise screening tool to predict construction noise levels and to determine compliance with noise limits for a variety of construction projects of varying complexity.

Construction stage activities were divided into phases to assess potential impacts during various portions of the Construction stage. For the onshore pipeline, the construction phases assessed included clearing/RoW preparation, construction along the RoW, and backfilling. HDD activities were also assessed as a separate activity. For the NGL Plant, the construction phases assessed included clearing, cut, and fill. Pile-driving activities for the NGL Plant site were also assessed as a separate activity.

Specific details of the Construction stage are not yet finalized. This assessment has therefore been based upon preliminary estimates of likely construction activities, equipment selection, and use. Noise data for individual construction equipment (in terms of source L_{max} at 15.2 meters) were taken from the FHWA RCNM User's Guide (FHWA 2006) as presented in Table 7.5-7. Construction has been assumed to occur for 10 hours per day during daytime hours, with the exception of HDD activities. The majority of HDD crossings will occur during daytime hours; however, the HDD activity that could potentially need to be conducted at night is the pull-back (which needs to be completed once it is started to avoid the borehole closing). The duration of exposure for a residential structure during nighttime HDD activities would be expected to be less than one night (and likely no more than a few hours). In addition, the potential exists for a 24/7 operation associated with aggregate unloading near the NGL Plant site to avoid tidal restrictions prior to full dredging scope being completed. This activity, if needed, would generate increased minor noise levels on a restricted footprint (excavator at barge and trucks from barge to laydown area), similar in scope to pipeline backfill activities. The predicted extents of Project-related airborne noise levels at various distances from the construction activities for each construction phase are presented in Table 7.5-8. Predicted sound levels associated with construction of the onshore pipeline and NGL Plant at noise monitoring locations in proximity to each Project component are presented in Table 7.5-9 and Table 7.5-10. Detailed calculations are included in Appendix J, Construction Noise Calculations.

Table 7.5-7: Representative Construction Equipment and Estimated Maximum Sound Levels at 15.2 Meters

Construction Component/Phase	Number of Units	Acoustical Use Factor [a] (%)	L_{max} Spec. at 15.2 meters [a]
Non-road Construction Equipment—NGL Plant [a]			
Phase 1—Clearing			
555D Skidder Tractor	1	50	85
Tigercat 720G Wheel Feller Buncher	1	50	85
586 C Tractor w/ HM825 Grinder	1	50	89
D6 Dozer w/ Winch	1	50	85
CAT 320 Excavator w/ Thumb Attachment	1	50	85
730 Dump Truck	3	50	88
Phase 2—Cut			
730 Dump Truck	19	50	88
D6 Dozer	2	50	85
CAT 320 Excavator	3	50	85
Phase 3—Fill			
730 Dump Truck	19	50	88
D6 Dozer	3	50	85
CAT 320 Excavator	3	50	85
CAT 815K Sheep's Foot Compactor	5	50	82
Barrell/Smooth Drum Compactor	2	50	82
Pile-driving			
Impact Hammer [c]	3	50	101
Non-road Construction Equipment—Onshore Pipeline [a]			
Phase 1—Clearing/RoW			
555D Skidder Tractor	1	50	85
Tigercat 720G Wheel Feller Buncher	1	50	85
586 C Tractor w/ HM825 Grinder	1	50	89
D6 Dozer w/ Winch	1	50	85
CAT 320 Excavator w/ Thumb Attachment	1	50	85
730 Dump Truck	1	50	88
Phase 2—Construction along RoW			
Pipe Bending Machine	1	50	85
Manual Welding Station	3	50	85
X-Ray Station	1	50	85
Joint Coating Station	2	50	85
Side booms	3	50	83
Phase 3—Backfill [a]			
D6 Dozer	1	50	85
CAT 320 Excavator	1	50	85
CAT 815K Sheep's Foot Compactor	1	50	82
HDD Activity [b]			
HDD Entry Point Equipment	1	100	83

[a] FHWA 2006
[b] Conservatively assumed HDD entry point equipment at each HDD location, which generates more noise than HDD exit point equipment (Burge and Kitech 2009).
[c] Conservative assumption; the Project may use drilled piles (using an excavator with driving head) in lieu of impact hammer-driven piles. This would result in lower noise levels (similar to those of a CAT 320 Excavator).

Table 7.5-8: Extent of Project-Related Airborne Noise Levels during Construction Stage

Construction Component/Phase [a]	Predicted Distance to Various Impact Thresholds for Construction Stage (meters) (Daytime / Nighttime)						
	Distance to Negligible Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [b]	Distance to Minor Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [b]	Distance to Moderate Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [b]	Distance to Major Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [b]	Duration	Potential Daytime Activity	Potential Nighttime Activity
NGL Plant							
Phase 1—Clearing	>380 / NA	215–380 / NA	68–215 / NA	<68 / NA	Long term	Yes	No
Phase 2—Cut	>705 / NA	395–705 / NA	125–395 / NA	<125 / NA	Long term	Yes	No
Phase 3—Fill	>740 / NA	415–740 / NA	132–415 / NA	<132 / NA	Long term	Yes	No
Pile-driving	>1180 / NA	660–1180 / NA	210–660 / NA	<210 / NA	Long term	Yes	No
Onshore Pipeline							
Phase 1—Clearing/RoW	>177 / NA	99–177 / NA	56–99 / NA	<56 / NA	Short term	Yes	No
Phase 2—Construction along RoW	>180 / NA	102–180 / NA	57–102 / NA	<57 / NA	Short term	Yes	No
Phase 3—Backfill	>96 / NA	54–96 / NA	30–54 / NA	<30 / NA	Short term	Yes	No
HDD Activity	>65 / >295	38–65 / 184–295	22–38 / 111–184	<22 / <111	Short term	Yes	Yes

NA = not applicable; < = less than; > = greater than
[a] With the potential exception of HDD activities, no nighttime construction is planned; therefore, distances to nighttime noise thresholds are only shown for HDD activities.
[b] Based on impact thresholds defined in Table 7.5-5. Detailed calculations are included in Appendix J, Construction Noise Calculations.

Table 7.5-9: Predicted Construction Stage Noise Levels at Baseline Monitoring Locations—Onshore Pipeline

Construction Component/Phase	Predicted Noise Levels and Measured Background at Baseline Monitoring Locations for Construction Stage							
	M-4		M-5		M-6		M-7	
	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]
Onshore Pipeline								
Phase 1—Clearing/RoW	70.9 / NA	61.4 / 62.2	70.1 / NA	62.6 / 60.4	74.9 / NA	55.1 / 55.5	67.7 / NA	60.8 / 59.5
Phase 2—Construction along RoW	71.1 / NA	61.4 / 62.2	70.3 / NA	62.6 / 60.4	75.1 / NA	55.1 / 55.5	67.9 / NA	60.8 / 59.5
Phase 3—Backfill	65.5 / NA	61.4 / 62.2	64.8 / NA	62.6 / 60.4	69.6 / NA	55.1 / 55.5	62.4 / NA	60.8 / 59.5
HDD Activity	65.1 / 65.1	61.4 / 62.2	62.7 / 62.7	62.6 / 60.4	71.6 / 71.6	55.1 / 55.5	58.3 / 58.3	60.8 / 59.5

NA = not applicable
[a] With the potential exception of HDD activities, no nighttime construction is planned; therefore, predicted nighttime noise levels are only shown for HDD activities. Detailed calculations are included in the Appendix J, Construction Noise Calculations.
[b] Baseline daytime and nighttime sound levels are based on measured data, as detailed in the Appendix I, Baseline Noise Monitoring Report.

Table 7.5-10: Predicted Construction Stage Noise Levels at Baseline Monitoring Locations—NGL Plant

Construction Component/Phase	Predicted Noise Levels and Measured Background at Baseline Monitoring Locations for Construction Stage					
	M-1		M-2		M-3	
	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]	Predicted Daytime/Nighttime Noise at Location (dBA L_{eq}) [a]	Measured Daytime/Nighttime Baseline (dBA L_{eq}) [b]
NGL Plant						
Phase 1—Clearing	51.7 / NA	NM	48.8 / NA	62.4 / 64.9	51.0 / NA	NM
Phase 2—Cut	57.0 / NA	NM	54.1 / NA	62.4 / 64.9	56.4 / NA	NM
Phase 3—Fill	57.5 / NA	NM	54.6 / NA	62.4 / 64.9	56.8 / NA	NM
Pile-driving	61.5 / NA	NM	58.6 / NA	62.4 / 64.9	60.8 / NA	NM

hr = hour; m = meter; NM = not measured (location was not accessible during field survey)
[a] NA = not applicable. No nighttime construction is planned for the NGL Plant; therefore, no predicted nighttime noise levels are presented. Detailed calculations are included in Appendix J, Construction Noise Calculations.
[b] Baseline daytime and nighttime sound levels are based on measured data, as detailed in Appendix I, Baseline Noise Monitoring Report.

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Operations Stage Airborne Noise Modeling

Brüel & Kjaer's Predictor V2020.1 noise modeling software was used to estimate noise emissions from Operations stage activities using the methods identified in ISO 9613 Part 2 for the propagation of noise. The model incorporates identifiable noise source data, meteorological data, surrounding terrain characteristics, and barrier impacts of nearby buildings and structures. The model was used to estimate noise levels at various distances from the source in tabular and graphical (contours) formats. The model accounted for atmospheric absorption (assumed a temperature of 25°C and 60 percent relative humidity) and assumed meteorological conditions favorable[11] to sound propagation per ISO 9613 Part 2 (i.e., downwind propagation with wind speeds between 1 and 5 meters per second). Major noise-generating sources (e.g., pressure letdown station, coolers, compressors, etc.), with the exception of flares, were modeled on the assumption that each individual unit will generate a sound level of 85 dBA at 3 meters, representing the worst-case operating scenario for which worker hearing protection would not be required. Flares were modeled as point sources under the assumption of noise levels of 115 dBA at 3 meters. Receiver heights above ground levels were assumed to be 1.5 meters, and source heights were assumed to range from 4 to 120 meters aboveground. For this model analysis, it was conservatively assumed that the terrain is flat, there will be no barriers (e.g., dense foliage/ vegetation, earth berms, hills, etc.) that will block the direct noise transmission between noise sources and receivers, and the ground condition is "hard" (i.e., reflective).

Only the NGL Plant will generate Operations stage noise. The following are the key noise-generating equipment that will be operated at the NGL Plant:

- Pressure letdown station (continuous)
- Aerial coolers (continuous)
- Turbo expander module (continuous)
- Compressor modules (continuous)
- High-pressure drop valve (intermittent)
- Power generators (intermittent)
- Flare (intermittent)

Each piece of continuously operating equipment will be designed to operate at a sound level of 85 dB or less at 3 meters from the unit (e.g., pressure letdown station, coolers, compressors), with the exception of the flare and high-pressure drop valve, which will operate intermittently and will be designed to operate at a sound level of 115 dB or less at 3 meters from the unit. Two operational scenarios were modeled: a primary scenario (Scenario 1) with all continuous equipment operating, including power generators; and a secondary scenario (Scenario 2) with all continuous equipment operating, including power generators, and including the flare and the high-pressure drop valve.

[11] This is a conservative approach as not all receptors may be located downwind of the sources (i.e., receptors located upwind would experience less noise because noise propagates farther downwind than upwind).

The predicted extents of Operations stage Project-related airborne noise levels at various distances from the NGL Plant sources are presented in Table 7.5-11. Predicted sound levels associated with NGL Plant operational Scenarios 1 and 2 at noise monitoring locations near the NGL Plant are presented in Table 7.5-12 and Table 7.5-13. Figure 7.5-2 displays contour plots of modeled airborne noise levels for Operations stage Scenario 1. Figure 7.5-3 displays contour plots of modeled airborne noise levels for Operations stage Scenario 2.

Table 7.5-11: Extent of Project-Related Airborne Noise Levels during Operations Stage (NGL Plant)

Construction Component/Phase	Distance to Various Impact Thresholds for Operational Scenarios Phases from Airborne Noise Sources (meter)						
	Distance to Negligible Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [a]	Distance to Minor Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [a]	Distance to Moderate Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [a]	Distance to Major Significance Daytime Noise Level/Nighttime Noise Level ($L_{eq,}$ 1 hour) (meter) [a]	Duration	Daytime Activity	Nighttime Activity
NGL Plant							
Scenario 1—Continuous Sources	>460 / >1,210	307–460 / 893–1,210	205–307 / 634–893	<205 / <634	Long term	Yes	Yes
Scenario 2—Continuous and Intermittent Sources	>1,170 / >3,710	805–1,170 / 2,535–3,710	583–805 / 1,706–2,535	<583 / <1,706	Long term	Yes	Yes

NA = not applicable
[a] Based on impact thresholds defined in Table 7.5-5. Detailed calculations are included in the Appendix J, Construction Noise Calculations.

Table 7.5-12: Predicted Operations Stage Noise Impacts at Baseline Monitoring Locations (Scenario 1—Continuous Sources)

Receptor ID #	Project Operations Noise L_{eq} (dBA) [a]		Baseline Noise Level, L_{eq} (dBA) [b]		Project Noise + Baseline Noise Level, L_{eq} (dBA) [c]		Noise Increase Above Baseline Level, (dBA) [d]	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
M-1	40.1	40.1	62.4 [e]	64.9 [e]	62.4	64.9	0	0
M-2	28.7	28.7	62.4	64.9	62.4	64.9	0	0
M-3	35.3	35.3	62.4 [e]	64.9 [e]	62.4	64.9	0	0

NM = not measured (location was not accessible during field survey); NA = not applicable
[a] Predicted daytime and nighttime noise results obtained from Predictor V2020.1 noise modeling software. Detailed calculations are included in in the Appendix J, Construction Noise Calculations.
[b] Baseline daytime and nighttime sound levels are based on measured data, as detailed in Appendix I, Baseline Noise Monitoring Report.
[c] Project noise and baseline levels were added logarithmically to determine total noise levels.
[d] Noise increase above baseline levels = (Project noise + baseline levels) minus baseline levels
[e] M-2 baseline levels used as proxy values

Table 7.5-13: Predicted Operations Stage Noise Impacts at Baseline Monitoring Locations (Scenario 2—Continuous and Intermittent Sources)

Receptor ID #	Project Operations Noise L_{eq} (dBA) [a]		Baseline Noise Level, L_{eq} (dBA) [b]		Project Noise + Baseline Noise Level, L_{eq}, (dBA) [c]		Noise Increase Above Baseline Levels, (dBA) [d]	
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
M-1	56.2	56.2	62.4 [e]	64.9 [e]	63.3	65.4	0.9	0.5
M-2	50.2	50.2	62.4	64.9	62.7	65.0	0.3	0.1
M-3	53.5	53.5	62.4 [e]	64.9 [e]	62.9	65.2	0.5	0.3

NM = not measured (location was not accessible during field survey); NA = not applicable
[a] Predicted daytime and nighttime noise results obtained from Predictor V2020.1 noise modeling software. Detailed calculations are included in Appendix J, Construction Noise Calculations.
[b] Baseline daytime and nighttime sound levels are based on measured data, as detailed in Appendix I, Baseline Noise Monitoring Report.
[c] Project noise and baseline levels were added logarithmically to determine total noise levels.
[d] Noise increase above baseline levels = (Project noise + baseline levels) minus baseline levels
[e] M-2 baseline levels used as proxy values

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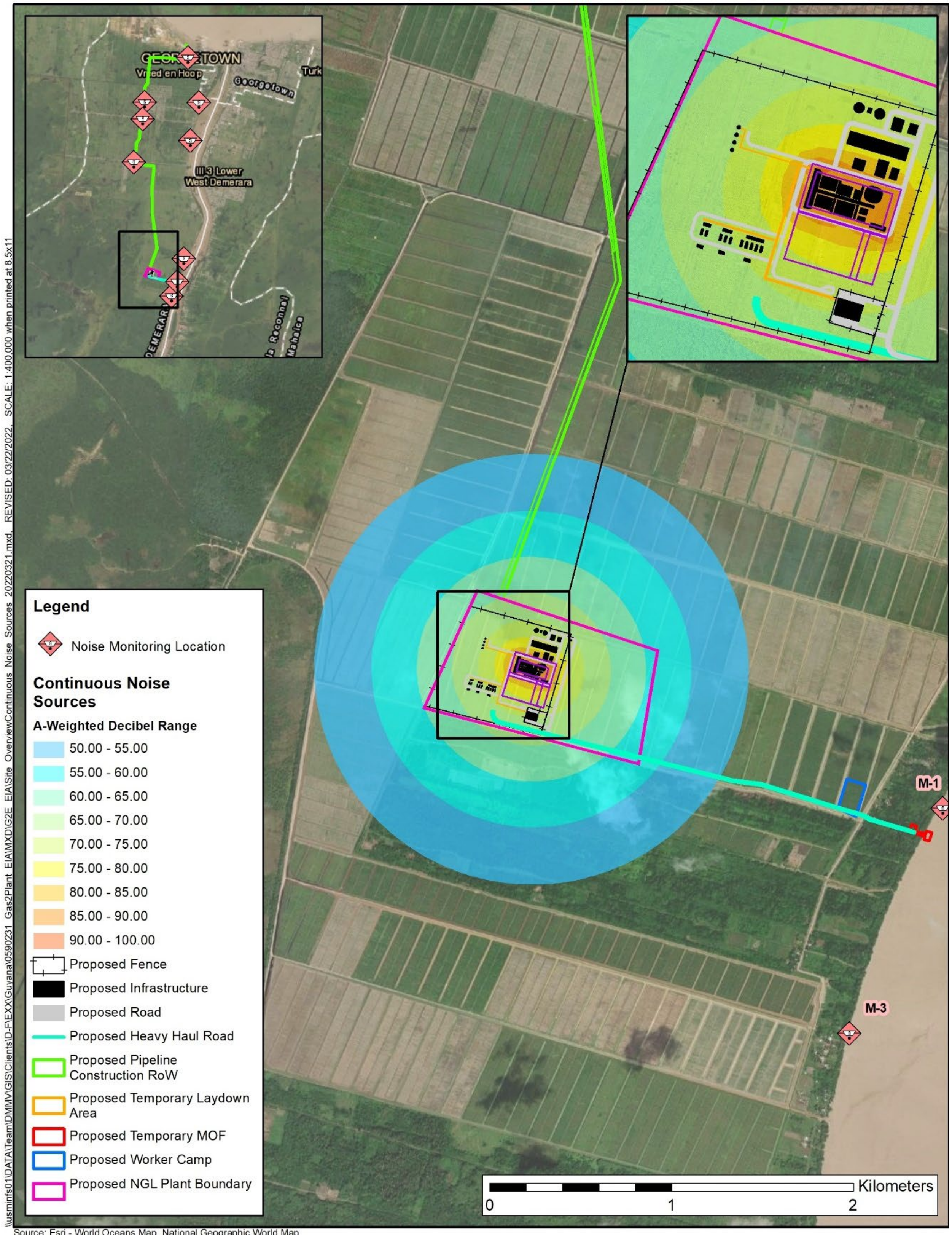

Figure 7.5-2: NGL Plant Operation Noise Contours—Scenario 1

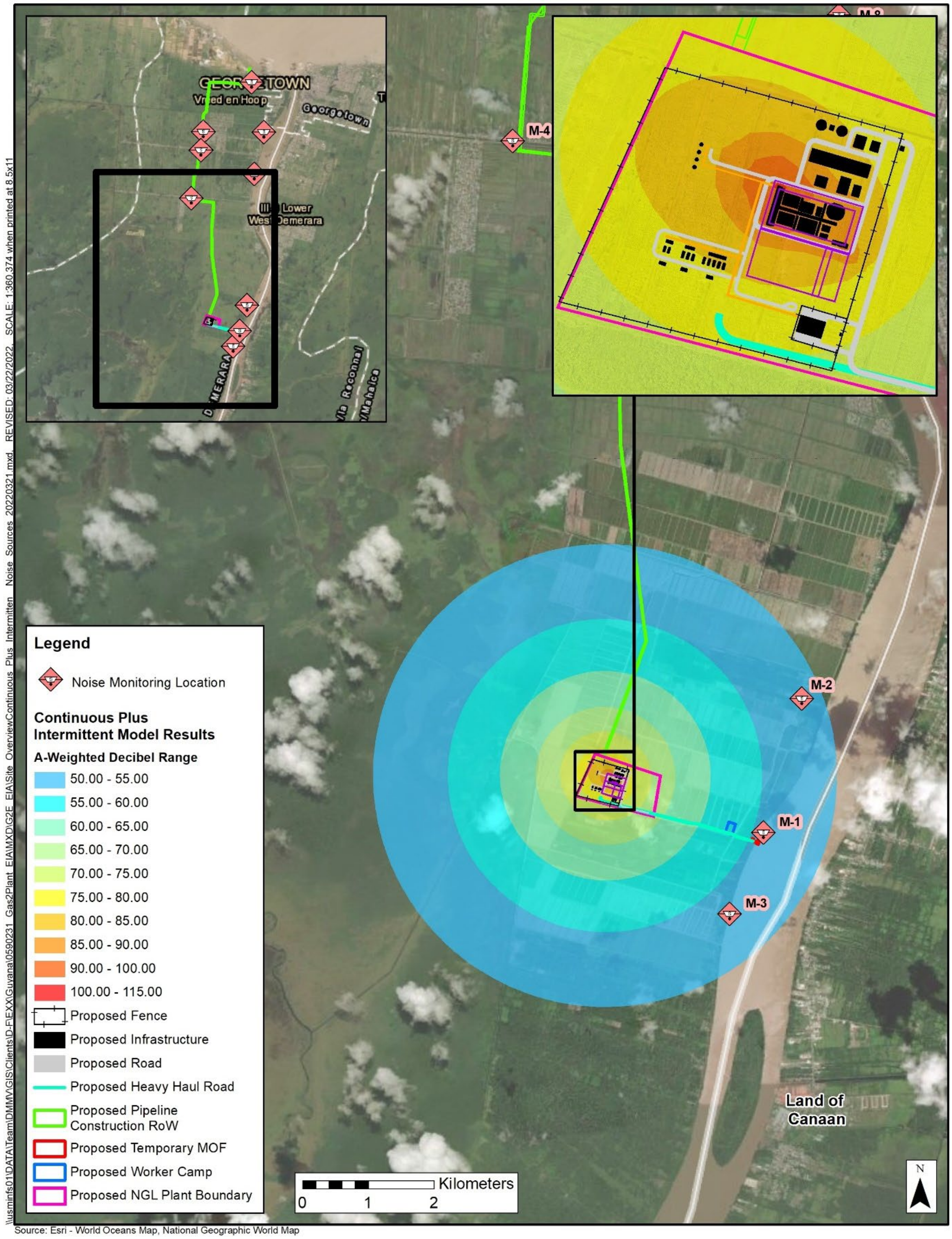

Figure 7.5-3: NGL Plant Operation Noise Contours—Scenario 2

7.5.4.4. Pre-Mitigation Impact Significance Ratings—Airborne Noise

Based on the results of the noise modeling described above, this section provides pre-mitigation impact significance ratings for noise impacts during the Construction and Operations stages. The pre-mitigation significance ratings reflect consideration of embedded controls that will be in place to reduce noise impacts. The key embedded controls that will be in place to reduce noise impacts during Construction and Operations stages include the following:

- Construction activities will be limited to daytime hours aside from infrequent instances in which a particular activity cannot be stopped mid-completion (e.g., the pull-back for an HDD boring).
- Onshore construction equipment, power generators, and vehicles will be maintained in accordance with manufacturer's specifications, to reduce generation of noise to the extent practicable.
- NGL Plant operational equipment will be designed so that in-plant sound levels in accessible areas do not exceed 85 dBA under normal operations or 115 dBA for emergency events and so that community and/or fenceline noise levels do not exceed applicable regulations.
- NGL Plant operational equipment will be subjected to routine maintenance in accordance with manufacturer's specifications.

Potential Increase in Airborne Noise Levels at Noise Sensitive Receptors during Construction Stage

Airborne noise levels associated with the Project Construction stage were predicted using the method described in Section 7.5.4.2, Impact Assessment Methodology—Airborne Noise. Based on the result of Construction stage noise level modeling, the distances from construction activities to the various significance thresholds are presented in Table 7.5-8 for each of the separate types of NGL Plant and onshore pipeline construction activities modeled. Geographic information system (GIS) mapping was then used to assess the number of potential residential structures located within each of the distance "bands" reflected in Table 7.5-8. Based on this mapping, the following conclusions are drawn:

- For NGL Plant construction activities, pile driving is the activity predicted to generate the highest noise levels of the various activities considered. Overlaying the modeled extents to the various significance thresholds from this activity indicates that there will be no potential residential structures predicted to be exposed to noise levels above a **Negligible** significance.
- For open trench onshore pipeline installation, the "Phase 2—Construction along RoW" activity is predicted to generate the highest noise levels of the three phases. Overlaying the modeled extents to the various significance thresholds indicates that there will be 38 potential residential structures predicted to be exposed to a **Major** level of noise exposure, 69 potential residential structures predicted to be exposed to a **Moderate** level of noise exposure, and 169 potential residential structures predicted to be exposed to a **Minor** level of noise exposure. These potential residential structures are located along the onshore

pipeline corridor predominantly between kilometer post (KP) 7.2 and KP 8.2 and between KP 8.5 and KP 9.1. Based on the estimated rate of progress for open-cut trenching (on the order of 80 meters per day), the noise level at a given residential structure would be expected to increase in significance as the pipeline construction operation approaches the structure at an approximate rate of one level per day until reaching the maximum level of noise exposure (i.e., when the pipeline construction operation was at its closest point to the structure), and then to decrease at the same rate. This operation will occur only during daytime hours.

- For HDD activities completed during daytime hours, overlaying the predicted extents to the various significance thresholds identifies between 0 and 8 potential residential structures distributed across four HDD segments that could be exposed to a **Minor** level of noise exposure, depending on the side of the HDD segment on which the HDD rig is positioned. Based on the length of the HDD segments and the estimated rate of progress for HDD activities, the duration of exposure for a given residential structure will be between 2 and 4 days.
- For HDD activities completed during nighttime hours (an infrequent instance, which will be avoided to the extent practicable), overlaying the predicted extents to the various significance thresholds identifies between 12 and 38 potential residential structures distributed across five HDD segments that could be exposed to a **Major** level of noise exposure; between 78 and 143 potential residential structures distributed across six HDD segments that could be exposed to a **Moderate** level of noise exposure; and between 245 and 304 residential structures distributed across seven HDD segments that could be exposed to a **Minor** level of noise exposure—in each case depending on the side of the HDD segment on which the HDD rig is positioned. The duration of exposure for a residential structure during nighttime HDD activities would be expected to be less than one night (and likely no more than a few hours), as the only phase of the HDD activity that could potentially need to be conducted at night is the pull-back (which needs to be completed once it is started to avoid the borehole closing). It is also noted that the HDD source noise levels on which modeling were based are for the louder portions of the HDD operation (initial boring operation), and the activities that would likely be the cause of nighttime operation would be the quieter portions of the HDD operation (pull-back). Accordingly, the modeling likely overestimates the noise that would be experienced for HDD nighttime activities.

Potential Increase in Airborne Noise Levels at Noise Sensitive Receptors during Operations Stage

Airborne noise levels associated with the Operations stage were predicted using the method described in Section 7.5.4.2, Impact Assessment Methodology—Airborne Noise. Based on the result of Operations stage noise level modeling, the distances from construction activities to the various significance thresholds are presented in Table 7.5-11 for the two modeled scenarios: Scenario 1—operation of all continuous noise sources, including power generators; and Scenario 2—operation of all continuous noise sources included in Scenario 1 as well as intermittent operation of the flare and high-pressure drop valve. GIS mapping was used to assess the number of potential residential structures located within each of the distance "bands" reflected in Table 7.5-11. Based on this mapping, the following conclusions are drawn:

- For Operations stage Scenario 1, overlaying the modeled extents to the various significance thresholds from this activity indicates that there will be no potential residential structures predicted to be exposed to noise levels above a **Negligible** significance for both daytime and nighttime hours (both in terms of sound contribution from the NGL Plant and incremental increases above baseline levels).
- For Operations stage Scenario 2, overlaying the modeled extents to the various significance thresholds from this activity indicates that there will be no potential residential structures predicted to be exposed to noise levels above a **Negligible** significance for daytime hours (both in terms of sound contribution from the NGL Plant and incremental increases above baseline levels).
- For Operations stage Scenario 2, overlaying the modeled extents to the various significance thresholds from this activity indicates that there will be 12 potential residential structures that could be exposed to noise levels of a **Moderate** significance during nighttime hours and 82 potential residential structures that could be exposed to noise levels of a **Minor** significance (both in terms of sound contribution from the NGL Plant). Based on the measured ambient baseline levels at measurement location M-1, none of these potential residential structures would be expected to experience an incremental increase in baseline noise levels above a **Negligible** level. Scenario 2 is expected to occur infrequently, primarily during facility startup, maintenance activities, and upset conditions.

Potential Increase in Airborne Noise Levels at Noise-Sensitive Receptors during Operations Stage

Decommissioning activities will be almost entirely limited to activities at the NGL Plant site. While noise modeling was not conducted for Decommissioning stage activities, it is anticipated that the nature of noise emission from a decommissioning operation will be similar in nature to those associated with NGL Plant construction activities (for which modeling predicted no potential residential structures predicted to be exposed to noise levels above a **Negligible** significance).

7.5.5. Impact Management and Monitoring Measures

For those activities expected to result in **Negligible** to **Minor** significance noise impacts on residential structures, no additional mitigation measures are proposed to supplement the embedded controls already in place. It is noted, however, that the low significance of these potential noise impacts is supported by these embedded controls (see summary in Chapter 15, Commitment Register).

For those activities with the potential to result in **Moderate** to **Major** significance noise impacts on residential structures, the following mitigation measures are recommended:

- During open trenching and HDD operations along the onshore pipeline corridor, conduct noise monitoring during the initial stages of construction and again during later stages of construction (as warranted based on changes in the nature of construction activities, weather conditions, or other factors) to quantify the actual extent of Project noise impacts. Based on the result of this assessment, implement additional mitigations, if practicable, for areas where residential structures fall within **Moderate** to **Major** noise level effects areas distances at which noise levels are reaching—ideally prior to the pipeline construction operation arriving at these areas.
- To the extent practicable, position the HDD rig on the side of the HDD segment associated with the smaller number of potential residential structures that could experience a **Moderate** to **Major** noise level.
- Plan HDD operations to avoid operation during nighttime hours, such that nighttime operations are conducted only if an unexpected situation results in a delay that extends an uninterruptable activity into nighttime hours or if the length of the boring is such that there is not reasonable means for avoiding nighttime hours.
- To reduce the potential for residential structures to experience **Moderate** noise levels during nighttime instances where intermittent noise sources are operating at the NGL Plant, conduct planned start-up and maintenance activities during daytime hours to the extent practicable.
- If noise levels at a potential residential structure for planned activities are expected to exceed **Moderate** significance levels, make reasonable efforts to communicate with the residents in the respective structures ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts.
- Prominently display contact information for EEPGL's Community Grievance Mechanism during construction activities in residential areas.

Table 7.5-14 summarizes the management and monitoring measures relevant to airborne sound.

Table 7.5-14: List of Management and Monitoring Measures

Embedded Controls
Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD boring).
Maintain marine and onshore construction equipment, power generators, and vehicles in accordance with manufacturer's specifications to reduce noise generation the extent practicable.
Design equipment at NGL Plant so that in-plant sound levels in accessible areas do not exceed 85 dBA under normal operations or 115 dBA for emergency events and so that community and/or fenceline noise levels do not exceed applicable regulations.
Subject NGL Plant operational equipment to routine maintenance in accordance with manufacturer's specifications.

Mitigation Measures
Based on the result of noise monitoring during onshore pipeline construction, develop additional mitigations, as needed, for areas where residential structures are expected to fall within **Moderate** to **Major** noise level—ideally prior to the pipeline construction operation arriving at these areas.
To the extent practicable, position the HDD rig on the side of the HDD segment associated with the smaller number of potential residential structures that could experience a **Moderate** to **Major** noise level.
Plan onshore pipeline HDD operations to avoid operation during nighttime hours, such that nighttime operations are conducted only if an unexpected situation results in a delay that extends an uninterruptable activity into nighttime hours or if the length of the boring is such that there is not reasonable means for avoiding nighttime hours.
To reduce the potential for residential structures to experience **Moderate** noise levels during nighttime instances where intermittent noise sources are operating at the NGL Plant, conduct planned start-up and maintenance activities during daytime hours to the extent practicable.
If noise levels at a potential residential structure for planned activities are expected to exceed **Moderate** significance levels, make reasonable efforts to communicate with the residents in the respective structures ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts.
Prominently display contact information for EEPGL's Community Grievance Mechanism during construction activities in residential areas.
Monitoring Measures
During open trenching and HDD operations along the onshore pipeline corridor, conduct noise monitoring during the initial stages of construction and again during later stages of construction (as warranted based on changes in the nature of construction activities, weather conditions, or other factors) in order to quantify the actual extent of Project noise impacts.

7.5.6. Assessment of Residual Impacts

Considering implementation of the mitigation measures described above, and on the basis that EEPGL will implement additional mitigations agreeable to a resident in a structure exposed to noise levels of a **Major** significance, the residual impact significance rating for potential sound impacts is rated as **Negligible** to **Moderate**.

Table 7.5-15 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on sound.

Table 7.5-15: Summary of Potential Pre-Mitigation and Residual Impacts—Sound and Vibration

<table>
<tr><th>Stage</th><th>Potential Impact</th><th>Pre-Mitigation Significance Rating</th><th>Proposed Mitigation Measures</th><th>Residual Significance Rating</th></tr>
<tr><td rowspan="4">Construction</td><td>Increases in noise levels at sensitive receptor locations (onshore pipeline, open trenching)</td><td>Negligible to Major</td><td rowspan="3">• Based on the result of noise monitoring during onshore pipeline construction, develop additional mitigations, as needed, for areas where residential structures are expected to fall within Moderate to Major noise level—ideally prior to the pipeline construction operation arriving at these areas
• To the extent practicable, position the HDD rig on the side of the HDD segment associated with the smaller number of potential residential structures that could experience a Moderate to Major noise level
• Plan HDD operations to avoid operation during daytime hours, such that nighttime operations are conducted only if an unexpected situation results in a delay that extends an uninterruptable activity into nighttime hours or if the length of the boring is such that there is not reasonable means for avoiding nighttime hours</td><td>Negligible to Moderate</td></tr>
<tr><td>Increases in noise levels at sensitive receptor locations (onshore pipeline, HDD, daytime)</td><td>Negligible to Minor</td><td>Negligible to Minor</td></tr>
<tr><td>Increases in noise levels at sensitive receptor locations (onshore pipeline, HDD, nighttime)</td><td>Negligible to Major</td><td>Negligible to Moderate</td></tr>
<tr><td>Increases in noise levels at sensitive receptor locations (NGL Plant)</td><td>Negligible</td><td>None</td><td>Negligible</td></tr>
<tr><td rowspan="2">Operations</td><td>Increases in noise levels at sensitive receptor locations (NGL Plant—daytime)</td><td>Negligible</td><td>None</td><td>Negligible</td></tr>
<tr><td>Increases in noise levels at sensitive receptor locations (NGL Plant—nighttime)</td><td>Negligible to Moderate</td><td>Conduct planned start-up and maintenance activities during daytime hours to the extent practicable</td><td>Negligible to Moderate</td></tr>
<tr><td>Decommissioning</td><td>Increases in noise levels at sensitive receptor locations (NGL Plant)</td><td>Negligible</td><td>None</td><td>Negligible</td></tr>
</table>

7.6. Air Quality, Climate, and Climate Change

7.6.1. Baseline Methodology

Ambient air quality guidelines are specific concentration levels in air that are established to protect human health in locations where exposure can potentially occur. These generally include a margin of safety to protect individuals with a higher sensitivity to air pollutants. The EPA has not established specific ambient air quality standards for Guyana. Therefore, the guidelines used for reference in this assessment are those established by the WHO and the USEPA. WHO guidelines can be found in the *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005* (WHO 2005) and the more recent *WHO Global Air Quality Guidelines* (WHO 2021), except for carbon monoxide (CO), hydrogen sulfide (H_2S), and toluene, for which WHO guidelines were published in the *WHO Air Quality Guidelines for Europe, 2nd edition* (WHO 2000). The USEPA National Ambient Air Quality Standards (NAAQS) are summarized in USEPA 2021. The ambient air quality guidelines considered for assessment of existing conditions and the impact assessment are summarized in Table 7.6-1.

Table 7.6-1: Ambient Air Quality Guidelines Considered in the Assessment

Pollutant	Averaging Period	Guideline Concentration (µg/m³ except as noted)			
		WHO 2000	WHO 2005	WHO 2021	USEPA 2021
NO_2	1-hour	—	200 (106.4 ppb)	—	—
	1-hour (98th percentile)	—	—	—	188 (100 ppb)
	24-hour (99th percentile)	—	—	25 (13.3 ppb)	—
	Annual	—	—	10 (5.3 ppb)	100 (53 ppb)
SO_2	10-minute	—	500 (190.9 ppb)	—	—
	1-hour (99th percentile)	—	—	—	196 (75 ppb)
	24-hour (99th percentile)	—	—	40 (15 ppb)	—
PM_{10}	24-hour (99th percentile)	—	—	45	—
	24-hour (second high)	—	—	—	150
	Annual	—	—	15	—
$PM_{2.5}$	24-hour (99th percentile)	—	—	15	—
	24-hour (98th percentile)	—	—	—	35
	Annual	—	—	5	12
CO	15-minute	—	100,000 (87.3 ppm)	—	—

Pollutant	Averaging Period	Guideline Concentration (µg/m^3 except as noted)			
		WHO 2000	WHO 2005	WHO 2021	USEPA 2021
	1-hour	—	35,000 (30.5 ppm)	—	40,000 (35 ppm)
	8-hour	—	10,000 (8.7 ppm)	—	10,000 (9 ppm)
	24-hour (99th percentile)	—	—	4,000 (3.5 ppm)	—
H_2S	24-hour	150 (107.6 ppb)	—	—	—
Ozone	8-hour	—	—	100 (50.8 ppb)	137 (69.5 ppb)
	Peak season average	—	—	60 (30.5 ppb)	—
Toluene	1-week	260 (69 ppb)	—	—	—
Benzene	24-hour	—	—	—	30 (9.4 ppb)
Ethylbenzene	Annual	—	—	—	1.0 (0.23 ppb)
Xylene	24-hour	—	—	—	434 (100 ppb)

— = no applicable standard; µg/m^3 = micrograms per cubic meter; NO_2 = nitrogen dioxide; PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide

Note: For the sake of clarity, details of guideline value statistical assessment are not specified in this document. Such details are provided in the referenced documents.

The guidelines shown in Table 7.6-1 were used to assess the existing conditions of the ambient airshed (i.e., undegraded vs. degraded) based on measured concentrations. The WHO 2000 and WHO 2005 guidelines do not specify a “ranking” for values to be compared to short-term (10-minute to 8-hour) guidelines (e.g., the highest value, the second highest value, etc.); accordingly, the maximum observed concentration is compared to WHO 2000 and WHO 2005 guidelines. The single highest value was compared to a WHO 2005 1-hour guideline. By contrast, the WHO 2021 and USEPA NAAQS guidelines employ a statistically based metric for comparison to some guidelines (e.g., the 98th percentile value for 1-hour nitrogen dioxide [NO_2]; the 99th percentile value for 24-hour NO_2; the 99th percentile value for 1-hour SO_2 [sulfur dioxide]). For the air quality measurements presented herein, the WHO 2005 guideline and the USEPA NAAQS guideline for 1-hour NO_2 are both used for comparison purposes; the USEPA NAAQS guideline provides a more robust comparison that does not assess the single highest hourly value, while the WHO 2005 guideline considers the single highest hourly value—effectively representing an extreme upper bound estimate. Similarly, the WHO guideline and the USEPA NAAQS guideline for 24-hour PM_{10} (particulate matter with aerodynamic diameter of less than 10 micrometers) and $PM_{2.5}$ (particulate matter with aerodynamic diameter of less than 2.5 micrometers) are both used for comparison purposes. For each pollutant and averaging time, if more than one guideline for a given averaging period is listed in the table above (e.g., annual average $PM_{2.5}$), the lowest was used in the assessment.

7.6.2. Existing Conditions and Baseline Studies

This section describes the existing air quality conditions and climate in the Project AOI. In additional, the section provides a discussion of the current scientific understanding of the potential consequences of global climate change.

Air quality in a geographic area is determined by the presence of background concentrations due to natural and distant sources, the type and amount of pollutants emitted locally into the atmosphere, the topography of the area, and the weather and climate conditions in the area. The levels of pollutants and pollutant concentrations in the atmosphere are typically expressed in units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$) averaged over various periods of time (e.g., 1-hour average, 24-hour average).

7.6.2.1. Existing Conditions—Air Quality

This section describes the existing ambient air quality conditions in the Project AOI. Existing air quality conditions are described for the area where community receptors could potentially be impacted by emissions to air from the Project.

Given the scarcity of available information regarding ambient air quality in Guyana, EEPGL commissioned an ambient air quality monitoring program in August 2018. To date, monitoring has been conducted at four sites (see Figure 7.6-1). Three of the four sites for which monitoring programs have been concluded are within 7 kilometers of the onshore pipeline corridor and within 25 kilometers of the NGL Plant site. Given this proximity relative to the Project infrastructure, the data presented herein are considered to be relevant to characterize existing ambient air quality conditions in the onshore portion of the Project AOI.

Figure 7.6-1: Ambient Air Quality Monitoring Sites

The air quality monitoring sites and their rationale for selection are as follows:

- New Amsterdam (Rose Hall Estate), Berbice. The New Amsterdam site was selected to represent rural, near-coast conditions, upwind of the Georgetown urban area. Monitoring was performed at this site from 15 October 2018 through 3 December 2018.
- Carifesta, Georgetown. The Carifesta monitoring site was established adjacent to the Guyana Telephone & Telegraph, Carifesta Avenue location. This coastal site represents a more urban setting compared to the New Amsterdam site, but is still generally upwind of larger point source emission sources in the Georgetown urban area. This site was monitored twice—from 15 August 2018 through 3 October 2018, and from 11 December 2018 through 21 March 2019. The initial Carifesta monitoring period characterized air quality during the dry season, while the second deployment was representative of the rainy season.
- New Guyana School. This monitoring site, near the east bank of the Demerara River, is generally downwind of the most densely populated and developed areas of Georgetown. It is thus expected to be representative of the higher ambient concentrations of pollutants that could be emitted from the Georgetown urban area. Monitoring was performed at this site from 12 April 2019 through 25 August 2019.
- Friendship Education Department. This monitoring site, near the east bank of the Demerara River, was established to characterize ambient air quality conditions further south of the Georgetown area, and closer to the NGL Plant site. It is further removed from the influence of the more densely populated and trafficked areas of Georgetown. Data collection is ongoing at this location as of the writing of this EIA, and the initial data are presented herein.

Monitoring results from the first three of the above monitoring sites have been previously documented in a comprehensive report submitted with the Yellowtail Development Project EIA (ERM 2022). Data from the most recent monitoring site, Friendship Education Department, are included as Appendix K, Ambient Onshore Air Quality Monitoring Report. All four of the air monitoring programs and their results are presented below.

The pollutants assessed at each monitoring location included PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and the non-methane volatile organic compounds BTEX. Additionally, ozone was monitored at the Friendship Education Department. All parameters were measured continuously or semi-continuously during the referenced monitoring periods.

At the New Amsterdam and Carifesta sites, local meteorological parameters were also monitored by separate monitoring installations collocated with the ambient air quality monitoring system. At the New Guyana School site, wind speed and direction measurements were integrated with the ambient air quality monitoring system. At the Friendship Education Department site, wind speed, wind direction, standard deviation of wind direction (sigma theta), temperature, dew point, wet-bulb temperature, relative humidity, precipitation, pressure, solar radiation, and visibility were integrated with the ambient air quality monitoring system.

The measurements of PM_{10}, $PM_{2.5}$, CO, SO_2, H_2S, NO_2, and BTEX at the four monitoring sites are summarized in Tables 7.6-2 through 7.6-12. The monitoring results for CO, NO_2, H_2S, and

SO_2 were all below the WHO and USEPA guideline values. The low concentrations limit the extent to which NO_2 or SO_2 would be likely to promote ozone or secondary $PM_{2.5}$ formation.

As illustrated in the tables, maximum 24-hour average and "full monitoring period" average PM concentrations (both PM_{10} and $PM_{2.5}$) were near or exceeded WHO guideline values at all three onshore monitoring sites. PM_{10}, and to a lesser extent $PM_{2.5}$, at all three sites were likely influenced by vehicle traffic (e.g., engine emissions, rubber tire dust, re-suspended road dust), agricultural-related emissions (e.g., tilling, harvesting, residue burning), and open burning. In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning are probably also $PM_{2.5}$ emission sources impacting the three monitoring sites.

With respect to PM_{10} and $PM_{2.5}$, the comparison between the full monitoring period averages and the WHO and USEPA annual average guideline values should be considered indicative, rather than directly comparable, as the monitoring durations at each of the three sites were less than 365 days (between 50 and 141 days). The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Additionally, the measured maximum 24-hour average PM_{10} and $PM_{2.5}$ values cannot be directly compared with the USEPA and WHO guideline values since those guidelines are intended for comparison to statistical values (i.e., not the single highest average values), which would be lower than the highest average values.

The only measured exceedance of a gaseous pollutant criterion was the 24-hour average benzene levels at the Carifesta monitoring site. At Carifesta, the maximum 24-hour average was significantly higher than the 24-hour USEPA guideline value. The Carifesta site is situated between two roadways that are often busy and sometimes congested. The sample inlet was located 34 meters from Carifesta Road and 69 meters from Seawall Public Road—making vehicle emissions a likely source for these elevated benzene levels. At the New Amsterdam and the New Guyana School monitoring sites, the maximum 24-hour average benzene measurements were significantly lower than the USEPA guideline value.

Table 7.6-2: Summary of PM_{10} Monitoring Results

Site	Maximum 1-Hour Average (µg/m³)	Maximum 24-Hour Average (µg/m³)	Monitoring Period Average [a] (µg/m³)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	61.9	37.3	17.3	91%	45
Carifesta #2 (rainy season)	266.8	154.3	33.3	97%	93
Carifesta (combined)	266.8	154.3	28.3	95%	138
New Amsterdam	110.7	39.8	20.6	99%	50
New Guyana School	103.3	60.0	25.5	97%	132
Friendship Education Department	NA	NA	NA	NA	NA

Site	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Guideline	—	45 (WHO) 150 (USEPA)	15 (WHO Annual)		

NA = not available; PM analyzer for monitoring period to date at Friendship Education Department was not operational; PM monitoring will be initiated at this site as soon as the equipment is repaired.
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 7.6-3: Summary of $PM_{2.5}$ Monitoring Results

Location	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	31.8	13.1	7.1	91%	45
Carifesta #2 (rain season)	92.7	53.1	12.7	97%	93
Carifesta (combined)	92.7	53.1	11.0	95%	138
New Amsterdam	38.3	13.5	6.8	99%	50
New Guyana School	45.8	18.2	9.3	97%	132
Friendship Education Department	NA	NA	NA	NA	NA
Guideline	—	15 (WHO) 35 (USEPA)	5 (WHO Annual) 12 (USEPA Annual)		

NA = not available; PM analyzer for monitoring period to date at Friendship Education Department was not operational; PM monitoring will be initiated at this site as soon as the equipment is repaired.
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 7.6-4: Summary of CO Monitoring Results

Location	Maximum 1-Hour Average (ppm)	Maximum 8-Hour Average (ppm)	Monitoring Period Average (ppm)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1.36	1.01	0.43	99%	50
Carifesta #2 (rainy season)	1.45	1.15	0.51	99%	98
Carifesta (combined)	1.45	1.15	0.48	99%	148
New Amsterdam	1.05	0.66	0.35	98%	50
New Guyana School	1.20	0.86	0.49	95%	131

Location	Maximum 1-Hour Average (ppm)	Maximum 8-Hour Average (ppm)	Monitoring Period Average (ppm)	Data Recovery	Valid Monitoring Days
Friendship Education Department	1.51	1.21	0.42	100%	37
Guideline	30.5 (WHO) 35 (USEPA)	8.7 (WHO) 9.0 (USEPA)	—		

Table 7.6-5: Summary of NO_2 Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Monitoring Period Average [a] (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	15.0	3.1	96%	50
Carifesta #2 (rainy season)	12.5	-0.7 [b]	95%	98
Carifesta (combined)	15.0	0.6	95%	148
New Amsterdam	21.7	-1.4 [b]	79%	40
New Guyana School	15.8	1.3	93%	130
Friendship Education Department	40.5	2.02	95%	35
Guideline	106.4 (WHO) 100 (USEPA)	5.3 (WHO Annual) 53 (USEPA Annual)		

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.
[b] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 7.6-6: Summary of SO_2 Monitoring Results

Location	Maximum Daily 1-hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	7.2	0.3	-1.0 [a]	96%	50
Carifesta #2 (rainy season)	2.9	0.3	-0.1 [a]	95%	98
Carifesta (combined)	7.2	0.3	-0.4 [a]	95%	148
New Amsterdam	-0.1 [a]	-1.0 [a]	-1.3 [a]	95%	50
New Guyana School	11.7	3.3	0.9	93%	132
Friendship Education Department	14.1	5.2	0.06	97%	36
Guideline	75 (USEPA)	15 (WHO)	—		

[a] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 7.6-7: Summary of H_2S Monitoring Results

Location	Maximum 30-Minute Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	14.2	1.9	0.4	96%	50
Carifesta #2 (rainy season)	32.4	1.3	0.1	95%	98
Carifesta (combined)	32.4	1.9	0.2	95%	148
New Amsterdam	5.8	0.4	-0.1 [a]	95%	50
New Guyana School	110.6	16.0	2.8	93%	132
Friendship Education Department	4.1	1.1	0.48	97%	36
Guideline	—	107.6 (WHO 24-hour)	—		

[a] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated.

Table 7.6-8: Summary of Benzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1,272.6	131.9	18.4	95%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	7.9	0.4	0.0	99%	50
New Guyana School [a]	NA	0.7	NA	NA	8
New Guyana School [b]	16.1	0.8	0.0	74%	21
Friendship Education Department	NA	NA	NA	NA	NA
Guideline	—	9.4 (USEPA)	—		

NA = not analyzed
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019

Table 7.6-9: Summary of Toluene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	1,134.6	169.5	20.7	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	6.7	5.4	5.0	99%	50
New Guyana School [a]	NA	6.0	NA	100%	8
New Guyana School [b]	2,396.7	99.9	0.0	74%	21
Friendship Education Department	NA	NA	NA	NA	NA
Guideline	—	—	69 (WHO)		

NA = not analyzed
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019

Table 7.6-10: Summary of Ethylbenzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	31.6	3.3	0.08	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	0.6	0.1	0.0	99%	50
New Guyana School [a]	NA	0.2	ND	100%	8
New Guyana School [b]	18.4	0.0	0.0	74%	21
Friendship Education Department	NA	NA	NA	NA	NA
Guideline	—	—	0.23 [c] (USEPA Annual)		

NA = not analyzed; ND = below minimum laboratory reporting level of 0.14 ppb by volume
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019
[c] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

Table 7.6-11: Summary of Xylenes Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitorin g Days
Carifesta #1 (dry season)	137.1	12.3	0.4	94%	47
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	14.4	0.9	0.1	99%	50
New Guyana School [a]	NA	0.6	NA	100%	8

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
New Guyana School [b]	0.0	0.0	0.0	74%	21
Friendship Education Department	NA	NA	NA	NA	NA
Guideline	—	100 (USEPA)	—		

NA = not analyzed
[a] Data from integrated 24-hour Summa samples
[b] Data from Mocon installed on 27 June and operated until 22 August 2019

Table 7.6-12: Summary of Ozone Monitoring Results

Location	Maximum 8-Hour Average (ppb)	Peak Season Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta #1 (dry season)	NA	NA	NA	NA	NA
Carifesta #2 (rainy season)	NA	NA	NA	NA	NA
Carifesta (combined)	NA	NA	NA	NA	NA
New Amsterdam	NA	NA	NA	NA	NA
New Guyana School	NA	NA	NA	NA	NA
Friendship Education Department	28.3		14.5	100%	37
Guideline	50.8 (WHO) 69.5 (USEPA)	30.5 (WHO)	—		

NA = not analyzed

7.6.2.2. Existing Conditions—Climate

Guyana has a wet tropical climate characterized by two pronounced wet seasons and year-round warm temperatures. The bimodal wet/dry regime is caused by the annual migration of the Inter-Tropical Convergence Zone (ITCZ), which changes latitude based on the Earth's position and angle in relation to the sun. Northward movement of the ITCZ occurs as energy from the sun is strongest in the Northern Hemisphere during the Northern Hemisphere's summer, thereby increasing solar heating in that hemisphere. The relative change in solar heating slightly shifts the atmosphere's primary circulation cells, which causes the area of trade wind convergence closest to the equator to migrate seasonally. In the areas closest to the ITCZ, one can typically expect increased thunderstorm activity and heavy rainfall between mid-April and the end of July, with peak rainfall in June. This period is known in Guyana as the primary wet season. The secondary wet season occurs during the southward migration of the ITCZ from mid-November to the end of January, with typical peak rainfall in December. The intervening periods (January to April and mid-August to mid-November) are typically relatively dry, but rain can occur at any time of the year. Average monthly rainfall totals range between approximately 100 millimeters and 300 millimeters (World Weather & Climate Information 2016).

The climate in Guyana is influenced by the El Niño Southern Oscillation. During El Niño years (approximately every 3 to 6 years), Guyana's long dry season is often drier and warmer than normal; during La Niña years, wetter- and cooler-than-normal conditions typically prevail during the long wet season as compared to other years (McSweeney et al. 2010). With respect to the ambient air quality presented herein, El Niño conditions existed in late 2018 and into mid-2019.

Although the ITCZ moves seasonally, it is generally located between 5 degrees (°) north latitude and 5° south latitude. North and south of the ITCZ, atmospheric circulation and the Coriolis impact create global wind patterns including the Northern Hemisphere's trade winds and westerlies (NOAA 2008). Guyana's coastal zone is located approximately between 6° and 8° north latitude, and the Stabroek Block is located between 7° and 8° latitude, both within the southern portion of the area impacted by the trade winds. The influence of the trade winds produces a strongly dominant east-northeast wind offshore of Guyana, which gives rise to the afternoon "sea breeze" that usually blows inland across coastal Guyana from the ocean.

Annual average temperatures in coastal Guyana are relatively constant, with an annual average daytime maximum temperature of 29.6 °C and an annual average nighttime minimum temperature of 24°C. The average daily temperature is approximately 27°C. Relative humidity is high at 80 percent or more year-round in the coastal zone.

To develop more specific climate information regarding onshore climate conditions, EEPGL deployed a meteorological station at two of the three ambient onshore monitoring air quality sites discussed above (Carifesta and New Amsterdam) between December 2017 and April 2019. The instrument measured and logged the following:

- Air temperature
- Relative humidity
- Atmospheric pressure
- Solar radiation
- Precipitation
- Wind speed
- Wind direction
- Gust speed

7.6.2.3. Current Scientific Understanding of Consequences of Climate Change

As part of placing existing climate conditions in context, a review of the current scientific understanding of the potential consequences of global climate change was conducted. The review focused on the following climatic conditions:

- Sea level rise
- Ocean temperature and ocean acidification
- Storm intensity

The following discussion references the *Summary for Policymakers* from the Intergovernmental Panel on Climate Change (IPCC) Working Group 1 report, *AR6 Climate Change 2021: The Physical Science Basis* (IPCC 2021). This report presents global and regional findings, and it is important to note that statements made in the *Summary for Policymakers* regarding regional-scale climate change may not apply specifically to Guyana. The report does assess some region-specific climate changes in specific, defined regions. However, with the exception of heavy precipitation and relative sea level, the climatic conditions considered here are not specifically assessed for the region that includes Guyana (northern South America or "NSA"). Notably, the report ascribes low confidence in current extreme precipitation trends in the NSA region due to lack of observations, and medium confidence in future increases in intensity and frequency of heavy precipitation in the NSA region. Projected changes in relative sea level for South America under both low and high emission scenarios are similar to projected global mean sea level rise under the same scenarios.

Sea Level Rise

The IPCC (2021) reports that global mean sea level increased by 200 millimeters between 1901 and 2018, with the average rate of sea level rise at 1.3 millimeters per year between 1901 and 1971, increasing to 1.9 millimeters per year between 1971 and 2006, and further increasing to 3.7 millimeters per year between 2006 and 2018 (high confidence).[12]

The IPCC concludes that it is virtually certain that global mean sea level will continue to rise over the 21st century. The projected global mean sea level rise (relative to 1995–2014) under the various greenhouse gas (GHG) emissions scenarios considered is shown in Table 7.6-13.

Table 7.6-13: Projected Global Mean Sea Level Rise Relative to 1995–2014

Year	Greenhouse Gas Emissions Scenario [a]				
	Very Low	Low	Intermediate	High	Very High
2100	0.28 to 0.55 meter	0.32 to 0.62 meter	0.44 to 0.76 meter	0.55 to 0.90 meter	0.63 to 1.01 meters
2150	0.37 to 0.86 meter	0.46 to 0.99 meter	0.66 to 1.33 meters	0.92 to 1.67 meters	0.98 to 1.88 meters

Source: IPCC 2021

[a] The IPCC 2021 report discusses predicted future conditions under five key scenarios, as follows: Scenario SSP1-1.9 (referred to as the *very low GHG emissions* scenario), Scenario SSP1-2.6 (referred to as the *low GHG emissions* scenario), Scenario SSP2-4.5 (referred to as the *intermediate GHG emissions* scenario), Scenario SSP3-7.0 (referred to as the *high GHG emissions* scenario), and Scenario SSP5-8.5 (referred as the *very high GHG emissions* scenario).

The IPCC 2021 report states that global mean sea level rise above the likely ranges summarized above for the Very High GHG emissions scenario (i.e., approaching 2 meters by 2100 and 5 meters by 2150 [both low confidence]) cannot be ruled out due to deep uncertainty in ice sheet processes. From a regional perspective, the IPCC reports that relative sea-level rise is extremely likely to continue in the oceans around Central and South America, contributing to

[12] The IPCC 2021 report discusses its predictions using levels of confidence expressed using five qualifiers: *very low*, *low*, *medium*, *high*, and *very high*; and assessed likelihoods of an outcome or a result as follows: *virtually certain* 99 to 100 percent probability, *very likely* 90 to 100 percent probability, *likely* 66 to 100 percent probability, *about as likely as not* 33 to 66 percent probability, *unlikely* 0 to 33 percent probability, *very unlikely* 0 to 10 percent probability, and *exceptionally unlikely* 0 to 1 percent probability. Where these terms are used in Section 7.6.2.3, they refer to this nomenclature.

increased coastal flooding in low-lying areas (high confidence) and shoreline retreat along most sandy coasts (high confidence) (IPCC 2021).

In addition to the IPCC 2021 report, supplemental information related to regional sea level rise was researched. Altimetry data from the Copernicus Climate Change Service for the Atlantic coast of South America—averaged from 50 kilometers offshore to the coast—show an average sea-level rise on the order of approximately 3.6 millimeters per year, based on data from 1993 to 2020 (WMO 2021).

The World Bank identifies Guyana as one of the most vulnerable countries to global climate change due to its low-lying coastal areas, many of which are bmsl, and a high percentage of the population and critical infrastructure located along the coast (World Bank 2016). As such, the country invests continuously in the construction and maintenance of sea and river defense infrastructure. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems.

Ocean Temperature and Ocean Acidification

The IPCC concludes that it is virtually certain that the global upper ocean (0 to 700 meters) has warmed since the 1970s, and that GHG emissions since 1750 have committed the global ocean to future warming (high confidence). Over the rest of the 21st century, the IPCC predicts likely ocean warming ranges from 2 to 4 times (low GHG emissions scenario) to 4 to 8 times (very high GHG emissions scenario) the 1971–2018 change. The IPCC reports that the mean sea surface temperature of the Atlantic Ocean and Caribbean around Central and South America increased from 0.25 to 1°C over the period 1982 to 1998. The IPCC projects that sea surface temperature in the Central and South America region is projected to increase by 1°C under an intermediate GHG emissions scenario and 2°C under a very high GHG emissions scenario (high confidence).

The IPCC concludes it is virtually certain that ocean pH has declined globally over the last 40 years. Ocean acidification and associated reductions in the saturation state of calcium carbonate—a constituent of skeletons or shells of a variety of marine organisms—is expected to increase in the 21st century under all emissions scenarios (high confidence). The IPCC report predicts that ocean acidification will increase in the Central and South America region under an intermediate or greater GHG emissions scenario (high confidence). Based on multiple lines of evidence, the IPCC predicts upper ocean stratification (virtually certain), ocean acidification (virtually certain), and ocean deoxygenation (high confidence) will continue to increase in the 21st century, at rates dependent on future emissions. Ocean acidification and deoxygenation have already emerged over most of the global open ocean. Over the past two to three decades, a pH decline in the ocean interior has been observed in all ocean basins (high confidence) (IPCC 2021).

Storm Intensity

The IPCC reports that frequency and intensity of heavy precipitation events have increased since the 1950s over most land area for which observational data are sufficient for trend analysis (high confidence); Guyana does not fall within any of the regions for which there are enough data to evaluate these trends, so it is unclear from the IPCC report whether this is true specifically for Guyana. The IPCC concludes that it is very likely that heavy precipitation events will intensify and become more frequent in most regions with additional global warming. At the global scale, extreme daily precipitation events are projected to intensify by about 7 percent for each 1°C of global warming. The proportion of intense tropical cyclones (Categories 4–5) and peak wind speeds of the most intense tropical cyclones are projected to increase at the global scale with increasing global warming (IPCC 2021).

The IPCC concludes that it is likely that the global proportion of major (Category 3–5) tropical cyclone occurrence has increased over the last four decades and that these changes cannot be explained by internal variability alone (medium confidence). However, the IPCC states that there is low confidence in long-term (multi-decadal to centennial) trends in the frequency of “all-category” tropical cyclones, and that while data support a high confidence that climate change increases heavy precipitation associated with tropical cyclones, data limitations inhibit clear detection of past trends on the global scale (IPCC 2021).

In addition to the IPCC 2021 report, information related to regional storm intensity was researched. In 2020, the Atlantic Basin, which includes Guyana, registered a historical record of 30 storms, two of which reached a Category 4—where wind speeds exceed 209 kilometers per hour (WHO and UNFCC 2020; National Hurricane Center and Central Pacific Hurricane Center Undated). Caribbean regional climate projections estimate that Category 4 and 5 hurricane frequency is expected to increase by 25 to 30 percent in the future (USAID 2018). Intensity of tropical cyclones is expected to increase on average by 1 to 10 percent according to model projections for a 2°C warming of the globe (GFDL 2021).

7.6.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on air quality due to criteria pollutant emissions. This section also addresses GHG emissions resulting from planned Project activities. The key potential impacts assessed herein include increases in ambient concentrations of criteria pollutants as a result of stationary and mobile combustion sources associated with planned Project activities, and increases in global GHG emissions from these same sources.

The significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

7.6.3.1. Relevant Project Activities and Potential Impacts

Emissions of criteria pollutants and GHGs from the Project will be generated during all stages of the Project. The key sources of emissions that are considered for these stages include the following:

- Construction—Project construction equipment for the onshore and offshore components of the Project
- Operations—NGL Plant process infrastructure, focusing on the key emission sources including the hot oil heater, molecular sieve regeneration gas heater, essential generator, emergency generator, and safety, intermittent, and non-routine flaring.
- Decommissioning—Project construction equipment for the decommissioning component of the Project (focused on NGL Plant operations).

Regarding potential air quality impacts from criteria pollutants, depending on the magnitude and extent of the increases in ambient air criteria pollutant concentrations relative to the location of potential onshore human receptors in Guyana, the increases from Project activities could have the potential to contribute to health impacts. Because potential air quality-related health impacts for Project workers will be addressed through standard occupational exposure guidelines, the air quality impact assessment is limited to consideration of potential onshore community receptors (i.e., outside of the NGL Plant fenceline). ExxonMobil and its affiliates generally follow the American Conference of Governmental Industrial Hygienist's Threshold Limit Values to set the exposure limits for chemical, physical, and biological substances.

Table 7.6-14 summarizes the planned Project activities that could result in potential impacts on air quality and climate / climate change.

Table 7.6-14: Summary of Relevant Project Activities and Key Potential Impacts—Air Quality and Climate / Climate Change

Stage	Project Activity	Resource	Key Potential Impacts
Construction	Operation of non-road construction equipment	Air quality	Increased concentrations of criteria pollutants in ambient air, particularly focused on dust—potentially contributing to nuisance or health impacts for community receptors
		Climate / Climate Change	Emissions of GHGs from the Project, contributing to global GHG emissions
Operations	Operation of NGL Plant facilities	Air quality	Increased concentrations of criteria pollutants in ambient air, potentially contributing to health impacts for community receptors

Stage	Project Activity	Resource	Key Potential Impacts
		Climate / Climate Change	Emissions of GHGs from the Project, contributing to global GHG emissions
Decommissioning	Decommissioning of NGL Plant	Air quality	Increased concentrations of criteria pollutants in ambient air, particularly focused on dust—potentially contributing to nuisance or health impacts for community receptors
		Climate / Climate Change	Emissions of GHGs from the Project, contributing to global GHG emissions

For the purpose of assessing the significance of potential impacts, separate discussions are provided for the following components, with the assessment focusing on the specific potential impacts that are relevant to each component:

- Air quality
- Climate / climate change

As the impact assessment for both components is based on the estimated emissions from the Project sources described above, the following subsection presents the Construction and Operations stages emissions inventories developed for the Project, including criteria pollutant emissions and GHG emissions. This subsection is followed by separate discussions of potential impacts on air quality and to climate / climate change.

Emissions Inventory

Emissions to air from the Project have been estimated based on a number of factors, including activity levels, fuel types, equipment capacities, and standard emission factors that are published by the USEPA in the publication *AP-42: Compilation of Air Pollutant Emission Factors* (USEPA 1996, 2000, 2008, 2018). As described in AP-42, an emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., milligrams of nitrogen oxides (NO_x) emitted per cubic meter of natural gas combusted). In most cases, these factors are averages of available data of an acceptable quality, and are generally assumed to be representative of long-term averages for a particular type of source.

Project Emissions Inventory—Construction Stage

The emission inventory for the Project's Construction stage was developed based on consideration of emissions from estimated fuel usage by non-road construction equipment that will be used for construction of the onshore and offshore components of the Project.

As is often the case at the EIA phase for a project, a detailed construction plan and schedule for the Project has not been finalized at this time, but a conceptual plan has been developed, and the emissions inventory presented herein for the Construction stage is based on a preliminary estimate of the types of equipment that will be used for construction, the estimated operating time for these types of equipment, and the estimated fuel consumption rates. Table 7.6-15 summarizes the key activities, preliminary equipment types supporting those activities, and operating days for construction of the three primary Project components. These preliminary estimates form the basis of the estimated Construction stage emissions inventory.

Table 7.6-15: Preliminary Summary of Fuel Usage by Construction Equipment during Project Construction Stage

Project Component	Activity	Total Fuel Usage (liters)
Offshore Pipeline	Deliveries for SURF installation	420,000
	SURF installation	9,825,000
	Deliveries for offshore pipeline installation	420,000
	Offshore pipeline installation	14,144,000
Onshore Pipeline	Clearing / RoW preparation	696,330
	Pipeline construction	213,138
	Trenching / backfill	250,560
	HDD operations	150,960
NGL Plant, Heavy Haul Road, Temporary MOF	Clearing	102,540
	Dewatering	119,280
	Cut	383,040
	Fill	1,903,140
	Deliveries from shorebases to temporary MOF	540,800
	Site Power	2,197,560
	Underground installation	33,5970
	Aboveground installation	622,924
	Drainage / finish grade	165,960
	Dredging	1,343,750
	Temporary MOF installation	93,120
	Deliveries from temporary MOF to NGL Plant site	67,680

Based on the preliminary information summarized in Table 7.6-15, the estimated total emissions of criteria pollutants for the approximately 3-year Construction stage are summarized in Table 7.6-16.

Table 7.6-16: Summary of Estimated Construction Stage Emissions from Fuel Combustion

Pollutant	Project Component	Estimated Emissions (tonnes)
Nitrogen oxides (NO_x)	Offshore Pipeline	3.81
	Onshore Pipeline	0.33
	NGL Plant, Heavy Haul Road, Temporary MOF	1.28
	Total	5.42
Sulfur dioxide (SO_2)	Offshore Pipeline	39.63
	Onshore Pipeline	21.43
	NGL Plant, Heavy Haul Road, Temporary MOF	72.68
	Total	133.73

Pollutant	Project Component	Estimated Emissions (tonnes)
Particulate matter (PM)	Offshore Pipeline	15.89
	Onshore Pipeline	2.21
	NGL Plant, Heavy Haul Road, Temporary MOF	11.94
	Total	30.05
Carbon monoxide (CO)	Offshore Pipeline	1.95
	Onshore Pipeline	0.47
	NGL Plant, Heavy Haul Road, Temporary MOF	1.46
	Total	3.88
Non-methane volatile organic compounds (VOCs)	Offshore Pipeline	47.75
	Onshore Pipeline	25.82
	NGL Plant, Heavy Haul Road, Temporary MOF	87.57
	Total	161.13
GHGs (kilotonnes carbon dioxide-equivalents)	Offshore Pipeline	45.46
	Onshore Pipeline	1.62
	NGL Plant, Heavy Haul Road, Temporary MOF	10.17
	Total	57.25

Project Emissions Inventory—Operations Stage

The Project emissions inventory developed for the Operations stage considered all of the embedded controls reflected in the Project design. Project emissions will be generated by the following sources at the NGL Plant:

- Hot oil heater
- Molecular sieve regeneration gas heater
- Cold flare
- Wet flare
- Essential generator
- Emergency generator

The main sources of routine emissions for the NGL Plant are the hot oil heater and the molecular sieve regeneration gas heater. The hot oil heater is part of the hot oil system, which provides the heat required by the NGL Plant and the inlet facilities. The hot oil heater is supplied by fuel gas before sending the heating medium to hot oil users. A 2 x 50 percent configuration for the hot oil heater allows for an increase in reliability so that the heating medium is available more consistently. The current design includes one hot oil heater, which will be sufficient to provide the required heating duty to send rich gas directly to the Power Plant. The hot oil heater is expected to run constantly (8,760 hours per year). Emissions were calculated based on the hot oil heater fuel gas consumption, with a 33 percent design contingency and 75 percent overall heater efficiency. Emission factors from AP-42 Chapter 1.4, Natural Gas Combustion (USEPA 2008), were used for emission calculations, as summarized in Table 3-1 in Appendix L, Emissions Inventory and Air Quality Modeling Report. Because low NO_x burners will be used as controls for the hot oil heater, the emission factors representative of this technology were applied.

The molecular sieve regeneration gas heater is part of the gas dehydration unit, which serves to remove water from the gas to avoid freezing in the NGL recovery unit. A two-bed configuration of the molecular sieve vessels allows for one bed to remain in normal operation by adsorbing the wet gas, while the other is being thermally regenerated to desorb the compounds which were loaded during the adsorption steps. The desorption stage requires a fuel gas supply from the NGL Plant's fuel gas system and heat from the molecular sieve regeneration gas heater. It is anticipated that the molecular sieve regeneration gas heater will only operate during the initial switch-out of one bed to the other. However, for the purposes of modeling, a conservative estimate is to assume that the molecular sieve regeneration gas heater will operate constantly (8,760 hours per year). A 10 percent design contingency with 75 percent overall heater efficiency was added for emission calculations. Similar to the hot oil heater, emission factors from AP-42 Chapter 1.4, Natural Gas Combustion (USEPA 2008), for low NO_x burners were used, as summarized in Table 3-1 in Appendix L, Emissions Inventory and Air Quality Modeling Report.

Other sources of emissions from the NGL Plant include the combustion of flare pilot and purge gas that is required to maintain the flares in a safe operational state. The purpose of the flare pilot and purge gas is to prevent oxygen from potentially entering the flare if there is not a constant supply of gas. For this purpose, the hours of operation for flare pilot and purge gas considered for modeling was 8,760 hours per year. Pilot and purge gas will be supplied by the fuel gas system and will be routed to both the wet and cold flares. Emission factors from AP-42 Chapter 13.5, Industrial Flares (USEPA 2018), were used for emission calculations, as summarized in Table 3-1 in Appendix L, Emissions Inventory and Air Quality Modeling Report.

An estimated quantity of intermittent emission sources as well as potential non-routine flaring emissions was accounted for in the emissions inventory. Potential intermittent sources to the flare include gas from storage bullets venting and loading rack venting. Potential non-routine emissions include flaring of gas from initial start-up; maintenance purging; maintenance pigging; and gas-freeing of process equipment during maintenance events (e.g. vessel inspections and mole sieve change outs), Power Plant turbine trips, power demand swings, NGL Plant process upsets. The emissions sources and estimates reflect the conceptual stage of project definition and are subject to updates during Front-End Engineering Design (FEED) and detailed design.

The essential and emergency generators are also considered sources of non-routine emissions, as they are expected to operate only intermittently. The essential generator will supply power during start-up or when the power supply from the Power Plant is not available. The emergency generator will have black-start capabilities. This generator will provide power to the electric firewater pumps; emergency/egress lighting; control room heating, ventilating, and air-conditioning systems; uninterruptible power supply systems; and any other emergency power users. The essential generators are designed for a driver rating of 7,500 kilowatts, and the emergency generators are designed for 500 kilowatts. The primary fuel for the generators will be diesel, which will be pumped from the diesel storage tank by the diesel pump during a non-routine event. For emission calculations, the volume of diesel required was estimated based on a generator efficiency of 35 percent and a 46 megajoule/kilogram heating value. The sulfur content of fuel was assumed to be 0.1 percent (weight basis). For the purpose of modeling, both generators are estimated to operate for 72 hours per year. Emission factors from AP-42 Chapter 3.3, Gasoline and Diesel Industrial Engines, and Chapter 3.4, Large Stationary Diesel and All Stationary Dual-Fuel Engines (USEPA 1996), were used, as summarized in Table 3-1 in Appendix L, Emissions Inventory and Air Quality Modeling Report.

Flaring during a blowdown event was also considered. A blowdown event is considered non-routine, as it will only happen during an emergency event such as hydration formation in the pipeline or when there a potential leak requires a complete inventory blowdown. Based on a preliminary flow assurance analysis, a full blowdown of the pipeline inventory will result in an average flare rate of 36 million standard cubic feet per day over a duration of approximately 5 days, or 120 hours. Emission factors from AP-42 Chapter 13.5, Industrial Flares (USEPA 2018), were used for the blowdown event emissions calculations, as summarized in Table 3-1 in Appendix L, Emissions Inventory and Air Quality Modeling Report.

Table 7.6-17 provides a summary of the estimated annual Operations stage emissions across a range, with two scenarios representing the range: a “lower-end” scenario (including operation of the heaters, cold and wet flares, estimated safety and other flaring (see above for potential sources of flaring taken into account), and intermittent operation of the essential and emergency generators); and a “higher-end” scenario (based on an additional amount of non-routine flaring including an assumed single annual occurrence of a flaring event involving a full blowdown of the pipeline and NGL Plant inventory). For these scenarios, emissions from the following sources were modeled:

- Lower-end: hot oil and molecular sieve regeneration gas heaters, cold and wet flares (inclusive of an assumed amount of flaring as described above), and essential and emergency generators (intermittent, with assumed total operating time); and
- Higher-end: hot oil and molecular sieve regeneration gas heaters, cold and wet flare (inclusive of an assumed amount of flaring as described above), essential and emergency generators (intermittent, with assumed total operating time), and emergency flaring through a wet flare (single annual blowdown event assumed).

Table 7.6-17: Summary of Estimated Annual Project Air Emissions[13]

Pollutant	Source Category	Hours of Operation per Year	Lower-end Scenario	Higher-end Scenario
			Estimated Range of Annual Emissions (tonnes)	
Nitrogen oxides (NO_x)	Hot Oil Heater	8,760	1.02E+01	1.02E+01
	Molecular Sieve Regeneration Gas Heater	8,760	6.70E-01	6.70E-01
	Flaring [b]	8,760	2.03E+01	2.75E+01
	Essential Generator [b]	72	7.17E+00	7.17E+00
	Emergency Generator [b]	72	6.59E-01	6.59E-01
	Total		3.90E+01	4.62E+01
Sulfur dioxide (SO_2)	Hot Oil Heater	8,760	1.55E-01	1.55E-01
	Molecular Sieve Regeneration Gas Heater	8,760	1.28E-02	1.28E-02
	Flaring [b]	8,760	2.25E+00	3.81E+00
	Essential Generator [b]	72	2.41E-01	2.41E-01
	Emergency Generator [b]	72	1.60E-02	1.60E-02
	Total		2.67E-00	4.23E+00
Particulate matter (PM) [a]	Hot Oil Heater	8,760	1.56E+00	1.56E+00
	Molecular Sieve Regeneration Gas Heater	8,760	1.00E-01	1.00E-01
	Flaring [b]	8,760	0.00E+00	0.00E+00
	Essential Generator [b]	72	1.35E-01	1.35E-01
	Emergency Generator [b]	72	4.87E-02	4.87E-02
	Total		1.84E+00	1.84E+00
Carbon monoxide (CO)	Hot Oil Heater	8,760	1.71E+01	1.71E+01
	Molecular Sieve Regeneration Gas Heater	8,760	1.12E+00	1.12E+00
	Flaring [b]	8,760	8.42E+01	1.14E+02
	Essential Generator [b]	72	1.91E+00	1.91E+00
	Emergency Generator [b]	72	1.42E-01	1.42E-01
	Total		1.04E+02	1.34E+02
Greenhouse gases (GHGs) (kilotonnes carbon dioxide-equivalents)	Hot Oil Heater	8,760	2.46E+01	2.46E+01
	Molecular Sieve Regeneration Gas Heater	8,760	1.62E+00	1.62E+00
	Flaring [b]	8,760	3.95E+01	5.39E+01
	Essential Generator [b]	72	8.20E-04	8.20E-04
	Emergency Generator [b]	72	1.50E-07	1.50E-07
	Total		6.57E+01	8.00E+01

[13] The emissions sources and estimates reflect the conceptual stage of Project definition and are subject to updates during FEED and detailed design. If during the detailed design stage of the NGL Plant equipment sizing or design changes cause a major impact to the emissions estimates, the Project will document the change and provide an updated basis.

Pollutant	Source Category	Hours of Operation per Year	Lower-end Scenario	Higher-end Scenario
			Estimated Range of Annual Emissions (tonnes)	
Non-methane volatile organic compounds (VOCs)	All Sources	8,760	1.53E+02	1.91E+02

NA = not applicable;
[a] PM emissions represent total PM.
[b] The emission rates in this table reflect estimated annual totals based on the assumed number of operating hours shown.

7.6.3.2. Air Quality

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact; and (2) the sensitivity of the resource. Separate approaches were used for assessment of potential impacts on air quality for the Construction and Decommissioning stages (for which the focus is potential dust emissions from short-term to medium-term activities), and for the Operations stage (for which the focus is on criteria pollutant emissions from long-term activities).

Construction and Decommissioning Stages

The approach to the assessment of Construction and Decommissioning stage impacts focuses on dust emissions, as this is typically the primary concern related to construction activities. Considering the type of construction and decommissioning activities that will be undertaken, construction and demolition criteria published in the *Guidance on the Assessment of Dust from Demolition and Construction* by the United Kingdom Institute of Air Quality Management (IAQM 2014) were adopted to develop criteria for magnitude, as outlined Table 7.6-18.

Table 7.6-18: Definitions for Magnitude Ratings for Potential Construction and Decommissioning Stage Impacts on Air Quality

Rating	Definition
Negligible	• No demolition or building construction works; or: • Earthworks: – Total site area < 500 m^2 – Soil type with large grain size (e.g., sand) – < 5 heavy earthmoving vehicles active at any one time – Formation of bunds < 2 meters in height – Total material moved < 5,000 tonnes

Rating	Definition
Small	• Demolition: – Total building volume < 20,000 m^3 – Construction material with low potential for dust release (e.g., metal cladding, timber) and/or – Demolition activities undertaken < 10 meters above ground level • Construction: – Total building volume < 25,000 m^3 and/or – Construction material with low potential for dust release (e.g., metal cladding, timber) • Earthworks: Total site area 500 m^2 to 2,500 m^2 – Soil type with large grain size (e.g., sand) – < 5 heavy earthmoving vehicles active at any one time – Formation of bunds < 4 meters in height – Total material moved 5,000 to 20,000 tonnes
Medium	• Demolition: Total building volume 20,000–50,000 m^3 – Construction material with potential for dust release and/or – Demolition activities undertaken 10–20 meters above ground level • Construction: – Total building volume 25,000–100,000 m^3 – Potentially dusty construction material (e.g., concrete) and/or – On-site concrete batching • Earthworks: – Total site area 2,500 m^2 to 10,000 m^2 – Moderately dusty soil type (e.g., silt) – 5–10 heavy earthmoving vehicles active at any one time – Formation of bunds > 8 meters in height – Total material moved 20,000 tonnes to 100,000 tonnes
Large	• Demolition: – Total building volume > 50,000 m^3 – Potentially dusty construction material e.g., concrete – On site crushing and screening and/or – Demolition activities undertaken > 20 meters above ground level • Construction: – Total building volume > 100,000 m^3 – Potentially dusty construction material (e.g., concrete) and/or – On site concrete batching and sandblasting • Earthworks: – Total site area > 10,000 m^2 – Potentially dusty soil type (e.g., clay, which will tend to be prone to suspension when dry due to small particle size) – > 10 heavy earthmoving vehicles active at any one time – Formation of bunds > 8 meters in height – Total material moved > 100,000 tonnes

The sensitivity ratings for human receptors to the health impacts of dust follows the United Kingdom Institute of Air Quality Management (IAQM) criteria for PM_{10}. For nature areas, the sensitivity is defined on the basis of their designated importance as an ecological resource and for their amenity value. This is typically determined on the basis of the statutory protection of the receptor. The sensitivity criteria adopted for this assessment are presented in Table 7.6-19.

Table 7.6-19: Definitions for Resource Sensitivity Ratings for Potential Construction and Decommissioning Stage Impacts on Air Quality

Rating	Definition
Low	• Human Receptors: – Locations where human exposure is transient [a] • Nature Areas: – Areas of specific ecological interest, not subject to statutory protection
Medium	• Human Receptors: – Locations where the people exposed are workers [b], and exposure is over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for 8 hours or more in a day) [c] • Nature Areas: – Nationally designated sites
High	• Human Receptors: – Locations where members of the public are exposed over a time period relevant to the air quality objective for PM_{10} (in the case of the 24-hour objectives, a relevant location would be one where individuals may be exposed for eight hours or more in a day) • Nature Areas: – Internationally designated sites

[a] In accordance with the IAQM guidance, there are no standards that apply to short-term exposure (e.g., 1 or 2 hours, but there is still a risk of health impacts, albeit less certain).
[b] Notwithstanding the fact that air quality objectives and limit values are not intended to apply to people in the workplace, such people can be affected to exposure of PM_{10}. However, they are considered to be less sensitive than the general public as a whole, because those most sensitive to the impacts of air pollution, such as young children, are not normally workers. For this reason, workers are included in the **Medium** sensitivity category.
[c] This follows UK Department for Environment Food and Rural Affairs (DEFRA) guidance as set out in Local Air Quality Management–Technical Guidance published in 2009.

As summarized in Table 7.6-16, a preliminary Construction stage inventory of potential criteria pollutant emissions was developed. However, consistent with the Terms and Scope for the EIA, these estimates were not modeled for the purpose of predicting maximum ground-level concentrations and were thus not used to develop impact significance ratings separate from those based on predicted dust impacts.

Operations Stage

For assessment of potential Operations stage impacts on air quality, the magnitude of potential impact on air quality is not determined based on the standard combination of frequency, duration, and intensity. Instead, magnitude for potential air quality impacts for Operations stage activities is determined on the basis of two factors:

- The increase in pollutant concentrations in air as a result of the Project (Project Contribution [PC])—predicted using air dispersion modeling; and
- The total air pollutant concentration arising as a result of the PC added to the existing conditions (the Predicted Environmental Concentration [PEC]—measured using ambient air quality monitoring).

The PC and PEC are considered in the context of the ambient air quality guidelines presented in Table 7.6-1. The approach taken to assign magnitude ratings is based on guidance from the

IFC for undegraded airsheds that states: “Emissions [should] not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.” This assessment has developed definitions for the various magnitude levels based on this guidance (Figure 7.6-2).

Magnitude of Impacts

	Undegraded Airshed (Baseline < AQS)	Degraded Airshed (Baseline >AQS)
Negligible	PC < 25% of AQS	PC <10% of AQS
Small	PC >25% of AQS, <50% of AQS, and PEC <100% of AQS	PC >10% of AQS, <15% of AQS
Medium	PC >25% of AQS, <50% of AQS, and PEC >100% of AQS; or PC >50% of AQS, <100% of AQS, and PEC <100% of AQS	PC >15% of AQS, <25% of AQS
Large	PC >50% of AQS, <100% of AQS, and PEC >100%; or PC >100% of AQS	PC >25% of AQS

AQS = air quality standard (air quality guidelines were used for the AQS in this assessment); undegraded airshed = environmental conditions where measured existing (baseline) concentrations exceed a specific AQS.

Figure 7.6-2: Definitions for Magnitude Ratings for Potential Operations Stage Impacts on Air Quality

For Operations stage impacts, the approach taken assumes that the sensitivity to air pollutant-related health impacts for receptors within the general population is **Medium**. This is on the basis that, as air quality standards are set to protect the most vulnerable individuals in society, there is inherently a margin of safety within air quality standards. There are a small number of specific cases where receptor sensitivity may be defined as **High**; these cases include where there are particularly vulnerable individuals (e.g., a hospital where there are intensive care wards and high-dependency wards where patients will be particularly sensitive to air pollution).

Impact Magnitude Ratings—Air Quality

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to air quality is provided in Table 7.6-23.

Construction and Decommissioning Stages

It is noted that the air quality impacts associated with the abovementioned construction activities will be managed through the implementation of embedded control measures, as discussed in Table 7.6-23.

Based on the area of excavation (greater than 10,000 m^2), the surficial soil type (silts and clays), and the total material to be moved (greater than 100,000 tonnes), the magnitude of potential dust-related impacts for Construction stage activities during the earthworks phases at the NGL Plant site and along the non-HDD portions of the onshore pipeline corridor (approximately 20 kilometers) are both rated as **Large**. The magnitude of potential dust-related impacts for Construction stage activities along the HDD segments will be **Negligible**.

During the construction (fabrication) phase at the NGL Plant site, the building volume may be as high as 25,000 m^3, but is unlikely to exceed 100,000 m^3. On-site concrete batching will potentially occur. Sandblasting may be performed on field welds, but standard procedures will be to conduct such activities within containment areas (e.g., with plastic sheeting) to isolate the activity from the surrounding environment. On this basis, the magnitude of potential dust-related impacts for Construction stage activities during the fabrication phase is rated as **Medium**.

During the Decommissioning stage at the NGL Plant, it is assumed that the total building volume to be demolished could be as high as 20,000 m^3, but will not exceed 50,000 m^3, and demolition activities are not expected to be conducted above 20 meters above ground level. On this basis, the magnitude of potential dust-related impacts for Decommissioning stage activities at the NGL Plant is rated as **Medium**.

Operations Stage

Air Dispersion Modeling

Modeling of Operations stage Project emissions was carried out to assess air quality impacts for potential onshore human receptors. A detailed discussion of the methodology and results of air dispersion modeling is included in Appendix L, Emissions Inventory and Air Quality Modeling Report. The key elements of the modeling are discussed below, including receptors, source inputs, model selection, and meteorological data.

Receptors: A grid of potential receptor points was established for areas in the Project AOI, with a denser grid used closer to Project sources and a coarser grid used in more distant regions. The grid extended for a distance of 50 kilometers from the NGL Plant fenceline. For each pollutant, dispersion modeling was used to predict the maximum concentration at any time (for the relevant averaging periods) at any one of the receptor grid points; these maximum predicted concentrations were then compared to ambient air quality guidelines. Under this conservative approach, if the maximum predicted concentrations are determined to be less than the respective ambient air quality guidelines, it follows that ambient air quality guidelines would be met at any specific receptor location. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling. No receptors were placed inside the NGL Plant boundaries on the basis that community receptors will not have access to the NGL Plant site.

Sources: With regard to source characteristics, point sources were modeled with fixed stack parameters, including physical dimensions and exhaust characteristics. Flares were also modeled as stacks, with adjustments made to account for and maintain thermal buoyancy associated with the high temperature of the flare.

Figure 7.6-3 shows the nearfield portion of the receptor grid, the NGL Plant fenceline boundary, and the locations of the modeled Project sources. The full extent of the far-field receptor grid is shown in Appendix L, Emissions Inventory and Air Quality Modeling Report.

Model Selection: The modeling was performed using the latest version of the AERMOD modeling system (version 21112). AERMOD is the USEPA's recommended air dispersion model for near-field (within 50 kilometers) application, AERMOD calculates concentrations in a manner that accounts for changes in dispersion rate with height, allows for a non-Gaussian plume in convective conditions, and accounts for a dispersion rate that is a continuous function of meteorology. AERMOD also contains advanced algorithms for estimating plume dispersion in the convective and stable boundary layers, plume rise, and buoyancy. Characteristic wind speeds and directions through the plume thickness are estimated to account for the effect of wind shear on pollutant transport.

Meteorological Data: The Weather Research and Forecasting (WRF) model (WRF-ARW, Version 4.0) (Skamarock 2019) was used to develop a simulated 3 years (2017 through 2019) of meteorological data set for the air quality modeling because there is limited suitable observational data available for the region. The WRF model is a state-of-the-science numerical meteorological model that is designed to simulate atmospheric systems on a wide range of spatial and temporal scales. A full three-dimensional grid of WRF-simulated meteorological data was used for the AERMOD simulations for the Project. These data include simulated meteorological conditions across the modeling domain at a grid resolution of 1 kilometer. Observational data from 2017 through 2019 were used as input for the WRF model. This period was simulated to identify the worst-case dispersion conditions (i.e., leading to the maximum predicted concentrations) that would be expected during the Project life cycle. The meteorological data generated by the WRF model were processed into the AERMOD model-ready meteorological files using the Mesoscale Model Interface program.

Predicted Ambient Air Concentrations

Using the methodology described above, modeling was conducted with AERMOD to predict maximum ground-level concentrations of each pollutant as a result of emissions from Project sources in the area within 50 kilometers of the NGL Plant fenceline. Modeling was performed for the lower-end scenario and the higher-end scenario, as defined above. Model results were developed for each modeled pollutant, for each averaging period with an associated ambient air quality guideline (Table 7.6-1). Modeling results are summarized in Table 7.6-20.

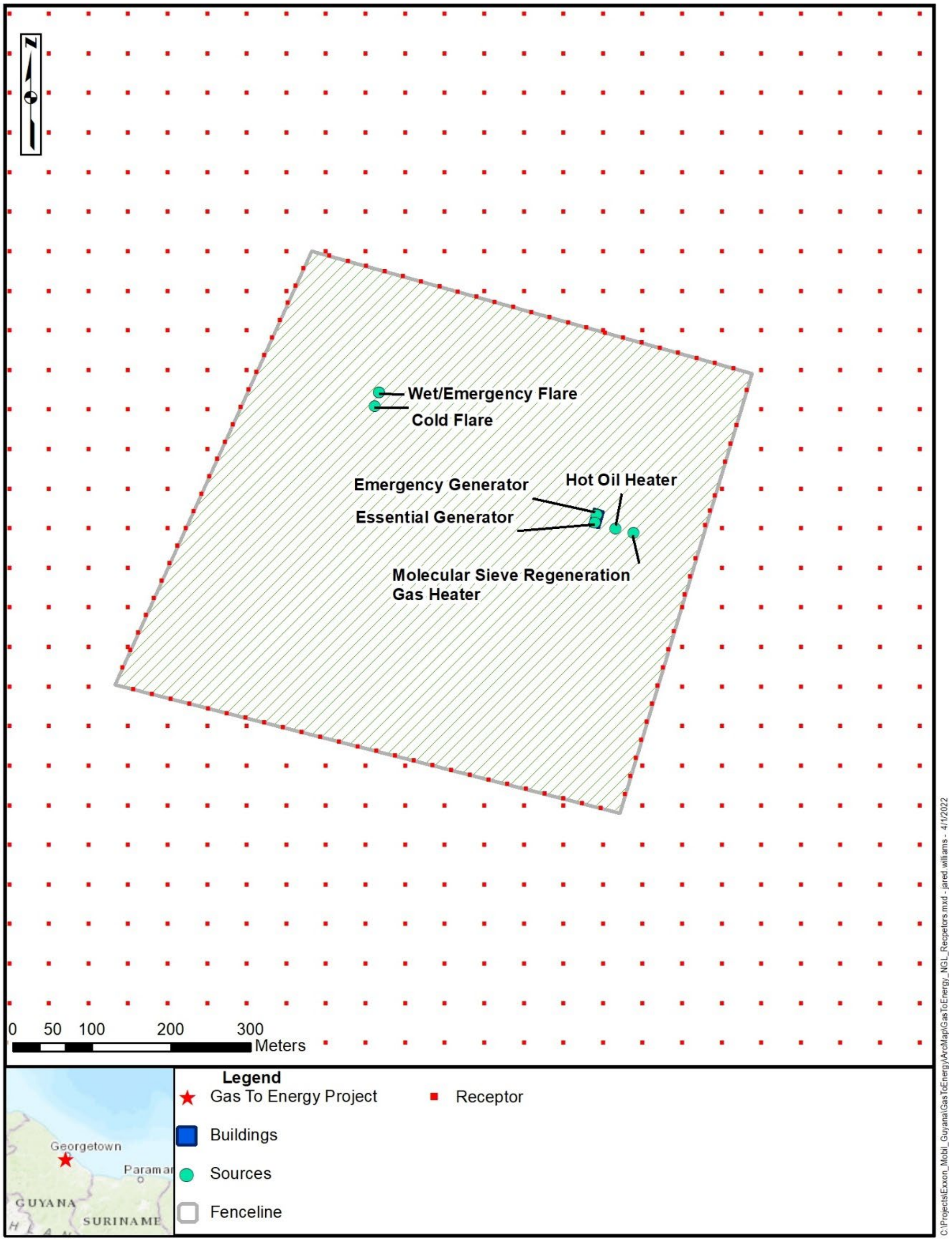

Figure 7.6-3: Nearfield Receptor Grid and NGL Plant Source Locations

Table 7.6-20: Summary of Modeling Results—Maximum Predicted Project (NGL Plant Operations) Impacts

Pollutant	Averaging Period	Ranking [a]	Guideline Concentration (µg/m³) [b]	Maximum Predicted Concentration (µg/m³)		Percent of Guideline	
				Lower-end Scenario	Higher-end Scenario	Lower-end Scenario	Higher-end Scenario
Nitrogen dioxide (NO_2) [c]	1-hour	Max	200	10.11	11.02	5.1%	5.5%
	1-hour	98th percentile	188	7.46	7.98	4.0%	4.2%
	24-hour	99th percentile	25	1.67	1.78	6.7%	7.1%
	Annual	Max	10	0.72	0.78	7.2%	7.8%
Sulfur dioxide (SO_2)	10-minute	Max	500	1.77	2.13	0.4%	0.4%
	1-hour	99th percentile	196	0.89	1.26	0.5%	0.6%
	24-hour	99th percentile	40	0.18	0.25	0.5%	0.6%
Particulate matter (PM_{10}) [d]	24-hour	99th percentile	45	0.09	0.09	0.2%	0.2%
	24-hour	Second high	150	0.09	0.09	0.1%	0.1%
	Annual	Max	15	0.03	0.03	0.2%	0.2%
Particulate matter ($PM_{2.5}$) [d]	24-hour	99th percentile	15	0.09	0.09	0.6%	0.6%
	24-hour	98th percentile	35	0.08	0.08	0.2%	0.2%
	Annual	Max	5	0.03	0.03	0.7%	0.7%
Carbon monoxide (CO)	15-minute	Max	100,000	60.92	59.08	0.1%	0.1%
	1-hour	Max	35,000	46.17	44.78	0.1%	0.1%
	1-hour	Second high	40,000	38.67	43.33	0.1%	0.1%
	8-hour	Max	10,000	17.69	19.28	0.2%	0.2%
	8-hour	Second high	10,000	17.52	19.19	0.2%	0.2%
	24-hour	99th percentile	4,000	6.84	7.44	0.2%	0.2%

[a] The ranking of the modeled concentration was computed across the modeled meteorological years (2017–2019).
[b] WHO 2005; WHO 2021; 40 U.S. Code of Federal Regulation Part 50.
[c] NO_x to NO_2 conversion for AERMOD model-predicted concentrations was based on Plume Volume Molar Ratio Method.
[d] PM emissions represent total PM. A breakdown between PM_{10} and $PM_{2.5}$ is not available, so the full PM concentration was conservatively assigned to both PM_{10} and $PM_{2.5}$ for the purpose of comparison to guideline concentrations.

Characterization of Ambient Airshed

To support interpretation of the result of air dispersion modeling, the guideline values shown in Table 7.6-1 were used to review existing conditions in the ambient airshed. As discussed in Section 7.6.1, Methodology, to date, EEPGL has facilitated measurement of ambient onshore air concentrations of various pollutants at four locations in Guyana (i.e., Carifesta, New Amsterdam, New Guyana School, and Friendship Education Department). For each of the parameters subjected to modeling and each of the averaging periods for which a guideline is provided in Table 7.6-1, Table 7.6-21 shows the maximum measured concentrations for the same averaging periods based on consideration of the data from Carifesta, New Guyana School, and Friendship Education Department. The data from New Amsterdam were excluded from consideration for this assessment because the New Amsterdam monitoring site is significantly farther (approximately 90 kilometers) from the NGL Plant site, as compared to the other three sites. The maximum measured concentrations were developed based on combining the separate monitoring campaigns for the three sites into a single data set. For PM with aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) and PM with aerodynamic diameter less than 10 microns (PM_{10}), data for the ongoing program at the Friendship Education Department site were not available for the monitoring period to date because the PM measurement equipment was not operational for this period. Accordingly, the maximum concentrations for these parameters are based on consideration of only the Carifesta and New Guyana School monitoring sites. These maximum measured concentrations were used to represent the existing ambient air concentrations where a receptor could potentially be located.

The monitoring data suggest that the airshed is non-degraded for NO_x, SO_2, and CO, and degraded (baseline existing concentrations exceed guideline concentrations) for PM_{10} and $PM_{2.5}$.

Table 7.6-21: Summary of Maximum Measured Baseline Ambient Air Concentrations from Combined Carifesta, New Guyana School, and Friendship Education Department Monitoring Sites

Pollutant	Averaging Period	Ranking	Maximum Concentration (µg/m³)	Guideline Concentration (µg/m³)	Airshed Designation
Nitrogen dioxide (NO_2)	1-hour	Max / 98th percentile	43.8 / 35.5	200 / 188	Non-degraded
	24-hour	99th percentile	10.3	25	Non-degraded
	Full period [a] (314 days)	Max	1.7	10	Non-degraded
Sulfur dioxide (SO_2)	10-minute	Max	43.3	500	Non-degraded
	1-hour	99th percentile	21.5	196	Non-degraded
	24-hour	99th percentile	5	40	Non-degraded
Particulate matter (PM_{10}) [b]	24-hour	99th percentile/2nd high	154.3 / 140.4	45 / 150	Degraded

Pollutant	Averaging Period	Ranking	Maximum Concentration ($\mu g/m^3$)	Guideline Concentration ($\mu g/m^3$)	Airshed Designation
	Full Period [a] (270 days)	Max	26.9	15	Degraded
Particulate matter ($PM_{2.5}$) [b]	24-Hour	99th percentile	53.1 / 58.8	15 / 35	Degraded
	Full Period [a] (270 days)	Max	10.1	5	Degraded
Carbon monoxide (CO)	15-minute	Max	2,767	100,000	Non-degraded
	1-hour	Max / 2nd high	1,726 / 1,660	35,000/40,000	Non-degraded
	8-hour	Max / 2nd high	1,385 / 1,317	10,000/10,000	Non-degraded
	24-hour	99th percentile	939	4,000	Non-degraded

[a] The maximum measured concentration across the aggregate number of monitoring days for the three monitoring sites (270 to 314 days depending on parameter) was compared to the annual guideline concentration.
[b] Maximum concentration based on consideration of Carifesta and New Guyana school monitoring data only.

Assignment of Magnitude Rating

As shown in Table 7.6-20, the maximum concentrations predicted to result from planned Project activities for all modeled averaging periods are all 0.7 percent or less of the respective ambient air quality guidelines for PM_{10}, and $PM_{2.5}$, and are all 7.8 percent or less of the respective ambient air quality guidelines for other criteria pollutants. Accordingly, following the definitions on Figure 7.6-2, the magnitude of potential Project impacts on air quality is considered **Negligible**.

Sensitivity of Resource—Air Quality

Construction and Decommissioning Stages

Dust from construction activities is typically re-deposited within 350 meters of the source (IAQM 2014). The assessment of sensitivity of receptors for potential dust-related impacts during the Construction and Decommissioning stages is therefore focused on potentially impacted receptors within this distance from each of the construction worksites. Considering this potential radius of effect from dust emissions, there are residential structures that could potentially be affected along approximately 3.5 kilometers (in aggregate) of the approximately 25-kilometer onshore pipeline corridor. Using the definitions in Table 7.6-19, and assuming that the pipeline construction operation will move at a rate of approximately 80 meters per day (meaning immediately proximal structures could be exposed to dust emissions for more than 1 day per given receptor), these structures are rated as a **High** sensitivity. There are no residential structures located within close proximity to the onshore pipeline (or the type of activity is not likely to generate substantial dust [e.g., HDD drilling]) for the remaining approximately 21.5 kilometers of the onshore pipeline corridor. The receptor sensitivity for these segments of the onshore pipeline is therefore rated as **Low**.

There are no residential structures located within 350 meters of the NGL Plant site. However, there are a few structures located within 350 meters of the proposed heavy haul road approach to the temporary MOF. These structures are rated as **High** sensitivity for Construction and

Decommissioning (of the heavy haul road), but otherwise, the receptor sensitivity in the vicinity of the NGL Plant site during Construction and Decommissioning stages is rated as **Low**.

Operations Stage

Based on the methodology discussed above, the sensitivity of most potential onshore community receptors is considered **Medium**, with the potential for some more sensitive receptors to have a **High** sensitivity.

Pre-mitigation Impact Significance—Air Quality

Assuming implementation of the embedded controls listed in Table 7.6-23, the pre-mitigation magnitude ratings for potential Construction stage (dust-related) impacts on air quality range from **Negligible** (HDD segments of onshore pipeline corridor) to **Medium** (post-earthworks phase of NGL Plant) to **Large** (earthworks phases of NGL Plant and onshore pipeline corridor). Coupled with sensitivity ratings of **Low** (for areas where no residential receptors are located within 350 meters of construction activities) to **High** (for areas where residential receptors are located within 350 meters of construction activities). Pre-mitigation magnitude ratings for Decommissioning activities are rated as **Medium**. Accordingly, the pre-mitigation impact significance for air quality range from **Negligible** to **Major** for Construction activities and **Minor** for Decommissioning activities.

7.6.3.3. Climate and Climate Change

Impact Assessment Methodology

Potential climate / climate change impacts are a global concern and stem from cumulative worldwide GHG concentrations. The Global Circulation Models used to predict climate impacts from global concentrations are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contribution from a single project such as the GTE Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate using observed data, and can be used to estimate future local climate changes based on the results of Global Circulation Models. However, the reverse approach of predicting the impact of local GHG emissions on global (or local) climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions. For these reasons, while it is possible to quantify the total GHG emissions from the Project, it is difficult to assign a magnitude rating that reflects the potential impacts the resource will experience specifically as a result of the Project (as is done for other resources assessed in this EIA). Recognizing this limitation, this EIA provides a rating for what is referred to herein as *impact significance*. The assessment of potential impact significance for the Project's impacts on global climate / climate change is conducted differently from the assessment for other resources.

The approach taken is to assign a significance rating for potential Project GHG emissions, as a proxy for impacts on global climate change, based on comparison of Project GHG emissions to those of Guyana (i.e., without the Project) and to regional and global GHG emissions.

As discussed above, the Project design includes a series of embedded controls that serve to further reduce emissions of atmospheric pollutants (Table 7.6-23). Many of these embedded controls also serve to decrease GHG emissions.

Table 7.6-17 summarizes the estimated annual GHG emissions for the lower-end and higher-end scenarios. Estimated GHG emissions were calculated in three parts: the quantity of carbon dioxide (CO_2) in the fuel that is emitted directly as CO_2; products of combustion of various fuel components based on the potential for each component to contribute to GHG emissions; and the CO_2-equivalent (CO_2e) emissions of other emitted compounds such as methane and nitrous oxides. Emission factors from the AP-42 document noted above were used to calculate the combustion-related GHG emissions (USEPA 2018). Estimated annual GHG emissions from the NGL Plant are approximately 65.7 kilotonnes of CO_2-equivalents (CO_2e) for the lower-end scenario, and approximately 80.0 kilotonnes of CO_2-equivalents (CO_2e) for the higher-end scenario.

Guyana published its Second National Communication on Climate Change in 2012 (Government of Guyana 2012) and it reported in this communication to be a net sink of GHGs (meaning its national "removals" exceeded its national emissions). This document provided country-level GHG estimates, the most recent of which was for 2004. For 2004, the document states that reported net annual removals for Guyana were approximately 56.9 million tonnes of CO_2e, comprising total removals of approximately 61.5 million tonnes of CO_2e and total emissions of approximately 4.671 million tonnes of CO_2e. Guyana's most recent submittal to the United Nations Framework Convention on Climate Change (UNFCCC) under the Paris Agreement, titled *Guyana's Revised Intended Nationally Determined Contribution*) (Guyana NDC 2016), states that the most recent GHG inventory for Guyana is still for the year 2004, and comprised aggregate emissions of 4.617 million tonnes CO_2e (excluding removals). Referring to the Second National Communication (which is cited in the Revised Intended Nationally Determined Contribution for this value), the correct value appears to be 4.671 million tonnes CO_2e. Guyana's Office of Climate Change is currently updating the Second National Communication to the United Nations; in a document from the United Nations Development Programme discussing the pending update, an annual emission rate of 4.213 million tonnes of CO_2e is cited for 2016, with the note that this value excludes emissions from the Land-Use, Land Use Change, and Forests category (UNDP 2020).

As a conservative measure, considering only the figures provided in Guyana's submittals to the UNFCCC (i.e., 4.671 million tonnes CO_2e), the overall emissions at a country level would be increased by approximately 1.4 percent under the lower-end scenario and 1.7 percent under the higher-end scenario; net country-level removals would decrease from 56.9 million tonnes of CO_2e to 56.83 million tonnes of CO_2e for the lower-end scenario (i.e., an approximately 0.11 percent decrease) and from 56.9 million tonnes of CO_2e to 56.82 million tonnes of CO_2e for the higher-end scenario (i.e., an approximately 0.14 percent decrease).

According to the World Resources Institute (WRI) Climate Analysis Indicators Tool, Guyana emitted 19.12 million tonnes (19,120 kilotonnes) CO_2e in 2018 (WRI Undated_a). Around 74 percent of these emissions (or 14.09 million tonnes CO_2e) were attributable to land-use change and forestry. The total WRI estimate for 2018 excluding Land-Use Change and Forestry is 5,030 kilotonnes CO_2e.

From a regional perspective, the Inter-American Development Bank, in its 2013 publication *The Climate and Development Challenge for Latin America and the Caribbean* (Vergara et al. 2013), projected regional emissions of 6,730 million tonnes per year CO_2e by 2050 for a "business as usual"[14] scenario and 1,450 million tonnes per year for a "GHG target" scenario (which is based on a target of 2 tonnes per capita). Considering these regional estimates, the Project's estimated annual GHG emissions (0.066 to 0.080 million tonnes per year) represent between 0.001 and 0.006 percent of these projected regional 2050 emissions.

From a global perspective, the WRI's Climate Watch tool cites a global GHG emission level of 48.93 gigatonnes CO_2e/year for 2018 (WRI Undated_b). The ranges of global GHG emissions modeled by the IPCC to determine the median target global GHG emissions necessary to reach the commonly discussed target scenarios of "Below 1.5°C" and "Below 2.0°C" above pre-industrial levels (both based on a 66 percent probability of estimated temperature outcomes) by the end of the century are 25 and 41 gigatonnes per year CO_2e, respectively, for the year 2030 (UNEP 2019, Table 3.1). Under the lower-end scenario, the Project will emit an estimated average of 65.7 kilotonnes (i.e., approximately 0.000066 gigatonnes) CO_2e per year. This amounts to approximately 0.00006 percent of the 2018 baseline emission level and 0.00016 to 0.00026 percent of the global GHG emissions modeled by the IPCC for the 1.5°C and 2°C scenarios, respectively.

Table 7.6-22 summarizes the comparison of the estimated Project average annual GHG emissions during the Operations stage to the other emission levels discussed above.

Table 7.6-22: Comparison of Estimated Project Average Annual Operations Stage GHG Emissions to Guyana, Latin America and Caribbean Region, and Global Emissions

	GHG Emissions (million tonnes CO_2e/year)	Percent Represented by Project Average Annual Emissions during Operations Stage
NGL Plant Average Annual Emissions during Operations Stage	0.066 (lower-end) 0.080 (higher-end)	—
Most recent Nationally Determined Contribution estimate of Guyana's GHG Emissions (2004)[a]	4.671	1.4% (lower-end) 1.7% (higher-end)
Most recent Nationally Determined Contribution estimate of Guyana's Net GHG Removals (2004)	56.9	0.12% (lower-end) 0.14% (higher-end)
Most recent WRI estimate of Guyana's GHG Emissions (2018) [b]	19.12	0.34% (lower-end) 0.42% (higher-end)

[14] The cited "business as usual" is the judgment of the referenced authors, and is not a term used by the IPCC.

	GHG Emissions (million tonnes CO_2e/year)	Percent Represented by Project Average Annual Emissions during Operations Stage
Latin America and Caribbean [c] Business As Usual Projection [d] by 2050	6,730	0.0010% (lower-end) 0.0012% (higher-end)
Latin America and Caribbean GHG Target [f] by 2050 [e]	1,450	0.0045% (lower-end) 0.0055% (higher-end)
Global Emissions in 2018 [g]	48,930	0.00013% (lower-end) 0.00016% (higher-end)
Global Emissions (1.5°C and 2°C scenarios; by 2030) [h]	25,000 to 41,000	0.00026% to 0.00032% (lower-end) 0.00016% to 0.00020% (higher-end)

[a] Government of Guyana 2012
[b] WRI Undated_a
[c] Latin America and Caribbean includes the following countries: Argentina, Bahamas, Bolivia, Brazil, Cuba, Chile, Colombia, Ecuador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Venezuela.
[d] Business as Usual" projection in 2050 (i.e., trajectory if certain mitigations and controls are not enacted)
[e] Vergara et al. 2013
[f] The Latin America and Caribbean GHG target is 2 tonnes per capita, which converts to roughly 1.45 gigatonnes CO2e.
[g] WRI Undated_b
[h] UNEP 2019, Table 3.1

Pre-mitigation Impact Significance—Climate / Climate Change

The Project represents an increase in GHG emissions, but the percentage increase relative to national GHG emission is less than 1 percent, and the percentage increases relative to regional and global emissions are all several orders of magnitude below 1 percent. However, recognizing that climate change has a high importance as a global concern and that the Project will contribute to an increase in global GHG emissions, a pre-mitigation significance rating of **Minor** is assigned for the Operations stage. Based on the relatively low GHG emissions associated with Construction and Decommissioning stages, pre-mitigation significance ratings of **Negligible** are assigned for these stages.

7.6.4. Impact Management and Monitoring Measures

Based on the fact that potential Construction stage impacts on air quality are rated as high as **Major** for some phases and locations within the construction footprint, the following additional mitigation measures are recommended:

- Minimize dust-emitting activities such as cutting, grinding, and sawing by employing alternative methods or technologies, such as the use of pre-fabricated material wherever possible.
- Review construction plan and confirm availability of water for dust suppression on site for dust suppression.
- Keep uncovered stockpiles moist.
- Apply water to unpaved haul roads to minimize dust generation.

- Train workers to employ material handling methods that will minimize dust emissions. These include minimizing drop heights to control the fall of materials and minimizing exposure of stockpiles to wind by removal of earth from small areas of secure covers when needed.
- Undertake early liaison with the relevant property owners or operators prior to construction and demolition, as part of the stakeholder engagement plan, to inform them of the work activities and feedback/complaints procedure.
- Use the CGM to obtain feedback or complaints, and investigate and take action to address any issues that may arise during Construction or Decommissioning stage activities.

Based on the **Negligible** significance of potential Operations stage impacts on air quality, no mitigation measures are proposed. It is noted, however, that the limited significance of potential air quality impacts for this particular Project is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

Based on the **Negligible** significance of potential impacts on climate / climate change, no mitigation measures are warranted. It is noted, however, that the limited significance of potential climate / climate change impacts for this particular Project is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

EEPGL will annually quantify direct Project GHG emissions from the dedicated Project facilities and equipment used within the Project AOI. Additionally, each year, as part of its annual planning process, EEPGL will review these quantified GHG emissions and establish plans to achieve continuous improvement.

Table 7.6-23 summarizes the management and monitoring measures relevant to air quality and climate / climate change.

Table 7.6-23: List of Management and Monitoring Measures

Embedded Controls
Use appropriate control measures to minimize dust arising from construction works.
Require construction equipment and other workforce vehicle drivers to adhere to Project-established speed limits within the construction worksites.
With respect to non-routine flaring of gas, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low NO_x emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere; • Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; and • Minimize flame lift off and/or flame lick.
Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and NGL Plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Implement inspection, maintenance, and surveillance programs (including Leak Detection and Repair systems) to identify and prevent unplanned emissions to atmosphere from the NGL Plant.
Avoid routine venting (excludes tank flashing emissions, truck loading, standing / working / breathing losses) except during safety and emergency conditions.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions to the extent reasonably practicable.
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Mitigation Measures
Minimize dust-emitting activities such as cutting, grinding, and sawing by employing alternative methods or technologies, such as the use of pre-fabricated material wherever possible.
Review construction plan and confirm availability of water for dust suppression on site for dust suppression.
Keep uncovered stockpiles moist.
Apply water to unpaved haul roads to minimize dust generation.
Train workers to employ material handling methods that will minimize dust emissions. These include minimizing drop heights to control the fall of materials and minimizing exposure of stockpiles to wind by removal of earth from small areas of secure covers when needed.
Undertake early liaison with the relevant property owners or operators prior to construction and demolition, as part of the stakeholder engagement plan, to inform them of the work activities and feedback/complaints procedure.
Use the CGM to obtain feedback or complaints, and investigate and take action to address any issues that may arise during Construction or Decommissioning stage activities.
Annually quantify direct Project GHG emissions from the dedicated Project facilities and equipment used within the Project AOI. Annually review these quantified GHG emissions and establish plans to achieve continuous improvement.

Monitoring Measures
During construction, monitor dust levels along portions of the onshore pipeline corridor with residential structures in close enough proximity to potentially be affected by dust emissions.
Monitor on an ongoing basis the volume of fuel used by all combustion sources and equipment at the NGL Plant.
Monitor volume of fuel used for helicopter operation.
Keep records of non-routine flaring of gas.
Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations.

7.6.5. Assessment of Residual Impacts

On the basis of implementation of the mitigation measures described above, the residual significance of potential Construction stage impacts on air quality will be reduced to a range of **Negligible** to **Moderate**. However, it is recommended that the efficacy of the combined embedded controls and mitigation measures supporting this expectation be confirmed through monitoring of dust levels during construction activities in areas proximal to residential receptors.

As described above, no mitigation measures are warranted to address potential Operations stage impacts on air quality or climate / climate change. Accordingly, the residual impact significance ratings for these potential impacts remain unchanged at **Negligible**.

Table 7.6-24 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on air quality, climate, and climate change.

Table 7.6-24: Summary of Potential Pre-Mitigation and Residual Impacts—Air Quality, Climate, and Climate Change

Stage	Resource—Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction (open trenching segments of onshore pipeline)	Increased concentrations of criteria pollutants in ambient air, particularly focused on dust—potentially contributing to nuisance or health impacts for community receptors	Large	High (areas near residential receptors) Low (other areas)	Moderate to Major	See Section 7.6.4	Minor to Moderate
Construction (HDD segments of onshore pipeline)		Negligible	High (areas near residential receptors) Low (other areas)	Negligible	None	Negligible
Construction (NGL Plant earthworks)		Large	High (areas near residential receptors) [a] Low (other areas)	Moderate to Major	See Section 7.6.4	Minor to Moderate
Construction (NGL Plant Fabrication)		Medium	Low	Minor	See Section 7.6.4	Negligible
Decommissioning		Medium	High (areas near residential receptors) [a] Low (other areas)	Minor to Major	See Section 7.6.4	Negligible to Moderate
Operations	Air Quality—Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for community receptors	Negligible	Medium (most of population) High (more sensitive receptors)	Negligible	None	Negligible
Construction Decommissioning	Climate / Climate Change—Emissions of GHGs from the Project, contributing to global GHG emissions	—	—	Negligible	None	Negligible

Stage	Resource—Impact	Magnitude Rating	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Operations	Climate / Climate Change—Emissions of GHGs from the Project, contributing to global GHG emissions	—	—	Minor	Annually quantify direct Project GHG emissions from the dedicated Project facilities and equipment used within the Project AOI. Annually review these quantified GHG emissions and establish plans to achieve continuous improvement	Minor

[a] Limited to a few residential structures near the proposed heavy haul approach to the temporary MOF.

7.7. WASTE MANAGEMENT AND INFRASTRUCTURE CAPACITY

7.7.1. Baseline Methodology

The information presented herein was gathered from information available in the public domain, Project design information obtained from EEPGL, and from two key documents prepared by EEPGL: the Cradle to Grave Waste Analysis Study (EEPGL 2021) and the Comprehensive Waste Management Plan (CWMP; Volume III of the EIA)—both of which were submitted to and have been approved by the EPA. These documents provide a framework for waste management practices for all of EEPGL's activities in Guyana—including those of the Project.

This section provides an overview of the waste management framework and waste management infrastructure capacity in Guyana, describes the anticipated types and quantities of wastes that will be generated by the Project, and assesses the potential impacts of the Project's anticipated waste generation on the existing waste management infrastructure (i.e., in terms of its capacity to serve the Project and other users).

7.7.2. Existing Conditions and Baseline Studies

This section provides an overview of the administrative framework for waste management and the existing waste management infrastructure capacity within Guyana.

7.7.2.1. Waste Management Authorities

Currently, several public sector agencies are involved in regulating waste management in Guyana, including the EPA, Ministry of Local Government and Regional Development (MLGRD), Ministry of Public Health, Ministry of Natural Resources, Regional Democratic Councils (RDCs), Neighborhood Democratic Councils (NDCs), and Town Councils (TCs); among these agencies, there are some overlaps in roles and responsibilities. The two key agencies involved in waste management are the EPA and the MLGRD; their roles in waste management are further elaborated below.

Guyana Environmental Protection Agency

Waste management is one of the EPA's program areas, which includes the permitting of waste disposal facilities. Under the EPA's Industry/Waste Management program area, the EPA manages the policies, guidelines, and standard operational procedures regarding waste management and resource recovery. The stated aim of the program is to realize maximum value from natural resources and ensure a "green environment."

The core function of the Waste Management sub-program within this program area is to manage waste entering into the environment in an environmentally sound manner. Through this program area, the EPA provides technical assistance in the development, management, and operation of waste management facilities; conducts research and analysis on the recovery of useful energy from solid waste; and develops guidelines and standards for the disposal of hazardous waste and other types of waste. Through the same program area, the EPA also coordinates and implements the obligations of the Basel Convention and controls the import and export of hazardous waste through granting of authorizations. The waste management component of the program area focuses on three topics:

- Solid waste management
- Hazardous waste management
- Waste reduction and recovery

Since 2020, the EPA has been developing a draft set of requirements for hazardous and non-hazardous waste management, which the Consultants understand will eventually become part of revised waste regulations. Accordingly, it is envisioned that waste service providers' operations may need to be updated in the future. It is understood that one of the major revisions to these regulations will be the adoption of U.S. Resource Conservation and Recovery Act-like disposal treatment standards.

Ministry of Local Government and Regional Development

The MLGRD is the primary government agency that links the various local authorities with the central Government of Guyana. It facilitates, coordinates, and monitors the execution and implementation of a number of projects, programs, and activities in the various local government arms and ensures that these activities are in conformity with the legal framework and the policies of the government. The MLGRD is also leading development of Guyana's National Solid Waste Management Strategy. The MLGRD has direct oversight over the Haags Bosch Landfill (HBL) site, as well as the waste management activities of RDCs, NDCs, the Georgetown City Council, and TCs.

7.7.2.2. Municipal/Non-hazardous Waste Management Facilities

In Region 4, the HBL, which is located in the Eccles East Bank Demerara area, is government-owned under the jurisdiction of the MLGRD (Sanitation Management Unit) and is operated by a third-party contractor—Waste Solutions Landfill Inc. (joint venture between Puran Brothers and Cevons Waste Management). The HBL began operations in early 2011 and, at present, the HBL is the only engineered landfill in Guyana for the disposal of municipal solid waste and non-hazardous commercial/industrial wastes. The HBL is the current destination for most municipal and commercial solid non-hazardous waste generated from the greater Georgetown area, including wastes generated from the more than 25 NDCs between Mahaica, the Seawall, Timehri, and Parika.

The original HBL disposal cell (Cell 1) is at capacity, and a second cell (Cell 2) began operations in late March 2021 (Damon 2021). The HBL facility currently receives approximately 500 tonnes of waste per day. At current disposal rates, the Government of Guyana estimates that Cell 2 has approximately 4 to 6 years of disposal capacity. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next 5 years. Space remains for the development of additional cell(s) at the HBL location in the future.

The currently available landfill capacity appears sufficient to support the Project and other users for the short term, even considering forecasted growth in waste volumes from expanding industrial activity. Presuming additional cell(s) would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years).

Aside from the HBL in Region 4, most regions in Guyana rely on dumpsites for the disposal of municipal waste, with each region having at least one dumpsite. In addition to receiving municipal waste from household collections, these dumpsites are also used for the disposal of commercial and industrial waste. Although the dumpsites are intended only for the disposal of non-hazardous wastes, the control over incoming waste is generally not rigorous.

The Government of Guyana is seeking to develop a more coordinated approach to waste infrastructure planning that is compatible with land use planning and promotes coordination and optimization of waste management facilities across all regions. The Ministry of Communities' (predecessor to MLGRD) stated strategy in 2017 was to progressively rehabilitate illegal dumpsites, disused dumpsites, and poorly operated dumpsites (Gilkes 2017). In 2019, the government's Sanitation Unit collaborated with the EPA to embark on a number of assessments of existing dumpsites and proposed landfill sites in each administrative region across Guyana. The project was working toward a countrywide sustainable waste management system. The MLGRD has controlled dumpsites at Lusignan in Region 4, Byderabo in Bartica, Rose Hall, Esplanade in New Amsterdam, and Bon Success in Lethem. In early 2021, the government announced it would be moving to create temporary regional dumpsites in Regions 2, 3, and 5 in 2021. The creation of the dumpsites is covered under a $1.1 billion GYD ($5,500,000 USD) line item allocated for solid waste management in the 2021 national budget. The allocation also included funds for completion of Cell 2 construction at the HBL Site and disposal site upgrades at Rose Hall, Port Kaituma, Belle Vue, Lethem, Lima, Charity, Lusignan, and D'Edward village (Garnett 2021).

7.7.2.3. Industrial/Hazardous Waste Management Facilities

There are a limited number of facilities for the treatment of hazardous and industrial waste in Guyana, although the construction and proposal of additional facilities are growing, commensurate with the planned expansion of oil and gas activities. Tiger Rentals Guyana Inc. (TRG), located at the Guyana Shorebase Inc. (GYSBI) facility, is currently the primary provider of hazardous and non-hazardous waste treatment services in Guyana. TRG employs a variety of waste treatment technologies (sorting/segregation of recyclables, physical/chemical/thermal treatment of hazardous and non-hazardous wastes), discharges its treated fluids as permitted effluent to the Demerara River, and sends its treated non-hazardous solid waste—as well as other wastes received (including general waste, paper/cardboard, and scrap wood)—to the HBL.

In addition to TRG, several additional private waste management facilities have recently come online or are expected to come online in the near-term for hazardous (and non-hazardous) waste treatment, including the following:

- Sustainable Environmental Solutions Guyana, Inc. (SES) has constructed a new integrated waste management facility at GYSBI for managing wastes generated from offshore oil and gas operations; this facility went fully operational in 4Q 2021. The facility employs various hazardous and non-hazardous waste management technologies, including hot oil thermal desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing operations.
- Liquid Mud Plants (LMPs) (of which there are currently three) are operated by onshore drilling services providers that operate cement and drilling fluids facilities, including Schlumberger Guyana, Inc. / MI-Swaco (located adjacent to the GYSBI facility), Halliburton Guyana, Inc. (located at the G-Port facility at the mouth of the Demerara River), and Baker Hughes Guyana Inc. (also located at the G-Port facility). The LMPs manufacture drilling fluids (mud) for offshore oil and gas operations, but also receive spent mud from the offshore drilling operations for onshore reconditioning. The used muds are reclaimed using mechanical (centrifugation) and chemical processes, and the reconditioned muds are then returned to the drill ships for use in new drilling operations. The LMPs generate hazardous and non-hazardous wastes from their reconditioning operations, including fluids, cuttings, and other solids recovered from the used muds, as well as other operational wastes (e.g., wastewaters, oily rags, general refuse). Until recently, these wastes have been managed by TRG. In 3Q 2021, the SES facility commissioned thermal desorption and incinerator operations and began receiving centrifuge solids from the LMPs. Commissioning of wastewater treatment operations at the SES facility is forecasted for 1Q 2022.
- Oilfield Waste Management Services (OWMS) submitted a permit application to the EPA in 2020 for the construction of a 5,000-square-meter drilling waste processing plant in the Little Diamond East Bank Demerara area (located approximately 5 kilometers south of the GYSBI). OWMS will employ thermal desorption separator (hammer mill) technology to treat drilling muds. Oil and water recovered from the process are proposed to be recycled in the formulation of new drilling muds, and the solids are proposed to be used in the bitumen manufacturing process or sent to the HBL. It is unknown when the OWMS plant will become operational.
- Environmental Waste Management Services Guyana Inc. submitted a permit application in late 2020 for the construction and operation of a waste treatment (bioremediation) facility for mud sludge generated from activities in the oil and gas sector. The proposed facility location is at Lots 21 and 22, Block XXV111 Zone Plantation Friendship, East Bank Demerara area. According to the EPA Public Notice issued December 2020, the operation will involve the development of two treatment ponds lined with high-density polyethylene geomembrane liners and contained by 91.4-centimeter-high berms. The status of this application is not currently known, and it is also unknown when the facility would become operational.

- GYSBI currently operates a steel-pipe warehouse, storage, and handling operation at its GYSBI Annex location that involves the washing of virgin steel pipe prior to transfer to the wharf and loading onto the vessels for offshore transit. The non-hazardous effluent from this washing operation is currently collected and treated in on-site evaporators, with no discharge of the effluent. This location is being considered as part of a feasibility assessment for developing a new facility to manage used plastic drill pipe thread protectors generated from pipe-handling operations. Pipe thread protectors are designed to protect the critical threads of the steel pipes during storage, handling, and transport; tens of thousands of these metal-reinforced plastic caps will be generated as a result of planned offshore well installation operations. If the referenced facility is operationalized, these used plastic caps would first be subject to grinding to separate the plastic and metal parts, and the plastic would then be melted and pelletized and returned to the original manufacturer as a raw material for the production of new plastic caps. The recovered metal would also be recycled. Although being considered, it is uncertain whether or when this type of facility would move forward at this location.

7.7.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on waste management infrastructure capacity. The relevant planned Project activities and the associated potential impacts of these activities on waste management infrastructure capacity are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

7.7.3.1. Relevant Project Activities and Potential Impacts

The planned activities of the Project will generate various hazardous and non-hazardous wastes during the Construction, Operations, and Decommissioning stages; many of these wastes will be recycled, treated, and/or disposed using waste management infrastructure in Guyana. The assessment of potential impacts for this resource is therefore focused on the potential impacts on the capacity of Guyana's waste management infrastructure to accommodate the needs of the Project as well as other non-Project needs. As described below, EEPGL will first seek to identify options for reuse or recycling of decommissioned equipment from the Project. Accordingly, an estimate of the quantity of wastes that will require disposal in Guyana at the time of decommissioning (more than 20 years in the future) would be very preliminary in nature. The assessment is therefore focused on waste generation for the Construction and Operations stages.

Various Project waste streams generated offshore (e.g., associated with marine installation or decommissioning vessels) will be treated and/or discharged directly to the sea in accordance with applicable international standards. All of these waste streams are subject to some type of pre-treatment and/or monitoring prior to discharge overboard in accordance with permit requirements, international conventions, relevant international standards, or good international oilfield practice. Further details about waste streams discharged to the sea and applicable discharge standards are presented in Section 5.5.3, Effluent Discharges. Potential impacts of Project discharges to sea are discussed in Section 7.4, Water Quality.

The remainder of this section focuses on Project-generated wastes that will be generated and managed onshore, or generated offshore and transported for management onshore.

Table 7.7-1 summarizes the planned Project activities that could result in potential impacts on waste management infrastructure capacity.

Table 7.7-1: Summary of Relevant Project Activities and Key Potential Impacts—Waste Management Infrastructure Capacity

Stage	Project Activity	Key Potential Impacts
Construction Operations	Generation of non-hazardous and hazardous waste from onshore and offshore construction, onshore NGL Plant operations, and decommissioning.	• Overburdening of Guyana-based non-hazardous waste management infrastructure. • Overburdening of Guyana-based hazardous waste management infrastructure.

Wastes generated by the Project will be managed in accordance with EEPGL's CWMP (Volume III of the EIA), which has been approved by the EPA. The CWMP is intended to accommodate all projects in Guyana associated with EEPGL's exploration and appraisal drilling, development drilling, installation and hook-up, commissioning, and startup, office construction, production operations, and related activities. This CWMP is inclusive of the Liza Phase 1 Development Project, Liza Phase 2 Development Project, Payara Development Project, Guyana Fiber Optic Cable Project, and Guyana Office Complex Project, as well as permitted exploration drilling projects. In addition, the CWMP makes provision for projects currently under review by the EPA, including the Yellowtail Development Project and the Gas to Energy Project. As design and construction details are finalized for the GTE Project and any other new projects that are proposed by EEPGL, pending their authorization, the CWMP will be updated as needed to account for these details.

The CWMP provides a summary of the representative types of wastes that will be generated by the Project. It specifies the primary and alternative treatment/disposal methods for various waste streams, as well as the associated monitoring and reporting requirements. The CWMP also indicates the roles and responsibilities of the different parties involved in managing Project wastes, and the national and international waste management regulations and good international oilfield practice that are applicable to management of wastes from the Project. Consistent with the CWMP, the Project will follow the principles of the waste management hierarchy[15] and will, as far as practical, take steps to avoid and minimize the generation of waste, maximize the amount of waste that is reused and recycled, and minimize the amount of waste that needs to be disposed (and in particular landfilled). The CWMP provides details as to how different types of waste will be handled, stored, and transported to shore to avoid potential environmental, health, and safety issues. Specifically, it describes how different types of waste will be segregated, the types of containers that will be used, and the labeling requirements for waste containers. Transfers of waste from offshore Project facilities to shorebases will be covered by marine transport manifests and will be undertaken in suitably licensed vessels. On-land transfers of waste will similarly be covered by use of waste transfer documentation so that movements of waste can be tracked through to the point of final disposal.

A range of different onshore treatment and disposal methods will be used for the different types of Project wastes, as follows:

- Third-party waste contractor(s) will treat hazardous wastes onshore using thermal treatment methods such as thermal desorption and/or stabilization technologies to treat solid wastes, and thermal oxidation or filtration and separation to treat wastewaters. Treated wastewaters will be discharged through permitted outfalls to the Demerara River either directly or via a canal adjacent to the NGL Plant. Only contractors that are licensed by the EPA and have been assessed by EEPGL as meeting certain standards will be used to treat the Project's wastes.
- Ash from the incineration of waste, residual solid waste from treated hazardous solid wastes, and general non-hazardous wastes will be taken to a landfill that has, at the time of waste generation, been permitted by the EPA and assessed by EEPGL as meeting certain standards. Currently, the only Georgetown-based facility EEPGL has identified as meeting these requirements is the HBL.
- Specific wastes that can be recycled locally, such as scrap metal and electronic waste, will be taken to approved local recyclers.

Any new or unanticipated wastes, such as from an emergency response, will be assessed to determine the most appropriate handling/on-site management and treatment/disposal methods.

The Project will manage its wastes in accordance with applicable national regulations and appropriate international waste management standards and good international oilfield practice, as described in the CWMP. EEPGL will undertake its own assessments to assess whether contractors are operating to the standards of ExxonMobil's corporate-level Approved Waste Site List Program, which governs ExxonMobil's usage of third-party waste management facilities globally.

[15] The waste management hierarchy used by EEPGL is as follows: (1) Generation of waste should be Avoided, Prevented, or Reduced at the source whenever feasible; (2) Wastes that are not Avoided or Prevented should be Reused or Recycled in an environmentally safe manner, whenever feasible; (3) Wastes that are not Avoided, Prevented, or Recycled/Reused should be Treated in an environmentally safe manner, whenever feasible; and finally, (4) Disposal should be employed as a last option and, when employed, should be conducted in an environmentally responsible manner (IOGP 2009).

The estimated quantities of Project-generated wastes that will be managed onshore in Guyana are summarized in Table 7.7-2 and discussed in further detail below.

Table 7.7-2: Summary of Estimated Annual Generation for Project Wastes that will be Managed Onshore in Guyana

Project Stage	Non-Hazardous Solid Waste (tonnes annually)	Hazardous Waste (tonnes annually)
Construction	420	55
Operations	50	10

Offshore Pipeline Installation

For the offshore pipeline installation, waste collection, storage, and processing for many of the waste streams will be implemented onboard vessels supporting pipeline installation and hook-up, according to the waste management plans for the vessels and the CWMP. If wastes are discharged overboard, such discharges will be conducted according to the applicable provisions of MARPOL 73/78 Annexes IV and V, which prohibit disposal of solid waste overboard with the exception of comminuted or ground food waste and treated sanitary waste and grey water. Any excess sediments generated from offshore trenching will be discharged on the seabed adjacent to the offshore pipeline trench or placed as a small berm on top of the pipeline trench following pipeline placement. Some wastes from the offshore pipeline installation vessels and smaller supply/support vessels assisting in this work could be brought to shore for appropriate management (treatment, disposal, recycling). These types of wastes include used oil, used oil filters, oily rags, wastes from vessel maintenance operations, and non-hazardous solid waste not appropriate for overboard discharge as per MARPOL 73/78.

Onshore Pipeline and NGL Plant Construction

The construction of the onshore pipeline, NGL Plant, and temporary MOF will generate a variety of non-hazardous solid waste, including domestic waste from the workers, as well as some construction debris / building materials. These materials will be transported by an approved waste hauler and disposed of in the HBL. Sanitary wastes generated during the Construction stage will be managed through temporary sanitary waste management facilities (e.g., portable toilet facilities) and the wastes from these facilities will be collected periodically by licensed contractors and managed in accordance with permits maintained by these contractors. A limited amount of hazardous waste will be generated, generally limited to waste oils, solvents, paints, and contaminated rags. These hazardous materials will be transported by an approved waste hauler to an approved hazardous waste treatment facility in Guyana. Soils that are removed from the areas in which Project infrastructure will be constructed (e.g., for grading or structural support purposes) will be redistributed within the NGL Plant site, and none are expected to be transported for off-site management.

Operations

During the Operations stage, solid and hazardous wastes will be generated only by planned activities at the NGL Plant. The sources of these solid and hazardous wastes are described below:

- Domestic Waste: The Project will generate small quantities of domestic waste (e.g., trash, food wastes, packaging) from the approximately 40 full-time-equivalent workforce and various deliveries to the NGL Plant. This waste will be hauled periodically by an approved waste transporter to the HBL for disposal.
- Various Scrap Metals: Replaced equipment and other scrap metals will be transported to a scrap metal consolidation and exporting facility for recycling/reuse, where possible. Scrap metals that cannot be recycled/reused will be hauled by an approved waste transporter to the HBL for disposal.
- Wastewater Treatment Plant Sludge: The NGL Plant will have a wastewater treatment plant to treat domestic and process waste. This treatment plant will generate a sludge, which will be periodically removed, transported by an approved waste hauler, and treated and disposed at approved local waste treatment and disposal facilities.
- Process Wastes: The natural gas will be processed to remove various impurities and NGL to produce a gas meeting the power plant specifications. The NGL Plant operations will generate various waste oils/solvents, spent molecular sieve media, and spent hydrogen sulfide and mercury absorbent beds. Table 7.7-3 summarizes these waste types and quantities
  - Waste oils/solvents, oily rags, used oil filters: Lubricating oil for mechanical rotating equipment (e.g., compressors, pumps) will be required to prevent corrosion and friction that could impact equipment efficiency and life. Used lubricating oil will be drained to containers during oil changes. This used oil, as well as any oily rags or used oil filters, will be transported to an approved third-party facility for waste treatment and disposal facility, with any non-hazardous residuals from the treatment process disposed in local non-hazardous waste management facilities.
  - Spent Molecular Sieve Media: The molecular sieve media is regenerative, but has a life expectancy of 4 to 5 years and then needs to be replaced. Spent molecular sieve media will be transported to approved media/catalyst vendors for regeneration, or to local waste management facilities for treatment.
  - Spent Catalyst Absorbent Beds: The absorbent beds remove impurities in the gas (i.e., hydrogen sulfide, mercury). The hydrogen sulfide absorbent bed will require change-out approximately every 2 months to 4 years, depending on the actual average concentration of hydrogen sulfide in the natural gas. The mercury absorbent bed will require less frequent change-out (approximately every 10 years) because of the lower mercury concentrations in the gas. Hydrogen sulfide absorbent beds will be transported by an approved waste hauler, and treated and disposed at approved local waste treatment and disposal facilities. The current expectation is for mercury absorbent beds

to be transboundary shipped for treatment. At the time when these beds need to be changed out, EEPGL will assess the capabilities of local waste management facilities to treat spent mercury catalyst beds.

Table 7.7-3: Summary of Estimated Project Operations Stage Process Wastes

Waste Type	Estimated Quantity	Comments
Waste oil/solvents, oily rags, used filters	1.7 m^3 waste oils/solvents per year	Includes lubricating oil used for machinery during oil change
Spent molecular sieve media	162 m^3 every 4 to 5 years	Total amount of solid media being used for both beds. This material is regenerative but has a life of 4 to 5 years.
Spent hydrogen sulfide absorbent beds	156 m^3 every 1 year	Total amount of solid media being used for both beds at maximum projected hydrogen sulfide concentration.
Spent mercury absorbent beds	1.5 m^3 every 10 years	Total amount of solid media being used at maximum projected mercury concentration.

Decommissioning

Waste streams associated with decommissioning activities, including hazardous and non-hazardous (e.g., demolition debris) wastes, will be managed and disposed of in accordance with applicable Guyanese regulations, good international industry practice, and EEPGL's CWMP (or its equivalent in effect at the time of decommissioning).

It is expected that most of the waste generated as part of decommissioning should be able to be treated (as needed), recycled and/or disposed of within Guyana. EEPGL will seek to first identify options for reuse or recycling of decommissioned equipment from the Project. Infrastructure for waste management is expected to continue to develop as the oil and gas industry and other industries expand in Guyana, and EEPGL thus expects that its CWMP will continue to evolve to reflect expanding waste management capabilities in Guyana.

7.7.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for waste management infrastructure capacity (Table 7.7-4). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for waste management infrastructure capacity sensitivity are provided in Table 7.7-5.

Table 7.7-4: Definitions for Intensity Ratings for Potential Impacts on Waste Management Infrastructure Capacity

Criterion	Definition
Intensity	**Negligible**: Anticipated Project waste volumes will not contribute significantly to driving demand for the capacity of existing waste management infrastructure, or will contribute significantly to driving a demand, but that demand is well within the existing waste management infrastructure capacity.
	Low: Anticipated Project waste volumes will contribute significantly to driving a demand that could exceed the existing waste management infrastructure capacity, but that would be within the reasonably anticipated waste management infrastructure capacity.
	Medium: Anticipated Project waste volumes will contribute significantly to driving a demand at or slightly beyond the reasonably anticipated waste management infrastructure capacity.
	High: Anticipated Project waste volumes will contribute significantly to driving a demand that is well beyond the existing or reasonably anticipated waste management infrastructure capacity.

Table 7.7-5: Definitions for Resource Sensitivity Ratings for Potential Impacts on Waste Management Infrastructure Capacity

Criterion	Definition
Sensitivity	**Low**: Waste management infrastructure capacity users are able to adapt to impacts on waste management infrastructure capacity with no outside assistance or mitigation.
	Medium: Waste management infrastructure capacity users are able to adapt to impacts on waste management infrastructure capacity, but requires some outside assistance or mitigation to do so.
	High: Waste management infrastructure capacity users cannot adapt to impacts on waste management infrastructure capacity, even with outside assistance or mitigation.

7.7.3.3. Impact Magnitude Ratings—Waste Management Infrastructure Capacity

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to waste management and infrastructure capacity is provided in Table 7.7-7.

EEPGL routinely reviews its contracted waste management facilities to confirm they are of a sufficient quality to manage its wastes. These reviews include routine audits that cover a range of topics (e.g., financial, environmental, safety, security, health), as well as periodic assessments focused on more specific topics, such as infrastructure capacity as described further below. In 2018 and 2019, EEPGL conducted audits of the TRG facility and the HBL facility, and both facilities were assessed as operating at a sufficient quality level to continue managing EEPGL's wastes.

In May 2019, EEPGL conducted a capacity assessment of the TRG facility, with the specific objective of assessing whether the facility had any potential constraints that could challenge its ability to accommodate EEPGL's anticipated waste streams. The results of the assessment indicated that, without modifications, the infrastructure capacity of the facility would likely be unable to keep up with treating the increased volume of EEPGL's hazardous solids and waste oil liquids anticipated to be generated by future EEPGL activities.

Since the May 2019 capacity assessment, there has been significant expansion of third-party commercial hazardous waste handling, storage, and treatment facilities in Georgetown. This has included the addition of a pug mill (for waste stabilization), an additional thermal treatment unit, and a wash bay with pre-/post-treated water storage (for waste treatment) at the TRG facility. Construction is continuing at the TRG facility to add a further 2,000-barrel (318,000-liter) treated water storage tank, additional thermal treatment capacity, additional pug mill facilities, and storage for post-treatment solids. Additionally, as noted above, SES has developed an integrated waste management facility that became operational in 2021; this will provide additional capacity for management of both hazardous and non-hazardous wastes.

Several additional qualified third-party waste management operators are currently seeking authorization for facility developments or expansions, as discussed above. These are expected to further expand the capacity of onshore waste management infrastructure to manage the Project's hazardous, non-hazardous, and exempt hazardous waste storage, processing, treatment, and/or recycling needs.

All non-hazardous solid wastes generated to date from EEPGL's projects that are managed onshore have been disposed at the HBL, and this is the plan for management of these wastes from the Project. The total non-hazardous waste volumes received by the HBL on a daily basis are currently approximately 500 tonnes per day.

As discussed above, at current disposal rates, the recently opened Cell 2 of the HBL will have approximately 4 to 6 years of disposal capacity. However, with the increase in offshore activity, along with potential for growth in other industrial and commercial sectors, the quantity of wastes going to the HBL is expected to increase going forward. Considering these factors, the currently available landfill capacity appears sufficient for the short-term (2 to 3 years), even considering forecasted growth in waste volumes from industrial use. Presuming the additional HBL cell(s) discussed above would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years).

As residential and commercial development and infrastructure grow in the vicinity of HBL, new landfill development in the region may be appropriate going forward. Subsequent decisions to further expand existing or develop new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the MLGRD and the EPA and participation of the public and other stakeholders.

Balancing the above-noted recent and ongoing expansions of hazardous waste treatment infrastructure capacity with the fact that the Project will be generating—on average—approximately 4.5 tonnes of hazardous waste per month during the Construction stage and less than 1 tonne of hazardous waste per month during the Operations stage, the intensity of potential Project impacts on Georgetown-based hazardous waste treatment facilities is considered to be **Negligible** for both the Construction and Operations stages. Waste management and disposal will take place throughout the entire Project life cycle, yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for both the Construction and Operations stages. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of potential impacts on hazardous waste management infrastructure is rated as **Negligible**.

The Project's projected combined peak non-hazardous and hazardous waste generation is on the order of approximately 475 tonnes per year during the Project's approximately 3-year Construction stage (0.3 percent of the total non-hazardous waste volumes received by the HBL each year) and approximately 60 tonnes per year during its Operation stage (0.03 percent of the total non-hazardous waste volumes received by the HBL each year). Taking into consideration the opening of Cell 2 at the HBL, the reasonably anticipated development of additional cell(s) at the HBL, and the limited percent contribution of the Project, the intensity of potential Project impacts on non-hazardous waste management infrastructure capacity (i.e., the HBL) is considered to be **Negligible**. Waste management and disposal will take place throughout the entire Project life cycle (at least 20 years), yielding a frequency designation of **Continuous** for all stages. Duration will be **Long-term** for both the Construction and Operations stages. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of potential impacts on non-hazardous waste management infrastructure is rated as **Negligible**.

7.7.3.4. Sensitivity of Resource—Waste Management Infrastructure Capacity

As described in Table 7.7-6, sensitivity for waste management infrastructure capacity is rated based on consideration of the users of such capacity. Aside from EEPGL itself, these include non-Project users of Georgetown-based hazardous waste management facilities (currently predominated by other oil and gas-related companies) and—for Georgetown-based non-hazardous waste management facilities—the general Georgetown community.

Based on the sensitivity rating definitions in Table 7.7-5, Table 7.7-6 summarizes the sensitivity ratings assigned for the users that could potentially experience impacts on waste management infrastructure capacity as a result of planned activities of the Project.

Table 7.7-6: Sensitivity Ratings for Users that Could be Affected by Potential Impacts on Waste Management Infrastructure Capacity

User	Sensitivity Rating	Rationale for Rating
Non-Project users of Guyana-based hazardous waste management facilities	Low	Non-Project users of Guyana-based hazardous waste treatment facilities are largely limited to other oil and gas exploration/production or oil and gas industry support companies. These companies have the ability to access alternate regional providers for this service, albeit likely at an increased cost and a commensurate reduction in their operational efficiency.
Non-Project users of Guyana-based non-hazardous waste management facilities (landfills)	High	Non-Project users of Guyana-based landfills include other industrial waste generators, as well as the general Georgetown-area community. Focusing on the latter, the general Georgetown-area community currently has no feasible alternative options for the proper management of its municipal wastes.

7.7.3.5. Pre-mitigation Impact Significance—Waste Management Infrastructure Capacity

Assuming implementation of the embedded controls listed in Table 7.7-7, the intensity ratings for potential Project impacts on waste management infrastructure capacity are **Negligible** for both non-hazardous and hazardous waste management infrastructure, and for both Construction and Operations stages. This results in a pre-mitigation magnitude rating of **Negligible.** Coupled with sensitivity ratings of **Low** (for non-Project users of hazardous waste management facilities) and **High** (for non-Project users of non-hazardous waste management facilities), the pre-mitigation impact significance of potential Project impacts on waste management infrastructure capacity is **Negligible** for hazardous waste management infrastructure and non-hazardous waste management infrastructure.

7.7.4. Impact Management and Monitoring Measures

Based on the **Negligible** significance of potential impacts on waste management infrastructure capacity, no Project-specific mitigation measures are proposed. It is noted, however, that the **Negligible** significance of potential impacts on waste management infrastructure capacity is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

Although the Project itself is not considered a potentially impacted user for the purpose of the EIA, the viability of its operations depends on reliable access to waste management infrastructure of a sufficient quality and with sufficient capacity. In view of this need, and despite the **Negligible** pre-mitigation significance ratings for potential impacts on waste management infrastructure capacity, EEPGL has, at an affiliate level, initiated the following mitigation measures:

- As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions.
- Continue monitoring plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.

In addition to these measures, Table 7.7-7 summarizes the management and monitoring measures relevant to waste management infrastructure capacity. Additional embedded controls are included in the CWMP.

Table 7.7-7: List of Management and Monitoring Measures

Embedded Controls
For transport of hazardous wastes off site for treatment or disposal, confirm that the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.
Provide for adequate onshore waste management equipment and facilities for the proper management of waste in accordance with local regulation and good international oil field practice.
For wastes generated offshore that cannot be reused, treated, or discharged/disposed on marine vessels, properly manifest and transfer such wastes to appropriate onshore facilities for management.
Periodically audit waste contractors to verify that appropriate waste management practices are being used.
Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with the waste management hierarchy.
Mitigation Measures
To address future waste capacity constraints in Georgetown relative to Project's predicted waste management needs: • As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions. • Continue monitoring plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.
Monitoring Measures
Record type and quantity of each individual waste stream any time a new waste is generated.
Inspect on a regular basis temporary waste storage areas and containers; log inspections.
Sample and perform analytical testing as needed to properly classify wastes for disposal/treatment.

7.7.5. Assessment of Residual Impacts

As described above, no Project-specific mitigation measures are proposed to address potential impacts on waste management infrastructure capacity. Accordingly, the residual impact significance ratings remain unchanged at **Negligible**.

Table 7.7-8 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on waste management infrastructure capacity. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, as well as the resource-specific methodology described above.

Table 7.7-8: Summary of Potential Pre-Mitigation and Residual Impacts—Waste Management Infrastructure Capacity

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction Operations	Overburdening of Guyana-based non-hazardous waste management infrastructure.	High	Negligible	Negligible	None	Negligible
	Overburdening of Guyana-based hazardous waste management infrastructure	Low	Negligible	Negligible	None	Negligible

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8. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIESò BIOLOGICAL RESOURCES

This chapter focuses on biological resources, and has been organized into a review of nearby protected areas; a description of the affected marine, terrestrial, and freshwater habitats; and a broader discussion of ecological balance and ecosystems. Each of these sections includes a description of methodology, a review of existing conditions, an assessment of potential impacts from planned Project activities, and identification of proposed mitigation measures.

8.1. PROTECTED AREAS

8.1.1. Baseline Methodology

The information presented for protected areas was primarily gathered from government documents and information available in the public domain, and supplemented with data from EEPGL-commissioned studies focusing on sea turtles.

8.1.2. Existing Conditions and Baseline Studies

In 2011, Guyana enacted the Protected Areas Act, which established a Protected Areas Commission to oversee and manage protected areas. This legislation established a list of prohibited activities, including unlawfully entering or remaining within a protected area; disturbing or destroying the vegetation (common or endangered); removing or exterminating wildlife species (common or endangered); damaging archaeological finds or sites; and mining. Guyanaìs National Biodiversity Strategy and Action Plan (EPA and MoNRE 2015) describes the overall importance of biodiversityìs role within the country.

> îGuyanaìs biodiversity provides an important basis for climate regulation, poverty reduction, provisioning of fresh water and hydropower, economic growth and development in areas such as agriculture, forestry and fisheries, payment for forest climate services, community based economies, particularly in hinterland communities and biodiversity-related education, scientific research and recreation. Loss of biodiversity and any disruption in the provision of ecosystem services would impact negatively on the economy and more particularly on the quality of life in the hinterland and indigenous communities.ï

Guyana has designated five nationally protected areas, with a total land area of approximately 1.79 million hectares, or about 8.5 percent of Guyanaìs land area, as summarized in Table 8.1-1 (Protected Areas Trust 2021). Figure 8.1-1 illustrates the locations of Guyanaìs protected areas. There are currently no designated marine protected areas in Guyana.

Table 8.1-1: Protected Areas in Guyana

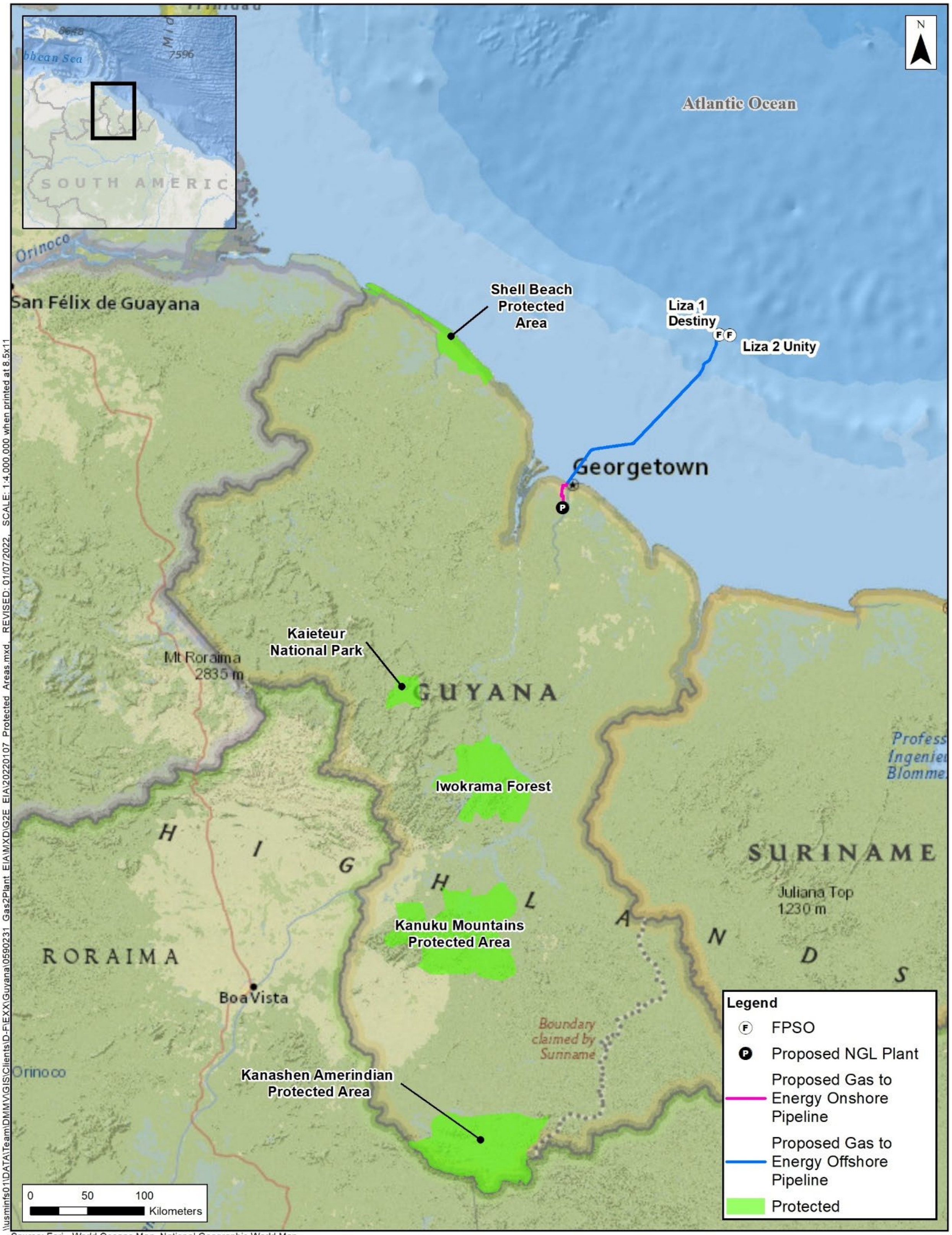
Protected Area	Area (hectares)
Kaieteur National Park	62,700
Iwokrama Forest	371,000
Kanashen Amerindian Protected Area	625,000
Kanuku Mountains Protected Area	611,000
Shell Beach Protected Area	123,000

Source: Protected Areas Trust 2021

Shell Beach Protected Area (SBPA) is the only protected area in Guyana located on the coast; it extends across the full coastline of Region 1 and a small portion of Region 2. Although the SBPA does not extend into the Atlantic Ocean, the ecology of the coastal zone and Shell Beach are inextricably connected to the coastal marine ecosystem. Shell Beach, which derived its name from the fact that its entire stretch of coastline is comprised mainly of pulverized crustacean shells (EPA et al. 2004), is a dynamic area. Its landscape constantly changes due to the competing impacts of erosion and accretion along the shoreline. The area is 70 percent forested; the rest is made up of mostly swamp (less than 30 percent) and sandy beaches (less than 1 percent) (Kandaswamy 2014).

Shell Beach is best known as a marine turtle nesting site. The composition of the substrate at Shell Beach, its geographical location, and the low anthropogenic activity makes it an ideal nesting site for marine turtles (*Convention* on Biological Diversity 2015). Most nesting beaches in Guyana are used by only one or two species of marine turtles, but four species (leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], olive ridley turtle [*Lepidochelys olivacea*], and green turtle [*Chelonia mydas*]) nest at Shell Beach (Pritchard 2001). The SBPA also supports rich bird, herpetofauna (reptiles and amphibians), and mammal communities. The 2004 Rapid Biodiversity Assessment (EPA et al. 2004) documented 170 species of birds, 20 species of mammals, and 31 species of herpetofauna.

Areas within and near Shell Beach have been inhabited for 10,000 years by Amerindian groups from the Warao, Carib, and Arawak tribes (Charles et al. 2004). Indigenous communities have historically used the Shell Beach area for subsistence fishing, crabbing, trapping, farming, logging, and palm harvesting.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 8.1-1: Protected Areas of Guyana

8.1.3. Impact Prediction and Assessment

No Government of Guyana designated protected areas, including the SBPA, are located within the Project Area of Influence (AOI). The closest Project facility is more than 120 kilometers to the east of the SBPA, which is the nearest protected area (Figure 8.1-1).

8.1.4. Impact Management and Monitoring Measures

No additional management measures are proposed for protected areas.

8.1.5. Assessment of Residual Impacts

There will be no residual impacts on the SBPA or any other Guyana protected area.

8.2. MARINE AND COASTAL BIODIVERSITY

8.2.1. Baseline Methodology

The biological resources discussion presented herein is based on a combination of primary data generated from EEPGL-commissioned studies and secondary data from peer-reviewed scientific literature, government publications, and non-governmental scientific organizations. In many cases, data presented herein for the Project AOI have been extrapolated from larger datasets that have previously been developed for the Stabroek Block or the wider Guyana Exclusive Economic Zone (EEZ).

8.2.2. Existing Conditions and Baseline Studies

8.2.2.1. Marine Birds

Marine birds are birds that spend extensive time in nearshore and/or offshore marine environments away from land, except when they are nesting. Types or groups of marine birds prevalent in this region include frigatebirds, pelicans, petrels, shearwaters, storm-petrels, jaegers, tropicbirds, boobies, gulls, and terns.

Birds observed offshore Guyana typically fit one or more of three characterizations: (1) birds that spend extensive time in waters of the Caribbean away from land or other structures (commonly referred to as pelagic birds or marine birds); (2) birds engaged in seasonal, usually latitudinal, migrations through the area (migratory birds); and (3) birds that have wandered outside their normal ranges, including birds affected by severe weather events, including seasonal storms.

Marine birds feed on fish and other marine organisms that concentrate on or near the surface of the water, either by surface feeding (from flight or swimming) or by diving (Hunt and Furness 1996). As such, the presence and availability of marine bird prey in a given area, which is strongly influenced by the ocean's currents, is a major determinant in the occurrence of marine birds. Further, water clarity can impact a marine bird's foraging success and some studies have suggested that marine birds in the Atlantic Ocean prefer areas with clear water where they can more easily see their prey (Schreiber 2001). Marine birds in the Offshore Project AOIare transients, moving opportunistically with schools of fish, oceanic arthropods, plankton, and other prey.

More than 100 bird species have populations that migrate between North America and South America, and most of these species nest in the north and reside in the southern range until the next nesting season. Many of these birds fly over the Atlantic Ocean and, in some cases the Project AOI, during migration. Although migration routes are well defined for some bird species, the routes and timing of migration can vary markedly depending on climate and storms (McGrady et al. 2006).

Historical Data

Twenty-two species of marine birds are historically known to breed in the Caribbean and dozens more occur as migrants through the region. Marine bird data specific to Guyana are extremely limited and no comprehensive survey of marine birds has ever been conducted in Guyana (BirdLife International 2021a). The authoritative historical list for bird species present in Guyana, published by the Smithsonian Institution, lists 25 marine bird species (Braun et al. 2007). BirdLife International lists 22 species of marine birds for Guyana (BirdLife International 2021a). The eBird-arbitrated observation list[1] for offshore Guyana contains 22 marine bird species (eBird 2021). Combining all of these sources, a total of 31 marine bird species are reported to occur in Guyana (Table 8.2-1). This list is not specific to the Offshore Direct and Indirect AOIs, but does contain many of the species that have been documented in the Offshore Direct and Indirect AOIs by EEPGL-commissioned bird surveys.

Table 8.2-1: Marine Bird Species Known to Occur Offshore Guyana Based on Historical Data

Common Name	Scientific Name
Great Shearwater [a,b]	*Ardenna gravis*
Cory's Shearwater [a,c]	*Calonectris borealis*
Audubon's Shearwater [a,b]	*Puffinus lherminieri*
Wilson's Storm-Petrel [a,b,c]	*Oceanites oceanicus*
Leach's Storm-Petrel [a,b]	*Oceanodrama leucorhoa*
Brown Pelican [a,b,c]	*Pelecanus occidentalis*
Brown Booby [a,b,c]	*Sula leucogaster*
Masked Booby [c]	*Sula dactylatra*
Red-footed Booby [c]	*Sula sula*
Magnificent Frigatebird [a,b,c]	*Fregata magnificens*
White-tailed Tropicbird [c]	*Phaethon lepturus*
Red-billed Tropicbird [c]	*Phaethon aethereus*
Parasitic Jaeger [b,c,d]	*Stercorarius parasiticus*
Pomarine Jaeger [a,b,c]	*Stercorarius pomarinus*

[1] eBird is an online database of bird observations through user-submitted checklists. Country records in eBird are arbitrated by a team of local experts who are unpaid volunteers managed by eBird. This arbitration process is conducted to ensure data quality and avoid erroneous records. Only the arbitrated country record list is considered scientifically valid.

Common Name	Scientific Name
Great Skua [a,b]	*Stercorarius skua*
Lesser Black-backed Gull [c,d]	*Larus fuscus*
Laughing Gull [a,b,c]	*Leucophaeus atricilla*
Brown Noddy [a,b,c]	*Anous stolidus*
Black Tern [b,c,d]	*Chlidonias niger*
Gull-billed Tern [a,b,c]	*Gelochelidon nilotica*
Bridled Tern [b]	*Onychoprion anaethetus*
Sooty Tern [a,b]	*Onychoprion fuscatus*
Black Skimmer [a,b,c]	*Rynchops niger*
Roseate Tern [a,c]	*Sterna dougalli*
Common Tern [a,b,c]	*Sterna hirundo*
Royal Tern [a,b,c]	*Thalasseus maximus*
Sandwich Tern [b,c,d]	*Thalasseus sandvicensis*
Least Tern [b,c]	*Sternula antillarum*
Neotropical Cormorant [b]	*Nannopterum brasilianus*
Large-billed Tern [c]	*Phaetusa simplex*
Yellow-billed Tern [c]	*Sternula superciliaris*

[a] Braun et al. 2007
[b] BirdLife International 2021a
[c] eBird 2021
[d] Sight record only (Braun et al. 2007)

This number is consistent with other countries in the region. For example, 32 and 30 species of marine birds are documented in Trinidad and Tobago and Venezuela, respectively (BirdLife International 2021b and 2021c, respectively). Any of the species could occur in the Offshore Direct and Indirect AOIs at some time during the year (specific timing of occurrence is dependent on the species and environmental conditions).

Based on eBird reporting, an additional 29 species of marine birds are known to inhabit the southern Caribbean, but have not been reported in Guyana (eBird 2021). These species and others could also occur in Guyanese offshore waters. Thus, the number of species that occur offshore Guyana is likely to be higher than 31, as documented through EEPGL-commissioned marine bird survey work conducted offshore Guyana between 2017 and 2020.

Marine Bird Survey Data within and near the Project AOI

EEPGL-Commissioned Marine Bird Surveys

EEPGL commissioned 12 marine bird surveys by teams of international and Guyanese bird specialists aboard various vessels within the Stabroek Block and in the area between the Stabroek Block and the Guyana coast in 2017, 2018, 2019, and 2020. Twelve survey events encompassing 875 survey hours were conducted during these surveys (ERM 2020b). Figure 8.2-1 depicts the locations of the surveys.

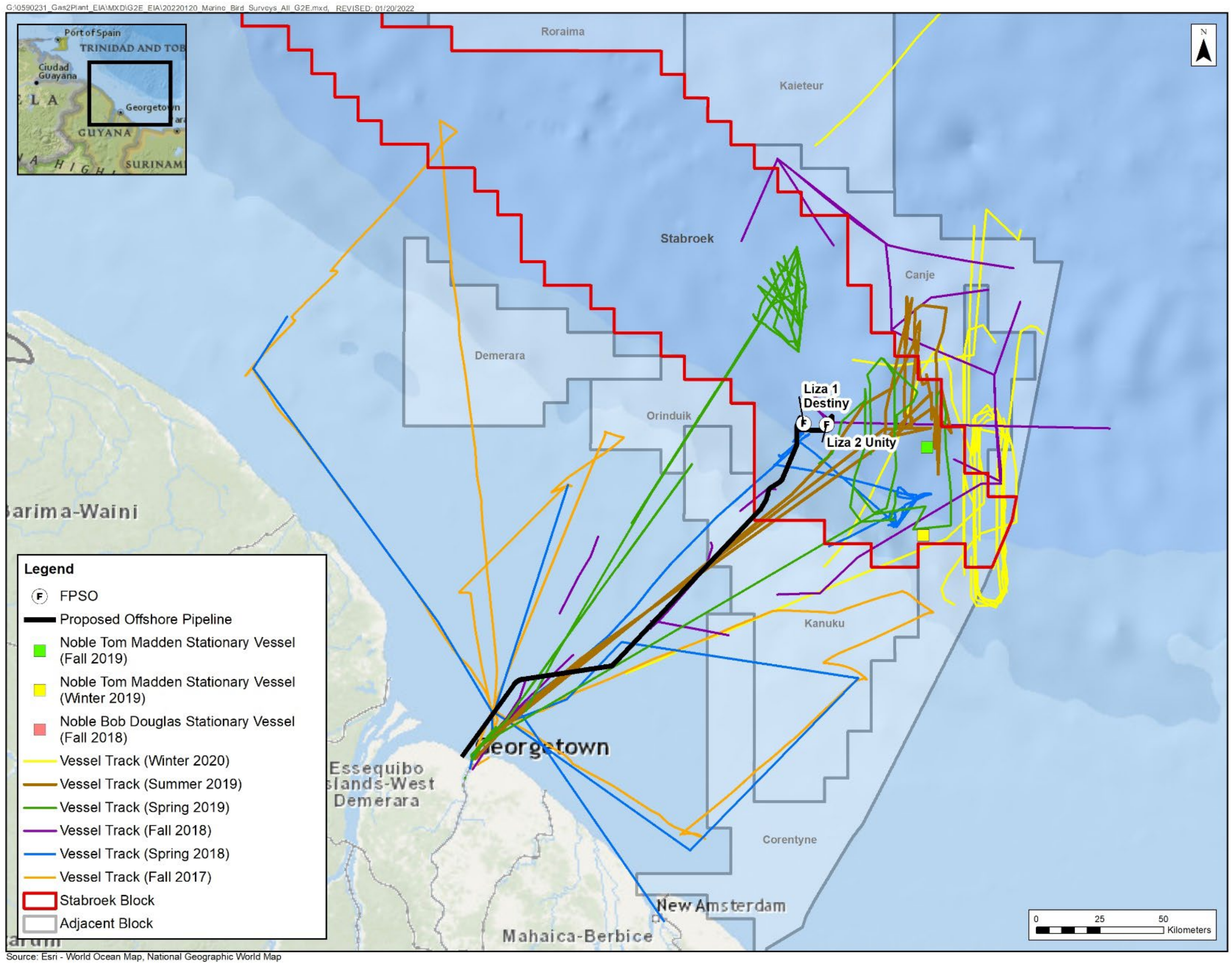


Figure 8.2-1: Map of EEPGL-commissioned Marine Bird Survey Locations, 2017–2020

Species Assemblage

The 12 EEPGL-commissioned marine bird survey events yielded a total of 3,706 bird observations of 53 species offshore Guyana. Fewer than half of the species observed during the surveys are classified as pelagic species[2] (18 of 53 species). The other species are nearshore marine birds undertaking short-distance movements between breeding and non-breeding areas (14 species), migratory shorebirds (10 species) or landbirds (9 species) that fly over the Caribbean during seasonal (spring and fall) migrations, coastal birds on long-distance offshore foraging trips (1 species), and non-migratory landbirds that were offshore for unknown reasons (1 species) (Table 8.2-2).

The EEPGL-commissioned marine bird surveys yielded eight new records for Guyana (based on available documentation, these species had not been observed in the country previously). The new records registered for Guyana are Bridled Tern (*Onychoprion anaethetus*), Manx Shearwater (*Puffinus puffinus*), Red-billed Tropicbird (*Phaethon aethereus)*, White-tailed Tropicbird (*Phaethon lepturus*), Bulwer's Petrel (*Bulweria bulwerii*), Masked Booby (*Sula dactylatra*), Great Black-backed Gull (*Larus marinus*), and Arctic Tern (*Sterna paradisaea*). Two unconfirmed species, Black-browed Albatross (*Thalassarche melanophrys*) and Northern Gannet (*Morus bassanus*), may be additional new records for Guyana, but these species require field or photographic confirmation before they are added to the definitive species list.

[2] This includes species that spend their lives at sea except when breeding.

Table 8.2-2: Bird Species Observed during EEPGL-Commissioned Marine Bird Surveys Conducted in the Stabroek Block and between the Stabroek Block and Georgetown, 2017–2020

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Arctic Tern	*Sterna paradisea*	Pelagic					1				1	1
Audubon's Shearwater	*Puffinus lherminieri*	Pelagic					5	4			9	2
Brown Booby	*Sula leucogaster*	Pelagic	1	1	4		2	17	8		33	6
Brown Noddy	*Anous stolidus*	Pelagic	2		2	1				2	7	4
Bulwer's Petrel	*Bulweria bulwerii*	Pelagic		1	4						5	2
Cory's Shearwater	*Calonectris diomedea*	Pelagic					1			4	5	2
Great Shearwater	*Ardenna gravis*	Pelagic			1		1	1			3	3
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Pelagic		17			23			11	51	3
Manx Shearwater	*Puffinus puffinus*	Pelagic					1				1	1
Masked Booby	*Sula dactylatra*	Pelagic		3	37	21	66	22	20	114	283	7
Parasitic Jaeger	*Stercorarius parasiticus*	Pelagic		2			3			4	9	3
Pomarine Jaeger	*Stercorarius pomarinus*	Pelagic	2	4		5	3		1	4	19	6
Red-billed Tropicbird	*Phaethon aethereus*	Pelagic		2			6			8	16	3
Red-footed Booby	*Sula sula*	Pelagic	1	2	2	2			2	1	10	6
Sooty Shearwater	*Ardenna grisea*	Pelagic				2					2	1

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Sooty Tern	*Onychoprion fuscatus*	Pelagic					43			1,941	1,984	2
White-tailed Tropicbird	*Phaethon lepturus*	Pelagic					2			1	3	2
Wilson's Storm-Petrel	*Oceanites oceanicus*	Pelagic		5			68				73	2
Great Black-backed Gull	*Larus marinus*	Nearshore Marine				1					1	1
Lesser Black-backed Gull	*Larus fuscus*	Nearshore Marine								1	1	1
Black Skimmer	*Rynchops niger*	Nearshore Marine	1				12				13	2
Black Tern	*Chlidonias niger*	Nearshore Marine			46						46	1
Bridled Tern	*Onychoprion anaethetus*	Nearshore Marine	13		2						15	2
Brown Pelican	*Pelecanus occidentalis*	Nearshore Marine	1		2			7			10	3
Cayenne Tern	*Thalasseus eurygnatha*	Nearshore Marine	10								10	1
Common Tern	*Sterna hirundo*	Nearshore Marine	28	9	190		9	14	8		258	6
Laughing Gull	*Leucophaeus atricilla*	Nearshore Marine	19	11	102		3	5	1		141	6
Least Tern	*Sternula antillarum*	Nearshore Marine			11						11	1
Magnificent Frigatebird	*Fregata magnificens*	Nearshore Marine	136	8	65	26	12	177	3	4	431	8
Roseate Tern	*Sterna dougalli*	Nearshore Marine			2						2	1
Royal Tern	*Thalasseus maximus*	Nearshore Marine	3	3	6		2	3			17	5

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Sandwich Tern	*Thalasseus sandvicensis*	Nearshore Marine	1		8						9	2
Little Blue Heron	*Egretta caerulea*	Coastal	5		5			1			11	3
American Golden Plover	*Pluvialis dominica*	Shorebird							1		1	1
Black-bellied Plover	*Pluvialis squatarola*	Shorebird			25						25	1
Least Sandpiper	*Calidris minutilla*	Shorebird			2						2	1
Lesser Yellowlegs	*Tringa flavipes*	Shorebird			5				2		7	2
Pectoral Sandpiper	*Calidris melanotos*	Shorebird	1								1	1
Ruddy Turnstone	*Arenaria interpres*	Shorebird		1	4						5	2
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird					1		1		2	2
Semipalmated Sandpiper	*Calidris pusilla*	Shorebird	1		16						17	2
Spotted Sandpiper	*Actitis macularius*	Shorebird	1						1		2	2
Whimbrel	*Numenius phaeopus*	Shorebird	1				5				6	2
Cliff Swallow	*Petrochelidon pyrrhonota*	Migratory Landbird			8				2		10	2
Bank Swallow	*Riparia riparia*	Migratory Landbird			1						1	1
Barn Swallow	*Hirundo rustica*	Migratory Landbird	4		84				39	3	130	4

Common Name	Scientific Name	Life History Category	2017 Fall	2018 Spring	2018 Fall	2019 Winter	2019 Spring	2019 Summer	2019 Fall	2020 Winter	Total Abundance	Number of Surveys Observed
Black-whiskered Vireo	*Vireo altiloquus*	Migratory Landbird							1		1	1
Bobolink	*Dolichonyx oryzivorus*	Migratory Landbird			1						1	1
Eastern Kingbird	*Tyrannus tyrannus*	Migratory Landbird							1		1	1
Purple Martin	*Progne subis*	Migratory Landbird			1						1	1
Yellow Warbler	*Setophaga petechia*	Migratory Landbird							1		1	1
Yellow-billed Cuckoo	*Coccyzus americanus*	Migratory Landbird							1		1	1
Eurasian Collared-Dove	*Streptopelia decaocto*	Non-migratory Landbird			1						1	1
Total Abundance			**231**	**69**	**637**	**58**	**269**	**251**	**93**	**2,098**	**3,706**	
Total Species Richness			**19**	**14**	**28**	**7**	**21**	**10**	**17**	**13**	**53**	

Bird Abundance

The data collected during the EEPGL-commissioned marine bird surveys indicate that bird abundance offshore is generally low and decreases with greater distance from shore. Bird abundance was generally highest in the area between 1 and 25 kilometers from shore and steadily decreased with increased distance from shore, with the fewest number of birds in areas more than 100 kilometers from shore.

The greatest abundance of birds was generally observed during the fall and spring surveys (Figure 8.2-2), with the notable exception of the Winter 2020 results, which were skewed by multiple detections of large flocks of Sooty Terns (*Onychoprion fuscatus*) (five observations totaling approximately 1,900 birds). Without the five large flocks of Sooty Terns, the Winter 2020 detection rate was 1.6 birds per survey hour, which is lower than both the Fall 2017 and Fall 2018 Survey 1b detection rates and comparable to the Winter 2019 detection rate (also 1.6 birds per survey hour).

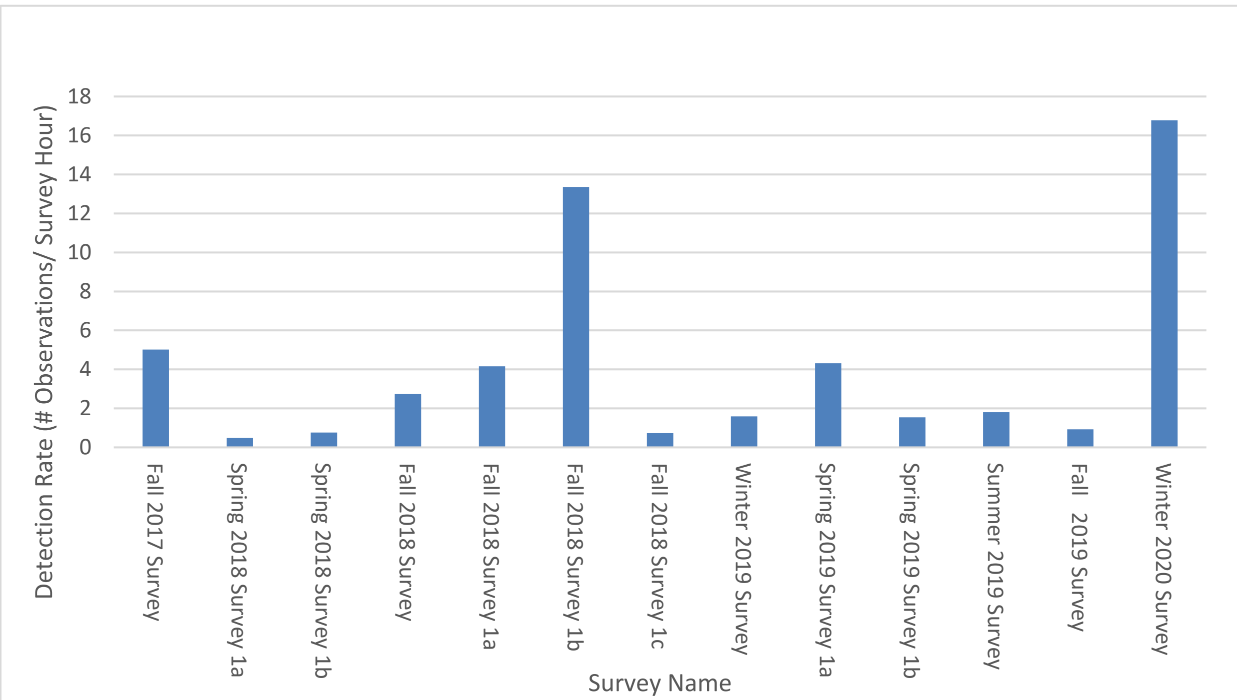


Figure 8.2-2: Overall Bird Abundance Documented per Survey Event during EEPGL-Commissioned Marine Bird Surveys, 2017–2020 (All Surveys)

For all survey events combined, the most commonly observed bird species were the Sooty Tern, Magnificent Frigatebird (*Fregata magnificens*), Masked Booby, Common Tern (*Sterna hirundo*), and Laughing Gull (*Leucophaeus atricilla*). Figure 8.2-3 depicts the total abundance (all surveys combined) for the dominant species observed (species with at least 10 observations during the EEPGL-commissioned survey events.

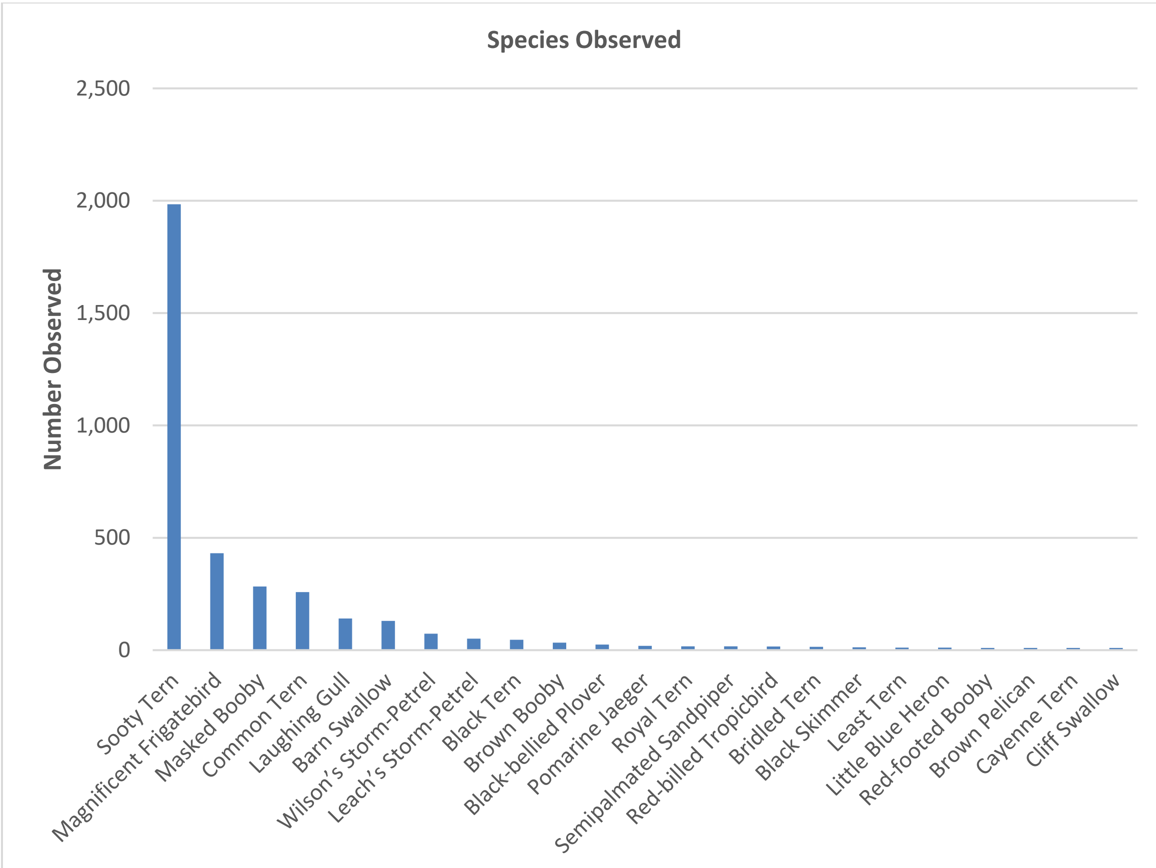


Figure 8.2-3: Most Frequently Observed Bird Species during the EEPGL-commissioned Marine Bird Surveys, 2017–2020 (All Surveys)

Species Richness and Diversity

The EEPGL-commissioned marine bird surveys documented a broad range of bird types (i.e., landbirds, coastal birds, shorebirds, and pelagic and nearshore birds) offshore Guyana. The species assemblage (types of birds) observed differed by season (Figure 8.2-4).

All spring and fall surveys across the study period had higher species richness than the winter and summer surveys (Figure 8.2-4) due to the presence of migratory species in spring and fall.

The differences seen across survey periods are typical of seasonal patterns—with higher richness and abundance during migration periods—as well as some random variation between periods. The following are key seasonal differences:

- The fall surveys had a preponderance of migratory swallow and migratory shorebird species (e.g., sandpipers, plovers).
- A substantial number of the pelagic birds sighted during the spring surveys in 2018 and 2019 were Leach's Storm-Petrel (*Oceanodroma leucorhoa*), listed as Vulnerable on the IUCN Red List Version 2021.3 (IUCN 2021), suggesting the region lies within a migratory corridor for the species.

- Winter and summer surveys had lower abundance, and the species assemblage during these periods was heavily dominated by pelagic and nearshore marine species (Figure 8.2-4).

Shorebirds and migratory landbirds were almost exclusively observed during spring and fall (migratory) periods (Figure 8.2-4). The seasonal variations described above indicate that the Stabroek Block and surrounding offshore area serve as habitat for marine birds undergoing multiple types of trans-continental migrations: classic Nearctic-Neotropic migration (jaegers and Common Tern); transoceanic migration (Bulwer's Petrel, Band-rumped Storm-Petrel, Leach's Storm-Petrel); and austral migration (shearwaters, Wilson's Storm-Petrel [*Oceanites oceanicus*]).

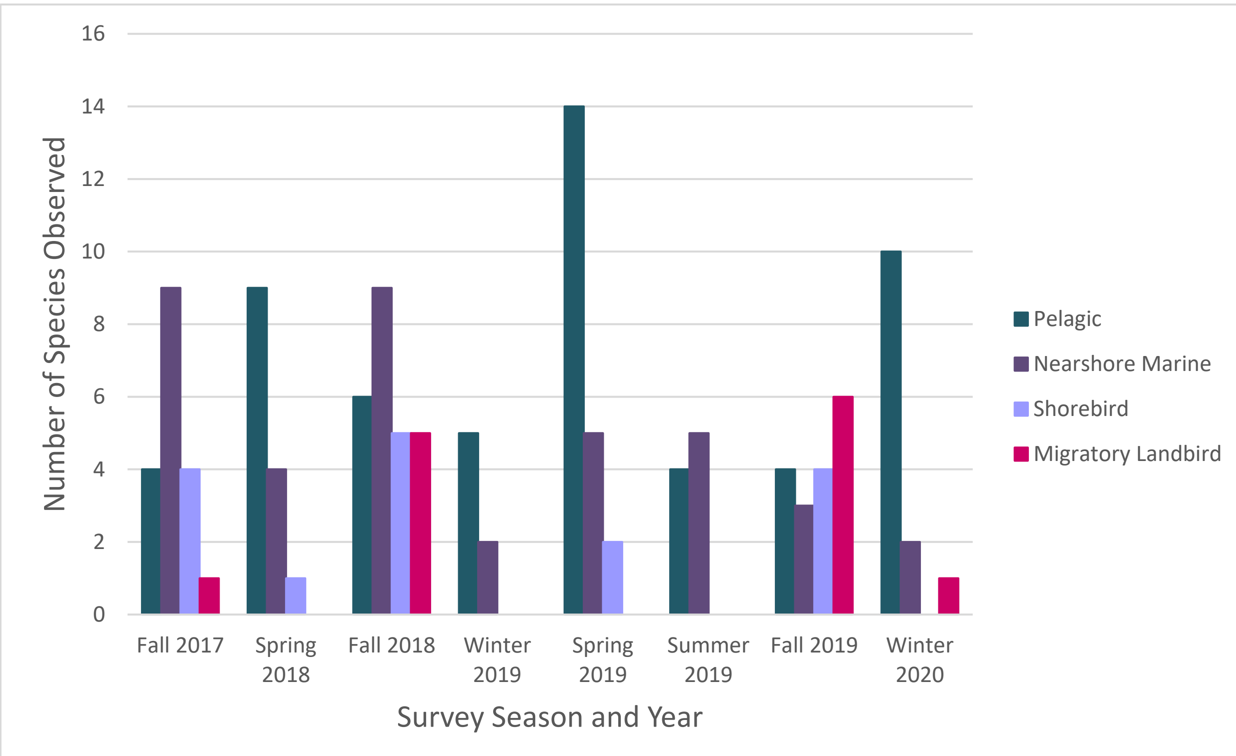


Figure 8.2-4: Bird Species Assemblage (Life History Categories) Recorded during EEPGL-Commissioned Marine Bird Surveys

In addition to the trans-continental migrations described above, the marine bird survey data indicate that the Stabroek Block and the surrounding offshore area are used by a variety of non-migratory marine birds for regional dispersal (movements between non-breeding and breeding sites). The use of the area for seasonal movements to breeding sites such as the nearby Important Bird Areas (IBAs) in Tobago and St. Vincent and the Grenadines is demonstrated by the sightings of Red-billed Tropicbird, Magnificent Frigatebird, and multiple booby species in breeding plumage flying in a northwesterly direction toward Tobago and St. Vincent and the Grenadines, where these species are known to nest.

Incidental Marine Bird Observations within and near the Stabroek Block

Incidental observations within and *en route* to the Stabroek Block have been recorded by Protected Species Observers (PSOs) during various EEPGL-commissioned environmental and geophysical sampling and survey activities offshore Guyana from 2015 through 2021 (RPS 2018; RPS 2019; RPS 2020a,b,c,d,e; RPS 2021). To date, PSOs have documented 7,566 individual birds representing 70 bird species offshore and nearshore Guyana during 1,891 survey days from May 2015 through May 2021 (RPS 2018; RPS 2019; RPS 2020a,b,c,d,e; RPS 2021). Of these 70 species, 43 were also observed during the targeted EEPGL-commissioned marine bird surveys described above and 27 species were not documented during the targeted EEPGL-commissioned marine bird surveys. Of the 27 species not observed, four are pelagic marine birds and 23 are landbirds or coastal birds. The four pelagic marine bird species recorded by PSOs, but not documented during EEPGL's targeted marine bird surveys, include Black-capped Petrel (*Pterodroma hasitata*), Great Skua (*Stercorarius skua*), South Polar Skua (*Stercorarius maccormicki*), and Northern Gannet.[3] Of these species, two (South Polar Skua and Northern Gannet) would be new country records for Guyana if confirmed with photographic evidence.

Similar to that documented in the EEPGL-commissioned marine bird surveys, the most common identified species documented through the incidental observations were Masked Booby, Magnificent Frigatebird, Barn Swallow (*Hirundo rustica*), and Brown Booby (*Sula leucogaster*).

8.2.2.2. Coastal Birds

Historical Data

The bird community along Guyana's coastline is abundant and diverse, with 208 recorded species within 21 families representing multiple bird groups including parrots and macaws, passerines, waterfowl, colonial waterbirds, shorebirds, and raptors. The bird groups most strongly affiliated with the coast (collectively referred to in this EIA as coastal birds) are waterfowl, shorebirds, and colonial waterbirds.[4] Guyana's coastal bird community is better known than the marine bird community described above; nevertheless, no systematic, multi-year coastal bird survey of Guyana's coastline is known to have been conducted until the EEPGL-commissioned surveys described in the section below.

Several other bird surveys along Guyana's coastline have been reported, but these surveys covered only a portion of the coastline (e.g., around Georgetown or within the SBPA) and were short in duration (e.g., conducted during one or two seasons during the same year). Braun et al. (2007) developed a comprehensive checklist of the 814 bird species within 11 habitats

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[3] The Northern Gannet was provisionally identified during the EEPGL-commissioned marine bird surveys, but the observations were not confirmed by photographic identification. As such, these are considered provisional records and are not included in the confirmed species list for the EEPGL-commissioned marine bird surveys or the related data analysis.

[4] Waterfowl are species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese). Shorebirds are found mainly on beaches and mudflats between the low and high water marks and are typically migratory, using Guyana's coastline during the course of their biannual migrations. Colonial waterbirds are birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons).

documented in Guyana, including coastal habitats (mangrove forests had 47 coastal bird species documented, and mudflats had 38 coastal bird species documented; Braun et al. 2007). Another coastal bird survey conducted along the coast in the Georgetown region by Bayney and Da Silva (2005) documented 32 coastal bird species. A more recent bird survey within coastal mangrove habitats in southeast Guyana identified 37 coastal bird species (Da Silva 2014). Lastly, two biodiversity surveys undertaken within SBPA over roughly the past decade documented over 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats of Shell Beach (Mendonca et al. 2006; EPA et al. 2004). Collectively, species accounts from all these reports document the presence of 95 species of coastal birds from 32 families in Guyana.

EEPGL-Commissioned Coastal Bird Surveys

EEPGL commissioned a series of seasonal coastal bird surveys along the Guyana coast between 2017 and 2020. Surveys of coastal birds were conducted across six regions by teams of international and Guyanese bird specialists (ERM 2020a). Figure 8.2-5 shows the survey locations in Regions 3 and 4 in the vicinity of the Project AOI. A total of 225 bird species were documented across all regions during these surveys. The number of species documented in Regions 3 and 4 was 130 (Table 8.2-3).

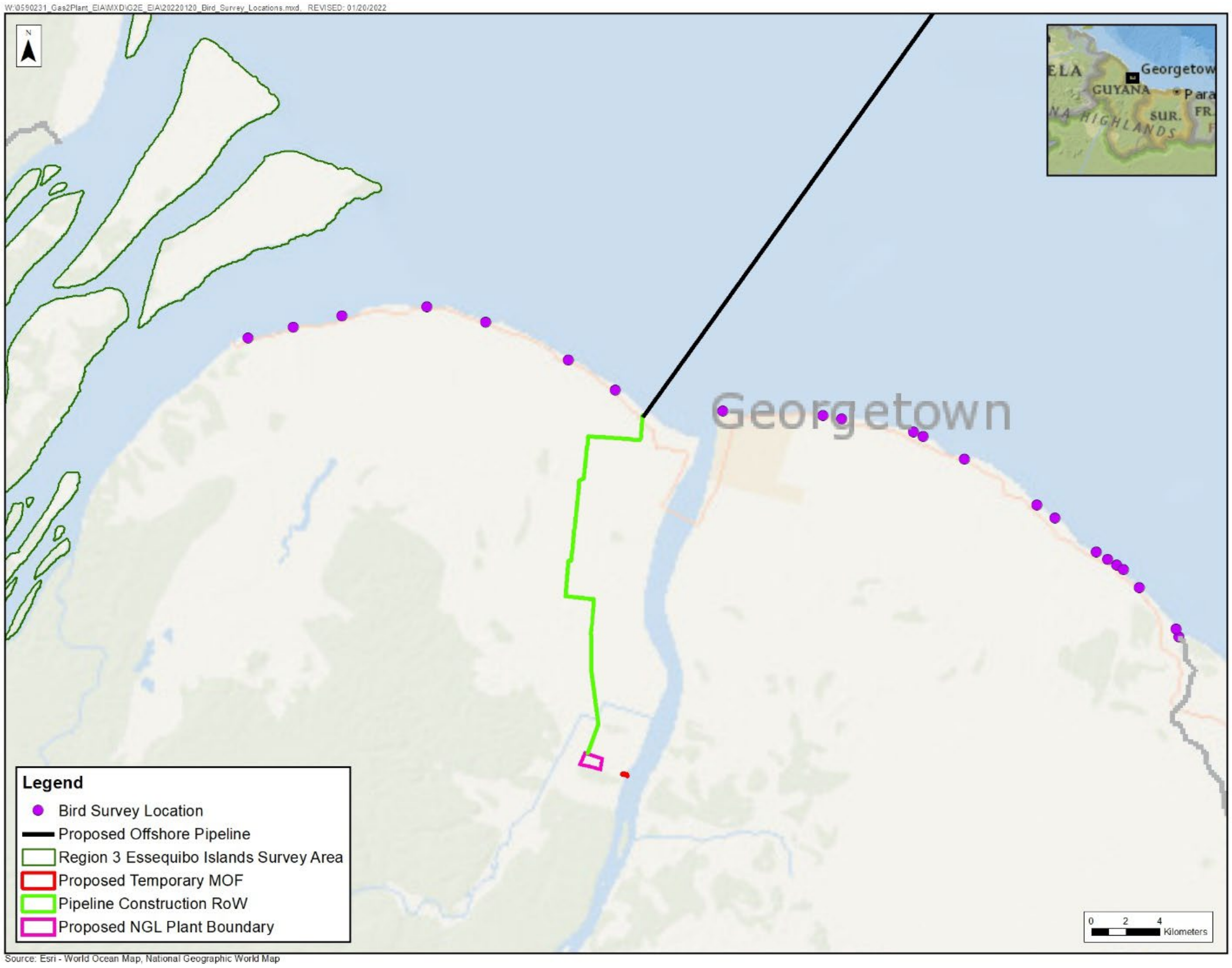


Figure 8.2-5: Coastal Bird Survey Locations - Regions 3 and 4 Survey Points

Table 8.2-3: Bird Species Observed during EEPGL-Commissioned Coastal Bird Surveys Conducted in Regions 3 and 4, 2017–2020

Common Name	Scientific Name	Life History Category	Region 3 (Coastal)	Region 4 (Coastal)
Northern Waterthrush	*Parkesia noveboracensis*	Migratory landbird		X
Yellow Warbler	*Setophaga petechia*	Migratory landbird	X	X
Fork-tailed Flycatcher	*Tyrannus savana*	Migratory Landbird		X
Gray Kingbird	*Tyrannus dominicensis*	Migratory Landbird	X	X
Piratic Flycatcher	*Legatus leucophaius*	Migratory Landbird	X	
Tropical Kingbird	*Tyrannus melancholicus*	Migratory Landbird	X	X
Magnificent Frigatebird	*Fregata magnificens*	Nearshore marine	X	X
Black Skimmer	*Rynchops niger*	Nearshore marine	X	X
Common Tern	*Sterna hirundo*	Nearshore marine		X
Gull-billed Tern	*Gelochelidon nilotica*	Nearshore marine	X	X

Common Name	Scientific Name	Life History Category	Region 3 (Coastal)	Region 4 (Coastal)
Large-billed Tern	*Phaetusa simplex*	Nearshore marine	X	X
Laughing Gull	*Leucophaeus atricilla*	Nearshore marine	X	X
Least Tern	*Sternula antillarum*	Nearshore marine	X	X
Royal Tern	*Thalasseus maximus*	Nearshore marine	X	X
Yellow-billed Tern	*Sternula superciliaris*	Nearshore marine		X
Brown Pelican	*Pelecanus occidentalis*	Nearshore marine	X	X
Neotropic Cormorant	*Phalacrocorax brasilianus*	Nearshore marine	X	X
Green Kingfisher	*Chloroceryle americana*	Non-migratory landbird	X	X
Ringed Kingfisher	*Megaceryle torquata*	Non-migratory landbird		X
Band-rumped Swift	*Chaetura spinicaudus*	Non-migratory landbird	X	
Fork-tailed Palm-Swift	*Tachornis squamata*	Non-migratory landbird		X
Grayish Saltator	*Saltator coerulescens*	Non-migratory landbird	X	X
Black Vulture	*Coragyps atratus*	Non-migratory landbird	X	X
Turkey Vulture	*Cathartes aura*	Non-migratory landbird		X
Common Ground-Dove	*Columbina passerina*	Non-migratory landbird	X	X
Pale-vented Pigeon	*Patagioenas cayennensis*	Non-migratory landbird	X	X
Rock Pigeon	*Columba livia*	Non-migratory landbird	X	X
Ruddy Ground-Dove	*Columba talpacoti*	Non-migratory landbird	X	X
White-tipped Dove	*Leptotila verreauxi*	Non-migratory landbird	X	X
Variable Chachalaca	*Ortalis motmot*	Non-migratory landbird	X	
Greater Ani	*Crotophaga major*	Non-migratory landbird		X
Smooth-billed Ani	*Crotophaga ani*	Non-migratory landbird	X	X
Striped Cuckoo	*Tapera naevia*	Non-migratory landbird		X
Straight-billed Woodcreeper	*Dendroplex picus*	Non-migratory landbird	X	X
Violaceous Euphonia	*Euphonia violacea*	Non-migratory landbird	X	
Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	Non-migratory landbird	X	X
Pale-breasted Spinetail	*Synallaxis albescens*	Non-migratory landbird	X	X
Barn Swallow	*Hirundo rustica*	Non-migratory landbird	X	X
Gray-breasted Martin	*Progne chalybea*	Non-migratory landbird	X	X
White-winged Swallow	*Tachycineta albiventer*	Non-migratory landbird	X	X
Carib Grackle	*Quiscalus lugubris*	Non-migratory landbird	X	
Red-breasted Meadowlark	*Leistes militaris*	Non-migratory landbird	X	X
Shiny Cowbird	*Molothrus bonariensis*	Non-migratory landbird	X	X
Yellow Oriole	*Icterus nigrogularis*	Non-migratory landbird	X	X
Yellow-hooded Blackbird	*Chrysomus icterocephalus*	Non-migratory landbird	X	X
Blood-colored Woodpecker	*Veniliornis sanguineus*	Non-migratory landbird		X
White-bellied Piculet	*Picumnus spilogaster*	Non-migratory landbird	X	X
Brown-throated Parakeet	*Eupsittula pertinax*	Non-migratory landbird	X	X
Red-shouldered Macaw	*Diopsittaca nobilis*	Non-migratory landbird	X	

Common Name	Scientific Name	Life History Category	Region 3 (Coastal)	Region 4 (Coastal)
Orange-winged Parrot	*Amazona amazonica*	Non-migratory landbird	X	
Short-tailed Swift	*Chaetura brachyura*	Non-migratory landbird		X
Barred Antshrike	*Thamnophilus doliatus*	Non-migratory landbird	X	X
Black-crested Antshrike	*Sakesphorus canadensis*	Non-migratory landbird	X	X
Bananaquit	*Coereba flaveola*	Non-migratory landbird	X	X
Bicolored Conebill	*Conirostrum bicolor*	Non-migratory landbird	X	X
Blue-black Grassquit	*Volatinia jacarina*	Non-migratory landbird	X	X
Blue-grey Tanager	*Thraupis episcopus*	Non-migratory landbird	X	X
Burnished-buff Tanager	*Tangara cayana*	Non-migratory landbird	X	X
Palm Tanager	*Thraupis palmarum*	Non-migratory landbird	X	X
Red-capped Cardinal	*Paroaria gularis*	Non-migratory landbird	X	X
Silver-beaked Tanager	*Ramphocelus carbo*	Non-migratory landbird	X	
White-lined Tanager	*Tachyphonus rufus*	Non-migratory landbird	X	
Wing-barred Seedeater	*Sporophila americana*	Non-migratory landbird	X	
Black-throated Mango	*Anthracothorax nigricollis*	Non-migratory landbird	X	
Glittering-throated Emerald	*Amazilia fimbriata*	Non-migratory landbird	X	X
Plain-bellied Emerald	*Amazilia leucogaster*	Non-migratory landbird	X	
White-chested Emerald	*Amazilia brevirostris*	Non-migratory landbird	X	
House-wren	*Troglodytes aedon*	Non-migratory landbird	X	X
Pale-breasted Thrush	*Turdus leucomelas*	Non-migratory landbird	X	X
Boat-billed Flycatcher	*Megarynchus pitangua*	Non-migratory Landbird	X	X
Brown-crested Flycatcher	*Myiarchus tyrannulus*	Non-migratory Landbird	X	X
Common Tody Flycatcher	*Todirostrum cinereum*	Non-migratory Landbird	X	X
Great Kiskadee	*Pitangus sulphuratus*	Raptor	X	X
Lesser Kiskadee	*Pitangus lictor*	Raptor	X	X
Mouse-colored Tyrannulet	*Phaeomyias murina*	Raptor	X	
Pied Water Tyrant	*Fluvicola pica*	Raptor	X	X
Rusty-margined Flycatcher	*Myiozetetes cayanensis*	Raptor	X	X
Short-crested Flycatcher	*Myiarchus ferox*	Raptor	X	X
Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	Raptor	X	X
Spotted Tody Flycatcher	*Todirostrum maculatum*	Raptor	X	X
Tropical Mockingbird	*Mimus gilvus*	Raptor	X	X
Yellow-bellied Elaenia	*Elaenia flavogaster*	Raptor	X	X
Yellow-crowned Tyrannulet	*Tyrannulus elatus*	Raptor	X	
Ashy-headed Greenlet	*Hylophilus pectoralis*	Raptor	X	X
Black-collared Hawk	*Busarellus nigricollis*	Raptor	X	X
Osprey	*Pandion haliaetus*	Raptor	X	X
Peregrine Falcon	*Falco peregrinus*	Raptor		X

Common Name	Scientific Name	Life History Category	Region 3 (Coastal)	Region 4 (Coastal)
Great Black Hawk	*Buteogallus urubitinga*	Raptor		X
Grey-lined Hawk	*Buteo nitidus*	Raptor	X	X
Long-winged Harrier	*Circus buffoni*	Raptor		X
Pearl Kite	*Gampsonyx swainsonii*	Raptor	X	
Roadside Hawk	*Rupornis magnirostris*	Raptor	X	X
Rufous Crab-hawk	*Buteogallus aequinoctialis*	Raptor	X	X
Snail Kite	*Rostrhamus sociabilis*	Raptor	X	X
Zone-tailed Hawk	*Buteo albonotatus*	Raptor		X
Bat Falcon	*Falco rufigularis*	Raptor		X
Crested Caracara	*Caracara cheriway*	Raptor		X
Yellow-headed Caracara	*Milvago chimachima*	Raptor	X	X
Black-bellied Plover	*Pluvialis squatarola*	Shorebird		X
Hudsonian Godwit	*Limosa haemastica*	Shorebird		X
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird	X	X
Southern Lapwing	*Vanellus chilensis*	Shorebird	X	X
Greater Yellowlegs	*Tringa melanoleuca*	Shorebird		X
Least Sandpiper	*Calidris minutilla*	Shorebird	X	X
Lesser Yellowlegs	*Tringa flavipes*	Shorebird	X	X
Pectoral Sandpiper	*Calidris melanotos*	Shorebird		X
Red Knot	*Calidris canutus*	Shorebird		X
Ruddy Turnstone	*Arenaria interpres*	Shorebird	X	X
Sanderling	*Calidris alba*	Shorebird	X	X
Semipalmated Sandpiper	*Calidris pusilla*	Shorebird	X	X
Short-billed Dowitcher	*Limnodromus griseus*	Shorebird		X
Solitary Sandpiper	*Tringa solitaria*	Shorebird	X	X
Spotted Sandpiper	*Actitis macularius*	Shorebird	X	X
Western Sandpiper	*Calidris mauri*	Shorebird	X	X
Whimbrel	*Numenius phaeopus*	Shorebird	X	X
White-rumped Sandpiper	*Calidris fuscicollis*	Shorebird		X
Willet	*Tringa semipalmata*	Shorebird	X	X
Limpkin	*Aramus guarauna*	Waterbird	X	X
Black-crowned Night-Heron	*Nycticorax nycticorax*	Waterbird	X	X
Cattle Egret	*Bubulcus ibis*	Waterbird	X	X
Cocoi Heron	*Ardea cocoi*	Waterbird		X
Great Egret	*Ardea alba*	Waterbird	X	X
Little Blue Heron	*Egretta caerulea*	Waterbird	X	X
Snowy Egret	*Egretta thula*	Waterbird	X	X
Striated Heron	*Butorides striata*	Waterbird	X	X
Tricolored Heron	*Egretta tricolor*	Waterbird	X	X

Common Name	**Scientific Name**	**Life History Category**	**Region 3 (Coastal)**	**Region 4 (Coastal)**
Yellow-crowned Night-Heron	*Nyctanassa violacea*	Waterbird		X
Wattled Jacana	*Jacana jacana*	Waterbird	X	X
Scarlet Ibis	*Eudocimus ruber*	Waterbird	X	X

The most common shorebirds observed during the 2017–2021 surveys (more than 1,000 individuals each) included one species of nearshore marine bird (Black Skimmer [*Rynchops niger*]), five species of waterbirds (Great Egret [*Ardea alba*], Little Blue Heron [*Egretta caerulea*], Scarlet Ibis, Snowy Egret [*Egretta thula*], and Tricolored Heron [*Egretta tricolor*]), three species of shorebirds (Lesser Yellowlegs [*Tringa flavipes*], Semipalmated Plover [*Charadrius semipalmatus*], and Semipalmated Sandpiper [*Calidris pusilla*]), one species of migratory landbird (Barn Swallow), and two species of non-migratory landbirds (Gray-breasted Martin [*Progne chalybea*] and Great Kiskadee [*Pitangus sulphuratus*]).

Generally, Regions 3 and 4 had lower average abundance across all surveys than other regions (Figure 8.2-6).

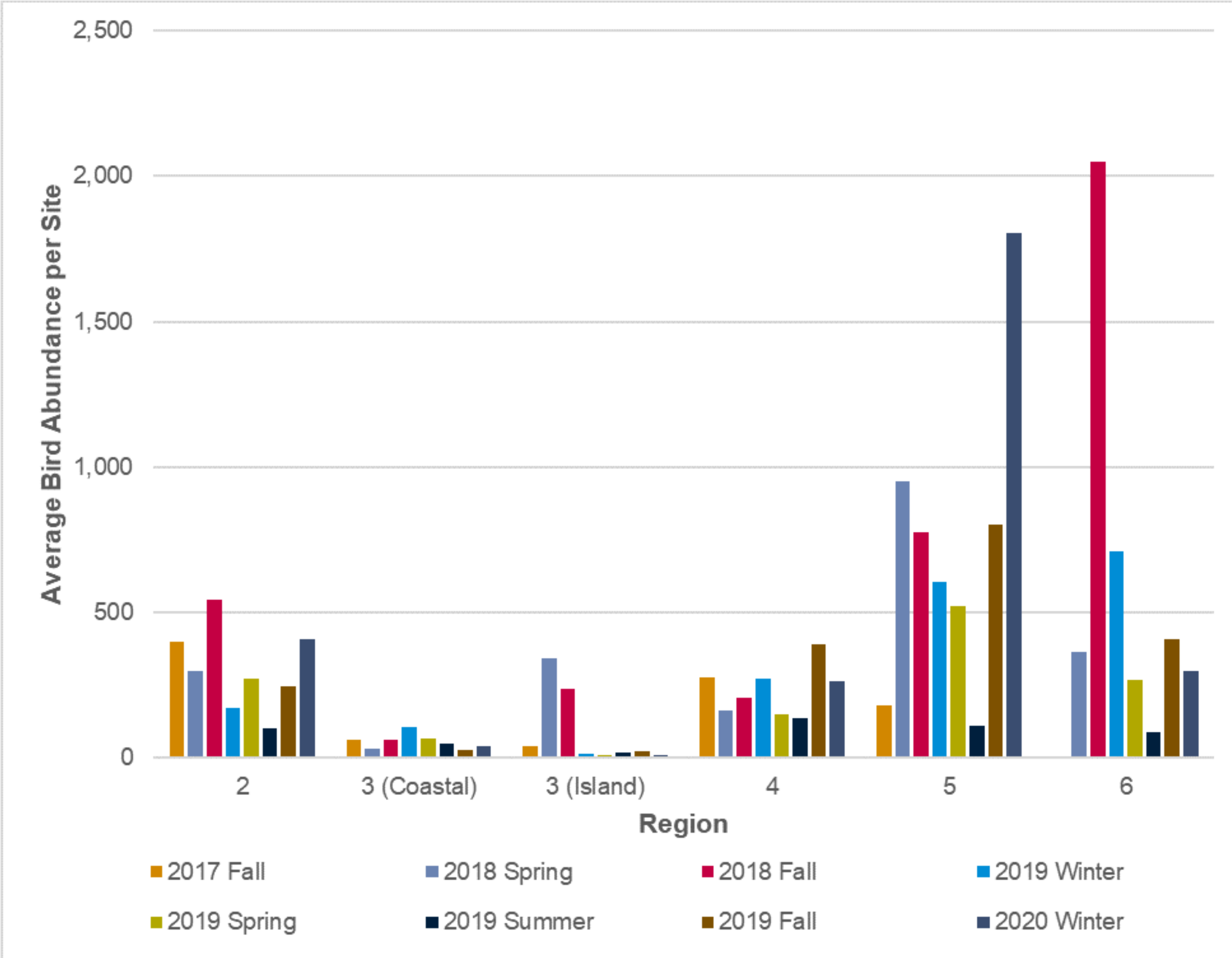


Figure 8.2-6: Average Bird Abundance per Site, by Region and Survey Period

Average species richness varied less than abundance across survey periods and regions. There were no clear seasonal patterns in species richness, with all coastal (i.e., non-island) surveys ranging between 11 and 21 species per site on average (Table 8.2-4).

Table 8.2-4 Average Species Richness per Site, by Region and Survey Period

Region	Fall 2017	Spring 2018	Fall 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020
1	NS	23	NS	NS	NS	NS	NS	NS
2	18	16	19	13	15	12	16	13
3—Coastal	20	11	14	17	14	14	11	11
3—Islands	10	24	30	6	5	5	7	4
4	19	14	16	12	14	16	16	14
5	17	18	21	18	18	21	18	17
6	NS	12	15	15	15	16	15	12

NS = not sampled

8.2.2.3. Marine Mammals

The equatorial waters of Guyana are located within subregion VI of the Wider Caribbean Region, which includes the countries of Guyana, Suriname, and French Guiana (Ward and Moscrop 1999). Many cetacean species are known to occur either seasonally or year-round in the Caribbean region, but there are limited data describing the life history, behavior, and movement patterns of most marine mammals offshore Guyana. In contrast, more detailed records exist for Venezuela and the southern Caribbean region. It should be noted that the scarcity of cetacean records for subregion VI can be attributed to a lack of survey effort rather than an absence of marine mammals (de Boer 2015).

Historical Data

The 2007 Global Bycatch Assessment of Long-lived Species Country Profile of Guyana (Project GloBAL 2007) provides a list of marine mammals whose distributions overlap with Guyana's EEZ. The cetacean species documented in this report are listed in Table 8.2-5.

Table 8.2-5: Marine Mammals with Ranges that Include Waters Offshore Guyana

Common Name	Scientific Name	Notes
Sei whale	*Balaenoptera borealis*	The sei whale is a baleen whale that prefers temperate waters in the mid-latitude range of the Atlantic, Pacific, and Indian oceans. It is the third-largest whale after the blue whale and the fin whale.
Bryde's whale	*Balaenoptera edeni*	Bryde's whales are moderately sized and closely resemble their relative, the sei whale.
Blue whale	*Balaenoptera musculus*	Blue whales are the largest mammals on earth. Their diet consists almost entirely of krill. Blue whales were hunted nearly to extinction.
Fin whale	*Balaenoptera physalus*	Fin whales are the second-largest mammal after blue whales. They are found worldwide and their food consists of small fish, squid, copepods, and krill.
Minke whale	*Balaenoptera acutorostrata*	Minke whales are the second-smallest baleen whale.
Common dolphin	*Delphinus delphis*	Common dolphins occur throughout warm temperate and tropical oceans. Common dolphins can occur in aggregations of hundreds or even thousands of dolphins. They sometimes associate with other cetacean species, such as pilot whales.
Long-beaked common dolphin[5]	*Delphinus capensis*	Long-beaked common dolphin is more geographically restricted (i.e., smaller in area) than that of the common dolphin. It has a varied diet. One of the main threats to this dolphin is fishery by-catch.
North Atlantic right whale	*Eubalaena glacialis*	The North Atlantic right whale is a baleen whale that was once a preferred target for whalers. They feed mostly on copepods and krill.
Pygmy killer whale	*Feresa attenuata*	The pygmy killer whale is a poorly known and rarely seen dolphin that avoids human contact. They are often caught in drift gill nets.

[5] The taxonomic status of Long-beaked common dolphin is currently the subject of debate. The IUCN and the Society for Marine Mammalogy Committee on Taxonomy consider it a subspecies of *Delphinus delphis*, but acknowledge that it may eventually be listed as a separate species. It is listed separately here to maintain consistency with EEPGL's PSO reports and marine mammal database for Guyana waters.

Common Name	Scientific Name	Notes
Short-finned pilot whale	*Globicephala macrorhynchus*	Short-finned pilot whales are very sociable and are rarely seen alone. They are found in groups of 10 to 30, although some pods are as large as 50. The species primarily feeds on squid, but will also feed on certain species of fish and octopus. They feed nearly 300 meters deep or more, and spend great lengths of time at depth. A pod may spread out up to 800 meters to cover more area to find food.
Risso's dolphin	*Grampus griseus*	Risso's dolphins are found worldwide in temperate and tropical waters, just off the continental shelf on steep banks. Risso's dolphins feed almost exclusively on neritic and oceanic squid, mostly nocturnally.
Pygmy sperm whale	*Kogia breviceps*	The pygmy sperm whale is not much larger than many dolphins. Pygmy sperm whales are normally either solitary or found in pairs. They feed mainly on cephalopods.
Dwarf sperm whale	*Kogia simus*	The dwarf sperm whale is the smallest species commonly known as a whale. Dwarf sperm whales feed mainly on squid and crab. Their preferred habitat appears to be just off the continental shelf.
Fraser's dolphin	*Lagenodelphis hosei*	Fraser's dolphin is normally sighted in deep tropical waters. Fraser's dolphins swim quickly in large, tightly packed groups of about 100 to 1,000 in number.
Humpback whale	*Megaptera novaeangliae*	The humpback whale is found in oceans and seas around the world. Humpback whales typically migrate up to 25,000 kilometers each year. Humpbacks feed only in summer, in polar waters, and migrate to tropical or subtropical waters to breed and give birth in the winter. Once hunted to the brink of extinction, its population fell by an estimated 90% before a 1966 moratorium. Since this time, stocks have partially recovered.
Blainville's beaked whale	*Mesoplodon densirostris*	Blainville's beaked whale is found in tropical and warm waters in all oceans, and has been known to range into very high latitudes. The whales are seen in groups of three to seven individuals. Dives have been measured as long as 22 minutes.
Gervais' beaked whale	*Mesoplodon europaeus*	Gervais' beaked whale forms small groups. They most likely feed on squid. Although this species frequently strands, until 1998, no one had made a confirmed sighting of the species at sea.
True's beaked whale	*Mesoplodon mirus*	True's beaked whales have been seen in small groups, and are believed to be squid eaters. Little else is known.
Melon-headed whale	*Peponocephala electra*	Melon-headed whale is closely related to the pygmy killer whale and pilot whale; collectively this dolphin species is known by the common name blackfish. It is also related to the false killer whale. The melon-headed whale is widespread throughout the world's tropical waters, although not often seen by humans because it prefers deep water.
Sperm whale	*Physeter macrocephalus*	The sperm whale is the largest of the toothed whales that can be found anywhere in the open ocean. Females and young males live together in groups while mature males live solitary lives outside of the mating season. Females give birth every 4 to 20 years and care for the calves for more than a decade. A mature sperm whale has few natural predators. They feed on squid and fish and usually dive between 300 to 800 meters to forage.
False killer whale	*Pseudorca crassidens*	False killer whales live in temperate and tropical waters throughout the world. As its name implies, the false killer whale shares characteristics, such as appearance, with the more widely known

Common Name	Scientific Name	Notes
		killer whale. Like the killer whale, the false killer whale attacks and kills other cetaceans.
Pantropical spotted dolphin	*Stenella attenuata*	Pantropical spotted dolphin is found in the world's temperate and tropical oceans. This species was threatened due to the killing of millions of individuals in tuna purse seines until the rise of “dolphin-friendly” tuna capture methods in the 1980s benefited the species. It is now one of the most abundant dolphin species in the world.
Clymene dolphin	*Stenella clymene*	Clymene dolphins spend most of their lives in waters more than 100 meters in depth, but occasionally move into shallower, coastal regions. They feed on squid and small schooling fish, hunting either at night, or in mesopelagic waters where there is only limited light.
Striped dolphin	*Stenella coeruleoalba*	The striped dolphin inhabits temperate or tropical, offshore waters. It moves in large groups—usually up to thousands of individuals in number. The adult striped dolphin eats fish, squid, octopus, krill, and other crustaceans.
Spinner dolphin	*Stenella longirostris*	The spinner dolphin is a small dolphin found in offshore tropical waters around the world. The species primarily inhabits coastal waters, islands, or banks.
Rough-toothed dolphin	*Steno bredanensis*	Rough-toothed dolphins can be found in deep warm and tropical waters around the world and are typically social animals. An average group has between 10 and 20 members. They have also been reported to school together with other species of dolphin, and with pilot whales, false killer whales, and humpback whales.

Source: Project GloBAL 2007; de Boer 2015; IUCN 2021; Minasian et al. 1984

In 2015, the Dutch Institute for Marine Resources and Ecosystem Studies published a peer-reviewed article summarizing marine mammal data collected off Suriname (de Boer 2015). The data included observations in 2012 from an offshore survey area as well as incidental observations off Suriname and adjacent waters from 2008 to 2012 (de Boer 2015). The study documented ten identifiable species. The article also documented incidental sightings of various marine mammals, including common bottlenose dolphins (*Tursiops truncatus*) off Trinidad, dolphins (*Stenella* sp.) off Guyana, and Guiana dolphin (*Sotalia guianensis*) at the entrance of the Suriname River during transit to the survey area (from Trinidad to Suriname). Accordingly, these species may possibly be encountered closer to shore.

De Boer (2015) reported the cetacean community in the Suriname area as primarily composed of odontocetes (toothed whales, sperm whales, beaked whales, killer whales, and dolphins). In general, these animals are more common offshore of Suriname than the baleen whales.
De Boer (2015) noted that the most abundant species documented offshore Suriname were sperm whale (*Physeter macrocephalus*) and melon-headed whale (*Peponocephala electra*). Spinner dolphin (*Stenella longirostris*) and pantropical spotted dolphin (*Stenella attenuata*) were also frequently encountered in large groups.

EEPGL Marine Mammal Survey Data

EEPGL has commissioned the collection of marine mammal data offshore Guyana since 2015, during various survey activities related to oil and gas activities. Data on marine mammals have been collected using visual and auditory detection methods. EEPGL's PSO data were collected by PSOs participating in various programs offshore Guyana from 2015 through 2021. Together, these survey efforts represent more than 19,000 hours of survey time and have generated the most comprehensive dataset available on marine mammal activity off the coast of Guyana (RPS 2018; RPS 2019). Data were collected during five types of surveys—three-dimensional (3D)/four-dimensional (4D) surface seismic; field geotechnical; automated underwater vehicle (AUV); vertical seismic profile (VSP); and environmental baseline/metocean surveys.

Over the approximately 6-year study period since EEPGL initiated marine mammal surveys offshore Guyana (2015–2021), 1,345 marine mammals have been detected (including unidentified dolphins and whales). Of these detections, 693 were identifiable to species (Figure 8.2-7). To date, 15 cetacean species have been confirmed as observed in the Stabroek Block. Figure 8.2-8 summarizes the locations of marine mammal sightings across the various surveys.

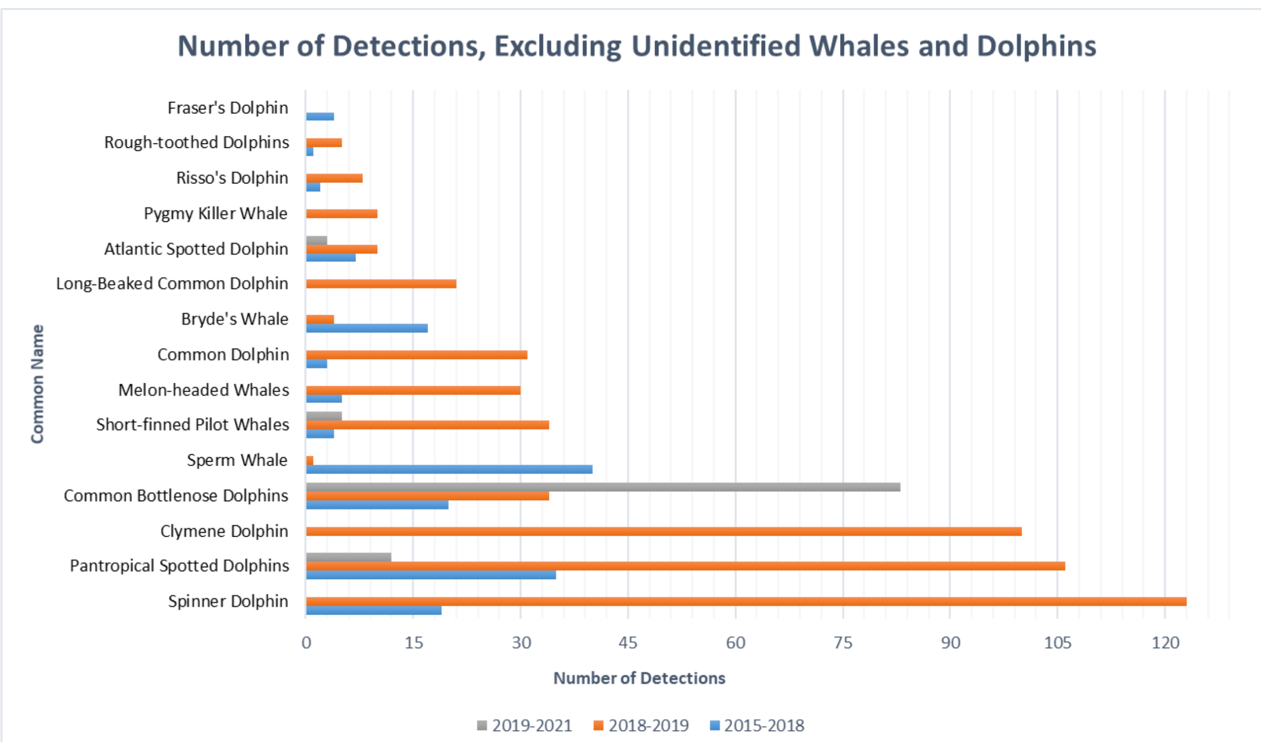
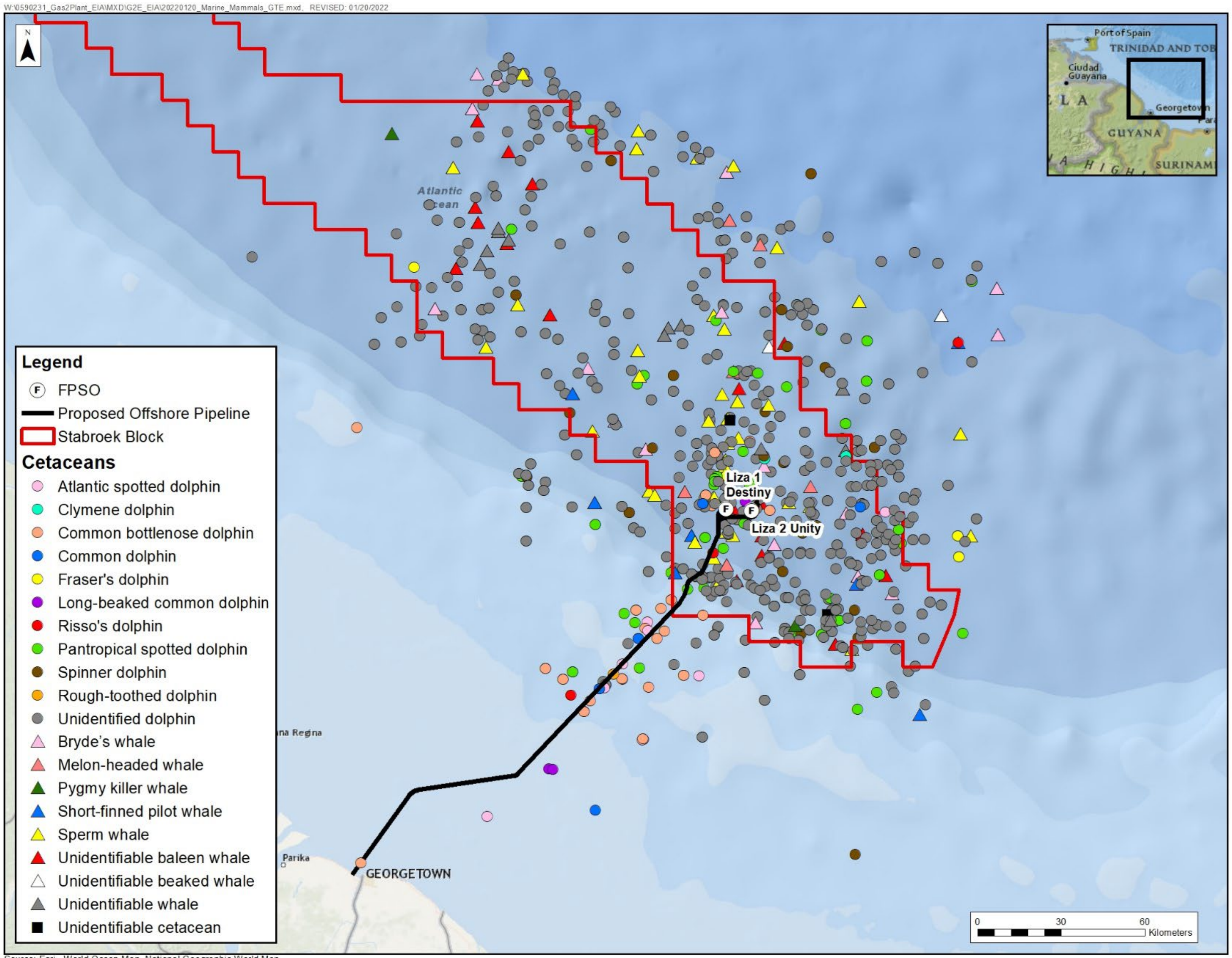


Figure 8.2-7: Confirmed Marine Mammal Sightings in the Stabroek Block, by Species, for the 2015–2018, 2018–2019, and 2019–2021 Survey Periods



Source: Esri - World Ocean Map, National Geographic World Map

Figure 8.2-8: Locations of Marine Mammal Sightings Relative to Offshore Project Components (2015–2021)

Table 8.2-6 summarizes the species visually documented during the EEPGL-commissioned surveys. Most of the species identified are relatively common according to the IUCN (Least Concern status); it is noted, however, that several of the whales listed in Table 8.2-5 are globally rare (e.g., blue whale [*Balaenoptera musculus*], sei whale [*Balaenoptera borealis*], North Atlantic right whale [*Eubalaena glacialis*]) and would not necessarily be expected to be detected, even though their historically documented range includes the survey area. It should also be noted that this does not necessarily mean that rare or uncommon species listed in Table 8.2-6 do not occur in the Guyana EEZ; rather, it means they are less likely to be detected if they occur in the area.

Table 8.2-6: Marine Mammal Species Visually Observed during EEPGL Activities (2015–2021)

Common Name	Scientific Name
Bryde’s whale	*Balaenoptera brydei*
Sperm whale	*Physeter macrocephalus*
Melon-headed whale	*Peponocephala electra*
Short-finned pilot whale	*Globicephala macrorhynchus*
Pygmy killer whale	*Feresa attenuata*
Atlantic spotted dolphin	*Stenella frontalis*
Common bottlenose dolphin	*Tursiops truncatus*
Common dolphin	*Delphinus delphis*
Long-beaked common dolphin	*Delphinus capensis*
Fraser's dolphin	*Lagenodelphis hosei*
Pantropical spotted dolphin	*Stenella attenuate*
Risso’s dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Spinner dolphin	*Stenella longirostris*
Clymene dolphin	*Stenella clymene*

Source: RPS 2019

Over the complete monitoring period (2015–2021), dolphins have accounted for over 80 percent of all detections. Unidentified dolphins were the most frequently detected group of marine mammals, accounting for 44 percent of all detections. After unidentified dolphin sightings, the most frequently detected marine mammal species were pantropical spotted dolphin, spinner dolphin, common bottlenose dolphin, and clymene dolphin (*Stenella clymene*), which together comprised 36.6 percent of all the detections over the monitoring period. Short-finned pilot whales (*Globicephala macrorhynchus*), followed by sperm whales, were the most frequently detected whale species (Figure 8.2-9). Marine mammal overall detection rates were similar across all surveys (0.0370, 0.0413, and 0.0748 detections per hour of monitoring effort for the periods 2015–2018, 2018–2019, and 2019–2021, respectively).

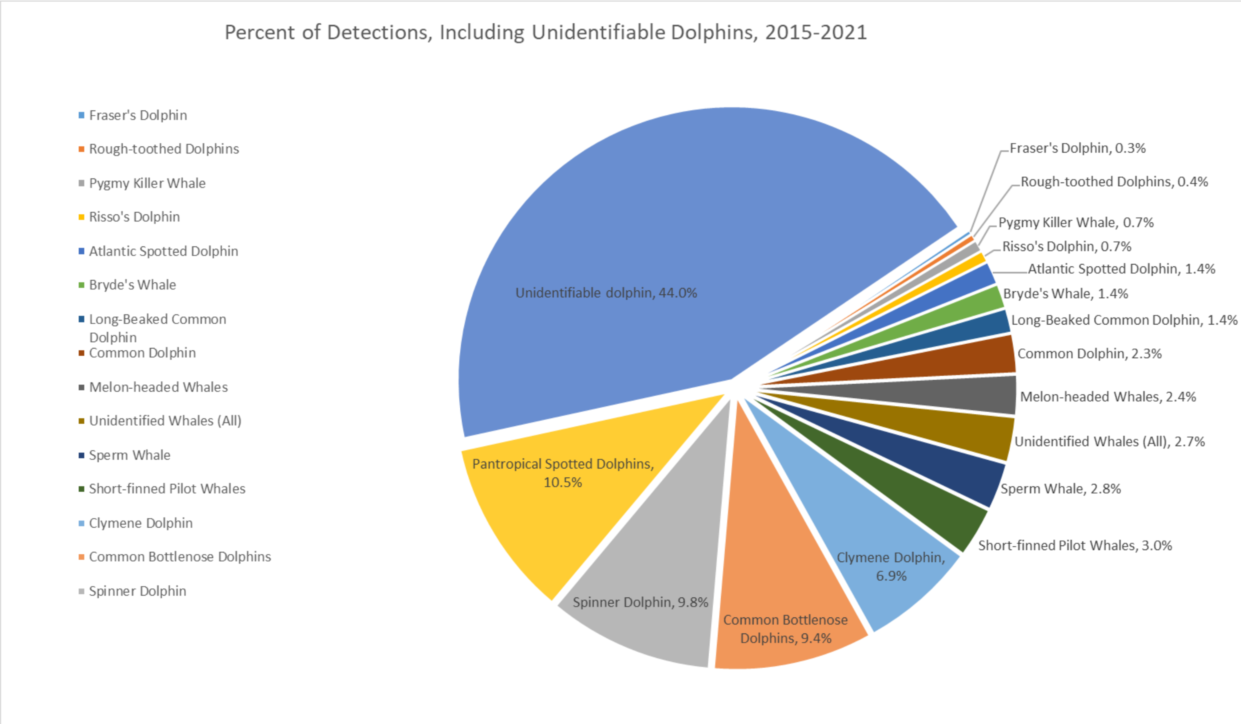


Figure 8.2-9: Distribution of Marine Mammal Sightings in the Stabroek Block, by Species/Group (2015–2021)

Detection rates by month for the survey period from 2015 through 2018 indicate toothed whale detections showed seasonal variability, with an increase in autumn and winter and a decrease in spring and summer (Figure 8.2-10). Accounting for the amount of survey effort, the seasonal pattern in detections (normalized per hour of observation) was consistent among years. Based on these detections, toothed whale abundance offshore Guyana likely varies with season. Some seasonal variability was observed in baleen whales, but the relatively small number of baleen whale detections compared to toothed whale detections makes comparisons between the two groups difficult.

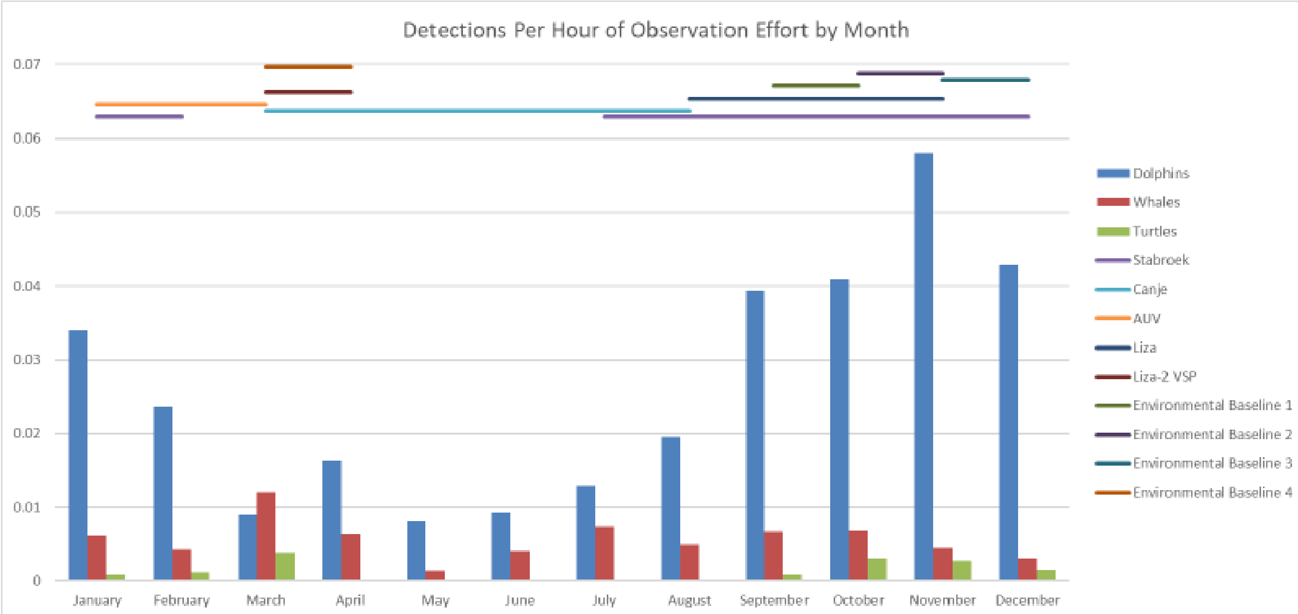


Figure 8.2-10: Seasonal Variations in Marine Mammal and Turtle Sightings in the Stabroek Block (2015–2018)

A survey of 125 nearshore Guyanese fisherfolk indicated they encounter various marine mammals, such as Amazon River dolphin (*Inia geoffrensis*; locally referred to as boto), Gray river dolphin (*Sotalia fluviatilis*; locally referred to as tucuxi), spotted dolphin, common dolphin, spinner dolphin, and bottlenose dolphin (Charles et al. 2004). Although two of the six species mentioned in the survey (botos and tucuxis) were not recorded in the above-referenced EEPGL-commissioned surveys, the findings were generally consistent with the results from the EEPGL-commissioned surveys as follows:

- Botos and tucuxis are primarily associated with freshwater and—less frequently—estuarine environments, so these species are not expected to occur offshore where EEPGL-commissioned surveys took place.
- The fisherfolk surveyed did not mention frequent encounters with any whale species.
- The Guyana fishing fleet has historically concentrated its efforts in comparatively shallow continental shelf waters, south of most of the EEPGL-commissioned survey areas.
- With the exception of two sightings of short-finned pilot whales a short distance south of the Stabroek Block in waters over the continental slope, the EEPGL-commissioned surveys did not document any whales farther south (i.e., shallower) than the Stabroek Block.

The combined findings of the EEPGL-commissioned surveys and the Charles et al. (2004) survey suggest that the Project's offshore pipeline is likely near or south of the southern boundary of the primary habitat for whales offshore Guyana. These findings also suggest that dolphins may be present throughout the offshore portion of the Project AOI at all times of the year; however, they are likely to be more abundant in the Project AOI in the autumn and winter months.

Figures 8.2-11 and 8.2-12 are photographs of marine mammals observed in the Stabroek Block during EEPGL-commissioned surveys in 2018 and 2019.

Photo credit: Meshach Pierre

Note: Observed in the Stabroek Block during marine bird surveys conducted aboard the *Captain Grady*, April 2019

Figure 8.2-11: Common Bottlenose Dolphin (*Tursiops truncates*)

Photo credit: RPS 2019

Note: Observed in the Stabroek Block from the *Sea Service*, October 2018

Figure 8.2-12: Rough-toothed Dolphin (*Steno bredanensis*)

8.2.2.4. Marine Turtles

According to the Regional Sea Turtle Conservation Program and Action Plan for the Guianas, (Reichart et al. 2003 and Dow et al. 2007), marine turtles are found throughout the Caribbean and the Guiana Shield region, which includes Venezuela, Guyana, Suriname, French Guiana, and Brazil. The existing conditions for marine turtles offshore Guyana are described using observational data collected during various offshore exploration activities from 2015 to 2019 and marine turtle tagging and telemetry studies conducted at the SBPA.

Five marine turtle species are found in Guyana and the surrounding region. Four marine turtles (green turtle [*Chelonia mydas*], leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], and olive ridley turtle [*Lepidochelys olivacea*]) nest on Guyana's beaches. A fifth species, loggerhead turtle (*Caretta caretta*), also occurs offshore Guyana, but rarely comes ashore to nest in Guyana. In addition to relying on sandy beaches for egg-laying, marine turtles rely on healthy coral reef, seagrass, and hard-bottom habitats for food and refuge. Based on available information, post-hatchlings and juvenile green turtles are reported to feed on prey found within sargassum mats (NOAA Fisheries 2022), while the other marine turtle life stages are associated with clearer offshore waters or coral reef environments where they prey on a variety of species (Piniak and Eckert 2011).

Marine Turtle Nesting in Guyana

According to available information, most marine turtle nesting in Guyana occurs on beaches within the SBPA, which is located in Region 1 on the northwestern coast of Guyana (e.g., Alvarez-Varas et al. 2016). The exact locations of secondary nesting sites in Guyana change each year with coastal erosion, which either creates or destroys nesting areas, but they are generally distributed along the northwest coast between the Pomeroon River and the Waini River estuaries. Historically, leatherback turtles were the most common species that nested on Guyana's beaches (e.g., Almond Beach); however, many leatherback turtles and eggs were intentionally taken by residents in the late-1980s so it is difficult to determine whether they remain the most common nesting species (Pritchard 1986). Nonetheless, leatherback and green turtles commonly nest on Guyana's beaches, followed by olive ridley and hawksbill turtles, which nest infrequently. According to the Center for Rural Empowerment and the Environment, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) is February to August; nesting occurs at night (PAC 2014).

Habitat Use by Marine Turtles

Only female marine turtles come ashore to nest, so the mature female life stage is most easily studied and well known; much less information is available about habitat use and movements of subadults and juveniles. Young marine turtles live in the open ocean for the first few years of life, a period that has been termed the surface-pelagic or open-ocean stage. Reich et al. (2007) used stable isotope analysis to confirm that following the initial post-hatching "scramble" to the water, young green turtles lead a carnivorous existence in offshore habitats for 3 to 5 years before making a rapid shift to coastal habitats, where they switch to an herbivorous feeding strategy. Putman and Mansfield (2015) reported that hatchling green and Kemp's ridley turtles are capable of directional swimming and do exhibit some degree of volitional movement while in the open ocean (McClellan and Read 2007; McClellan et al. 2009; McClellan and Read 2009; McClellan et al. 2010).

During the EEPGL-commissioned participatory fishing study that occurred from January 2019 to February 2020, additional anecdotal information on marine turtle distribution and habitat use was collected by interviewing fisherfolk. Fisherfolk reported encountering all four species of marine turtles known to nest in Guyana. Leatherback and green turtles were reported to be seen or caught and released by study participants in Regions 1, 2, 5, and 6. They indicated that turtles attempted to nest on the sand banks in Riverview (Region 4) and Lima (Region 2) several years ago, but that turtles are no longer attempting to nest in those areas given the recently established mangrove planting programs in those regions. Many fisherfolk in Region 2 indicated they have been seeing marine turtles in the seaweed just off the Pomeroon River; it is possible the seaweed could be suitable habitat for green turtles. Almost all of the fisherfolk interviewed in Region 1 reported observing marine turtles during fishing activities, and several fisherfolk reported accidentally catching marine turtles in their fishing gear. A few fisherfolk in Waramuri (Region 1) indicated they frequently encounter marine turtles in the vicinity of Shell Beach. Similarly, fisherfolk from Smith's Creek (Region 1) report frequently encountering juvenile marine turtles.

All of the study participants who acknowledged catching marine turtles indicated that the turtles were released alive. This is possibly due both to the awareness of the important special status of marine turtles and/or to superstitions held by the fisherfolk. Some fisherfolk believe that catching turtles leads to lower future fish catches, while others believe that the turtles are crying in their nets (as a result of natural excretion of saline fluid from the turtles' eyes) (ERM and EMC 2020).

Protected Species Observer Data for Marine Turtles

During the approximately 2,000 hours of survey time, from May 2015 through April 2020, in and around the Stabroek, Canje, and Kaieteur blocks, and between the blocks and the Guyana coast, 17 marine turtles were detected. The species detected include green, hawksbill, loggerhead, and olive ridley turtles. No leatherback turtles were detected during the surveys. Unidentified shelled marine turtles represented five of the 17 observations, followed by five detections of loggerhead turtles, three detections of green turtles, and two detections each of hawksbill and olive ridley turtles.

Recent Marine Turtle Satellite Tracking Studies

In May 2012, the Sea Turtle Conservancy tracked three leatherback turtles from their nesting site at Shell Beach and discovered that each turtle remained offshore of Shell Beach and in Guyana's territorial waters for several weeks. By the second to third week of June, two had moved farther offshore in transit to the waters off Nova Scotia, while one remained off the coast of Guyana until the third week of July and eventually transited to Honduran waters. These movements are consistent with other researchers (Pritchard 1973; Fossette et al. 2010) that have reported most marine turtles migrate away (approximately a few hundred kilometers) from nesting beaches during post-nesting periods. Most turtles remain relatively close to nesting beaches during the nesting season (Shillinger et al. 2010; Bond and James 2017) because they often return to nesting beaches multiple times to lay additional eggs (multiple clutches).

To study turtle movements in Guyana, a consultant team commissioned by EEPGL enlisted the assistance of the Chelonian Research Institute in 2018 and 2019 to develop and conduct a research program on marine turtle movements. The program included three deployments to the SBPA during which turtles were tagged and subsequently tracked using telemetry, two in 2018 and one in 2019, as described in Table 8.2-7.

Table 8.2-7: EEPGL-commissioned Marine Turtle Tagging and Tracking Studies Completed to Date

Deployment	Date	Tagging Results (names assigned for tracking purposes)
Deployment 1	21 to 27 March 2018	Four green turtles (Sibille, Becky, Violet, and Karin)
Deployment 2	9 to 14 June 2018	Three leatherback turtles (Julie, Denise, and Arleen).
Deployment 3	7 to 17 May 2019	Two green turtles (designated Sadie and Michelle), and five leatherback turtles (Teij, Kari, Christine, Regina, and Rhonda).

The 2018 data showed turtles returned to nest between two and six times, exclusively on Almond Beach (a beach located within the SBPA) at about 12-day intervals, except for one green turtle (Violet) who also nested across the Barima-Waini river mouth and at a longer time interval than the other turtles. With respect to the area used by the turtles during the inter-nesting period, there were no significant differences among species or individuals; however, leatherback turtles were generally found farther from shore than green turtles.

The turtles' inter-nesting movements was generally concentrated within the territorial seas of Guyana in the direct vicinity of Almond Beach, but it also included the territorial seas of Venezuela and Trinidad. The leatherback turtles generally demonstrated more itinerant[6] movement behaviors than green turtles although one green turtle (Karin) ventured northwest to the Trinidadian coast, farther than any other individual tagged that year (Figure 8.2-13). Leatherback turtles also occupied slightly deeper water than green turtles during the inter-nesting period. Green turtles spent most of their time in less than 5 meters of water, while leatherback turtles spent most of their time in less than 10 meters of water. Green and leatherback turtles tagged in 2019 displayed similar inter-nesting movements as in 2018, with leatherbacks generally venturing farther out to sea than the green turtles (Figure 8.2-14).

[6] Moving from place to place

Green Turtles **Leatherback Turtles**

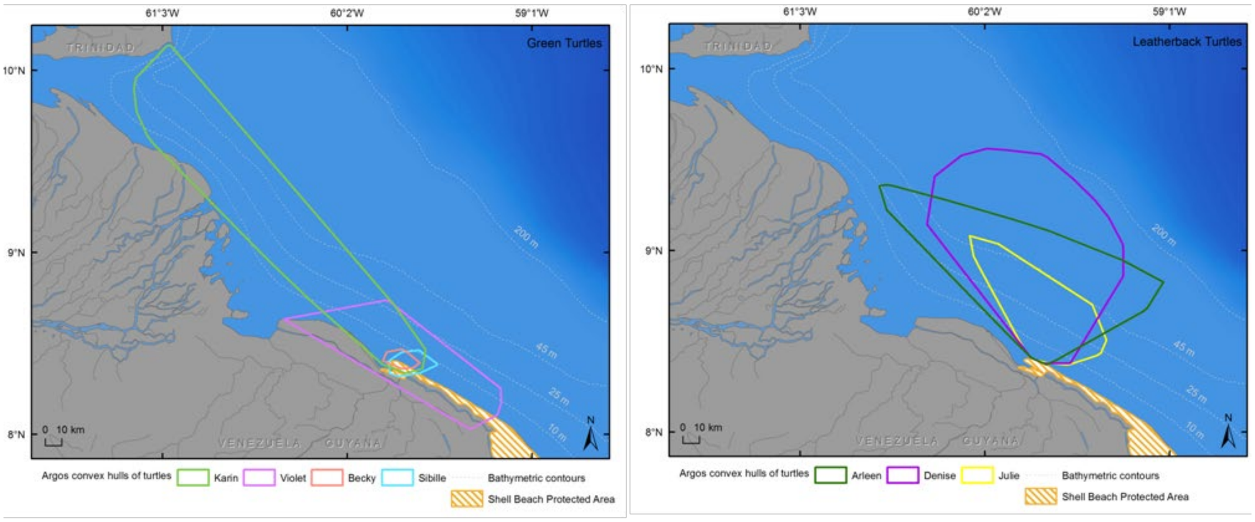


Figure 8.2-13: Spatial Footprints of Green and Leatherback Turtle Inter-nesting Movements from Almond Beach in 2018

Green Turtles **Leatherback Turtles**

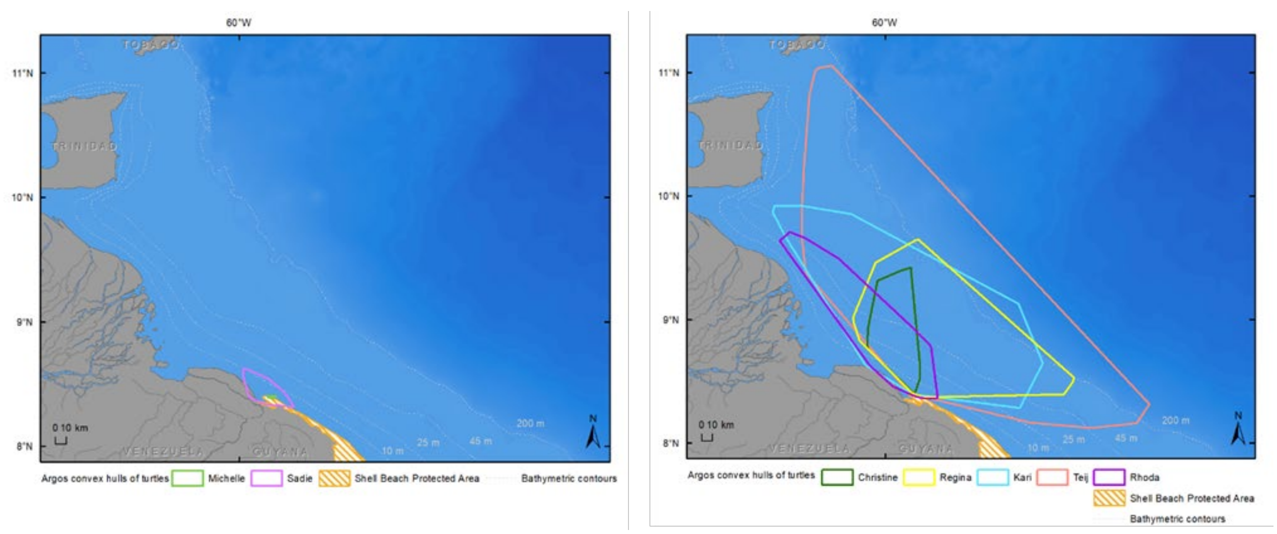
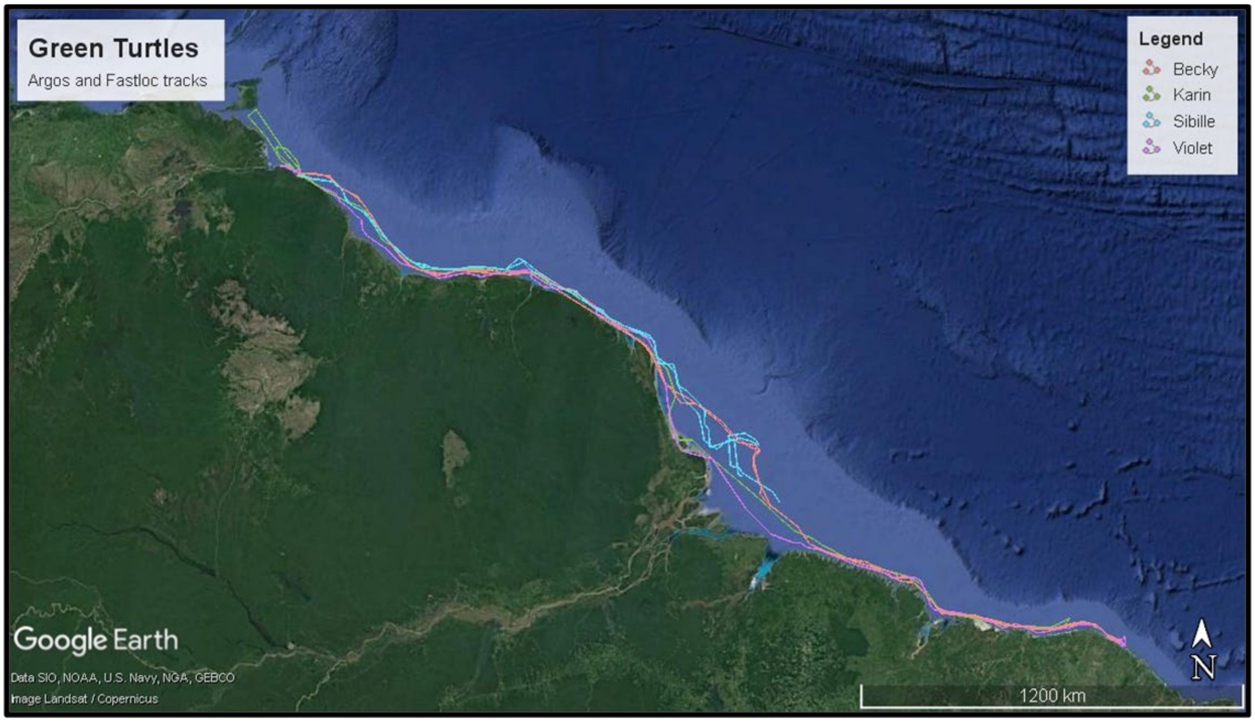


Figure 8.2-14: Spatial Footprints of Green and Leatherback Turtle Inter-nesting Movements from Almond Beach in 2019

Post-nesting movements were also tracked as turtles departed the Shell Beach nesting site to their foraging grounds. In 2018, all four green turtles migrated southeast to Brazil following a near-shore corridor across an average distance of 2,485 kilometers (Figure 8.2-15); all three leatherback turtles initially headed directly out to sea in a northeasterly direction (Figure 8.2.16). Three green turtles displayed movements to the foraging grounds near Ceará, Brazil. Two of three turtles overlapped geographically in the area, adjacent to the Mundaú River Estuary

Environmental Protection Area. The three green turtles displayed similar foraging habitat use and movements.



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc location data. In most cases, the difference is unapparent.

Figure 8.2-15: 2018 Migration Routes of Green Turtles Tracked from Shell Beach

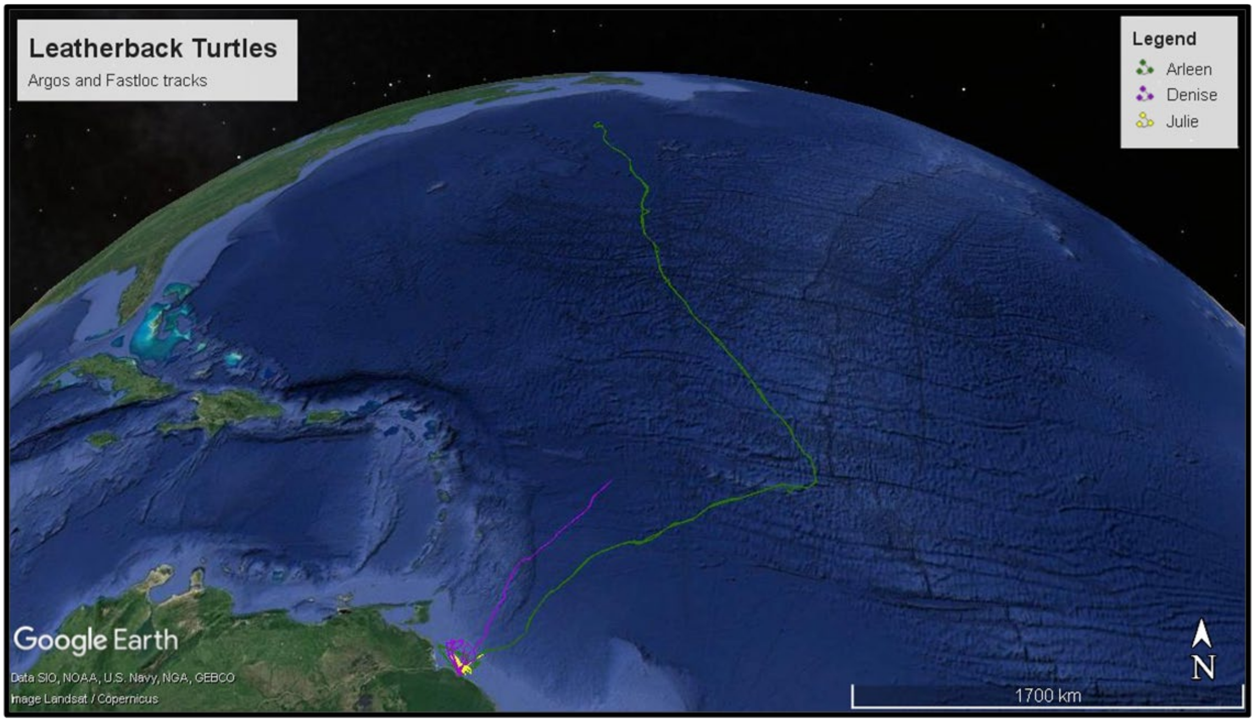


Figure 8.2-16: 2018 Migration Routes of Leatherback Turtles Tracked from Shell Beach

In 2019, both green and leatherback turtles used deeper waters during their migration period than in prior tracking periods. Similar to 2018, the two green turtles (Michelle and Sadie) headed southeast to Brazil by following a near-shore corridor while the leatherbacks swam northward before dispersing across the eastern seaboard of North America (Figures 8.2-17 and 8.2-18, respectively). Michelle stopped at a well-known green turtle foraging area (Naro-Maciel et al. 2007; Godley et al. 2003) near Almofala, where she foraged for 24 days before moving farther down the coast and settling at another site in the state of Rio Grande do Norte, where she remained for 68 days. Sadie foraged farther north near Parnaiba, Brazil, until her final transmission 62 days later. Both green turtles made various deep dives (60 meters) before or after moving near major river mouths (i.e., the Essequibo River, Guyana; the Corentyne River, Suriname; the Amazon and Pará rivers, the Mearima River / Arraial Bay, and the Parnaíba River, Brazil).

For the first time, both coastal and oceanic foraging habitats for the leatherbacks were observed. The indicators for these periods were area-restricted search movements, coupled with a change in dive behavior marked by a progression of shallow dives, which were consistent in both types of habitats. Two of the leatherback turtles (Christine and Rhoda) initially headed directly out to sea in a northeasterly direction towards the coastal southeastern United States. These turtles remained in near-shore waters, moving up and down the coast of the United States—likely in search of jellyfish. The coastal zone of the southeastern United States has been identified as important foraging habitat for leatherbacks (Eckert et al. 2006; Fossette et al. 2014; Stewart et al. 2016).

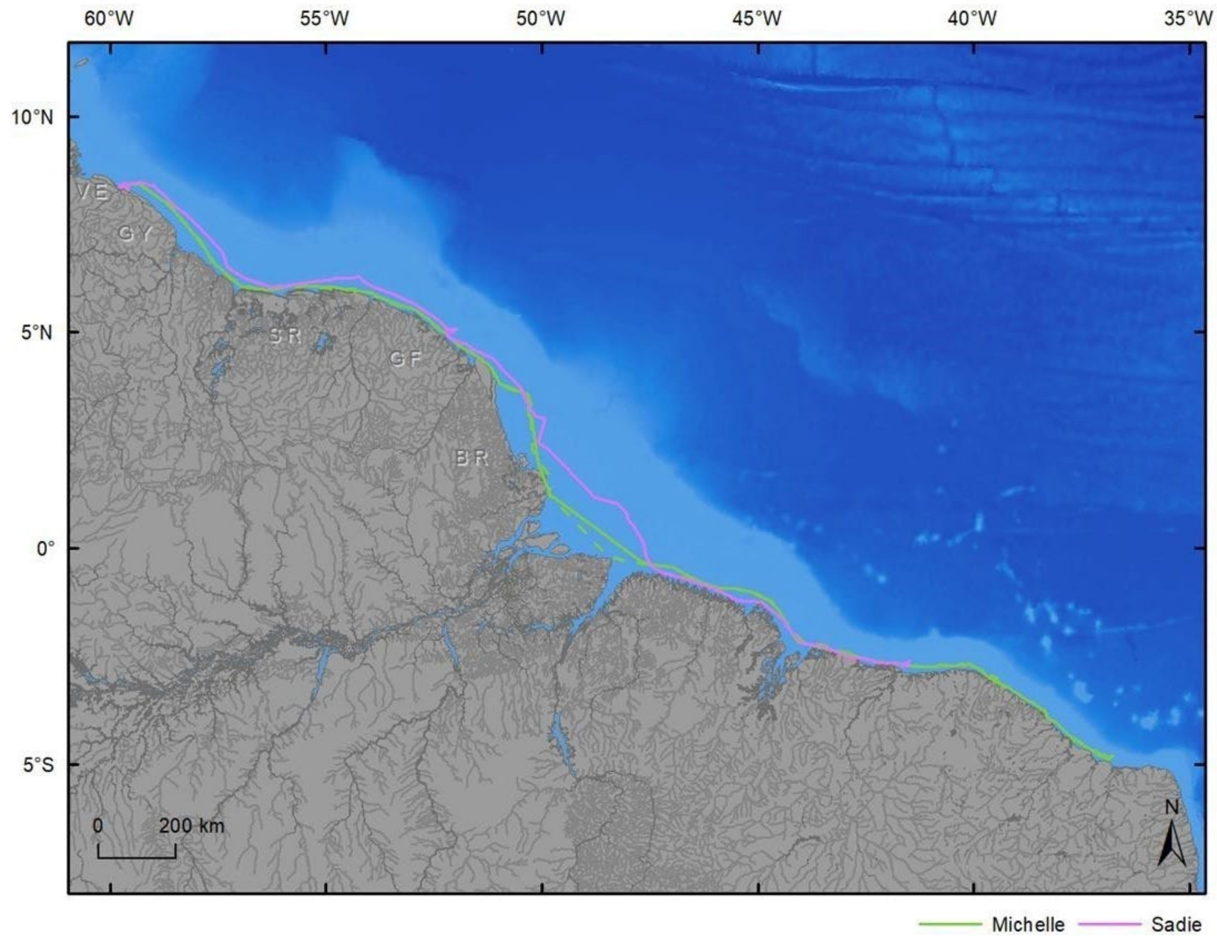


Figure 8.2-17: 2019 Migration Routes of Green Turtles Tracked from Shell Beach

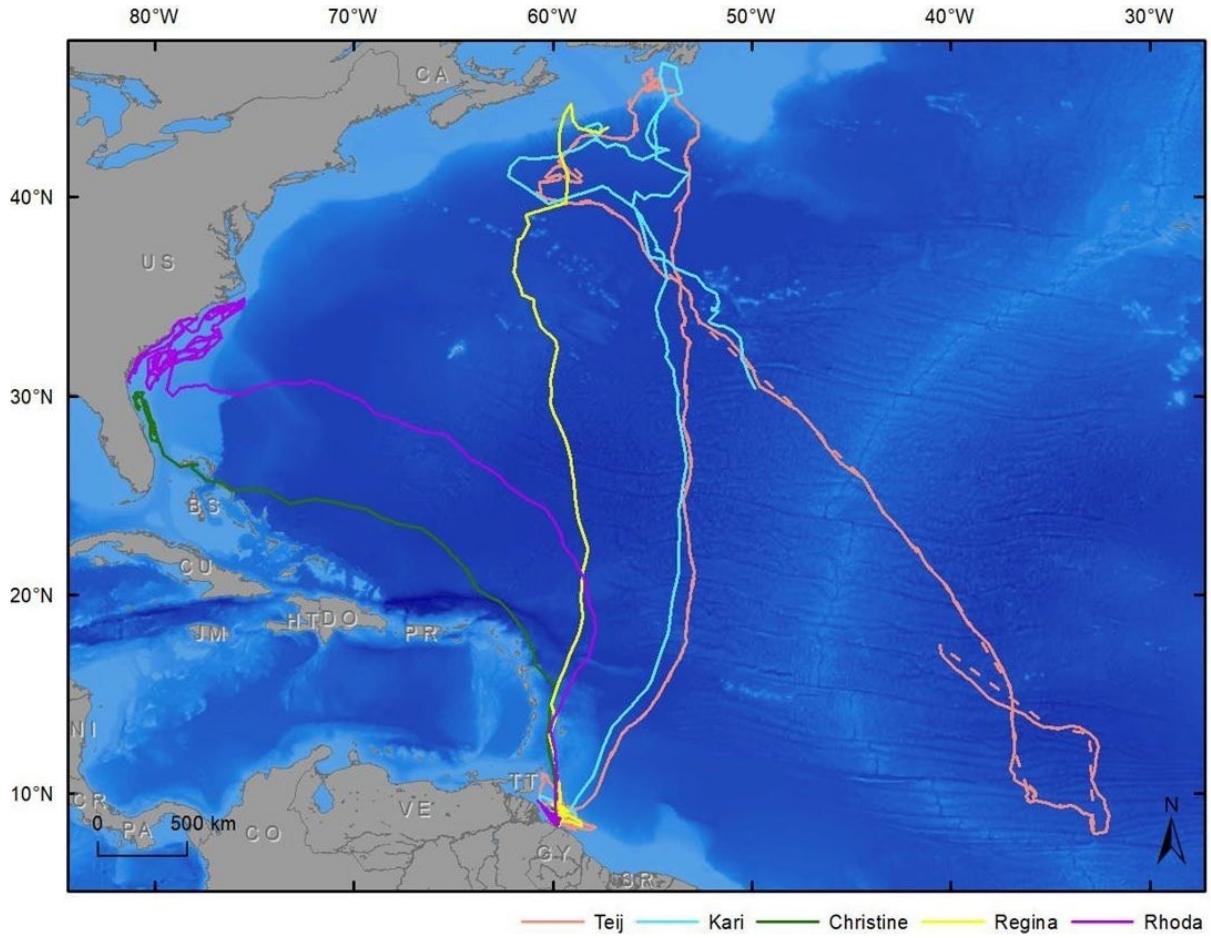


Figure 8.2-18: 2019 Migration Routes of Leatherback Turtles Tracked from Shell Beach

The other three leatherbacks (Teij, Kari, and Regina) headed due north to the offshore Canadian Maritime Provinces. Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have also been previously described as critical foraging habitat for leatherback turtles (James et al. 2005, 2006) and capture studies in this area have previously confirmed flipper tag recoveries from the Guianas (James et al. 2007). These three turtles displayed foraging behavior in this region near Placentia Bay, Newfoundland, and over abyssal depths (more than 3,000 meters) off of Nova Scotia. In some cases, they remained in these areas for prolonged periods, but in others they moved to other sites quickly, likely depending upon the availability of prey resources encountered. The leatherback turtles concentrated their foraging dives in the upper 30 meters of the water column.

The leatherbacks tended to dive deeper than the green turtles during their migration; however, similar to 2018, they remained in the upper 500 meters of the water column. Kari had the deepest recorded dive from the study, reaching a depth of 1,413.5 meters. Leatherbacks have been previously known to dive deeper than 1,000 meters. These dive depths are rare and the reasons unknown; however, three possibilities have been proposed: thermoregulation, predator avoidance, and scouting prey. Of these possibilities, the “prey scouting” theory has emerged as the most credible and assumes the turtles use these dives to locate concentrations of prey items and then return to the surface to wait for them to rise through the water column at night to consume at their leisure near the surface (Houghton et al. 2008). The leatherback turtles in the study recorded deeper water depths during foraging than during the inter-nesting period, and the turtles foraging in Canadian waters occupied deeper waters than the turtles that remained in the southeastern United States. The habitat use areas and distances from shore were similar between inter-nesting and foraging periods, but dispersal among sites was greater than during the inter-nesting period.

8.2.2.5. Marine Fish

Guyana's marine fish community inhabits a large and ecologically diverse marine area, from shallow, turbid, coastal waters to the deep, clear, open ocean. The life cycles of many of the fish species present in the community exemplify the ecological connectivity among the mangroves, estuaries, and offshore zones, because many fish species are dependent on different habitats at specific life stages or occur in more than one habitat type. Several species that occur in the inshore and offshore zones as adults are dependent on coastal mangroves and estuaries as juveniles, particularly drums, croakers, marine catfishes, and snappers. Catfishes occur in the mangroves, estuaries, and oceanic waters as adults. Some other species, including snooks and tarpon, may occur occasionally in the ocean, but are specifically adapted to completing their entire life cycles in mangrove-lined estuaries (MOA 2013). Farther offshore near the edge of the continental shelf the fish community is more complex, consisting of pelagic, highly migratory species such as tunas, jacks, and mackerels in the upper water column and a diverse groundfish community, including snappers and groupers, in the demersal zone (lowest section of the water column, near the seafloor) (MOA 2013). Sharks are found across the continental shelf and in deeper oceanic waters.

Prior to 2015, much of the available information about marine fishes offshore Guyana was known from studies of commercial landings, or inferred studies of similar locales. Beginning in 2015, EEPGL commissioned a program of collecting incidental observations of marine fish from PSOs engaged in marine mammal–focused surveys offshore Guyana. EEPGL subsequently commissioned a series of surveys targeted at fish in the Stabroek Block and in the area between the Stabroek Block and the Guyana coast from 2017 to 2019. These surveys were conducted in separate zones within this area by teams of international and Guyanese fish experts.

Deepwater and Offshore Pelagic Fish Community

Deepwater fish sampling points in the general vicinity of the Project's offshore pipeline alignment are depicted on Figure 8.2-19. Guyana's deepwater environment is comprised of a combination of highly migratory and demersal species. Deepwater species documented by EEPGL's studies offshore Guyana are summarized in Table 8.2-8.

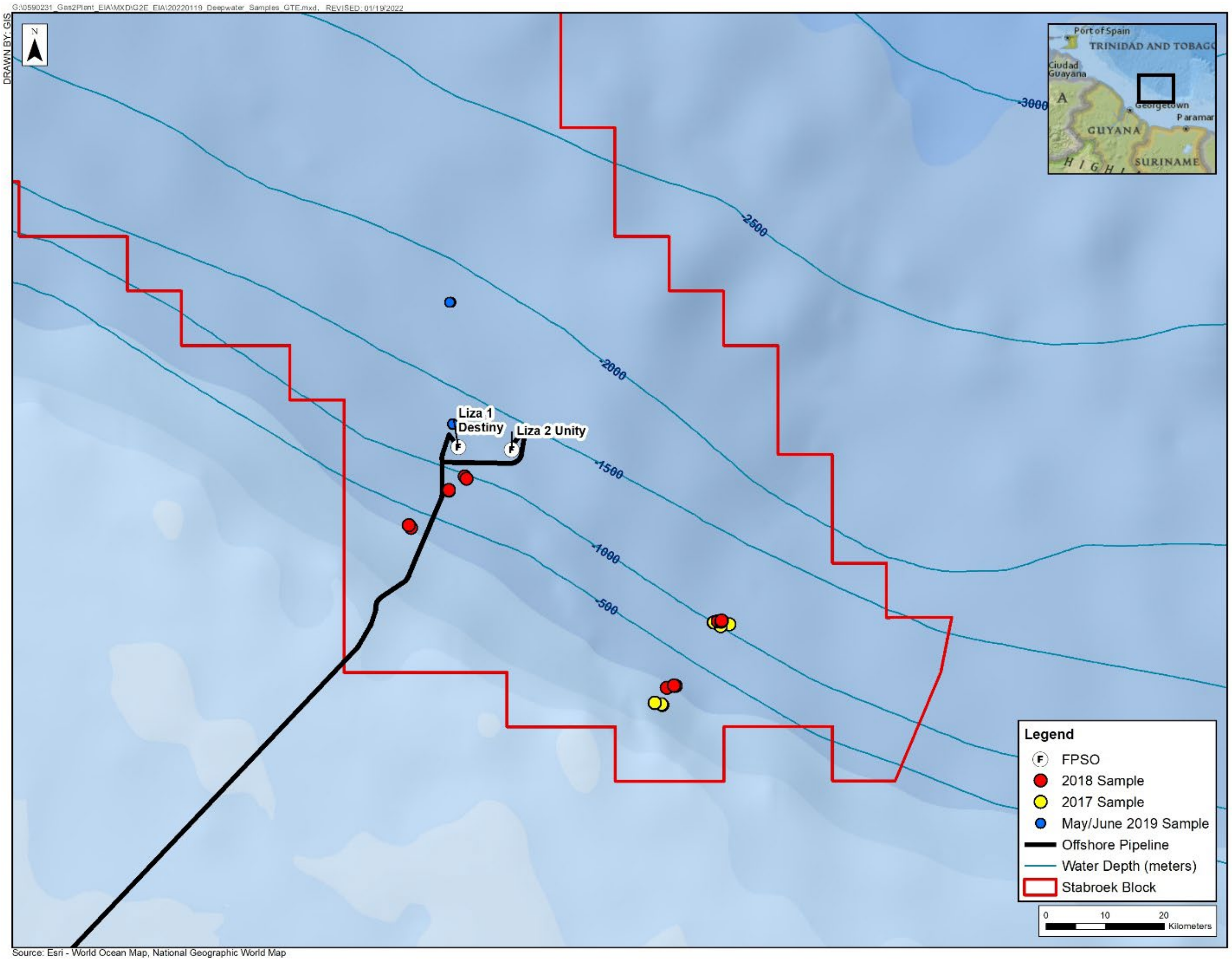


Figure 8.2-19: Location of Deepwater Fish Sampling Stations in Vicinity of Project Offshore Pipeline

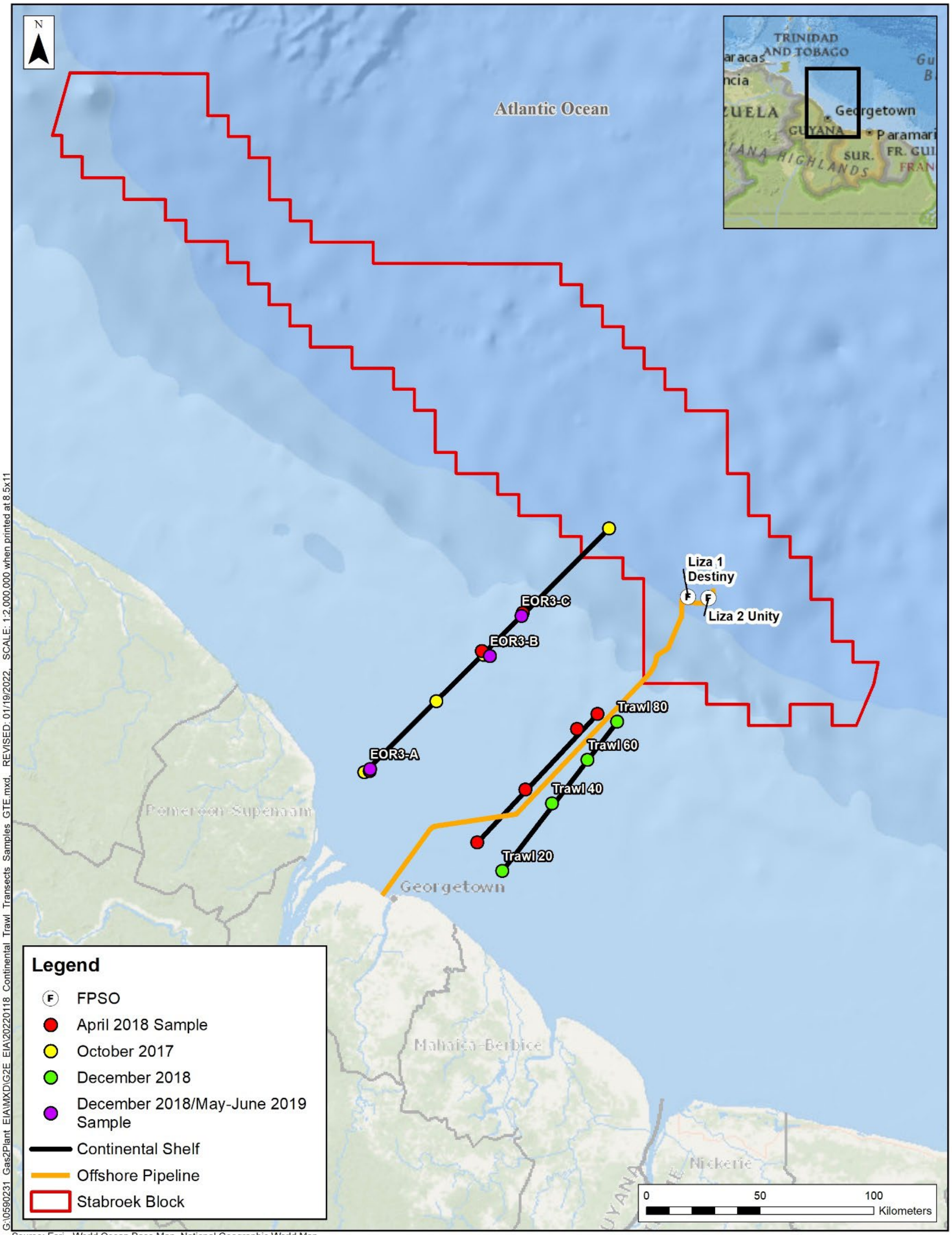
Table 8.2-8 Deepwater Fish Species Observed during EEPGL-Commissioned Studies

Common Name	Scientific Name
Atlantic bonito	*Sarda sarda*
Atlantic flying fish	*Chellopogon melanurus*
Atlantic tripletail	*Lobotes surinamensis*
Bar jack	*Caranx ruber*
Blackfin tuna	*Thunnus atlanticus*
Blackwing flying fish	*Hirundichthys rondeletii*
Blue marlin	*Makaira nigricans*
Clearwing flying fish	*Cypselurus comatus*
Eelpout	*Lycodonus* sp.
Four-wing flying fish	*Hirundichthys affinis*
Jack crevalle	*Caranx hippos*
King mackerel	*Scomberomorus cavalla*
Largehead hairtail	*Trichiurus lepturus*

Common Name	Scientific Name
Little tunny	*Euthynnus alletteratus*
Dolphinfish/mahi-mahi	*Coryphaena hippurus*
Manta ray	Mobula sp.
Margined flying fish	*Cheilopogon cyanopterus*
Ocean sunfish	*Mola mola*
Planehead filefish	*Stephanolepis hispidus*
Porcupinefish	*Diodon hystrix*
Rainbow runner	*Elagatis bipinnulata*
Sailfish	*Istiophrous albicans*
Skipjack tuna	*Katsuwonus pelamis*
Smalleye smoothhound	*Mustelus higmani*
Southern red snapper	*Lutjanus purpureus*
Swordfish	*Xiphiaa gladius*
Unidentified grenadiers	Macrouridae
Unidentified skates and rays	Rajiformes
Tiger shark	*Galeocerdo cuvier*
Tripodfish	Bathypterois sp.
Yellowfin tuna	*Thunnus albacares*
Robinson's hagfish	Myxine *c.f.* robinsorum
Sharp-tailed eel	*Coloconger meadi*
Unidentified lanternfish	Myctophidae

Continental Shelf Fish Community

The continental shelf was the most species-rich environment sampled during the EEPGL-commissioned marine fish assessment (compared to nearshore and deepwater environments), accounting for 109 fish species in the first study year, and 92 species in the second study year. The continental shelf component of the fish assessment incorporated the entire Guyana continental shelf, but the locations of the survey transects closest to the Project's offshore pipeline alignment are depicted on Figure 8.2-20.



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Source: Esri - World Ocean Base Map, National Geographic World Map

Figure 8.2-20: Locations of Continental Shelf Fish Sampling Stations in Vicinity of Project Offshore Pipeline

Historical fishery-dependent trawl data (Lowe-McConnell 1962) and EEPGL's own study suggest that catfishes, drums, jacks, and grunts dominate the nearshore zone; in contrast, snappers and various other demersal species, including some that are typical of clear water tropical reef systems, are more abundant at deeper sites farther offshore. Based on the EEPGL-commissioned studies, the most diverse groups across the continental shelf consisted of:

- Sea catfishes, including gillbacker catfish (*Sciades parkeri*), curass (*Sciades proops*), highwaterman catfish (*Hypophthalmus edentatus*);
- Croakers/seatrouts, including bangamary (*Macrodon ancylodon*), white bashaw (*Cynoscion acoupa*), sea trout (*Cynoscion virescens*); and
- Snappers and grunts, represented chiefly by banded grunt (*Conodon nobilis*), Caesar grunt (*Haemulon carbonarium*), mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), and southern red snapper (Figure 8.2-21).

highwaterman catfish (*Hypophthalmus edentatus*)

gillbacker catfish (*Sciades parkeri*)

lane snapper (*Lutjanus synagris*)

curass (*Sciades proops*)

bangamary (*Macrodon ancylodon*)

mutton snapper (*Lutjanus analis*)

sea trout (*Cynoscion virescens*)

southern red snapper (*Lutjanus purpureus*)

luna lionfish (*Pterois lunulata*)

Figure 8.2-21 Characteristic Fishes from Guyana's Continental Shelf

Although biomass and species composition in the continental shelf samples varied between the first and second study years, seasonal and spatial distribution of fish species diversity on the continental shelf were remarkably consistent between years. The mid- to outer-shelf stations produced the highest number of species in both seasons in both study years, indicating that despite seasonal increases in nearshore diversity in the wet season, the highest fish diversity is consistently found on the mid- to outer-continental shelf. Visual observations made by the field team during the second study year indicate that the portion of the continental shelf from 60 to 100 kilometers offshore is an area of transition from the mixture of "blackwater"[7] and highly turbid silt-laden water nearshore to clearer waters more characteristic of offshore conditions, an observation supported by the turbidity data collected from the continental shelf stations.

Based on comparisons with species lists from nearby countries, Lowe-McConnell (1962) determined that about 50 percent of Guyana's marine fish species were widely distributed coastal species, about 10 percent were clear-water associated species more typical of the Caribbean Islands, about 5 percent were more southerly species typical of the Brazilian coast, and the balance were habitat generalists with no defined regional habitat associations. Lowe-McConnell also noted that the North Atlantic Continental Shelf is continuous from the Gulf of Mexico to Brazil and that there were no major barriers to migration through this area, so Guyana's marine fish community would be expected to have many species in common with other countries in the region. This finding is consistent with the findings of the EEPGL-commissioned continental shelf fish surveys in both study years.

The EEPGL study also documented the exotic luna lionfish (*Pterois lunulata*) and red lionfish (*Pterois volitans*) in the same depth range as the corals and reef-associated native species (Figure 8.2-21). The presence of invasive lionfish in the tropical western Atlantic Ocean has been a topic of conservation concern for more than three decades since they first appeared in southern Florida (FWC 2018) and began threatening native fishes and commercial ground-fisheries (NOAA 2020). The presence of luna lionfish and red lionfish offshore Guyana and the apparently coincident decline of coral-associated fishes offshore may indicate that the invasion is having an effect on Guyana's native fishes.

Pelagic sampling of the continental shelf during the 2017–2018 fish study also documented the importance of the continental shelf as a nursery area for sharks (Figure 8.2-22). Spinner shark (*Carcharinus brevipinna*) comprised a significant component of the longline samples during the wet and dry seasons. Spinner sharks accounted for nearly 20 percent of the total abundance in the 2017 longline samples from the continental shelf, second only to the spearfish remora (*Remora brachyptera)*, which are often associated with sharks and other large pelagic marine animals. No spinner sharks were positively identified in the 2018 samples, but juvenile *Carcharinus* that were too small to identify comprised 50 percent of the total longline catch on

[7]The clarity of water flowing out of Guyana's rivers onto the continental shelf is limited by two types of influences. The first is so-called "blackwater" contributions, which come from swamps and other wetlands that characteristically have deep accumulations of organic debris. Water flowing from these areas has a very dark color and low light transmissivity because of the high tannin content, but typically has very low suspended solids. The second type has no colloquial name in Guyana, but consists of non-tannic runoff from coastal tributary streams. In the estuaries and nearshore marine environments where both of these types of water mix with oceanic water, water clarity is typically low.

the continental shelf in 2018, possibly indicating a seasonal component to the value of the area as nursery habitat for the species. Sharks occurred in the second-year catches from the continental shelf, but were not as common as in the first year. Although the sharks in the study were identified in the field as spinner sharks, field identification of *Carcharinus* species (especially of immature specimens) can be very difficult. A recent genetic study of sharks in Guyanese fish markets did not document spinner sharks, but did identify the very similar smalltail shark (*C. porous)* and blacktip shark (*C. limbatus)*, which together comprised over 25 percent all samples in the study (Kolman et al. 2017); accordingly, the identification of the sharks in the 2017–2018 fish study should be viewed as provisional.

Regardless of the species, the presence of large numbers of immature *Carcharinus* sharks is significant both in terms of the ecology of the area—as sharks are apex predators on the continental shelf—and in terms of fishery management. Sharks are a target species for the demersal longline (locally referred to as Cadell lines) fishery, and shark stocks are well-known to be highly sensitive to fishing pressure due to their low reproductive success rates and long generation times. There are no official management plans or quotas in place for the Guyanese shark fishery, so the fishery may be susceptible to over-exploitation, particularly if large numbers of juveniles are being removed from the population before having the opportunity to reproduce.

Figure 8.2-22: Juvenile *Carcharinus* Sharks from Guyana's Continental Shelf, March 2018

Nearshore Fish Community

The discussion of nearshore fish community data is derived from sampling conducted across all of the wet- and dry-season sampling dates identified above (i.e., September–October 2017, April 2018, January 2019, and May–June 2019). These nearshore surveys (Figure 8.2-23) sampled coastal fish communities in Regions 1 through 5. The nearshore fish community was the second-most diverse marine zone sampled during the EEPGL-commissioned marine fish study (behind the continental shelf), accounting for 79 fish species.

A total of 48 different species were captured during the nearshore fish assessment in the first year of the EEPGL-commissioned marine fish study. Twenty-five species were captured during the dry season, and the two most common species (bangamary and highwaterman catfish) were also common on the inner continental shelf during this period, underscoring the importance of marine influence near shore during periods of low riverine discharge. The nearshore community shifts to a more freshwater/brackish community in the wet season; in fact, eight of the nine species captured in the 2018 wet season estuarine surveys also appeared in the wet season nearshore dataset. Most of the species captured in the nearshore zone during the wet season (April 2018) were anadromous or euryhaline species.

The wet season nearshore samples yielded 46 species. The January 2019 nearshore data included 29 species (54 percent of all species collected in that survey) that had not been collected at the nearshore stations in 2017 or 2018. Seven of these species were anchovies in the genera *Anchovia*, *Anchoviella*, *Lycengraulis*, and *Pseudenbatos*. Despite belonging to the same family (Engraulidae), this group exhibits a wide range of habitat requirements and life histories. Their coincident presence suggests that conditions in the nearshore zone in January 2019 were temporarily supportive of species from both the wet-season and dry-season communities.

Sixty-two species were captured at the nearshore stations during the second study year. Thirty-four of these species were captured in both seasons. The most common species observed at the nearshore stations were white spring cariss (*Cathorops melanopus*), rockhead (*Stellifer microps*), highwaterman catfish, parassi mullet (*Mugil incilis*), and Pemecou sea catfish (*Sciades herzbergii*). Nearshore catches consisted primarily of catfish, which were found in salinities from 3.5 to 34 parts per thousand (ppt). The extreme variability in salinities at the nearshore stations is attributed to substantial freshwater inputs from rivers, which explains the dominance of estuarine species in all nearshore samples (including those located several kilometers away from river mouths) and the presence of freshwater species in some low salinity areas along the coast. Most of the species captured during the wet season were anadromous species that had presumably entered the coastal area from the sea in response to increased freshwater discharge to the coastal zone, or euryhaline species that entered the study area from farther up the rivers.

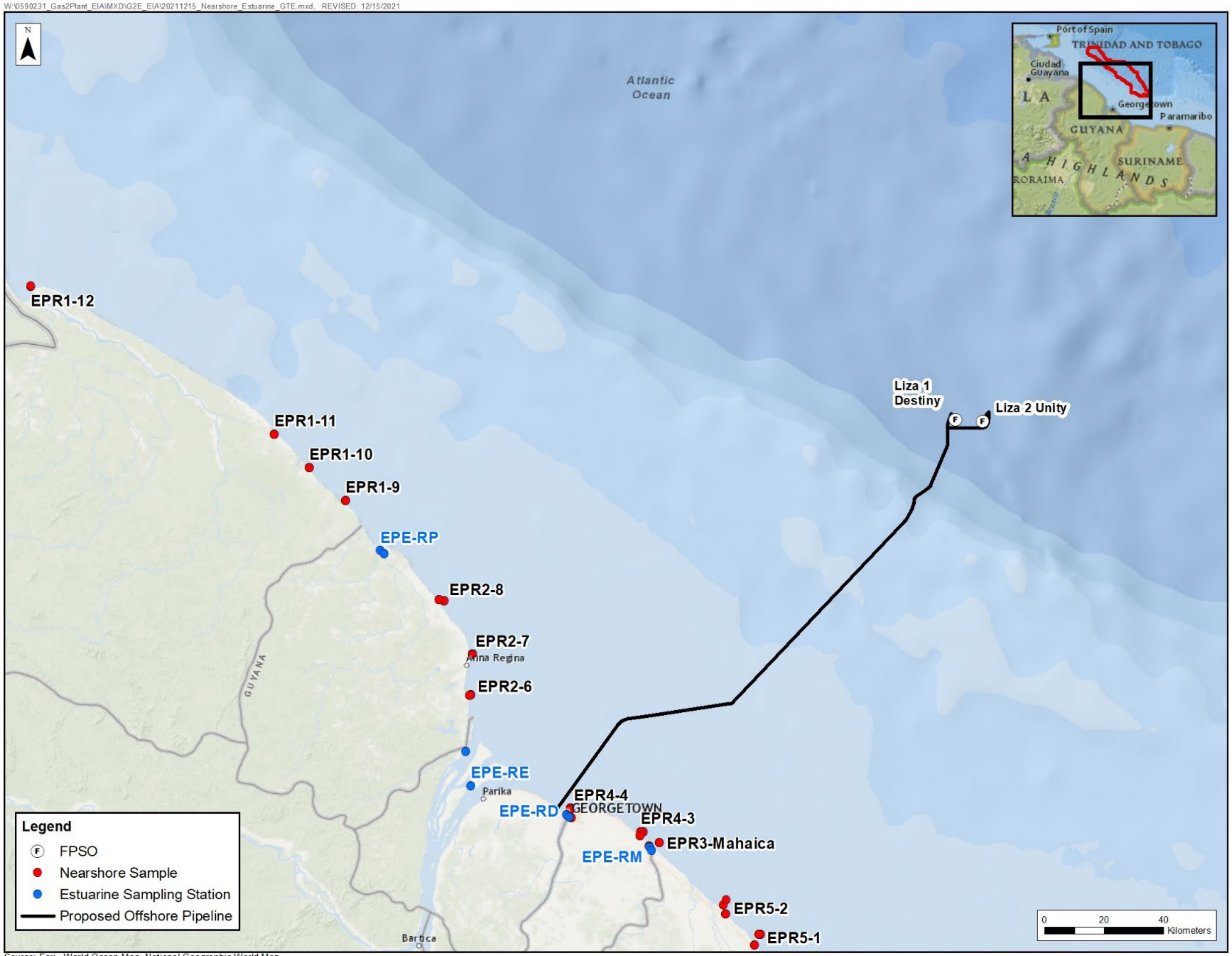


Figure 8.2-23: Nearshore and Estuarine Fish Sampling Stations during the First and Second Year of EEPGL-Commissioned Marine Fish Study

Region 2 had the most diverse fish community in both years and in both seasons in the second study year, which illustrates the importance of the Essequibo River's freshwater inputs in shaping the nearshore fish community. Although freshwater inputs clearly influence fish distribution, proximity to rivers is not the only factor that influences nearshore fish diversity. A few nearshore stations in close proximity to river mouths had lower than average species diversity. This phenomenon was exemplified at station EPR2-6. No fish were captured at this station during the wet season in the second study year, when freshwater influence was presumably near its annual peak. It is possible that a moderate amount of freshwater increases fish diversity, but that above a certain threshold, diversity begins to decrease as large numbers of marine species are excluded.

Estuarine Fish Community

The discussion of estuarine fish community data is derived from sampling conducted across all of the wet- and dry-season sampling dates (i.e., September–October 2017, April 2018, January 2019, and May–June 2019). These estuarine surveys (Figure 8.2-23) sampled coastal fish communities in Regions 1 through 5. Eight species were captured at the estuarine stations in the first year of the EEPGL-commissioned study. Catches were dominated by white basha (*Plagioscion* sp.) and white puffer (*Colomesus psitacus*). Twenty-one species were captured at the estuarine/riverine stations during the second study year. Parassi mullet, rockhead, Zabaleta anchovy (*Anchovia clupeoides*), and false herring (*Harengula clupeola*) were the most common species collected at the estuarine stations during the second study year. The stations with the highest catches of juvenile fish in both years were near riparian vegetation such as aquatic plants, grass, submerged palm trees, and plants of small size with abundant foliage. Smaller catches were associated with areas among mangrove roots. The abundance of Leptocephali (a larval form that is unique to elopomorphic fish, primarily the marine and diadromous eels) in the estuarine samples points to the value of the estuaries as nursery areas. A noteworthy aspect of the estuarine surveys was the prevalence of leptocephalus[8] larvae in the first-year samples. The larvae were not identified to species, but they comprised more than 30 percent of the entire catch across the five estuarine stations and were the most common species in the wet season (April) estuarine dataset in 2018. Tarpon and ladyfish are both nearshore marine/estuarine species, but the leptocephali could also have been the larvae of a marine eel, such as a moray. Regardless of the species, their ubiquity and abundance in the estuarine stations underscores the importance of the estuaries as fish nursery habitats.

8.2.2.6. Marine Benthos

The marine benthic biological resources of Guyana have not been extensively studied, but the coastal and nearshore areas of Guyana do not support the matrix of shallow coral reefs and seagrass meadows often considered emblematic of coastal, tropical Atlantic environments elsewhere in the world. This is because of the area's highly turbid conditions, which do not

[8] A leptocephalus is a slim, transparent larval form of eels and other more distantly related species including tarpon (*Megalops atlanticus*), known as "cuffum" in Guyana, and ladyfish (*Elops saurus*), known as "silverfish" in Guyana.

support the growth of warm water corals that rely on symbiotic photosynthetic algae for nourishment.

Environmental Baseline Survey Data

EEPGL conducted environmental baseline surveys (EBSs) in 2017, 2018, 2019, 2020, and 2021 to characterize the marine benthic environment. These EBSs emphasized water and sediment sampling, but also included benthic biological components because benthic infauna (macrofauna) communities are useful indicators of environmental health due to their relative sensitivity to changes in sediment, physical, and chemical conditions. This section draws on information provided in the scientific literature, maps, AUV photographs, and field data collected by box coring and sediment profile imaging during the EBSs in the nearshore, shallow-water, and continental shelf environments (Figure 8.2-24). Additionally, observations of incidental catch of corals during other biological surveys of shallow-water areas are also discussed.

Shallow Environmental Baseline Survey Data

The 2021 EBS (EAME 2021) describes benthic infauna analysis of 15 samples collected over water depths ranging from 1.4 to 18.2 meters along the Project's offshore pipeline route. A total of ten specimens in seven taxa were observed from the 2021 benthic samples (Table 8.2-9). Several factors, including extensive sedimentation from surrounding river systems, absence of coarser sand and gravel, persistent mixing from wind and river, and a high total suspended solid load, are likely major contributors to the observations of low total abundance and reduced taxa richness and diversity observed in each of the 2021 benthic samples. The substrate matrices for each of the 2021 samples were characterized as soft, silty clay (fines with diameters less than 0.063 millimeters), with no visible differences in overall sample composition. These findings suggest a nearshore surficial sediment environment that is relatively homogenous and limiting to colonization by benthic infauna.

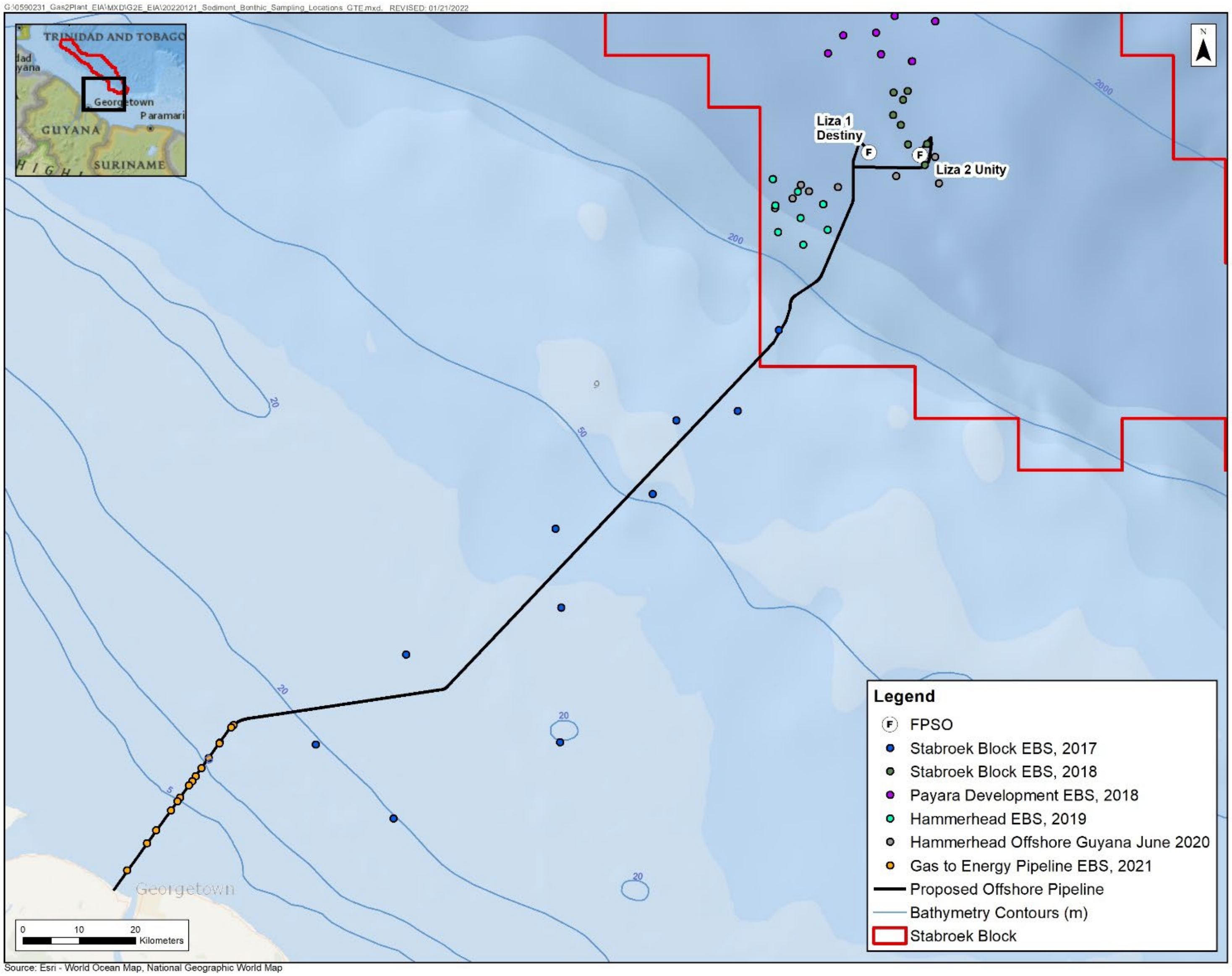


Figure 8.2-24: Survey Locations Sampled in EBSs Conducted from 2014 to 2021 in or near the Offshore Project AOI

Table 8.2-9: Number of Specimens Identified in 2021 Nearshore Benthic Samples, by Family

Taxon (Family Level)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	SUM
Ampeliscidae								3								3
Ampharetidae			1													1
Amphiuridae	1															1
Acoetidae		1														1
Nuculidae							1						1			2
Onuphidae							1									1
Ophiolepididae						1										1
Total Per Station	**1**	**1**	**1**	**0**	**0**	**1**	**2**	**3**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**10**

Phylum	Class	Order	Family (Taxa)	Abundance	% Abundance (Phylum)	% Abundance (Taxa)
Annelida	Polychaeta	Eunicida	Onuphidae	1	3 (30%)	3 (43%)
		Phyllodocida	Acoetidae	1		
		Terebellida	Ampharetidae	1		
Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	3	3 (30%)	1 (14%)
Echinodermata	Ophiuroidea	Amphilepidida	Amphiuridae	1	2 (20%)	2 (28%)
			Ophiolepididae	1		
Mollusca	Bivalvia	Nuculida	Nuculidae	2	2 (20%)	1 (14%)

Source: EAME 2021

The benthic macrofaunal analysis in the 2017 EBS is representative of most of the continental shelf portion of the Project AOI, extending across water depths of approximately 20 to 150 meters (Figure 8.2-24). The 2017 EBS indicated that the benthic community along the continental shelf was diverse in species composition and abundance at the time of sampling, but abundance was much higher generally than in the 2021 EBS samples. A total of 4,101 specimens belonging to 133 taxa (family) were found within 30 samples in the 2017 EBS, with an average of 136.7± 223.09 specimens and 20.4 ± 9.05 taxa per 0.1 m^2 grab sample. Abundance per station ranged from 45 to 1,353 specimens per sample. An arthropod belonging to the family Chevaliidae was the most abundant organism, accounting for 54.8 percent (2,247) of all specimens detected. Data analysis showed low similarity in faunal distributions among stations, but that abiotic factors such as depth and grain size were not significantly correlated to these biological differences. The differences between the 2017 and 2021 EBS results are likely attributable to the different habitats covered by the two surveys. The 2021 survey took place in shallow water where wave energy reaches to or near the seafloor, exacerbating naturally high turbidity and creating an essentially constant state of disturbance along the seafloor. The 2017 EBS was conducted in comparatively deeper, clearer, and more hydrodynamically stable habitat. These differences are consistent with a more robust and diverse benthic community in the 2017 samples as compared to the 2021 samples.

Deep Environmental Baseline Survey Data

Additional EBSs were conducted in 2018, 2019, and 2020 in the Stabroek Block and are representative of the deepest and most northern extent of the Project AOI (Figure 8.2-24). Of the environmental parameters assessed, there were no strong correlations between any parameter and macrofaunal communities. Sediment samples for benthic macrofauna community analysis were collected from the Payara and Liza fields during two separate surveys in 2018, the Hammerhead field during the 2019 survey, and the Hammerhead field again during the 2021 survey. The study areas for these surveys were located around and between the Liza Destiny and Liza Unity FPSO locations, effectively covering the deepwater portion of the Project AOI. The 2018 EBS in the Payara field documented a total of 59 taxa (the data were rationalized to account for juveniles, pelagic, colonial, or damaged individuals), with annelids (51 percent) being the most prevalent, followed by arthropods (30.3 percent), mollusks (9 percent), echinoderms (2.6 percent), and other taxa (7.1 percent) (Fugro 2019a). The macrofaunal abundances surveyed in 2018 in the Payara area of the Stabroek Block are considered low. The faunal community within the survey area was found to be relatively diverse and non-dominated, with a large number of taxa occurring in relatively low abundances. Moderate to high variability was demonstrated across the survey area, with polychaete worms and arthropods the most numerous taxa recorded (Fugro 2019a). One arthropod individually recorded and classified as *Aspidoniscus* sp. A, as well as three arthropod individuals recorded and classified as *Heteromesus*, are considered likely to be new records of these species (Fugro 2019a). The second 2018 EBS was in the Liza field. It documented 76 distinct taxa. Nearly all of these taxa were typical of slope habitats over wide geographic ranges of the global ocean. Twenty-two of the 76 taxa identified comprised 75 percent of total abundance. Thirteen of these were polychaete worms from families common to slope sediments, six were crustaceans, and the rest were sipunculids, oligochaetes, or nematodes. No taxa identified at the species or genus level exceeded 5 percent of total abundance, indicating evenness in the species distribution (Maxon Consulting et al. 2019).

The most recent EBS studies from the Stabroek Block were conducted in 2019 and 2020 across the southeastern portion of the Stabroek Block in the Hammerhead field. Samples collected in the Hammerhead 2019 survey documented moderately diverse communities with overall low mean abundances. Arthropods and annelids were the most numerous taxa recorded. The number of individuals per 0.2 m^2 ranged from 27 to 77. In total, 477 individual animals and 140 benthic taxa were collected, of which 57 (40.7 percent) were arthropods, 46 (32.9 percent) were annelids, 26 (18.6 percent) were mollusks, 5 (3.6 percent) were echinoderms and 6 (4.3 percent) were other phyla, specifically sea anemones, ribbon worms, and peanut worms. Statistical analysis of these data demonstrated moderately higher to higher variability across the survey stations, as compared to prior EBS surveys, likely a result of high numbers of taxa and low numbers of individuals across samples. No correlations were observed between the macrofaunal community and the physico-chemical parameters sampled across the Hammerhead survey area.

The Hammerhead field was sampled again in 2020. These samples produced a total of 204 individuals across 37 total taxa from eight phyla. The overall infauna density ranged from 98 to 359.2 individuals per square meter, with a mean density of 208.2 ± 79.3 individuals per square meter. Annelids comprised the majority of sampled organisms (60.3 percent), followed by arthropods (19.6 percent) and nematodes (17.2 percent). Annelids were also the most abundant infaunal taxon (24) followed by arthropods (6), and echinoderms (2). The phyla Sipunculida, Nematoda, Nemertea, Mollusca, and Chordata were each represented by a single taxon. Community-wide measures of density and abundance were generally low when compared with other deep-sea areas in similar water depths (Grassle and Maciolek 1992; Oliver et al. 2011).

Incidental Observations

Two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) are known to occur on Guyana's continental shelf. Both species were documented on the shallow continental shelf (at depths of 40 to 90 meters) based on fragments of live coral found at several locations during the 2017–2018 EEPGL-commissioned (Year 1) Marine Fish Study (Figure 8.2-25). Additionally, during the Year 2 Marine Fish Study, the sampling team reported the presence of live fragments of *M. oculata* and *S. variabilis* in some of the trawl samples on the outer continental shelf, providing further documentation of living corals on Guyana's continental shelf.

It is unknown whether the corals represent the remnant of a long-established population or a nascent recovery. Many cold-water corals construct reefs that support highly diverse invertebrate and fish fauna (NOAA 2014). Both *M. oculata* and *S. variabilis* are technically considered reef-building corals, but *M. oculata* is particularly fragile and does not often form deepwater reefs. It more frequently occurs as a commensal[9] species living within or on reefs that were originally constructed by more robust species such as *S. variabilis*. In 2019, Fugro published an investigation of so-called *hard seafloor features* in the south-central Stabroek Block which identified a single occurrence of the black coral *Bathypathes* sp. (Fugro 2019b).

[9] Living in close association, such that one species benefits without harming the other

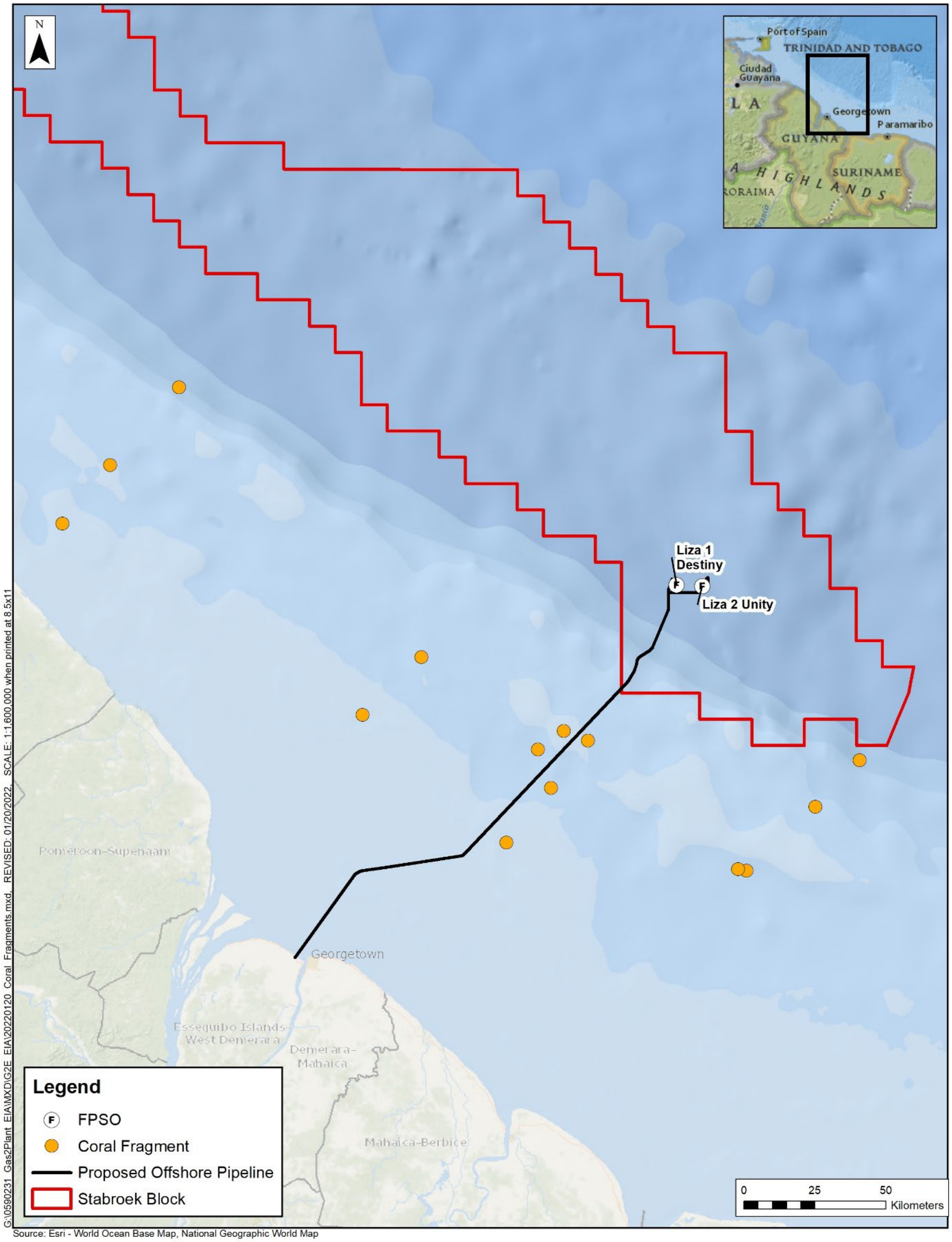


Figure 8.2-25: Locations Where Live Coral Fragments Were Found on the Continental Shelf during 2017–2019 Marine Fish Surveys

8.2.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned Project activities on marine and coastal biodiversity. The relevant planned Project activities and the associated potential impacts of these activities on marine and coastal biodiversity are identified and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

8.2.3.1. Relevant Project Activities and Potential Impacts

The planned Project activities that could affect components of marine and coastal biodiversity in the Project AOI are described under the three Project stages of Construction, Operations, and Decommissioning. Specific activities associated with each of these stages that could potentially impact marine and coastal biodiversity are identified and assessed at the resource-specific level. Table 8.2-10 summarizes the planned Project activities that could result in potential impacts on marine and coastal biodiversity.

Table 8.2-10: Summary of Relevant Project Activities and Key Potential Impacts—Marine and Coastal Biodiversity

Stage	Project Activity	Key Potential Impacts
Construction	• Installation of the offshore pipeline • Ballast water exchanges • Discharges from installation and support vessels • Hydrostatic testing	• Temporary disturbance of marine benthic habitat from pipeline installation • Mortality and injury of benthic organisms from pipeline installation • Entrainment of marine organisms in ballast water intakes • Disturbance of marine mammals and fish and other marine organisms due to increased noise from installation activities • Temporary impacts from degraded water quality from installation activities • Temporary impacts from degraded water quality from vessel discharges • Decreased water quality from hydrostatic test water discharge
Operations	None	None
Decommissioning	• Ballast water exchanges • Discharges from decommissioning and support vessels	• Disturbance of fish and other marine organisms due to increased noise from operation of decommissioning vessels • Temporary impacts from degraded water quality from vessel discharges

8.2.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity) and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for marine and coastal biodiversity (Table 8.2-11). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for marine and coastal biodiversity sensitivity are provided in Table 8.2-12.

Each of the following Project activities are considered in the assessment of the significance of potential impacts on marine and coastal biodiversity:

- Installation of the offshore pipeline
- Ballast water exchanges
- Discharges from installation and support vessels
- Discharges from decommissioning and support vessels
- Underwater noise generated from Project vessels
- Hydrostatic testing

Table 8.2-11: Definitions for Intensity Ratings for Potential Impacts on Marine and Coastal Biodiversity

Criterion	Definition
Intensity	**Negligible**: No measurable ecosystem-level changes; the ecosystem continues to function as it did prior to the Project activities occurring.
	Low: Changes are perceptible but affect only a small number of species within the ecosystem, and only at one trophic level, and/or across a limited spatial area.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level, and/or across a significant portion of the area that an ecosystem physically occupies.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are substantially altered.

Table 8.2-12: Definitions for Resource Sensitivity Ratings for Potential Impacts on Freshwater Biodiversity

Criterion	Definition
Sensitivity	**Low**: Habitat integrity and function and species assemblage is highly modified and/or is capable of withstanding disturbance (physical and chemical) and degradation without reaching an irreversible ecological threshold (i.e., are highly resilient). In the context of the sensitivity rating, resilience may derive from a variety of conditions including, but not limited to, high regenerative and/or assimilative capacity. Rare or disturbance-sensitive species are absent or uncommon. Community is dominated by non-native and/or habitat generalist species.
	Medium: Habitat integrity and function and species assemblage is modified and is moderately resilient to disturbance and degradation. In the context of the sensitivity rating, resilience may derive from a variety of conditions including, but not limited to, moderate

Criterion	Definition
	regenerative and/or assimilative capacity. Rare or disturbance-sensitive species may be present but are not dominant.
	High: Habitat integrity and function and species assemblage is natural (i.e., minimal anthropogenic disturbance and high biodiversity value/function) and has low resilience to disturbance and degradation. Community is dominated by native and/or habitat specialist species and contains important habitat for or populations of rare species.

8.2.3.3. Impact Magnitude Ratings—Marine and Coastal Biodiversity

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to marine and coastal biodiversity is provided in Table 8.2-13.

Marine Habitat

Loss and Disturbance of Marine Benthic Habitat from Offshore Pipeline Installation

Offshore pipeline installation activities will either remove natural habitat or disturb habitat by changing the bathymetric contours and the physical characteristics of the seafloor. Three different types of installation techniques—direct lay, jetting, and trenching—may be used in the deep, intermediate, and shallow segments of the offshore pipeline, respectively. These activities will remove natural benthic habitat (in sections of the pipeline that are laid directly on the sea floor), and disturb natural benthic habitat in areas where installation activities alter the biophysical characteristics of the marine sediments that serve as habitat to marine taxa living on or within the seafloor.

The outer diameter of the marine pipeline will be 0.323 meters, and the pipeline may be laid directly on the seafloor across a maximum of 205 kilometers of seafloor (depending on whether the intermediate pipeline segments are laid directly on the seafloor or jetted and whether the shallow segments are pulled across the seafloor or bored). Conservatively assuming that all 205 kilometers of pipeline in the shallow, intermediate, and deep sections are laid directly on the seafloor, the maximum amount of benthic habitat lost within the footprint of the pipeline will be 6.62 hectares.

In terms of habitat disturbance, the main disturbance mechanism outside of the footprint of the pipeline will be deposition of re-suspended sediment displaced from the trench during installation. As described in Section 7.3.3, Impact Prediction and Assessment (Sediments), biologically relevant thresholds for significance of impacts from sediment deposition vary by species and sediment impermeability. A suggested threshold of 6.5 millimeters has been reported (Smit et al. 2006); this is representative of instantaneous burials adversely affecting 5 percent of the studied benthic species (i.e., the more sensitive members of the population). As predicted by hydrodynamic modeling, the maximum distance from the pipeline that will be affected by sediment deposition above the 6.5-millimeter thickness is approximately 38 meters. Conservatively assuming that the entire shallow and intermediate sections of pipeline (164 kilometers) will cause sediment accumulation in excess of the 6.5 millimeters to a distance of 38 meters from the pipeline, an additional 623 hectares of benthic habitat will be temporarily disturbed during construction of the offshore pipeline.

Based on the analysis presented above, a total amount of approximately 629 hectares of benthic habitat will be either lost or temporarily impacted by installation of the marine pipeline. This total conservatively assumes that the 130 kilometers of pipeline in the intermediate depth zone will be buried. It also assumes that the 6.5-millimeter depositional threshold will be exceeded to the full 38 meter distance from the pipeline continuously in every portion of the pipeline that could potentially be buried, when hydrodynamic modeling suggests that most areas affected by sediment deposition would be narrower than 38 meters. This approach significantly overestimates the potential impacts that will likely occur, but is appropriate given the uncertainty concerning the techniques that will be used to install this portion of the offshore pipeline.

The conservative estimate of 629 hectares of total benthic habitat loss and disturbance corresponds approximately to the full extent of the Direct AOI for the offshore pipeline and represents less than 1 percent of the total benthic habitat within the portion of the Guyana EEZ between the Stabroek Block and the coast. Installation activities will affect numerous benthic species at different trophic levels but will not substantially alter the basic trophic and biodiversity attributes of the benthic ecosystem on Guyana's continental shelf. Therefore the intensity of the habitat loss and disturbance associated with offshore pipeline installation is rated as **Medium**. While there will be periods during installation when sediment disturbance and deposition will not occur, the impact will be present throughout the Construction stage, yielding a **Continuous** frequency rating. The impacts will persist for less than a year in aggregate, so the duration of this impact is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on benthic habitat is considered **Medium**.

Temporary Impacts from Degraded Water Quality from Seafloor Disturbance during Offshore Pipeline Installation Activities

The Project is not expected to have permanent impacts on marine biota from degraded marine water quality. Temporary impacts on marine biota from degraded water quality stemming from disturbance of the seafloor will be limited to the Construction stage and will only directly affect marine fish and marine benthos. These impacts will derive from increased turbidity from the disturbance of the seafloor and potential exposure to contaminants, if any, in suspended sediment.

Marine fish and marine benthos respire in the water rather than in the air, so elevated turbidity levels can foul their gills and cause respiratory distress. Turbidity plumes are expected to dissipate rapidly downcurrent of the disturbance area, and fish are expected to temporarily vacate the immediate vicinity of activities at the seafloor until turbidity reaches acceptable levels. This behavioral response will limit fishes' exposure to turbidity, and fish are expected to return to the vicinity of the Project's subsea infrastructure once seafloor disturbance activities are complete. Benthos may experience higher levels of distress and potentially experience mortality from elevated turbidity in the immediate vicinity of the installation activities because of their comparative lack of mobility relative to fish.

Marine benthos and some fish live at or near the marine seafloor, so they may also be exposed to any contaminants that may occur in sediments that are resuspended during the installation process. As described in Section 7.3.2, Existing Conditions and Baseline Conditions (Sediments), the average (mean) concentrations of two anthropogenic indicator metals (arsenic and nickel) exceeded the U.S. National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (ERL) values (NOAA 2019) and the mean background continental crust values in several of the EBSs conducted within the Project AOI over the past several years (ESL 2018a; ESL 2018b; Fugro 2016; Fugro 2019a; Fugro 2019b; Fugro GB Marine Ltd 2019), including in the most recent EBS conducted in the shallow portion of the offshore pipeline corridor in 2021 (see Appendix F, Environmental Baseline Survey). Exposure to elevated levels of metals in sediments can lead to a variety of genetic, metabolic, and behavioral impacts in marine benthos (Watson et al. 2021) and developmental and metabolic impacts in fish (Sfakianakis et al. 2015; Pandey et al. 2008). The ERL is a screening level threshold. As such, the ERL does not represent a threshold above which exposure to sediments would necessarily be harmful. The ERL represents the lower end of the range at which impacts may be observed based on numerous variables such as other water quality factors, duration and mechanism of exposure, chemical state of the contaminant at the time of exposure, etc. Nevertheless, the presence of contaminants in the water column represent a potential risk to marine fish and marine benthos. This risk would be limited to the Direct AOI, so the intensity of degraded water quality-related impacts on marine benthos and marine fish is rated **Low**. These impacts will occur on a **Continuous** basis during installation of the marine pipeline. These impacts will persist for less than a year in aggregate, so the duration is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on marine and coastal biodiversity from offshore pipeline installation activities is considered **Small.**

To the extent that marine mammals, marine turtles, and marine birds will be indirectly impacts by a temporary loss or decrease in forage availability due to these impacts, the intensity of these impacts will be **Negligible**. These impacts will occur on a **Continuous** basis during installation of the offshore pipeline. These impacts will persist for less than a year in aggregate, so the duration is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on these taxa components of marine and coastal biodiversity from offshore pipeline installation activities is rated as **Negligible.**

Temporary Impacts from Degraded Water Quality from Vessel Discharges During Offshore Pipeline Installation and Decommissioning

As described in Section 5.5.3, Effluent Discharges, several types of effluent discharges will be released from marine vessels during installation of the offshore pipeline. These discharges will include treated sanitary sewage (blackwater), other domestic treated wastewater (grey water), and food wastes. These discharges will have the potential to affect a variety of marine biota including marine birds, marine mammals, marine fish, and marine benthos. Installation activities will be temporary, affect a small portion of the marine ecosystem, and marine mammals and birds are typically wide ranging species that follow food resources across large expanses of ocean rather than residing in a particular area for an extended period. This natural tendency toward mobility will limit their exposure to direct and indirect impacts from degraded water quality during installation. Black and grey wastewater will be treated with a combination of digesters, biological treatment, and/or chemical treatment according to regulatory requirements and the specific treatment facilities available onboard the installation and support vessels. These effluents will be discharged to the sea according to applicable standard international practices (i.e., International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 [MARPOL 73/78]).

Potential direct impacts on marine birds, marine mammals, and marine turtles from vessel discharges will be limited because the only impact mechanism for direct water quality-related impacts on these taxa is dermal exposure. The only potential indirect impact mechanism relevant to these species is food chain impacts from decreased forage availability or quality. For these reasons, the intensity of potential water quality-related impacts on marine mammals and birds is rated as **Negligible**. These impacts will occur on a **Continuous** basis during installation of the offshore pipeline. These impacts will persist for less than a year in aggregate, so the impact duration is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of potential impact on water quality from installation activities is considered **Negligible**.

Similar to the water quality-related impacts from seafloor-disturbing activities discussed above, impacts from vessel discharges will have a more intense impact on marine fish and benthos because they live and breathe in the water column. In the deep segments of the offshore pipeline, the discharges will be at the surface and will be expected to dissipate to *de minimis* concentrations by the time the discharge plume reaches the deep portion of the water column, where it could affect resident fish or marine benthos. Fish in the upper portion of the water column along the deep portions of the offshore pipeline will be closer to the discharge point and will be exposed to a more concentrated effluent stream, but fish species in the upper portion of the water column in the open ocean and outer continental shelf are almost entirely highly migratory species. Their exposure to the effluent stream will be limited by their tendency to remain mobile. The fish species that occur at the shallow end of the offshore pipeline tend to be less mobile and the marine benthos will be closer to the discharge point by virtue of the shallow depths, but the water quality in the shallow coastal portion of the offshore pipeline corridor is comparatively poor due to a variety of natural and anthropogenic stressors, and the fish and benthic communities are comprised of species that are tolerant of these conditions. Marine fish and marine benthos will have greater exposure to vessel discharges to a greater extent than marine birds and marine mammals, but a combination of physical and biological factors will tend to limit the impacts of that exposure. For these reasons, the intensity of water quality-related impacts on marine mammals and birds is rated as **Low**. These impacts will occur on a **Continuous** basis during installation of the offshore pipeline. These impacts will persist for less than a year in aggregate, so the impact duration is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on marine and coastal biodiversity from offshore pipeline installation activities is rated as **Small**.

Marine Biota

Mortality and Injury of Benthic Organisms from Offshore Pipeline Installation

As described, the shallow sediment layer will be disturbed during offshore pipeline installation on the seabed. Individual benthic organisms are likely to be crushed, dislocated from the substrate (immobile organisms), or injured as a result of installation activities. Some benthic fauna will be impacted through burial and smothering by sediments displaced during pipeline burial and trench creation. Smothering is a biological impact on benthos induced by the physical impact of burial (Hendrick et al. 2016). The severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material (and the resulting anoxic conditions beneath the depositional layer), and the duration of the burial. Thickness thresholds vary by species and sediment permeability. Previous EIAs for the offshore Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects in Guyana have used a threshold deposition rate of 5 centimeters per month for smothering impacts on benthic communities, as recommended based on publications by Ellis and Heim (1985) and MarLIN (2019), but for relatively instantaneous depositions similar to what would occur during offshore pipeline trenching, a threshold of 6.5 millimeters is recommended, as described above.

Immobile individuals are likely to be either injured or killed in the immediate vicinity of the pipeline as the pipeline is being installed. Using the same rationale as was used to rate impacts on marine habitat above, these impacts are conservatively expected to occur over a total of approximately 629 hectares of benthic habitat. This area represents less than 1 percent of the total benthic habitat within the portion of the Guyana EEZ between the Stabroek Block and the coast. Installation activities will affect numerous benthic species at different trophic levels, but will not substantially alter the basic trophic and biodiversity attributes of the benthic ecosystem on Guyana’s continental shelf. Benthic macrofauna, including shrimp and crabs, are capable of moving rapidly away from impacted areas, and these species will have greater capacity to avoid injury and mortality due to smothering. Giant marine isopods occur in deep water in the infield portion of the pipeline. They are comparatively less mobile than shrimp and crabs and will therefore be comparatively more sensitive to potential impacts from smothering than crabs and shrimp. Populations of sessile life forms will likely take longer to replace individuals lost during installation activities. The intensity of mortality- and injury-related impacts on marine benthos associated with pipeline installation reflects the rating for impacts on marine habitat for the same Project activities, and is rated as **Medium**. While there will be periods during installation when sediment disturbance and deposition will not occur, the impact will be present throughout the Construction stage, yielding a **Continuous** frequency rating. The impacts will persist for less than a year in aggregate, so the duration of this impact is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on benthic habitat is considered **Medium**.

Entrainment of Marine Organisms in Ballast Water and Hydrostatic Test Water Intakes during Installation of the Offshore Pipeline

There are two types of marine water intakes that will occur due to the Project: ballast water intakes and an intake for hydrostatic testing of the offshore pipeline. Both types of intakes will occur only during the Construction stage.

Ballast water is water carried in ships' ballast tanks to improve vessel stability, balance, and trim; it is essential for the safe operations of oceangoing ships. It is taken onboard or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in foul weather. When ships take on ballast water, aquatic plants and animals may also be entrained into the ballast tanks. When the ballast intake is made in preparation for a transoceanic voyage these organisms are generally killed, either by treatment with biocides, filtering, or transportation and discharge in an unsuitable environment as a result of measures taken to reduce the potential for introduction of invasive species. When the intake and discharge is done in the same general area (as will occur with the installation vessels as they take on pipe loads at the shorebase and then gradually offload pipe along the installation corridor), such treatment methods may not be applied and some organisms may survive the intake/discharge cycle, although significant mortality will still occur in these cases due to physical injury from passing through the ballast pumps.

There are numerous ways that ballasting operations can affect marine life. Larval and juvenile organisms can be entrained in the intake or impinged on the screens installed to remove particulates from the water before it is taken into the ballast tanks. Once inside the vessel, organisms can be killed as they go through the ballast pumps. If they survive the intake process, organisms can be killed when they are discharged into inhospitable environments. Nearshore intakes generally pose a higher risk of entrainment and impingement than offshore intakes (WaterReUse 2011). Information on the entrainment and/or impingement rates at offshore intakes is sparse, but there is some recent evidence that losses from entrainment and impingement are insignificant at the population level, even at power plants in coastal and estuarine settings (Barnthouse 2013). The U.S. Minerals Management Service noted that coastal power plants require much higher volumes of water than individual offshore oil and gas facilities (approximately 10 million gallons per minute for a nuclear power plant; Martinez-Andrade and Baltz 2003), meaning that the entrainment losses at oil and gas facilities would likely be much lower than at power plants. In most cases, extrapolation of the losses of larval fish and eggs at power plant intakes to an equivalent number of adults indicates that entrainment losses are insignificant compared to natural and fishing-related mortality (Barnthouse 2013; WaterReUse 2011). As an embedded control, ballast water intakes on vessels used during the Construction, Operations, and Decommissioning stages will be equipped with screens to reduce entrainment. On this basis, the intensity of potential impacts associated with entrainment of marine organisms in water intakes is considered **Negligible**. The potential for ballast water intake will extend through the Construction stage, so the frequency of this impact is considered **Continuous** and the duration is considered **Long-term**. This yields a magnitude rating of **Negligible** for potential impacts associated with entrainment of marine organisms in water intakes.

Discharge of hydrostatic test water may create toxicological impacts due to the presence of one or more test chemicals in the hydrostatic test water. As described in Section 7.4.3.1, Marine Water Quality, the assessment assumes that the water treatment chemicals such as RX-5254 and/or SLB HydroHib will be present in the hydrostatic test water discharge and both chemicals are toxic to marine life at the concentrations at which they will occur in the offshore pipeline. Based on the modeling results, as described in Section 7.4.3.1, RX-5254 will be present at concentrations higher than the acute guidance threshold for toxicity at 100 meters from the discharge location. Dilution will be sufficient to meet the acute guidance threshold for RX-5254 within 500 meters from the discharge location under most scenarios[10]. For SLB HydroHib, all modeled scenarios predict sufficient dilution to meet the acute guidance threshold at 100 meters.

Stress and mortality associated with a hydrostatic discharge in the marine environment will affect a small portion of the EEZ, and will be a one-time event. This intensity of this impact is therefore rated **Low**. The impact will occur once over a 24-hour period, so the duration is considered **Short-term**, and impacts will be **Continuous** while the event occurred. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biodiversity is rated as **Small.**

Disturbance of Fish and Other Marine Organisms due to Increased Noise from Offshore Pipeline Installation and Decommissioning Activities

No impulsive sounds will be generated by Project activities, and the primary non-impulsive sound that will be generated will be from vessel operations. Maximum noise generation will be during the Construction stage, which a secondary peak during Decommissioning. Marine birds will not be exposed to sound in the water column and marine benthos and marine turtles are not generally considered to be susceptible to impacts from vessel noise, so this assessment focuses on auditory impacts on marine mammals and marine fish.

The potential for anthropogenic sound to impact marine animals depends on how well the animals can detect the sound and react. Sounds are less likely to be disruptive if they are at frequencies that animals cannot detect. However, when the sound pressure is high enough, it can cause physical injury through non-auditory mechanisms (i.e., barotrauma). For sound levels below such extremes, frequency weighting may be applied to scale the importance of sound components at particular frequencies in a manner reflective of an animal's sensitivity to those frequencies.

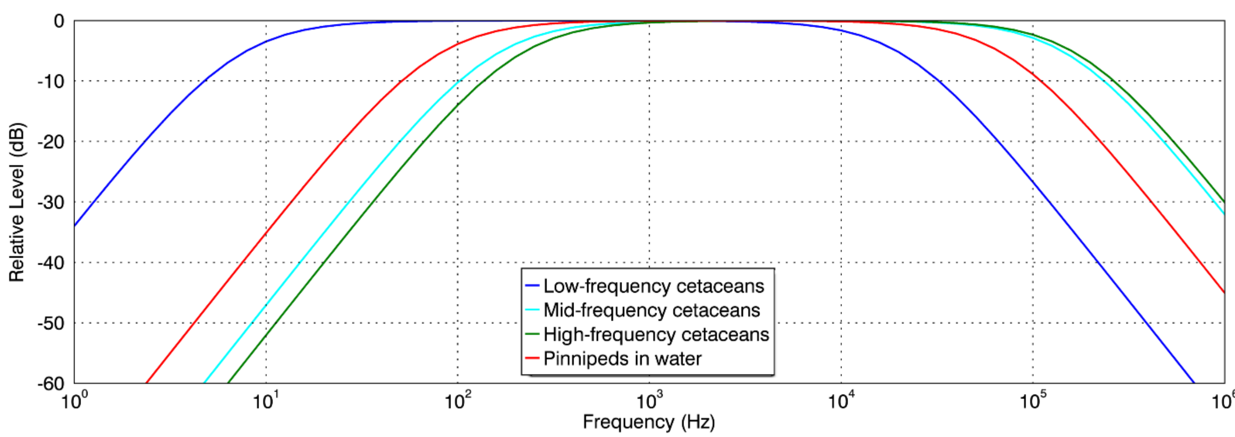
Auditory weighting functions for marine mammals, called M-weighting functions, were initially proposed by Southall et al. (2007) and then later modified by NOAA (2013) and Finneran (2015). For this assessment, values are presented using Southall et al. (2007) M-weighting functions and the weighting functions suggested by Finneran (2015).

[10] The scenarios that do not meet acute guidance thresholds are for discharges on the continental shelf at 50 kilometers offshore at low current velocities and 75 kilometers offshore at moderate current velocities. Sufficient dilution to meet acute guidance thresholds will be achieved at all locations under high current conditions and at the infield (pipeline end termination) discharge location under all current conditions.

Southall et al. (2007) proposed M-weighting functions for five functional hearing groups of marine mammals:

- Low-frequency cetaceans (LFCs)—mysticetes (baleen whales);
- Mid-frequency cetaceans (MFCs)—some odontocetes (toothed whales);
- High-frequency cetaceans—odontocetes specialized for using high-frequencies;
- Pinnipeds in water[11]—seals, sea lions, and walruses (not addressed here); and
- Pinnipeds in air (not addressed here).

NOAA (2013) suggested further modifications to the LFC function, including two variations (for phocid and otariid pinnipeds) to the Southall et al. (2007) M-weighting function for pinnipeds in water. A U.S. Navy Technical *Report* (Finneran 2015) recommended new auditory weighting functions that consider the overall shape of the auditory weighting functions to be more like human A-weighting functions, which follow the sensitivity of the human ear at low sound levels. Although the inclusion of some species changed (e.g., the addition of hourglass [*Lagenorhynchus cruciger*] and Peale's [*Lagenorhynchus australis*] dolphins to the high-frequency functional hearing group), the five recommended functional hearing groups remain as presented in NOAA 2013. The auditory weighting functions recommended by Southall et al. (2007) and Finneran (2015) are shown on Figure 8.2-26 and Figure 8.2-27, respectively.

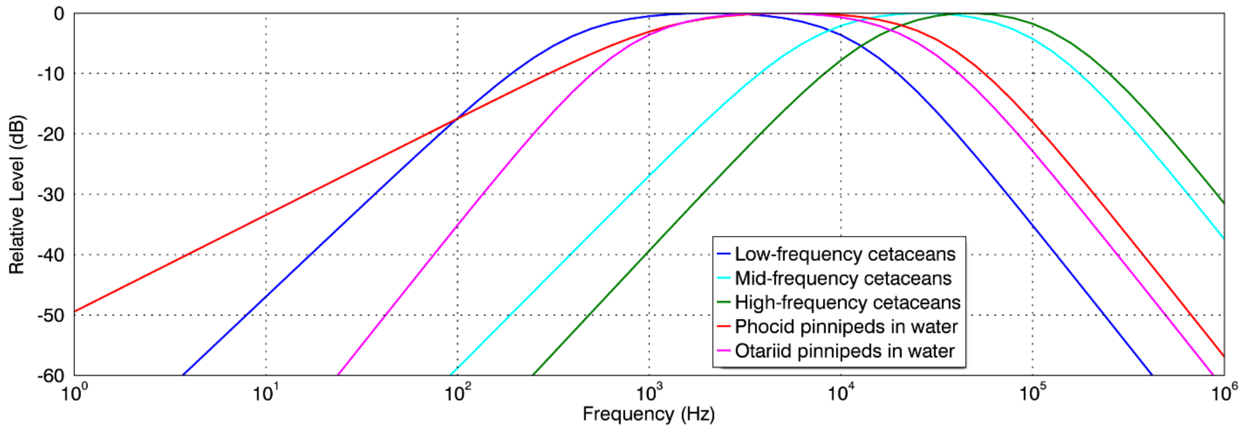


Source: JASCO 2016

Hz = hertz; dB = decibel

Figure 8.2-26: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Southall et al. (2007)

[11] Pinnipeds were included in Southall et al. 2007, but are not relevant to this analysis of auditory impacts because pinnipeds are either likely extinct or extirpated offshore Guyana.



Source: JASCO 2016

Hz = hertz; dB = decibel

Figure 8.2-27: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Finneran (2015)

Only LFCs (including baleen whales) and MFCs (including dolphins and toothed whales) have been observed within or near the Direct AOI, so this section focuses on these marine mammal hearing groups.

Prior modeling conducted for the Liza Phase 1 Development Project included analysis of non-impulsive sound associated with operation of an FPSO. Although an FPSO is much larger and supports more process-related and power generation equipment than any vessels that will be used for the Project, the Consultants believe the modeling results for operation of a FPSO represents a reasonable, albeit conservative, proxy for noise levels associated with construction and installation of the offshore pipeline. Modeling predicted that non-impulsive underwater sound for operational sound from an FPSO would attenuate to below permanent threshold shift (PTS)-onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 6 meters (19.7 feet) and less than 5 meters (16.4 feet), respectively.

Anthropogenic sounds below acoustic injury thresholds have the potential to mask relevant or naturally occurring sounds in the animals’ environment. Masking can occur from natural and anthropogenic sounds (Hildebrand 2005) and can cause behavioral changes that can have ecological consequences for marine mammals. These may include changes in biologically important behaviors (e.g., breeding, calving, feeding, or resting), diving behavior (e.g., reduced or prolonged dive times, increased time at the surface, or changes in swimming speed), and historical migration routes (NOAA Undated).

Although the above changes could occur as a result of Project-generated sound, findings from U.S. territorial waters suggest that the population-level significance of disturbance from impulsive sound over a small area such as the offshore pipeline corridor will likely be minor and temporary. The U.S. National Marine Fisheries Service reported that

> “…available data do not indicate that sound and disturbance from oil and gas exploration and development activities since the mid-1970s had lasting population level adverse impacts on bowhead whales. Data

> indicate that bowhead whales are robust, increasing in abundance, and have been approaching (or have reached) the lower limit of their historic population size at the same time that oil and gas exploration activities have been occurring in the Beaufort Sea and, to a lesser extent, the Chukchi Sea." (MMS and NOAA 2007)

The U.S. Bureau of Ocean Energy Management also reported that despite more than 50 years of oil and gas exploration and development in the Gulf of Mexico, there are no data to suggest these activities are significantly impacting marine mammal populations (BOEM 2014). Furthermore, the offshore pipeline corridor is not known to be an important feeding, breeding, or calving area for marine mammals. It is highly likely individual animals would divert around the offshore pipeline corridor to avoid Project-generated sound, but no significant impacts on life functions or potential population-level implications from underwater sound are expected. However, the potential extent for disturbance impacts will be larger than the extent for potential injury impacts (although still expected to be limited to the Direct AOI).

The potential for acoustic injury of marine mammals is remote but potential disturbance-level auditory impacts could extend outside of the Direct AOI via sound propagation, so the intensity of acoustic impacts on marine mammals is considered **Low**. These sounds will be present whenever installation or support vessels are operating within the Project AOI. This will occur on a **Continuous** basis during the Construction phase, but on an **Episodic** basis through the balance of the Project's life cycle. Although the amount of vessel sound will diminish after construction is complete, it will occur over the entire span of the Project, so the duration of impact from non-impulsive sound on marine mammals is considered **Long-term**. This results in a magnitude ratings of **Small** for non-impulsive sound impacts on marine mammals throughout the Project life cycle.

A 2014 Environmental Impact Statement conducted by the U.S. Department of the Interior as part of a Programmatic Environmental Impact Statement for proposed geological and geophysical investigations in the Atlantic Outer Continental Shelf off the southeastern United States (BOEM 2014) contained a comprehensive review of auditory impacts on fish from non-impulsive and impulsive sources (including seismic surveys). This study found that fish may experience a range of impacts from non-impulsive sound, including increased stress and threshold shift, and fish may employ behavioral strategies to avoid the sound source (BOEM 2014).

Pelagic marine and nearshore demersal fishes will receive the highest exposure to non-impulsive sound because they will be closest to the sound source (i.e., the marine vessels associated with the Project). The extent to which auditory impacts will actually occur is highly dependent on the hearing abilities and sensitivities of the species of these fish species and these abilities and sensitivities are currently unknown, but pelagic fishes' capacity to avoid approaching vessels would not be limited by their swimming ability. The nearshore fish community (including those in the approaches to the Demerara River) is dominated by highly mobile species, so the intensity of potential auditory impacts on pelagic marine species and nearshore demersal species from vessel activity (during all Project stages) is considered **Negligible**. Due to the depths present offshore and the resulting distance between the seafloor and vessels at the surface, the intensity of impacts on offshore (continental shelf and deepwater) demersal species from non-impulsive sound (during all Project stages) is also considered **Negligible**. These sounds will be present whenever an installation or support vessels are operating within the Project AOI. This will occur on a **Continuous** basis during the Construction phase, but on an **Episodic** basis through the balance of the Project's life cycle. Although the amount of vessel sound will diminish after construction is complete, it will occur over the entire span of the Project, so the duration of impact from non-impulsive sound on fish is considered **Long-term**. This results in a magnitude ratings of **Negligible** for non-impulsive sound impacts on marine fish throughout the Project life cycle.

8.2.3.4. Pre-mitigation Impact Significance—Marine and Coastal Biodiversity

Assuming implementation of the embedded controls listed in Table 8.2-13 and in Chapter 15, Commitment Register, the pre-mitigation intensity ratings for potential Project impacts on marine and coastal biodiversity will range from **Negligible** to **Medium**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Medium.** The marine and coastal habitat and biota in the Project AOI are generally comprised of disturbance-tolerant biota, but the benthic community does contain some disturbance-intolerant corals and other biological communities on small hard seafloor features. These communities are recognized as having high conservation interest because of the habitat value they provide for other marine organisms and of their elevated sensitivity to physical disturbance compared with more common and widespread infaunal species. The sensitivity of marine and coastal biodiversity within the Project AOI is therefore rated as **Low** with the exception of marine benthos and marine mammals, which are considered to have a **Medium** sensitivity**.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the pre-mitigation impact significance for marine and coastal biodiversity ranges from **Negligible** to **Moderate**.

8.2.4. Impact Management and Monitoring Measures

Based on the **Negligible** to **Minor** significance of most marine and coastal biodiversity impacts, mitigation measures are not warranted. It is noted, however, that the limited significance of these potential impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register).

Table 8.2-13: List of Management and Monitoring Measures

Embedded Controls
Monitor and manage suction dredging or jet plowing and burial rates to improve efficiency and reduce turbidity.
Avoid suction/jetting any deeper than what is required for protection of the pipeline.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. Consider the Offshore Chemical Notification Scheme (CEFAS 2019) as a resource for chemical selection. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of material safety data sheets; • Evaluation of alternate chemicals;

Embedded Controls
• Consideration of hazard properties while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Using the minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flow lines/risers commissioning fluids, including hydrotesting waters).
Maintain marine and onshore construction equipment, power generators, and vehicles in accordance with manufacturer's specifications to reduce noise generation the extent practicable.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions to the extent reasonably practicable.
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO and MARPOL 73/78 requirements.
Inspect and maintain onboard equipment (engines, compressors, generators, STP, and oil-water separators) in accordance with manufacturers' guidelines in order to maximize efficiency and minimize malfunctions and unnecessary discharges into the environment.
Use OCNS Gold Standard hydrostatic test chemicals to test the pipeline.
Monitoring Measures
Perform daily inspections to verify no visible sheen from discharges from pipeline installation and support vessels.
Monitor chlorine concentration of treated sewage discharges from pipeline installation and support vessels.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters from pipeline installation and support vessels.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book for Project construction/installation vessels.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book on pipeline installation and support vessels.
Record estimated volume of ballast water discharged and location (per ballasting operation) on pipeline installation and support vessels.
Monitor visual detections of marine mammals onboard pipeline installation and support vessels.

IMO = International Maritime Organization; MARPOL 73/78 = International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978; OCNS = Offshore Chemical Notification Scheme; ppm = parts per million; STP = sewage treatment plant

8.2.5. Assessment of Residual Impacts

Based on implementation of the embedded controls described Table 8.2-13, the residual impact significance ratings range from **Negligible** to **Moderate**.

Table 8.2-14 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on freshwater biodiversity.

Table 8.2-14: Summary of Potential Pre-Mitigation and Residual Impacts—Marine and Coastal Biodiversity

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Loss and disturbance of marine benthic habitat from offshore pipeline installation	Low	Medium	Minor	None	Minor
	Temporary impacts from degraded water quality from seafloor disturbance during offshore pipeline installation activities—marine fish and marine benthos	Low	Small	Negligible	None	Negligible
	Temporary impacts from degraded water quality from vessel discharges during offshore pipeline installation and decommissioning—marine birds marine mammals, marine turtles	Low	Negligible	Negligible	None	Negligible
	Mortality and injury of benthic organisms from offshore pipeline installation	Medium	Medium	Moderate	None	Moderate
	Entrainment of marine organisms in ballast water intakes	Low	Negligible	Negligible	None	Negligible
	Stress and mortality associated with hydrostatic testing water discharge	Low	Small	Negligible	None	Negligible
	Disturbance of marine mammals due to increased noise	Medium	Small	Minor	None	Minor
	Disturbance of marine fish due to increased noise	Low	Negligible	Negligible	None	Negligible
Decommissioning	Temporary impacts from degraded water quality from vessel discharges—marine fish and marine benthos	Low	Small	Negligible	None	Negligible

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	Temporary impacts from degraded water quality from vessel discharges—marine birds, marine mammals, marine turtles	Low	Negligible	Negligible	None	Negligible
	Disturbance of marine mammals due to increased noise	Low	Small	Negligible	None	Negligible
	Disturbance of marine fish due to increased noise	Low	Negligible	Negligible	None	Negligible

8.3. TERRESTRIAL BIODIVERSITY

8.3.1. Baseline Methodology

The biological resources discussion presented herein is based on a combination of primary data generated from EEPGL-commissioned studies and secondary data from peer-reviewed scientific literature, government publications, and non-governmental scientific organizations. This section covers key terrestrial taxa groups including ecosystems and vegetation communities, terrestrial birds, riverine birds, terrestrial mammals, and terrestrial insects.

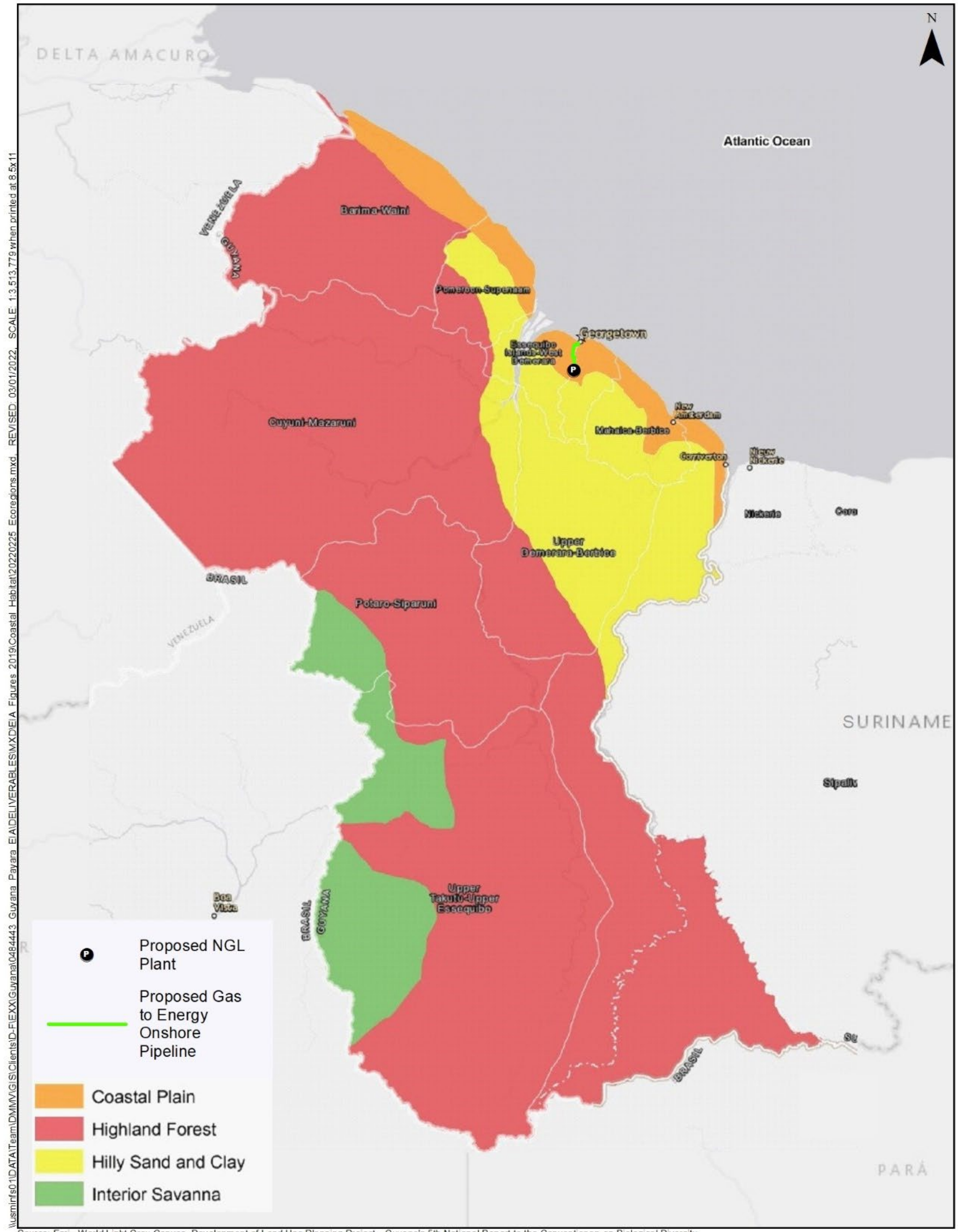
8.3.2. Existing Conditions and Baseline Studies

8.3.2.1. Ecosystems and Vegetation Communities

Ecosystems

The World Wildlife Fund (WWF) defines an ecoregion as a "relatively large unit of land or water containing a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions" (Olson 2001). These assemblages are often characterized by conditions including geology and soils, vegetation, wildlife, hydrology, land forms, and land use (Omernik 2004). Guyana has four ecoregions: Coastal Plain, Highland Forest, Hilly Sand and Clay, and Interior Savannah (Figure 8.3-1). These ecoregions are differentiated by geology and soils, hydrology, land use, and the presence of a variety of neo-tropical habitats, including forest, savannah, freshwater, wetland, coastal, and marine (EPA and MNRE 2014).

The onshore Project AOI (onshore Direct and Indirect AOI) lies within the Coastal Plain ecoregion in northern Guyana (Figure 8.3-1). This ecoregion extends approximately 440 kilometers from the Corentyne River to Waini Point, and ranges from 8 to 65 kilometers wide. Agricultural practices are common within the Coastal Plain, supported by soils that are comprised of a mix of recent and old deltaic and fluvio-marine clays, silts, and inland sands. Flooding is common within portions of the Coastal Plain and frequently occurs during Guyana's two wet seasons: from April to August and from November to January. Elevations within the Coastal Plain range from 2 meters below sea level to 9 meters above sea level. Construction of artificial sea defense infrastructure is common practice throughout the ecoregion to combat flooding caused from northern draining rivers and seasonally intensive high tide conditions. Water management infrastructure such as irrigation canals, ditches, and other flood protection defenses are common throughout the coastal plain landscape (EPA and MNRE 2014; GEA Undated).



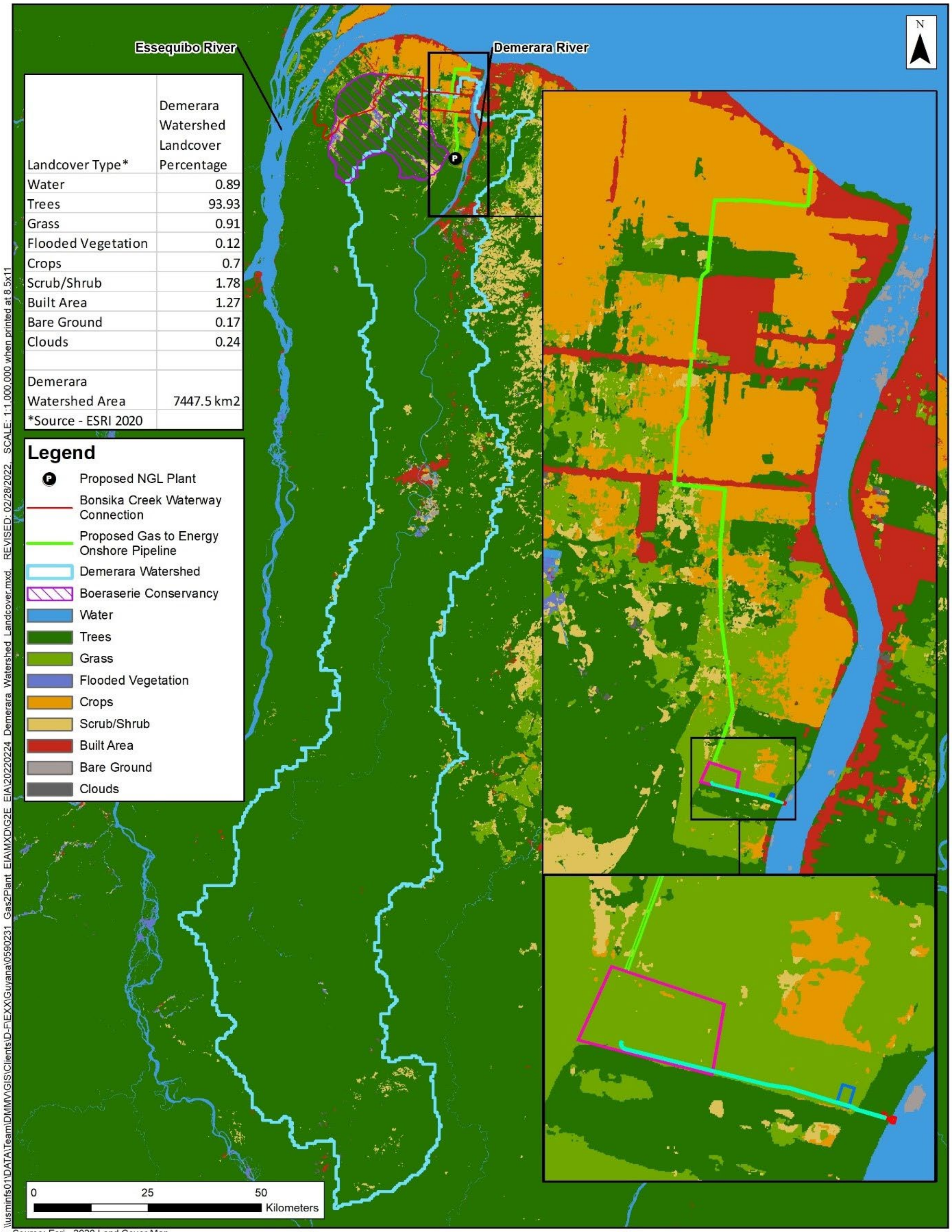
Source: Esri - World Light Gray Canvas, Development of Land Use Planning Project-- Guyana's 5th National Report to the Conventionon on Biological Diversity

Figure 8.3-1: Guyana Ecoregions

The primary terrestrial ecosystems within the Coastal Plain ecoregion are classified as "Guianan moist forests" (WWF Undated). Types of Guianan Moist Forests within the Coastal Plain ecoregion include mangrove forests and coastal or tidal swamp forests near the coast, and seasonally flooded palm marsh and swamp forest inland along the rivers and streams (de Granville 1988; EPA and MNRE 2014). According to the Vegetation Map of Guyana (ter Steege 2001), the dominant ecosystems (also referred to herein as vegetation communities) within the ecoregion includes herbaceous swamp, tall evergreen seasonal forests (dominated by *Coupia*, *Swartzia*, and *Aspidosperma* species), tall evergreen forests, and agriculture (Center for the Study of Biological Diversity 1995). Agricultural products produced within Guyana's coastal plain include rice, sugarcane, fruits and vegetables (particularly pineapple), and livestock (GEA Undated).

Habitat modification and anthropogenic influence is common throughout the Coastal Plain, as this region supports approximately 90 percent of Guyana's population. The expansion of extractive industries, such as timber and gold mining, agricultural practices, development of new settlements, and urbanization, have resulted in significant loss and degradation of natural habitats, leaving a patchwork of fragmented mangrove forests, coastal swamp forest, seasonally flooded palm marsh and swamp forest, urban areas, cultivated fields, and early successional vegetation (EPA and MNRE 2015; ESRI 2020).

The onshore Project AOI reflects this fragmented condition and is heavily dominated by agriculture; however, vast expanses of intact native forest still occur south and west of the onshore Project AOI within the farthest inland reaches of the Coastal Plain ecoregion and the adjacent Hilly Sand and Clay ecoregion (Figure 8.3-1 and Figure 8.3-2). In fact, over 93 percent of the Demerara River Watershed (which traverses multiple ecoregions) is forested, but all of the intact forests occur south and west of the Project AOI (Figure 8.3-2).



Source: ESRI 2020

Figure 8.3-2: Land Cover in the Demerara River Watershed and the Project's Onshore Direct AOI

Vegetation Communities

Vegetation community mapping of the onshore Direct AOI was conducted using high-resolution LiDAR imagery combined with field verification by biological and botanical specialists. The mapping exercise identified 14 vegetation communities within the Direct AOI (Figure 8.3-3 and Table 8.3-1). The dominant communities within the onshore Direct AOI include shrubland/swamp, which dominates the Project footprint south of Canal 2 and encompasses 50 percent of the total area within the Direct AOI, and active or inactive (i.e., fallow) agriculture, which dominates the area north of Canal 2 and encompasses just over 20 percent of the Direct AOI (Figure 8.3-3 and Table 8.3-1). The agriculture types within the area include a combination of sugarcane, rice, and pineapple. The remaining portion of the onshore Direct AOI contains a mix of early- to mid-successional vegetation communities, including grassland and herbaceous habitats with small, fragmented forest stands sporadically interspersed throughout the central and southern portions of the onshore pipeline corridor and secondary disturbed forest along the Demerara River within the onshore portion of the proposed temporary material offloading facility (MOF) site. Figure 8.3-3 and Appendix M, Pipeline Alignment and Vegetation Mapbook, depict the vegetation communities within the onshore Direct AOI, and Table 8.3-1 summarizes the total area and proportion of these vegetation communities within the onshore Direct AOI.

Table 8.3-1: Vegetation Communities within the Project's Onshore Direct AOI

Vegetation Community	Primary Location within Onshore Direct AOI	Area within Onshore Direct AOI (hectare)	Percentage of Total (%)
Active Agriculture (Rice)	Onshore pipeline corridor	18.0	12.5
Active Agriculture (Pineapple)	Onshore pipeline corridor north of Canal 2	3.2	2.2
Inactive Agriculture (Sugarcane)	Onshore pipeline corridor south of Canal 2	9.7	6.7
Bamboo Forest	Onshore pipeline corridor south of Canal 2	4.3	3.0
Riparian Forest (Mangrove Associated Species)	Onshore portion of temporary MOF	0.1	0.04
Modified Secondary Forest	Onshore portion of temporary MOF	0.4	0.3
Coastal Strand Vegetation	Pipeline shore landing	0.3	0.2
Early Successional Bamboo/Palm Forest	Onshore pipeline corridor	1.2	0.9
Early Successional Forest/Swamp	Onshore pipeline corridor	3.1	2.1
Herbaceous/Grass Swamp	Onshore pipeline corridor	22.9	16.0
Herbaceous/Grassland	Onshore pipeline corridor	0.1	0.1
Managed Grassland/Herbaceous – Residential	Onshore pipeline corridor	0.6	0.4
Shrubland/Swamp	Onshore pipeline corridor, NGL Plant site, worker camp, heavy haul road	71.5	50.0
Shrubland/Grass	Onshore pipeline corridor	1.3	0.9

Vegetation Community	Primary Location within Onshore Direct AOI	Area within Onshore Direct AOI (hectare)	Percentage of Total (%)
Unvegetated - Other (dirt, building, road, water)	Throughout onshore Direct AOI	7.4	2.1
TOTAL		**144.1**	**100%**

Vegetation Species

Field-based vegetation surveys of the onshore Direct AOI were conducted from October 2021 through March 2022 (Figure 8.3-3 through Figure 8.3-6). Surveys were conducted opportunistically in association with other survey and site investigation activities, during which vegetation species, percent cover, vegetation height, and other elements of the vegetation community were recorded. A total of 54 vegetation survey points were surveyed by Guyanese specialists, during which 47 plant species were recorded. Not all vegetation communities in the Direct AOI were surveyed due to access restrictions, including lack of site access approval or physical or health and safety limitations that prohibited access (Figure 8.3-3 through Figure 8.3-6). Table 8.3-2 summarizes the species observed, the component(s) of the onshore Direct AOI where the species was observed, and the most frequently observed species. All of the vegetation species recorded during the vegetation surveys are common in the Coastal Plain of Guyana, and the species composition is characteristic of areas dominated by agriculture and other types of current and/or historic anthropogenic disturbance. Twelve (20 percent) of the vegetation species observed are non-native to Guyana, four of which are also considered invasive.

The most frequently observed non-agricultural *vegetation* species observed during the surveys of the onshore Direct AOI include West Indian foxtail grass (*Andropogon bicornis*), para grass (*Brachiaria mutica*), swamp flatsedge (*Cyperus ligularis*), doveweed (*Murdannia nudiflora*), razor grass (*Scleria secans*), various other grass species of the Poaceae family in the herbaceous layer; and (in the shrub and forested habitats) vismia species (*Vismia* sp.), currant wood (*Antidisma bunius*), Congo pump (*Cecropia obtusa*), moco-moco (*Montrichardia arborescens*), acia palm (*Euterpe oleracea*), and common bamboo (*Bambusa vulgaris)*.

In terms of vegetative diversity, the vegetation communities surveyed in the onshore Direct AOI with the highest vegetative diversity were those that are less influenced by anthropogenic disturbance, including inactive sugarcane, herbaceous/grass swamp, shrubland/swamp, and modified forest/riparian forest (these forest types were combined for the species richness calculation because they occur together at the proposed temporary MOF location and have many species in common) (Table 8.3-3).

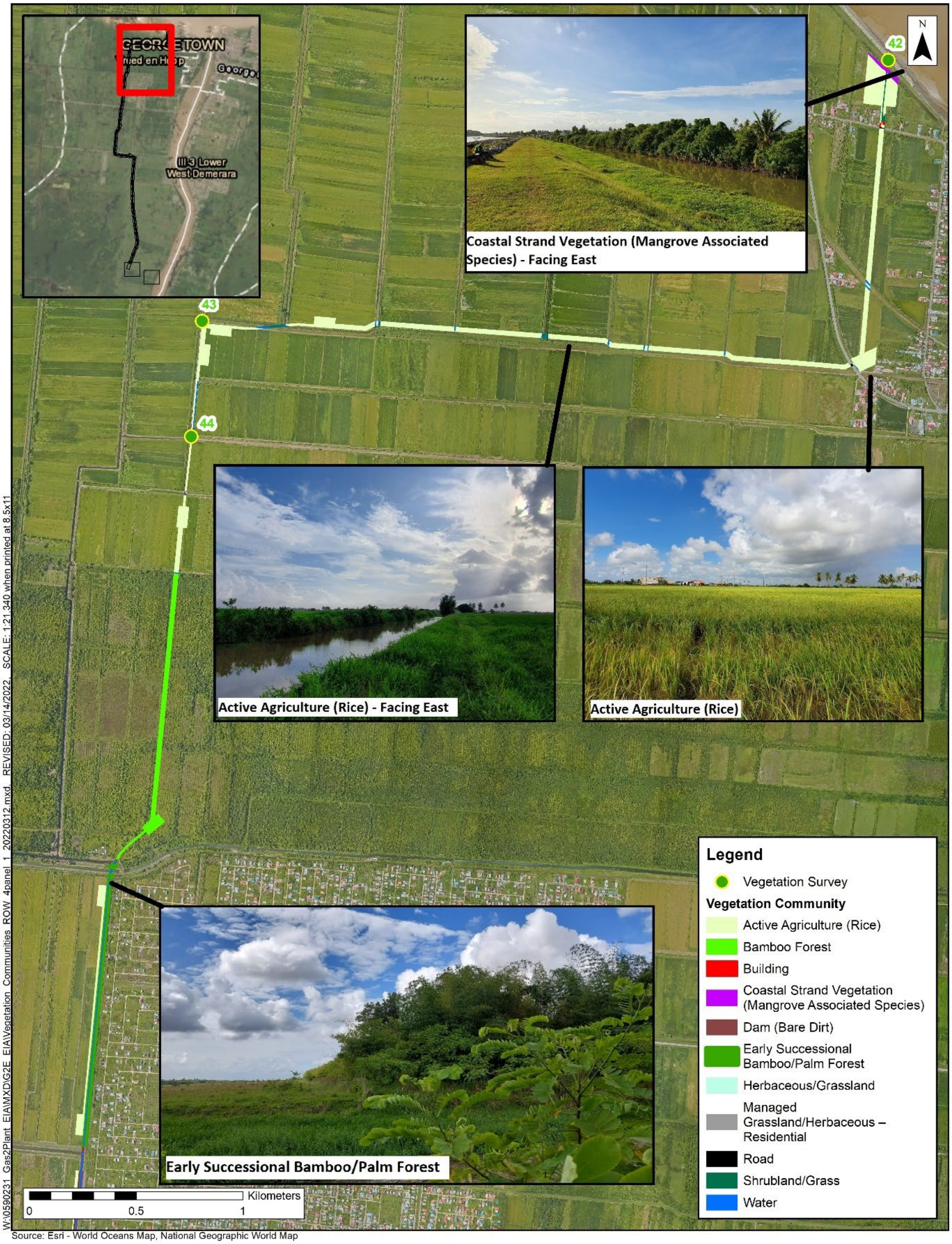
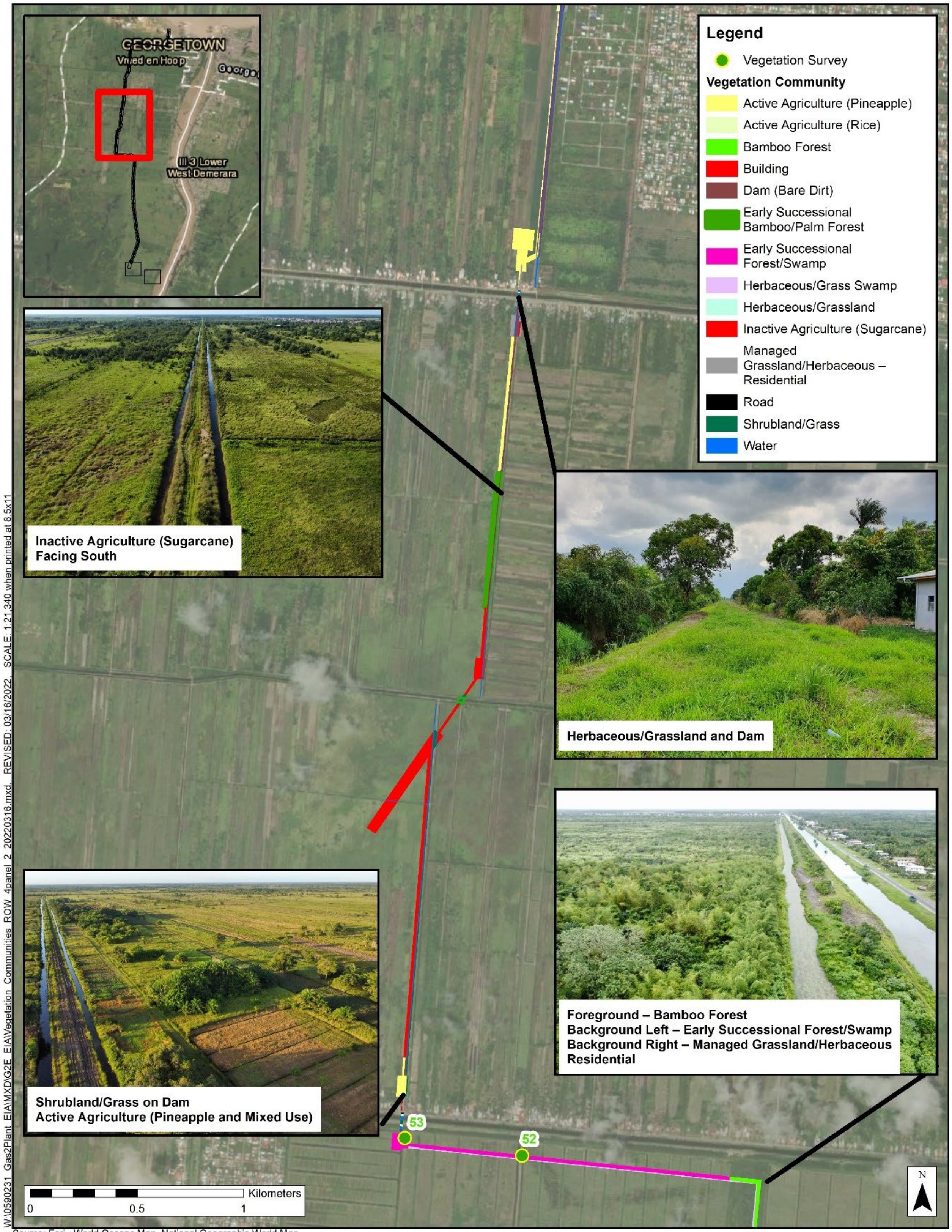


Figure 8.3-3: Vegetation Communities within the Onshore Direct AOI (Map 1 of 4)



Source: Esri - World Oceans Map, National Geographic World Map

Figure 8.3-4: Vegetation Communities within the Onshore Direct AOI (Map 2 of 4)

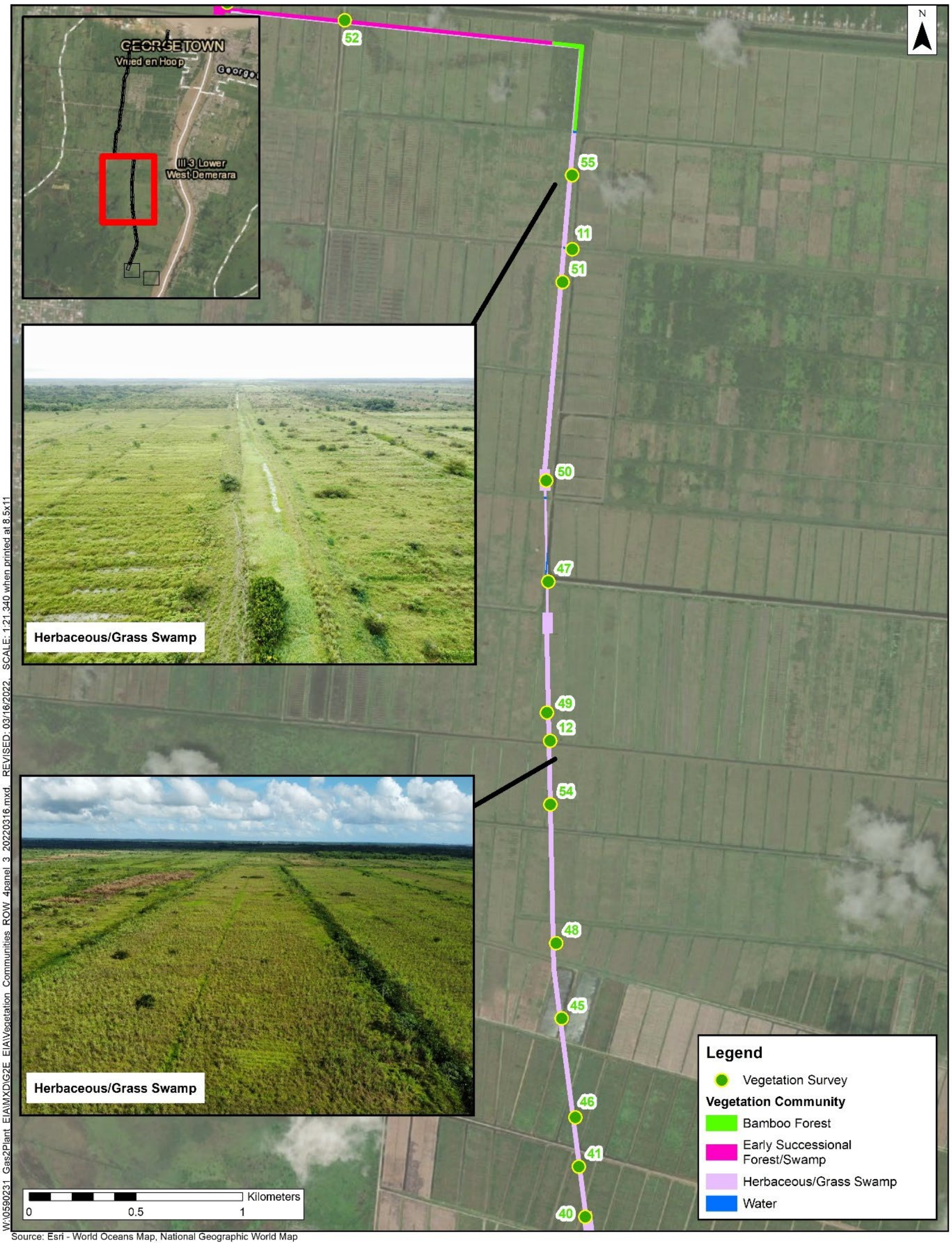
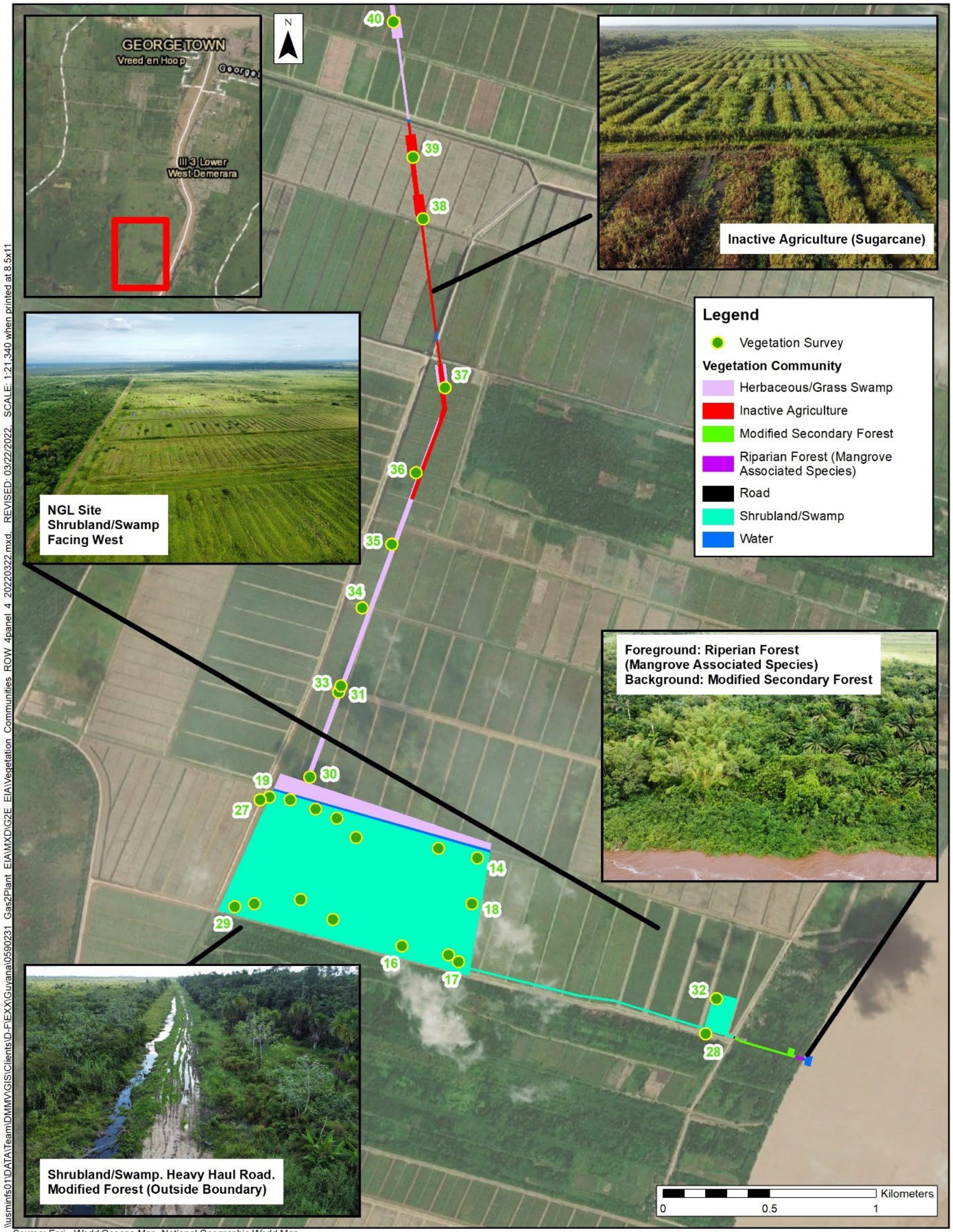


Figure 8.3-5: Vegetation Communities within the Onshore Direct AOI (Map 3 of 4)



Source: Esri - World Oceans Map, National Geographic World Map

Figure 8.3-6: Vegetation Communities within the Onshore Direct AOI (Map 4 of 4)

Table 8.3-2: Vegetation Species Observed within the Onshore Direct AOI

Scientific Name / Common Name	Location within Onshore Direct AOI Where Recorded	Number of Survey Points where Observed
Agricultural Crops		
Cocos nucifera Coconut	Onshore pipeline corridor	1
Oryza sativa Rice	Onshore pipeline corridor	2
Saccharum officinarum Sugarcane	Onshore pipeline corridor	11
Grasses/Herbaceous Species		
Andropogon bicornis West Indian foxtail grass	Onshore pipeline corridor, NGL Plant site	10
Brachiaria mutica Para grass	Onshore pipeline corridor, NGL Plant site	16
Colocasia esculenta Dasheen/ elephant ears	Onshore pipeline corridor	1
Commelina diffusa Spreading dayflower	Onshore pipeline corridor, NGL Plant site	6
Cordia curassavica Black sage	Onshore pipeline corridor, NGL Plant site	3
Costus arabicus Variegated spiral ginger	Onshore pipeline corridor, NGL Plant site	2
Cyperus ligularis Swamp flatsedge	Onshore pipeline corridor, NGL Plant site	17
Desmodium incanum Creeping beggarweed	Onshore pipeline corridor, NGL Plant site	6
Echinochola colona Jungle rice/ Deccan grass	Onshore pipeline corridor, NGL Plant site	4
Echinochola crusgalli Cockspur/ Japanese millet	Onshore pipeline corridor	1
Echinochola pyramidalis Antelope grass	Onshore pipeline corridor	2
Erechtites hieracifolia Fire weed/ pilewort	Onshore pipeline corridor, NGL Plant site	3
Heliconia psittacorum Parrot heliconia	Onshore pipeline corridor, NGL Plant site	4
Hemarthria altissima Limp grass	Onshore pipeline corridor	1
Lantana camara Wild sage/ Sweet sage	Onshore pipeline corridor, NGL Plant site	4
Murdannia nudiflora Doveweed	Onshore pipeline corridor, NGL Plant site, temporary MOF	10
Nephrolepis biserrata Broad sword fern	Onshore pipeline corridor, NGL Plant site	3
Persicaria amphibian Water smartweed	Onshore pipeline corridor, NGL Plant site	7

Scientific Name / Common Name	Location within Onshore Direct AOI Where Recorded	Number of Survey Points where Observed
Poaceae *sp.* Grass sp.	Onshore pipeline corridor, NGL Plant site	9
Scleria microcarpa Tropical nutrush	Onshore pipeline corridor, NGL Plant site	3
Scleria secans Razor grass	Onshore pipeline corridor, temporary MOF	11
Solanum sp. Nightshade	Onshore pipeline corridor, NGL Plant site	7
Tectaria incisa Halberd fern	Onshore pipeline corridor	1
Urochloa arrecta African signal grass	Onshore pipeline corridor, NGL Plant site	3
Shrubs		
Cassia alata Carrion crow bush	Onshore pipeline corridor	1
Psychotria nervosa Wild coffee	Temporary MOF	1
Senna alata Candle bush	Onshore pipeline corridor, NGL Plant site	2
Vismia sp. Vismia	Onshore pipeline corridor, NGL Plant site	9
Trees		
Antidisma bunius Currant wood	Onshore pipeline corridor, NGL Plant site, temporary MOF	11
Avicennia germinans Black mangrove	Temporary MOF	1
Bambusa vulgaris Common bamboo	Onshore pipeline corridor, temporary MOF	1
Cecropia angulate Cecropia	Temporary MOF	1
Cecropia obtusa Congo pump	Onshore pipeline corridor, NGL Plant site	15
Ceiba pentranda Silk cotton/ceiba	Onshore pipeline corridor	1
Cordia tetrandra Clammy cherry	Onshore pipeline corridor	5
Euterpe oleracea Acia palm	Temporary MOF	1
Ficus citrifolia Shortleaf fig	Onshore pipeline corridor	2
Mangifera indica Mango	Onshore pipeline corridor	1
Montrichardia arborescens Moco-moco	Onshore pipeline corridor, NGL Plant site	25
Musa sp. Banana	Temporary MOF	1

Scientific Name / Common Name	Location within Onshore Direct AOI Where Recorded	Number of Survey Points where Observed
Rhizophora mangle Red mangrove	Temporary MOF	1
Solanum subinerme Guyana patamona	Temporary MOF	1
Syzygium cumini Jamoon/black plum	Temporary MOF, NGL Plant site	1
Triplaris surinamensis Long John	Temporary MOF, NGL Plant site	2

Table 8.3-3: Vegetation Species Richness within Surveyed Vegetation Communities in the Onshore Direct AOI

Vegetation Community	Species Richness (# of Species Observed)
Active Agriculture (Rice)	7
Inactive Agriculture (Sugarcane)	16
Early Successional Forest/Swamp	5
Herbaceous/Grass Swamp	27
Herbaceous/Grassland	4
Shrubland/ Swamp	27
Modified Secondary Forest and Riparian Forest	25
Total Number of Unique Vegetation Species Observed	**47**

Species of Conservation Interest

There are three vegetation species (all trees) with elevated conservation status that occur in forested habitats within the Coastal Plain of Guyana. These include Spanish cedar (*Cedrela odorata*), bloodwood (*Pterocarpus officinalis*), and whitewood (*Tabebuia insignis*). These species could potentially occur in the forested habitats within the onshore Direct AOI, although these species are typically found in intact forest habitats as opposed to the highly fragmented forested stands that occur in the onshore Direct AOI. None of these species was detected during vegetation surveys of the onshore Direct AOI. Section 8.6, Special Status Species, provides additional information about these species.

Although not rare, there are three other tree species of importance that occur in the onshore Direct AOI: silk cotton (*Ceiba pentranda*), red mangrove (*Rhizophora mangle*), and black mangrove (*Avicennia germinans*). The silk cotton tree, or ceiba tree, is culturally important throughout the Guianas because it is associated with deep spiritual beliefs (see Section 9.5, Cultural Heritage). Red and black mangrove trees are protected from disturbance or removal by Guyanese law, and they are cornerstone species of the coastal and riverine ecosystem, providing flood control, shoreline protection, wildlife habitat, and many other ecological and human benefits. Vegetation surveys of the onshore Direct AOI documented three silk cotton trees within or near the onshore pipeline corridor (Section 9.5, Cultural Heritage) and three mangrove trees (two red mangrove trees and one black mangrove tree) along the Demerara River shoreline at the location of the proposed temporary MOF.

8.3.2.2. Terrestrial Birds

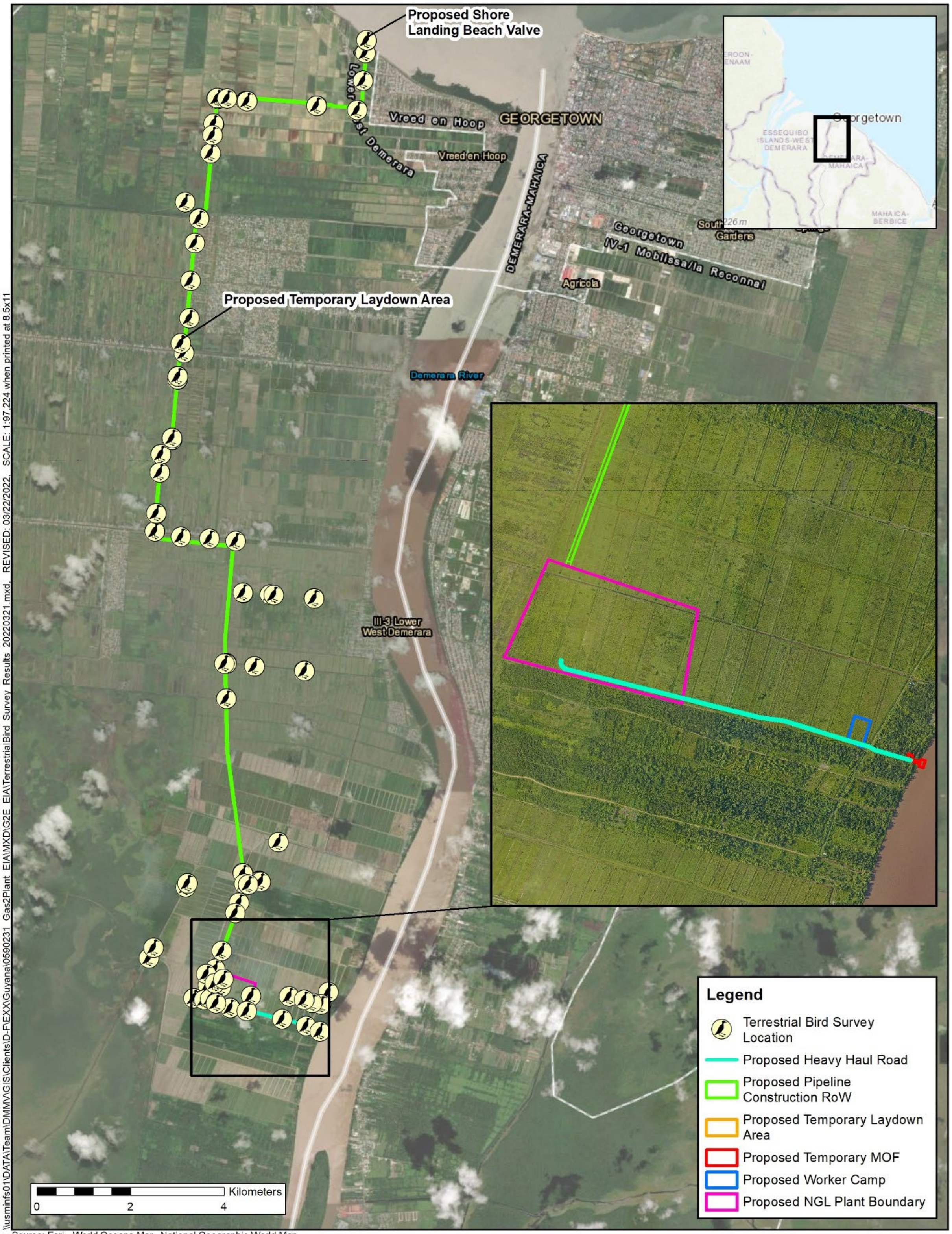
As described above in Section 8.3.2.1, Ecosystems and Vegetation Communities, much of the onshore Direct AOI is heavily influenced by current and former anthropogenic activities. The northern portion of the onshore Direct AOI is more heavily influenced by anthropogenic activities (e.g., human settlement and active agriculture) than the southern portion of the onshore Direct AOI, which is largely former sugarcane field that has reverted to shrub/swamp and early successional forest. Despite these differences, the terrestrial avifauna throughout the onshore Direct AOI exhibits little variation and consists of widespread ecological generalist species, owing to the area's long history of anthropogenic disturbance and highly modified habitats. Many of the characteristic forest bird species of the Guiana Shield, including most of the region's endemic species, are absent from the Coastal Plain, particularly in areas like the onshore Direct AOI that lack extensive forest cover or continuous connections between the interior and coastal forests.

Historical Data

There are no published bird surveys of the onshore Direct AOI or surrounding area. Historical data for the area is limited to eBird records from various locations in and near Georgetown (eBird 2022). Common terrestrial birds (i.e., landbirds) recorded in the general area include Ruddy Ground Dove (*Columbina talpacoti*), Great Kiskadee (*Pitangus sulphuratus*), Tropical Kingbird (*Tyrannus melancholicus*), House Wren (*Troglodytes aedon*), Gray-breasted Martin (*Progne chalybea*), Pale-breasted Thrush (*Turdus leucomelas*), and Blue-gray Tanager (*Thraupis episcopus*), all of which are abundant in Georgetown and surrounding areas and were observed during EEPGL-commissioned baseline surveys.

Baseline Survey Results

Terrestrial bird surveys of the onshore Direct AOI were conducted during Guyana's dry and wet seasons from October 2021 through March 2022. Guyanese bird specialists conducted a total of 291 bird surveys at 79 survey points located within and near the onshore Direct AOI (Figure 8.3-7). Survey point locations were selected based on site accessibility, habitat type, visibility, and presence of habitat features that could attract birds (e.g., topographic depressions containing standing water, fruit trees, etc.). Survey points were surveyed multiple times during the dry and wet seasons, but not all survey points were surveyed the same number of times due to accessibility and other constraints. At each survey point, surveyors conducted 15-minute point count surveys, during which surveyors recorded all birds seen and heard within a radius around the survey point (within visibility and hearing range, which varied depending on location and habitat type). To the extent practicable, surveys were conducted in the morning hours between 6:00 a.m. and 10:00 a.m., when birds are most active. However, this was not always possible due to site accessibility, weather conditions, or other constraints.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 8.3-7: Terrestrial Bird Survey Locations within and near the Onshore Direct AOI

The terrestrial bird surveys documented a total of 126 species and 4,147 birds across all survey sites (Table 8.3-4). The 126 species include raptors (13 species), waterbirds/waterfowl (9 species), a marine bird (1 species), shorebirds (3 species), and landbirds (100 species). The vast majority of the species observed during the surveys are year-round residents (118 of 126 species), and very few of the species detected are long-distance migrants (8 of 126 species). No significant seasonal differences in bird abundance or species composition was documented when comparing the data across the dry and wet seasons. This was expected, since most of the bird species documented during the terrestrial bird surveys are year-round residents and food resources for these species do not vary greatly by season.

In terms of species diversity, the greatest number of species (highest diversity or species richness) occurred in the less disturbed southern portion of the onshore Direct AOI within shrub/swamp habitat (90 species of the total 126 species observed during the surveys) (Table 8.3-5). The second highest species diversity occurred in the herbaceous/grass swamp (64 species) and bamboo forest (61 species) habitats located just south of Canal 2 (Table 8.3-5). The lowest bird species diversity occurred in the coastal strand / disturbed forest / riverine forest habitats (combined due to habitat similarity and small sample size), but this is likely a function of survey effort; these habitats comprise only a very small portion of the onshore Direct AOI and, as such, had correspondingly few sample points. High species diversity/richness did not track with bird abundance: while the shrub/swamp and bamboo habitats had the highest species diversity, these habitats had relatively low bird abundance compared with other habitats. Highest bird abundance was recorded in highly modified habitats, including managed grassland/herbaceous-residential and active agriculture (rice), with over 1,000 individuals recorded in each of these habitats (Table 8.3-5). The high bird abundance in these habitats was primarily due to the frequent presence of mixed flocks of common landbird species such as Carib Grackle (*Quiscalus lugubris)* and Yellow-headed Blackbird (*Chrysomus icterocephalus*) and species that are characteristic of residential and agricultural areas such as Rock Pigeon (*Columba livia*), Smooth-billed Ani (*Crotophaga ani*), and Great Kiskadee.

The number of species detected during the terrestrial bird surveys is slightly fewer than the 136 species known to occur in the riverine portion of the Direct AOI (see Section 8.3.2.3, Riverine Birds). As expected for two areas in close proximity, bird species overlap was high between the riverine and terrestrial survey sites. Compared to the riverine bird community, the terrestrial community contained fewer shorebirds, waterbirds, fish-eating birds, and species typical of mangrove-dominated habitats. Most of the shared species were common, widespread, resident landbirds, which made up a greater proportion of both species and individuals on the terrestrial surveys. Several colonial waterbird species were present in the terrestrial survey area, but these sightings were typically of transient individuals moving through the area or of waterbird species such as Cattle Egret (*Bubulcus ibis*) that regularly forage in terrestrial environments found in the onshore Direct AOI, including pastures and old agricultural fields. Thirty-five species observed on the terrestrial bird surveys were not recorded on the riverine surveys; the majority of these species were observed in habitats unique to the terrestrial survey points, primarily active agriculture, shrub/swamp, and herbaceous/grass swamp. Table 8.3-6 includes representative photographs of the terrestrial avifauna documented during bird surveys in the onshore Direct AOI.

Table 8.3-4: Terrestrial Bird Species Observed within the Onshore Direct AOI

Scientific Name	Common Name	Species Group/ Life History	Resident/ Migrant [a]	Number of Sightings
Cathartes aura	Turkey Vulture	Raptor	Resident	29
Circus buffoni	Long-winged Harrier	Raptor	Resident	36
Milvago chimachima	Yellow-headed Caracara	Raptor	Resident	20
Busarellus nigricollis	Black-collared Hawk	Raptor	Resident	5
Rupornis magnirostris	Roadside Hawk	Raptor	Resident	9
Rostrhamus sociabilis	Snail Kite	Raptor	Resident	10
Falco rufigularis	Bat Falcon	Raptor	Resident	3
Coragyps atratus	Black Vulture	Raptor	Resident	8
Buteo albonotatus	Zone-tailed Hawk	Raptor	Resident	6
Buteogallus urubitinga	Great Black Hawk	Raptor	Resident	2
Herpetotheres cachinnans	Laughing Falcon	Raptor	Resident	4
Cathartes burrovianus	Lesser Yellow-headed Vulture	Raptor	Resident	4
Caracara cheriway	Crested Caracara	Raptor	Resident	1
Dendrocygna autumnalis	Black-bellied Whistling Duck	Waterfowl	Resident	16
Nycticorax nycticorax	Black-crowned Night Heron	Waterbird	Resident	1
Bubulcus ibis	Cattle Egret	Waterbird	Resident	116
Butorides striata	Striated Heron	Waterbird	Resident	21
Ardea alba	Great Egret	Waterbird	Resident	70
Aramus guarana	Limpkin	Waterbird	Resident	15
Egretta caerulea	Little Blue Heron	Waterbird	Resident	12
Mesembrinibis cayennensis	Green Ibis	Waterbird	Resident	2
Egretta thula	Snowy Egret	Waterbird	Resident	38
Leucophaeus atricilla	Laughing Gull	Marine Bird	Migrant	2
Actitis macularius	Spotted Sandpiper	Shorebird	Migrant	6
Calidris alba	Sanderling	Shorebird	Migrant	15
Vanellus chilensis	Southern Lapwing	Shorebird	Resident	37
Pitangus sulphuratus	Great Kiskadee	Landbird	Resident	169
Troglodytes aedon	House Wren	Landbird	Resident	25
Crotophaga ani	Smooth-billed Ani	Landbird	Resident	169
Tyrannus melancholicus	Tropical Kingbird	Landbird	Resident/ Migrant	91
Volatinia jacarina	Blue-black Grassquit	Landbird	Resident	46
Thraupis episcopus	Blue-grey Tanager	Landbird	Resident	68
Synallaxis albescens	Pale-breasted Spinetail	Landbird	Resident	52
Myiozetetes cayanensis	Rusty-margined Flycatcher	Landbird	Resident	35

Scientific Name	Common Name	Species Group/ Life History	Resident/ Migrant [a]	Number of Sightings
Jacana jacana	Wattled Jacana	Landbird	Resident	41
Leptotila verreauxi	White-tipped Dove	Landbird	Resident	13
Certhiaxis cinnamomeus	Yellow-chinned Spinetail	Landbird	Resident	97
Sakesphorus canadensis	Black-crested Antshrike	Landbird	Resident	33
Progne chalybea	Gray-breasted Martin	Landbird	Resident/ Migrant	62
Columbina talpacoti	Ruddy Ground Dove	Landbird	Resident	45
Sporophila americana	Wing-barred Seedeater	Landbird	Resident	34
Icterus nigrogularis	Yellow Oriole	Landbird	Resident	39
Elaenia flavogaster	Yellow-bellied Elaenia	Landbird	Resident	47
Todirostrum cinereum	Common Tody Flycatcher	Landbird	Resident	21
Patagioenas cayennensis	Pale-vented Pigeon	Landbird	Resident	20
Molothrus bonariensis	Shiny Cowbird	Landbird	Resident	71
Mimus gilvus	Tropical Mockingbird	Landbird	Resident	37
Thamnophilus doliatus	Barred Antshrike	Landbird	Resident	24
Eupsittula pertinax	Brown-throated Parakeet	Landbird	Resident	40
Quiscalus lugubris	Carib Grackle	Landbird	Resident	420
Tachornis squamata	Fork-tailed Palm Swift	Landbird	Resident	67
Crotophaga major	Greater Ani	Landbird	Resident	21
Turdus leucomelas	Pale-breasted Thrush	Landbird	Resident	16
Thraupis palmarum	Palm Tanager	Landbird	Resident	43
Tapera naevia	Striped Cuckoo	Landbird	Resident	17
Hylophilus pectoralis	Ashy-headed Greenlet	Landbird	Resident	13
Coereba flaveola	Bananaquit	Landbird	Resident	6
Hirundo rustica	Barn Swallow	Landbird	Migrant	27
Megarynchus pitangua	Boat-billed Flycatcher	Landbird	Resident	5
Stilpnia cayana	Burnished-buff Tanager	Landbird	Resident	9
Sporophila castaneiventris	Chestnut-bellied Seedeater	Landbird	Resident	15
Columbina passerina	Common Ground Dove	Landbird	Resident	42
Tyrannus dominicensis	Gray Kingbird	Landbird	Migrant	6
Amazona amazonica	Orange-winged Parrot	Landbird	Resident	22
Leistes militaris	Red-breasted Meadowlark	Landbird	Resident	31
Ramphocelus carbo	Silver-beaked Tanager	Landbird	Resident	60
Picumnus spilogaster	White-bellied Piculet	Landbird	Resident	11
Cantorchilus leucotis	Buff-breasted Wren	Landbird	Resident	13
Attila cinnamomeus	Cinnamon Attila	Landbird	Resident	4
Chionomesa fimbriata	Glittering-throated Emerald	Landbird	Resident	3
Sicalis luteola	Grassland Yellow-Finch	Landbird	Resident	25
Chloroceryle Americana	Green Kingfisher	Landbird	Resident	5
Phaeomyias murina	Mouse-colored Tyrannulet	Landbird	Resident	4
Fluvicola pica	Pied Water Tyrant	Landbird	Resident	7

Scientific Name	Common Name	Species Group/ Life History	Resident/ Migrant [a]	Number of Sightings
Legatus leucophaius	Piratic Flycatcher	Landbird	Resident	16
Megaceryle torquata	Ringed Kingfisher	Landbird	Resident	3
Todirostrum maculatum	Spotted Tody Flycatcher	Landbird	Resident	9
Tangara mexicana	Turquoise Tanager	Landbird	Resident	10
Arundinicola leucocephala	White-headed Marsh Tyrant	Landbird	Resident	5
Polytmus guainumbi	White-tailed Goldenthroat	Landbird	Resident	20
Tyrannulus elatus	Yellow-crowned Tyrannulet	Landbird	Resident	5
Cacicus cela	Yellow-rumped Cacique	Landbird	Resident	14
Chloroceryle amazona	Amazon Kingfisher	Landbird	Resident	6
Mustelirallus albicollis	Ash-throated Crake	Landbird	Resident	11
Schistochlamys melanopis	Black-faced Tanager	Landbird	Resident	9
Veniliornis sanguineus	Blood-colored Woodpecker	Landbird	Resident	3
Pheugopedius coraya	Coraya Wren	Landbird	Resident	3
Campephilus melanoleucos	Crimson-crested Woodpecker	Landbird	Resident	3
Forpus passerinus	Green-rumped Parrotlet	Landbird	Resident	17
Geothlypis aequinoctialis	Masked Yellowthroat	Landbird	Resident	5
Saltator olivascens	Olivaceous Saltator	Landbird	Resident	23
Diopsittaca nobilis	Red-shouldered Macaw	Landbird	Resident	28
Orthopsittaca manilata	Red-bellied Macaw	Landbird	Resident	14
Columba livia	Rock Pigeon	Landbird	Resident	1,002
Anurolimnas viridis	Russet-crowned Crake	Landbird	Resident	18
Myiarchus ferox	Short-crested Flycatcher	Landbird	Resident	3
Tringa solitaria	Solitary Sandpiper	Landbird	Migrant	5
Dendroplex picus	Straight-billed Woodcreeper	Landbird	Resident	5
Ortalis motmot	Variable Chachalaca	Landbird	Resident	29
Euphonia violacea	Violaceous Euphonia	Landbird	Resident	4
Tachyphonus rufus	White-lined Tanager	Landbird	Resident	5
Tachycineta albiventer	White-winged Swallow	Landbird	Resident	3
Setophaga petechia	Yellow Warbler	Landbird	Migrant	2
Porphyrio flavirostris	Azure Gallinule	Landbird	Resident	1
Donacobius atricapilla	Black-capped Donacobius	Landbird	Resident	8
Anthracothorax nigricollis	Black-throated Mango	Landbird	Resident	2
Ara ararauna	Blue-and-yellow Macaw	Landbird	Resident	26
Chlorostilbon mellisugus	Blue-tailed Emerald	Landbird	Resident	1
Myiarchus tyrannulus	Brown-crested Flycatcher	Landbird	Resident	1
Psarocolius decumanus	Crested Oropendola	Landbird	Resident	1
Tyrannus savana	Fork-tailed Flycatcher	Landbird	Migrant	3
Molothrus oryzivorus	Giant Cowbird	Landbird	Resident	1
Leptotila rufaxilla	Gray-fronted Dove	Landbird	Resident	1
Trogon viridis	Green-backed Trogon	Landbird	Resident	1

Scientific Name	Common Name	Species Group/ Life History	Resident/ Migrant [a]	Number of Sightings
Dryocopus lineatus	Lineated Woodpecker	Landbird	Resident	1
Synallaxis gujanensis	Plain-crowned Spinetail	Landbird	Resident	1
Porphyrio martinica	Purple Gallinule	Landbird	Resident	2
Sporophila minuta	Ruddy-breasted Seedeater	Landbird	Resident	5
Glaucis hirsutus	Rufous-breasted Hermit	Landbird	Resident	1
Chaetura brachyura	Short-tailed Swift	Landbird	Resident	5
Camptostoma obsoletum	Southern Beardless Tyrannulet	Landbird	Resident	3
Stelgidopteryx ruficollis	Southern Rough-winged Swallow	Landbird	Resident	5
Emberizoides herbicola	Wedge-tailed Grassfinch	Landbird	Resident	2
Myrmoborus leucophrys	White-browed Antbird	Landbird	Resident	1
Ramphastos tucanus	White-throated Toucan	Landbird	Resident	6
Chrysomus icterocephalus	Yellow-hooded Blackbird	Landbird	Resident	130
Total				**4,147**

[a] Species marked "Resident/Migrant" are present in Guyana year-round, but are either nomadic or are represented by both resident and migrant populations at various points in the year.

Table 8.3-5: Bird Species Richness and Abundance within Surveyed Vegetation Communities in the Onshore Direct AOI

Vegetation Community	Species Richness (# of Species Observed)	Bird Abundance (# of Individuals Observed)
Active Agriculture (Pineapple)	46	235
Active Agriculture (Rice)	50	1,025
Inactive Agriculture (Sugarcane)	46	183
Herbaceous/Grass Swamp	64	240
Managed Grassland/Herbaceous - Residential	48	1,260
Shrubland/Swamp	90	687
Early Successional Forest/Swamp	31	106
Coastal Strand/Modified Secondary Forest/Riverine Forest (Mangrove Associated Species)	27	138
Bamboo Forest	61	273
Total Number of Bird Species Observed	**126**	**4,147**

Species of Conservation Interest

There are six species of terrestrial birds with elevated conservation status that occur in forested habitats within the Coastal Plain of Guyana: Agami Heron (*Agamia agami),* White-throated Toucan *(Ramphastos tucanus),* Channel-billed Toucan (*Ramphastos vitellinus),* Orange-breasted Falcon *(Falco deiroleucus),* Blackpoll Warbler *(Setophaga striata)*, and Ringed Woodpecker (*Celeus torquatus*). These species could occur as transients in the forested, savannah, and residential habitats within the onshore Direct AOI where there is ample forage (e.g., fruit trees for the toucans, small mammal prey for the falcon). One of these species, White-throated Toucan, was detected during both the terrestrial and riverine bird surveys conducted within the onshore and riverine components of the Direct AOI. None of the species is expected to breed or occur regularly within the onshore Direct AOI based on habitat conditions present and the species' habitat preferences. Section 8.6, Special Status Species, provides additional information about these species.

In addition to the six species with elevated conservation status, the range-restricted Blood-colored Woodpecker (*Veniliornis sanguineus*; Figure 8.3-8) was detected three times in shrub/swamp and fallow sugarcane habitats during the terrestrial bird surveys. It was also observed on the riverine surveys, and although it has a limited range, it is relatively common from the Essequibo River eastward through the Coastal Plain of Guyana and Suriname. The species is a year-round resident of forested and shrub habitats, including urban parks, gardens, and abandoned plantations.

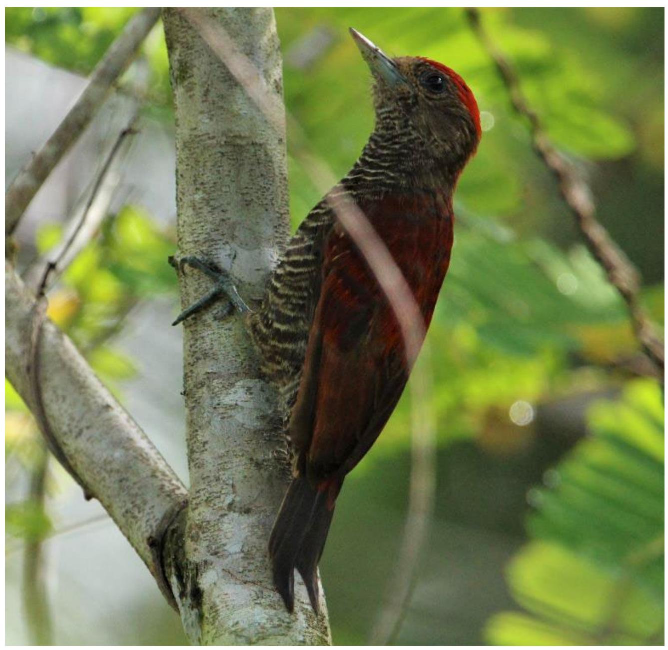
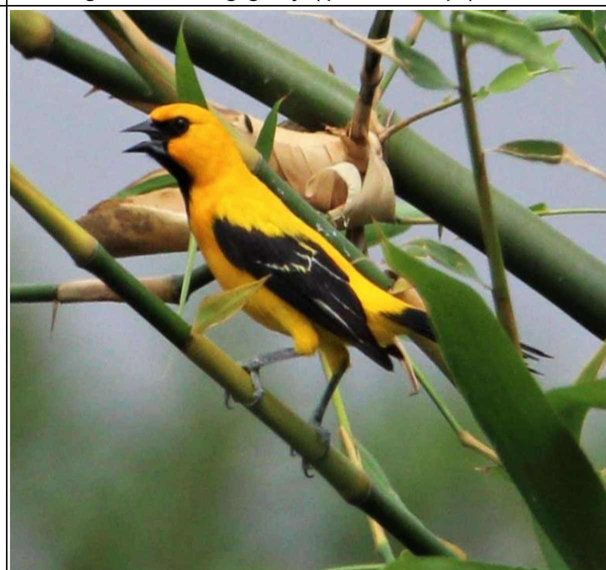


Figure 8.3-8: Blood-colored Woodpecker (*Dryobates sanguineus*), Male

Table 8.3-6: Representative Photographs of Terrestrial Birds Documented during Surveys of the Onshore Direct AOI

 Black-crested Antshrike (*Sakesphorus canadensis*)	 Tropical Mockingbird (*Mimus gilvus*)
 Spotted Tody-Flycatcher (*Todirostrum maculatum*)	 Southern Lapwing (*Vanellus chilensis*)

 Wing-barred Seedeater (*Sporophila americana*)	 Black-throated Mango (*Anthracothorax nigricollis*) feeding on morning glory (*Ipomoea* sp.)
 Roadside Hawk (*Rupornis magnirostris*)	 Yellow Oriole (*Icterus nigrogularis*)

8.3.2.3. Riverine Birds

The riverine portion of the Direct AOI includes the lower Demerara River and associated shoreline habitats. The biological conditions within and along the lower Demerara River have been degraded following decades of industrial and other human activities. There is considerable boat traffic on this portion of the river, where docking and maintenance support for many marine industries (e.g., fishing, shipping, and oilfield services) is centered. The river level fluctuates both daily and seasonally, with peak flows during two periods of high rainfall (May to June, and January to February), and lowest flows occurring from November to March (Lehman 2004). During daily low tides, extensive mudflats are exposed along the river edge, where many waterbird species congregate to forage and rest.

Settled centuries ago, the area immediately adjacent to the lower Demerara River features a largely urbanized landscape on the East Bank of the river, including the City of Georgetown, and predominantly agricultural land on the West Bank. What little natural habitat remains along the river is mostly confined to the river edge, where mangroves dominate in the brackish, tidal ecosystem, and on small islands further upriver, such as Inver Island near Land of Canaan (see the Bird Concentration Areas subsection below).

Despite the limited high quality habitats, the lower Demerara River supports a diverse avifauna due to a variety of factors, including the area's proximity to the Atlantic Ocean and the diversity of both aquatic and terrestrial habitats along the coastline and inland along the river. The high productivity of Guyana's coastal zone, including the lower portions of major river systems including the Demerara River, support diverse ecosystems with abundant birdlife, and many of Guyana's bird species are restricted to this zone.

Historical Data

Previous information on the avifauna of the lower Demerara River consists mainly of anecdotal accounts and species lists posted to the eBird database (eBird 2022). A review of the eBird database revealed records of 44 bird species dating back to 2007 (eBird 2022). However, based on anecdotal information and the EEPGL-commissioned riverine bird surveys conducted in the lower Demerara River, the true number of bird species that occur along the lower Demerara River is far higher.

The mouth of the Demerara River and its adjacent coastline support many species of aquatic birds including pelicans; frigatebirds; gulls and terns; herons, egrets, and ibises; and sandpipers and plovers, all of which frequent coastal and riverine forests and mudflats and nearshore and offshore marine waters, using both artificial structures and mangrove-dominated forest fragments for roosting, foraging, and breeding. The same mangrove habitats harbor a suite of resident landbirds, several of which are restricted to the mangrove biome, including Mangrove Cuckoo (*Coccyzus minor*), Rufous Crab Hawk (*Buteogallus aequinoctialis*), and Bicolored Conebill (*Conirostrum bicolor*). Due to their relative inaccessibility, mangroves offer safe roost sites for many bird species, and large evening congregations regularly occur in areas with extensive shoreline mangroves (see the Bird Concentration Areas subsection below).

Guyana's riverine and coastal avifauna is considerably more dynamic than the terrestrial avifauna, with many species showing large fluctuations in abundance over the course of a year. Most terrestrial bird species breed year-round in Guyana, whereas aquatic species are more seasonal, with breeding periods concentrated toward the end of the dry season (from February through April). Although some marine and coastal aquatic bird species—particularly terns and skimmers—range inland during this time to breed on exposed river sandbars, most species of waterbirds (e.g., herons, ibis, egrets) remain in the coastal zone and form large breeding colonies in mangrove fragments and other sites with limited human activity/disturbance. Adults and young disperse widely after breeding, and many individuals return to the same breeding site each breeding period.

Baseline Survey Results

EEPGL commissioned a series of monthly riverine bird surveys spanning wet and dry seasons in the lower Demerara River and the immediately adjacent portion of the Guyana coastline west of the Demerara River from late July 2021 through early December 2021. Guyanese bird specialists conducted a total of four survey events, each encompassing 4 days of surveys (16 total survey days). Surveys were conducted via boat at 15 pre-established survey points along the coastline (T1 to T3) and river (B1 to B12) (Figure 8.3-9) between 6:00 a.m. and 6:00 p.m. (sunrise to sundown) concurrent with river mammal surveys (see Section 8.4.2.4, Riverine Mammals). Surveyors conducted 15-minute point count surveys at each of the survey points. At each survey site, all birds seen and heard during the 15-minute surveys were recorded.

The riverine bird surveys detected 114 species across all survey sites. An additional 22 species have been reported to eBird (eBird 2022) between 2007 and 2021 at four sites located along the lower Demerara River within the survey area, bringing the number of species known from this area to 136 (Table 8.3-7). It should be noted that numerous species are known to occur in this area that were not detected on the surveys or recorded in eBird. The 136 species span seven bird species groups including raptors (17 species), waterfowl (1 species), waterbirds (17 species), shorebirds (9 species), marine birds (5 species), coastal birds (3 species), and landbirds (84 species) (Table 8.3-7).

The majority of birds (107 species) documented during the riverine bird survey and through eBird records are permanent residents, found throughout the year in coastal Guyana, although their numbers may vary substantially on a seasonal basis. An additional 19 species are long-distance migrants from North America (17 species) or southern South America and the Caribbean Basin (one species each). Ten additional species occur in Guyana year-round, but have both resident and non-resident (migrant) populations that mix at certain times of the year. The most abundant species in the dataset are those that tend to form large concentrations, usually for roosting but also sometimes for feeding and breeding. These include Snowy Egret (*Egretta thula*), Cattle Egret, Great Egret (*Ardea alba*), Semipalmated Sandpiper (*Calidris pusilla*), Scarlet Ibis (*Eudocimus ruber*), Orange-winged Parrot (*Amazona amazonica*), and Gray-breasted Martin (*Progne chalybea*). The cumulative counts for these species alone account for 63.5% of all birds observed during the riverine bird surveys.

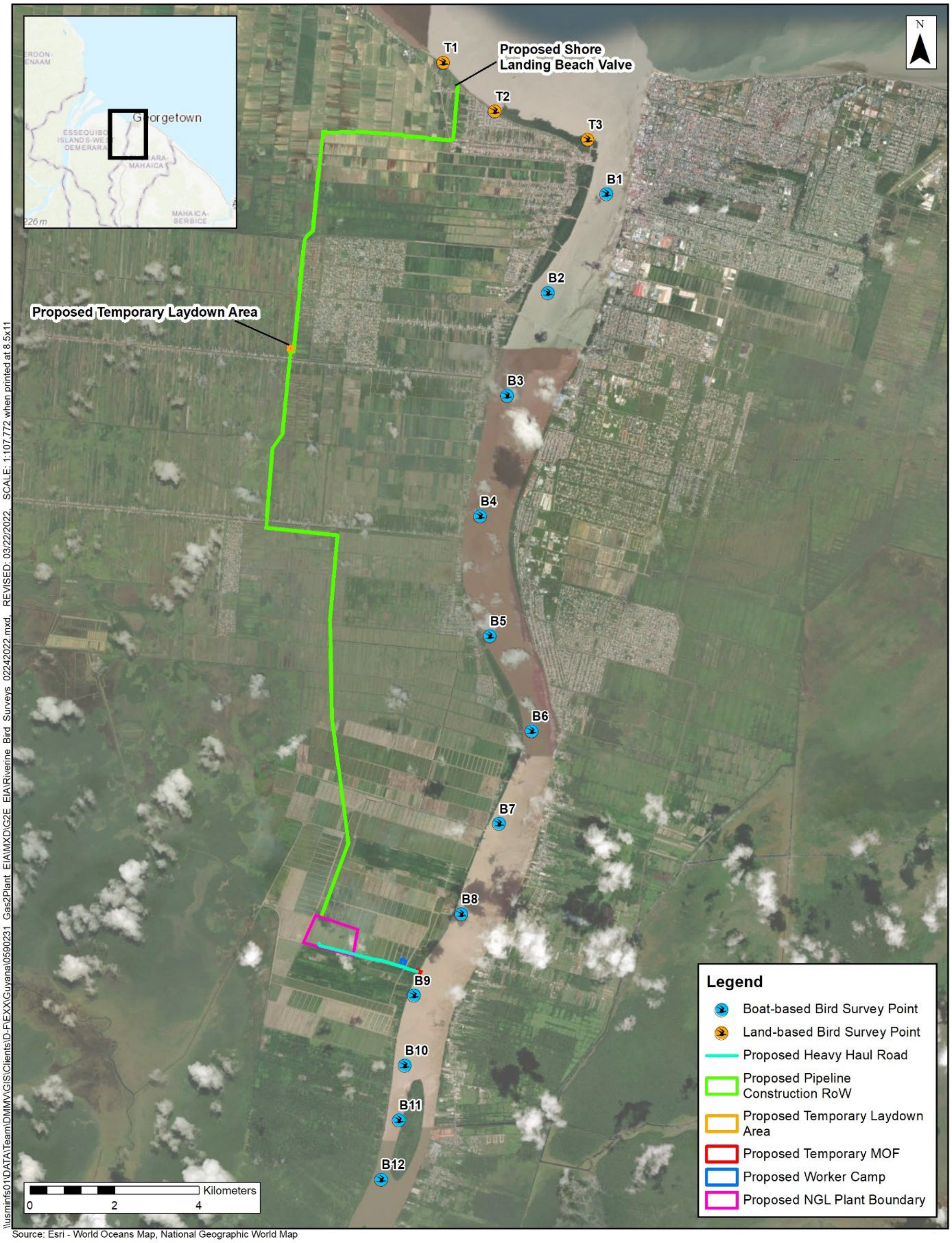


Figure 8.3-9: Riverine Bird Survey Locations within the Riverine Component of the Direct AOI

The data indicate that the species composition of the bird community and the abundance of certain species varies throughout the year. Data from the monthly surveys that spanned from July to December 2021 reveal that only 5 of 114 species were seen on every survey, whereas 42 species were observed only once. This suggests strongly that additional species would be added to the species list with continued survey effort. Abundance data also reflect a highly dynamic avifauna in the survey area. Total counts of the most numerous species (all surveys combined) (i.e., Snowy Egret and Cattle Egret) varied by up to three orders of magnitude from one month to the next. For some species, notably migrant shorebirds, variation in abundance was due to the presence of transient individuals during migration; as expected, many long-distance migrant species' peak counts occurred near the peak of southbound migration in September and October. However, for resident (non-migrant) species, there was no clear seasonal abundance pattern. It should be noted that, except in extreme circumstances, surveys were conducted regardless of time of day, tide stage, or weather. All of these factors may have affected the detectability of birds or influenced their distributions around the survey points.

Table 8.3-7: Birds Observed During Riverine Bird Surveys Conducted within the Onshore Direct AOI from July to early December 2021 and Reported from eBird 2017–2021

Scientific Name	Common Name	Observed during Riverine Bird Surveys	Species Group/Life History	Resident/ Migrant[a]	Colonial Breeder
Circus buffoni	Long-winged Harrier		Raptor	Resident	
Buteogallus aequinoctialis	Rufous Crab Hawk	X	Raptor	Resident	
Rostrhamus sociabilis	Snail Kite	X	Raptor	Resident	X
Busarellus nigricollis	Black-collared Hawk	X	Raptor	Resident	
Rostrhamus hamatus	Slender-billed Kite	X	Raptor	Resident	
Rupornis magnirostris	Roadside Hawk	X	Raptor	Resident	
Buteo albonotatus	Zone-tailed Hawk	X	Raptor	Resident	
Cathartes aura	Turkey Vulture	X	Raptor	Resident	
Coragyps atratus	Black Vulture	X	Raptor	Resident	
Cathartes burrovianus	Lesser Yellow-headed Vulture	X	Raptor	Resident	
Cathartes melambrotus	Greater Yellow-headed Vulture	X	Raptor	Resident	
Milvago chimachima	Yellow-headed Caracara	X	Raptor	Resident	
Caracara cheriway	Crested Caracara	X	Raptor	Resident	
Herpetotheres cachinnans	Laughing Falcon	X	Raptor	Resident	
Falco peregrinus	Peregrine Falcon	X	Raptor	Migrant	
Pandion haliaetus	Osprey	X	Raptor	Migrant	
Tyto alba	Barn Owl		Raptor	Resident	
Dendrocygna autumnalis	Black-bellied Whistling Duck	X	Waterfowl	Resident	

Scientific Name	Common Name	Observed during Riverine Bird Surveys	Species Group/Life History	Resident/ Migrant[a]	Colonial Breeder
Chloroceryle aenea	American Pygmy Kingfisher		Waterbird	Resident	
Chloroceryle Americana	Green Kingfisher		Waterbird	Resident	
Megaceryle torquata	Ringed Kingfisher	X	Waterbird	Resident	
Anhinga	Anhinga	X	Waterbird	Resident	X
Aramus guarana	Limpkin	X	Waterbird	Resident	
Ardea alba	Great Egret	X	Waterbird	Resident/ Migrant	X
Bubulcus ibis	Cattle Egret	X	Waterbird	Resident/ Migrant	X
Egretta caerulea	Little Blue Heron	X	Waterbird	Resident/ Migrant	X
Nycticorax nycticorax	Black-crowned Night Heron	X	Waterbird	Resident/ Migrant	X
Egretta tricolor	Tricolored Heron	X	Waterbird	Resident/ Migrant	X
Egretta thula	Snowy Egret	X	Waterbird	Resident/ Migrant	X
Nyctanassa violacea	Yellow-crowned Night Heron	X	Waterbird	Resident/ Migrant	X
Butorides striata	Striated Heron	X	Waterbird	Resident	
Ardea cocoi	Cocoi Heron	X	Waterbird	Resident	X
Fregata magnificens	Magnificent Frigatebird	X	Waterbird	Resident	X
Opisthocomus hoazin	Hoatzin		Waterbird	Resident	X
Eudocimus ruber	Scarlet Ibis	X	Waterbird	Resident	X
Actitis macularius	Spotted Sandpiper	X	Shorebird	Migrant	
Numenius phaeopus	Whimbrel	X	Shorebird	Migrant	
Calidris pusilla	Semipalmated Sandpiper	X	Shorebird	Migrant	
Tringa flavipes	Lesser Yellowlegs	X	Shorebird	Migrant	
Calidris alba	Sanderling	X	Shorebird	Migrant	
Calidris fuscicollis	White-rumped Sandpiper	X	Shorebird	Migrant	
Arenaria interpres	Ruddy Turnstone	X	Shorebird	Migrant	
Tringa solitaria	Solitary Sandpiper	X	Shorebird	Migrant	
Charadrius semipalmatus	Semipalmated Plover	X	Shorebird	Migrant	
Larus fuscus	Lesser Black-backed Gull		Marine Bird	Migrant	
Leucophaeus atricilla	Laughing Gull	X	Marine Bird	Migrant	
Phaetusa simplex	Large-billed Tern	X	Marine Bird	Resident	
Sterna hirundo	Common Tern	X	Marine Bird	Migrant	
Thalasseus maximus	Royal Tern	X	Marine Bird	Migrant	

Scientific Name	Common Name	Observed during Riverine Bird Surveys	Species Group/Life History	Resident/ Migrant[a]	Colonial Breeder
Rynchops niger	Black Skimmer	X	Coastal Bird	Resident	
Pelecanus occidentalis	Brown Pelican	X	Coastal Bird	Resident	X
Nannopterum brasilianum	Neotropic Cormorant	X	Coastal Bird	Resident	X
Mimus gilvus	Tropical Mockingbird	X	Landbird	Resident	
Setophaga petechia	Yellow Warbler	X	Landbird	Migrant	
Chaetura brachyura	Short-tailed Swift	X	Landbird	Resident	
Tachornis squamata	Fork-tailed Palm Swift	X	Landbird	Resident	
Hydropsalis maculicaudus	Spot-tailed Nightjar		Landbird	Resident	
Vanellus chilensis	Southern Lapwing	X	Landbird	Resident	
Leptotila rufaxilla	Gray-fronted Dove	X	Landbird	Resident	
Columbina talpacoti	Ruddy Ground Dove	X	Landbird	Resident	
Patagioenas subvinacea	Ruddy Pigeon	X	Landbird	Resident	
Columba livia	Rock Pigeon (Feral Pigeon)	X	Landbird	Resident	
Columbina passerina	Common Ground Dove	X	Landbird	Resident	
Patagioenas cayennensis	Pale-vented Pigeon	X	Landbird	Resident	
Leptotila verreauxi	White-tipped Dove	X	Landbird	Resident	
Coccyzus minor	Mangrove Cuckoo		Landbird	Resident	
Tapera naevia	Striped Cuckoo		Landbird	Resident	
Crotophaga major	Greater Ani	X	Landbird	Resident	
Crotophaga ani	Smooth-billed Ani	X	Landbird	Resident	
Euphonia violacea	Violaceous Euphonia		Landbird	Resident	
Certhiaxis cinnamomeus	Yellow-chinned Spinetail	X	Landbird	Resident	
Dendroplex picus	Straight-billed Woodcreeper	X	Landbird	Resident	
Synallaxis albescens	Pale-breasted Spinetail	X	Landbird	Resident	
Galbula galbula	Green-tailed Jacamar	X	Landbird	Resident	
Heliornis fulica	Sungrebe		Landbird	Resident	
Progne tapera	Brown-chested Martin		Landbird	Resident/ Migrant	
Tachycineta albiventer	White-winged Swallow	X	Landbird	Resident	
Progne chalybea	Gray-breasted Martin	X	Landbird	Resident/ Migrant	
Hirundo rustica	Barn Swallow	X	Landbird	Migrant	
Icterus nigrogularis	Yellow Oriole		Landbird	Resident	
Icterus cayanensis	Epaulet Oriole		Landbird	Resident	

Scientific Name	Common Name	Observed during Riverine Bird Surveys	Species Group/Life History	Resident/ Migrant[a]	Colonial Breeder
Chrysomus icterocephalus	Yellow-hooded Blackbird	X	Landbird	Resident	
Molothrus bonariensis	Shiny Cowbird	X	Landbird	Resident	
Cacicus cela	Yellow-rumped Cacique	X	Landbird	Resident	X
Molothrus oryzivorus	Giant Cowbird	X	Landbird	Resident	
Quiscalus lugubris	Carib Grackle	X	Landbird	Resident	
Psarocolius decumanus	Crested Oropendola	X	Landbird	Resident	X
Jacana jacana	Wattled Jacana	X	Landbird	Resident	
Dryocopus lineatus	Lineated Woodpecker	X	Landbird	Resident	
Veniliornis sanguineus	Blood-colored Woodpecker	X	Landbird	Resident	
Picumnus spilogaster	White-bellied Piculet	X	Landbird	Resident	
Pionus menstruus	Blue-headed Parrot		Landbird	Resident	
Amazona amazonica	Orange-winged Parrot	X	Landbird	Resident	
Amazona ochrocephala	Yellow-crowned Parrot	X	Landbird	Resident	
Orthopsittaca manilata	Red-bellied Macaw	X	Landbird	Resident	
Ara ararauna	Blue and Yellow Macaw	X	Landbird	Resident	
Diopsittaca nobilis	Red Shouldered Macaw	X	Landbird	Resident	
Eupsittula pertinax	Brown-throated Parakeet	X	Landbird	Resident	
Aramides cajanea	Grey-cowled Wood Rail	X	Landbird	Resident	
Ramphastos tucanus	White-throated Toucan	X	Landbird	Resident	
Sakesphorus canadensis	Black-crested Antshrike	X	Landbird	Resident	
Sclateria naevia	Silvered Antbird	X	Landbird	Resident	
Thraupis palmarum	Palm Tanager		Landbird	Resident	
Sporophila americana	Wing-barred Seedeater		Landbird	Resident	
Paroaria gularis	Red-capped Cardinal		Landbird	Resident	
Saltator olivascens	Olivaceous Saltator	X	Landbird	Resident	
Tangara mexicana	Turquoise Tanager	X	Landbird	Resident	
Thraupis episcopus	Blue-grey Tanager	X	Landbird	Resident	
Coereba flaveola	Bananaquit	X	Landbird	Resident	
Ramphocelus carbo	Silver-beaked Tanager	X	Landbird	Resident	
Stilpnia cayana	Burnished-buff Tanager	X	Landbird	Resident	
Sicalis luteola	Grassland Yellow-Finch	X	Landbird	Resident	
Conirostrum bicolor	Bicolored Conebill	X	Landbird	Resident	
Volatinia jacarina	Blue-black Grassquit	X	Landbird	Resident	
Chrysuronia brevirostris	White-chested Emerald		Landbird	Resident	

Scientific Name	Common Name	Observed during Riverine Bird Surveys	Species Group/Life History	Resident/ Migrant[a]	Colonial Breeder
Chrysuronia leucogaster	Plain-bellied Emerald		Landbird	Resident	
Anthracothorax nigricollis	Black-throated Mango		Landbird	Resident	
Troglodytes aedon	House Wren	X	Landbird	Resident	
Turdus leucomelas	Pale-breasted Thrush		Landbird	Resident	
Pitangus sulphuratus	Great Kiskadee	X	Landbird	Resident	
Todirostrum maculatum	Spotted Tody Flycatcher	X	Landbird	Resident	
Tyrannus savana	Fork-tailed Flycatcher	X	Landbird	Migratory	
Myiozetetes cayanensis	Rusty-margined Flycatcher	X	Landbird	Resident	
Tyrannus melancholicus	Tropical Kingbird	X	Landbird	Resident/ Migrant	
Camptostoma obsoletum	Southern Beardless Tyrannulet	X	Landbird	Resident	
Inezia caudata	Pale-tipped Tyrannulet	X	Landbird	Resident	
Myiarchus ferox	Short-crested Flycatcher	X	Landbird	Resident	
Pitangus lictor	Lesser Kiskadee	X	Landbird	Resident	
Megarynchus pitangua	Boat-billed Flycatcher	X	Landbird	Resident	
Elaenia flavogaster	Yellow-bellied Elaenia	X	Landbird	Resident	
Legatus leucophaius	Piratic Flycatcher	X	Landbird	Resident	
Phaeomyias murina	Mouse-colored Tyrannulet	X	Landbird	Resident	
Tolmomyias flaviventris	Yellow-breasted Flycatcher	X	Landbird	Resident	
Tyrannus dominicensis	Gray Kingbird	X	Landbird	Migrant	
Todirostrum cinereum	Common Tody Flycatcher	X	Landbird	Resident	
Hylophilus pectoralis	Ashy-headed Greenlet	X	Landbird	Resident	

[a] Species marked "Resident/Migrant" are present in Guyana year-round, but are either nomadic or are represented by both resident and migrant populations at various points in the year.

Species of Conservation Interest

The lower Demerara River supports four categories of birds with elevated biological importance due to their conservation status and/or life history (e.g., coloniality, migratory status, limited geographic distribution, habitat association):

- *Special status species*: There are eight special status bird species that occur in the riverine portion of the Direct AOI. These include two migratory shorebird species Semipalmated Sandipiper (*Calidris pusilla*) and Red Knot (*C. canutus*) that feed on the mudflats along the lower Demerara River, and six other species that occur in the riparian and mangrove forest habitats along the river's edge including Agami Heron, Rufous Crab Hawk, Bicolored

Conebill, White-bellied Piculet (*Picumnus spilogaster*), White-throated Toucan, and Channel-billed Toucan. With the exception of Agami Heron and Channel-billed Toucan, all of these species were observed during the riverine bird surveys conducted in 2021. Agami Heron and Channel-billed Toucan are known to occur in the area based on eBird records (eBird 2022). Section 8.6, Special Status Species, provides additional information about these species.

- *Colonial waterbirds*: The area contains known roosting and breeding sites for waterbirds, primarily herons, ibis, and egrets, which form colonies in undisturbed riverine (particularly mangrove forest) vegetation and on small riverine and nearshore coastal islands. The number of birds in these aggregations can be substantial, numbering hundreds or thousands of individuals. Other bird species often take advantage of the relative safety of these relatively isolated habitats to roost, either mixed among the waterbirds or in separate areas. The most numerous of these other cohabitating species are the Snail Kite (*Rostrhamus sociabilis*), Orange-winged Parrot, and (seasonally) Fork-tailed Flycatcher (*Tyrannus savana*).
- *Seasonal migrants*: The coast of the Guianas is well known to be a major stopover area for shorebirds migrating between breeding grounds in the Arctic and wintering areas in southern South America. Many species of sandpipers and plovers occur on mudflats and in mangroves along and adjacent to the lower Demerara River. As a group, shorebirds are in decline due in part to overhunting, coastal development, and pollution, and are therefore of international conservation concern. Nine species of migratory shorebirds were observed during the riverine bird surveys in the lower Demerara River. Two of these species (the Semipalmated Sandpiper and Red Knot) are considered special status species because of their international threatened status (see Section 8.6, Special Status Species, for more information).
- *Ecologically specialized species*: The Hoatzin (*Opisthocomus hoazin*) is not considered a special status species but is a habitat specialist and important culturally, as it is Guyana's national bird. This species is confined to riparian vegetation and there is an unconfirmed report from 2010 of Hoatzins near Land of Canaan upriver from the proposed temporary MOF, but their current status in the area is unknown. The Rufous Crab Hawk is restricted to mangrove habitats and does not occur inland; it feeds principally on crabs, and is therefore vulnerable to habitat degradation from pollution and removal or disturbance of mangroves. This species was observed 25 times along the lower Demerara River shoreline during the riverine bird surveys conducted from July to early December 2021.

Bird Concentration Areas

The riverine bird surveys documented eight bird concentration areas (BCAs) where concentrations of birds were reliably observed during the monthly riverine bird survey events or where birds are known to congregate based on information from local experts and eBird data (eBird 2022). These areas contain a mix of foraging, roosting, and breeding activities by waterbirds and other cohabitating bird species. Figure 8.3-10 depicts the location of these eight BCAs and the type of bird use at each site.

Most notable of these eight BCAs are two island habitats: (1) a sunken barge located near the mouth of the Demerara River that now supports a dense mangrove forest (BCA #1 on Figure 8.3-10 and Table 8.3-8); and (2) Inver Island, which is a forested island located in the middle of the Demerara River near Land of Canaan, approximately 2 kilometers upstream from the proposed temporary MOF site (BCA #8 on Figure 8.3-10 and Table 8.3-8). The sunken barge island supports thousands of roosting and nesting waterbirds, particularly Snowy Egret, Cattle Egret, Black-crowned Night-Heron (*Nycticorax nycticorax*), Yellow-crowned Night-Heron (*Nyctanassa violacea*), and Magnificent Frigatebird (*Fregata magnificens*), but also many other species of waterbirds, coastal birds, and raptors. Inver Island supports thousands of roosting Orange-winged Parrots, and several other species of parrots (including three species of macaws) are known to congregate on this island for communal roosting and possibly breeding.

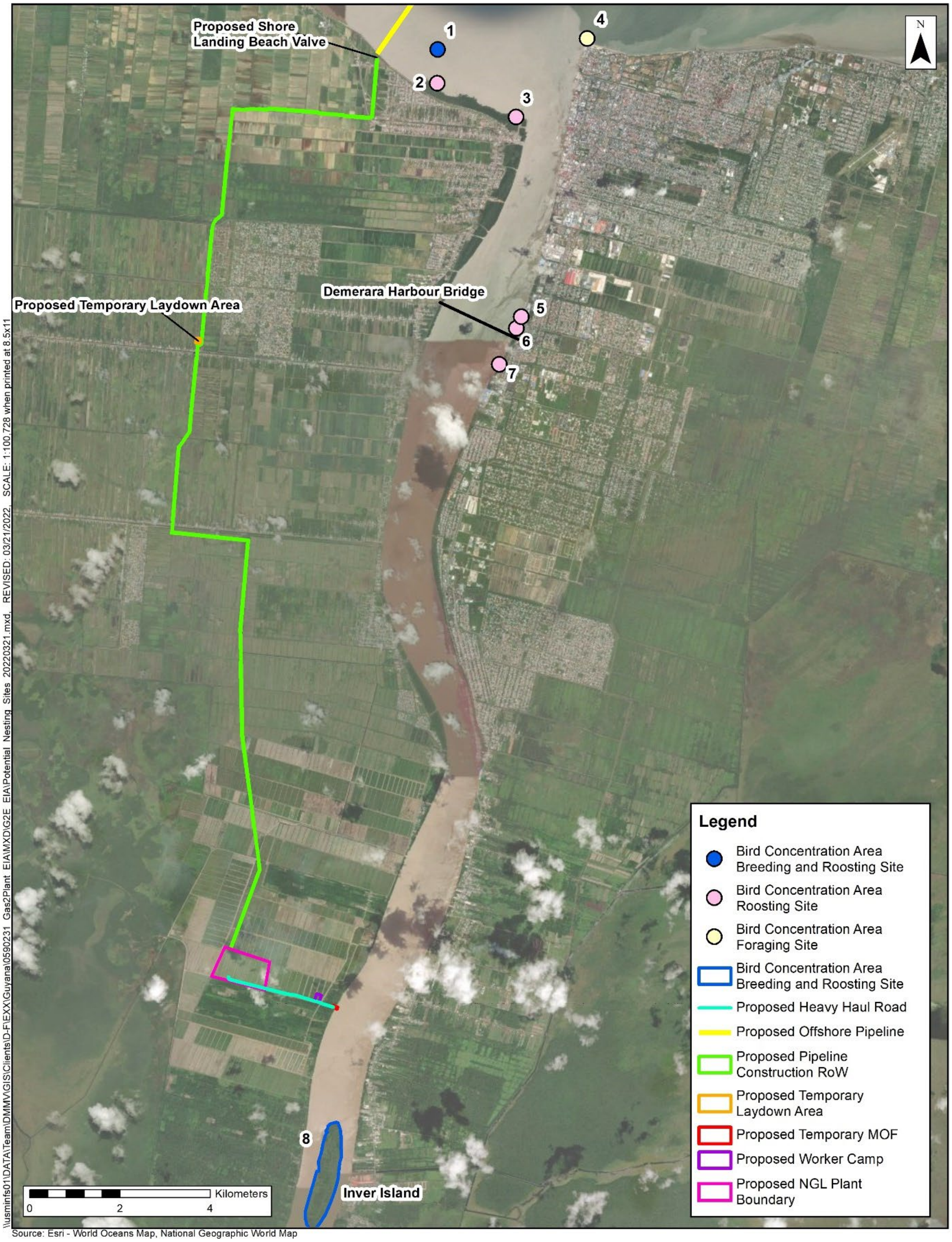
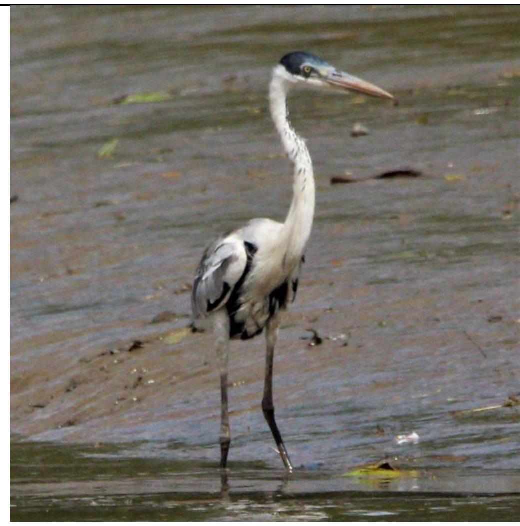


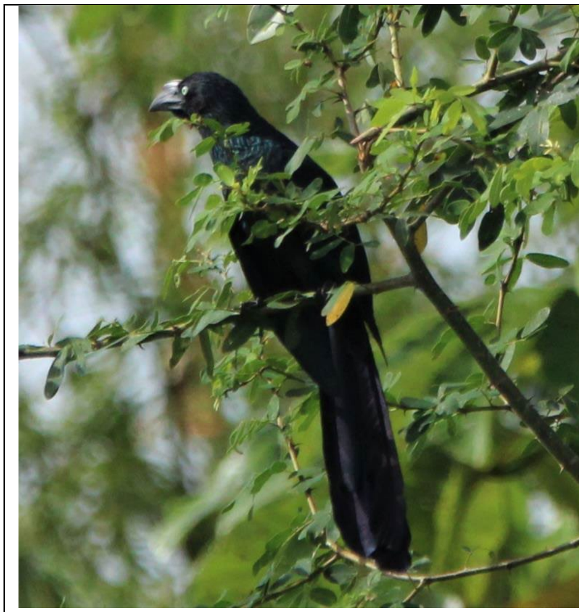
Figure 8.3-10: Bird Concentration Areas along the Lower Demerara River and Adjacent Coastline

Table 8.3-8: Photographs of Sunken Barge Island and Inver Island Bird Concentration Areas within the Coastal Portion of the Project AOI

 Aerial view of the sunken barge island (white spots on trees are roosting or nesting waterbirds).	 Sunken barge island with Magnificent Frigatebird (*Fregata magnificens*) and Cattle Egret (*Bubuculus ibis*) present.
 Congregation of roosting Snowy Egret (*Egretta thula*), Cattle Egret (*Bubulcus ibis*), Black-crowned Night-Heron (*Nycticorax nycticorax*), and Snail Kite (*Rostrhamus sociabilis*) roosting on the sunken barge island.	 Blue-and-yellow Macaw (*Ara ararauna*) flying near Inver Island.
 Breeding Cattle Egrets (*Bubuculus ibis*) on the sunken barge island.	 Blue-and-yellow Macaw (*Ara araruana*) flock on Inver Island.

Table 8.3-9: Representative Photographs of Riverine Birds Observed During Field Surveys of the Lower Demerara River

 Scarlet Ibis (*Eudocimus ruber*) subadult on the bank of the Demerara River.	 Little Blue Heron (*Egretta caerulea*) flying over the lower Demerara River.
 Spotted Sandpiper (*Actitis macularius*) flying over the lower Demerara River.	 Cocoi Heron (*Ardea cocoi*) on a mud bank along the shore of the Demerara River.



Greater Ani (*Crotophaga major*) in riparian forest along the bank of the lower Demerara River.

Snail Kite (*Rostrhamus sociabilis*) perched in a black mangrove tree along the bank of the lower Demerara River.

8.3.2.4. Terrestrial Mammals

Historical Data

There are no published terrestrial mammal surveys of the onshore Direct AOI or surrounding area. There are 225 species of mammals known to occur in Guyana, most of which occur in the country's interior region (Engstom and Lim 2008). Of the 225 species, 121 are terrestrial, non-volant species and 104 are flying mammals (mostly bats).

Baseline Survey Results

Surveys of mammals within the Onshore Direct AOI were conducted using a variety of methods from November 2021 through February 2022. Direct survey methods included transect surveys, camera trap surveys, and otter surveys. During transect surveys, Guyanese specialists walked along trails and access roads and documented all mammals seen and heard and recorded the occurrence of tracks, scat, and other signs of habitat use by mammals. These transects were surveyed multiple times during the dry and wet seasons.

Camera trap surveys for terrestrial mammals were conducted from December 2021 through February 2022 at 13 locations within the onshore Direct AOI: specifically, at the proposed NGL Plant site, along or near the onshore pipeline corridor near Crane Village, and where the onshore pipeline corridor crosses Canals 1 and 2. Cameras were placed opportunistically at sites suspected of being frequented by mammal species, such as potential mammal den sites, trails, feeding or drinking stations, and fallen trees across waterbodies. A total of 247 trap days (5,928 trap hours) were conducted during the sample period. Trail cameras equipped with 120-degree, wide-angle motion and night vision sensors were set to operate continuously and to wait approximately 10 seconds between photographs.

Based on the presence of potentially suitable otter habitat and historical and anecdotal evidence that Neotropical otter (*Lontra longicaudis*) and giant otter (*Pteronura brasiliensis*) (both are species of elevated conservation status; see Section 8.6, Special Status Species) may utilize the canal systems in and near the Project AOI, targeted surveys for otters were conducted via boat within canals within or crossed by the onshore pipeline corridor, as well as canals just outside the Direct AOI that could form part of territories for the species. The areas surveyed included:

- The canal from the Free and Easy koker to the onshore pipeline corridor
- The canals along Parfaite Harmonie
- The canal at Parfaite backlands
- The canal at the end of Cogland Dam
- The canals within Wales Estate

The survey methodology followed the IUCN standardized methodology for conducting distribution surveys for giant otter (Groenendijk et al. 2005), during which all potential dens and campsites (rest areas) of the species were marked with a global positioning system (GPS) unit, and notes on their use status (in use versus not in use) were made. Opportunistic sightings were also recorded. During the surveys, Guyanese specialists surveyed the shoreline for otters and evidence of otter dens, food caches, and campsites. Camera traps were also placed near potential otter trails in an attempt to photograph otter use of the area.

Figure 8.3-11: Surveyor Attaching a Camera Trap on a Tree near an Animal Trail

In addition to the camera trap and otter surveys, incidental observations of mammals were recorded during other survey activities being conducted in the onshore Direct AOI. Table 8.3-10 lists the mammal species documented during baseline surveys conducted within the Onshore Direct AOI and the method by which each species was documented.

Table 8.3-10: Mammal Species Documented during Surveys of the Onshore Direct AOI

Order/Family/Species Scientific Name	Common Name	Visual Sighting	Tracks	Camera Traps	Scat	Other
CARNIVORA						
Mustelidae						
Eira barbara	Tayra		7		1	
Pteronura brasiliensis	Giant otter	3				Den, Crossover
Lontra longicaudis	Neotropical otter	1				
Felidae						
Leopardus pardalis	Ocelot			2		
Procyonidae						
Procyon cancrivorus	Crab-eating raccoon	1	10	6	2	
Canidae						
Cerdocyon thous	Crab-eating fox		1	1	1	
PRIMATA						
Atelidae						
Alouatta seniculus	Howler monkey	15				
Cebidae						
Saimiri sciureus	Squirrel monkey	5				
Cebus apella	Brown capuchin	11				
RODENTIA						
Cavidae						
Hydrochoerus hydrochaeris	Capybara		3		1	
Cuniculidae						
Cuniculus paca	Labba		1	1		
Dasyproctidae						
Dasyprocta agouti	Red-rumped agouti	2	3			

In total, there were 73 mammal observations during the survey period along the proposed onshore pipeline corridor and at the proposed NGL Plant site. These included 12 species from three mammalian orders and nine families (Table 8.3-10). All of the 12 species recorded were found along the proposed onshore pipeline corridor or in and along canals within or near the pipeline corridor. Observations at the proposed NGL Plant site included tayra (*Eira barbara*), crab-eating raccoon (*Procyon cancrivorus*), crab-eating fox (*Cerdocyon thous*), and howler monkey (*Alouatta seniculus*). The 12 mammal species recorded in the area represents approximately 10 percent of the 121 species of non-volant (flightless) mammals that are known to occur in Guyana.

The otter survey resulted in four sightings of otters and confirmed otter use, including one observation of Neotropical otter and three observations of giant otter. The Neotropical otter is relatively common in the area and has been previously documented in and around the Direct AOI. The observations of the giant otter are notable because of the highly elevated conservation status of this species, which is considered by scientists to be one of the most endangered mammals in South America (see Section 8.6, Special Status Species), and because they are the first known confirmed records of giant otter use of the area. Giant otters are known from more remote areas further inland and also the Boerasarie Conservancy located west of the Direct AOI. It is believed that the interconnected canal system where they were observed in and near the Direct AOI form part of their extensive territories that extend from the south and west into the Direct AOI. Individual giant otters and otter use areas were documented during the survey (Table 8.3-11 and Figure 8.3-12).

Table 8.3-12 includes representative photographs of mammal species observed during surveys within the Onshore Direct AOI.

Table 8.3-11: Summary of Giant Otter Survey Results Within and Near the Direct AOI

Siting ID Number	Type of Observation	Location	GPS Coordinate	Elevation (meter)	Sighting Description
1	Sighting	Parfaite Canal	N 06.79064° W058.23875°	3	1 individual Adult
2	Sighting	Parfaite Canal	N 06.79067° W058.23868°	6	1 individual Adult
3	Sighting	Parfaite Canal	N 06.79061° W058.23883°	6	3 individuals
4	Den	Canal from Free and Easy koker to onshore pipeline corridor	N 06.66860° W058.21576	13	Den along bank of canal, In use
5	Crossover point from canal to land	Parfaite Canal	N 06.79165° W058.23364°	3	Fresh and regularly used exit point from canal onto bank of canal
6	Crossover point from canal to land	Parfaite Canal	N 06.78993° W058.20702°	3	Fresh and regularly used exit point from canal onto bank of canal
7	Campsite	Parfaite Canal	N 06.79172° W058.23498°	2	Area used for fecal deposition on land, which is used for territory marking; Active use

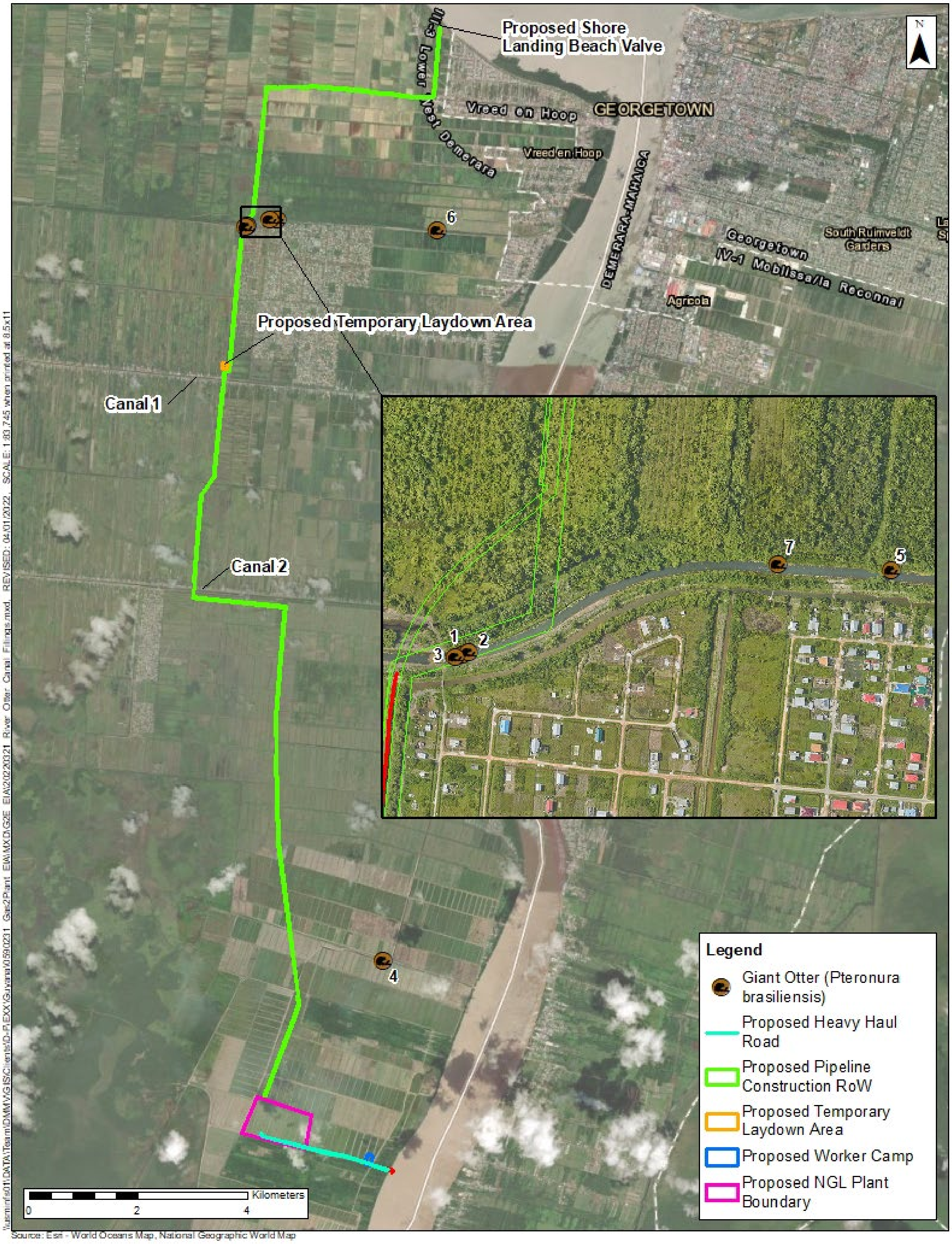


Figure 8.3-12: Locations of Giant Otter Observations (Including Individuals or Evidence of Use) During Surveys Conducted within the Onshore Direct AOI

Table 8.3-12: Representative Photographs of Mammal Species Observed within the Onshore Direct AOI

 Labba (*Cuniculus paca*) documented with camera trap	 Ocelot (*Leopardus pardalis*) documented with camera trap
 Crab-eating raccoon (*Procyon cancrivorus*) documented with camera trap	 Crab-eating raccoon tracks
 Tayra (*Eira barbara*) tracks	 Crab-eating fox (*Cerdocyon thous*) scat

 Red-rumped agouti (*Dasyprocta agouti*) track	 Ocelot (*Leopardus pardalis*) track
 Neotropical otter (*Lontra longicaudis*) adult in Parfaite Harmonie canal	 Giant otter campsite along the bank of Parfaite Harmonie canal

Species of Conservation Interest

There are six species of mammals with elevated conservation status that occur in the Coastal Plain of Guyana: Neotropical otter, giant otter, giant anteater (*Myrmecophaga tridactyla*), bush dog (*Speothos venaticus*), lowland tapir (*Tapirus terrestris*), and white-lipped peccary (*Tayassu pecari*). Of these, two were observed during surveys conducted within the onshore Direct AOI, as described above: the Neotropical otter and giant otter were both observed in and around canal habitats, particularly the less disturbed canals including the canal that runs along Parfaite Harmonie. Most terrestrial mammals range widely and utilize a wide variety of habitats in search of food and cover. As such, all of the six species with elevated conservation status could occur as transients within any of the habitats in the onshore Direct AOI. Section 8.6, Special Status Species, provides additional information about these species.

8.3.2.5. Insects

Historical Data

There are no published terrestrial insect surveys of the onshore Direct AOI or surrounding area. Insect populations are intricately associated with habitat types and, in many cases, specific species of vegetation, so the expected insect assemblage for the Direct AOI can be inferred from the habitats and vegetation species present. Over 100 insect species are known to occur in Guyana's Coastal Plain, all of which are common in the region. Some species that are associated with agricultural habitats are non-native pest species.

Baseline Survey Results

A terrestrial insect survey within the onshore portion of the Direct AOI was conducted during the dry season (five sample sites sampled from 10 to 21 November 2021) and the wet season (eight sites sampled from 12 to 15 January 2022 and 6 to 14 February 2022). The terrestrial insect survey focused on areas within and immediately adjacent to canal and riverine habitats being sampled for the aquatic biodiversity survey, as many species of terrestrial insects spend part of their life cycle in the water (e.g., mayflies, dragonflies, etc.). Terrestrial insects were collected by manually (hand picking), examining the substrate, boulders, leaves, and submerged vegetation from waterways at each location.

The terrestrial insect surveys yielded a total of 932 individuals in 56 families across the dry and wet seasons. During both dry and wet seasons, Libelluidae (skimmer-dragonflies) was one of the dominant insect families recorded (Table 8.3-13). Site DD-08, located along a relatively undisturbed canal within Wales Estate, was the most family-rich and diverse site during both dry and wet seasons with high populations of Libellulidae, Chrysomelidae (leaf beetles), and Membracidae (treehoppers). The least family-rich site was Site CVR-04, located along a degraded canal near Cogland Dam, with pollution-tolerant Libellulidae, predatory Vespidae (eusocial wasps), and Syrphidae (hoverflies) dominating the insect assemblage. Site WW-13, located along a canal close to the Demerara River, had the highest total abundance of all sites surveyed, with high populations of Libelluidae and Tettigoniidae (katydids).

The health of the terrestrial habitats was assessed based on the presence of Chrysomelidae (leaf beetles), Tettigoniidae, Nymphalidae (brush-footed butterflies), Formicidae, and Termitidae (higher termites), as these families typically indicate healthier environments. The Chrysomelidae family was recorded in all of the sites sampled except one during the dry season and all but two sites during the wet season. Absence of individuals of this family indicates that the host plant necessary to the family was absent from the area, likely due to disturbance (Sánchez-Reyes et al. 2019; Wendorff and Schmitt 2019). Tettigoniidae were found in all habitats.

Butterflies of the families Nymphalidae, Pieridae (whites, sulphurs, and yellows), Lycaenidae (gossamer-winged butterflies), and Hesperiidae (skippers) were found in low numbers at all sites. The most common butterfly family that was found within all eight different sites sampled during both dry and wet seasons was Nymphalidae. This butterfly family is somewhat intolerant of pollution and disturbed conditions (Sousa et al. 2019; Porath and Aranda 2020). The

Libellulidae family was the most abundant and ubiquitous family of the terrestrial odonates (dragonflies and damselflies) recorded at the sites during both seasons. This family is relatively pollution-tolerant, as were the other families found at the survey sites.

In summary, the terrestrial insect population within the Onshore Direct AOI is quite diverse given the highly modified condition of the habitats present throughout most of the area, and the species assemblage mirrors the level of habitat degradation where they were found, containing a mix of disturbance tolerant and disturbance-sensitive species.

Table 8.3-13: Dominant Terrestrial Insect Families Documented during Surveys of the Onshore Direct AOI

Sample Site ID [a]	Season	Dominant Terrestrial Insect Families [b]	Percentage of Total Comprised by the Dominant Families
MB-01	Dry	Sphecidae, Pieridae, Libellulidae	46.15
	Wet	Cicadellidae, Lycaenidae, Acrididae	61.68
CD-10	Dry	Tettigoniidae, Formicidae, Chrysomelidae	59.18
	Wet	Phoridae, Tettigoniidae, Chironomidae	47.42
CC-11	Wet	Libellulidae, Tettigoniidae, Cicadellidae	57.78
CVR-04	Dry	Libellulidae, Vespidae, Syrphidae	50.00
	Wet	Membracidae, Libellulidae, Coenagrionidae, Acrididae	53.85
CC-12	Wet	Libellulidae, Formicidae, Nymphalidae, Acrididae	70.49
WW-13	Wet	Libellulidae, Pieridae, Tettigoniidae	59.54
DD-08	Dry	Libellulidae, Chrysomelidae, Membracidae	42.37
	Wet	Tettigoniidae, Libellulidae, Apidae	37.63
DDR-06/ DR-07	Dry	Formicidae, Termitidae, Vespidae	66.06
	Wet	Acrididae, Formicidae, Phoridae	53.23

[a] Figure 8.4-1 in Section 8.4, Freshwater Aquatic Biodiversity, depicts the location of these sample sites.
[b] In cases where the third and fourth most dominant taxa had the same abundance, both groups were considered as the third dominant.

Species of Conservation Interest

No terrestrial insect species of elevated conservation status is known or expected to occur in the Onshore Direct AOI or the surrounding area.

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Table 8.3-14: Representative Photographs of Terrestrial Insect Species Observed within the Onshore Direct AOI

 Tettigoniidae	 Pierdae
 Acrididae	 Apidae

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8.3.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on terrestrial biodiversity. The relevant planned Project activities and the associated potential impacts of these activities on terrestrial biodiversity are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

For the purpose of assessing the significance of potential impacts on terrestrial biodiversity, separate discussions are provided for terrestrial vegetation and terrestrial wildlife.

8.3.3.1. Terrestrial Vegetation

Relevant Project Activities and Potential Impacts

The planned Project activities that could affect terrestrial vegetation in the Project AOI are described under the three Project stages of Construction, Operations, and Decommissioning. Specific activities associated with each of these stages that could potentially impact terrestrial vegetation are identified and assessed at the resource-specific level. Table 8.3-15 summarizes the planned Project activities that could result in potential impacts on terrestrial vegetation and the key potential impacts of those activities.

Table 8.3-15: Summary of Relevant Project Activities and Key Potential Impacts—Terrestrial Vegetation

Stage	Project Activity	Key Potential Impacts
Construction	• Installation of the onshore pipeline • Construction of the NGL Plant, heavy haul road, and temporary MOF • Vegetation clearing • Earth moving / stockpiling materials • Construction and operation of worker accommodations • Creation of staging/material laydown areas	• Direct loss of vegetation • Vegetation conversion and degradation • Changes in habitat condition/quality • Topsoil loss/disturbance • Introduction or expansion of invasive or exotic species • Vegetation exposure to air emissions
Operations	• Operation and maintenance of the NGL Plant and onshore pipeline • Air emissions from the NGL Plant • Maintenance of the onshore pipeline RoW	• Vegetation management (maintenance in herbaceous state) • Vegetation exposure to air emissions
Decommissioning	• Decommissioning of Project facilities	• Changes in vegetation from managed condition to natural

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. For terrestrial vegetation, resource-specific definitions for intensity are used in lieu of the general intensity definitions (Table 8.3-16). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for terrestrial vegetation sensitivity are provided in Table 8.3-17.

Table 8.3-16: Definitions for Intensity Ratings for Potential Impacts on Terrestrial Vegetation

Criterion	Definition
Intensity	**Negligible**: No measurable ecosystem- or vegetation community-level changes; the ecosystem continues to function as it did prior to the Project activities occurring.
	Low: Changes are perceptible but affect only a small number of species and/or across a limited spatial area.
	Medium: Changes are perceptible and affect many species within the ecosystem or vegetation community, at more than one trophic level, and/or across a significant portion of the area that the ecosystem physically occupies.
	High: Changes affect numerous species throughout the vegetation community or ecosystem, such that the basic trophic and biodiversity characteristics of the ecosystem are substantially altered.

Table 8.3-17: Definitions for Resource Sensitivity Ratings for Potential Impacts on Terrestrial Vegetation

Criterion	Definition
Sensitivity	**Low**: Habitat integrity and function and species assemblage are highly modified and/or are capable of withstanding disturbance (physical and chemical) and degradation without reaching an irreversible ecological threshold (i.e., is highly resilient). Rare or disturbance-sensitive species are absent or uncommon. The biological community is dominated by non-native and/or habitat generalist species.
	Medium: Habitat integrity and function and species assemblage are modified and moderately resilient to disturbance and degradation. Rare or disturbance-sensitive species may be present but are not dominant.
	High: Habitat integrity and function and species assemblage are natural (i.e., minimal anthropogenic disturbance and high biodiversity value/function) and have low resilience to disturbance and degradation. The biological community is dominated by native and/or habitat specialist species and contains important habitat for or populations of rare species.

For the purpose of assessing significance of potential impacts on terrestrial vegetation, the key potential impacts presented in Table 8.3-15 are summarized in the following broad categories:

- Direct loss of terrestrial vegetation;
- Vegetation community conversion and vegetation degradation;
- Introduction and spread of invasive and/or exotic vegetation species; and
- Toxicological impacts on vegetation from air emissions.

Impact Magnitude Ratings—Terrestrial Vegetation

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to terrestrial vegetation is provided in Section 8.3-4, Impact Management and Monitoring Measures.

Direct Loss of Terrestrial Vegetation

Installation of the onshore pipeline will directly impact a total of approximately 138.4 hectares of terrestrial vegetation and habitat. Table 8.3-18 summarizes the permanent and temporary impacts of the Project according to the vegetation communities present in the onshore Direct AOI. Table 8.3-19 summarizes the proportion of impacts related to each of the onshore Project components. Although the onshore pipeline itself poses the largest impact on terrestrial vegetation in terms of geographic scale because of its length, the direct habitat loss from this component totals 58.5 hectares, which represents only 42.2 percent of the total vegetation impacts from the Project. The construction of the NGL Plant will result in the greatest impact on vegetation from the Project (75 hectares or 54.2 percent of the total impacts). Together, the impacts on vegetation from construction of the NGL Plant and installation of the onshore pipeline comprise 96.4 percent of the total vegetation impacts caused by the Project. The remaining Project facilities, including the heavy haul road, temporary MOF, construction laydown areas, and worker camp, will cause minimal impacts on vegetation (< 5 hectares).

Of the approximately 138.4 hectares of impacts on terrestrial vegetation and habitat resulting from construction of the Project, approximately 101.6 hectares will be permanent impacts and approximately 36.8 hectares will be temporary impacts. A summary of permanent and temporary impacts by vegetation community is provided in Table 8.3-18. Project development will result in the largest permanent impacts on the following vegetation communities: shrubland/swamp (approximately 69.5 hectares), herbaceous/grass swamp (approximately 12.8 hectares), and active agriculture (rice; approximately 5.5 hectares). The largest temporary impacts will occur to the following vegetation communities: active agriculture (rice; approximately 11.3 hectares), herbaceous grass/swamp (approximately 8.9 hectares), inactive agriculture (sugarcane; approximately 6.1 hectares), and active agriculture (pineapple; approximately 2.6 hectares). Areas impacted during construction, but not within the direct footprint of the NGL Plant or other permanent Project features, will revegetate following disturbance. As such, impacts on vegetation in these areas are temporary rather than permanent.

Table 8.3-18: Terrestrial Vegetation Impacts According to Vegetation Community

Vegetation Community	Temporary Impact Area (hectare)	Permanent Impact Area (hectare)	Total Impact Area (hectare)	Percent of Total Impacts (%)
Active Agriculture (Rice)	11.3	5.5	16.8	12.2
Active Agriculture (Pineapple)	2.6	0.4	3.1	2.2
Inactive Agriculture (Sugarcane)	6.1	2.1	8.2	6.0

Vegetation Community	Temporary Impact Area (hectare)	Permanent Impact Area (hectare)	Total Impact Area (hectare)	Percent of Total Impacts (%)
Bamboo Forest	1.9	2.1	4.0	2.9
Riparian Forest (Mangrove Associated Species)	0.1	0.0	0.1	0.0
Modified Secondary Forest	0.1	0.3	0.4	0.3
Coastal Strand Vegetation	0.3	0.0	0.3	0.2
Early Successional Bamboo / Palm Forest	0.7	0.5	1.1	0.8
Early Successional Forest/Swamp	1.1	1.9	3.0	2.2
Herbaceous/Grass Swamp	8.9	12.8	21.6	15.6
Herbaceous/Grassland	0.0	0.0	0.0	0.0
Managed Grassland/Herbaceous—Residential	0.4	0.0	0.4	0.3
Shrubland/Swamp	1.9	69.5	71.4	51.6
Shrubland/Grass	0.2	0.9	1.1	0.8
Unvegetated—Other (dirt, building, road, water)	1.2	5.5	6.6	4.8
TOTAL	**36.8**	**101.6**	**138.4**	**100.00**

Table 8.3-19: Terrestrial Vegetation Impacts (Temporary and Permanent) Associated with Onshore Project Components

Onshore Project Component	Hectares	Percentage of Impacts
Onshore pipeline (including HDD permanent RoW, HDD work areas, and construction RoW)	58.5	42.2
NGL Plant	75.0	54.2
Heavy haul road	1.7	1.3
Temporary MOF	0.3	0.2
Construction laydown areas	1.0	0.7
Worker camp	1.9	1.4
Total	**138.4**	**100.0**

HDD = horizontal directional drilling

Throughout the Project’s Construction stage, vegetation clearing associated with the installation of the onshore pipeline will occur sequentially as the pipeline is constructed in an assembly line fashion. Vegetation clearing activities will include the removal of trees, shrubs, brush, and roots, and vegetation will generally be scraped or cut flush with the ground surface. Wherever possible, rootstock will be left in place. Cleared vegetation, including stumps, will either be burned, chipped, or hauled off-site for disposal. This sequential approach to onshore pipeline installation will allow for incremental vegetation restoration immediately following completion of each segment of onshore pipeline installation, involving replacement of parent soil containing the local seed bank to facilitate natural regeneration. Post-construction cleanup and restoration for the temporary impact areas around the NGL Plant, construction laydown areas, and temporary MOF will include spreading stockpiled vegetation, including mulch, large shrubs, and trees, across the temporarily disturbed areas to facilitate natural regeneration.

Impacts on terrestrial vegetation within the onshore Direct AOI will have no measurable long-term impact on ecological integrity in and around the Project AOI and the broader Coastal Plain ecoregion. Although the degree of vegetation modification or naturalness within the Direct AOI varies, all of the impacted vegetation communities and species are modified and widespread throughout the region. Based on the small amount of permanent vegetation loss, the common and widespread vegetation communities and species affected, and the anticipated natural restoration of temporary impact areas, the intensity of the impact associated with terrestrial vegetation loss is considered **Low**. While there will be periods during construction when vegetation removal will not occur, the impact will be present continuously during construction, yielding a **Continuous** frequency rating. The duration of the impact of vegetation loss will be **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on terrestrial vegetation is considered **Small**.

Compared to the Construction stage, the Project Operations stage will have a much lower impact on terrestrial vegetation in the Direct AOI, and will primarily involve the perpetuation of impacts caused during the Construction stage (permanent habitat conversion) and changes in vegetative species composition following construction-related disturbance. During the Operations stage, ongoing maintenance of the terrestrial vegetation within the onshore pipeline RoW will be required to maintain the vegetation in a herbaceous state. Since the vegetation loss and conversion will have already occurred during the Construction stage, the intensity of the impact of ongoing maintenance is considered **Negligible**. The impact will be present continuously during the Operations stage, yielding a **Continuous** frequency rating. Vegetation maintenance will be ongoing during the Operations stage, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of the impact related to vegetation loss during the Operations stage is rated as **Negligible**.

Activities associated with the Decommissioning stage are not expected to involve removal or disturbance to terrestrial vegetation, as the base case is that the onshore pipeline will be left in place. Vegetation maintenance activities conducted during the Operations stage will no longer occur so the vegetation will, over time, revert to natural conditions, potentially resulting in an ecological benefit if natural conditions are ultimately attained. The benefit will likely be small given the small size of the affected area and the disturbed landscape within which the Project lies. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of the impact related to vegetation loss during the Decommissioning Stage is rated as **Negligible**.

Vegetation Community Conversion and Degradation

During the Operations stage, vegetation within the onshore pipeline right-of-way (RoW) will be maintained in a herbaceous state (i.e., dominated by grasses and herbaceous plants and absence of woody vegetation) through periodic mowing, consistent with standard international practice for maintenance of pipeline RoWs. This conversion from existing conditions (a variety of modified vegetation communities) to a herbaceous vegetation community will continue for the operational life of the Project. Ground inspections of the onshore pipeline RoW will be periodically conducted to document the condition of vegetation and confirm there is adequate stabilizing herbaceous vegetation cover in the onshore pipeline RoW to limit soil erosion and to identify the need for mowing or manual removal of pioneer woody vegetation species. The NGL Plant will have a dedicated maintenance crew for routine maintenance at the NGL Plant, which may include mowing as needed. A detailed description of Project operation and maintenance activities is included in Section 5.4.2, Operations Stage.

Vegetation within the Indirect AOI will be exposed to dust generated from construction activities and equipment, which could degrade the condition of vegetation in affected areas. As described in Section 7.6, Air Quality, Climate Change, and Climate, dust from construction activities is typically re-deposited within as much as a 350-meter radius of the source. Dust deposition on plants can adversely affect critical plant growth processes including photosynthesis, respiration, transpiration, and reduced productivity (Farmer 1993; Lovett et al. 2009). However, dust emissions generated by Project activities will be limited in spatial scale and temporary (limited to the Construction and Decommissioning stages) and species in the region are habituated to dust because of the annual dry seasons and related dusty conditions. Further, dust emission minimization procedures are embedded controls in the Project design (Table 7.6-23) and will generally include use of construction methods that minimize dust-emitting activities through employing alternative technologies (such as use of pre-fabricated materials whenever possible), maintaining a non-toxic moist suppressant on uncovered stockpiles, application of water to unpaved haul roads, and providing materials handling training to workers to minimize dust emissions. Air quality sensitivity ratings for nature areas are described in Table 7.6-19 in Section 7.6.3.2, Air Quality [Sensitivity of Resource], and are categorized as **Low**.

On this basis, the intensity of the impact associated with conversion and degradation of terrestrial vegetation is considered **Low**. The impact of vegetation community conversion will be present continuously during all stages of the Project, yielding a **Continuous** frequency rating. The duration of vegetation community conversion will continue through the life of the Project and therefore will be **Long-term**. Construction and decommissioning activities that will generate dust are expected to be less than one year or **Medium-term**. Therefore, following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on terrestrial vegetation is considered **Small**.

Introduction and Spread of Invasive and/or Exotic Vegetation Species

The introduction and spread of invasive and exotic species is considered one of the biggest threats to biodiversity globally, second only to habitat loss in terms of its impact on biodiversity. Invasive and exotic plant species pose a threat to native ecosystems because they have few natural controls (e.g., animals that eat them, diseases to which they are susceptible, etc.) and can be aggressive competitors, allowing them to spread quickly and often out-compete native species on which native wildlife depend. Examples of species invasions from around the world include significant, and sometimes irreversible, biological and socioeconomic impacts resulting from the introduction and spread of invasive and exotic species. Not all exotic species are invasive and Guyana, like most areas of the world, is replete with exotic species. As such, the focus of this assessment is on those exotic species that are considered invasive ("invasive exotic species") and thus have the potential to cause significant environmental harm.

The primary pathways for introduction and spread of invasive exotic vegetation species include:

- Transport and introduction of plants or their seeds (e.g., "hitchhiker" or "stowaway" organisms) via construction equipment, construction supplies imported to Guyana, or the foreign Project workforce;
- Transportation and translocation of soil and plant debris following clearing and excavation;
- Use of imported nursery products (e.g., topsoil, soil amendments, seeds, and live plants) for reforestation and other land restoration activities; and
- Habitat disturbance, which can spur the spread of already-established invasive exotic species.

Construction of onshore Project facilities will require large quantities of construction equipment, materials, and supplies. For many of these items, no Guyanese suppliers currently exist or the limited local supply will not meet Project demands. A significant proportion of the needed construction equipment, materials, and supplies will likely need to be imported from foreign countries. Importing equipment and materials could introduce new invasive exotic species into the Direct AOI. In addition, clearing existing vegetation, moving vehicles, and transporting and translocating soil and plant debris following clearing and excavation will create opportunities for already-established invasive exotic plant species to spread and colonize new areas, leading to the potential for further habitat degradation outside the Direct AOI.

Due to the significant anthropogenic activity over the last several decades and the preponderance of agriculture and other disturbed habitats in the Direct AOI and much of Guyana's Coastal Plain more broadly, numerous species of invasive exotic plants are already established there, including antelope grass (*Echinochloa pyramidalis*), *black* currant tree (*Acacia mangium*), white leadtree (*Leucaena leucocephala*), and Bengal clock vine (*Thunbergia grandiflora*) (EPA 2011). Modified habitats may contain a prevalence of invasive species, which do not typically cause significant ecological harm within these environments as they are already disturbed (Meyer et al. 2021; Cassey et al. 2005). The spread of invasive species within pristine or undisturbed habitats can cause significant ecological damage through the displacement or out-competition of native species and the degradation of available habitat. As such, the impact of the potential introduction and spread of invasive and invasive exotic species in the Direct or Indirect AOI will likely be minimal unless a new highly invasive and destructive species is introduced.

On this basis, the intensity of the impact associated with invasion and spread of invasive species on terrestrial vegetation is considered **Low**. The potential for the impact will be present continuously during the Construction stage, yielding a **Continuous** frequency rating. If invasive and/or invasive exotic species are introduced or spread in the Indirect or Direct AOI, the duration of the impact will be **Long-term**. Therefore, following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on terrestrial vegetation is considered **Small**.

Toxicological Impacts on Vegetation from Air Emissions

The exposure of plants to air pollutants, such as ground-level ozone, nitrogen oxides, and sulfur dioxide (SO_2), can negatively impact photosynthesis and metabolic functions, damage foliage, and reduce or inhibit growth and root establishment (Weber et al. 2002; USEPA 2022). Air pollutants that can be toxic to vegetation, such as SO_2, will primarily be emitted during the Operations stage of the Project from process equipment at the NGL Plant. Emissions of these pollutants during Project operations are predicted to result in concentrations of 5.4 percent or less of the respective ambient air quality guidelines presented in Section 7.6, Air Quality, Climate, and Climate Change, well below the level at which impacts on vegetation would be expected to occur. Further, the Project AOI does not contain vegetation species, such as lichens and bryophytes, that are particularly susceptible to impacts from air pollution such as SO_2. (Adams et al. 1992; Askham 2020). As such, the intensity of this impact is rated as **Low**. The impact will be present continuously during the Operations stage, yielding a **Continuous** frequency rating. Air emissions will be ongoing during the Operations stage, so the duration of the impact is considered **Long-term**. Because the predicted ground-level concentrations of criteria pollutants are less than 25 percent of the respective air quality guidelines, the magnitude of potential Project impacts on vegetative communities during the Operations stage is considered **Small**.

Sensitivity of Resource—Terrestrial Vegetation

Based on the sensitivity rating definitions in Table 8.3-17, the resource sensitivity for terrestrial vegetation is considered **Low**. This rating is principally based on the size and widespread distribution of the affected vegetation communities relative to the impacts that are anticipated within them and the capacity of the terrestrial ecosystem to withstand Project-related impacts without reaching an irreversible ecological threshold (e.g., mass extirpation event, conversion of a food web, mass habitat conversion, etc.). Guyana's Coastal Plain in the vicinity of the Project is highly modified by past and current anthropogenic disturbance, particularly agriculture and human habitation, and further modifications to vegetation communities of the scale and type associated with the Project will not be expected to cause detectable changes in the vegetation species present or vegetation community/habitat functions or values.

Pre-mitigation Impact Significance—Terrestrial Vegetation

Assuming implementation of the embedded controls listed in Section 8.3.4, Impact Management and Monitoring Measures, the intensity ratings for potential Project impacts on terrestrial vegetation range from **Negligible** to **Low**. Considering the assigned frequency and duration ratings described above, this results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small.** Coupled with sensitivity ratings of **Low**, the pre-mitigation impact significance for terrestrial vegetation is rated as **Negligible**.

8.3.3.2. Terrestrial Wildlife

Relevant Project Activities and Potential Impacts

The planned Project activities that could affect terrestrial wildlife in the Project AOI are described under the three Project stages of Construction, Operations, and Decommissioning. Specific activities associated with each of these stages that could potentially impact terrestrial wildlife are identified and assessed at the resource-specific level. Table 8.3-20 summarizes the planned Project activities that could result in potential impacts on terrestrial wildlife and the key potential impacts of those activities.

Table 8.3-20: Summary of Relevant Project Activities and Key Potential Impacts—Terrestrial Wildlife

Stage	Project Activity	Key Potential Impacts
Construction	• Installation of the onshore pipeline • Construction of the NGL Plant, heavy haul road, worker camp, and temporary MOF • Earth moving / stockpiling materials • Vegetation clearing • Dredging in the Demerara River for the temporary MOF • Vegetation clearing • Construction-related traffic, including materials and equipment transport and workforce transport • Construction-related sound, light, and vibration • Solid waste and wastewater disposal from worker camp • Worker and associated population influx	• Wildlife injury and mortality • Wildlife disturbance and displacement due to human activity, sound, light, and vibration • Direct loss and conversion of habitat • Changes in habitat condition/quality • Changes in the biological availability of canal habitats • Wildlife exposure to solid and liquid waste • Increased hunting, fishing, or harvesting pressure from increased human access and presence of workers
Operations	• Operation and maintenance of the NGL Plant and onshore pipeline • Discharge of wastewater treatment plant effluent and stormwater discharges from the NGL Plant	• Wildlife mortality from vehicular traffic • Wildlife exposure to NGL Plant wastewater effluent and stormwater discharges • Ongoing displacement from habitat loss, increased human activity, sound, light, etc.
Decommissioning	• Decommissioning of Project facilities	• Similar, though fewer and less significant, impacts as in Construction stage

Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. For terrestrial wildlife, resource-specific definitions for intensity are used in lieu of the general intensity definitions (Table 8.3-21). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for terrestrial wildlife sensitivity are provided in Table 8.3-22.

Table 8.3-21: Definitions for Intensity Ratings for Potential Impacts on Terrestrial Wildlife

Criterion	Definition
Intensity	**Negligible**: No measurable ecosystem- or wildlife population-level changes; the ecosystem continues to function as it did prior to the Project activities occurring.
	Low: Changes are perceptible but affect only a small number of species and/or across a limited spatial area.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level, and/or across a significant portion of the area that the ecosystem physically occupies.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are substantially altered.

Table 8.3-22: Definitions for Resource Sensitivity Ratings for Potential Impacts on Terrestrial Wildlife

Criterion	Definition
Sensitivity	**Low**: Habitat integrity and function and species assemblage are highly modified and/or are capable of withstanding disturbance (physical and chemical) and degradation without reaching an irreversible ecological threshold (i.e., are highly resilient). Rare or disturbance-sensitive species are absent or uncommon. The biological community is dominated by non-native and/or habitat generalist species.
	Medium: Habitat integrity and function and species assemblage are modified and moderately resilient to disturbance and degradation. Rare or disturbance-sensitive species may be present but are not dominant.
	High: Habitat integrity and function and species assemblage are natural (i.e., minimal anthropogenic disturbance and high biodiversity value/function) and have low resilience to disturbance and degradation. The biological community is dominated by native and/or habitat specialist species and contains important habitat for or populations of rare species.

For the purpose of assessing the significance of potential impacts on terrestrial wildlife, the key potential impacts presented in Table 8.3-20 are summarized into the following broad impact categories:

- Impacts on wildlife from habitat loss and degradation;
- Wildlife injury and mortality;
- Wildlife disturbance and displacement;
- Wildlife impacts from loss of canal habitat; and
- Toxicological impacts on wildlife from effluent discharges.

Impact Magnitude Ratings—Terrestrial Wildlife

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to terrestrial wildlife is provided in Table 8.3-23.

Impacts on Wildlife from Habitat Loss and Degradation

Construction of the Project will result in loss of 138.4 hectares of terrestrial vegetation and wildlife habitat within the Direct AOI. All of the vegetation and habitat that will be impacted is modified, although the level of modification and, thus, the quality of the habitat varies throughout the Direct AOI, with the highest-quality habitats occurring south of Canal 2 within the onshore pipeline RoW, the NGL Site, the temporary MOF, and several canals that occur parallel to or intersect with the onshore pipeline corridor. The Direct AOI supports a wildlife assemblage dominated by common and widespread species and the amount of habitat loss that will be caused by the Project is negligible from a landscape perspective (at the ecosystem, watershed, or ecoregional scale). Nevertheless, the habitats are used by wildlife for essential behaviors (e.g., foraging, breeding, roosting, nesting, aestivating) so the loss of these habitats will force animals to move to other locations for these activities, increasing intra- and inter-species competition within newly occupied habitats.

Remnant areas of forest, particularly riparian forest along the lower Demerara River, support a higher abundance and diversity of wildlife than do the more disturbed habitats in the rest of the Direct AOI, including some migratory and rare species. Riparian forests possess uniquely diverse wildlife communities due to variable flood regimes, geographically unique channel processes, altitudinal climate shifts, and upland influences on the fluvial corridor (Naiman and Decamps 1997). Riparian corridors serve as effective forest refugia and/or dispersal areas for mammals, birds, amphibians, and reptiles (Rykken et al. 2007). The riparian forests along the lower Demerara River are valuable for numerous terrestrial wildlife species, particularly resident colonial waterbird species that flock there to forage, roost, and breed and migratory birds that use the river and its riparian forest to rest, forage, and drink water during annual migrations. These riparian forests are mature and contain many large trees that are used by many wildlife species, particularly mammals. Many mammals (particularly monkeys, marsupials, bats, rodents, and cats) require large trees for roosting in or beneath them in tunnels or root masses. These large, mature trees take decades, even centuries, to grow and the loss of such trees would be a significant impact on the wildlife that depend on them, as they are not rapidly replaced through reforestation or other means. Further, wildlife that use riparian and mangrove forests are often habitat specialists, relying on specific habitat types or features for key components of their life cycle. For example, Hoatzin, Rufous Crab Hawk, and Bicolored Conebill, all bird species that occur in riparian forests along the Demerara River, are habitat specialists that rely on mangrove or riparian forests for foraging and breeding. Impacts on these types of habitats that support specialized species have a greater biological significance than impacts on widespread and degraded habitats. Less than 5 percent of the habitat impacts in the Direst AOI will be to forest, mangrove, or other habitat that has heightened importance for wildlife. Surveys of the temporary MOF area documented only three individual mangrove trees in the area to be impacted during installation of the temporary MOF. These trees are not part of an intact mangrove forest, but rather isolated mangrove trees within a riparian forest comprised of mangrove-associated species.

Based on these considerations, the intensity of potential impacts on terrestrial wildlife as a result of habitat loss and degradation is rated as **Low**. The habitat loss and degradation and related effects on wildlife will be ongoing throughout the Construction stage, yielding a **Continuous** frequency rating. Impacts will be **Long-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on terrestrial wildlife is rated as **Small**.

Wildlife Injury and Mortality

The act of clearing vegetation during the Construction stage will kill or injure some animals during construction activities and result in the subsequent mortality of others not able to adapt to habitat loss or degradation. Herptiles and invertebrates are particularly susceptible to direct and indirect mortality during vegetation clearance because they typically have small home ranges and a sedentary lifestyle, and are behaviorally prone to rely on camouflage to avoid predation rather than actively evading a threat. Nevertheless, because of the sequenced, linear vegetation clearing approach planned for the Project, most wildlife will have the ability to detect and move away from vegetation-clearing activities and equipment.

Operation of vehicles and heavy equipment during all Project stages, but particularly during the Construction stage, will result in interactions between vehicles/equipment and wildlife, possibly leading to direct mortality or injury of animals. However, this impact is expected to be infrequent because most animals in the Direct and Indirect AOI, and Guyana's Coastal Plain more generally, are accustomed to vehicular traffic, and habituated to avoiding it. Further, the driver awareness training and speed restrictions included as embedded controls will increase driver awareness and reduce speeds, limiting the potential for vehicle-wildlife interactions.

Operation of the temporary MOF will expose riverine birds and other riparian wildlife species to disturbance and possible injury or mortality associated with vessel traffic. The Demerara River is already subject to noise and other disturbance from passing commercial and artisanal vessel traffic. Although an increase in overall vessel traffic is expected during the operation of the temporary MOF, as described in Section 9.4.3, Impact Prediction and Assessment [Transportation], the additional vessel trips associated with the temporary MOF represent a minimal percentage increase in vessel traffic in the lower Demerara River.

Based on these considerations, the intensity of potential impacts related to terrestrial wildlife injury and mortality will be **Low**. Impacts may occur intermittently throughout all stages of the Project, but particularly during the Construction and Decommissioning stages—when larger number of vehicles and equipment will be in use—so the frequency is considered **Episodic**. The impact will be **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on terrestrial wildlife is rated as **Small**.

Wildlife Disturbance and Displacement

With the exception of the few species of migratory birds and several mammal species (ocelot and otter species) that occur in the Direct AOI and Indirect AOI, the majority of wildlife species in the area are common, generalist species with moderate to high tolerance for human disturbance. Localized wildlife disturbance and displacement will occur as a result of human activity, light, sound, and vibration during vegetation clearance and facility construction. With the potential exception of horizontal directional drilling (HDD) activities, working hours during the Construction stage will be limited to daytime hours, but use of artificial lighting for nighttime security along the construction work fronts and at Project facilities during operation will be necessary. Artificial lighting will produce an envelope of unnatural light around facilities and result in the disturbance or displacement of light-sensitive species from within this envelope. Wildlife disturbance and displacement from elevated sound levels also will occur throughout the Direct AOI during the Construction stage. Displacement could cause affected wildlife to lose access to foraging habitat, mates, or dependent young. It could also increase intra- and inter-species competition in the new areas where displaced wildlife relocate. However, once human activities and related sound largely subside after the Construction stage, wildlife will quickly repopulate the area.

Medium- and large-sized mammals and birds that typically avoid populated or disturbed areas are more likely to be affected by disturbance and displacement impacts. Within the Direct AOI, disturbance impacts will be greatest in areas that currently experience a low level of disturbance, such as the more remote portions of the Direct AOI south of Canal 2 near the NGL Plant site or the temporary MOF, and lowest in areas such as the northern portion of the onshore pipeline RoW—which is already subject to high disturbance levels from existing human activities (e.g., agriculture, road networks, habitation). Many species that inhabit the more remote portions of the Direct AOI are sensitive to disturbance and will be affected by the increased levels of sustained human activity, particularly during the Construction stage. Disturbance-sensitive species will disperse away from disturbed areas in search of other undisturbed habitats in the region.

Colonial waterbird breeding colonies and communal roost sites are particularly vulnerable to disturbance, and human activity can cause desertion of the nesting and roosting sites. Several waterbird nesting and roosting areas occur in the lower Demerara River, including Inver Island, which is a forested island located in the middle of the Demerara River near Land of Canaan, approximately 2 kilometers upstream from the temporary MOF site that supports thousands of roosting Orange-winged Parrots, and several other species of parrots (including three species of macaws) and colonial waterbird species that are known to congregate on this island for communal roosting and breeding. Installation of the temporary MOF and dredging of the access channel will disturb and likely displace some riverine birds due to increased human activity and sound, but the influence of sound, light, and human activity associated with the temporary MOF will be limited to the area within close proximity to the temporary MOF site and should not extend to any of the Bird Concentration Areas noted in the Bird Concentration Areas portion of Section 8.3.2.3, Riverine Birds.

Based on these considerations, the intensity of impacts related to terrestrial wildlife disturbance and displacement ranges from **Low** for common wildlife that is habituated to disturbance to **Medium** for disturbance-sensitive species. Impacts will occur throughout the life of the Project, but to the greatest degree during the Construction stage, so the frequency is **Continuous**. Construction activities in the river will last on the order of a year, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment

Methodology, the magnitude of this potential impact on riverine birds is rated as **Small** to **Medium** for the Construction stage, and **Small** for the Operations stage (because during operations, disturbance levels will be lower than during construction and disturbance-sensitive species will largely be absent from the Project AOI).

Toxicological Impacts on Terrestrial Wildlife from Water Discharges

There will be two potential primary effluent discharge streams to the Demerara River, routed via the stormwater pond and a canal adjacent to the NGL Plant during the Construction stage: sanitary effluent discharge from the worker camp (if a worker camp is used), and the possible discharge of pipeline hydrostatic test water. The effluent from the worker camp will be routed through a dedicated wastewater treatment plant (WWTP) and the discharge will be managed in accordance with applicable World Bank Group EHS Guidelines (World Bank 2007a). The intensity of this impact is therefore considered **Low**. The discharge from the worker camp, if used, will be **Continuous** during the Construction stage and will last for more than a year, so the duration of this impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine water quality is rated as **Small.**

Hydrostatic test water from pipeline testing may potentially be discharged to the Demerara River routed via the stormwater pond and a canal adjacent to the NGL Plant. Two potential hydrostatic test water treatment chemicals were considered for the purpose of the EIA: RX-5245 and SLB HydroHib. Both compounds are toxic to aquatic organisms at the concentrations at which they will be used in the pipeline. Based on the hydrodynamic modeling described in Appendix C, Water Quality Modeling Report, SLB HydroHib would be expected to dilute to a concentration below the toxicity threshold within 100 meters of the discharge point under all seasonal and flow conditions. As such, no acute toxicity is expected from this substance outside of a 100-meter mixing zone. If RX-5245 is used, the modeling indicates that the effluent will be diluted to non-toxic concentrations within 100 meters of the discharge point during the wet season only. During the dry season, dilution to non-toxic concentrations would occur at 500 meters from the discharge location under high flow/current conditions, and within 1 to 1.5 kilometers under low flow/current conditions. Under the worst-case assumption that RX-5245 would be discharged during dry season low flow/current conditions, this could lead to acute mortality of aquatic biota fish within a 1- to 1.5-kilometer mixing zone surrounding the hydrostatic discharge point. A mortality event that incorporates a zone with a radius of over 1 kilometer would affect numerous species and would affect a substantial portion of the lower Demerara River ecosystem. Birds using the lower Demerara River could be exposed to these chemicals through ingestion of contaminated prey or through contact with the water's surface. No specific data exist on how these chemicals may specifically affect birds, but the chemicals are not bioaccumulative. Therefore, the intensity of this impact on riverine birds is rated **Medium**. The impact will occur continuously over a 24-hour period, so it is considered to have **Continuous** frequency and **Short-term** duration. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biodiversity is rated as **Small**.

Sensitivity of Resource—Terrestrial Wildlife

Based on the sensitivity rating definitions in Table 8.3-17, the resource sensitivity for terrestrial wildlife is considered **Low** for common species that are habituated to human disturbance and **Medium** for habitat specialists and disturbance-sensitive species**.** These ratings are principally based on the predominance of common generalist species and the capacity of the populations to withstand Project-related impacts without reaching an irreversible ecological threshold (e.g., local or mass extirpation event, alteration of a food web, etc.). Rare and disturbance-sensitive species are present but uncommon and, for the most part, transient in the Direct and Indirect AOI. Guyana's Coastal Plain in the vicinity of the Project is highly modified and most of the wildlife species present there are habituated to anthropogenic disturbance, and further modifications to wildlife communities of the scale and type associated with the Project will not be expected to cause detectable changes in the wildlife species assemblage or population levels in the Direct or Indirect AOI.

Pre-mitigation Impact Significance—Terrestrial Wildlife

Assuming implementation of the embedded controls listed in Section 8.3.4, Impact Management and Monitoring Measures, the intensity ratings for potential Project impacts on terrestrial vegetation range from **Negligible** to **Medium**. Considering the assigned frequency and duration ratings described above, this results in pre-mitigation magnitude ratings ranging from **Negligible** to **Medium**. Coupled with sensitivity ratings of **Low** to **Medium**, the pre-mitigation impact significance for terrestrial wildlife ranges from **Negligible** to **Moderate**.

8.3.4. Impact Management and Monitoring Measures

Supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register, and Table 8.3-23), the pre-mitigation significance of potential impacts on terrestrial vegetation and wildlife ranges from **Negligible** to **Moderate**. To further reduce potential impacts on terrestrial vegetation and wildlife, several mitigation measures are recommended to reduce the significance of potential impacts, as follows.

- Use Offshore Chemical Notification Scheme (OCNS) Gold Standard hydrostatic test chemicals to test the pipeline to minimize toxicological impacts on wildlife that use the river for foraging and roosting.
- Discharge hydrostatic test water to the Demerara River only under higher flow conditions to the extent practicable to maximize dilution.

Table 8.3-23 summarizes the impact management and monitoring measures relevant to terrestrial biodiversity.

Table 8.3-23: List of Management and Monitoring Measures

Embedded Controls
Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Conduct paced, sequential clearing to allow mobile wildlife to move away from work zones.
Restore and revegetate the onshore pipeline corridor following construction.
Monitor and manage excess overflow from hopper overflow on dredging facility to improve efficiency and reduce turbidity in dredging supernatant.
Use appropriate control measures to minimize dust arising from construction works.
Minimize dust-emitting activities such as cutting, grinding, and sawing by employing alternative methods or technologies, such as the use of pre-fabricated material wherever possible.
Review construction plan and confirm availability of water for dust suppression on site for dust suppression.
Keep uncovered stockpiles moist.
Apply water to unpaved haul roads to minimize dust generation.
Train workers to employ material handling methods that will minimize dust emissions. These include minimizing drop heights to control the fall of materials and minimizing exposure of stockpiles to wind by removal of earth from small areas of secure covers when needed.
Require construction equipment and other workforce vehicle drivers to adhere to Project-established speed limits within the construction worksites.
Monitor and manage suction rate to improve efficiency and reduce turbidity in the water column during dredging.
Regularly maintain equipment, vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Provide domestic WWTP that complies with World Bank Indicative Values for Treated Sanitary Sewage Discharges (World Bank 2007a) and Effluents Levels for Natural Gas Processing Facilities (World Bank 2007b).
Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and NGL Plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere from the NGL Plant.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions to the extent reasonably practicable.
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD boring).
Maintain marine and onshore construction equipment, power generators, and vehicles in accordance with manufacturer's specifications to reduce sound generation the extent practicable.
Design equipment at NGL Plant so that in-plant sound levels in accessible areas do not exceed 85 dBA under normal operations or 115 dBA for emergency events and so that community and/or fenceline noise levels do not exceed applicable regulations.

Conduct routine inspections to confirm the sanitary WWTP is working according to design specifications and monitor effluent quality regularly.
Conduct routine inspections to confirm the process WWTP is working according to design specifications and monitor effluent quality regularly.
During open trenching and HDD operations along the onshore pipeline corridor, conduct noise monitoring during the initial stages of construction and again during later stages of construction (as warranted based on changes in the nature of construction activities, weather conditions, or other factors) in order to quantify the actual extent of Project noise impacts.
Mitigation Measures
Use OCNS Gold Standard hydrostatic test chemicals to test the pipeline.
Discharge hydrostatic test water to the Demerara River only under higher flow conditions to the extent practicable.
Monitoring Measures
Monitor otter use of the canals in the Project AOI where otters are known to occur based on baseline surveys to document presence and activity during and post-construction (through 1 year post-construction).
Monitor birds and mammals at baseline survey sites for 1 year after the onshore pipeline is installed and every 3 years once the Project becomes fully operational throughout the Operations stage of the Project.
Conduct a single round of post-decommissioning monitoring of terrestrial vegetation, birds, mammals, and insects.
During construction, monitor dust levels along portions of the onshore pipeline corridor with residential structures in close enough proximity to potentially be affected by dust emissions.
Conduct post-restoration vegetative cover monitoring along the onshore pipeline corridor.

dBA = A-weighted decibel; IMO = International Maritime Organization; MARPOL 73/78 = International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978; ppm = parts per million; STP = sewage treatment plant

8.3.5. Assessment of Residual Impacts

As described above, two mitigation measures are proposed. These measures will reduce potential toxicity impacts associated with the possible release of hydrostatic test water in the Demerara River.

Based on implementation of the mitigation measures, the residual impact significance ratings for terrestrial biodiversity range from **Negligible** to **Minor**.

Table 8.3-24 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on terrestrial biodiversity.

Table 8.3-24: Summary of Potential Pre-Mitigation and Residual Impacts—Terrestrial Biodiversity

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Direct loss of terrestrial vegetation	Low	Small	Negligible	None	Negligible
	Vegetation community conversion and degradation	Low	Small	Negligible	None	Negligible
	Introduction and spread of invasive and/or exotic vegetation species	Low	Small	Negligible	None	Negligible
	Impacts on wildlife from habitat loss and degradation	Low	Small	Negligible	None	Negligible
	Wildlife injury and mortality	Low	Small	Negligible	None	Negligible
	Wildlife disturbance and displacement	Low to Medium	Small to Medium	Negligible to Moderate	None	Negligible to Moderate
	Toxicological impacts on wildlife from water discharges	Low	Small	Negligible	Use OCNS Gold Standard hydrostatic test chemicals. If possible, discharge hydrostatic test water to the river under high flow conditions.	Negligible
Operation	Direct loss of terrestrial vegetation	Low	Negligible	Negligible	None	Negligible
	Toxicological impacts on vegetation from air emissions	Low	Small	Negligible	None	Negligible
	Wildlife injury and mortality	Low	Small	Negligible	None	Negligible
	Wildlife disturbance and displacement	Low	Small	Negligible	None	Negligible
	Toxicological impacts on wildlife from water discharges	Low	Negligible	Negligible	None	Negligible
Decommissioning	Direct loss of terrestrial vegetation	Low	Negligible	Negligible	None	Negligible
	Wildlife disturbance and displacement	Low	Negligible	Negligible	None	Negligible

8.4. FRESHWATER BIODIVERSITY

8.4.1. Baseline Methodology

The biological resources discussion presented herein is based on a combination of primary data generated from EEPGL-commissioned studies and secondary data from peer-reviewed scientific literature, government publications, and non-governmental scientific organizations. Two EEPGL-commissioned baseline studies informed this section:

- A freshwater biodiversity baseline study was conducted in the 2021 dry season (10 to 21 November 2021) and the 2022 wet season (12 to 15 January and 6 to 14 February 2022). This study included physiochemical, aquatic macroinvertebrate, and fish components.
- A riverine mammal study was conducted from 2019 to 2021 and included visual scans of the Demerara River's surface with the naked eye, sonar, and binoculars from a vessel.

Inland sites were assessed according to the U.S. Environmental Protection Agency's (USEPA's) Rapid Bioassessment Protocols for Use in Streams and Wadeable River (Barbour et al. 1999). Riverine sites were assessed using a modified version of the USEPA protocols that were appropriate to the physical and biological conditions on the Demerara River.

8.4.2. Existing Conditions and Baseline Studies

8.4.2.1. Aquatic Habitat Surveys in the Project Area of Influence

Each survey site included in the freshwater biodiversity baseline study was categorized into one of two primary habitat types: river sites on the Demerara River (sites DRR-06 and DR-07) and canal sites (sites MB-01, CV-02, CD-10, PV-03, CC-11, CVR-04, CC-12, CV-05, WW-13, DD-08, WW-09) (Figure 8.4-1). Two sites (DRR-06 and DR-07) were surveyed on the Demerara River in the wet and dry season. Site DRR-06 was located on the eastern bank of the Demerara River, and Site DR-07 was located on the western bank of the Demerara in the approximate vicinity of the proposed nearshore Project activity. Eleven sites were surveyed on the canals (Table 8.4-4). Eight of these sites were surveyed in both the wet and dry seasons; three other sites were only surveyed during the wet season. Sites DRR-06, DR-07, MB-01, and CV-02 were tidally influenced and had brackish conditions[12] when the field survey was conducted. All other sites were non-tidal and had freshwater conditions.

[12] Brackish versus freshwater conditions were assessed mainly on the basis of the fish community present and evidence of tidal influence. Mean total dissolved solids measurements taken at these sites tended toward the upper portion of the range observed across the entire dataset, and ranged from 29 to 708 parts per million.

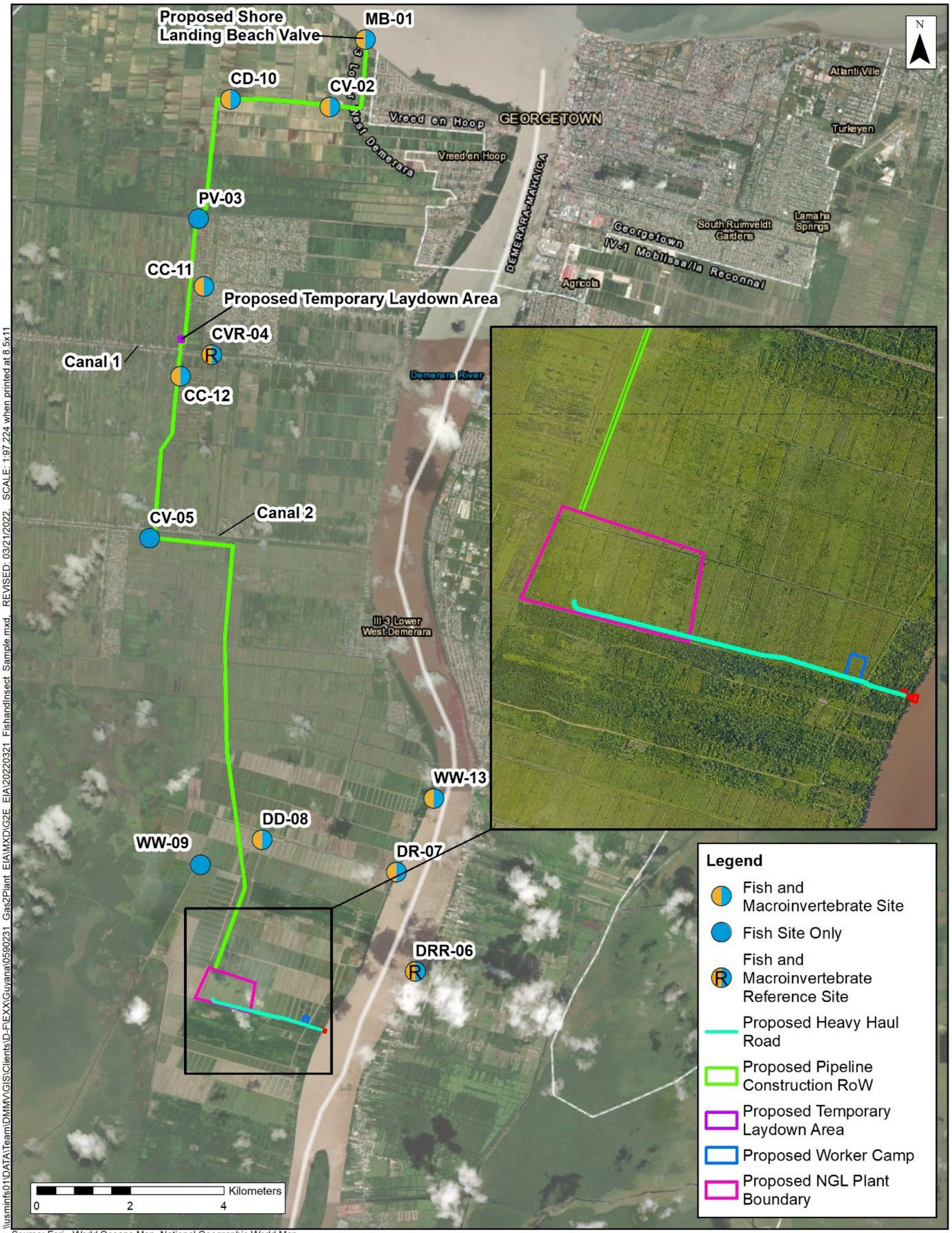


Figure 8.4-1: Site Locations for Freshwater Habitat, Macroinvertebrate, and Fish Surveys

Aquatic Habitat Survey Results

Demerara River Sites

The Demerara River sites had the largest intact riparian buffers of all sites surveyed, extending 30 to 35 meters on each side of the river. Surrounding land use at Site DRR-06 consisted of a narrow riparian fringe within a more broadly commercial and residential landscape. Land use at Site DR-07 was both commercial and forest. Red mangroves (*Rhizophora mangle*) were the dominant bank species at Site DRR-06; red mangrove, black mangrove (*Avicennia germinans*) and various thorny vines were identified along the bank at Site DR-07 (Table 8.4-1).

Table 8.4-1: Representative Photographs of Riverine Survey Sites in the Lower Demerara River

Site DRR-06

Site DR-07

Physical habitat parameters and freshwater physiochemical parameters of the Demerara River sites are presented in Tables 8.4-2 and 8.4-3, respectively. Trash and deceased livestock were observed in the water at both sites. Noticeable odors of sewage were also present at both sites. Suspension of fine particulates by tidal currents contributes to the elevated turbidity and resulting murky appearance characteristic of the lower Demerara River. The two Demerara River sites had turbidity values much higher than that of the canal sites. Additional water quality data from the Demerara River and the canals are presented in Section 7.4.2.2, Riverine Water.

Table 8.4-2: Physical Habitat Parameters of Survey Sites on the Demerara River

Site	Land Use Type	Shoreline Erosion	Apparent Watershed Pollution	Riparian Buffer Width (meter)		Bank Canopy Cover
				Left	Right	
DRR-06	Commercial	Slight	Heavy	30	30	Lightly Shaded
DR-07	Forested, Commercial	None	Heavy	30	35	Lightly Shaded

Table 8.4-3: Range of Freshwater Physiochemical Parameters at Survey Sites on the Demerara River

Site	Season	Temperature (°C)	pH	Turbidity (NTU)	Water Odors
DRR-06	Dry	27.63-27.64	5.17-5.44	1,000	Sewage
	Wet	26.03-26.24	3.87-6.29	10-12	Sewage
DR-07	Dry	28.24-28.27	5.73-6.17	>1,000	Sewage
	Wet	26.26-26.35	4.38-4.91	11-13	Sewage

°C = degrees Celsius; NTU = nephelometric turbidity unit

Canal Sites

The canals are much smaller waterbodies than the Demerara River. As described in Section 8.5.2.2, Freshwater Ecosystems, the canals connect to the Demerara River via a series of floodgates and to the Essequibo River watershed via the headwater tributaries of Bonsika Creek, to the west of the Project's Direct AOI. The floodgates are capable of allowing two-way flow, but serve primarily to prevent saltwater intrusion into the rice fields from the river and to drain excess freshwater from the rice fields into the river as necessary. The widest canal sites were located on Canal 1 and Canal 2 (sites CVR-04 and CV-05, respectively), each approximately 15 meters wide. Among the canal sites, sites CV-02, PV-03, CVR-04, and CV-05 possessed the lowest habitat diversity and were characterized by uniform depth and flow, little channel sinuosity, minimal diversity of instream or bank habitat, reduced or absent natural riparian zones, and general homogeneity in habitat features throughout the length of the site (Table 8.4-4). The wetted width of all other canals surveyed ranged from approximately 4 to 13 meters (Table 8.4-5). The physical and chemical habitat characteristics (Table 8.4-6) of canal sites tended to be linked with the types of surrounding land use. At these sites, various species of submerged and floating macrophytes, such as water hyacinth (*Pontederia crassipes*), shrimp grass (*Cabomba* species [sp.]) and water lilies (*Lilium* sp.), leaf litter, and smaller instream objects such as wood or other debris, constitute the primary form of habitat available to macroinvertebrates and fish.

The canal sites with the most diverse physical habitat were sites MB-01, DD-08, WW-09, CD-10, CC-12, and WW-13 (Table 8.4-6). These sites tended to have more varied instream and bank habitat, overhanging vegetation, riparian vegetation, and greater channel and depth complexity. These characteristics were most apparent at sites in minimally developed areas or adjacent to agricultural, forested, or pasture land. In addition to these characteristics, several species of floating and submerged macrophytes were also documented at these sites, providing additional habitat diversity. These sites provided a wider range of habitat for both fish and macroinvertebrates compared to sites within more residential or commercial landscapes.

Table 8.4-4: Representative Photographs of Freshwater Survey Sites in the Canals

Site MB-01

Site CV-02

Site CD-10

Site PV-03

Site CC-11

Site CVR-04

Site CC-12

Site CV-05

Site DD-08

Site WW-09

Site WW-13

Table 8.4-5: Physical Habitat Parameters of Canal Sites

Site	Land Use Type	Wetted Width	Watershed Erosion	Apparent Watershed Pollution	Water Depth (meter)			Riparian Buffer Width (meter)		Channelization	Canopy Cover
					Min	Avg	Max	Left	Right		
MB-01	Residential	8.3	None	Slight	0.4	0.6	1.0	10	20	Yes	Open
CV-02	Agricultural	9.5	Slight	Slight	0.4	0.7	1.1	0	0	Yes	Open
PV-03	Residential, Agricultural	12.9	Moderate	Moderate	0.6	1.1	1.5	30	30	Yes	Partial
CVR-04	Residential	15.6	None	Heavy	0.4	1	1.7	0	0	Yes	Open
CV-05	Agricultural, Residential	14.6	Slight	Slight	0.3	0.3	0.3	20	5	Yes	Open
DD-08	Forested, Agricultural (legacy)	9.3	Slight	No	0.6	0.6	1.2	0	0	Intermittently	Partial
WW-09	Forest, Pasture, Agricultural (legacy)	7.4	Heavy	No	0.8	1.2	1.5	2	1	Intermittently	Partial
CD-10	Forest, Agriculture	3.9	None	No	0.3	0.7	0.9	0	2	Yes	Partial
CC-11	Residential, Agricultural	11.1	Slight	Moderate	0.5	0.7	1.0	1	1	Yes	Abundant
CC-12	Residential, Agricultural	6.5	Slight	Moderate	0.4	1	1.2	3	0	Yes	Partial
WW-13	Agricultural (legacy)	5.6	Slight	Not Observed	0.5	0.8	1.1	3	1	No	Open

Table 8.4-6: Physiochemical Habitat Parameters of Canal Sites

Site	Season	Temperature (°C)	pH	Turbidity (NTU)	Water Odors
MB-01	Dry	28.70-30.1	6.85-7.40	38.6-177	Muddy
	Wet	26.1-26.8	6.71-7.26	47.6-446	
CV-02	Dry	28.64-28.94	6.74-8.18	144-144	Muddy

Site	Season	Temperature (°C)	pH	Turbidity (NTU)	Water Odors
	Wet	27.9-28.2	2.85-2.98	112.1-125.6	
PV-03	Dry	30.19-30.21	3.46-3.50	56.6-56.6	None
	Wet	27.9-28.2	2.85-2.98	0.45-42.51	
CVR-04	Dry	28.19-29.42	3.36-3.77	2.38-5.12	None
	Wet	25.9-26.0	3.23-3.46	0.19-604	
CV-05	Dry	27.48-27.70	3.43-3.84	4.33-9.66	None
	Wet	27.5-28.0	3.26-3.92	10.84-647	
DD-08	Dry	27.48-28.74	3.89-4.11	13.5-41.3	None
	Wet	25.8-26.0	3.50-3.68	9.45-20.9	
WW-09	Dry	27.76-27.91	3.95-4.16	4.22-5.63	None
	Wet	25.7-25.8	3.38-3.53	53.67-82.5	
CD-10	Dry	27.17-28.46	5.10-5.45	109-217	None
	Wet	25.3-28.0	4.13-7.03	6.15-531	
CC-11	Wet	26.7-27.4	3.16-3.85	10.66-21.69	None
CC-12	Wet	26.1-26.4	3.39-3.95	5.38-376	None
WW-13	Wet	26.0-26.2	4.10-5.00	11.00-500	None

°C = degrees Celsius; NTU = nephelometric turbidity unit

Varying levels and types of anthropogenic pollution were documented across all sites in both survey seasons. The most commonly observed types of pollution included trash, agricultural waste, and fecal contamination. Sites located within predominantly agricultural, pasture, or forested landscapes had less trash overall than sites in residential areas, but manual application of fertilizer and pesticides is ubiquitous in agricultural areas and likely leads to contaminated runoff entering the canals. The type of trash present in agricultural, pasture, or forested areas included predominantly agricultural-associated items such as empty containers of fertilizer or pesticide and seed or chemical bags. Household garbage, food scraps, diapers, plastics, clothing, metals, broken glass, rusted wires, and car tires were more abundant at canals in residential areas or those adjacent to major roadways, and these forms of trash were particularly prominent at Sites MB-01, CV-02, CVR-04, CV-05, and CC-11. At these sites, team members regularly encountered trash entangled in sampling gear. Piles of trash were also common along the banks at these sites (Table 8.4-7) and trash burning was observed frequently on the banks of Canal 1 and Canal 2. Trash at Sites MB-01 and CC-11 appeared to originate largely from dwellings of residents living directly on the bank or within close proximity, and input of sewage, garbage, and animal waste from some of these residences was observed (Table 8.4-7). An algae bloom observed at Site MB-01 indicated possible fecal contamination during the dry season survey. Sewage and runoff from fecal matter of free-ranging livestock and stray domestic animals was common throughout the survey area, and was particularly prominent at Sites MB-01, CV-02, CVR-04, CV-05, and CC-11, and CC-12.

Table 8.4-7: Representative Photographs of Riparian Zones along Canals

Trash along canal banks

Residential areas with trash at MB-01

Physical habitat for the canal sites was rated using the USEPA Rapid Bioassessment Protocol, which rates 12 physical habitat parameters on a numerical scale of 0 to 20, in which scores increase as habitat quality increases. Physical habitat at sites PV-03, DD-08, WW-09, and WW-13 had overall ratings on the low end of the sub-optimal range, and sites MB-01, CV-02, CVR-04, CV-05, CD-10, CC-11, and CC-12 had overall ratings of marginal. Scores tended to be consistently low for pool variability, bank stability, and riparian vegetative buffer condition, but somewhat higher for epifaunal substrate and channel flow status. Table 8.4-8 presents the physical habitat scores for the canal sites.

Table 8.4-8: Rapid Bioassessment Ratings for Physical Habitat Parameters of Canal Sites

Habitat Parameter	MB-01	CV-02	PV-03	CVR-04	CV-05	DD-08	WW-09	CD-10	CC-11	CC-12	WW-13
Epifaunal Substrate/Available Cover	11	10	11	11	10	16	16	15	16	16	16
Pool Substrate Characterization	13	11	15	15	15	15	15	11	16	16	16
Pool Variability	5	1	1	1	1	6	6	1	1	1	0
Sediment Deposition	10	10	10	10	10	10	10	10	10	10	10
Channel Flow Status	10	18	18	18	18	18	18	18	18	18	18
Channel Alteration	11	15	14	14	14	9	9	14	10	9	10
Channel Sinuosity	3	1	5	0	0	10	10	0	0	0	10
Bank Stability (Left Bank)	6	9	7	8	8	5	5	9	8	7	10
Bank Stability (Right Bank)	8	9	7	8	8	5	5	9	8	7	10
Vegetative Protection (Left Bank)	10	6	9	5	5	6	9	6	5	5	8
Vegetative Protection (Right bank)	6	6	10	4	4	6	8	6	5	5	8
Riparian Vegetative Zone Width (Left bank)	2	2	2	4	2	2	2	5	5	5	5
Riparian Vegetative Zone Width (Right bank)	0	1	2	2	3	2	2	5	5	5	5
Total Habitat Score	**95**	**99**	**111**	**100**	**98**	**110**	**115**	**109**	**107**	**104**	**126**
Qualitative Condition	**Marginal**	**Marginal**	**Suboptimal**	**Marginal**	**Marginal**	**Suboptimal**	**Suboptimal**	**Marginal**	**Marginal**	**Marginal**	**Suboptimal**

Key to Qualitative Condition Descriptions:
Optimal = exhibiting natural conditions (Total Habitat Score 200 to 160)
Suboptimal = exhibiting some alteration, but with natural conditions for most criteria (Total Habitat Score 159 to 110)
Marginal = exhibiting moderate levels of degradation, with severe degradation at frequent intervals throughout the evaluated reach (Total Habitat Score 109 to 60)
Poor = substantially altered; severely degraded conditions (Total Habitat Score 59 to 0)

8.4.2.2. Aquatic Macroinvertebrates

Aquatic macroinvertebrates include aquatic insects, gastropods, crustaceans, and mollusks. Aquatic insects account for approximately 60 percent of aquatic invertebrates, where they represent critical components of both flowing and non-flowing waterways (Collier et al. 2016). Due to their generally sedentary behavior and short generation times, many species of insects respond quickly to habitat degradation. These characteristics make them suitable as bioindicators. Aquatic insects are among the most frequently used groups in the biological assessment of water quality worldwide, and select terrestrial insect groups provide information on anthropogenic changes in terrestrial habitat types.

Macroinvertebrates Surveys within the Project Area of Influence

Adult and nymphal stages of macroinvertebrates (Class Insecta) were collected during the dry and rainy seasons to provide a quantitative description of the community composition and to assess the water and terrestrial habitat quality at each sampling site. During the dry season, data were collected at five sites on the west bank of the Demerara and west coast of the Atlantic from 11 to 22 November 2021. Sites included DD-08, CD-10, DDR-06, DR-07, MB-01, and CVR-04[13] (Figure 8.4-1). Data were collected during the wet season from 6 to 14 January and 8 to 14 February 2022 at these same sites as well as three new sites: CC-11, CC-12, and WW-13 (Figure 8.4-1). Each sampling event was conducted at the upstream and downstream ends of each sample site. Figure 8.4-1 depicts the sampling locations. The sampling methods are described in detail in the Gas to Energy Project Macroinvertebrate Survey (Wet and Dry Season) Diversity Report by the University of Guyana Centre for Study of Biological Diversity (CSBD) included in Appendix N.

Macroinvertebrate Survey Results

Insects were the only aquatic macroinvertebrates collected during the survey. The macroinvertebrate surveys yielded a total of 1,052 individuals in 18 families of insects. Most of these (882 aquatic organisms in 16 families) were collected from four sites (Table 8.4-9). No aquatic macroinvertebrates were collected at Site DRR-06/DR-07 during the dry season. Although total dissolved solids (TDS) at the two riverine biodiversity sites varied widely (708 parts per million [ppm] and 29 ppm), average TDS throughout the wider river (see Section 7.4.4.2) was higher in the river than in the canals during both the wet and the dry seasons (Table 8.4-9).

Table 8.4-9: Mean Total Dissolved Solids in the Demerara River and the Canals by Season

Season	River Sites	Canal Sites
Dry Season	2,183 ppm	1,037 ppm
Wet Season	396 ppm	64 ppm

[13] The insect density was conspicuously low at both Demerara River sites, so these two sites have been combined for the purposes of the aquatic macroinvertebrate analysis.

Using TDS as a proxy for salinity, the scarcity of aquatic macroinvertebrates at the river sites can likely be attributed to the comparatively high level of salinity in the water in the river relative to the canals and the heavy tidal flow. Table 8.4-10 lists the insect families recorded during the surveys.

During the dry season, the most family-rich site was MB-01, followed by Sites CD-10, CVR-04, DD-08, and DRR-06/DR-07. The total individuals collected at each site followed a similar pattern, with Site MB-01 accounting for 289 individuals followed by CD-10, CVR-04, DD-08, and DRR-06/DR-07 (in descending order). During the wet season, the most family-rich sites were DD-08 and WW-13, followed by sites CC-11, MB-01, and CD-10, CVR-04, CC-12, and DRR-06/DR-07. The most individuals in the wet season were collected from Site WW-13, followed by CD-10, MB-01, CC-11, CVR-04, CC-12, DD-08, and DRR-06/DR-07 (in descending order). Table 8.4-11 lists the family composition of macroinvertebrates at the survey sites. Figure 8.4-2 compares the aquatic macroinvertebrate families found at each site during the dry season and wet season.

Table 8.4-10: Macroinvertebrate Family Abundance at Survey Sites

Family	Feeding Guild	DD-08		CD-10		DRR-06/ DR-07[a]		MB-01		CVR-04		CC-11	CC-12	WW-13
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Wet	Wet
Belostomidae	Scavenger/ Predator	0	2	27	12	0	0	57	23	0	0	4	0	0
Baetidae	Scraper	0	0	0	0	0	0	0	0	0	0	6	0	6
Caenidae	Collector/ Gatherer	6	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae	Collector/ Gatherer	1	6	5	80	0	0	60	16	1	7	19	28	5
Coenagrionidae	Predator	0	0	2	1	0	0	2	6	19	9	8	3	4
Corixidae	Herbivore	0	6	0	2	0	0	0	2	0	0	17	1	5
Culicidae	Collector /Gatherer	0	4	17	3	0	1	2	0	1	0	2	0	30
Dytiscidae	Predator	0	1	4	12	0	3	0	11	0	0	0	1	30
Elmidae	Herbivore/ Detritivore	0	1	0	4	0	0	50	5	0	0	1	0	0
Gyrinidae	Scavenger/ Predator	0	2	0	0	0	0	0	0	0	0	0	0	0
Gerridae	Scavenger/ Predator	0	0	0	0	0	0	0	0	0	0	0	0	37
Hydrophilidae	Scavenger/ Predator	0	0	6	0	0	0	67	23	0	0	4	0	11
Lestidae	Scavenger/ Predator	1	0	0	0	0	0	39	0	2	0	0	0	0
Libellulidae	Predator	7	5	2	0	0	0	1	0	17	23	16	11	58
Mesoveliidae	Scavenger/ Predator	0	0	2	0	0	0	0	0	0	0	0	0	0
Nepidae	Predator	0	0	0	0	0	0	2	0	0	0	0	0	0
Notonectidae	Predator	0	2	27	4	0	0	9	13	4	5	0	0	8
Prosopistomatidae	Unknown	0	1	0	0	0	0	0	0	0	2	0	0	0

Family	Feeding Guild	DD-08		CD-10		DRR-06/ DR-07[a]		MB-01		CVR-04		CC-11	CC-12	WW-13
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Wet	Wet	Wet
Total Families		4	10	9	8	0	2	10	8	6	5	9	5	10
Total Individuals		15	30	92	118	0	4	289	99	44	46	77	44	194

Source: Gas to Energy Project Macroinvertebrate Survey (Dry and Wet seasons) Diversity Report in Appendix N

[a] No aquatic macroinvertebrates were collected at Site DRR-06/DR-07 during the dry season.

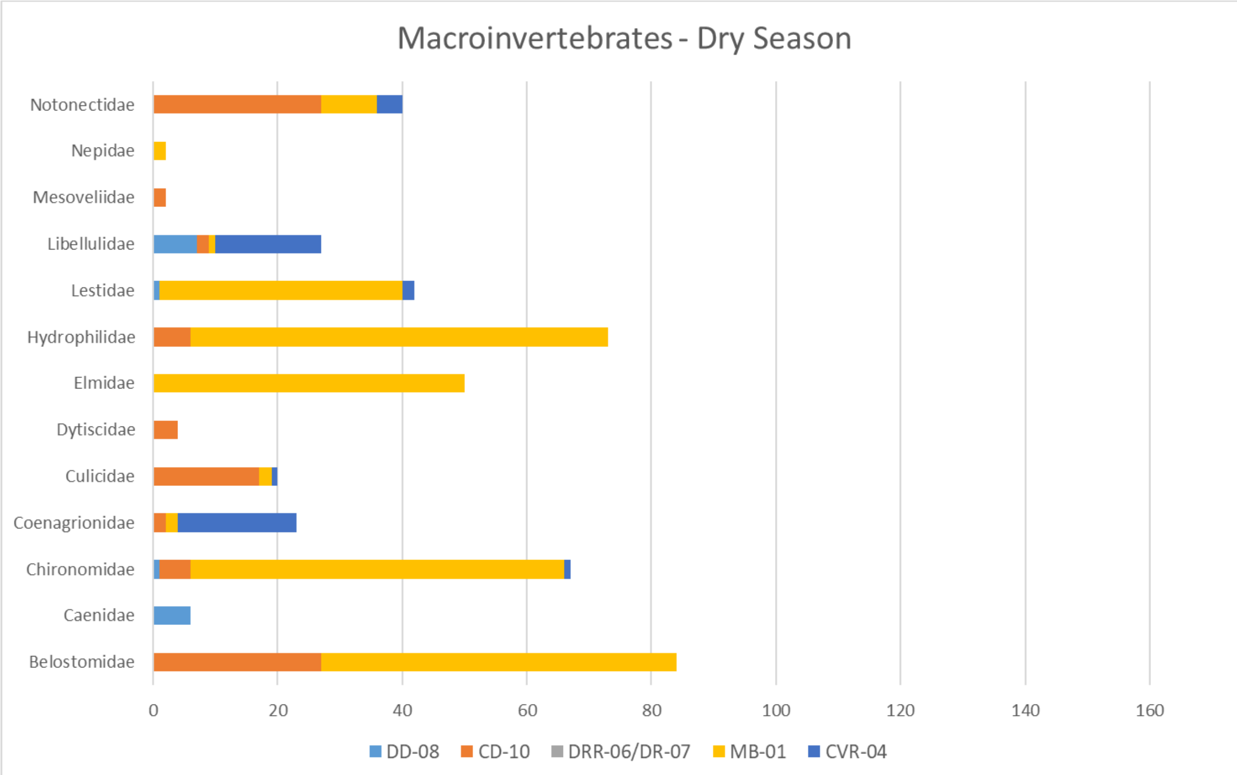
Table 8.4-11: Family Composition of Macroinvertebrates at the Survey Sites

Site	Season	Family Richness	Total Abundance	Shannon Diversity Index (H')	Simpson Diversity Index (1-D)	Pielou's J (Evenness)
DD-08	Dry	4	15	1.08	0.66	0.78
	Wet	10	30	2.09	0.89	0.91
CD-10	Dry	9	92	1.75	0.79	0.80
	Wet	8	118	1.16	0.52	0.56
DRR-06/ DR-07	Dry	0	0	--	--	--
	Wet	2	4	0.56	0.5	0.81
MB-01	Dry	10	289	1.79	0.82	0.78
	Wet	8	99	1.88	0.84	0.91
CVR-04	Dry	6	44	1.26	0.67	0.70
	Wet	5	46	1.33	0.69	0.83
CC-11	Wet	9	77	1.89	0.83	0.86
CC-12	Wet	5	44	0.98	0.54	0.61
WW-13	Wet	10	194	1.92	0.82	0.84

Source: Gas to Energy Project Macroinvertebrate Survey (Dry and Wet Seasons) Diversity Report in Appendix N

Shannon Diversity Index: values increase with increasing diversity.
Simpson Diversity Index: values can range from zero to one, with a score of one representing maximum diversity.
Pielou's J (Evenness): values can range from zero to one, with a score of one supporting maximum evenness.[14]

[14] Relative abundances of species within a community. In a maximally even community, all species present are represented by an equal number of individuals.



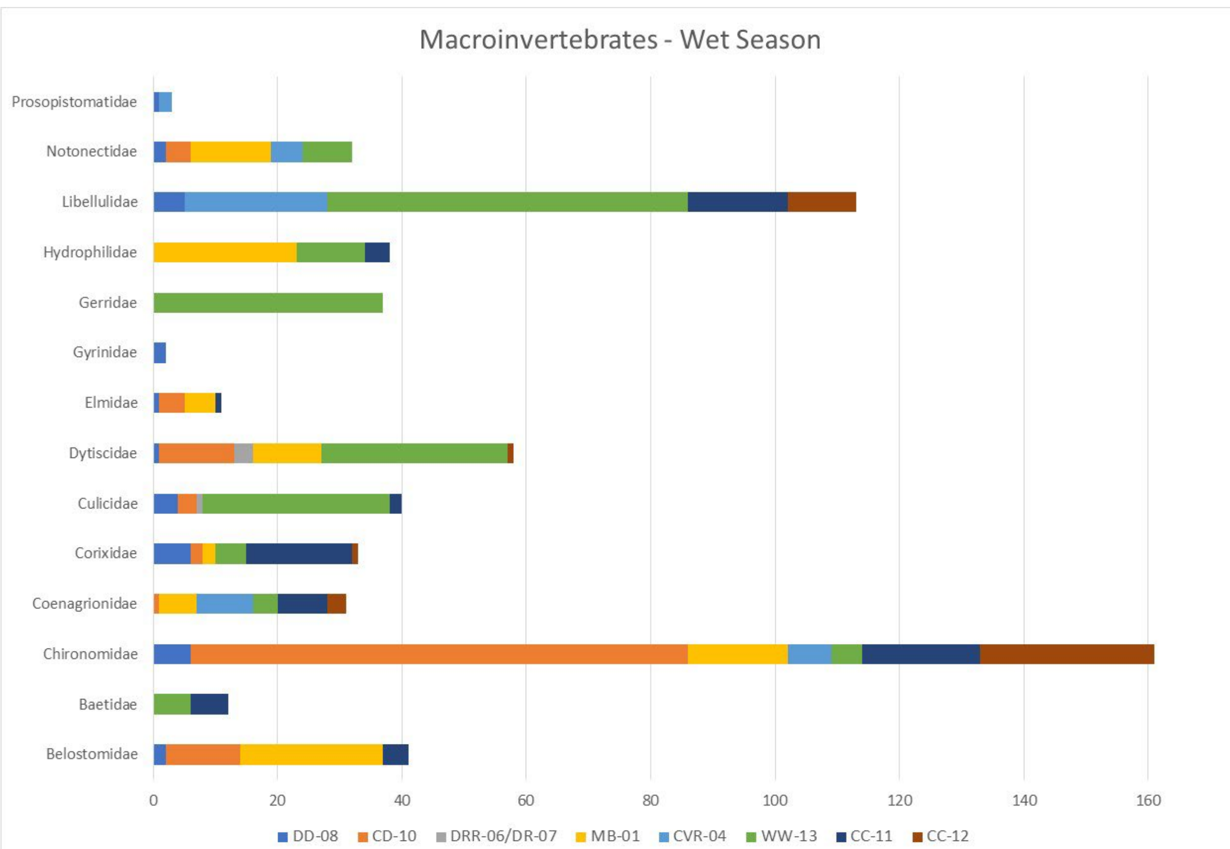


Figure 8.4-2: Comparison of Aquatic Macroinvertebrate Families Found at the Survey Sites

Chironomidae (red blood worms) and Libellulidae (skimmer dragonflies) were the most widespread and abundant of all the macroinvertebrate families sampled across both seasons. Both families are relatively pollution-tolerant, and are habitat generalists. Chironomidae were among the dominant families in six of the eight freshwater sites surveyed in at least one season. Libellulidae were one of the dominant families in five of the eight freshwater sites surveyed in at least one season. During the dry season, Chironomidae and Libellulidae were the most widespread of all families sampled; they occurred at four of the five sites sampled and were both among the dominant families, at two sites each. Most of the families sampled in the dry season were generalist taxa; the only families captured during the survey that are known to be particularly sensitive to water quality are Caenidae (small square-gilled mayflies), which only occurred at Site DD-08 during the dry season, and Baetidae (small minnow mayflies), which only occurred at Site CC-11 in the wet season. The presence of caenid mayflies at Site DD-08 is broadly consistent with the water quality assessment, as Site DD-08 had the best water quality of the survey sites during the dry season and one of the highest physical habitat scores. Site CC-11 had poor water quality, so the presence of baetid mayflies at this site was unexpected.

During the wet season, Chironomidae and Libellulidae were similarly widespread, occurring at seven sites and five sites, respectively. Libellulidae was among the dominant families at all five sites where it occurred in the wet season, and Chironomidae was among the dominant families at four of the seven sites where it occurred (Table 8.4-10 and Table 8.4-12). Sites WW-13 and DD-08 were the richest in terms of family composition, with WW-13 having the highest total abundance of all sites surveyed with high populations of Libellulidae. Sites DD-08 and CVR-04 were the most diverse sites; however, DD-08 had lower abundance than all other sites except the tidally influenced Site DDR-06/DD-07. During the wet season, Site CD-10 was the least diverse canal site, with high populations of pollution-tolerant Chironomidae and small populations of Dytiscidae (predaceous diving beetles) and Belostomatidae (giant water bugs). The Canal 1 sites (CVR-04, CC-11, and CC-12) also had lower diversity compared to other sites with high populations of Libellulidae and Chironomidae. These results were consistent with the water quality assessment, as Sites CD-10, CVR-04, and CC-12 had poorer quality water than the other sites (Table 8.4-13).

Table 8.4-12: Dominant Macroinvertebrate Families Recorded at Survey Sites

Site	Season	Percent Dominant Taxa [a]	Dominant Aquatic Families
DD-08	Dry	100	Libellulidae, Caenidae, Chironomidae and Lestidae
	Wet	56.67	Corixidae, Libellulidae, Chironomidae
CD-10	Dry	77.17	Belostomidae, Notonectidae, Culicidae
	Wet	88.14	Chironomidae, Belostomatidae, Dytiscidae
DDR-06/ DR-07	Dry	0	None
	Wet	100	Culicidae, Dytiscidae
MB-01	Dry	63.68	Hydrophilidae, Chironomidae, Belostomidae
	Wet	62.63	Belostomatidae, Chironomidae, Hydrophilidae
CVR-04	Dry	90.91	Libellulidae, Coenagrionidae, Notonectidae

Site	Season	Percent Dominant Taxa [a]	Dominant Aquatic Families
	Wet	84.78	Chironomidae, Coenagrionidae, Libellulidae
CC-11	Wet	67.53	Corixidae, Chironomidae, Libellulidae
CC-12	Wet	95.45	Chironomidae, Coenagrionidae, Libellulidae
WW-13	Wet	79.90	Gerridae, Libellulidae, Dytiscidae, Culicidae

[a] Percentage of total individuals belonging to the three most abundant taxa at each site

The water quality of the survey sites was assessed based on two widely used macroinvertebrate-based indices, the Hilsenhoff Family Level Biotic Index (HFBI) and the Biological Monitoring Working Party (BMWP) Index. Details on how both metrics are calculated are available in the Macroinvertebrate Survey by CSBD included in Appendix N. Both the HFBI and the BMWP are calculated at the family level and provide a single number representing the invertebrate community's tolerance to pollution based on the tolerance values for all invertebrate families at a site. The BWMP and HFBI scores are inversely related to each other. The more sensitive a community is to pollution, the higher the BMWP score and the lower the HFBI score. The BMWP was also converted to an Average Score Per Taxon (ASPT). The ASPT is the average tolerance score of all taxa within the community and is calculated by dividing the BMWP by the number of families represented in the sample. Finally, the water quality of each site was assigned a qualitative description based on the ASPT scores. These calculations are summarized in Table 8.4-13. Based on the results of this analysis, all survey sites were polluted and poor water quality with substantial to very substantial pollution was observed (Table 8.4-13).

As noted above, the distribution of macroinvertebrate taxa was generally consistent with physiochemical data at the study sites, but there was less consistency between the diversity indices and the physiochemical data. As noted in the Macroinvertebrate Survey by CSBD in Appendix N, collector-gatherers generally become more dominant while other feeding guilds diminish with increasing pollution, but this principle did not uniformly apply to the macroinvertebrate study data. The predatory Libellulidae and collector-gatherer Chironomidae were co-dominant across a similar number of sites, spanning the range of water quality conditions as evaluated using the ASPT index. The predatory Belostomatidae and Hydrophilidae both occurred at Site CD-10, which had "extremely high" indications of pollution in the wet season (although Hydrophilidae was only detected there in the dry season when pollution indicators were slightly improved compared to wet season conditions) (Table 8.4-10).

Table 8.4-13: Water Quality Assessment of Survey Sites Based on Macroinvertebrate Indices

Site	Season	Family Richness	Total Abundance	HFBI Score		BWMP Score	ASPT Category
MB-01	Dry	10	289	7.15	Fairly poor water quality (significant organic pollution)	5.14	Doubtful quality
	Wet	8	99	7.17	Fairly poor water quality (significant organic pollution)	4.67	Probable moderate pollution
CVR-04	Dry	6	44	8.32	Poor water quality (very significant organic pollution)	5.25	Doubtful quality
	Wet	5	46	8.39	Poor water quality (very significant organic pollution)	5.25	Doubtful quality
DRR-06/ DR-07	Dry	0	--	Not assessed due to low numbers of organisms captured			
	Wet	2	4				
DD-08	Dry	4	15	8.13	Poor water quality (very significant organic pollution)	5.67	Doubtful quality
	Wet	10	30	6.97	Fairly poor water quality (significant organic pollution)	5.00	Doubtful quality
CD-10	Dry	9	92	6.51	Fairly Poor water quality (significant organic pollution)	5.17	Doubtful quality
	Wet	8	118	7.62	Poor water quality (very significant organic pollution)	4.67	Probable moderate pollution
CC-11	Wet	9	77	7.23	Fairly poor water quality (significant organic pollution)	5.00	Doubtful quality
CC-12	Wet	5	44	8.18	Poor water quality (very substantial pollution)	5.20	Doubtful quality
WW-13	Wet	10	194	7.21	Fairly poor water quality (significant organic pollution)	5.00	Doubtful quality

HFBI:
0–3.50 indicates excellent water quality (no apparent organic pollution)
3.51–4.50 indicates very good water quality (possible slight organic pollution)
4.51–5.50 indicates good water quality (some organic pollution)
5.51–6.50 indicates fair water quality (fairly significant organic pollution)
6.51–750 indicates fairly poor water quality (significant organic pollution)
7.51–8.50 indicates poor water quality (very significant organic pollution)
8.51–10.00 indicates very poor water quality (severe organic pollution)
(Hilsenhoff 1988)

BWMP/ASPT:
>6 indicates clean water
5–6 indicates doubtful quality
4–5 indicates probable moderate pollution
<4 indicates probable severe pollution
(Armitage et al.1983; Friedrich et al.1996; Mackie 2001)

8.4.2.3. Inland Fish of Guyana

Inland fish of the Project area are part of the Greater Amazonia biodiversity province, which encompasses the Amazon River and Orinoco River watersheds and the coastal rivers of the Guianas (Van Der Sleen and Albert 2018). The fish fauna of this region are the most diverse in the world, but the region's fish abundance, biomass, and species richness are primarily attributable to three highly diverse taxonomic groups: Characiforms, (piranhas, tetras, wolf-fishes, hatchet fishes, and relatives), Siluriformes (catfishes), and Cichlidae (peacock basses, freshwater angel fishes, oscars, and relatives). More than 3,000 fish species have been described in the Amazon-Orinoco-Guianas region, corresponding to a species density approximately seven times that of the United States (Van Der Sleen and Albert 2018). Explanations for such immense biodiversity of the Greater Amazonia include the evolutionary age, diversity, and size of drainage systems and river catchment events, habitat succession and niche diversity (Lowe-McConnell 1987), and abundance of stable, lowland environments capable of supporting large abundances of fish (Henderson and Crampton 1997).

Inland fishes observed in the coastal region of Guyana have varying tolerances to saltwater. Obligatory freshwater fishes, which occur in waters where total dissolved salt is less than 0.5 ppt, are represented by three large taxonomic groups, including Characiforms, Siluriformes, and Gymnotiformes (knifefishes and electric eel species), and a small number of species belonging to four families: Arapaimidae (*Arapaima gigas*), Osteoglassidae (two species of arowanas), Polycentridae (three species of leaf-fishes), and Lepidosirenidae (*Lepidosiren paradoxa*, the South American lungfish). In comparison, families Cichlinae (a subfamily of cichlidae), Rivulidae (rivuline killifishes), Cyprinodontidae (pupfishes), Anablepidae (four-eyed fishes), and Poeciliidae (livebearers) have greater tolerance for brackish conditions, and are referred to as secondary freshwater fish.

Groups with the highest tolerance for saltwater and more typically associated with marine environments, called peripheral fish, including Engraulidae (anchovies), Sciaenidae (drums), flatfishes (Achiridae), Gobiidae (gobies), Belonidae (needlefishes), Tetraodontidae (puffers), and Potamotrygonidae (stingrays), are also common coastal species in Guyana. They tend to be particularly abundant where there is direct connection to marine habitats, such as the Demerara River. Coastal tropical rivers are known to support freshwater and saltwater conditions simultaneously for long distances from the mouth upriver and downriver. The extent of this influence varies with seasonal conditions and tidal movements, which contributes to mixed populations of marine and freshwater fishes in these areas (Lowe-McConnell 1987).

Historical Data

Documented historical systematic studies of inland fish in Guyana within or near the Project AOI are few, but early surveys were conducted by Carl Eigenmann in 1908 in various coastal streams and canals in the vicinity of Georgetown and in the lower and upper Demerara River (Eigenmann 1909). These locations were resampled in 1998 to evaluate changes in community composition and environmental conditions over the 90 years between studies (Hardman et al. 2002; Eigenmann 1909, 1912). Eigenmann's complete 1908 survey documented a total of

336 species in Guyana, which included samples taken from coastal Georgetown sites, the Demerara, the Essequibo, and the Potaro drainages. The 1998 replication of Eigenmann's study increased the number of confirmed species in Guyana to 383, and most sites had nearly identical assemblages as reported in 1908, with the exception of coastal sites sampled in the vicinity of Georgetown, where a total of 44 species were identified in 1998 compared with 68 in 1908 (Hardman et al. 2002). Surveys of the coastal Georgetown area and sites along the Demerara together yielded a total of 158 species. Heavy pollution was documented around the coastal canal sites, particularly from street and agricultural runoff. Hardman reported that the decline in species at these sites was likely associated with environmental degradation and development, noting that the human population in Georgetown had nearly tripled over the 90 years between sampling events, from approximately 250,000 to 800,000 (Hardman et al. 2002).

1.1.1.1.1. Fish Surveys within the Project Area of Influence

Fish were collected during the dry and wet seasons to provide a quantitative description of the community composition and assess the water and terrestrial habitat quality at the same sampling sites and times as the habitat and macroinvertebrate assessments. The sampling methods are described in detail in the Ichthyofaunal Assessment of the Gas to Energy Project Sites by CSBD in Appendix H.

Fish Survey Results

During the freshwater biodiversity baseline surveys, 79 unique fish taxa[15] were documented comprising 4,613 individuals belonging to 31 families and 72 genera (Tables 8.4-14 and 8.4-15). The most abundant order was Characiformes (31 species), followed in descending order by Siluriformes (19 species), Cichliformes (12 species), Perciformes (1 species), Cyprinodontiformes (5 species), and Gymnotiformes (3 species), Clupeiformes (2 species), Myliobatiformes (2 species), and Pleuronectiformes and Eleopiformes both represented by only 1 species (Figure 8.4-3). The most abundant family was Characidae (11 species), followed in descending order by Cichlidae (12 species), Loricariidae (3 species), Crenuchidae (2 species), Polycentridae (1 species), Curimatidae and Erythrinidae (2 species each), Serrasalmidae (6 species), and Lebiasinidae (5 species). The remaining 22 families each accounted for three or less species and less than 2 percent of the total abundance across both the wet and dry season samples (Figure 8.4-4). Characids and cichlids were the dominant families both in terms of taxonomic richness and abundance, accounting for a combined 74 percent of the species richness and a combined 73 percent of the abundance documented across both seasons. A total of 43 of the 158 species documented during Eigenmann and Hardman's studies in 1908 and 1998 along coastal Georgetown and the Demerara River were documented during the freshwater baseline survey.

[15] Results are presented in terms of unique taxa because the presence of large numbers of juvenile fishes precluded the identification of some individuals to species. Although some immature specimens were not identifiable to species, they were generally recognizable as taxonomically distinct from other species in the samples.

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Table 8.4-14: Fish Order, Family, Species, Abundance, and Relative Abundance

Order/Family/Species	Common Name	Dry Season	Wet Season	MB-01	CV-02	PV-03	CVR-04	CV-05	DRR-06	DR-07	DD-08	WW-09	CD-10	CC-11	CC-12	WW-13	Abundance	Relative Abundance Percent
CHARACIFORMES																		
Acestrorynchidae																		
Acestrorhynchus microlepis	Dogfish/Fox fish	X		0	0	0	0	0	0	1	1	0	0	0	0	0	2	0.04
Anostomidae																		
Leporinus frederici	Threespot Leporinus		X	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.02
Characidae																		
Acanthocharax microlepis			X	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0.02
Astyanax bimaculatus	Silver fish	X	X	3	21	10	3	4	0	0	0	0	96	2	1	6	146	3.16
Charax gibbosus	Batfish	X		0	0	0	0	0	0	0	0	0	4	0	0	0	4	0.09
Heterocharax bellottii		X	X	0	0	0	4	0	0	0	0	3	0	0	0	0	7	0.15
Ctenobrycon spilurus	Silver Tetra		X	0	19	0	0	0	0	0	0	2	0	0	0	3	24	0.52
Hemigrammus micropterus			X	0	0	0	0	0	0	0	0	0	142	0	0	0	142	3.08
Hemigrammus stictus	Red base Tetra	X	X	0	0	0	0	0	0	0	78	8	0	0	0	0	86	1.86
Moenkhausia ceros	Ceros Tetra	X	X	0	0	0	0	0	0	0	41	22	0	2	0	58	123	2.67
Moenkhausia sp.		X		0	0	0	0	0	0	0	27	2	0	0	0	0	29	0.63
Pristella maxillaris	Featherfin Tetra	X	X	7	2	973	5	77	0	0	42	136	151	33	0	18	1,444	31.30
Roeboides thurni	Pihab		X	128	42	2	0	0	0	0	0	0	723	0	0	0	895	19.40
Crenuchidae																		
Crenuchus spilurus	Sailfin	X	X	0	0	0	0	0	0	0	91	44	0	0	0	0	135	2.93
Poecilocharax bovaliorum			X	0	0	0	0	0	0	0	4	0	0	0	0	0	4	0.09
Curimatidae																		
Curimata cyprinoides	Coroor	X	X	11	5	0	11	3	27	27	14	11	0	0	0	7	116	2.51
Cyphocharax spilurus		X		0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.02
Erythrinidae																		
Hoplerythrinus unitaeniatus	Yarrow	X	X	0	0	18	19	17	0	0	0	0	0	9	17	0	80	1.73
Hoplias malabaricus	Huri	X	X	9	2	4	6	3	0	0	0	4	8	0	0	1	37	0.80
Gasteropelecidae																		
Carnegiella strigata	Hatchet Fish	X	X	0	0	0	0	0	0	0	22	11	0	0	0	0	33	0.72
Iguanodectidae																		
Bryconops melanurus	Pihab	X	X	0	0	0	0	0	0	0	8	27	0	0	0	0	35	0.76
Lebiasinidae																		
Copella arnoldi			X	0	0	0	0	0	0	0	0	0	0	1	4	0	5	0.11
Nannostomus beckfordi	Pencil Fish		X	0	0	0	0	0	0	0	12	0	0	0	0	0	12	0.26
Nannostomus harrisoni	Pencil Fish		X	0	0	0	0	0	0	0	0	3	0	0	0	0	3	0.07
Nannostomus marginatus	Pencil Fish	X	X	0	0	0	0	4	0	0	20	4	0	0	0	0	28	0.61
Pyrrhulina filamentosa	Pencil Fish	X	X	0	0	13	6	2	0	0	3	0	3	3	0	1	31	0.67
Serrasalmidae																		
Metynnis argenteus	Silver Dollar		X	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0.04
Pygopristis denticulatus	Pirai		X	0	0	0	0	0	0	0	0	0	17	0	0	0	17	0.37

Order/Family/Species	Common Name	Dry Season	Wet Season	MB-01	CV-02	PV-03	CVR-04	CV-05	DRR-06	DR-07	DD-08	WW-09	CD-10	CC-11	CC-12	WW-13	Abundance	Relative Abundance Percent
Pygocentrus nattereri	Red Belly Pirai	X	X	11	20	0	0	0	0	0	1	0	9	0	0	3	44	0.95
Serrasalmus rhombeus	Black Piranha	X	X	0	0	0	0	0	1	6	4	6	0	0	0	1	18	0.39
Serrasalmus sp.	Pirai	X		0	0	0	0	0	0	0	0	2	0	0	0	0	2	0.04
Serrasalmus sp. 1	Pirai	X		0	0	0	2	0	0	0	0	0	2	0	0	0	4	0.09
CICHLIFORMES																		
Cichlidae																		
Aequidens tetramerus	Saddle Cichlid		X	0	0	0	4	0	0	0	0	0	0	0	0	2	6	0.13
Acaronia nassa	Patwa	X	X	0	0	1	0	0	0	0	2	0	2	0	0	1	6	0.13
Apistogramma steindachneri	Patwa	X	X	0	0	1	0	0	0	0	4	2	4	0	0	0	11	0.24
Cichla ocellaris	Lukanani	X	X	0	0	1	0	0	0	0	0	0	2	0	0	0	3	0.07
Cichlasoma bimaculatum	Patwa	X	X	4	0	4	12	9	0	0	0	0	0	12	0	0	41	0.89
Crenicichla alta	Sunfish	X	X	0	0	1	2	1	0	0	0	2	1	3	0	2	12	0.26
Crenicichla albopuntata	Sunfish	X	X	1	0	0	0	2	0	0	0	1	0	1	0	1	6	0.13
Heros notatus	Patwa	X	X	0	0	0	0	0	0	2	12	6	0	0	0	0	20	0.43
Krobia guianensis	Patwa	X	X	0	0	16	135	56	0	0	1	1	0	9	15	2	235	5.09
Mesonauta guyanae	Granny Patwa	X	X	0	0	0	0	0	0	0	4	6	7	0	0	2	19	0.41
Nannacara anomala	Patwa	X	X	0	0	7	26	7	0	0	1	0	0	0	13	9	63	1.37
Oreochromis niloticus	Tilapia	X	X	7	15	0	0	7	0	0	29	0	0	0	0	0	58	1.26
CLUPEIFORMES																		
Engraulidae																		
Anchoa spinifer	Spicule Anchovy		X	0	0	0	0	0	0	20	0	0	0	0	0	0	20	0.43
Anchoviella lepidentostole	Broadband Anchovy		X	0	0	0	0	0	22	32	0	0	0	0	0	0	54	1.17
CYPRINODONTIFORMES																		
Rivulidae																		
Liamosemion agilae	Killifish	X	X	0	0	0	1	1	0	0	0	0	0	1	0	0	3	0.07
Poeciliidae																		
Poecilia reticulata	Guppy	X	X	0	3	0	0	0	0	0	0	0	0	0	0	3	6	0.13
Poecilia vivipara	Guppy	X	X	4	34	0	0	0	0	0	0	0	0	0	0	1	39	0.85
Tomeurus sp.			X	0	0	0	0	0	0	10	0	0	0	0	0	0	10	0.22
ELOPIFORMES																		
Megalops atlanticus	Tarpon		X	3	1	0	0	0	0	0	0	0	0	0	0	0	4	0.09
GYMNOTIFORMES																		
Hypopomidae																		
Steatogenys elegans		X	X	0	0	0	0	0	0	0	14	11	0	0	0	0	25	0.54
Sternopygidae																		
Eigenmannia nigra			X	0	0	0	0	0	0	0	6	0	0	0	0	0	6	0.13
Sternopygus macrurus	Knife fish	X	X	0	0	0	0	0	1	0	5	2	0	0	0	0	8	0.17
MYLIOBATIFORMES																		
Potamotrygon cf. *orbignyi*	Smooth back Stingray		X	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.02
Potamotrygon sp.			X	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.02

Order/Family/Species	Common Name	Dry Season	Wet Season	MB-01	CV-02	PV-03	CVR-04	CV-05	DRR-06	DR-07	DD-08	WW-09	CD-10	CC-11	CC-12	WW-13	Abundance	Relative Abundance Percent
PERCIFORMES																		
Centropomidae																		
Centropomus ensiferus	Snook	X		10	0	0	0	0	0	0	0	0	0	0	0	0	10	0.22
Sciaenidae																		
Plagioscion squamosissimus	Basha	X	X	0	0	0	0	0	1	7	0	0	0	0	0	0	8	0.17
Polycentridae																		
Polycentrus schomburgkii	Leaf Fish	X	X	26	0	29	6	16	0	0	3	4	1	28	5	2	120	2.60
PLEURONECTIFORMES																		
Achiridae																		
Apionichthys dumerili	Flounder	X		0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.02
SILURIFORMES																		
Ariidae																		
Amphiarius rugispinis	Softhead catfish	X	X	0	0	0	0	0	9	6	0	0	0	0	0	0	15	0.33
Sciades couma	Sea catfish		X	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0.04
Aspredinidae																		
Aspredo aspredo	Banjoman	X	X	0	0	0	0	0	1	1	0	0	0	0	0	0	2	0.04
Auchenipteridae																		
Ageneiosus inermis	Driftwood Catfish	X	X	0	0	0	0	0	3	0	0	0	0	0	0	0	3	0.07
Tatia sp.	Driftwood Catfish	X	X	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.02
Trachelyopterus galeatus	Driftwood Catfish		X	0	0	1	0	0	0	0	0	0	0	2	0	0	3	0.07
Callichthyidae																		
Hoplosternum littorale	Hassar	X	X	4	0	0	0	0	0	0	0	0	3	0	0	0	7	0.15
Megalechis thoracata		X	X	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0.02
Cetopsidae																		
Helogenes marmoratus		X		0	0	0	0	0	0	0	2	0	0	0	0	0	2	0.04
Doradidae																		
Doras carinatus	Thorny Catfish	X	X	0	0	0	0	0	1	0	4	0	0	0	0	0	5	0.11
Amblydoras affinis		X	X	0	0	0	0	0	0	0	0	0	4	0	0	0	4	0.09
Heptapteridae																		
Pimelodella cristata	Cassie	X	X	0	2	0	0	0	5	0	0	0	4	0	0	0	11	0.24
Rhamdia sp.	Cassie		x	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0.04
Loricariidae																		
Hypostomus plecostomus	Smoke hassa	X	X	9	1	0	0	0	5	2	1	0	0	0	0	0	18	0.39
Parotocinclus britskii			X	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.02
Rineloricaria fallax	Long tail hassa	X	X	67	43	0	0	0	0	0	0	2	41	0	0	17	170	3.69
Pimelodidae																		
Hypopthylamus marginatus	Highwater	X	X	0	0	0	0	0	12	9	0	0	0	0	0	0	21	0.46
Pimelodus blochii	Cassie	X	X	0	15	0	0	0	20	0	0	0	0	0	0	2	37	0.80
Pseudoplatystoma fasciatum	Tiger fish	X		0	0	0	0	0	0	0	0	1	0	0	0	0	1	0.02

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Table 8.4-15: Fish Family Abundance and Biomass at Survey Sites

Site	Season	Species	Abundance	Biomass	Margalef Species Richness Index	Shannon-Weiner Diversity Index	Pielou's J (Evenness)
Canal Sites							
MB-01	Dry	14	232	4,491	13.82	1.62	0.61
	Wet	12	72	5,112	11.77	2.19	0.51
CV-02	Dry	11	142	3,516	11.80	1.99	0.80
	Wet	12	88	1,796	11.78	1.96	0.44
PV-03	Dry	6	31	672	5.71	1.44	0.80
	Wet	14	1,054	4,905	13.86	0.43	0.06
CVR-04	Dry	12	120	3,725	10.79	1.21	0.50
	Wet	10	103	6,189	9.78	1.61	0.35
CV-05	Dry	9	58	6,818	8.75	1.81	0.82
	Wet	14	159	3,199	13.80	1.71	0.34
DD-08	Dry	19	188	2,583	17.81	2.31	0.78
	Wet	23	253	4,413	22.82	2.25	0.41
WW-09	Dry	20	81	58	19.77	2.49	0.83
	Wet	18	247	2,009	17.82	1.73	0.31
CD-10	Dry	21	459	4,928	22.84	1.84	0.59
	Wet	16	810	3,509	15.85	0.92	0.14
CC-11	Wet	14	107	2,998	13.79	1.97	.042
CC-12	Wet	6	55	4,014	5.75	1.54	0.38
WW-13	Wet	21	142	2,840	20.80	2.15	0.43
Demerara River Sites							
DRR-06	Dry	4	17	1,456	3.65	1.08	0.76
	Wet	14	66	11,630	13.76	1.92	0.46
DR-07	Dry	10	48	7,234	9.74	1.74	0.76
	Wet	8	81	3,373	7.77	1.67	0.38

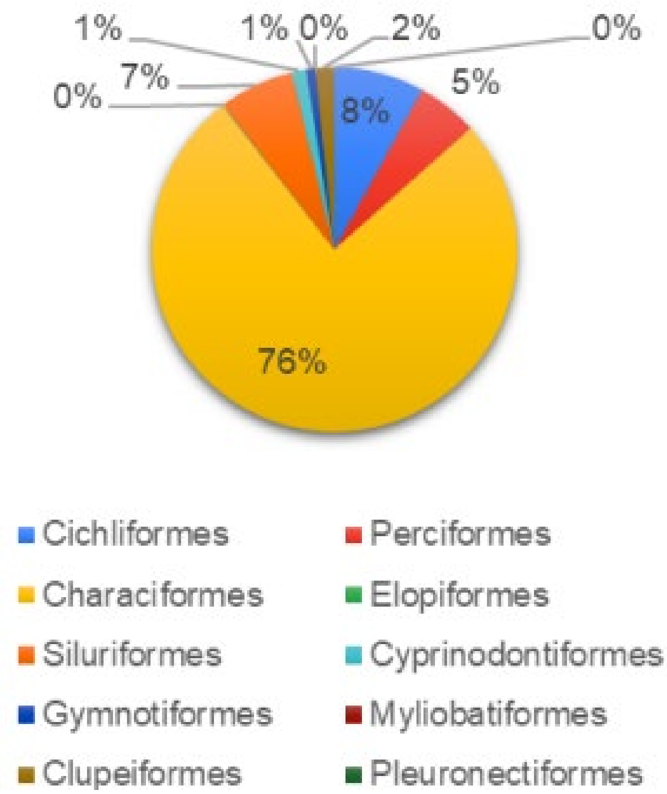


Figure 8.4-3: Fish Abundance in the Freshwater Biodiversity Baseline Study, by Order

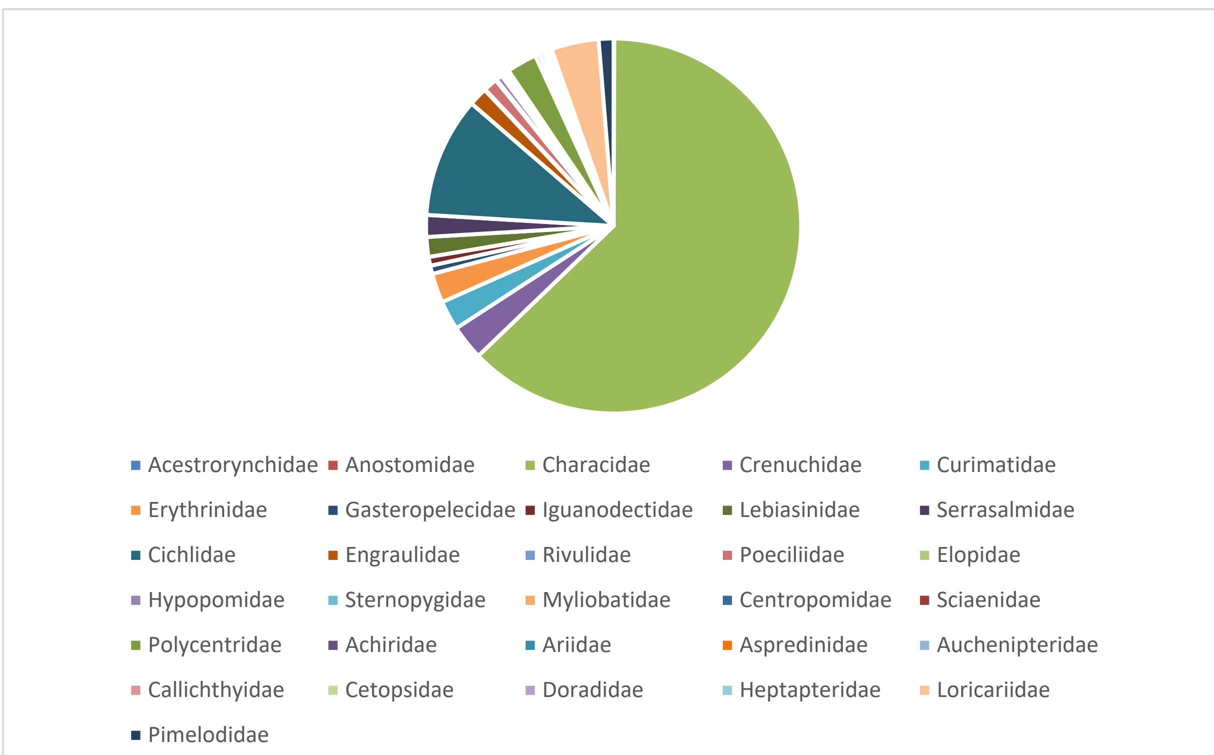


Figure 8.4-4: Fish Abundance in the Freshwater Biodiversity Baseline Study, by Family

The largest number of species recorded for the combined surveys (dry and wet seasons) was observed at Site DD-08 (32 species), followed by Sites WW-09 and CD-10 (26 and 24 species, respectively). The site with the largest abundance of individuals for the combined surveys for both dry and wet seasons was Site CD-10 (1,229), comprising 26.64 percent of the total abundance. The second highest abundance was recorded at Site PV-03 (1,081), comprising 23.43 percent, followed by Site DD-08 (460), comprising 9.97 percent, and the remaining sites comprised 7 percent or less of the total fish abundance collected.

More than twice the number of fish were collected during the wet season survey than during the dry season survey. This disparity is largely driven by collections at Sites CC-11, CC-12, and WW-13, which were only surveyed in the wet season (Figure 8.4-5); however, if these sites are disregarded, total abundance was still higher in the wet season. This trend was most obvious at Sites PV-03 and CD-10 (Figure 8.4-6). Together these two sites accounted for 2,354 fishes across 29 species, or 37 percent of the total fish species and 51 percent of the total fish abundance captured during both seasons of the freshwater biological baseline survey. Characids (particularly *Pristella maxillaris* at PV-03 and *Roeboides thurni* at CD-10) accounted for the bulk of the overall abundance at each of these sites; however, both species were disproportionately abundant in the wet season and the magnitude of the difference in seasonal abundance at Sites PV-03 and CD-10 was unique in the dataset. These species' seasonal dominance at both of these sites is clearly represented in the Pielou's J (evenness) scores for both PV-03 and CD-10, which were conspicuously low compared to other sites in the wet season, even as relative abundance was simultaneously conspicuously high at these sites (Table 8.4-15 and Figure 8.4-8).

A total of 24 species in two orders (Myliobatiformes and Elopiformes) were documented during the wet season survey only. These orders comprise species tolerant of brackish conditions; Myliobatiformes included the two species of stingrays collected from Site DRR-06 at low tide in the shallow waters of the mud flats and Elopiformes included juvenile cuffum (tarpon) and snook collected from Sites MB-01 and CV-02. The presence of these species in the canal network indicates that some estuarine species do enter the canal network from the Demerara River; however the lack of other estuarine species in the canals (particularly the anchovies, which were abundant in the Demerara River) suggests that not all estuarine species move freely between the Demerara River and the canals.

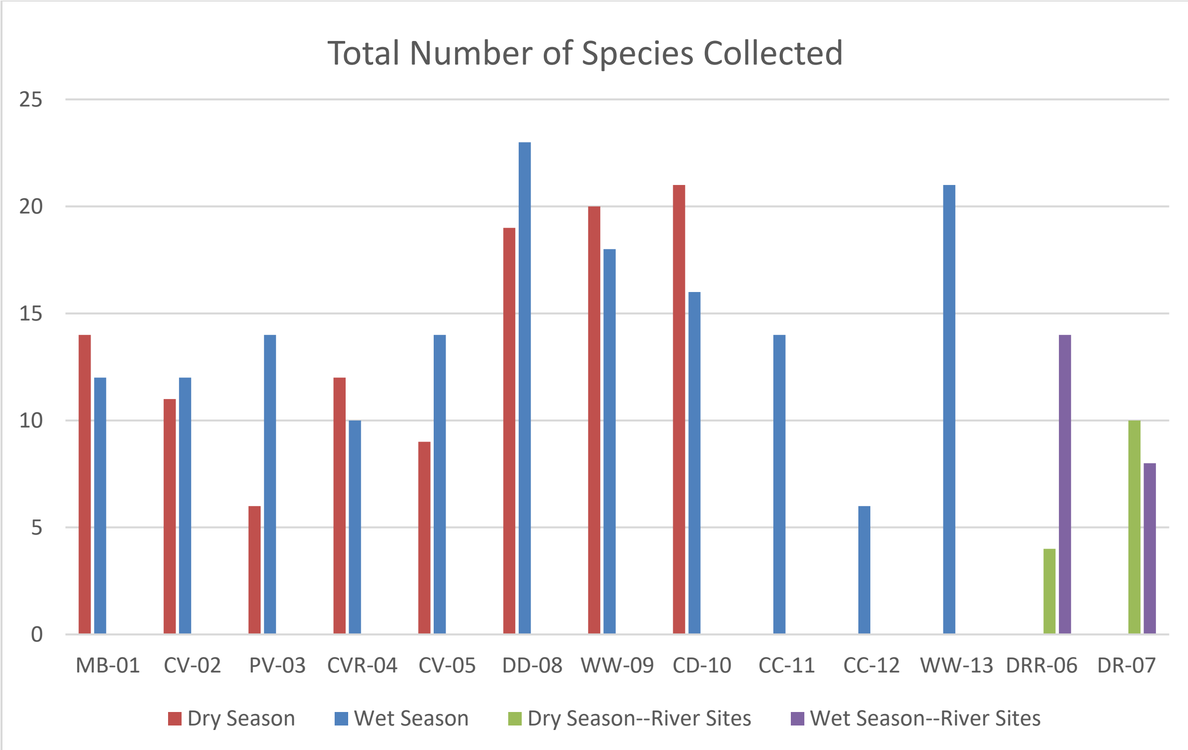


Figure 8.4-5: Number of Fish Species Collected by Site

Habitat and biological diversity in streams are closely linked (Raven et al. 1998), and loss of biodiversity can be an indication of major stressors affecting aquatic systems, including habitat degradation and chemical contamination. Species diversity varied substantially across sampling sites (Figure 8.4-8). Measures of species richness, evaluated using the Margalef Species Richness Index score, was highest in the wet season at Site DD-08 (22.82) and in the dry season at site CD-10 (22.84), while the lowest wet season and dry season richness index values were observed at CC-12 (5.75) and DRR-06 (3.65), respectively (Table 8.4-15 and Figure 8.4-6). The Shannon Diversity Index scores (H') were highest in the wet season at Site DD-08 (2.25) and in the dry season at site WW-09 (2.49) (Table 8.4-15 and Figure 8.4-6). Diversity was lowest in the wet season at Site PV-03 (6.43) and in the dry season at Site CVR-04 (1.21). Evenness scores were highest in the wet season at Site MB-01 (0.51) and in the dry season at Site WW-09 (0.83); evenness scores were lowest at Site WW-09 (0.31) in the wet season and at Site CVR-04 (0.50) in the dry season (Table 8.4-15 and Figure 8.4-6).

There was no seasonal trend in biomass across sites, as would be expected if the AOI supported seasonal migrations of adult fish (e.g., for reproductive purposes) (Figure 8.4-7). This suggests that the fish community is predominantly resident within the AOI. Sites with conspicuously high abundance (PV-03 and CD-10) did not have correspondingly high biomass, indicating that the fish at these sites were generally small-bodied specimens. Both of the river sites had relatively high biomasses, driven largely by a few large stingrays in those samples.

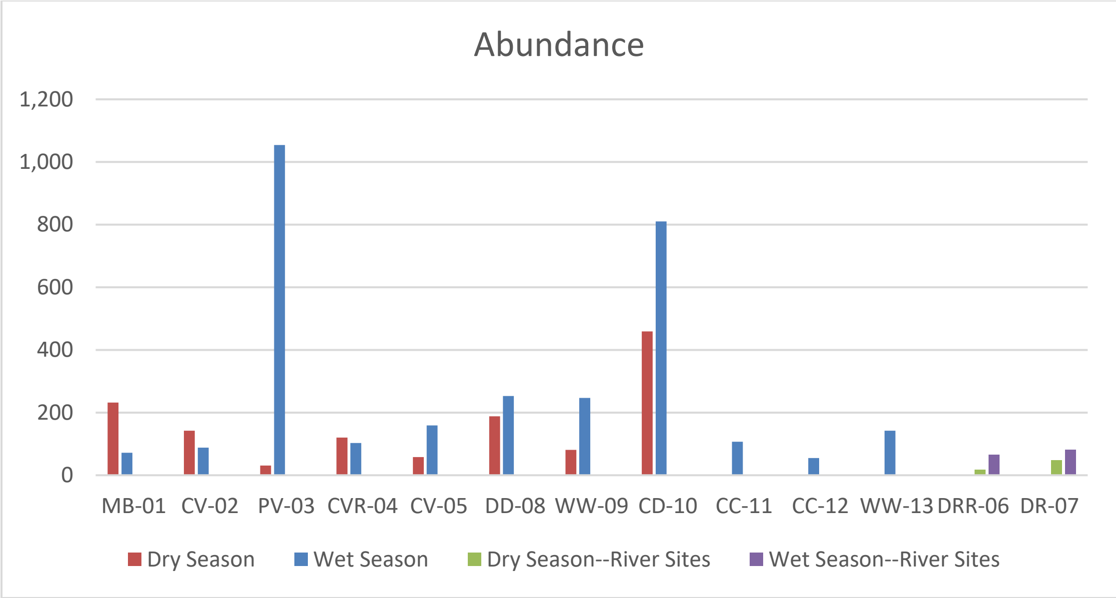


Figure 8.4-6: Fish Population Abundance by Site

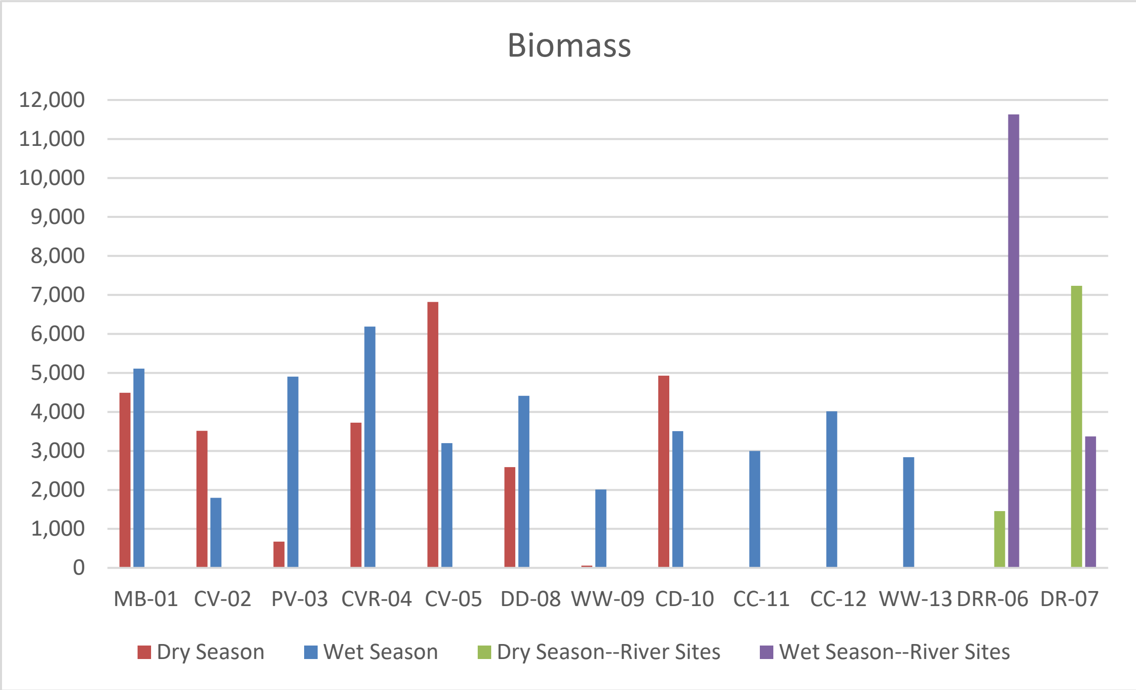


Figure 8.4-7: Fish Population Biomass by Site

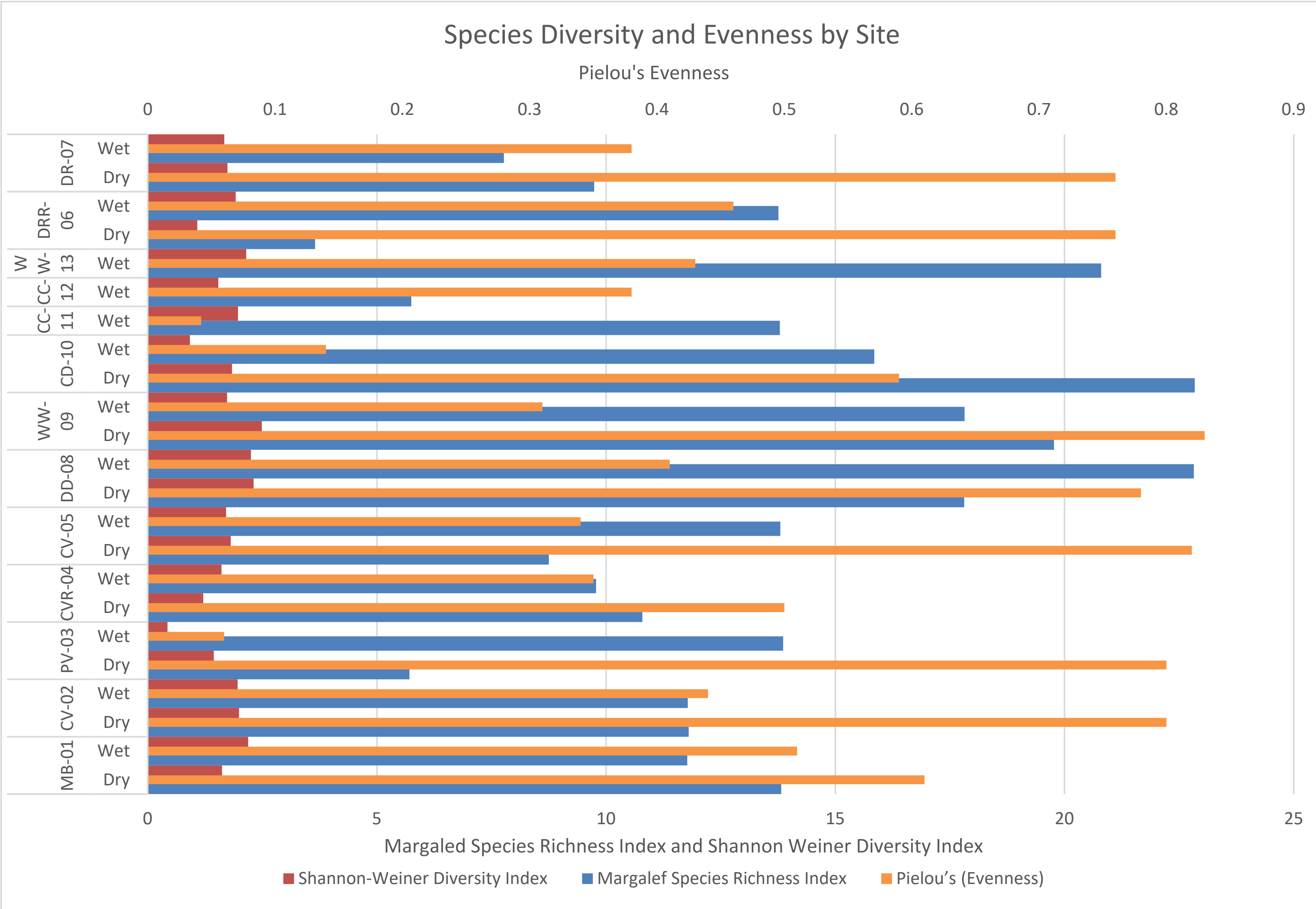


Figure 8.4-8: Biodiversity Index Ratings and Evenness Scores for Survey Sites

The majority of species recorded were from the order Characiformes, a diverse order of ray-finned fishes with over 1,800 species (Mirande 2010; Table 8.4-14). Almost all of the extant species of this order are common in freshwater habitats throughout South and Central America (Nelson 2010). Ecologically, Characiformes are important in the food chains of freshwater ecosystems. They consume smaller vertebrates and invertebrates as well as algae and plant materials (Nelson 2010). Some of these species can become large and are important food fishes for locals. They are also popular in the aquarium trade. The preferred habitat of Characiformes includes slow water velocity, abundant instream vegetation, and the presence of macroinvertebrates, which were common conditions throughout canal sites in the study area.

Most species collected belong to the Cichlidae family, with all species collected belonging to the order Cichliformes. The large number of cichlid species documented is consistent with its known diversity as the third most species-rich family in the neotropics (Van Der Sleen and Albert 2018). The family is commonly found in lowland, freshwater ecosystems of tropical and subtropical regions. Preferred habitat of these species includes low-velocity streams, lakes, and channels, which were the dominant conditions observed across sites in the study area. Cichlids typically feed on a variety of invertebrates and plant matter. A few species in the family are also tolerant of brackish environments and are found along the coastline (e.g., tilapia) as documented in the dry season survey. Many cichlids reach larger adult body sizes, and in the Project area, are commonly collected by locals as a food fish (Ichthyofaunal Assessment by CSBD in Appendix H).

Although most species collected were from the family Cichlidae, the three most abundant species collected during the survey were each from the Characidae family. The most common species collected was pihab (*Roeboides thurni*), a widely distributed species in the neotropics and in the rivers of Guyana (Table 8.4-16). These species are distinguished from other similar-looking genera by the presence of teeth outside the mouth that are specialized in eating scales of other fish (Peterson and Winemiller 1997). They are usually small-bodied and occur in habitats with a pH range of 6.0 to 7.5 (Lucena 2007), coinciding to pH conditions of sites MB-01, CV-02, and CD-10, where they were most abundant. *R. thurni* is likely tolerant of agricultural runoff, which was common to these sites. This species is not commonly collected as a source of food for humans, but is sought in the aquarium trade (Ichthyofaunal Assessment by CSBD in Appendix H).

The second most-abundant species was featherfin tetra (*Pristella maxillaris)*, a widely distributed species that can tolerate both acidic and alkaline conditions and both brackish and freshwater (Weitzman and Palmer 1997; Table 8.4-16). Often found in calm waters with dense vegetation, *P. maxillaris* feeds on worms, small crustaceans, and insects (Weitzman and Palmer 1997). The majority of these species were recorded at site CD-10, where abundant bank vegetation and insect population were documented along the length of the site. This species is not collected for subsistence, but is a popular aquarium fish.

The third most-abundant species was silverfish (*Astyanax bimaculatus*), which is widely distributed in Central and South America and common in Guyana (Table 8.4-16). They tend to occupy several habitats with clear flowing rivers, small flowing streams, ponds, coastal swamps, and black water streams (UWI 2016; Planquette et al. 1996). The majority collected during surveys were juveniles. This was expected, as the juveniles move in schools as they search for food (UWI 2016). They feed on zooplankton, detritus, higher plants, and sometimes fish scales (Planquette et al. 1996). This species is not relied on for subsistence, but is collected in the aquarium trade.

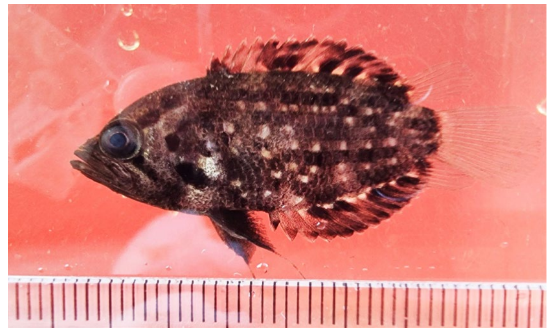
Marine species such as the basha (*Plagioscion squamosissimus*), flounder (*Apionichthys dumerili*), and tarpon were less common; however, these species are generally more abundant in brackish waters such as the Demerara River.

Various forms of pollution and anthropogenic alteration were observed at the majority of sites in the study area. The dominant species collected, *R. thurni*, *A. bimaculatus,* and *P. maxillaris*, likely have greater relative tolerance to varying levels and types of pollution, as they were the most abundant species at sites MB-01, which has extensive anthropogenic pollution, and CD-10, which has extensive agricultural runoff. These findings suggest that more common species encountered during surveys are generalists, and are adaptable to a wide range of habitat conditions and pollution.

Table 8.4-16: The Most Commonly Collected Species from Canal Sites

 a. *Roeboides thurni*	 b. *Pristella maxillaris*
 c. *Astyanax bimaculatus*	 d. *Krobia guianensis*

e. *Curimata cyprinoides*



f. *Polycentrus schomburgkii*

8.4.2.4. Riverine Mammals

Riverine mammals are aquatic mammals that live in inland and coastal riverine and wetland environments. Many riverine mammal species also spend time in nearshore marine environments, so they have a wide range of salinity tolerance. The distribution and composition of riverine mammals in Guyana is poorly understood. Riverine mammals[16] known to occur in Guyana include American manatee (*Trichechus manatus*) and Guiana dolphin (*Sotalia guianensis*). The Guiana dolphin is predominantly an estuarine and coastal species. The American manatee is found in fresh, estuarine, and coastal marine waters, but requires periodic access to fresh water. Tucuxi (*Sotalia fluviatilis*) and Amazon River dolphin (*Inia geoffrensis*) are freshwater species and may also occur infrequently in southern Guyana when seasonal rains connect the Amazon and Essequibo rivers via the Rupununi wetlands, but neither species is expected to be encountered in or near the area of planned Project activities.

Table 8.4-17 lists these species along with their IUCN Red List classification (IUCN 2021) and their habitat preferences. Other species of marine mammals (particularly dolphins) may occasionally occur in riverine habitats of Guyana, but since these species are primarily associated with marine habitats, they are not discussed further in this section.

Table 8.4-17: Riverine Mammals of Guyana

Common Name	Scientific Name	IUCN Status	Habitat Preferences
American manatee	*Trichechus manatus*	VU	Inhabits rivers, lakes, coastal and inland lagoons, and coastal marine environments, including seagrass, mangrove, and coral reef ecosystems (Deutsch et al. 2008).
Guiana dolphin	*Sotalia guianensis*	NT	Inhabits coastal and estuarine habitats across Central and South America in the Caribbean and Atlantic Oceans. This species is concentrated in tropical and subtropical shallow and coastal waters of the continental shelf (de Jesus Lobo et al. 2021).

[16] For the purposes of this section, riverine mammals are defined as dolphins and manatees. Neotropical otters and giant otters may also occur in freshwater habitats, but these species are discussed in Section 8.3, Terrestrial Biodiversity.

Common Name	Scientific Name	IUCN Status	Habitat Preferences
Tucuxi	*Sotalia fluviatilis*	EN	Inhabits the inland freshwaters of the white, clear, and black waters of the Amazonian rivers. Display a preference for the junctions of rivers and channels. The most preferred habitat is where a sediment-rich white-water channel meets low pH black water (Martin et al. 2004). Not expected to occur within or near Project activities.
Amazon River dolphin	*Inia geoffrensis*	EN	Inhabits the inland freshwaters of the Amazon and Orinoco rivers. Sexual segregation is common; females with dependent calves spend more time inside the flooded forest and in lakes and small tributaries during the rainy season, while most adult males spend most of their time in the main rivers. During the dry season, this species is often concentrated below channel confluences (da Silva et al. 2018). Not expected to occur in or near the area of Project activities.

Source: IUCN 2021

EN = Endangered; NT = Near Threatened; VU = Vulnerable

Regional Setting and Species Descriptions

The riverine mammals of Guyana occupy a wide variety of inland and coastal habitats, including inland rivers and wetlands and coastal and nearshore marine waters. These habitats are by extension interconnected with similar habitats of the Amazon River in Brazil and the Orinoco River delta in Venezuela via the Amazonian-Orinoco Influence Zone and the Rupununi portal. The Amazonian-Orinoco Influence Zone is an Ecologically or Biologically Significant Area (EBSA) that encompasses the offshore waters of eastern Trinidad, Guyana, Suriname, French Guiana, and northern Brazil, and borders the shoreline from the Orinoco River in the north to the Amazon River in the south (Secretariat of the Convention on Biological Diversity 2014). This EBSA's uniqueness and biological productivity are driven largely by the influence of freshwater inputs from the Amazon River and the nutrients it carries, which extend north and west across the coast of northern South America to the Orinoco River delta in Venezuela. The Rupununi portal is a unique hydrogeographic feature that allows for a seasonal hydrological connection between the Essequibo River and the Amazon River watershed via the Rupununi savannas and wetlands (de Souza et al. 2020).

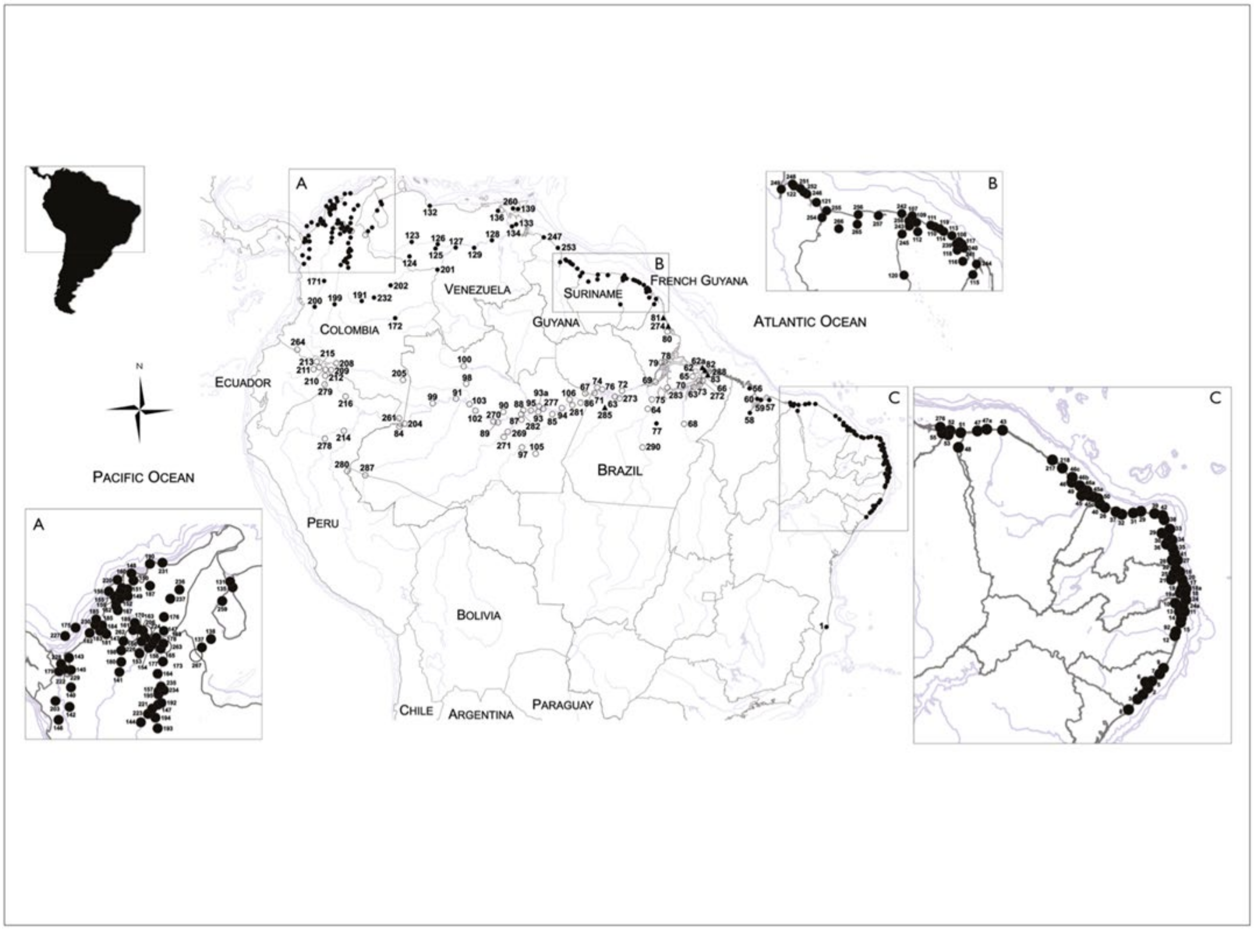
American Manatee

The American manatee is known to occur throughout the Gulf of Mexico and the Atlantic Ocean. Two subspecies of the American manatee are currently recognized based on skull characteristics (Domning and Hayek 1986): the Antillean manatee (*T. manatus manatus*) and the Florida manatee (*T. manatus latirostris*). There is also a smaller species of manatee, *Trichechus inunguis*, landlocked in the Amazon River watershed, which may occasionally penetrate into southern Guyana close to the boundary with Brazil, but since this species is a rare transient species in southern Guyana, it is not discussed further. The two subspecies of American manatee are not easily distinguishable externally, but they occupy distinctively different geographic ranges. The range of the Florida manatee is limited to the southeastern United States. The Antillean manatee occurs throughout the Caribbean and the Northwestern Atlantic Ocean from Mexico, east to the Greater Antilles, and south to Brazil. The subspecies is extant or transient in 41 countries in the Caribbean region (Deutsch et al. 2008).

Throughout most of its range, the American manatee prefers the shallow waters of rivers and estuaries that contain aquatic vegetation. Early records from a study by Bertram and Bertram (1960) on the status of the American manatee in the Guianas revealed that in Guyana, manatees live mainly in the rivers of the coastal plain, particularly in the regions of wet savannah where suitable vegetation is available for food. Northwestern Guyana and the eastern region near the Suriname border support the greatest number of manatees in the country, but nowhere are they abundant. The study also documented that very little is known about the life history of manatees in the Guianas (UNEP 2010).

There have been no comprehensive population studies on manatees in Guyana over the past decade; the most recent population estimate was provided by the United Nations Environment Programme (UNEP 2010), which estimated approximately 100 individuals in Guyana, with a declining population. Incidental captures of manatees by fisherfolk from Canal 1, the Demerara River, and coastal areas of Lusignan and Buxton were relocated by the Guyana Wildlife Conservation and Management Commission on several occasions in recent years (2017 to 2019) (Cromwell 2021, pers. comm.). All available sightings of manatees in South America are shown on Figure 8.4-9.

No recent systematic, range-wide survey or population estimate of American manatees, particularly the Antillean subpopulation, exists. However, in 2010 the previously cited UNEP study estimated the entire population of American manatee (including all subspecies) to be approximately 9,000 individuals. The IUCN estimates that fewer than 2,500 mature Antillean manatees currently exist, scattered widely through the Caribbean region (IUCN 2021). Geographic distribution is not continuous and local populations are patchy and fragmented.



Source: Bonvicino et al. 2020

South America map showing all available records of manatees: A) detail of north Colombia and northwestern Venezuela; B) north of Guyana, Suriname, and French Guiana; C) northern Brazil. Black circles indicate *Trichechus manatus* localities, open circles *T. inunguis*, open square sympatry between them, and black triangles *Trichechus* sp. localities. Numbers refer to names of localities listed in Appendix 1 of Bonvicino et al. 2020.

Figure 8.4-9: Concentration of Manatees along the South America Coastlines

The IUCN lists the American manatee as Vulnerable because the number of mature individuals is currently estimated to number less than 10,000 (based on combined population estimates for the Florida and Antillean subspecies) and the species is expected to decline at a rate of at least 10 percent over the course of three generations (given a generation time of about 20 years). The Antillean manatee is currently threatened by habitat degradation and loss, hunting, accidental fishing-related mortality, pollution, and human disturbance (IUCN 2021).

Guiana Dolphin

The Guiana dolphin occurs primarily in shallow waters near shore and in estuaries, bays, or other sheltered areas along the Atlantic coast of northern and eastern South America, although their presence has been reported 300 kilometers up river in the lower Orinoco River close to Ciudad Bolívar, Venezuela (Borobia et al. 1991; Boher et al. 1995; Trujillo et al. 2000). Guiana dolphins are reported to occur in the Demerara, Cuyuni, Mazaruni, and Essequibo river mouths

(Williams et al. 2016; Herald 1967 as cited in da Silva Best 1994). Guiana dolphins have patchy distribution (Borobia et al. 1991; Flores and da Silva 2009; Da Silva et al. 2010) and small home ranges, possibly extending only 10 to 15 kilometers (Flores and Bazzalo 2004), and occur in groups of 1 to 40 individuals (Azevedo et al. 2017). The distribution of Guiana dolphin in nearshore areas indicates that some populations may be exposed to high levels of pollution from industrial and agricultural activities, including both indirectly by degradation of habitat and directly through contamination of prey (IUCN 2021). Artisanal fishing with gillnets and other gear is a known cause of incidental mortality throughout most of the species' range, with high bycatch reported where monitoring has occurred. It is also known that some Guiana dolphins are killed intentionally to be used as shark bait (da Silva and Best 1994; IWC 2007; Flores and da Silva 2009). Offshore oil development in Brazil, Venezuela, and Colombia may not pose a direct threat to Guiana dolphins; however, oil spills, particularly in estuaries, could affect local populations (da Silva and Best 1994; Culik 2004). In recent years, skin diseases have been observed on dolphins in estuaries (Van Bressem et al. 2009). Abundance estimates are not available for individual populations across their range (IUCN 2021), and historical estimates often conflict with later estimates made using more rigorous methods. The Guiana dolphin is listed as Near Threatened by IUCN (IUCN 2021) and is legally protected within most of its range.

Tucuxi

The freshwater dolphin tucuxi is found in the Amazon River drainage and has been reported to occur in the Orinoco River; however, no confirmed sightings or modern surveys have documented this species in Guyana, and the IUCN does not include Guyana or the neighboring coastal countries in the species' known range (IUCN 2021). There are no records of past or recent commercial fisheries for the species (IWC 2001). It is assumed dolphins cannot traverse the rapids at the Casiquiare Channel, which connects the Orinoco River and Amazon River watersheds and is the only possible point of contact with the Amazon River (da Silva and Best 1996; Bangueria-Hinestroza et al. 2002). Historically unverified sightings of tucuxi in the Orinoco River were likely actually Guiana dolphin. The tucuxi is listed as Endangered by the IUCN (IUCN 2021). Tucuxi are threatened primarily by incidental mortality in fishing gear, deliberate killing for use as bait, damming of rivers, and environmental pollution from organochlorides and heavy metals (Best and da Silva 1989; Trujillo et al. 2010). Although tucuxi can hypothetically occur in Guyana, encounters with them are not expected in the riverine and coastal areas where Project-related activities will occur.

Amazon River Dolphin

Amazon River dolphin is the most widespread river dolphin, inhabiting rivers and lakes throughout the Amazon River and Orinoco River watersheds in Brazil, Bolivia, Colombia, Ecuador, Peru, and Venezuela. The species may occur up to the Brazil border with Guyana (WWF Undated); however, IUCN does not include Guyana within its range. No survey data for the species in Guyana exists. Water level affects the use of habitat by Amazon River dolphins for all age classes; however, females with dependent calves spend more time inside interior flooded forests and in lakes and small tributaries during the rainy season, while most adult males spend most of their time in the main rivers. During the dry season, this species is often concentrated below channel confluences (da Silva et al. 2018). The IUCN lists the Amazon River dolphin as Endangered (IUCN 2021). Amazon dolphins are threatened by similar activities as listed for the Guiana dolphin and the tucuxi. Populations in Brazil may suffer mortality from use of explosives as well as from oil spills occurring in Peru, northern Ecuador, and Venezuela; however, overall threats by oil and gas extraction remain low (WWF Undated). Although this species may occur within interior Guyana along the Brazil border, it is not expected to occur within or near the area where Project activities are planned.

Riverine Mammal Surveys within the Project Area of Influence

EEPGL commissioned a year-long targeted survey of riverine mammals in 2019–2020 in the area between the Demerara Harbour Bridge and the mouth of the Demerara River. The survey was extended through December 2021 and the survey area was expanded upriver to the Project vicinity to support the biological baseline for the Project. The objective of the extended survey was to document the species assemblage and abundance of riverine mammals within the lower Demerara River between the planned location of the temporary MOF and the river mouth. The survey was conducted 2 days per month during daylight hours from dawn to dusk (roughly 24 hours of survey time per month).

Riverine Mammal Survey Results

The only riverine mammal detected during the study was American manatee. The survey covered four dry seasons and three intervening wet seasons between 2019 and 2021 and detected manatees on 22 occasions (Figure 8.4-10). During the entire study period, 27 individuals were sighted. Fourteen of the 27 individuals were sighted during dry season conditions. The remaining 13 individuals were sighted during wet season conditions.

The observers documented a range of activities including courtship, diving, and directional swimming. Most manatee sightings were recorded close to the river banks, outside of the shipping channel. Of the 27 manatee sightings recorded, 14 occurred at the mouth of the river near the seawall on the east bank. This area may be favored by the manatees for feeding since submerged rocks covered in aquatic vegetation are found close to the riverbank in the area. Vessel traffic was observed to be very low near the riverbank compared to further offshore in the main channel, which suggests the manatees may also be using nearshore areas to avoid the busier parts of the river.

Manatees are known to move elsewhere in their range during high tide; sightings in the Demerara River were distributed nearly equally across the range of tidal conditions (high, low, and transitional). Fish (1994) surmised that manatees might avoid ship channels during high discharge periods, particularly in large riverine-driven systems, because movement may be more difficult and energetically costly when the direction of flow opposes the direction of travel.

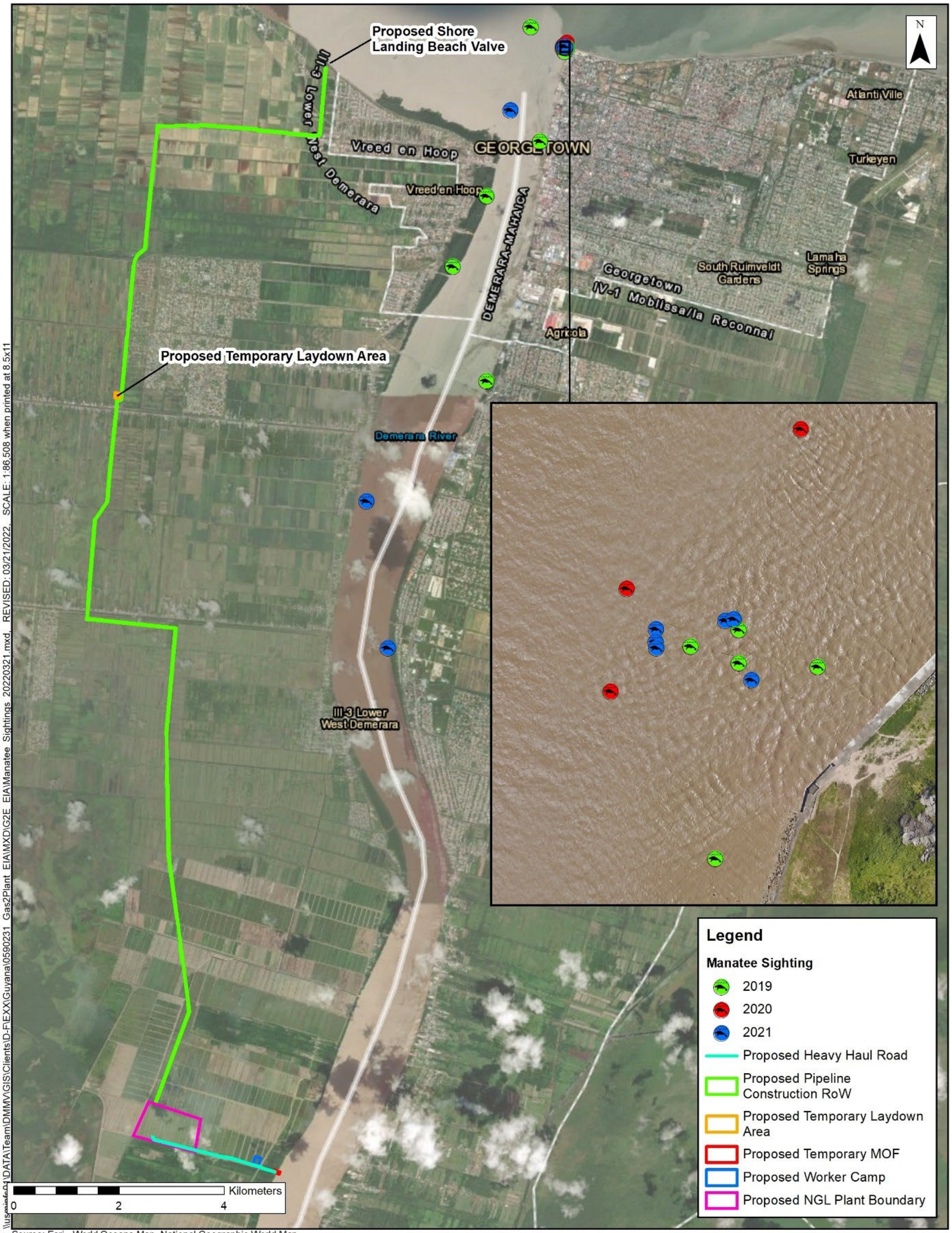


Figure 8.4-10: Location of Riverine Mammal Sightings Recorded During EEPGL-Commissioned Riverine Mammal Surveys

8.4.3. Summary of Aquatic Biodiversity Baseline Conditions

Based on the results of the freshwater aquatic biodiversity baseline studies, the following findings are significant and are relevant to the assessment of potential impacts from the Project:

- The freshwater aquatic habitat within the Project AOI has been extensively modified, initially to drain land for agriculture and settlement, and more recently through the contamination of surface water sources with refuse, sewage, and other discharges.
- Management of riparian buffers for conservation-oriented outcomes is low to non-existent along the canals in the inland portion of the Project AOI, but there is evidence of efforts to conserve mangroves in the riparian zone of the Demerara River.
- Aquatic habitat quality in the Project AOI generally suffers from a lack of physical diversity.
- The aquatic macroinvertebrate community is dominated by taxa that are tolerant of poor water quality and degraded physical habitat, although a small number of more intolerant taxa are present. This indicates that macroinvertebrate diversity could be improved if habitat conditions were improved.
- The fish community within the canals generally comprises freshwater species. A few estuarine species (snook and tarpon) are present in the canals at the northern end of the canal system near Vreed-en-Hoop, but south of this point, the fish community is composed of obligatory freshwater species. This suggests that the kokers along the Demerara River largely restrict movement of water and fish between the Demerara River and the canals.
- Although the freshwater fish community is rich in species, it is dominated by a few highly abundant and widespread taxa. In this sense, the freshwater fish community within the Project AOI is similar to freshwater fish communities elsewhere in the greater Amazonian region.
- Special status species are largely absent from the freshwater fish community in the Project AOI (with the exception of tarpon in the coastal canals).
- The fish community in the canals is economically valuable. Several species of characins, cichlids, piranha, and catfishes are targeted by small-scale fisheries elsewhere in the country, and are likely harvested on a subsistence or recreational basis from the canals. Other species present in the canals are sold in the aquarium trade, particularly in the characin and cichlid families, but also a few pencilfishes, killifishes, and catfishes.
- The most common riverine mammal in the Demerara River is the American manatee, which is a special status species. It is either absent or very rare in the canals.
- American manatee in the Demerara River tend to concentrate near the seawall at the eastern side of the river mouth, and are much less common elsewhere in the lower Demerara River. When they do occur elsewhere in the river, they tend to remain in shallow water near the shoreline.

The information presented in this section was accumulated from a combination of literature sources and field surveys in and around the Project AOI. The field surveys were conducted during different seasons under a variety of environmental conditions, documented a range of common and uncommon species, and incorporated local Guyanese expertise in the reporting of results. Therefore, the Consultants consider the information presented in this section adequate to support an assessment of potential Project impacts on freshwater biodiversity.

8.4.4. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on freshwater biodiversity. The relevant planned Project activities and the associated potential impacts of these activities on freshwater biodiversity are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

8.4.4.1. Relevant Project Activities and Potential Impacts

The planned Project activities that could affect components of freshwater biodiversity in the Project AOI are described under the three Project stages of Construction, Operations, and Decommissioning. Specific activities associated with each of these stages that could potentially impact freshwater biodiversity are identified and assessed at the resource-specific level. Table 8.4-18 summarizes the planned Project activities that could result in potential impacts on freshwater biodiversity.

Table 8.4-18: Summary of Relevant Project Activities and Key Potential Impacts—Freshwater Biodiversity

Stage	Project Activity	Key Potential Impacts
Construction	• Installation of the onshore pipeline • Construction of the NGL Plant, heavy haul road, and temporary MOF • Discharges of sanitary effluent and hydrostatic test water • Dredging of the approach channel to the temporary MOF • Clearing of riparian vegetation	• Erosion and sedimentation from riparian disturbance • Changes in aquatic habitat quality from clearing of riparian vegetation • Changes in the biological availability canal habitats • Mortality and injury of benthic organisms in the Demerara River • Disturbance of fish and other aquatic organisms due to increased underwater noise in the Demerara River • Shading of the water column under the temporary MOF structure • Increased turbidity associated with dredging • Decreased water quality from sanitary effluent discharge • Decreased water quality from hydrostatic test water discharge
Operations	• Discharges of process wastewater and sanitary	• Disturbance of aquatic biota from operation of the temporary MOF

Stage	Project Activity	Key Potential Impacts
	wastewater effluent from NGL Plant • Maintenance of the onshore pipeline RoW	• Changes in distribution and composition of estuarine biodiversity due to operational effluent discharges
Decommissioning	• Removal of temporary MOF	• Changes in aquatic habitat condition/quality

8.4.4.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for freshwater biodiversity (Table 8.4-19). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for freshwater biodiversity sensitivity are provided in Table 8.4-20.

Each of the following Project activities are considered in the assessment of the significance of potential impacts on freshwater biodiversity:

- Installation of the onshore pipeline
- Construction of the NGL Plant, heavy haul road, and temporary MOF
- Discharges of sanitary effluent and hydrostatic test water
- Clearing of riparian vegetation
- Dredging of the approach channel to the temporary MOF
- Discharges of process wastewater and sanitary wastewater effluent from NGL Plant
- Maintenance of the onshore pipeline RoW
- Removal of the temporary MOF

Table 8.4-19: Definitions for Intensity Ratings for Potential Impacts on Freshwater Biodiversity

Criterion	Definition
Intensity	**Negligible**: No measurable ecosystem-level changes; the ecosystem continues to function as it did prior to the Project activities occurring.
	Low: Changes are perceptible but affect only a small number of species within the ecosystem, and only at one trophic level, and/or across a limited spatial area.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level, and/or across a significant portion of the area that an ecosystem physically occupies.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are substantially altered.

Table 8.4-20: Definitions for Resource Sensitivity Ratings for Potential Impacts on Freshwater Biodiversity

Criterion	Definition
Sensitivity	**Low**: Habitat integrity and function and species assemblage is highly modified and/or is capable of withstanding disturbance (physical and chemical) and degradation without reaching an irreversible ecological threshold (i.e., is highly resilient). In the context of the sensitivity rating, resilience may derive from a variety of conditions including, but not limited to, high regenerative and/or assimilative capacity. Rare or disturbance-sensitive species are absent or uncommon. Community is dominated by non-native and/or habitat generalist species.
	Medium: Habitat integrity and function and species assemblage is modified and is moderately resilient to disturbance and degradation. In the context of the sensitivity rating, resilience may derive from a variety of conditions including, but not limited to, moderate regenerative and/or assimilative capacity. Rare or disturbance-sensitive species may be present but are not dominant.
	High: Habitat integrity and function and species assemblage is natural (i.e., minimal anthropogenic disturbance and high biodiversity value/function) and has low resilience to disturbance and degradation. Community is dominated by native and/or habitat-specialist species and contains important habitat for or populations of rare species.

8.4.4.3. Impact Magnitude Ratings—Freshwater Biodiversity

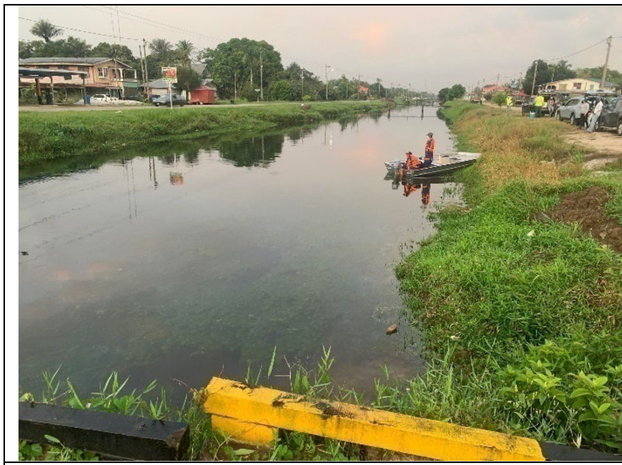
The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to freshwater biodiversity is provided in Table 8.4-23.

Aquatic Habitat

Changes in Erosion and Sedimentation Rates as a Result of Riparian Habitat Disturbance

During the Construction stage, the onshore pipeline RoW will be cleared of vegetation, except for herbaceous ground cover, to facilitate construction activities. Clearing associated with construction activities will disturb riparian habitat in areas where the pipeline corridor is in close proximity to a canal, and increase the potential in these locations for erosion of canal banks and increased sedimentation in the canals. The increase in erosion/sedimentation and the resulting decrease in riparian and aquatic habitat quality will be smallest where the riparian zone is currently intensively managed in an herbaceous condition (Table 8.4-21, left) and greatest in areas where riparian vegetation is thickest and the stabilizing impacts of the vegetation are greatest (Table 8.4-21, right). Maintenance of the permanent onshore pipeline RoW in an herbaceous condition during the Operations stage may also cause minor re-disturbance of the riparian buffers along some segments of the pipeline corridor.

Table 8.4-21: Examples of Riparian Zone Vegetation along the Pipeline RoW

	
Riparian zone in intensely managed, herbaceous condition (Site CVR-04)	Riparian zone in unmanaged, near-natural condition (Site DD-08)

All major surface water features that must be crossed by the onshore pipeline will be crossed using HDD. All HDD boring entry/exit points will maintain a minimum 25-meter buffer from surface waters. During the Construction stage, temporary erosion controls will be installed along the RoW prior to initial disturbance of the soil, and will be maintained in place until the RoW is revegetated or otherwise restored. These embedded controls will manage erosion and sedimentation at the waterbody crossings. On this basis, the intensity of impacts on freshwater biodiversity from sedimentation or habitat disturbance will range from **Negligible** in areas where riparian vegetation currently consists of intensively managed herbaceous vegetation to **Medium** in areas where thick, natural vegetative growth currently dominates the shoreline. These impacts will occur initially during Construction activities, and then on an occasional basis throughout the Operations stage, so the frequency of this impact is considered **Episodic**. Effects to riparian zones will persist for the duration of the Project life cycle, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riparian vegetation is rated as **Negligible** to **Small**.

Changes in Aquatic Habitat Quality due to Removal and Disturbance of Riparian Vegetation

The removal and subsequent intensive management of riparian vegetation along the portions of the pipeline RoW proximal to canals will have implications not only for the physical aspects of aquatic habitat quality (i.e., erosion and sedimentation) but also for the biological aspects of aquatic habitat quality. Where riparian vegetation is prolific and either extends into the water or over the water, it provides refuges for aquatic biota and quality habitat for vegetation-adapted species. Several aquatic macroinvertebrate families, particularly the dragonflies and damselflies (Coenagrionidae, Lestidae, and Libellulidae), are vegetation-dependent, and certain fishes common to the Project AOI (e.g., *Apistogramma steindachneri, Mesonauta guyanae, Eigenmannia nigra, Polycentrus schomburgkii)* are also characteristically present in thickly vegetated habitats. These species will be particularly susceptible to loss of habitat within the RoW due to clearing and maintenance of riparian vegetation.

Similar to the intensity of impacts on erosion and sedimentation, the intensity of impacts on biological habitat quality from clearing riparian vegetation along the portions of the pipeline RoW proximal to canals will range from **Negligible** to **Medium** depending on the current condition of the riparian zone and the degree to which intensive management of the riparian zone will reduce the amount of vegetation in the water at each crossing. These impacts will occur on an occasional basis throughout the Project lifespan, so the frequency of this impact is considered **Episodic**. Effects on riparian zones will persist for the duration of the Project life cycle, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riparian vegetation is rated as **Negligible** to **Small**.

The widest and most intact riparian vegetation corridors within the Project AOI are located along the Demerara River. The riparian zones along the Demerara River support important nearshore and instream habitat, as well as ecologically significant mangroves. During the Construction stage, vegetation will be cleared from the temporary MOF site and the footprint of the heavy haul road. Temporary erosion controls will be installed along the construction RoW prior to initial disturbance of the soil and will be maintained in place until permanent erosion controls are installed or restoration is completed. On the basis of these embedded controls, the intensity of impacts on aquatic habitat quality from removal or disturbance of riparian vegetation along the Demerara River is considered **Low** during the Construction stage. These impacts will occur on an essentially continuous basis while the relevant Project activities are occurring, so the frequency of this impact is considered **Continuous**. Vegetation clearing is expected to take longer than a week but less than a year, so the duration is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riparian vegetation is rated as **Small**.

Decommissioning activities are not expected to involve removal or larger-scale disturbance to riparian vegetation, as the temporary MOF will be removed using roads and areas cleared during the Construction stage and maintained during Operations, and the pipeline will be decommissioned and left in place. The intensity of impacts on aquatic habitat quality from these activities is therefore considered **Negligible**. These impacts will occur on an essentially continuous basis while the relevant Project activities are occurring, so the frequency of this impact is considered **Continuous**. Vegetation clearing is expected to take longer than a week but less than a year, so the duration is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riparian vegetation during the Decommissioning stage is rated as **Negligible**.

Alteration of Local Hydrological Conditions

Alteration of local hydrological conditions will occur as a result of installation of foundations for the NGL Plant, onshore pipeline construction, grading and filling to create the heavy haul road, and the installation of the stormwater management pond at the NGL Plant.

The NGL Plant site will occupy up to 75 hectares on land that was formerly used for sugarcane cultivation and is now shrubland and swamp comprised of various pioneer plant species. The NGL Plant site will be located in a low-lying area that may be subject to localized flooding. Four existing secondary (north-south oriented) drainage canals will be filled as part of site preparation; the two primary (east-west oriented) canals immediately north and south of the NGL Plant footprint will be retained. Small canals that formerly provided drainage of previously cultivated fields within the NGL Plant footprint will be filled. These canals do not provide permanent aquatic habitat, and their only value as aquatic habitat is on an ephemeral, seasonal basis. The overall NGL Plant site will be raised approximately 2.5 meters by bringing in fill material and additional soil improvements. Stormwater will be collected from curbed areas, and first flush rainfall will be routed to the process WWTP, with subsequent rainfall collected routed to the stormwater pond. The stormwater pond will also receive treated water from the process and sanitary WWTPs. The stormwater pond will discharge to the Demerara River either directly or potentially via a canal adjacent to the NGL Plant site. Water quality will be analyzed prior to discharge into the Demerara River. The land and network of canals on which the NGL Plant will operate has been highly altered by human activity. Although routing stormwater collected on the NGL Plant site will alter the path of runoff in the immediate vicinity, this activity will not substantially change the fundamental hydrological characteristics of runoff dispersion in the vicinity of the NGL Plant. The heavy haul road will also require grading, which will alter runoff rates and drainage patterns in the immediate vicinity of the road, but these effects will be very localized and are not expected to significantly affect nearby aquatic habitat.

The primary biological implications of hydrological alterations are changes in movement patterns of aquatic biota and changes in seasonal availability of peripheral habitats such as wetlands or vegetated floodplains. In natural tropical floodplains, these seasonally flooded peripheral habitats are often important for fish reproduction as adults and juveniles move between the main channel and the peripheral habitats, but the extensive channelization that has occurred throughout the Direct AOI and immediate vicinity has effectively eliminated the natural floodplain. Small-scale changes in drainage patterns are unlikely to have a significant effect on the biota that currently occupies the canals. As such, the intensity of biological impacts from hydrological changes is considered **Low**. These impacts will persist as long as the Project is in place, so the frequency of this impact is considered **Continuous**, and the duration of the impact will be **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biota is rated as **Small**.

Aquatic Biodiversity

Impacts on Riverine Biodiversity Due to Installation of the Temporary MOF and Dredging of the Access Channel

Installation of the temporary MOF and dredging of the access channel will involve several impacts on riverine biodiversity, including direct mortality and injury of benthic organisms, disturbance of fish and other aquatic organisms due to increased noise, shading of the water column under the temporary MOF structure, and increased turbidity associated with dredging.

Installation of the piles for the temporary MOF and dredging the access channel will have the potential to injure or kill benthic organisms that are crushed by machinery, entrained in dredges, or otherwise eliminated from the Project's riverine footprint by machinery operating in the Demerara River during the Construction stage. This effect will generally be limited to the footprint of the channel and the temporary MOF, which represents a small portion of the lower Demerara River. As demonstrated by the macroinvertebrate surveys in the Demerara River, macroinvertebrate densities in the river are low compared to densities in the canals, and the macroinvertebrate community is comprised of habitat generalists that will be able to quickly re-colonize disturbed areas after construction activities cease. Fish are generally more mobile than macroinvertebrates and will be expected to mostly avoid injury or mortality from construction activities in the river. Based on these considerations, the intensity of mortality and injury-related impacts on aquatic biota in the Demerara River from construction activities will be **Low**. Construction activities in the river will last on the order of a year, so the duration is considered **Long-term**. Impacts will occur intermittently throughout that period (concurrent with the sediment removal intervals of the dredge cycle), so the frequency is considered **Episodic**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biota is rated as **Small**.

Piles will be driven into the riverbed during construction of the in-water component of the temporary MOF, and this will generate impulsive underwater sound in the Demerara River. The method for installing piles at the temporary MOF had not been determined at the time this EIA was prepared. Based on experimental data, impact-driven steel piles generate higher peak sound pressures and sound exposure levels than equivalent wooden piles or vibratory driving techniques (Swan 2012), so for the purposes of the impact analysis a conservative assumption was made that steel piles would be driven into the river bottom using an impact pile driver. Impacts of sound on fish and aquatic mammals has been intensively researched over the past few decades, and in 2020 the California Department of Transportation published a landmark guidance document describing the current state of research into acoustic impacts on fish from pile driving (CALTRANS 2020). This report synthesized research from a number of academic institutions and state and federal governments including the NOAA and the state transportation departments in Oregon and Washington. This report identified typical sound levels for a range of pile types with and without attenuation, and identified 206 decibels (dB) Peak Sound Pressure as an appropriate auditory threshold for protection of fish. This threshold was subsequently adopted by NOAA for all federal projects on the west coast of the United States of America. Table 8.4-22 summarizes a range of underwater sound pressures associated with driving a variety of sizes and types of piles in water.

Table 8.4-22: Example Underwater Sound Pressure Data by Pile Type and Size—With and Without Attenuation

Pile type/size	Single Strike at 10 meters (No attenuation)			Single Strike at 10 meters (5 dB reduction – bubble curtain)		
	PEAK	SEL	RMS	PEAK	SEL	RMS
12-inch wood	182	157	167	177	152	162
18-inch concrete	185	160	170	180	155	165
14-inch Steel H-Beam	179	154	144	174	149	139
12-inch Steel Pipe Piles	192	167	177	187	162	172
24-inch Steel Pipe Piles	205	175	190	200	170	185
36-inch Steel Pipe Piles	210	183	193	205	178	188

Source: CALTRANS 2020

PEAK = the maximum value reached by the sound pressure; RMS = root mean square; SEL = sound exposure level

As shown in Table 8.4-22, pile size affects the level of sound that fish experience in the water, as does the application of sound attenuating measures (or lack thereof). For the largest pile size evaluated, fish would experience adverse impacts at a distance of 10 meters from the source; with attenuating measures in place, the limit of negative effect would be less than 10 meters even for the largest steel piles considered in the analysis. Based on the small area within which the effect could occur, as determined in the California Department of Transportation (CALTRANS) study, the magnitude of acoustic impacts on fish from pile driving for the temporary MOF is considered **Low**. Pile driving activities would likely last longer than a week but less than a year, so the duration is considered **Medium-term**. Impacts would occur routinely throughout that period, so the frequency is considered **Continuous**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biota is rated as **Small**.

Construction of the temporary MOF will shade a portion of the littoral zone of the Demerara River bottom. This type of impact can be significant in areas where the aquatic biological community is dependent on abundant aquatic vegetation growth (e.g., marine seagrass meadows), but aquatic plants are scarce at the planned temporary MOF site. Although the shading will represent a change in physical habitat conditions, it is not expected to have a significant effect on aquatic biodiversity in the Demerara River. The magnitude of shading-related impacts is therefore considered **Negligible**. These impacts would last longer than a year, so the duration is considered **Long-term**. Impacts would occur continuously for as long as the temporary MOF is in place, so the frequency is considered **Continuous**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biota is rated as **Negligible**.

As described in Section 7.4.3, Impact Prediction and Assessment (Water Quality), dredging for the access channel will temporarily increase turbidity in the Demerara River. Elevated turbidity can have a range of adverse impacts on aquatic biota, including respiratory distress, dermal irritation, interference with foraging activities, and decreased habitat availability (especially if increased turbidity ultimately leads to increased accretion of fine sediments). Existing turbidity levels in the Demerara River vary widely and often exceed the impact threshold used in the water quality impact assessment (Section 7.4.3, Impact Prediction and Assessment), which suggests that the biota in the Demerara River are acclimated to high turbidity and would not be particularly sensitive to elevated turbidity levels from dredging. The modeling analysis indicates that the area that would be affected by elevated turbidity levels would range from 1.8 to 3 square kilometers (km^2). Based on the analysis presented in Section 7.3, Sediments, the intensity of impacts on sediments resuspension, transport, and accumulation are considered **High** during the Construction stage. These impacts will occur on a temporary basis only during the active dredging portions of each dredge cycle, so the frequency of this impact is considered **Episodic** during this stage. Dredging of the temporary MOF area is expected to be completed within approximately one year, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine water quality is rated as **Medium.**

Changes in Distribution and Composition of Estuarine Biodiversity Due to Construction-related Discharges

There will be two potential primary discharge streams to the Demerara River (either directly or via a canal adjacent to the NGL Plant) during the Construction stage: sanitary effluent discharge from the worker camp (if a worker camp is used), and discharge of pipeline hydrostatic test water. The most significant impact on biodiversity related to the sanitary effluent discharge is likely to be avoidance of the mixing zone by aquatic biota that are intolerant of elevated nutrient levels or hypoxic conditions, but the high rate of tidal exchange through the river will tend to rapidly disperse the effluent, which will minimize this impact as well as the size of the mixing zone associated with the outfall. The effluent from the worker camp will also be routed through a dedicated wastewater treatment plant, and the discharge will be managed in accordance with applicable World Bank Group EHS Guidelines. The intensity of this impact is therefore considered **Low**. The discharge from the worker camp, if used, will last for the duration of the NGL Plant construction, which is expected to last more than a year, so the duration of this impact is considered **Long-term**. Impacts will occur on a **Continuous** basis during this period. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine water quality is rated as **Small.**

The Project's base case design includes discharge of hydrostatic test water offshore; however, an alternate option would be to possibly discharge hydrostatic test water in the Demerara River, so in addition to sanitary effluent discharges from the worker camp, hydrostatic test water from pipeline testing could potentially be discharged to the Demerara River. There are two potential hydrostatic test water treatment chemicals that were considered for the purpose of the EIA: RX-5245 and SLB HydroHib. Both compounds are toxic to aquatic organisms at the concentrations at which they will be used in the pipeline. Based on the hydrodynamic modeling described in Appendix C, Water Quality Modeling Report, SLB HydroHib would be expected to dilute to a concentration below the toxicity threshold within 100 meters of the discharge point under all seasonal and flow conditions, so no acute toxicity is expected from this substance outside of a 100-meter mixing zone. If RX-5245 is used, the modeling indicates that the effluent will be diluted to non-toxic concentrations within 100 meters of the discharge point during the wet season only. During the dry season, dilution to non-toxic concentrations would occur at

500 meters from the discharge location under high flow/current conditions, and within 1 to 1.5 kilometers under low flow/current conditions. For the purposes of this impact assessment, the Consultants have made a worst-case assumption that RX-5245 would be discharged during dry season low flow/current conditions, which could lead to acute mortality of fish within a 1 to 1.5 kilometer mixing zone surrounding the hydrostatic discharge point. A mortality event that incorporates a zone with a radius of over 1 kilometer would affect numerous species and would affect a substantial portion of the lower Demerara River ecosystem. This intensity of this impact is therefore rated **High**. The impact would occur once over a 24-hour period, so the duration is considered **Short-term**, and the mortality event would be **Continuous** while the event occurred. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on aquatic biodiversity is rated as **Medium.**

Impacts on Riverine Biodiversity due to Operation of the Temporary MOF

The primary biological implication of activities associated with the Operations stage of the temporary MOF is disturbance of riverine species caused by underwater noise from vessel traffic. The Demerara River is already subject to noise from passing commercial and artisanal vessel traffic. Although an increase in overall vessel traffic is expected during the operation of the temporary MOF, as described in Section 9.4.3, Impact Prediction and Assessment (Transportation), the additional vessel trips associated with the temporary MOF represent a minimal percentage increase in vessel traffic near the temporary MOF. On this basis the intensity of this impact is rated as **Low**. Impacts from vessel-related underwater noise will occur on an episodic basis when vessels approach or leave the temporary MOF, so the frequency of this impact is considered **Episodic**. The temporary MOF is expected to operate for longer than one year, so the duration of this impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine biodiversity is rated as **Small**.

Changes in Distribution and Composition of Estuarine Biodiversity Due to Operation-related Wastewater Discharges (including sanitary and process discharges)

Operation of the pipeline will not entail any routine operational discharges; however, operation of the NGL Plant will produce sanitary and industrial wastewater effluents via a combined effluent stream that will be discharged from the facility's stormwater management pond. As described in Section 7.4.3.2, Riverine Water Quality, background concentrations of several of the constituents anticipated to be detectable in these discharges are already above applicable World Bank reference values in Demerara River water and sediments. The only constituent that was modeled at exceeding its freshwater reference standard at 100 meters from the discharge point is cyanide. Cyanide can have a number of harmful impacts on aquatic wildlife, including induced respiratory distress, involuntary muscular movements, erratic swimming, and a variety of other abnormal behaviors (Ramzy 2014; Govind 2013).

Discharges from the Project would be managed to World Bank Group EHS Guidelines for Natural Gas Processing Facilities, but nevertheless would – if discharged at the maximum concentration prescribed by the guidelines, contribute to an exceedance of the applicable freshwater reference value for cyanide within a localized area of the Demerara River. For this reason, the intensity of the impact of operational discharges from the NGL Plant on aquatic biodiversity is considered **Low**. Discharges from the stormwater management pond will occur intermittently, so the frequency of the impact is considered **Episodic**. The discharge would continue for the operational life of the Project, so the impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine biodiversity is rated as **Small**.

8.4.4.4. Pre-mitigation Impact Significance—Freshwater Biodiversity

Assuming implementation of the embedded controls listed in Table 8.4-23, the pre-mitigation intensity ratings for potential Project impacts on freshwater biodiversity will range from **Negligible** to **High**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Medium.** The freshwater aquatic habitat and biota in the Project AOI are highly modified, and the aquatic biological community is comprised almost entirely of disturbance-tolerant species. The sensitivity of the freshwater habitat and biota within the Project AOI is therefore rated as **Low.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the pre-mitigation impact significance for freshwater biodiversity ranges from **Negligible** to **Minor**.

8.4.5. Impact Management and Monitoring Measures

Supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register), all potential impacts on freshwater biodiversity are rated between **Negligible** and **Minor**. To further reduce potential impacts, several mitigation measures are recommended to reduce many of the potential impacts with a **Minor** significance rating:

8.4.5.1. Impacts on Riverine Biodiversity Due to Installation of the Temporary MOF and Dredging of the Access Channel

Numerous strategies have been developed to mitigate the auditory impacts of pile driving on aquatic organisms. Common approaches include air bubble curtains, isolation casings, and dewatered cofferdams. Alternative hammer types such as vibratory hammers and oscillating, rotating, or press-in systems may also be used to reduce the levels of noise produced by pile driving. The Consultants recommend that the smallest practicable diameter pipes be used for the piles, and application of one or more attenuating methods as appropriate, especially if large-diameter steel pipes are used. These measures would reduce the intensity of auditory impacts of pile driving to **Negligible** and the magnitude of the impact to **Negligible**.

8.4.5.2. Changes in Distribution and Composition of Estuarine Biodiversity Due to Construction-related Discharges

Considering that the magnitude of this impact is largely driven by the area of the river that would be affected, which is in turn driven by the relatively high toxicity of RX-5245 and the seasonal differences in natural dilution potential between the wet and dry season, the Consultants recommend using hydrostatic test chemicals that are less toxic than RX-5245 (e.g., SLB

HydroHib) and, in any case, scheduling the hydrostatic test water discharge to occur under high flow conditions during the wet season. Application of these mitigation measures would not eliminate all risks to aquatic biota, but would reduce the area of the river that would be affected (potentially by an order of magnitude or more), thereby lowering the intensity of the impact to **Medium** and the magnitude of the impact to **Small**. Table 8.4-23 summarizes the management and monitoring measures relevant to freshwater biodiversity.

Table 8.4-23: List of Management and Monitoring Measures

Embedded Controls
Implement soil erosion, stormwater runoff, and sedimentation control measures during soil disturbance (e.g., use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from construction areas, use of sediment basins, and check dams to control water runoff).
Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable, and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Monitor and manage excess overflow from hopper overflow on dredging facility to improve efficiency and reduce turbidity in dredging supernatant.
Monitor and manage suction rate to improve efficiency and reduce turbidity in the water column during dredging.
Dewater any trenches by first installing temporary drainage and use methods to prevent excessive transport of sediments into existing canals.
Manage stormwater to minimize potential erosion and excessive sediment transport into canals adjacent to the onshore pipeline corridor.
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO and MARPOL 73/78 requirements.
Use procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.
Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plant, and oil-water separators) in accordance with manufacturers’ guidelines to maximize efficiency and minimize malfunctions and unnecessary discharges into the environment.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers’ guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Provide domestic wastewater treatment plant that complies with World Bank Indicative Values for Treated Sanitary Sewage Discharges (World Bank 2007a) and Effluents Levels for Natural Gas Processing Facilities (World Bank 2007b).
Mitigation Measures
Use smallest practicable diameter pipes for the piles for the temporary MOF.
Use noise attenuating methods when driving piles in the Demerara River as appropriate, especially if large-diameter steel pipes are used as piles.
Use OCNS Gold Standard hydrostatic test chemicals to test the pipeline.
Discharge hydrostatic test water to the Demerara River only under higher flow conditions to the extent practicable.

Embedded Controls
Monitoring Measures
Monitor aquatic macroinvertebrates, fish, and water quality at baseline survey sites for 1 year after the pipeline is installed and every 3 years once the Project becomes fully operational throughout the Operations stage of the Project.
Conduct a single round of post-decommissioning monitoring of macroinvertebrates, fish, and water quality.

IMO = International Maritime Organization; MARPOL 73/78 = International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978

8.4.6. Assessment of Residual Impacts

As described above, several mitigation measures are proposed. These measures will reduce acoustic impacts on aquatic biota in the Demerara River, and reduce potential toxicity impacts associated with the potential release of hydrostatic test water.

Based on implementation of the mitigation measures, the residual impact significance ratings range from **Negligible** to **Minor**.

Table 8.4-25 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on freshwater biodiversity.

Table 8.4-24: Summary of Potential Pre-Mitigation and Residual Impacts—Freshwater Biodiversity

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	Erosion and Sedimentation from riparian disturbance	Low	Negligible to Small	Negligible	None	Negligible
	Changes in aquatic habitat quality from clearing of riparian vegetation during construction—canals	Low	Negligible to Small	Negligible	None	Negligible
	Changes in aquatic habitat quality from clearing of riparian vegetation during construction—Demerara River	Low	Small	Negligible	None	Negligible
	Alteration of local hydrological conditions	Low	Small	Negligible	None	Negligible
	Mortality and injury of benthic organisms in the Demerara River	Low	Small	Negligible	None	
	Disturbance of fish and other aquatic organisms due to increased noise in the Demerara River	Low	Small	Negligible	Use smallest diameter piles as practicable Use noise attenuation methods	Negligible
	Shading of the water column under the temporary MOF structure	Low	Negligible	Negligible	None	Negligible
	Increased turbidity associated with dredging; Changes in aquatic habitat condition/quality	Low	Medium	Minor	None	Minor
	Decreased water quality from sanitary wastewater discharge	Low	Small	Negligible	None	Negligible
	Decreased water quality from hydrostatic test water discharge	Low	Medium	Minor	Use OCNS Gold Standard hydrostatic test chemicals to test the pipeline	Negligible

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Operations	Erosion and sedimentation from riparian disturbance during permanent RoW maintenance	Low	Negligible to Small	Negligible	None	Negligible
	Changes in aquatic habitat quality from clearing of riparian vegetation during permanent RoW maintenance—canals	Low	Negligible to Small	Negligible	None	Negligible
	Disturbance of aquatic biota from vessel noise during operation of the temporary MOF	Low	Small	Negligible	None	Negligible
	Changes in distribution and composition of estuarine biodiversity due to operational effluent discharges	Low	Small	Negligible	None	Negligible
Decommissioning	Changes in aquatic habitat quality from clearing of riparian vegetation during decommissioning	Low	Negligible	Negligible	None	Negligible

8.5. Ecological Balance and Ecosystems

8.5.1. Baseline Methodology

Ecological balance and ecosystems include the major ecosystems in the Project AOI—marine, inland freshwater, and terrestrial—and the ecological functions within these habitats.

The Large Marine Ecosystem (LME) model, developed cooperatively by the University of Rhode Island and NOAA to assess and manage ecological functions at the regional scale, was used to define the marine ecosystem portion of the Project. LMEs are defined as relatively large areas of ocean space of approximately 200,000 km^2 or greater, adjacent to continents in coastal waters where primary productivity is generally higher than in open ocean areas. Each LME is defined by a unique combination of bathymetry, metocean conditions, food chain interactions, and marine productivity.

The marine portion of the Project AOI lies within the North Brazil Shelf LME, which comprises the coastal waters adjacent to northeastern South America from the eastern edge of the Caribbean Sea to the Parnaiba River in Brazil (Figure 8.5-1). It extends roughly 500 kilometers off the coast of Guyana (Marineregions.org 2019). The marine ecoystems portion of this section describes the ecology of the Project AOI in terms of the marine foodweb (i.e., the marine planktonic community) and productivity as expressed in the marine nutrient cycle (including carbon storage).

Similar to marine resources, freshwater/estuarine ecosystems are grouped broadly according to Major Habitat Types, each of which is defined by a unique set of dynamic ecological processes. Upland streams and rivers of Guyana are classified as Tropical and Subtropical (Abell et al. 2008; FEOW Undated). The Major Habitat Types framework can be used to understand the physical, chemical, and biological processes that characterize the area. Most of the freshwater/estuarine portion of the Direct AOI is located in the Demerara River watershed (with the exception of a portion along the coast, which is technically in the Atlantic Drainage). The watershed defines the physical boundaries of the freshwater/estuarine ecosystem, but the Direct AOI is also hydrologically connected to the Essequibo River via canals—which allows commingling of species between river basins. Consequently, from a biological perspective, the Direct AOI and portions of the Indirect AOI are part of a larger freshwater/estuarine ecosystem that encompasses not only the lower Demerara basin but also the Essequibo watershed and northern Amazonian region.

Figure 8.5-1: The North Brazil Shelf Large Marine Ecosystem

Terrestrial ecosystem function is controlled by five variables: climate, soils, topography, species present, and time (Chapin et al. 2002). Terrestrial ecosystems, particularly those that are floodplains of large rivers, are influenced by interactions between the water and the land. In addition to hydrologic flow that influences soil water conditions and plant community composition, periodic flooding of areas adjacent to rivers affect an areas productivity (Bayley 1995). Ecosystem function is evaluated based on the vegetation community structure and composition, disturbance, and the availability of resources.

8.5.2. Existing Conditions and Baseline Studies

8.5.2.1. Marine Ecosystems

The North Brazil Shelf LME largely coincides with the Amazonian-Orinoco Influence Zone, an Ecologically or Biologically Significant Area that encompasses the offshore waters of eastern Trinidad, Guyana, Suriname, French Guiana, and northern Brazil, and borders the shoreline from the Orinoco River in the north to the Amazon River in the south (Secretariat of the Convention on Biological Diversity 2014). Ecologically or Biologically Significant Areas are identified on the basis of the following seven criteria: (1) uniqueness or rarity; (2) special importance for life history stages of species; (3) importance for threatened, endangered, or declining species and/or habitats; (4) vulnerability, fragility, sensitivity, or slow recovery; (5) biological productivity; (6) biological diversity; and (7) naturalness. According to the Secretariat, which designated the Amazonian-Orinoco Influence Zone in 2014, the zone's uniqueness and biological productivity are driven largely by the influence of freshwater inputs from the Amazon River and the nutrients it carries, which extend north and west across the coast of northern South America to the Orinoco River delta in Venezuela. As described in Section 8.2, Marine and Coastal Biodiversity, the Amazonian-Orinoco Influence Zone is important for specific life history stages of several species (several of which are special status species), including colonial marine birds, marine mammals, marine turtles, and fish.

Plankton plays an important role in the functioning of marine ecosystems serving at the base of the pelagic food web (Roemmich and McGowan 1995). Planktonic organisms have a direct link with fish (even if this link may only exist during the relatively short period when pelagic fish are mainly planktivorous) because they represent a major source of energy (Cushing 1997, in Beaugrand 2005). The plankton community is also highly influenced by hydro-climatic forces such as currents, temperature, solar radiation, and bioavailability of marine nutrients, so it is the first trophic[17] level at which physical oceanographic and climatic factors are integrated into the pelagic food web.

An EEPGL-commissioned survey of ichthyoplankton[18] was conducted in nearshore and offshore waters of Guyana and the result of this survey indicated that the region provides valuable habitat for various early life stages of fish (Section 8.2.2.5, Marine Fish). There were a larger number of marine organisms collected at nearshore sample stations than at the offshore stations, although taxa richness was higher at the offshore stations. The offshore stations were

[17] Relating to a specific rank or position in the food chain
[18] Ichthyoplankton are the eggs and larvae of fish.

also more homogeneous in terms of the number of taxa at each station, as compared to the nearshore stations. It is not known whether these apparent differences between the offshore and nearshore stations represent a seasonal or permanent phenomenon, but as described in Section 7.4, Water Quality, the Guiana Current is known to move seasonally, oscillating between offshore and inshore alignments, and intermittently producing eddies and loop currents that separate from the main current. Off Brazil, researchers have reported that the greatest concentration of larvae varied from nearshore to offshore depending on the season, and temperature can also play a major role in plankton distribution. In light of the dynamic nature of the Guiana Current and the influence that macro-oceanographic factors have on plankton distribution, it is likely that the abundance and distribution of plankton across the North Brazil LME varies over time. This expected variability notwithstanding, the data available indicate that Guyana's marine ichthyoplankton community is similar to that of other nearby regions (e.g., Brazil [de Macedo-Soares et al. 2014]) in terms of relative abundance, but may be more diverse in terms of the number of taxa than other regions within the western Atlantic basin, such as the Gulf of Mexico (Ditty 1986; Espinosa-Fuentes et al. 2013).

Gene Flow

Marine environments are often considered homogenous across large geographical distances. Consistent with this view, several studies have shown significantly lower genetic differentiation among populations of marine fish species as compared to freshwater fish species. Based on observed rates of genetic differentiation between generations, genetic exchange between marine fish populations has been estimated to occur at 10 to 100 times the rate of exchange in freshwater populations (Ward et al. 1994). Nevertheless, since the late 1990s, studies have increasingly documented genetic differentiation among populations of marine organisms. Genetic boundaries between populations tend to occur along geomorphic and current boundaries (Ruzzante et al. 1998; Nielsen et al. 2003; Johannesson and Andre 2006). Genetic exchange across large expanses of open ocean is aided by the prevalence of planktonic early life stages in numerous taxa.

Several studies of marine biota have been conducted within or in the vicinity of the offshore portion of the Direct AOI in recent years—including studies of marine mammals, marine turtles, marine fish, and marine benthos, and none have detected the presence of endemic species. In 2016, environmental DNA was collected from sediment and seawater samples during a baseline survey of the Liza Field. No data suggesting the presence of regionally endemic species were reported. These results are consistent with the concept that genetic isolation is much rarer in the open ocean than on land (CEGA 2016).

Marine Nutrient Cycle

The three most important nutrients in the marine nutrient cycle are nitrogen, phosphorous, and silicon (Nihoul and Chen 2008). The primary source of all of these nutrients in the marine food web is phytoplankton, which assimilate the nutrients from the surrounding seawater. Nitrogen and phosphorous are essential nutrients to all plant life, and silicates enter the marine nutrient cycle largely through diatoms, a specific class of phytoplankton that construct hard silicate exoskeletons. Each of the world's LMEs has its own rate of biological productivity, which is influenced by bathymetric, hydrographic, and other physical conditions that distinguish it from adjacent LMEs (NOAA 2021). The 66 LMEs that have been delineated are placed in one of five productivity categories, from Very Low to Very High. The North Brazil Shelf LME is in the Highly Productive category (indicating more than 300 grams of carbon produced per square meter of ocean surface per year) and daily primary productivity rates can occasionally exceed 8 grams of carbon per square meter of ocean surface per year in the LME, owing to large nutrient inputs from the Amazon Basin, as well as complementary inputs from smaller rivers that drain the Guiana Shield (Heileman 2009). High turbidity, particularly near the coast in waters directly influenced by these rivers, is both a function of the high nutrient load and a control on the primary production that these nutrients promote. As such, primary productivity has been found to be highest in the transition zone between nutrient-rich coastal waters with low sunlight transmission and clearer offshore waters where light is transmitted more readily, but nutrients are comparatively scarcer (Heileman 2009).

Biodiversity

One of the most readily apparent ecological characteristics of a marine LME is the biodiversity it contains. Detailed information on the marine biodiversity aspects of the offshore portion of the Project AOI is provided in Section 8.2.2, Existing Conditions and Baseline Studies.

Carbon Storage

The deep ocean ecosystem plays a major role in climate regulation, as it is one of the world's major carbon storage systems (also referred to as a carbon sink). The Intergovernmental Panel on Climate Change has estimated that the ocean contains 50 times more carbon than the atmosphere (IPCC 2014). The ocean absorbs carbon dioxide from the atmosphere through numerous chemical, physical, and biological processes, often collectively referred to as the ocean carbon pump, which moves carbon from at or near the ocean surface to the seafloor. The ocean carbon pump has a biological component, which transfers surface carbon and dissolved carbon in upper surface waters toward the seafloor via the food web, and a physical component, which transports dissolved carbon through ocean circulation. The sinking carbon is an important part of the marine food web, as it serves as a food source for many marine organisms. Carbon that reaches the seafloor is consumed by benthic organisms or buried by natural sedimentation processes that sequester the carbon for thousands to millions of years (Xiao et al. 2010).

8.5.2.2. Freshwater Ecosystems

The freshwater ecosystem of the Guianas Ecoregion contains many small- to medium-sized basins fed by water draining from the north and eastern slope of the Guiana Shield, including all waters between the Demerara River south to the Oyapock River, emptying into the Atlantic Ocean (FEOW 2019). The predominantly flat coastal plain in which the Project AOI is located contains many predominantly low-gradient rivers and streams as well as numerous wetland areas. Some of these waterbodies (including the Demerara River, as described below) have seasonal inter-basin connections with other river systems.

Physical Characteristics

Seasonal flow variability, connectivity with other watersheds, and habitat modification (primarily channelization) are three key defining physical characteristic of freshwater habitat in the Direct AOI. By latitudinal distribution, freshwater systems in the tropics experience the greatest volume of runoff (Milliman 1990) and have minimal temperature and daylight fluctuations throughout the year (Lowe-McConnell 1987). Two periods of high rainfall (May through June, and January through February) cause peak flow conditions in Guyana's streams and rivers, temporarily expanding aquatic habitat, connecting permanent aquatic habitats, and leading to the appearance of seasonal/ephemeral habitats (i.e., wetlands, swamps, and flooded forests). Inter-basin connections via seasonally flooded inland connections or via coastal marine waters, where salinities temporarily decrease due to massive freshwater contributions from the rivers, is a defining hydrologic feature of Guyana's coastal rivers, including the Demerara River.

The Demerara River watershed functions as a discrete habitat unit in the dry season, but in the wet season it is an extension of the larger Amazon Basin via the Essequibo River. The Essequibo River is seasonally connected to the Amazon basin during the rainy season via the Rupununi savanna, which becomes a large wetland in the rainy season (de Souza et al. 2020). Flooded wetlands connecting the Ireng and Takutu rivers on the Amazonian side with the Rupununi River on the Essequibo side establish a temporary connection between the two basins, called the Rupununi Portal (Figure 8.5-2). The Demerara and Essequibo watersheds are connected in the vicinity of the Direct AOI via the connections between Canals 1 and 2 (on the Demerara side) and Bonsika Creek, a tributary of the Essequibo River. Seasonal inundation of wetlands in the headwaters and riparian zones of rivers and streams create wet season connections between these otherwise isolated ecosystems, and these connections mean that surface water bodies across large areas of the Guiana Shield often function hydrologically and ecologically as one large network, rather than physically discrete entities (de Souza et al. 2012; de Souza et al. 2020).

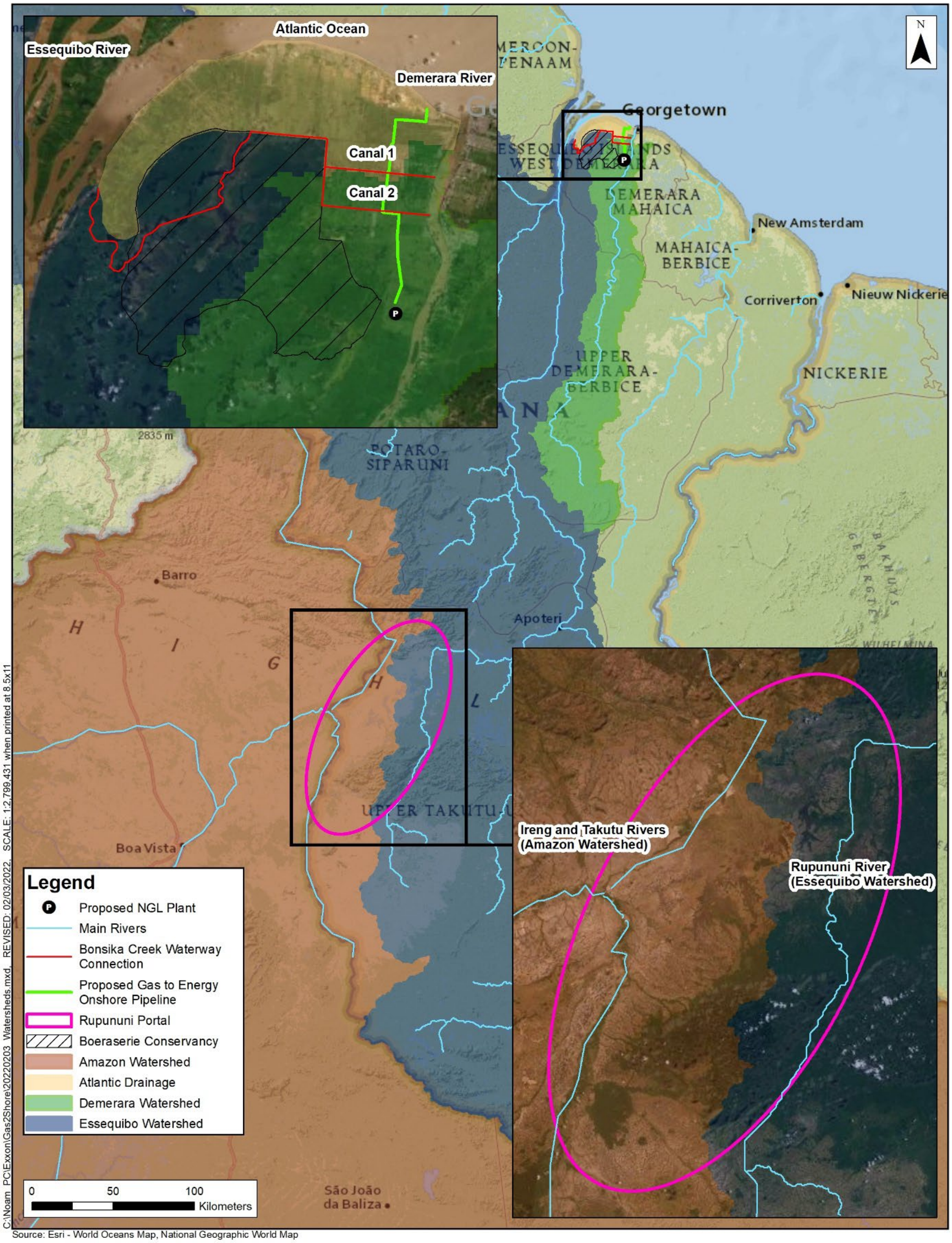


Figure 8.5-2: Essequibo and Demerara River Watersheds

The onset of the rainy season can cause increased turbidities and lowered water temperatures, along with other chemical and physical changes such as increased acidity and lowered dissolved oxygen, but these are conditions for which fish in the tropics are well adapted and which many exploit for special foraging and spawning/rearing opportunities (Lowe-McConnell 1987).

Biological Characteristics

Tropical river systems harbor the richest and most diversified fish fauna in the world, but are also the most poorly understood (Irvine et al. 2016; Barton 2007). The Guianas Ecoregion was classified separately from the Essequibo Ecoregion, which lies directly adjacent and to the north, because of its unique assemblages of fish and a rate of endemism as high as 40 percent (Ringuelet 1975; Gery 1969). The diverse and unique biotic components of Guyana's freshwater ecosystems are threatened by the need for enhanced food production, accelerating urban development, overexploitation of fisheries, industry pollution, land use changes, species introductions, and loss of connectivity, similar to many tropical areas throughout the world (Irvine et al. 2016). In Guyana, the main pressures that threaten biodiversity are linked to agriculture and extractive industries, including forestry and mining (CBD Undated), both of which can strongly influence important aspects of inland freshwater ecology.

Many neotropical drainages, such as the Orinoco floodplain that lies in the region south of Guyana, have tributaries with varied sediment loads and chemistry profiles. These characteristics provide a complex, diverse array of habitats and feeding niches that contribute to trophic versatility in resident fish assemblages, and at least partially explain the high rate of speciation observed in the tropical streams and rivers. Fish assemblages in tropical systems, although the most diverse in the world, originate from comparatively few major base taxa, with explosive adaptive radiations particularly observed in characoids (tetras) and silurids (catfish) groups (Lowe-McConnell 1987). Field studies completed in support of this EIA confirm that these generalities apply to the Direct AOI. As described in Section 8.4.1, Baseline Methodology (Freshwater Biodiversity), water quality in the Direct AOI varies dramatically (especially with respect to turbidity and TDS). Characoid and silurids were the most diverse and second-most diverse families identified in the study area, respectively, together accounting for more than 58 percent of the total fish diversity identified in the Direct AOI.

As a critical component of the freshwater habitat network across the Guiana Shield, wetlands are often major breeding and roosting sites for resident and migratory birds (McCulloch et al. 2003). They also function as important spawning and nursery habitats for fish; however, because wetlands occur intermittently in space and time across landscapes and often occur at the peripheries of riverine systems, they are considered particularly vulnerable to conversion to other uses, including grazing and crop production (McCartney et al. 2011).

Seasonal interconnectivity between wetlands and rivers is a key contributor to the similarity of the species composition across the coastal/estuarine segments of Guyana's rivers, and is the main reason that Guyana's freshwater biological communities have so many species in common with the Amazon basin. The fish community in the Direct AOI is indicative of this connectivity; approximately 80 percent of the fishes known to occur in the Direct AOI are also known to occur in the Amazon basin (Jézéquel et al. 2020). The remaining species known to occur in the Direct AOI that do not occur in the Amazon basin are all known to occur in the Essequibo River.

8.5.2.3. Terrestrial Ecosystems

Terrestrial ecosystems are comprised of the community of living organisms occurring in habitats on land and the interactions of biotic and abiotic components in an area. Ecosystem functions depend on environmental conditions and the traits of species that comprise the ecological communities. Recent research has shown that much of the variability in terrestrial ecosystem function can be captured by three key vegetative metabolic factors:

- Maximum productivity, which indicates the capacity of the given ecosystem to uptake carbon dioxide (CO_2);
- Carbon use efficiency, which indicates the carbon respired versus carbon taken up; and
- Water use, which indicates the efficiency with which carbon is taken up per quantity of water transpired by plants (Migliavacca et al. 2021).

These metabolic factors have corresponding structural indicators. Productivity and carbon use are indicated by vegetative structure and the diversity in types of vegetative forms (e.g., grasses, shrubs, trees) found within an ecosystem, respectively. Water use is indicated by vegetative height and climate (Migliavacca et al. 2021). Convergent evolution of the anatomical traits of plants is caused by selective forces that are common to ecosystems across the globe and that constrain vegetative traits in similar ways across different ecosystems (Reich et al. 1997). The implication of these findings is that the physical attributes of a vegetative community combined with the climatological context in which the community is found can generally be used as a proxy for overall ecosystem function, regardless of the region in which the community occurs. The climate of the Project AOI is discussed in Section 7.6, Air Quality, Climate, and Climate Change; vegetative structure and vegetative heights in the Project AOI are discussed below.

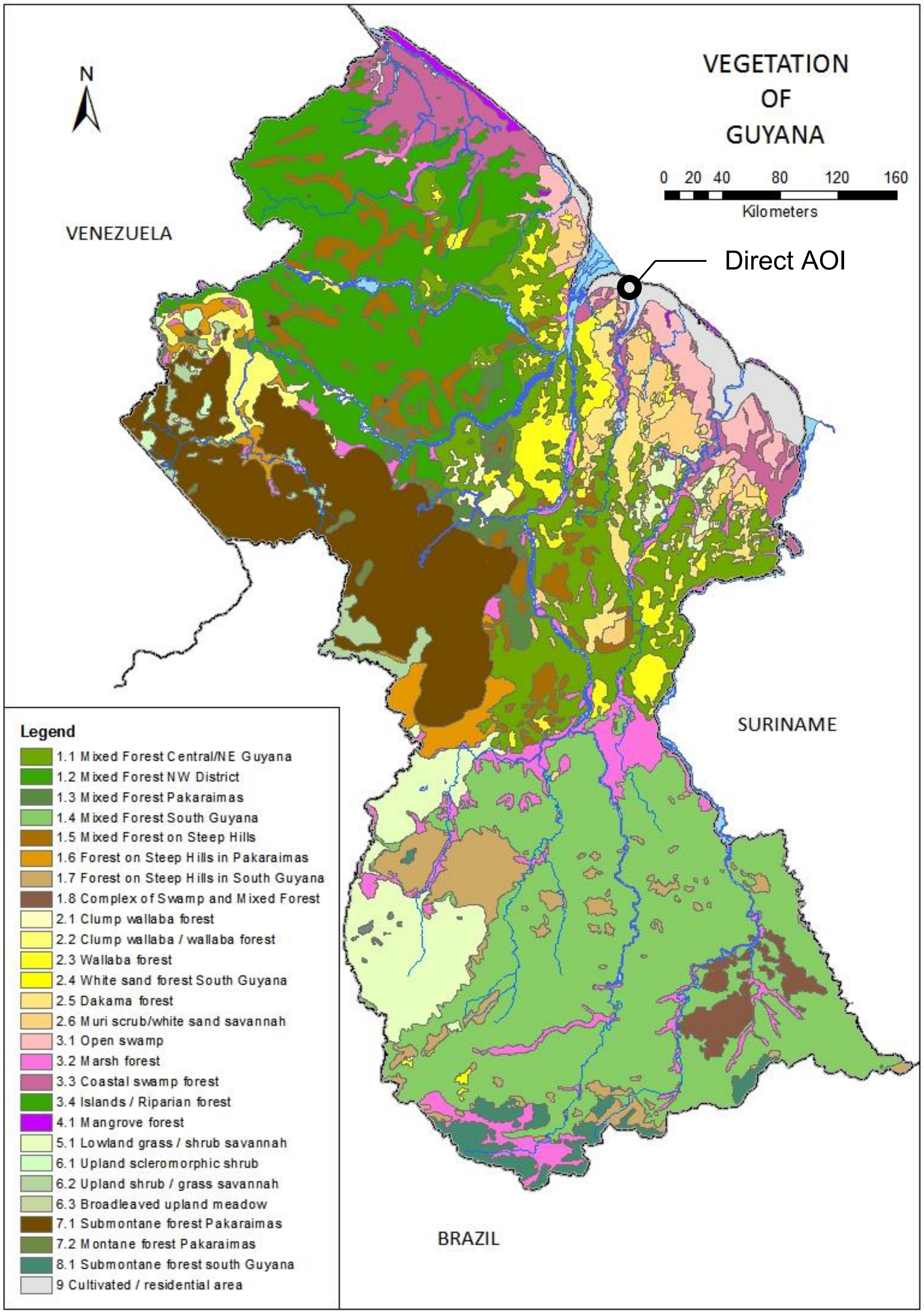
Vegetative Structure

In an ecological context, the term “vegetative structure” refers to the species composition of a vegetative community, the habit of those species, the shape and location of the community in the landscape, and its degree of connectivity to other natural landscapes. Section 8.3, Terrestrial Biodiversity, describes the species composition and habit of the communities within and immediately adjacent to the Direct AOI; this subsection describes the implication of those factors for ecosystem function and the broader landscape-scale attributes of these communities.

Guyana’s coastal plain vegetation is a patchwork of mangroves forests, coastal swamp forest, seasonally flooded palm marsh and swamp forest, urban areas, cultivated fields, and secondary vegetation (Government of Guyana 2015). Vegetation in the coastal plain and portions of the hilly sand and clay region can be periodically flooded. As described in Granville (1988), forests in these regions are divided into "tidal swamp forest" near the coast and "seasonal swamp forest" along the rivers and streams (Granville 1988). In Guyana, modification of vegetative communities by human activities has historically been most intensive along the coast, resulting in fragmentation and loss of natural habitats through agriculture, urbanization, and industrial activities.

The onshore section of the Direct AOI is located within the coastal plain and the hilly sand and clay region (Huber et al. 1995; Government of Guyana 2015). In 2001, the Guyana Forestry Commission published a national vegetation map (Figure 8.5-3) that was developed from satellite imagery, soil maps, research plots, and historical Food and Agriculture Organisation of the United Nations Forest Industry Development Survey data (ter Steege 2001, in Van der Hout 2015). As shown on Figure 8.5-3, the Direct AOI is located in the western portion of cultivated/residential landscape that extends from the Essequibo River in the west to the Suriname border in the east, and is bordered by the Atlantic Ocean to the north and a belt of swamp and marsh forest to the south. This forested belt stretches along the banks of the Demerara River for approximately 80 kilometers south of the Direct AOI.

The Direct AOI is heavily modified and the remnant natural vegetation communities within it are highly fragmented. The Direct AOI is in a transition zone between the heavily modified coastal plain and relatively intact areas of Dakama forest, marsh forest, and open swamp to the south and west. The Indirect AOI includes much of the Dakama forest in the Demerara watershed, areas of Walla forest on both sides of the Essequibo River, and the eastern portion of an expansive area of mixed forest that extends across the northeastern portion of Region 2 (Figure 8.5-3).



Source: ter Steege 2001

Figure 8.5-3: Vegetation of Guyana

Vegetative Height

Much of the vegetation within the Direct AOI is herbaceous or shrubby and reaches a maximum of 1 to 2 meters in height. The taller vegetation communities in the Direct AOI are principally limited to the bamboo forests and the successional forests (which are located primarily in riparian areas) along the pipeline RoW (see Section 8.3, Terrestrial Biodiversity). Vegetation height influences water demand because taller vegetation is more exposed to the atmosphere and the dessicating impacts of wind and solar radiation. Increased exposure to atmospheric exchange across the leaf surface and sunlight also increases respiration rates, which influence growth rates (and indirectly, carbon sequestration in plant tissues). These metabolic processes are expected to be generally uniform across vegetation classes of similar heights. However, in different types of forests where vegetation heights can vary more dramatically, more significant differences in metabolic activity can occur. For example, canopy heights in bamboo forests such as the forests that occupy large portions of the pipeline RoW can reach 10 to 20 meters, and the canopies in the mangrove/successional forest that occur along the Atlantic coast and Demerara shoreline can reach 5 to 25 meters depending on the dominant species. Studies of plant physiology have shown that in most cases growth rates slow as trees grow taller, trees reach lower maximum heights on resource-poor sites, and annual wood production declines after canopy closure for even-aged forests. Taller trees also usually respire, photosynthesize, and conduct water vapor at slower rates than younger trees (Ryan et al. 2006), but because of physiological changes that occur in trees as they age, wood production and potential for carbon sequestration increase with age (Sillett et al. 2010). The importance of vegetation height for ecosystem function is multifaceted, but in simple terms, trees exert progressively more demands for water on the ecosystem. This trend continues until the canopy closes and the trees along the edge of the stand can provide protection against dessication to the rest of the stand. However, as water demand reaches an upper limit in older forests (Migliavacca et al. 2021), wood production and carbon sequestration (and the habitat value and climate benefits thereof) continue to increase (Sillett et al. 2010).

8.5.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on ecological balance and ecosystems. The relevant planned Project activities and the associated potential impacts of these activities on ecological balance and ecosystems are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

8.5.3.1. Relevant Project Activities and Potential Impacts

In general, the planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to an assessment of impacts on ecological balance and ecosystems. Unlike the other physical and biological resource-specific subsections in Chapters 7 and 8 which describe impacts on separate ecosystem components individually, this section assesses the potential impacts of planned Project activities at the ecosystem level. Table 8.5-1 summarizes the planned Project activities that could result in potential impacts on ecosystem balance and ecosystems.

Table 8.5-1: Summary of Relevant Project Activities and Key Potential Impacts—Ecological Balance and Ecosystems

Stage	Project Activity	Key Potential Impacts
Construction	Installation of the offshore and onshore pipeline; construction of the NGL Plant, heavy haul road, and temporary MOF; hydrotesting of offshore and onshore pipeline; ballast exchanges from offshore vessels	• Changes in gene flow resulting from changes to local current patterns • Changes in the marine nutrient cycle from permitted discharges from installation vessels • Changes in marine biodiversity due to introduction of invasive species from ballast water exchanges • Interruption of the marine carbon cycle due to localized decreases in planktonic photosynthesis • Changes in the biological availability of canal habitat • Alternation of local drainage and shallow groundwater recharge • Impacts on coastal/estuarine biodiversity due to installation of the temporary MOF • Changes in vegetative structure and height due to clearing of the onshore pipeline route, NGL Plant footprint, and temporary MOF
Operations	Operational effluent discharges from NGL Plant	• Changes in drainage patterns from NGL Plant site • Changes in the biological availability of canal habitat • Changes in distribution and composition of estuarine biodiversity due to operational effluent discharges • Impacts on freshwater biodiversity due to operation of the temporary MOF
Decommissioning	Subsea infrastructure decommissioning	• Changes in gene flow resulting from changes to local current patterns • Changes in the marine nutrient cycle from discharge of pipeline flush water • Interruption of the marine carbon cycle due to localized decreases in planktonic photosynthesis • Changes in marine biodiversity due to introduction of invasive species from ballast water exchanges

8.5.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for ecological balance and ecosystems (see Table 8.5-2). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for ecological balance and ecosystem sensitivity are provided in Table 8.5-3.

As described above, ecological balance and ecosystems is a complex resource. For the purpose of assessing the significance of potential impacts on this resource, separate discussions are provided for the following ecological balance and ecosystems components, with the assessment focusing on the specific potential impacts that are relevant to each of these four ecosystem types:

- Marine Ecosystem
- Freshwater Ecosystem
- Coastal/Estuarine Ecosystem
- Terrestrial Ecosystem

Table 8.5-2: Definitions for Intensity Ratings for Potential Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Intensity	**Negligible**: No measurable ecosystem-level changes; the ecosystem continues to function as it did prior to the Project activities occurring.
	Low: Changes are perceptible but affect only a small number of species within the ecosystem, and only at one trophic level, and/or across a limited spatial area.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level, and/or across a significant portion of the area that an ecosystem physically occupies.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are substantially altered.

Table 8.5-3: Definitions for Resource Sensitivity Ratings for Potential Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Sensitivity	**Low**: Ecosystem is highly modified and/or is capable of withstanding disturbance and degradation without reaching an irreversible ecological threshold (i.e., is highly resilient). In the context of the sensitivity rating, resilience may derive from a variety of conditions including, but not limited to, high regenerative and/or assimilative capacity. Rare or disturbance-sensitive species are absent or uncommon; ecosystem is dominated by non-native and/or habitat generalist species.
	Medium: Ecosystem is modified and is moderately resilient to disturbance and degradation. In the context of the sensitivity rating, resilience may derive from a variety of conditions including, but not limited to, moderate regenerative and/or assimilative capacity. Rare or disturbance-sensitive species may be present but are not dominant.
	High: Ecosystem is natural (i.e., minimal anthropogenic disturbance and high ecosystem value/function) and has low resilience to disturbance and degradation. The ecosystem has low regenerative and/or assimilative capacity. Ecosystem is dominated by native and/or habitat specialist species and contains important habitat for populations of rare species.

8.5.3.3. Impact Magnitude Ratings—Ecological Balance and Ecosystems

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to ecological balance and ecosystems is provided in Table 8.5-4.

Marine Ecosystem

The only Project component with the potential to affect the marine ecosystem would be the offshore pipeline, inclusive of the subsea components that will connect the Unity and Destiny FPSOs in the Stabroek Block to the offshore pipeline. The discussion of the marine ecosystem therefore focuses on potential ecological balance and ecosystem-level impacts on the marine environment during the Construction and Decommissioning stages.

Gene Flow

Maintaining gene flow is critical to supporting genetic diversity in marine biological populations, which in turn is an important factor in the general resilience and vigor of marine flora and fauna. Obstacles to efficient gene flow can occur when physiochemical barriers to migration, breeding, or dispersal/colonization occur. Oceanic currents are a key driver of biological dispersal because many marine species spend all or part of their lives as plankton. A project activity or feature could potentially have significant impacts on gene flow if it impacts large-scale current patterns, alters the geological boundaries of ocean basins, or prevents site-specific reproductive events (such as spawning aggregations) from occurring.

From a marine biophysical perspective, the defining characteristics of the marine portion of the Project AOIs (and the North Brazil LME generally) are the influence of freshwater inputs from the Amazon River (via the Guiana Current) (Gyory et al. Undated) and rivers draining the Guiana Shield (Isaac and Ferrari 2017), and the bathymetric profile of Guyana's continental shelf. The currents bring immature life stages of fish and benthos from outside the Project AOI into the Project AOI, facilitating a flow of genetic material between the Project AOI and the larger marine seascape. As these currents interact with each other and flow over the continental slope and shelf, they determine how planktonic organisms are distributed through Guyana's EEZ, and ultimately where planktonic juvenile life stages settle and mature.

During the Construction stage, discharge of hydrostatic test water will create a temporary flow field at the offshore discharge location in the Stabroek Block, and potentially a second flow field at one of two possible intermediate discharge locations on the continental shelf. This flow field will change the direction of flow in the immediate vicinity of the discharges, but this impact will be temporary and localized - so it will not change any of the fundamental hydrological characteristics of the Amazon River, the macro-scale oceanographic characteristics of the Project AOI, or the seasonal flow regime of Guyana's rivers. The Project will not affect the bathymetry of the continental shelf at a seascape scale. Further, the Project's offshore construction activities will not impact any site-specific reproductive activities of marine biota that could be considered significant at a regional or ecosystem scale. There will be a similar temporary and localized effect during the Decommissioning stage when the pipeline is flushed and cleaned prior to being abandoned.

On this basis, the intensity of potential impacts on gene flow is considered **Negligible** during the Construction and Decommissioning stages. These potential impacts will occur on an essentially continuous basis while the relevant Project activities are occurring, so the frequency of this potential impact is considered **Continuous** during these stages. Hydrotesting discharge and discharge of flush water during offshore pipeline abandonment will each last less than a week in aggregate, so the duration is considered **Short-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on gene flow is rated as **Negligible** for both stages**.** Routine monitoring of offshore Project components during the Operations stage will be accomplished predominantly remotely, using instruments controlled from either the FPSOs or shore, with minimal requirements for marine vessel support. Accordingly, no impacts on gene flow are expected during the Operations stage.

Marine Nutrient Cycle

Installation of the offshore pipeline could potentially impact the marine nutrient cycle indirectly through associated impacts on marine water quality. As discussed in Section 7.4.3, Impact Prediction and Assessment (Water Quality), planned activities of the Project are predicted to have potential impacts on water quality ranging in significance from **Negligible** to **Minor** during the Construction and Decommissioning stages, and these potential impacts are predicted to be temporary and limited to a relatively localized zone around the offshore pipeline corridor and marine installation/decommissioning vessels. These localized, temporary impacts are not likely to persist long enough to change the species composition of the plankton community, or of the higher trophic levels that depend upon the plankton as a forage base. Based on the **Negligible** to **Minor** significance of potential marine water quality impacts, and the small portion of the Project AOI that will be exposed to these potential impacts, the Project is predicted to have little if any measurable ecosystem-level impacts on nutrient cycling. On this basis, the intensity of impacts on the marine nutrient cycle is considered **Negligible** during the Construction and Decommissioning stages. These potential impacts will occur on an essentially continuous basis while the associated Project activities are occurring, so the frequency of this potential impact is considered **Continuous** for both stages. These impacts are expected to last longer than a week but less than a year for both Construction and Decommissioning stages, so the duration of the impacts during both stages is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Negligible**. Routine monitoring of offshore Project components during the Operations stage will be accomplished predominantly remotely, using instruments controlled from either the FPSOs or shore, with minimal requirements for marine vessel support. Accordingly, no impacts on gene flow are expected during the Operations stage.

Marine Biodiversity

The Project is predicted to have potential impacts of varying levels of significance on marine species, but is not expected to impact the large-scale distribution of species or cause the loss of any species from within the Project AOI. Some benthic species will be displaced from the footprint of the offshore pipeline, and some pelagic species may be temporarily displaced from the immediate vicinity of the installation vessels due to the sediment and turbidity plumes formed by activities that disturb the seabed, but these potential impacts will be insignificant at the ecosystem scale. Additionally, there is no reasonable potential for the Project to cause the extinction or extirpation of any species from Project AOI, or to measurably exacerbate any of the risk factors that have contributed to the listing of special status species potentially occurring in the Project AOI.

The greatest potential for affecting biodiversity in the Project AOI is associated with the potential introduction of exotic species from ballast exchanges by construction and decommissioning vessels operating along the offshore pipeline alignment. The global movement of ballast water is considered the largest transfer mechanism for marine non-indigenous species (Ruiz et al. 2005). Ballast water is water carried in ships' ballast tanks to improve vessel stability, balance, and trim; it is essential for the safe operations of oceangoing ships. It is taken onboard or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in foul weather. When ships take on ballast water, aquatic plants and animals may also be entrained into the ballast tanks. Upon being discharged, some non-native species may survive and establish themselves in the new environment if the habitat conditions are suitable. If the non-native species become invasive, they may result in ecological, economic, and public health impacts (MCA 2008). If the invasive species become dominant in the new environment, they can displace native species, change local/regional biodiversity, and affect local economies based on fisheries (NOAA Undated). The Caribbean Invasive Alien Species Working Group, of which Guyana is a member, has identified one species, the green mussel (*Perna virdis*), as having been introduced to the Caribbean and South American coastal waters via ballast water (Caribbean Invasives.org 2021), which suggests that such long-term introductions are rare but have occurred.

Two types of ballast exchanges will occur at different Project stages:

- Ballast water exchanges by pipeline installation and decommissioning vessels while on route to Guyana; and
- Recurring intakes/discharges of ballast water by the pipeline installation and decommissioning vessels as they navigate along the offshore pipeline corridor and within Georgetown Harbour.

The first ballast water exchange noted above will, prior to arrival in Guyana waters, replace water taken on at the vessels' points of origin with water from deep international waters (an embedded control to reduce the potential impact of invasive species introduction). This practice is generally recognized to reduce the likelihood of introducing invasive species to new coastal habitats because oceanic organisms are considered unlikely to colonize coastal habitats (Ruiz et al. 2005). This rationale is based on an assumption that coastal waters (where most ports are located) are sufficiently different from the open ocean in terms of salinity and physical habitat conditions such that most organisms from the coast will not be able to survive and colonize the open ocean, and vice versa.

The second type of ballast water exchange noted above will occur repeatedly and will discharge ballast water taken on either immediately outside the Guyana EEZ (upon first entering the Direct AOI) or within the Direct AOI itself (while operating in the Direct AOI). These discharges will all occur within the Direct AOI. This process will occur throughout the Construction and Decommissioning stages, as the vessels adjust their ballast according to vessel load and sea state conditions on an as-needed basis. It will pose no substantial risk of introduction of non-native species because the water that will be discharged in the Direct AOI will be taken aboard near or in the Direct AOI.

Although the nature of the potential impacts of introductions via ballast water will be similar during the Construction and Decommissioning stages, the impact intensity will be greater during Construction stage because there will be more vessels operating during Construction than during Decommissioning. Based on the above discussion, the intensity of impacts on biodiversity from ballasting operations is considered **Low** during Construction, and **Negligible** during Decommissioning. Based on the expectation that such an event would be infrequent during both the Construction and Decommissioning stages, the frequency is considered **Episodic** in nature, regardless of Project stage. Under the conservative assumption that an invasive species introduction does occur and the introduced species becomes established, the resulting ecosystem impacts could occur over a long-term basis, so the duration of the impact is conservatively considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Small** during Construction, and **Negligible** during Decommissioning**.** Ballast exchanges will be eliminated once construction activities cease. Therefore, no impacts on marine biodiversity are expected during the Operations stage.

Carbon Storage

The net movement of carbon from the surface of the ocean to the deep ocean is the result of a number of chemical, physical, and biological processes, all of which operate at the seascape scale. The mechanisms underlying the so-called “ocean carbon pump” include ocean circulation, photosynthesis, assimilation of carbon fixed in plant and unicellular organisms’ tissue into higher trophic levels of the marine food web, and deposition of organic material into the deep ocean (Preuss 2001; Kerlin 2017). Some of these mechanisms may be temporarily affected at the local scale (e.g., ocean currents and photosynthesis) during the Construction stage, but these effects will be neither widespread nor long-term.

As described above, the Construction stage will include a number of potential water quality impacts, and hydrotesting the pipeline will create a temporary disturbance in currents near the deepwater discharge point and possibly at a second location on the continental shelf. Decommissioning will create a similar disturbance in local current patterns as the pipeline is flushed and flushing water is discharged prior to abandonment. The extents of the potential impacts will be confined to the immediate vicinity of the pipeline corridor. Accordingly, the intensity of potential Project impacts on carbon storage is considered **Negligible**. These potential impacts will occur on an essentially continuous basis during the Construction and Decommissioning stages, so the frequency of this impact is considered **Continuous** for these stages. These potential impacts are expected to last longer than a week but less than a year, so the duration of the impacts during the Construction and Decommissioning stages is considered **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact is rated as **Negligible.** Localized impacts on currents and photosynthetic potential will be eliminated once construction activities cease. Therefore, no impacts on marine carbon storage are expected during the Operations stage.

Freshwater Ecosystem

Physical Characteristics of Freshwater Habitats

The Project will have no impact on the seasonal flow regime of the Demerara River, the Essequibo River, or their tributaries within the Project AOI. The Demerara and Essequibo watersheds will continue to function as separate hydrologic systems during the dry season, and will continue to be connected via the same seasonally flooded waterbodies that currently connect them during the rainy season. The additional impervious surface within the footprint of the NGL Plant will affect drainage locally, effectively increasing the volume and rate of stormwater drainage and reducing recharge of shallow groundwater in the immediate vicinity of the facility. This may exacerbate seasonal water level changes in surface water features within a few hundred meters of the facility, but will not have a measurable effect at the ecosystem level.

The intensity of impacts on the hydrology of the freshwater aquatic ecosystem from this activity is considered **Negligible**, due to the small footprint of the impact compared to the size of the freshwater portion of the Demerara watershed. These impacts will occur once, during the Construction stage, so the frequency is considered **Episodic.** These impacts are expected to last longer than a week but less than a year, so the duration of these impacts is considered **Medium-term**. Impacts on surface drainage and groundwater recharge will persist through the entire Project life cycle, so the duration of the impact for this stage is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on hydrological characteristics of the freshwater aquatic ecosystem is rated as **Negligible.**

The additional impervious surface within the footprint of the NGL Plant will cause the land surface to drain more quickly than it does under current conditions, and increase the peak drainage volume from the NGL Plant site. The stormwater management facility will manage these changes by providing an intermediate destination for the stormwater and slowing the rate at which it is released to the environment, thereby buffering the effect of altered drainage conditions on surrounding habitats. The intensity of potential ecological impacts due to changes in drainage patterns at the NGL Plant site is considered **Negligible**, due to the small footprint of the potential impact compared to the size of the freshwater portion of the Demerara watershed. These impacts will occur throughout the Project lifecycle, so the frequency is considered **Continuous,** and will be **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on drainage patterns, and the implications for freshwater ecology from this activity is rated as **Negligible.**

Coastal and Estuarine Ecosystem

Constructing and operating the temporary MOF will change the biological attributes of the riparian and nearshore communities along the affected portion of the Demerara River and will decrease the total area available for aquatic species to occupy; however, as described in Section 8.4, Freshwater Biodiversity, it will not significantly reduce the total amount of habitat available in the Demerara River or Atlantic Coast watersheds, nor will it significantly alter the aquatic habitat composition in these watersheds. Aquatic species diversity is not expected to change as a result of installation or use of the temporary MOF. Accordingly, the intensity of this impact is rated **Negligible**. The impacts would persist for the duration of the Construction stage and far into the Operations phase as the MOF remains in place, so the frequency is considered **Continuous**. The temporary MOF likely would be in place for longer than a year, so the duration of the impact for this stage is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Negligible.**

As described in Section 7.4, Water Quality, the Project will produce domestic and process wastewater discharges. These discharge streams will be routed to a wastewater treatment facility that will be designed to meet World Bank Group effluent levels before discharging to the Demerara River (either directly or via a canal adjacent to the NGL Plant). Although these discharges will have the potential to affect water quality in the Demerara River within the mixing zone, and these effects may have localized effects on the biota of the river, they would occur across a limited spatial area. Accordingly, the intensity of this potential impact is rated **Low**. The potential impacts would occur continuously for the duration of the Operations stage, so the frequency is considered **Continuous** and the duration of the potential impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Small.**

Terrestrial Ecosystem

Vegetative Structure

The Project will require vegetation clearing within the footprint of Project facilities. Most of this area is currently characterized by active or inactive agriculture and/or by herbaceous/shrub vegetation. As described in Section 5.4.3.1, the vegetation within upland portions of the permanent onshore pipeline RoW will be maintained as height-controlled herbaceous cover (i.e., free of significant woody vegetation). Except for a few areas along the onshore pipeline route of mature shrub or forest, clearing and maintanance of the onshore pipeline corridor will not fundamentally change the structure of the vegetative community in the Direct AOI. The terrestrial ecosystem will remain a highly fragmented mosaic of early successional and secondary vegetation types. The footprint of the NGL Plant, which is the closest portion of the Direct AOI to the relatively less fragmented and modified habitats to the south and west of the Direct AOI, will become essentially unvegetated. This will reduce the ecological value of the transition zone in which the NGL Plant will be located, as described in Section 8.5.2, Existing Conditions and Baseline Studies, but agricultural lands are between the NGL Site and the higher-value habitats to the south and west of the Direct AOI, so construction of the NGL Plant will not push the transition zone farther to the south or west, or decrease the value of the habitats to the south and west of the Direct AOI.

Impacts on vegetative structure will have localized impacts on vegetation and wildlife, but these impacts are not expected to be significant at the landscape scale, so the intensity of this impact is rated **Low**. The impacts would be persistent through the entire Project life cycle, so the frequency is considered **Continuous** and the duration of the impact for this stage is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Small.**

Vegetative Height

As described in Section 8.5.2.3, vegetative height is an important ecological indicator because it influences macro-ecological processes such as water demand and carbon sequestration rates. Potential impacts on vegetation height will be similar in magnitude to potential impacts on vegetative structure. The relatively low herbaceous vegetation within the onshore pipeline corridor will remain largely unchanged, while isolated pockets of taller woody vegetation will be converted to lower herbaceous vegetation. The herbaceous/shrub vegetation that currently exists within the footprint of the NGL Plant will be largely eliminated, but this will represent a minor loss at the landscape/ecosystem scale. Accordingly, the intensity of this impact is rated **Low**. The impacts would be persistent through the entire Project life cycle, so the frequency is considered **Continuous** and the duration of the impact for this stage is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Small.**

8.5.3.4. Sensitivity of Resource—Ecological Balance and Ecosystems

Based on the sensitivity rating definitions in Table 8.5-4 above, the resource sensitivity for ecological balance and ecosystems is considered **Medium** for the marine ecosystem component, and **Low** for the freshwater, coastal/estuarine, and terrestrial ecosystem components. These ratings are principally based on the size of the respective ecosystems relative to the impacts that are anticipated within them and the capacity of each ecosystem to withstand Project-related impacts without reaching an irreversible ecological threshold (e.g., mass extirpation event, conversion of a food web, mass habitat conversion, etc.). The marine portion of the Project AOI (and the North Brazil LME generally) is relatively large and unaltered by human activity, supports a number of sensitive marine taxa, and is largely populated by native taxa. The freshwater aquatic and terrestrial ecosystems within the Direct AOI are highly modified by comparison, and further modifications of the scale and type associated with the Project would not be expected to cause detectable changes in ecological receptors' functions or values.

8.5.3.5. Pre-mitigation Impact Significance—Ecological Balance and Ecosystems

Assuming implementation of the embedded controls listed in Table 8.5-4, the intensity ratings for potential impacts on ecological balance and ecosystems from planned Project activities range from **Negligible** to **Low.** This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small.** Coupled with sensitivity ratings of **Low** (for the freshwater, coastal/estuarine, and terrestrial system components) and **Medium** (for the marine ecosystem component), the pre-mitigation impact significance for ecological balance and ecosystems ranges from **Negligible** to **Minor**.

8.5.4. Impact Management and Monitoring Measures

Based on the **Negligible** to **Minor** significance of potential impacts on ecological balance and ecosystems, no mitigation measures are proposed. It is noted, however, that the limited significance of potential ecological balance and ecosystems impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

Table 8.5-4 summarizes the management and monitoring measures relevant to ecological balance and ecosystems.

Table 8.5-4: List of Management and Monitoring Measures

Embedded Controls
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO and MARPOL 73/78 requirements.
For effluent released from the STPs on board Project marine vessels, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Use procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.
Inspect and maintain onboard equipment (engines, compressors, generators, STP, and oil-water separators) in accordance with manufacturers' guidelines, to maximize efficiency and minimize malfunctions, and unnecessary discharges into the environment.
For Project marine vessels necessitating ballast water exchanges, abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard), and abide with MARPOL 73/78.
Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Implement engineering controls, administrative controls, and training to protect offshore workforce from high noise levels in the offshore work environment.
Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Provide sanitary and process WWTPs that comply with appropriate World Bank discharge standards.

Provide a stormwater management facility at the NGL Plant site.
Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD boring).
Monitoring Measures
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book for Project construction/installation vessels.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book.
Record estimated volume of ballast water discharged and location (per ballasting operation) for Project construction/installation vessels.
Monitor effluent quality from the sanitary and process water WWTPs to document compliance with appropriate discharge standards.

IMO = International Maritime Organization; MARPOL 73/78 = International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978; STP = sewage treatment plant

8.5.5. Assessment of Residual Impacts

As described above, no mitigation measures are proposed to address potential impacts on ecological balance and ecosystems. Accordingly, the residual impact significance ratings remain unchanged at **Negligible** to **Minor**.

Table 8.5-5 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on ecological balance and ecosystems.

Table 8.5-5: Summary of Potential Pre-Mitigation and Residual Impacts—Ecological Balance and Ecosystems

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Changes in gene flow resulting from changes to local current patterns	Medium	Negligible	Negligible	None	Negligible
	Changes in the marine nutrient cycle from permitted discharges from installation vessels	Medium	Negligible	Negligible	None	Negligible
	Changes in marine biodiversity due to introduction of invasive species resulting from ballast water exchanges from marine vessels during offshore installation activities	Medium	Small	Minor	None	Minor
	Interruption of the marine carbon cycle due to localized decreases in planktonic photosynthesis	Medium	Negligible	Negligible	None	Negligible
	Changes in the hydrology of the canal network	Low	Negligible	Negligible	None	Negligible
	Alternation of local drainage and shallow groundwater recharge	Low	Negligible	Negligible	None	Negligible
	Changes in the biological availability of canal habitat	Low	Small	Negligible	None	Negligible
	Impacts on estuarine biodiversity due to construction of the temporary MOF	Low	Negligible	Negligible	None	Negligible
	Changes in vegetative structure and height due to clearing of the pipeline route and NGL Plant footprint	Low	Small	Negligible	None	Negligible
Operations	Changes in drainage patterns from NGL Plant site	Low	Negligible	Negligible	None	Negligible

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	Impacts on estuarine biodiversity due to operation of the Temporary MOF	Low	Negligible	Negligible	None	Negligible
	Changes in the biological availability and connectivity of canal habitat	Low	Small	Negligible	None	Negligible
	Changes in distribution and composition of estuarine biodiversity due to operational effluent discharges	Low	Negligible	Negligible	None	Negligible
Decommissioning	Changes in gene flow resulting from changes to local current patterns	Medium	Negligible	Negligible	None	Negligible
	Changes in the marine nutrient cycle from discharge of pipeline flush water	Medium	Negligible	Negligible	None	Negligible
	Interruption of the marine carbon cycle due to localized decreases in planktonic photosynthesis	Medium	Negligible	Negligible	None	Negligible
	Changes in marine biodiversity due to introduction of invasive species from ballast water exchanges	Medium	Negligible	Negligible	None	Negligible

8.6. Special Status Species

8.6.1. Baseline Methodology

The special status species discussion presented herein is based on a combination of primary data generated from EEPGL-commissioned surveys (see list below) and secondary data from peer-reviewed scientific literature and databases (e.g., eBird and iBAT) and non-governmental scientific organizations, particularly the IUCN Red List of Threatened Species Version 2021.3 (IUCN 2022). This assessment covers marine, coastal, riverine, and terrestrial species.

Primary data sources used for this assessment include the following EEPGL-commissioned surveys and monitoring activities conducted over the past several years:

- Marine bird surveys of the area between Georgetown and the Stabroek Block and within the Stabroek Block and surrounding waters offshore Guyana (12 sampling events) conducted between September 2017 and February 2020 (ERM 2020b).
- Coastal bird surveys of the Guyana coastline in Regions 1 through 6—excluding the Shell Beach Protected Area—(eight sampling events) conducted between September 2017 and February 2020 (ERM 2020a).
- Marine and coastal fish surveys of the area between Georgetown and the Stabroek Block and within the Stabroek Block and surrounding waters offshore Guyana (five sampling events) conducted between October 2017 and April/May 2019 (ERM 2021b).
- Protected species observer monitoring (paired observer and passive acoustic monitoring) conducted during EEPGL seismic programs from 2015 through 2021 (RPS 2018, 2019, 2020a, 2020b, 2020c, 2020d, 2020e, 2021).
- River mammal surveys conducted between the mouth of the Demerara River and the Demerara Harbour Bridge (two sampling events) conducted in April 2019 and May 2019 (ERM 2021a).
- Marine benthos surveys of the area between Georgetown and the Stabroek Block and within the Stabroek Block and surrounding waters offshore Guyana (six sampling events) conducted between 2014 and 2020: 2014 (Maxon and TDI Brooks 2014), 2016 (Fugro 2016), 2017 (ESL 2018), and 2018 (Fugro 2019b); and 2019 and 2020 (Fugro 2019a, 2019c).
- River mammal surveys in the Demerara River and along the adjacent coastline (four sampling events) conducted from July 2021 through December 2021 (Section 8.4, Freshwater Biodiversity).
- River bird surveys in the Demerara River and along the adjacent coastline (four sampling events) conducted from July 2021 through December 2021 (Section 8.3, Terrestrial Biodiversity).
- Inland fish and aquatic insect surveys in the Demerara River and inland canals within the Project AOI (two seasonal sampling events) conducted in November/December 2021 and

January/February 2022 Section 8.4, Freshwater Biodiversity, and Appendix H, Ichthyofaunal Assessment of the Gas to Energy Project Sites).

- Terrestrial bird surveys in the onshore portion of the Project AOI (two seasonal sampling events) from October 2021 through February 2022 (Section 8.3, Terrestrial Biodiversity).
- Terrestrial mammal surveys in the onshore portion of the Project AOI (two seasonal sampling events) from October 2021 through February 2022 (Section 8.3, Terrestrial Biodiversity).
- Terrestrial vegetation surveys in the onshore and coastal and riverine shoreline portions of the Project AOI (continuous opportunistic sampling) from November 2021 through February 2022 (Section 8.3 Terrestrial Biodiversity).

8.6.2. Existing Conditions and Baseline Studies

8.6.2.1. Background

The IUCN Red List is the definitive authority on global species conservation status. In addition to the global IUCN Red List, many countries have a National Red List that assesses species status at a national or smaller scale. Guyana does not have a National Red List (NRL 2018); therefore, the IUCN Red List Version 2021.3 (IUCN 2022) is used for this assessment.

According to the IUCN Red List classification scheme (IUCN 2022), species categorized as Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) are collectively considered to be internationally “threatened” and currently face a credible threat of extinction in all or part of their range, while Near Threatened (NT) species are considered to be close to qualifying as “threatened.” Conversely, Least Concern (LC) species are considered internationally widespread and abundant. Species listed as Data Deficient (DD) are poorly understood, so their conservation status and extinction risk are unknown. Table 8.6-1 summarizes the definitions of the IUCN Red List categories.

For the purposes of this assessment, special status species are defined as those that are categorized as CR, EN, VU, and NT on the IUCN Red List (IUCN 2022).

Table 8.6-1: Definitions of IUCN Red List Categories of Extinction Risk

IUCN Red List Status	Definition
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historical range have failed to record an individual.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the Criteria A to E [a] (reduction in population size, geographic range, population size estimated to number fewer than 250 mature individuals with estimated decline, population size estimated to number few than 50 mature individuals, and a quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer), and is therefore considered to be facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence indicates that it meets any of the Criteria A to E [a] (reduction in population size, geographic range, population size estimated to number fewer than 2,500 mature individuals with estimated decline, population sized estimated to number fewer than 250 mature individuals, and quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer), and is therefore considered to be facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the Criteria A to E [a] (reduction in population size, geographic range, population size estimated to number fewer than 10,000 mature individuals with estimated decline, population very small or restricted with conditions, and quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years) and is therefore considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable, or Near Threatened. Taxa that are widespread and abundant are included in this category.
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking.

Source: IUCN 2022

[a] Criteria are described in Section IV of the *IUNC Red List Categories and Criteria: Version 3.1* (IUCN 2012).

8.6.2.2. Existing Conditions

There are 2,359 species that have been assessed by the IUCN Red List that are known to occur or have the potential to occur in the marine, riverine, and terrestrial environments within a 50-kilometer buffer of the Project footprint (onshore, riverine, and offshore components). Of these 2,359 species, 2,186 are categorized as LC and considered to be abundant and widespread throughout their range. Fifty-four species are categorized as DD, including 33 species of fish, eight mammals, two reptiles, one amphibian, five mollusks, three crustaceans, one insect, and one marine invertebrate. Of these, 119 species are considered special status species due to their IUCN Red List categorization as NT, VU, EN, or CR (IUCN 2022). The special status species include:

- 3 plants—all terrestrial tree species
- 13 birds—5 terrestrial species and 8 coastal and marine species
- 12 mammals—5 marine and coastal species, 3 riverine species, and 4 terrestrial species
- 6 turtles—5 marine species and 1 terrestrial species
- 85 fish—all marine and coastal species

Table 8.6-2 summarizes the special status species by their broad habitat type (terrestrial, freshwater, and marine) and IUCN Red List status, and Table 8.6-3 summarizes the special status species according to taxa group and habitat association. The vast majority of the special status species occur in the coastal/marine environment, and the fewest number of special status species occur in the riverine environment. In terms of IUCN Red List status, all of the CR species—the highest IUCN Red List ranking and the species most threatened with extinction—occur in the coastal/marine environment (Table 8.6-2). Overall, there are 13 CR species (one turtle and 12 fish), 26 EN species (one bird, three mammals, one turtle, and 21 fish), 47 VU species (one tree, five birds, five mammals, four turtles, and 32 fish), and 33 NT species (two trees, seven birds, four mammals, and 20 fish) (Table 8.6-3).

Table 8.6-2: Special Status Species with Potential to Occur in the Project AOI, Categorized by IUCN Listing Status and Broad Habitat Association

IUCN Red List Status	Terrestrial	Riverine	Coastal/Marine
Critically Endangered (CR)	0	0	13
Endangered (EN)	0	1	25
Vulnerable (VU)	6	1	40
Near Threatened (NT)	7	1	25
TOTAL	**13**	**3**	**103**

Table 8.6-3: Summary of Special Status Species According to Taxa Group and Habitat Association

Taxa	CR	EN	VU	NT	TOTAL
Flora	0	0	1	2	**3**
Birds					
Marine/Coastal	0	1	4	3	8
Riverine	0	0	0	0	0
Terrestrial	0	0	1	4	5
Mammals					
Marine/Coastal	0	2	1	2	5
Riverine	0	1	1	1	3
Terrestrial	0	0	3	1	4

Taxa	CR	EN	VU	NT	TOTAL
Turtles					
Marine/Coastal	1	1	3	0	5
Terrestrial	0	0	1	0	1
Fish					
Marine/Coastal	12	21	32	20	85
Riverine	0	0	0	0	0
TOTAL	**13**	**26**	**47**	**33**	**119**

Any of these 119 special status species could occur within or traverse the Project AOI (including Direct and Indirect AOIs), but none is exclusively restricted to the Project AOI or immediate surroundings and none relies on the Project AOI for critical life cycles. The majority of the species are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 9.1.3, Existing Conditions and Baseline Studies (Economic), many of these fish species are also targeted by the Guyanese commercial fishing industry.

Table 8.6-4 lists the special status species and their current IUCN Red List status, population status and distribution, primary habitat association, and area of potential occurrence within the Project AOI based on the habitats present in the Project AOI and the species' known distribution and habitat requirements. This table also indicates whether each of the special status species has been detected during the EEPGL-commissioned biological survey and monitoring activities conducted over the past several years.

Table 8.6-5 contains photographs of some of the IUCN Red List species observed during EEPGL-commissioned surveys.

Table 8.6-4: Special Status Species with Potential to Occur in the Project AOI

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Plants					
Cedrela odorata Spanish Cedar	VU	Decreasing; Central America and northern South America	NA	Lowland forest, prefers well drained soils	Temporary MOF
Pterocarpus officinalis Bloodwood	NT	Decreasing; Caribbean, Central America, and northern South America	NA	Swamp forest, riparian zone just inland from mangrove forest	Temporary MOF, forested portions of the onshore pipeline corridor
Tabebuia insignis	NT	Decreasing; northern South America	NA	Forest and shrubland with poorly drained soils	Temporary MOF, forest/shrubland portions of the onshore pipeline corridor
Birds					
Oceanodroma leucorhoa [a] Leach's Storm-Petrel	VU	Decreasing; Atlantic, and Pacific oceans	M	Offshore marine	Offshore pipeline
Pterodroma hasitata [a] Black-capped Petrel	EN	Decreasing; Atlantic Ocean off the southeast Coast of North America, Caribbean, and northern South America	M (seasonality uncertain)	Offshore marine	Offshore pipeline
Calidris canutus [a] Red Knot	NT	Decreasing; coastal regions on all continents except Antarctica	M	Coastal mudflat and beach; marine during migration	Offshore pipeline
Calidris pusilla [a] Semipalmated Sandpiper	NT	Decreasing; eastern, norther, and central North America, Caribbean, and coastal regions of Central America and South America	M	Coastal mudflat and beach; marine during migration	Offshore pipeline
Agamia agami Agami Heron	VU	Unknown; eastern Central America and northern South America	R	Coastal lowland forest and marsh	Onshore pipeline, Demerara River, temporary MOF

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Buteogallus aequinoctialis [a] Rufous Crab Hawk	NT	Decreasing; eastern coast of South America	R	Coastal mangrove	Offshore pipeline (shore landing), temporary MOF
Conirostrum bicolor [a] Bicolored Conebill	NT	Decreasing; coastal north and eastern South America, and along the Amazon River	R	Coastal mangrove	Offshore pipeline (shore landing), temporary MOF
Picumnus spilogaster [a] White-bellied Piculet	VU	Decreasing; coastal northern South America and inland Venezuela, Guyana, and northern Brazil	R	Coastal mangrove	Temporary MOF
Ramphastos tucanus [a] White-throated Toucan	VU	Decreasing; northeast South America	R	Coastal and riverine forest; forages in a wide variety of habitats where fruits and seeds are plentiful including forest patches, mangroves, pasture trees, and gardens.	Onshore pipeline, temporary MOF
Falco deiroleucus Orange-breasted Falcon	NT	Decreasing; Forests of Central America and northern South America	R	Forest and savannah	Temporary MOF, onshore pipeline
Ramphastos vitellinus Channel-billed Toucan	VU	Decreasing; northeast South America	R	Forested lowlands, riverine forest, swamp forest	Temporary MOF
Setophaga striata Blackpoll Warbler	NT	Decreasing; north, east, central, and northwest North America, Caribbean, and north and northwestern South America	M	Lowland forest, secondary forest, forest edges, and plantations (wintering only)	Temporary MOF, onshore pipeline
Celeus torquatus Ringed Woodpecker	NT	Decreasing; northeast South America	R	Secondary forest	Demerara River riparian zone, temporary MOF

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Mammals					
Balaenoptera borealis Sei Whale	EN	Increasing; all oceans except the Arctic Ocean	M	Offshore Marine	Offshore pipeline
Balaenoptera musculus Blue Whale	EN	Increasing; all oceans	M	Offshore Marine	Offshore pipeline
Physeter macrocephalus [a] Sperm whale	VU	Unknown; all oceans	R	Offshore Marine	Offshore pipeline
Pseudorca crassidens False killer whale	NT	Unknown; all oceans except the Arctic Ocean	R	Offshore Marine	Offshore pipeline
Sotalia guianensis [a] Guiana dolphin	NT	Unknown; southeast coast of Central America, north, northeast, and central-east coasts of South America	R	Coastal Marine	Offshore pipeline (nearshore component), Demerara River
Trichechus manatus [a] American manatee	VU	Decreasing; southeast, south, and mid-Atlantic coasts of North America, east coast of Central America, Caribbean coastline, and north and northeast coasts of South America	R	Riverine	Offshore pipeline (nearshore component), Demerara River
Lontra longicaudis [a] Neotropical otter	NT	Decreasing; Central American and northern, central, and central-east South America	R	Mostly riverine (but some coastal) waterbodies, riparian forests, swamps, canals, and rocky shorelines	Canals crossed by or near Project footprint, temporary MOF
Pteronura brasiliensis [a] Giant otter	EN	Decreasing; north-central South America	R	Rivers and swamps (inland)	Canals crossed by or within onshore pipeline
Myrmecophaga tridactyla Giant anteater	VU	Decreasing; southern Central America and northern, central, and eastern South America	R	Forest, shrubland, savannah	NGL Plant site, temporary MOF, onshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Speothos venaticus Bush dog	NT	Decreasing; northern and central South America	R	Forest, shrubland, and savannah, usually near water	Onshore pipeline, NGL Plant site, temporary MOF
Tapirus terrestris Lowland tapir	VU	Decreasing; northern and central South America, east of the Andes mountains	R	Forest, savanna, grassland, shrubland, swampland	Onshore pipeline, NGL Plant site, temporary MOF, canals crossed by or near Project footprint with intact riparian vegetation
Tayassu pecari White-lipped peccary	VU	Decreasing; eastern Central American and northern and central South America, east of the Andes mountains	R	Variety of forest types, shrubland, and grassland; often near water	Onshore pipeline, NGL Plant site, temporary MOF
Marine and Terrestrial Turtles					
Caretta caretta [a] Loggerhead turtle	VU	Decreasing; oceans excluding the Arctic	M (breeding)	Offshore and coastal marine	Offshore pipeline
Chelonia mydas [a] Green turtle	EN	Decreasing; central Atlantic, Pacific, and Indian oceans	R	Offshore and coastal marine	Offshore pipeline
Dermochelys coriacea [a] Leatherback turtle	VU	Decreasing; oceans excluding the Arctic, Indian, and central Pacific oceans	R	Offshore and coastal marine	Offshore pipeline
Eretmochelys imbricata [a] Hawksbill turtle	CR	Decreasing; all oceans excluding the Arctic	M	Offshore and coastal marine	Offshore pipeline
Lepidochelys olivacea [a] Olive ridley turtle	VU	Decreasing; coastlines of all continents excluding Europe and Antarctica	R	Offshore and coastal marine	Offshore pipeline
Geochelone denticulata Yellow-footed tortoise	VU	Unspecified; northeastern South America	R	Riverine and interior forest	Temporary MOF

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Fishes					
Albula vulpes [a] Bonefish	NT	Decreasing; coastlines of the Caribbean, Central America, and South America around the Caribbean Sea	R	Coastal marine	Offshore pipeline
Balistes capriscus [a] Grey triggerfish	VU	Decreasing; eastern coast of North, Central, and South America, Caribbean, Western Coast of Europe and Africa, the Mediterranean Sea coastline and Black Sea coastline, and Atlantic Islands	R	Coastal marine	Offshore pipeline
Balistes vetula Queen triggerfish	NT	Decreasing; eastern coast of North, Central, and South America, Caribbean, Atlantic Islands, and West Coast of Africa	R	Coastal marine	Offshore pipeline
Carcharhinus acronotus Blacknose shark	EN	Decreasing; southeast and south coasts of North America, east coast of Central America, north, northeast, and central east coasts of South America, the Caribbean	R	Coastal marine	Offshore pipeline
Carcharhinus brevipinna [a] Spinner shark	VU	Decreasing; east and south coasts of North America, Gulf of Mexico coast, central-east coast of South America, coast of Africa, Indonesia, south coast of India, north coast of Australia, south coast of Japan	R	Coastal marine	Offshore pipeline
Carcharhinus isodon Finetooth shark	NT	Stable; east and south coasts of North America, coasts of Guyana and Trinidad and Tobago, south coast of Brazil	R	Coastal marine	Offshore pipeline
Carcharhinus limbatus Blacktip shark	NT	Decreasing; coasts of continents except Antarctica	R	Coastal marine	Offshore pipeline
Carcharhinus porosus Smalltail shark	CR	Decreasing; south coast of North America, east coast of Central America, north, northeast, and central-east coasts of South America	R	Coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Cynoscion acoupa [a] Acoupa weakfish	VU	Decreasing; northeast and central-east coast of South America	R	Coastal marine	Offshore pipeline
Epinephelus itajara Atlantic goliath grouper	VU	Decreasing; east coast of Central America, the coast of southern North America, Caribbean, and northeast and central-east coast of South America	M	Coastal marine	Offshore pipeline
Epinephelus morio [a] Red grouper	VU	Decreasing; east coast of Central America, the coast of southern North America, Caribbean, and northeast and central-east coast of South America	R	Offshore and coastal marine	Offshore pipeline
Epinephelus striatus Nassau grouper	CR	Decreasing; southeast coast of North America, east coast of Central America and Gulf of Mexico, Caribbean, and the north coast of South America	M	Coastal marine	Offshore pipeline
Ginglymostoma cirratum Atlantic nurse shark	VU	Decreasing; southeast and south coasts of North America, east coast of Central America, north, northeast, and central-east coasts of South America, Caribbean coastline, west coast of Africa, coast of the Bay of Biscay	R	Coastal marine	Offshore pipeline
Gymnura altavela Spiny butterfly ray	VU	Decreasing; east coast of North America, southeast coast of South America, west coast of Africa, coast of the Mediterranean and Black seas	R	Coastal marine	Offshore pipeline
Gymnura micrura [a] Smooth butterfly ray	NT	Decreasing; northeast and central-east coast of South America	R	Coastal marine	Offshore pipeline
Himantura schmardae Chupare stingray	EN	Decreasing; east coast of Central America, north and northeast coast of South America, Caribbean	R	Coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Hypanus americanus Southern stingray	NT	Decreasing; east and south coast of North America, east coast of Central America, north coast of South America, Caribbean	R	Coastal marine	Offshore pipeline
Hypanus guttatus [a] Longnose stingray	NT	Decreasing; east coast of Central America, north, northeast, and central-east coast of South America, Caribbean	R	Coastal marine	Offshore pipeline
Hyporthodus flavolimbatus Poey's grouper	VU	Decreasing; east and south coast of North America, east coast of Central America, southern Caribbean, north and central east coast of South America	R	Coastal marine	Offshore pipeline
Hyporthodus niveatus Snowy grouper	VU	Decreasing; east and south coast of North America, Caribbean, east coast of Central America, north and east coasts of South America	R	Offshore and coastal marine	Offshore pipeline
Isogomphodon oxyrhynchus Daggernose shark	CR	Decreasing; northeast coast of South America	R	Coastal marine	Offshore pipeline
Isurus oxyrinchus Shortfin mako	EN	Decreasing; all oceans except the Arctic Ocean	R	Offshore and coastal marine	Offshore pipeline
Lachnolaimus maximus Hogfish	VU	Decreasing; southeast and south coast of North America, east coast of Central America, north and northeast coast of South America, Caribbean	R	Coastal marine	Offshore pipeline
Lutjanus analis [a] Mutton snapper	NT	Decreasing; southeast and south coast of North America, east coast of Central America, north, northeast, and central-east coast of South America, Caribbean	R	Coastal marine	Offshore pipeline
Lutjanus cyanopterus Cubera snapper	VU	Decreasing; east and south coasts of North America, east coast of Central America, north, northeast, and central-east coasts of South America, Caribbean	R	Coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Lutjanus synagris [a] Lane snapper	NT	Decreasing; southeast and south coasts of North America, east coast of Central America, north, northeast, and central-east coasts of South America, Caribbean	R	Offshore and coastal marine	Offshore pipeline
Mycteroperca bonaci Black grouper	NT	Decreasing; south and southeast coast of North America, east coast of Central America, Caribbean, north and central-east coast of South America	R	Offshore and coastal marine	Offshore pipeline
Mycteroperca venenosa Yellowfin grouper	NT	Decreasing; south and southeast coast of North America, east coast of Central America, Caribbean, north and central-east coast of South America	R	Coastal marine	Offshore pipeline
Myliobatis freminvilliei Bullnose ray	VU	Decreasing; east and south coast of North America, east, north, and northeast coast of South America	R	Coastal marine	Offshore pipeline
Myliobatis goodei Southern eagle ray	VU	Decreasing; southeast coast of North America, east coasts of Central and South America	R	Coastal marine	Offshore pipeline
Negaprion brevirostris [a] Lemon shark	VU	Decreasing; southeast, south, and southwest coasts of North America, east and southwest coasts of Central America, north, northeast, and central-east coasts of South America, west coast of Africa	R	Coastal marine	Offshore pipeline
Pristis pristis Largetooth sawfish	CR	Decreasing; south and southwest coast of North America, Caribbean, east coast of Central America, northwest, north, northeast, and central-east coast of South America, west and east coast of Africa, south coast of Arabian Peninsula, south coast of India and southeast Asia, north coast of Australia	R	Coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Pomatomus saltatrix Bluefish	VU	Decreasing; east and south coast of North America; Gulf of Mexico; east coast of South America, west coast of Africa, south coast of Africa; south coast of Arabian Peninsula; Mediterranean and Black sea coastline; southwest coast of India; west, south, and east coasts of Australia	R	Coastal marine	Offshore pipeline
Pristis pectinate Smalltooth sawfish	CR	Decreasing; west coast of Africa	R	Coastal marine	Offshore pipeline
Pseudobatos percellens [a] Southern guitarfish	EN	Decreasing; east coast of Central America, north and east coast of South America, southern Caribbean	R	Offshore and coastal marine	Offshore pipeline
Raja cervigoni Venezuela skate	NT	Decreasing; northern coast of South America	R	Offshore and coastal marine	Offshore pipeline
Rhinoptera brasiliensis Brazilian cownose ray	VU	Decreasing; south coast of North America, east coast of Central America, and north and east coasts of South America	R	Coastal marine	Offshore pipeline
Rhizoprionodon lalandii Brazilian sharpnose shark	VU	Decreasing; southeast coast of Central America, north, northeast, and central-east coasts of South America	R	Coastal marine	Offshore pipeline
Rhizoprionodon porosus Caribbean sharpnose shark	VU	Decreasing; Caribbean, southeast coast of Central America, north, northeast, and central-east coasts of South America	R	Coastal marine	Offshore pipeline
Sciades parkeri [a] Gillbacker sea catfish	VU	Decreasing; east-northeast coast of South America	R	Coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Sphyrna tiburo Bonnethead shark	EN	Decreasing; east, south, and southwest coasts of North America, east and west coast of Central America, north, northeast, and central-east coasts of South America	R	Coastal marine	Offshore pipeline
Sphyrna media Scoophead shark	CR	Decreasing; southwest coast of North America, west and southeast coast of Central America, northwest, north, northeast and central-east coasts of South America	R	Coastal marine	Offshore pipeline
Sphyrna tudes Smalleye hammerhead shark	CR	Decreasing; north, northeast, and central-east coasts of South America	R	Coastal marine	Offshore pipeline
Styracura schmardae Atlantic chupare	EN	Decreasing; east coast of Central America, Caribbean, and north and northeast coasts of South America	R	Coastal marine	Offshore pipeline
Urotrygon microphthalmum [a] Smalleye round ray	CR	Decreasing; north and northeast coast of South America	R	Coastal marine	Offshore pipeline
Megalops atlanticus [a] Tarpon	VU	Decreasing; Caribbean; north, northeast, and central-east coast of South America; west coast of Africa; west coast of Europe	R	Coastal marine; Demerara River, Canals	Offshore pipeline, Demerara River, temporary MOF, canals crossed by or near Project footprint
Alopias vulpinus Common thresher shark	VU	Decreasing; coastline of continents except Antarctica, possibly in oceans excluding Arctic	R	Offshore and coastal marine	Offshore pipeline
Alopias superciliosus Bigeye thresher	VU	Decreasing; central Pacific, Atlantic, and Indian oceans	R	Offshore and coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Anguilla rostrata American eel	EN	Decreasing; eastern coast of North American, Gulf of Mexico, southern Greenland, Caribbean, and northern coast of South America	M	Offshore and coastal marine; Demerara River, Canals	Offshore pipeline, Demerara River, temporary MOF, canals crossed by or near Project footprint
Carcharhinus leucas Bull shark	VU	Decreasing; west coast of Africa; south coast of Asia and Middle East; north coast of Australia; east, southwest, and south coast of North America; Caribbean; coast of Central America; northwest, north, northeast, and central-east coast of South America	R	Offshore and coastal marine; Demerara River	Offshore pipeline, Demerara River, temporary MOF
Carcharhinus longimanus Oceanic whitetip shark	CR	Decreasing; all oceans except the Arctic Ocean	R	Offshore and coastal marine	Offshore pipeline
Carcharhinus obscurus Dusky shark	EN	Decreasing; Australian coast and Oceania, west and south coast of Africa, coast of the Arabian Sea, East China Sea, southwest, south, and east coasts of North America, northern Caribbean, east coast of Central America, north, northeast, and central-east coasts of South America	R	Offshore and coastal marine	Offshore pipeline
Carcharhinus perezi Caribbean reef shark	EN	Decreasing; southeast and south coast of North America, east coast of Central America, Caribbean, north, northeast, and central-east coasts of South America	R	Offshore and coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Carcharhinus plumbeus Sandbar shark	EN	Decreasing; east and south coast of North America, Caribbean, east coast of Central America, north, northeast, and central-east coasts of South America, west and southeast coast of Africa, coastline of the Mediterranean sea, Arabian peninsula coast, southwest coast of Indian, west coast of the Bay of Bengal, east coast of China, East China Sea, Yellow Sea, north coast of Australia and northern Oceania	R	Offshore and coastal marine	Offshore pipeline
Diplobatis picta Variegated electric ray	VU	Decreasing; northeastern coast of South America	R	Offshore and coastal marine	Offshore pipeline
Fontitrygon geijskesi [a] Sharpsnout stingray	CR	Decreasing; northeast coast of South America	R	Offshore and coastal marine	Offshore pipeline
Galeocerdo cuvier [a] Tiger shark	NT	Decreasing; east, south, and southwest coasts of North America; coasts of Central America; Caribbean; northwest, north, northeast, and central-east coasts of South America; north coast of Australia; Oceania; Pacific Islands; south coast of Asia; Middle East and Indian subcontinent; Indonesia; west coast of Africa; east coast of Greenland; south coast of Ireland; Atlantic islands	R	Offshore and coastal marine	Offshore pipeline
Lopholatilus chamaeleonticeps Golden tilefish	EN	Decreasing; east and south coasts of North America, southern Gulf of Mexico coast, north coast of South America	R	Offshore and coastal marine	Offshore pipeline
Mobula birostris Giant manta ray	EN	Decreasing; coastlines of North America, South America, Africa, Spain, India, Southeast and East Asia, and Australia	R	Offshore and coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Mobula hypostoma Atlantic devilray	EN	Decreasing; east and south coast of North America, Caribbean, north and east coast of South America, west coast of Africa	R (possibly extant)	Offshore and coastal marine	Offshore pipeline
Mobula mobular Spinetail devilray	EN	Decreasing; coastline of continents along the Pacific, Atlantic, and Indian oceans	R (possibly extant)	Offshore and coastal marine	Offshore pipeline
Mobula thurstoni Bentfin devilray	EN	Decreasing; coastline of continents along the Pacific, Atlantic, and Indian oceans	R (possibly extant)	Offshore and coastal marine	Offshore pipeline
Prionace glauca Blue shark	NT	Decreasing; all oceans except the Arctic	R	Offshore and coastal marine	Offshore pipeline
Rhincodon typus Whale shark	EN	Decreasing; all oceans except the Arctic	R	Offshore and coastal marine	Offshore pipeline
Rhinoptera bonasus [a] Cownose ray	VU	Decreasing; east and south coasts of North America; east coast of Central America; north and east coasts of South America	R	Offshore and coastal marine	Offshore pipeline
Mustelus higmani Smalleye smoothhound	EN	Decreasing; Atlantic Ocean off east coast of North America and west coast of Europe, Gulf of Mexico, Caribbean Sea, Atlantic off coast of Argentina, Pacific Ocean near vicinity of New Caledonia	R	Offshore and coastal marine	Offshore pipeline
Rhomboplites aurorubens Vermilion snapper	VU	Decreasing; southeast and east coast of North America; east coast of Central America; Caribbean; north, northeast, and central-east coasts of South America	R	Offshore and coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Sphyrna lewini Scalloped hammerhead shark	CR	Decreasing; east, south, and southwest coasts of North America; coasts of Central America; Caribbean; northwest, north, northeast, and central-east coasts of South America; north coast of Australia; Oceania; Pacific Islands; south coast of Asia; Middle East; Indian subcontinent; Indonesia; west and east coasts of Africa; west coast of Spain and Portugal; Atlantic islands	R	Offshore and coastal marine	Offshore pipeline
Sphyrna mokarran Squat-headed hammerhead shark	CR	Decreasing; east, south, and southwest coasts of North America; coasts of Central America; Caribbean; northwest, north, northeast, and central-east coasts of South America; north coast of Australia; Oceania; Pacific Islands; south coast of Asia; Middle East; Indian subcontinent; Philippines; west and east coasts of Africa; west coast of Spain and Portugal; Mediterranean	R	Offshore and coastal marine	Offshore pipeline
Carcharhinus falciformis Silky shark	VU	Decreasing; all oceans except the Arctic	R	Offshore marine	Offshore pipeline
Carcharhinus signatus Night shark	EN	Decreasing; east and south coasts of North America, Caribbean, northeast and east coast of South America, west coast of Africa	R	Offshore marine	Offshore pipeline
Isurus paucus Longfin mako	EN	Decreasing; all oceans except the Arctic	R	Offshore marine	Offshore pipeline
Kajikia albida White marlin	VU	Decreasing; Atlantic Ocean, Caribbean, Marmara, and Mediterranean seas	R	Offshore marine	Offshore pipeline
Makaira nigricans [a,b] Blue marlin	VU	Decreasing; Atlantic, Pacific, and Indian oceans	R	Offshore marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Mobula tarapacana Sicklefin devilray	EN	Decreasing; coastline of continents along the Pacific, Atlantic, and Indian oceans	R	Offshore marine	Offshore pipeline
Mola mola [a] Ocean sunfish	VU	Decreasing; coastline of all continents excluding Antarctica	R	Offshore marine	Offshore pipeline
Thunnus alalunga Albacore tuna	NT	Decreasing; all oceans except the Arctic and Pacific Ocean off the coast of Central American and northern South America	R	Offshore marine	Offshore pipeline
Thunnus albacares [a] Yellowfin tuna	NT	Decreasing; all oceans except the Arctic	R	Offshore marine	Offshore pipeline
Thunnus obesus Bigeye tuna	VU	Decreasing; all oceans except the Arctic	R	Offshore marine	Offshore pipeline
Thunnus thynnus Atlantic bluefin tuna	EN	Decreasing; Atlantic Ocean, Mediterranean Sea, North Sea, and Baltic Sea	R	Offshore marine	Offshore pipeline
Hypanus say Bluntnose stingray	NT	Decreasing; east and south coast of North America, Caribbean, northeast coast of South America	R	Coastal marine	Offshore pipeline
Heptranchias perlo Sharpnose sevengill shark	NT	Decreasing; east and south coasts of North America; central-west, north, northeast, and east coasts of South America; west coast of Europe; Mediterranean; west coast and south coasts of Africa; west coast of India; east coast of China; coast of Japan; coast of Australia; eastern Oceania	R	Coastal marine	Offshore pipeline
Hippocampus erectus Lined seahorse	VU	Decreasing; Gulf of Mexico, Atlantic Ocean off coast of North America, Caribbean Sea, Atlantic Ocean off north and central-east South America	R	Coastal marine	Offshore pipeline

Scientific Name/ Common Name	IUCN Red List Status	Population Status and Distribution	Migratory or Resident (M/R) in Guyana	Primary Habitat	Potential Area of Occurrence within Project AOI
Hippocampus reidi Long-snout seahorse	NT	Decreasing; south coast of North America, southeast coast of Central America, Caribbean, north and central-east coast of South America	R	Coastal marine	Offshore pipeline
Squatina david David's angelshark	NT	Decreasing; southeast cost of Central America, north coast of South America	R	Offshore marine	Offshore pipeline

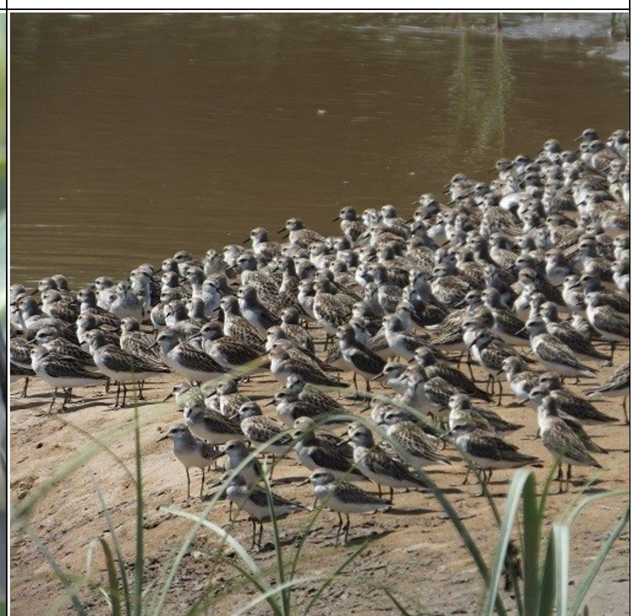
Source: IUCN 2022

NA = not applicable

[a] The species has been observed during EEPGL-commissioned surveys, which include those conducted for the Project, as listed above in Section 8.6.2.1, Background, and described in Section 8.1 through Section 8.4.

[b] Blue marlin is not listed by the IUCN as occurring in Guyanese waters; however, blue marlin have been reported in Guyanese waters from EEGPL-commissioned vessels operating offshore Guyana.

Table 8.6-5: Select Photographs of Special Status Species Observed during EEPGL-Commissioned Surveys

	
Rufous Crab Hawk (*Buteogallus aequinoctialis*) taking flight from the shoreline of the Demerara River, IUCN Red List Near Threatened (NT) and mangrove specialist	White-bellied Piculet (*Picumnus spilogaster*), IUCN Red List Vulnerable (VU)
	
Bicolored Conebill (*Conirostrum bicolor)*, IUCN Red List Near Threatened (NT)	Semipalmated Sandpipers (*Calidris pusilla*) at Leguan shoreline, Region 3, IUCN Red List Near Threatened (NT)

<table>
<tr><td></td><td></td></tr>
<tr><td>American manatee (Trichechus manatus) in the Demerara River, IUCN Red List Vulnerable (VU)</td><td>Giant otter (Pteronura brasiliensis) campsite along Parfaite Canal, IUCN Red List Endangered (EN)</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Tarpon (Megalops atlanticus; shown in center) fished from Crane Village canal, IUCN Red List Vulnerable (VU)</td><td>Blue marlin (Makaira nigricans) in the Stabroek Block, IUCN Red List Vulnerable (VU)</td></tr>
</table>

8.6.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on special status species. The relevant planned Project activities and the associated potential impacts of these activities on special status species are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

As discussed above in Section 8.6.2.2, Existing Conditions [Special Status Species], there are 119 special status species that are known to occur or have the potential to occur in the marine/coastal, freshwater/riverine, and terrestrial environments within a 50-kilometer buffer of the Project footprint (onshore, riverine, and offshore components) (Table 8.6.2).

The special status species include:

- 3 plants—all terrestrial tree species
- 13 birds—5 terrestrial species and 8 coastal and marine species
- 12 mammals—5 marine and coastal species, 3 freshwater/riverine species, and 4 terrestrial species
- 6 turtles—5 marine species and 1 terrestrial species
- 85 fish—all marine and coastal species

Any of these 119 special status species could occur within or traverse the Project AOI (including Direct and Indirect AOIs), but none is exclusively restricted to the Project AOI or immediate surroundings and none relies on the Project AOI for critical life cycles. The majority of the species are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 9.1.3, Existing Conditions and Baseline Studies (Economic), many of these fish species are targeted by the Guyanese commercial fishing industry.

8.6.3.1. Relevant Project Activities and Potential Impacts

In general, the planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to an assessment of impacts on special status species. Table 8.6-6 summarizes the planned Project activities that could result in potential impacts on special status species.

Table 8.6-6: Summary of Relevant Project Activities and Key Potential Impacts—Special Status Species

Stage	Project Activity	Key Potential Impacts
Marine and Coastal Special Status Species		
Construction	• Installation of the offshore pipeline • Ballast water exchanges • Discharges from installation and support vessels • Hydrostatic testing	• Temporary disturbance of marine benthic habitat from offshore pipeline installation • Mortality and injury of benthic organisms from offshore pipeline installation • Entrainment of marine organisms in ballast water intakes • Disturbance of marine mammals and fish and other marine organisms due to increased noise from installation activities • Temporary impacts from degraded water quality from installation activities • Temporary impacts from degraded water quality from vessel discharges • Decreased water quality from hydrostatic test water discharge
Operations	None	None
Decommissioning	• Ballast water exchanges • Discharges from decommissioning and support vessels	• Disturbance of fish and other marine organisms due to increased noise from operation of decommissioning vessels • Temporary impacts from degraded water quality from vessel discharges
Terrestrial Special Status Species		
Construction	• Installation of the onshore pipeline • Construction of the NGL Plant, heavy haul road, worker camp, and temporary MOF • Vegetation clearing • Earth moving / stockpiling materials • Construction and operation of worker accommodations • Creation of staging/material laydown areas • Dredging in the Demerara River for the temporary MOF • Construction-related traffic, including materials and equipment transport and workforce transport • Construction-related sound, light, and vibration • Solid waste and wastewater disposal from worker camp • Worker and associated population influx	• Direct loss of vegetation • Vegetation conversion and degradation • Changes in habitat condition/quality • Topsoil loss/disturbance • Introduction or expansion of invasive or exotic species • Vegetation exposure to air emissions • Wildlife injury and mortality • Wildlife disturbance and displacement • Direct loss and conversion of habitat • Changes in habitat condition/quality • Changes in the biological availability of canal habitats • Wildlife exposure to solid and liquid waste • Increased hunting, fishing, or harvesting pressure from increased human access and presence of workers
Operations	• Operation and maintenance of the NGL Plant and onshore pipeline • Air emissions from the NGL Plant	• Vegetation management (maintenance in herbaceous state) • Vegetation exposure to air emissions • Wildlife mortality from vehicular traffic

Stage	Project Activity	Key Potential Impacts
	• Maintenance of the onshore pipeline RoW • Discharge of wastewater treatment plant effluent and stormwater discharges from the NGL Plant	• Wildlife exposure to NGL Plant wastewater effluent and stormwater discharges • Ongoing displacement from habitat loss, increased human activity, sound, light, etc.
Decommissioning	• Decommissioning of Project facilities	• Changes in vegetation from managed condition to natural • Similar, though fewer and less significant, impacts on wildlife as in Construction stage
Freshwater Special Status Species		
Construction	• Installation of the onshore pipeline • Construction of the NGL Plant, heavy haul road, and temporary MOF • Discharges of sanitary effluent and hydrostatic test water • Dredging of the approach channel to the temporary MOF • Clearing of riparian vegetation	• Erosion and sedimentation from riparian disturbance • Changes in aquatic habitat quality from clearing of riparian vegetation • Changes in the biological availability of canal habitats • Mortality and injury of benthic organisms in the Demerara River • Disturbance of fish and other aquatic organisms due to increased underwater noise in the Demerara River • Shading of the water column under the temporary MOF structure • Increased turbidity associated with dredging • Decreased water quality from sanitary effluent discharge • Decreased water quality from hydrostatic test water discharge
Operations	• Discharges of process wastewater and sanitary wastewater effluent from NGL Plant • Maintenance of the onshore pipeline RoW	• Disturbance of aquatic biota from operation of the temporary MOF • Changes in distribution and composition of estuarine biodiversity due to operational effluent discharges
Decommissioning	• Removal of in-water Project facilities	• Changes in aquatic habitat condition/quality

8.6.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. For special status species, resource-specific definitions for intensity are used in lieu of the general intensity definitions (Table 8.6-7). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for sensitivity for special status species are provided in Table 8.6-8.

Table 8.6-7: Definitions for Intensity Ratings for Potential Impacts on Special Status Species

Criterion	Definition
Intensity	**Negligible**: No measurable population-level changes; the ecosystem and populations continue to function as they did prior to the Project activities occurring.
	Low: Changes are perceptible but affect only a small number of species within the ecosystem, and only at one trophic level, and/or across a limited spatial area.
	Medium: Changes are perceptible and affect many species within the ecosystem, at more than one trophic level, and/or across a significant portion of the area that an ecosystem physically occupies.
	High: Changes affect numerous species throughout the food web, such that the basic trophic and biodiversity characteristics of the ecosystem are substantially altered.

Table 8.6-8: Definitions for Resource Sensitivity Ratings for Potential Impacts on Special Status Species

Criterion	Definition
Sensitivity	**Low**: Species and sub-species listed as LC on the IUCN Red List (or not meeting criteria for higher IUCN listing status), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as VU or NT on the IUCN Red List; species protected under national legislation; species with a nationally restricted range; regionally important numbers of migratory or congregatory species; species not meeting rating criteria as EN or CR.
	High: Species on the IUCN Red List categorized as CR or EN; species having a locally restricted range, low number of sites where they occur, or highly fragmented population (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 km^2); internationally important numbers of migratory or congregatory species; species exhibiting or undergoing key evolutionary processes.

8.6.3.3. Impact Magnitude Ratings—Marine and Coastal Special Status Species

There are 103 special status species that occur in the marine and coastal environment within the Direct and Indirect AOI. These include 85 fish, 5 turtle, 5 mammal, and 8 bird species. Several of the bird species also occur in the freshwater/riverine environment. The following potential impacts could affect these marine and coastal species during the Construction, Operation, and/or Decommissioning stages of the Project:

- Loss and disturbance of marine benthic habitat from offshore pipeline installation;
- Temporary impacts from degraded water quality from seafloor disturbance during offshore pipeline installation activities;
- Temporary impacts from degraded water quality from vessel discharges during offshore pipeline installation and decommissioning;
- Entrainment of marine organisms in ballast water and hydrostatic test water intakes; and
- Disturbance of fish and other marine organisms due to increased noise.

These impacts on non-special status marine and coastal species are discussed in Section 8.2, Marine and Coastal Biodiversity [Impacts from Planned Events]. The impact mechanisms are the same for non-special status and special status species, so the impacts are not discussed further here. However, the sensitivity of special status species to impacts differs from that of non-special status species because of the elevated conservation status (rarity) of the special status species, as described in Table 8.6-10.

Marine turtles are not discussed in Section 8.2, Marine and Coastal Biodiversity because all of the marine turtles that could occur in the Direct and Indirect AOI are special status species. As such, potential impacts on marine turtles are described below.

Marine Turtles

The marine turtles that are found in Guyana's waters are not benthic organisms and marine turtles are not known to be sensitive to auditory impacts, so disturbance of the seafloor and vessel noise are not expected to impact these species. The only impacts from planned Project activities that would have the potential to affect marine turtles will be intake of hydrostatic test water and activities that affect water quality (i.e., routine discharges from vessels, turbidity from offshore pipeline installation activities, and discharge of hydrostatic test water). Intake of hydrostatic test water will have the potential to entrain very young sea turtles if they were entrained in the flow field around the intake structure. The hydrostatic test intake will be a one-time event, so the chances of entraining even a single sea turtle in the intake are low. If a small number of sea turtles were entrained, the event would be lethal for those individuals, but would be unlikely to affect the turtles significantly at a species level. The intensity of impacts from entrainment hydrostatic test intakes is therefore rated **Low**. The impact will be **Continuous** while the intake is occurring, but the intake will last less than a week, so it will be **Short-term.** This combination of factors produces a magnitude of **Small.**

Marine turtles are not known to be particularly sensitive to water quality, but they can experience a range of physiological impacts if they are exposed to significantly impacted water quality from vessel discharges or hydrostatic test water discharges for an extended period of time. Marine turtles use eyesight to find food, so the most significant element of degraded water quality in terms of potential impacts on turtles will be elevated turbidity. Green (*Chelonia mydas*), leatherbacks (*Dermochelys coriacea*), and hawksbill turtles (*Eretmochelys imbricata*) are not expected to be particularly susceptible to turbidity from Project activities because these species all leave Guyana waters rapidly after nesting and forage mainly in other regions, but loggerhead (*Caretta caretta*) and olive ridleys (*Lepidochelys olivacea*) may forage in Guyana's waters. Although the potential exists for installation activities to temporarily reduce foraging opportunities for these species within a small area around a working installation vessel, turtles will be expected to move a short distance away to clearer water. The intensity of impacts from degraded water quality (from any Project activity) is therefore rated **Low**. Impacts from discharges to the marine environment would be **Continuous** while the discharges are occurring. Activities that could degrade water quality during Construction would last for longer than a year in aggregate, but no turtles would be expected to be exposed to degraded water quality for more than a day or two as they pass through the Project AOI, so the duration will likely be **Short-term.** This combination of factors produces a magnitude of **Small.**

8.6.3.4. Impact Magnitude Ratings—Terrestrial Special Status Species

There are 13 special status species that occur in the terrestrial environment within the Direct and Indirect AOI. These include three plant, five bird, four mammal, and one turtle species. The following impacts could potentially affect these species during the Construction, Operations, and Decommissioning stages of the Project:

- Impacts from habitat loss and degradation
- Disturbance and displacement

Plants

The three special status plant species are all trees that occur in forested habitats. These species were not detected during vegetation surveys of the Direct AOI that were conducted in support of the EIA, but all are known to occur in forested habitats of the Coastal Plain and therefore could occur in the Indirect AOI. Because they are not located in the footprint of the Project, none of these species is expected to be impacted during any stage of the Project.

Although not specifically considered special status species, there are two other tree species of importance that occur in the onshore Direct AOI: red mangrove (*Rhizophora mangle*) and black mangrove (*Avicennia germinans*). Red and black mangrove trees are protected from disturbance or removal by Guyanese law, and they are cornerstone species of the coastal and riverine ecosystem, providing flood control, shoreline protection, wildlife habitat, and many other ecological and human benefits. Vegetation surveys of the onshore Direct AOI documented three mangrove trees (two red mangrove trees and one black mangrove tree) along the Demerara River shoreline at the location of the temporary MOF. These three trees will be removed during construction in association with installation of the temporary MOF. Because of the small number of impacted trees, the intensity of impacts from the Project on mangrove trees is considered to be **Negligible**. The impact will occur once, yielding a frequency rating of **Episodic**. Impacts will be **Long-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on mangrove trees is rated as **Negligible**.

Birds

The five terrestrial special status bird species that occur in the Direct and Indirect AOI are primarily associated with forested and savannah habitats. These species are not expected to nest within the Direct AOI due to lack of preferred nesting habitat, low habitat quality, and the level of anthropogenic disturbance in the area. However, these species use habitats within the Direct and Indirect AOI for foraging, resting, and other transient use. Birds are highly mobile and move in response to disturbance. As discussed in Section 8.3.3, Impact Prediction and Assessment [Terrestrial Biodiversity], potential impacts on birds from Project activities during all stages of the Project are expected to be of **Negligible** to **Minor** significance. The same impact mechanisms for non-special status birds apply to special status birds, so the impacts are not discussed in detail here.

Because of the limited use of the Direct AOI by terrestrial special status bird species, the small amount of direct habitat loss that will occur as a result of the Project (only a small portion of which is suitable for terrestrial special status bird species), and the birds' ability to move in response to disturbance, the intensity of impacts from the Project on terrestrial special status bird species is considered to be **Low**. The impact of habitat loss on birds will be ongoing throughout the Construction stage, yielding a **Continuous** frequency rating. Impacts will primarily be experienced during the Construction stage but will continue to be present, although at lower levels, through the life of the Project. As such, the duration of impacts is considered to be **Long-term.** Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on wildlife is rated as **Small**.

Mammals

There are four terrestrial special status mammal species that could occur as transients in the Direct and Indirect AOI. None of these species was detected during wildlife surveys of the Direct AOI that were conducted in support of this EIA, but the species are known to occur in relatively undisturbed portions of the Coastal Plain and could occur as transients in the Project AOI. Because the species are not expected to occur in the footprint of the Project due to lack of suitable habitat, the species or their habitats are not expected to be impacted during any stage of the Project.

Terrestrial Turtles

There is one terrestrial turtle special status species that could occur in forested habitats, particularly riparian forests, within the Project AOI. This species was not detected during wildlife surveys of the Direct AOI that were conducted in support of this EIA, but the species is known to occur in the Coastal Plain and could occur in the Indirect AOI. Because the species is not expected to occur in the footprint of the Project due to lack of suitable habitat, the species is not expected to be impacted during any stage of the Project.

8.6.3.5. Impact Magnitude Ratings—Freshwater Special Status Species

There are four special status species that occur in the freshwater/riverine environment within the Project AOI: American manatee (*Trichechus manatus*), neotropical otter (*Lontra longicaudis*), giant otter (*Pteronura brasiliensis*), and cuffum (also referred to as tarpon) (*Megalops atlanticus*). All of these are species that occur in the lower Demerara River and inland canal systems of the Project AOI.

The following impacts could occur to these freshwater during the Construction, Operations, and Decommissioning stages of the Project:

- Changes in erosion and sedimentation rates as a result of riparian habitat disturbance;
- Changes in aquatic habitat quality due to removal and disturbance of riparian vegetation;
- Alteration of local hydrological conditions;
- Impacts on riverine biodiversity due to installation of the temporary MOF and dredging of the access channel;

- Changes in distribution and composition of estuarine biodiversity due to construction-related discharges;
- Impacts on riverine biodiversity due to operation of the temporary MOF; and
- Changes in distribution and composition of estuarine biodiversity due to operation-related wastewater discharges (including sanitary and process discharges).

Potential impacts on the four freshwater special status species are not discussed in Section 8.4, Freshwater Biodiversity. As such, they are described below.

American Manatee

American manatees occur in the lower Demerara River. They do not occur in the canals in the Project AOI, so they would not be affected by construction of the onshore pipeline, but they could be affected by construction and operation of the temporary MOF and access channel and planned discharges to the Demerara River either directly or via a canal adjacent to the NGL Plant. Data from EEPGL's riverine mammal surveys suggest that manatees in the lower Demerara River tend to frequent the nearshore areas outside the main navigation channel, particularly near the seawall at the mouth of the river on the east shore. This location is several kilometers away from the planned location of the temporary MOF and access channel, so at a population level the impacts of construction and operation of the temporary MOF and access channel on manatees are expected to be insignificant. Nevertheless, the riverine mammal surveys indicate that occasionally manatees occur on the west bank of the Demerara River, so the potential exists for Project activities to disturb the occasional manatee either foraging or transiting along the western shoreline of the river. The intensity of such impacts is rated **Low**. The effect would be **Continuous** while the disturbance was occurring, and the duration would be **Short-term.** This combination of factors produces a magnitude of **Small.**

American manatees are not known to be particularly sensitive to water quality, but they could experience physiological impacts if they were exposed to significantly impacted water quality from sanitary or process water discharges via the stormwater management pond at the NGL Plant, or hydrostatic test water discharges for an extended period of time. The routine sanitary and process wastewater discharges will be treated to applicable World Bank standards (World Bank 2007a, 2007b) before being discharged to the Demerara River, so the intensity of impacts associated with routine discharges on American manatees is rated **Low**. Discharges from the stormwater management pond will occur intermittently, so the frequency of the impact is considered **Episodic**. The discharge will continue for the operational life of the Project, so the impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on riverine biodiversity is rated as **Small**.

The hydrostatic test water discharge will have similar effects as the discharge from the stormwater pond, but depending on the type of hydrostatic test chemicals used, the mixing zone associated with the hydrostatic test discharge could be substantially larger than the mixing zone associated with the discharges from the NGL Plant via the stormwater pond. The intensity of impacts associated with the hydrostatic test water discharge is therefore rated as **Medium**. The impact would occur once over a 24-hour period, so the duration is considered **Short-term**, and the event would be **Continuous**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on American manatees is rated as **Small.**

Neotropical Otter

Neotropical otters occur in the lower Demerara River and its adjacent coastal area as well as inland canals within the onshore portion of the Project AOI, so could be impacted by habitat degradation and disturbance. Neotropical otters are highly mobile and have large home ranges. They move between the Demerara River and the inland canals through interconnecting canals and kokers and also over land, particularly through riparian habitats. Individual neotropical otters were infrequently observed in several of the canals within the Direct AOI, but no den sites were observed during baseline surveys conducted in support of the EIA.

While the neotropical otter is an adaptable species capable of making use of all types of habitat with varying degrees of disturbance, the species prefers undegraded forest and riparian habitats with low levels of disturbance and modification (Alarcon et al. 2003). Despite this preference, the species shows some tolerance to anthropogenic disturbance and habitat degradation, as the species has been found in mildly to moderately degraded habitats, including watercourses with moderate levels of water quality degradation (de Almeida and Pereira 2017). Habitat fragmentation resulting from anthropogenic activities reduces the size of or access to viable habitat areas, and is a primary contributor to the loss of genetic diversity for neotropical otters (Trigila et al. 2016). The neotropical otter digs burrows in soft soils along watercourses (Krug et al. 2019). Because of these habitat requirements, the neotropical otter is vulnerable to habitat disturbance and displacement.

Onshore pipeline construction and related heavy equipment use associated with the Project may cause direct injury or mortality of individual otters if they are unable to avoid interactions with construction equipment. This type of direct impact is unlikely since neotropical otters are highly mobile and should be able to move to other undisturbed habitats and remain unharmed during construction activities. The more probable impact on this species is related to habitat disturbance and displacement during onshore pipeline construction, as riparian vegetation will be impacted and soils along the canal banks may be compacted during the Construction stage of the Project. Otters require intact riparian vegetation as a key habitat component that is critical for individual survival and rearing young, and soil compaction along the canal banks can prevent otters from digging burrows. Additionally, neotropical otter prey primarily consists of fish, with some studies indicating that their diet is comprised of up to 94 percent fish. Disturbance during pipeline construction may result in otter displacement from canal habitats in the vicinity of construction activities, resulting in temporary loss of foraging and burrow habitat (Lavariega et al. 2020). Provided that canal habitats used by otters remain intact following construction and habitat conditions are maintained at pre-construction levels, otters would be expected to return to previously used habitats following disturbance.

As such, the intensity of this impact on neotropical otter is rated as **Small**. The filling of the canals will occur prior to Project construction and occur over a several-month period, so the frequency of this impact is rated as **Continuous**. It will take several years for habitat conditions and biological communities within canal habitats disturbed during construction to recover such that they resemble pre-construction conditions, so the duration of the impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on neotropical otter is rated as **Small**.

Giant Otter

Similar to neotropical otters, giant otters also occur in the inland canal habitats of the Direct and Indirect AOI, and so could be impacted by habitat degradation and disturbance, particularly related to onshore pipeline construction that occurs in the vicinity of canals used by the species. Individual giant otters were infrequently observed in two canals within the Direct and Indirect AOI, and one giant otter den site was documented during baseline surveys conducted in support of this EIA (Figure 8.3-12). Most of the observations of individuals and the den were located in the onshore pipeline corridor just north of Parfaite Harmonie (Figure 8.3-12). The portion of the onshore pipeline corridor that overlaps with the giant otter sightings and den site will be installed using HDD techniques, so direct impacts on this section of the canal should be avoided or minimal.

The giant otter is vulnerable to habitat disturbance and displacement and are generally more reclusive and sensitive to disturbance than neotropical otters. A study by de Oliveira et al. (2015) determined that the level of anthropogenic disturbance is a primary determinant for the presence of giant otter populations and this factor is more important than other habitat factors such as food abundance and availability of river edge habitat. While the geographic range and distribution of giant otters in Guyana is vast, covering the entire interior region of the country, individual occurrence is low and irregular with populations currently estimated between 1,000 and 5,000 individuals (IUCN 2022). Along the Rewa River in Guyana, a population of only 35 individuals was documented along a 95-kilometer stretch of river (Pickles et al. 2011). Individuals are wide-ranging, using interconnected watercourses such as rivers and their tributaries, as well as manmade canals. Fragmentation or isolation of streams and other watercourses decreases the amount of available habitat for use by this species (Michalski and Peres 2005).

The same impact mechanisms described for neotropical otters above apply to giant otters; however, the intensity of impacts on giant otters is higher than the impacts on neotropical otters because of the proximity of Project features with giant otter sightings and, in particular the presence of a den site. The den site appeared to be in use based on the presence of food caches, actively used trails and crossings, and tunnels through the vegetation, but during surveys, no otters were observed in the den. If the giant otter den is active at the time of pipeline installation activities, the otters may abandon the den site, resulting in separation of family groups or mortality of young. Even if the den site is not active, baseline survey results indicate the area is actively used by giant otters, so any individuals present in the area impacted by onshore pipeline installation will be disturbed and likely displaced from the area.

As such, the intensity of this impact on giant otter is rated as **Medium**. The duration of the onshore pipeline construction activities in the area occupied by giant otters is most relevant for assigning impact duration. This impact duration is expected to be **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact on giant otter is rated as **Medium**.

Cuffum (Tarpon)

Based on the biological baseline surveys, the only freshwater portion of the Direct AOI that supports cuffum is the northern portion of the onshore pipeline RoW in the vicinity of Vreed-en-Hoop. Cuffum in this area will potentially be exposed to impacts from erosion and sedimentation from riparian disturbance and changes in aquatic habitat quality from clearing of riparian vegetation during the Construction stage of the Project, and these impacts will continue into the Operations stage as the onshore pipeline route is maintained. None of the onshore Project facilities in the northern portion of the onshore pipeline RoW will be removed during the Decommissioning stage, but some minor disturbance of riparian vegetation may be required to facilitate inspection and closure of the onshore pipeline RoW during Decommissioning. As discussed in Section 8.4, Freshwater Biodiversity, the intensity of impacts on habitat quality for aquatic species (including special status species) from clearing riparian vegetation along the portions of the onshore pipeline RoW proximal to canals during the Construction stage will range from **Negligible** to **Medium**, depending on the initial condition of the canal segment near the RoW. The frequency of this impact is considered **Episodic** and the duration of this impact is considered **Long-term**. This combination produces a magnitude rating of **Negligible** to **Small**.

8.6.3.6. Sensitivity of Resource—Special Status Species

Based on the sensitivity rating definitions in Table 8.6-8, the resource sensitivity for special status species ranges from **Medium** to **High**. These ratings are principally based on IUCN Red List Status, species distribution, and/or regulatory status. Table 8.6-10 presents the sensitivity ratings assigned to each of the special status species taxa groups.

8.6.3.7. Pre-mitigation Impact Significance—Special Status Species

Assuming implementation of the embedded controls listed in Table 8.6-9, the magnitude ratings for potential Project impacts on special status species range from **Negligible** to **Medium**. Coupled with sensitivity ratings of **Medium** and **High**, the pre-mitigation impact significance for special status species ranges from **Negligible** to **Major**.

8.6.4. Impact Management and Monitoring Measures

Based on the **Negligible** to **Minor** pre-mitigation significance of many of the potential special status species impacts, no mitigation measures are proposed for these potential impacts. It is noted, however, that the limited significance of these potential impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitments Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

The following mitigation measures are proposed to address potential **Moderate** or **Major** impacts on special status species:

- To minimize impacts on American manatee in the case of a possible discharge of hydrotest water to the Demerara River (either directly or via a canal adjacent to the NGL Plant), the Consultants recommend using low toxicity hydrostatic testing chemicals and discharging the hydrostatic test water during higher-flow conditions in the river.
- To minimize impacts on neotropical and giant otters, the Consultants recommend having a local expert conduct pre-construction surveys in the canals where otters are known to occur to determine whether otters are present and to determine if the giant otter den site identified during baseline surveys conducted in support of this EIA is active. If otters are found, consultation with local and international experts (e.g., IUCN Otter Specialist Group) and implementation of appropriate measures to minimize impacts on otters should occur.
- To mitigate for the loss of the three mangrove trees as a result of the Project, EEPGL should replace mangrove trees in cooperation with NAREI in accordance with Guyanese law.

Table 8.6-9 summarizes the management and monitoring measures relevant to special status species.

Table 8.6-9: List of Management and Monitoring Measures

Embedded Controls
Monitor and manage suction dredging or jet plowing and burial rates to improve efficiency and reduce turbidity.
To the extent practicable, avoid suction/jetting any deeper than what is required for protection of the pipeline.
Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances. Use low-hazard substances. Consider the OCNS (CEFAS 2019) as a resource for chemical selection. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of material safety data sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Using the minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flow lines/risers commissioning fluids, including hydrotesting waters).
Regularly maintain marine and onshore construction and operations equipment, power generators, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO and MARPOL 73/78 requirements.
Inspect and maintain onboard equipment (engines, compressors, generators, STP, and oil-water separators) in accordance with manufacturers' guidelines in order to maximize efficiency and minimize malfunctions and unnecessary discharges into the environment.

Use OCNS Gold Standard hydrostatic test chemicals to test the pipeline.
Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Implement soil erosion, stormwater runoff, and sedimentation control measures during soil disturbance (e.g., use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from construction areas, use of sediment basins, and check dams to control water runoff).
Conduct paced, sequential clearing to allow mobile wildlife to move away from work zones.
Restore and revegetate the onshore pipeline corridor following construction.
Monitor and manage excess overflow from hopper overflow on dredging facility to improve efficiency and reduce turbidity in dredging supernatant.
Dewater any trenches by first installing temporary drainage and use methods to prevent excessive transport of sediments into existing canals.
Manage stormwater to minimize potential erosion and excessive sediment transport into canals adjacent to the onshore pipeline corridor.
Keep uncovered stockpiles moist.
Use appropriate control measures to minimize dust arising from construction works.
Minimize dust-emitting activities such as cutting, grinding, and sawing by employing alternative methods or technologies, such as the use of pre-fabricated material wherever possible.
Review construction plan and confirm availability of water for dust suppression on site for dust suppression.
Apply water to unpaved haul roads to minimize dust generation.
Train workers to employ material handling methods that will minimize dust emissions. These include minimizing drop heights to control the fall of materials and minimizing exposure of stockpiles to wind by removal of earth from small areas of secure covers when needed.
Require construction equipment and other workforce vehicle drivers to adhere to Project-established speed limits within the construction worksites.
Provide domestic WWTP that complies with World Bank Indicative Values for Treated Sanitary Sewage Discharges (World Bank 2007a) and Effluents Levels for Natural Gas Processing Facilities (World Bank 2007b).
Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and NGL Plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Implement inspection, maintenance, and surveillance programs to identify and prevent unplanned emissions to atmosphere from the NGL Plant.
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD boring).
Design equipment at NGL Plant so that in-plant sound levels in accessible areas do not exceed 85 dBA under normal operations or 115 dBA for emergency events and so that community and/or fenceline noise levels do not exceed applicable regulations.
Conduct routine inspections to confirm the sanitary WWTP is working according to design specifications and monitor effluent quality regularly.
Conduct routine inspections to confirm the process WWTP is working according to design specifications and monitor effluent quality regularly.

During open trenching and HDD operations along the onshore pipeline corridor, conduct noise monitoring during the initial stages of construction and again during later stages of construction (as warranted based on changes in the nature of construction activities, weather conditions, or other factors) in order to quantify the actual extent of Project noise impacts.
Mitigation Measures
Conduct pre-construction surveys in the canals where Neotropical and giant otters are known to occur to determine whether otters are present and to determine if the giant otter den site identified during baseline surveys conducted in support of this EIA is active. If otters are found, consult with local and international experts (e.g., IUCN Otter Specialist Group) and implement appropriate measures to minimize impacts on otters.
Replace impacted mangrove trees in cooperation with NAREI in accordance with Guyanese law.
Use OCNS Gold Standard hydrostatic test chemicals to test the pipeline.
Discharge hydrostatic test water to the Demerara River only under high flow conditions, to the extent practicable.
Use smallest practicable diameter pipes for the piles for the temporary MOF.
Use noise attenuating methods when driving piles in the Demerara River as appropriate, especially if large-diameter steel pipes are used as piles.
Monitoring Measures
Perform daily inspections to verify no visible sheen from discharges from pipeline installation and support vessels.
Monitor chlorine concentration of treated sewage discharges from pipeline installation and support vessels.
Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters from pipeline installation and support vessels.
Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book on pipeline installation and support vessels.
Perform oil in water content (automatic) monitoring of bilge water to comply with 15 ppm MARPOL 73/78 limit and record in Oil Record Book on pipeline installation and support vessels.
Record estimated volume of ballast water discharged and location (per ballasting operation) on pipeline installation and support vessels.
Monitor visual detections of marine mammals from onboard pipeline installation and support vessels.
Monitor otter use of the canals in the Project AOI where otters are known to occur based on baseline surveys to document presence and activity of otter during and post-construction (through 1-year post-construction).
Monitor birds and mammals at baseline survey sites for 1 year after the onshore pipeline is installed and every 3 years once the Project becomes fully operational throughout the Operations stage of the Project.
Monitor aquatic macroinvertebrates, fish, and water quality at baseline survey sites for 1 year after the pipeline is installed and every 3 years once the Project becomes fully operational throughout the Operations stage of the Project.
Conduct a single round of post-decommissioning monitoring of terrestrial vegetation, birds, mammals, insects, aquatic macroinvertebrates, fish, and water quality.
Conduct post-restoration vegetative cover monitoring along the onshore pipeline corridor.

dBA = A-weighted decibel; IMO = International Maritime Organization; MARPOL 73/78 = International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978; ppm = parts per million; STP = sewage treatment plant

8.6.5. Assessment of Residual Impacts

Considering the management measures above, the residual impact significance ratings range from **Negligible** to **Moderate**.

Table 8.6-10 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts *on* special status species.

Table 8.6-10: Summary of Potential Pre-Mitigation and Residual Impacts—Special Status Species

Resource/ Receptor	IUCN Designation	Sensitivity Rating	Magnitude	Range of Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Range of Residual Significance Rating
Marine and Coastal Special Status Species						
Marine Fish	CR, EN	High	Negligible to Small (C)	Negligible to Moderate	None	Negligible to Moderate
	VU, NT	Medium	Negligible to Small (C)	Negligible to Minor	None	Negligible to Minor
Marine Mammals	EN	High	Negligible to Small (C)	Negligible to Moderate	None	Negligible to Moderate
	VU, NT	Medium	Negligible to Small (C)	Negligible to Minor	None	Negligible to Minor
Marine Turtles	CR, EN	High	Small (C)	Moderate	None	Moderate
	VU, NT	Medium	Small (C)	Minor	None	Minor
Marine Birds	EN	High	Negligible (C)	Negligible	None	Negligible
	VU, NT	Medium	Negligible (C)	Negligible	None	Negligible
Terrestrial Special Status Species						
Mangroves	NA	Medium	Negligible (C)	Negligible	Replacement of lost trees	Negligible
Terrestrial Birds	VU, NT	Medium	Small (C,O,D)	Minor	None	Minor
Freshwater Special Status Species						
Cuffum (tarpon) (*Megalops atlanticus*)	VU	Medium	Negligible to Small (C,O,D)	Negligible to Minor	None	Negligible to Minor
American manatee (*Trichechus manatus*)	VU	Medium	Small (C,O)	Minor	Use low toxicity hydrostatic testing chemicals Conduct hydrostatic testing during higher-flow conditions	Negligible to Minor
Neotropical otter (*Lontra longicaudis*)	NT	Medium	Small (C)	Minor	Conduct pre-construction surveys and consult with local and international	Negligible

Resource/ Receptor	IUCN Designation	Sensitivity Rating	Magnitude	Range of Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Range of Residual Significance Rating
					experts (e.g., IUCN Otter Specialist Group) and implement appropriate measures to minimize impacts on neotropical otter.	
Giant otter (*Pteronura brasiliensis*)	EN	High	Medium (C)	Major	Conduct pre-construction surveys and consult with local and international experts (e.g., IUCN Otter Specialist Group) and implement appropriate measures to minimize impacts on giant otter.	Minor

9. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—SOCIOECONOMIC RESOURCES

For the purposes of this EIA, "socioeconomic environment" is intended to encompass the human aspects of the potentially affected environment, with specific emphasis on the social and economic characteristics of the elements of society that could be affected by the Project. This chapter focuses on socioeconomic resources, including socioeconomic conditions (Section 9.1), community health and wellbeing (Section 9.2), social infrastructure and services (Section 9.3), transportation (Section 9.4), cultural heritage (Section 9.5), land use and ownership (Section 9.6), landscape, visual resources, and light (Section 9.7), ecosystem services (Section 9.8), and Indigenous Peoples (Section 9.9). Each of these sections includes a description of methodology, a review of existing conditions, an assessment of potential impacts from planned Project activities, and identification of proposed mitigation measures.

9.1. Socioeconomic Conditions

This section presents an overview of existing socioeconomic conditions in the vicinity of the Project, evaluates the potential socioeconomic impacts of the Project on local people and communities, and presents management and monitoring measures that will be applied to minimize potential adverse impacts and enhance potential benefits.

This section includes information related to population demographics and distribution, education, economy, employment, and livelihoods, as well as other related topics. Due to the interwoven nature of these topics, the contents of this section—including the baseline study methodology (Section 9.1.1) and the understanding of existing conditions (Section 9.1.2)—may be referenced throughout Chapter 9.

9.1.1. Baseline Methodology

9.1.1.1. Study Areas

Four separate study areas are referenced in the discussion of socioeconomic resources; together, these comprise the combined Onshore Direct Area of Influence (AOI) and Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology. The study areas are referred to throughout Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, and are described below (Figure 9.1-1):

- Direct AOI
  - **Primary Study Area[1]:** This study area includes communities and households located within 500 meters of the onshore pipeline corridor, within 1 kilometer of the natural gas liquids processing plant (NGL Plant) boundary and/or temporary material offloading facility (MOF); within the area extending from the Demerara River immediately north of

[1] The socioeconomic Primary Study Area includes the Direct AOI for biophysical components, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

Free and Easy village, south and west to the NGL Plant and temporary MOF, plus the area encompassing settlements in the Belle West housing scheme.

The communities that were engaged and/or studied in the Primary Study Area include Crane, Nouvelle Flanders, Westminster, Lust-en-Rust, Canal 1, Bordeaux, Canal 2, Alliance, Resource, L'oratoire; Genieve, Free and Easy, Catherina Sophia, Maria's Lodge, Jacob's Lust, Voorburg, Goldberg, and La Harmonie.

  - **Secondary Study Area:** This study area includes communities and households located between the Primary Study Area and the Demerara River.

    The communities that were engaged and/or studied in the Secondary Study Area include Vreed-en-Hoop, Coglan Dam / Pouderoyen, La Grange, Stanleytown, Sisters Village, Patentia, and Vriesland.

- Indirect AOI
  - **Tertiary Study Area**: This study area includes the communities on the East Bank of the Demerara River immediately across from the temporary MOF.

    The communities that were engaged and/or studied in the Tertiary Study Area include Brickery, Garden of Eden, and Land of Canaan.

  - **Regional Study Area:** This study area includes the remainder of Region 3, plus Regions 2 and 4.

    The communities that were engaged and/or studied in the Regional Study Area include Georgetown, Santa Aratak, and Pakuri.

The combined socioeconomic study areas are equivalent to the Onshore Indirect AOI as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

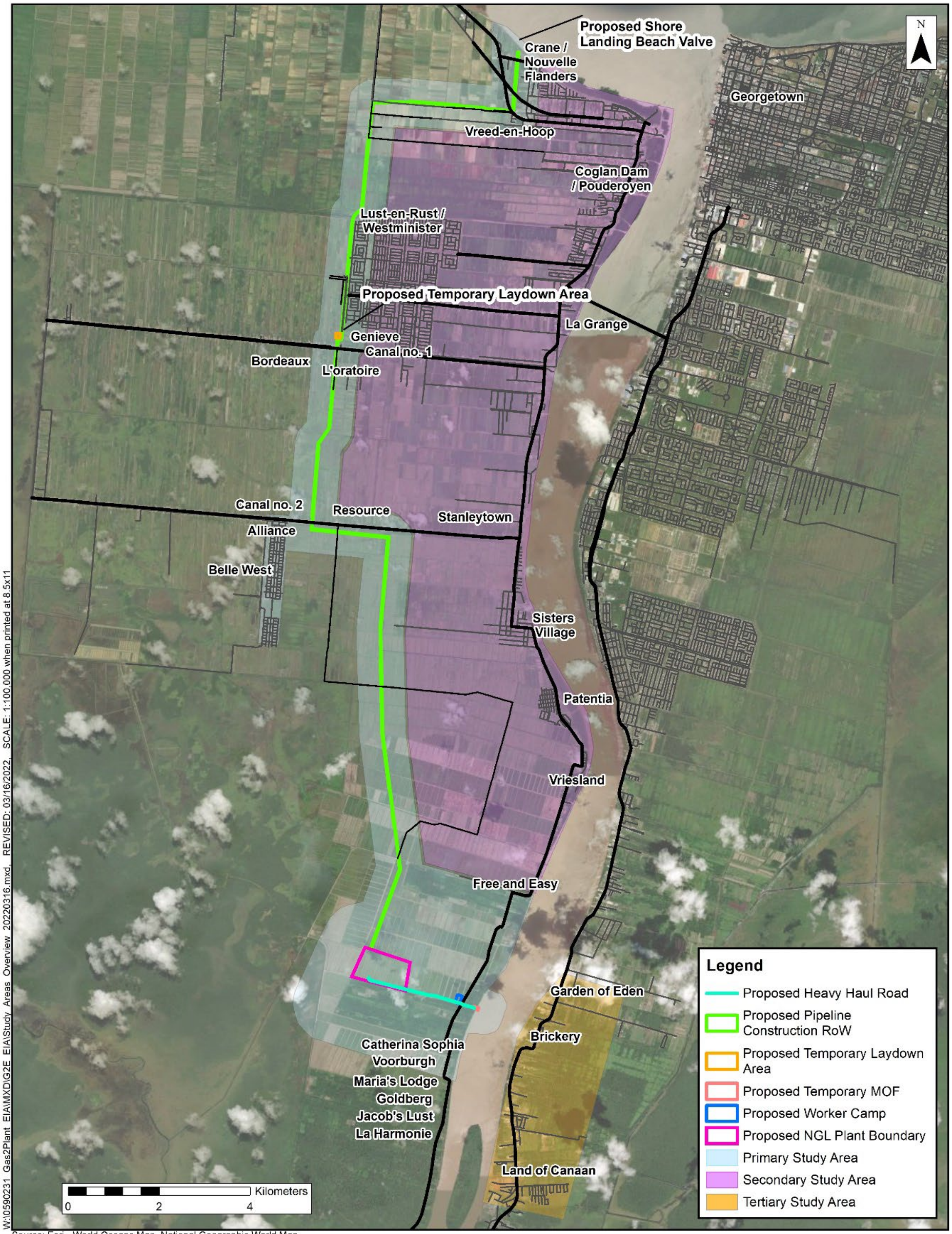


Figure 9.1-1. Socioeconomic Study Areas – Direct (Onshore) Area of Influence

9.1.1.2. Data Collection

Within this section, the understanding of existing conditions is described based on a combination of desktop (secondary) and field-based (primary) research. Desktop studies drew on publicly available information as noted throughout the subsections. For socioeconomic conditions, this included the 2012 Guyana national census (latest year it was conducted) and reports by government, non-governmental organizations (NGO), and multilateral institutions.

Field-based research included quantitative socioeconomic surveys (at both the household and business level) conducted in the vicinity of the Project in Region 3 (referred to herein as the 2021 household socioeconomic survey and the 2021 business socioeconomic survey, respectively). The 2021 socioeconomic household and business surveys included questions pertaining to the following categories, as outlined in Appendix 2 of the Terms and Scope for the Project (EPA 2021):

- Population / Demographic Movement
- Economic Environment
- Natural Resource Management and Land Use
- Community Organization and Local Institutions
- Social Services and Infrastructure
- Vulnerable Groups
- Cultural Heritage
- Employment and Labor
- Social Conflict
- Lifestyle and Culture
- Health
- Equity
- Induced Impacts and Associated Facilities
- Cumulative Impacts
- Bio-Physical Aspects
- Alternatives Analysis

Further to the above categories, the 2021 socioeconomic surveys also addressed topics related to ecosystem services and developing an understanding of how people are using the canals along the proposed onshore pipeline route and the mangroves/riparian forest near the proposed temporary MOF; where residents get their potable water and discharge wastewater near the canals; presence of vulnerable populations, including Indigenous Peoples; and tangible and intangible cultural heritage within the Direct AOI.

The Consultants also used the same screening and scoping methodology from the 2017 to 2019 Ecosystem Services Study that was completed along the entire coastline in Guyana to characterize the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment (see Section 9.8, Ecosystem Services, for more details). This information was obtained through the 2021 socioeconomic surveys, as well as through focus groups with the neighbourhood democratic councils (NDCs) in the Primary Study Area (Canal Polder, Toevlugt/Patentia, and Malgre Tout/Meer Zorgen).

The 2021 socioeconomic surveys consisted of two components: (1) quantitative questionnaires that the survey specialist communicated verbally to the survey respondent, for which findings were recorded in a tablet connected to the survey database (Appendix O, Socioeconomic Surveys—Questionnaires); and (2) qualitative assessments made by the survey specialist either through dialogue with stakeholders or visual observation during the study period. The surveys took place with respondents either at home (for household survey data collection) or at work (for business survey data collection). The 2021 socioeconomic survey team recorded data using a tablet equipped with the Survey 123 for ArcGIS application and a tailored electronic data collection form developed for the study.

During the months of November and December 2021, the 2021 socioeconomic survey teams interviewed 440 discrete individuals, 150 local businesses, and 30 members from the aforementioned NDCs. A map depicting the location of the surveys is provided on Figure 9.1-2. The data obtained from the surveys have been used and referenced throughout this section; the summary data tables are included in Appendix P, Socioeconomic Surveys—Summary Data Tables.

9.1.2. Existing Conditions and Baseline Studies (Social)

9.1.2.1. Administrative Divisions in Guyana

Guyana is divided into ten administrative regions, pictured on Figure 9.1-3, which are overseen by regional democratic councils (RDCs). These regions are further subdivided into 70 NDCs and 9 town councils (TCs) that are comprised of villages. Within the regions, there is a mixture of community development councils (CDCs) for some villages and village councils (VCs) in titled Amerindian villages. In titled Amerindian villages, the VCs are empowered by the Amerindian Act (2006) to act as village administrators and are comprised of the village leader (known as Toshao) and elected councilors. Elections are held in villages every 3 years to establish the VCs.

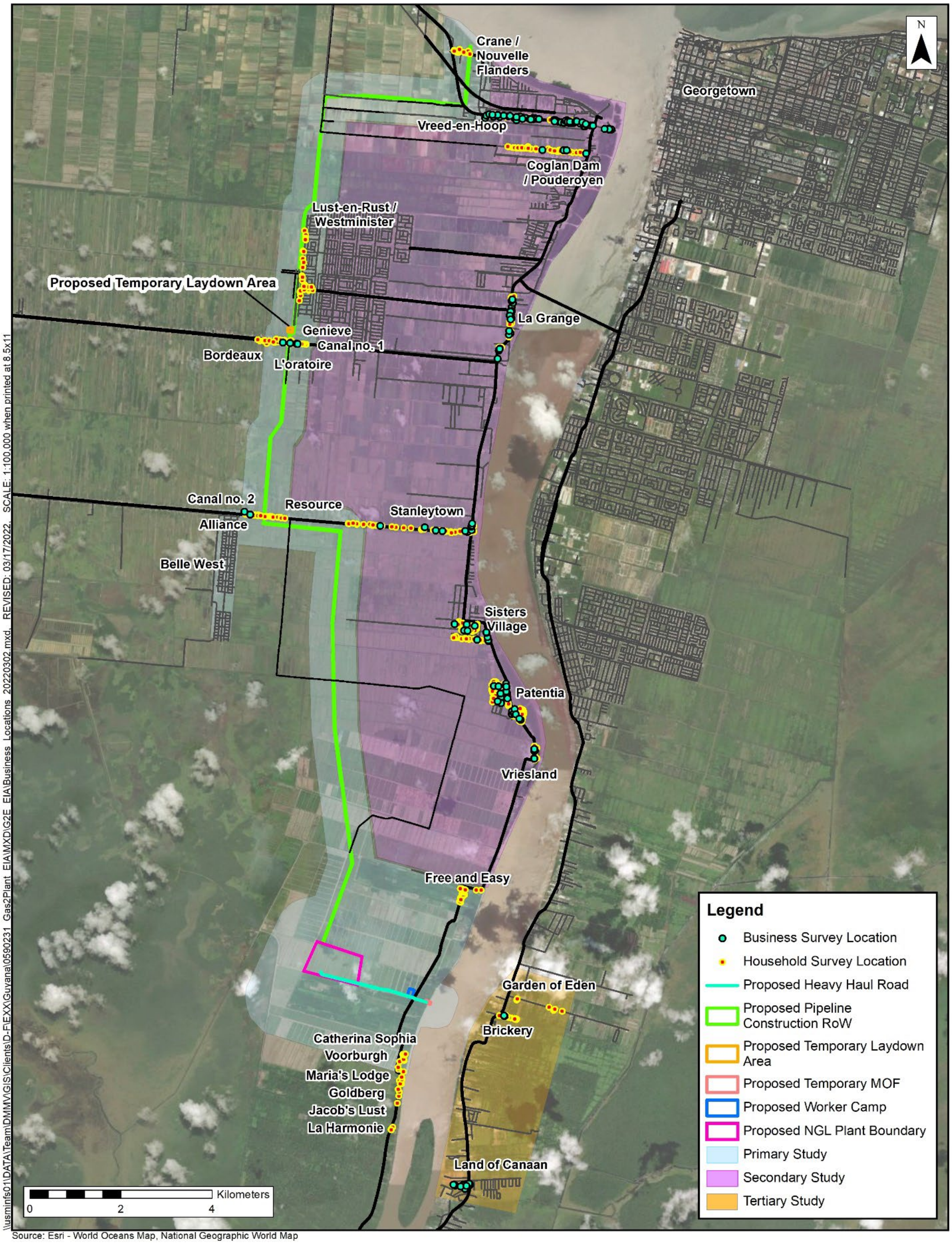


Figure 9.1-2: Socioeconomic Survey Locations

Figure 9.1-3: Guyana's Administrative Regions and Townships

In Guyana, there is one city that serves as the capital (Georgetown) and nine other townships. In 2015, three of these townships were gazetted as new townships by the Ministry of Communities as part of an administrative decentralization effort. Decentralization continued in 2018 when Mahdia (in Region 8) was gazetted as a township. Georgetown, like other townships, is administered by a mayor and City Council. Georgetown and the nine townships serve as an administrative hub for government services, such as passports and driver's licenses. They also provide utilities and public services, such as water and sanitation and banking. Of the ten administrative regions, this EIA is focused on Regions 2, 3, and 4. Together, the three regions account for 34 NDCs (Ministry of Local Government and Regional Development Councils 2022a) and one City Council in Georgetown (Ministry of Local Government and Regional Development 2022b).

Region 2

- Charity/Urasara
- Evergreen/Paradise
- Aberdeen/Zorg-en-Vlygt
- Anna Regina Town Council
- Annandale/Riverstown
- Good Hope/Pomona

Region 3

- Wakenaam (island)
- Leguan
- Mora/Parika
- Seafield/Tempie

Region 4[2]

- Georgetown
- Industry/Plaisance
- Better Hope/La Bonne Intention
- Beterverwagting/Triumph
- Mon Repos/La Reconnaissance
- Buxton/Foulis
- Unity/Vereeniging
- Haslington/Grove
- Enmore/Hope
- Haslington/Golden Grove
- Cane Grove

9.1.2.2. Population Profile

Table 9.1-1 summarizes the distribution of population within the 10 regions in 2012—the last year for which complete national census data are available. According to the Bureau of Statistics, Guyana's next national census will commence in 2022 to avoid conflicting with Guyana's General and Regional Elections.

Table 9.1-1: Regional Population Distribution in Guyana

Region		Population 2002	Population 2012	Percentage Population Change (2002–2012)	Percent of Guyana's Total Population
1	Barima-Waini	24,275	27,643	+13.9%	3.7%
2	Pomeroon–Supenaam	49,253	46,810	-5.0%	6.3%
3	Essequibo Islands—West Demerara	103,061	107,785	+4.6%	14.4%
4	Demerara-Mahaica	310,320	311,563	+0.4%	41.7%
5	Mahaica—Berbice	52,428	49,820	-5.0%	6.7%

[2] Region 4 list is limited to coastal communities and does not include inland or riverside communities.

Region		Population 2002	Population 2012	Percentage Population Change (2002–2012)	Percent of Guyana's Total Population
6	East Berbice—Corentyne	123,695	109,652	-11.4%	14.7%
7	Cuyuni-Mazaruni	17,597	18,375	+4.4%	2.5%
8	Potaro—Siparuni	10,095	11,077	+9.7%	1.5%
9	Upper Takutu—Upper Essequibo	19,387	24,238	+25.0%	3.2%
10	Upper Demerara—Berbice	41,112	39,992	-2.7%	5.3%
	Guyana	748,084	746,955	-0.6%	100.00%

Sources: BSG 2002, 2012

Note: Each region's change in population should be weighted based on that region's percent of the total population; therefore, the sum of percentage population changes in each region do not add up to the total national percentage population change.

Most of Guyana's population is located in the coastal regions; according to the 2012 national census (BSG 2002; BSG 2012), over 40 percent of the country's population lives in Region 4 (Demerara-Mahaica), which includes the capital city of Georgetown. Region 4 extends from the western bank of the Mahaica River to the eastern bank of the Demerara River. The population is concentrated along the coastland, particularly in Georgetown, the country's capital. Guyana's administrative and commercial activities are consolidated in this region, largely in Georgetown, the country's main port. In addition to administrative and commercial activities, Region 4 has numerous sugar estates that are managed by the Guyana Sugar Corporation. Residents of the region also engage in subsistence farming of coconuts, meat, and dairy (Ministry of Local Government and Regional Development 2022c).

Region 3, the Essequibo Islands-West Demerara Region of Guyana (which is comprised of islands in the Essequibo River and the western portion of mainland Demerara), is characterized by low coastlands, hilly sand and clay, and forested highlands. The primary crop in the area is rice, although sugar cane and coconut are also cultivated to a lesser extent. In addition to agriculture, residents in Region 3 also raise cattle for beef and dairy (Ministry of Local Government and Regional Development 2022d).

Population and other demographic information have not been historically collected and/or are not available at the NDC/CDC/VC/TC level; however, informal data collected from engagement with NDCs and CDCs/TCs by members of the Consultants in late 2017 and early 2018 (ERM/EMC 2018) and in 2019 (ERM/EMC 2020a) provide some estimates of the population ranges for coastal regions in Regions 2, 3, and 4, as described below:

- Region 2: In 2019, each of Region 2's NDCs had several thousand people. Riverstown/Annandale was the NDC with the smallest population at around 1,700, while the largest NDC (Charity/Urasara) had a population of nearly 6,700. The remaining NDCs (Evergreen/Paradise, Aberdeen/Zorg-en-Vlygt, Good Hope/Pomona, and Anna Regina) had populations ranging from 2,000 to 5,500 (Guynode 2019).

- Region 3: As of early 2018, each of Region 3's NDCs had several thousand people. The larger coastal NDCs ranged in population from Mora/Parika at approximately 10,000, to Best/Klien/ Pouderoyen at approximately 20,000, and Tuschen/Uitvlugt and Stewartville/Cornelia Ida at approximately 30,000 each.
- Region 4: As of mid-2019, Georgetown's population was estimated at 132,000. The populations of Industry/Plaisance, Haslington–Golden Grove, Better Hope/La Bonne Intention, and Mon Repos/La Reconnaissance were estimated at 25,000, 27,000, 30,000, and 40,000, respectively. The other NDC populations ranged from 7,000 to 13,000.

In addition to the estimated population ranges for Regions 2, 3, and 4 from the above-referenced 2017–2019 informal data collection, Guyana's most recent census in 2012 lends insight into the gender, age, and ethnicity demographic breakdowns of the regions, as listed in Table 9.1-2 through Table 9.1-4. A predictive data source by the U.S. Census Bureau estimates that by 2022 the population in Region 2 will increase to 41,970 with approximately 21,359 males and 20,611 females; Region 3 will similarly grow to 124,209 and have around 62,544 males and 61,665 females; and Region 4 will increase to 333,088 with approximately 165,115 males and 167,973 females (U.S. Census Bureau 2022).

According to a study conducted in 2020 (Matera et al. 2020), approximately only half of Guyanese people in the world live within Guyana's borders due to steady emigration from the country since the 1970s. An estimated 300,000 people emigrate from Guyana annually, one of the highest emigration rates in the world. Also known as the Guyana diaspora, the emigrating populations mostly go to the United States, Canada, and the United Kingdom, although many other countries including Venezuela, France, South Africa, Suriname, and others also have notable Guyanese populations. The consistent nature of emigration from Guyana has implications for the country's functioning, as many of the departing Guyanese are an educated and skilled community. However, with the anticipation of significant economic and social transformation due to the recent oil and gas activity, the country is hopeful it will attract—and keep—its local populations. Retention of Guyanese people who would otherwise emigrate is expected to have positive implications for population growth and overall development in the country (Matera et al. 2020).

Table 9.1-2: Regional Distribution by Gender in Guyana

Region		Gender	
		Male	Female
2	Pomeroon-Supernaam	23,131 (50.2%)	22,883 (49.8%)
3	Essequibo Islands—West Demerara	52,850 (49.4%)	53,069 (50.6%)
4	Demerara-Mahaica	144,013 (48.6%)	152,396 (51.4%)

Source: Guyana Lands and Surveys Commission 2012a

Table 9.1-3: Regional Distribution by Ethnic Group in Guyana

Region		Ethnicity							
		African/ Black	Amerindian	East Indian	Chinese	Mixed	Portuguese	White	Other
2	Pomeroon-Supernaam	5,671	8,601	20,680	40	10,886	104	31	1
3	Essequibo Islands—West Demerara	22,362	2,765	63,121	189	17,353	81	19	29
4	Demerara-Mahaica	120,087	6,536	104,056	703	63,710	1,074	175	68

Source: Guyana Lands and Surveys Commission 2012b

Table 9.1-4: Regional Distribution by Age in Guyana

Region		Age								
		0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80+
2	Pomeroon-Supernaam	9,105	10,801	6,642	5,609	5,657	4,328	2,267	1,139	466
3	Essequibo Islands—West Demerara	18,340	22,948	16,616	15,697	13,957	10,126	4,972	2,377	886
4	Demerara-Mahaica	52,731	62,557	48,116	43,762	36,531	27,656	15,020	6,990	3,044

Source: Guyana Lands and Surveys Commission 2012c

9.1.2.3. Education

Guyana's Constitution states that school attendance is compulsory up to the age of 15. Primary and secondary education is free. The Ministry of Education controls education budgets, policies, and standards, and administers these by districts. The country is divided into 11 education districts, 10 of which correspond with the administrative regions; Georgetown makes up the eleventh district.

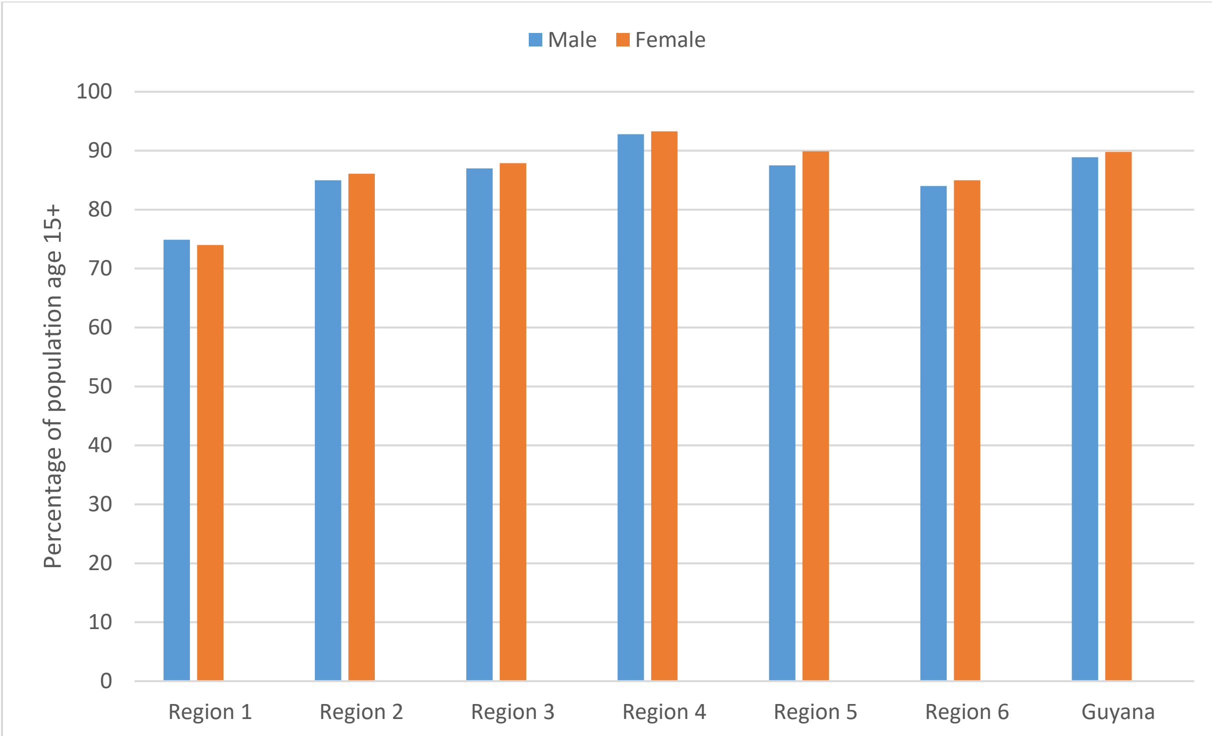
In 2021, $60.7 billion GYD (approximately $304 million USD), or 15.8 percent of the national budget, was allocated to the education sector (Khan 2021). This is consistent with prior years, as an average of 15 percent of the national budget has been allocated to education since 2009 (Ministry of Education 2014).

Approximately 25.6 percent of Guyana's working-age population has attained secondary education, but post-secondary and higher levels of study are less prevalent (BSG 2021). More than half of the population nationally has attained primary education only or has little/no formalized schooling.

Literacy

The adult literacy rate (defined as the percent of population age 15 and above that can read and write) increased by 2.5 percent between the 2002 and 2012 censuses. Region 3 is near the national average, while Region 4 has the highest level of literacy in the country. During that timeframe, the majority of regions showed a minor improvement in literacy rates.

Gender differences in literacy are minimal among the regions, with the female population showing a slightly higher rate of literacy than males across most of the coastal regions and the country as a whole (Figure 9.1-4).

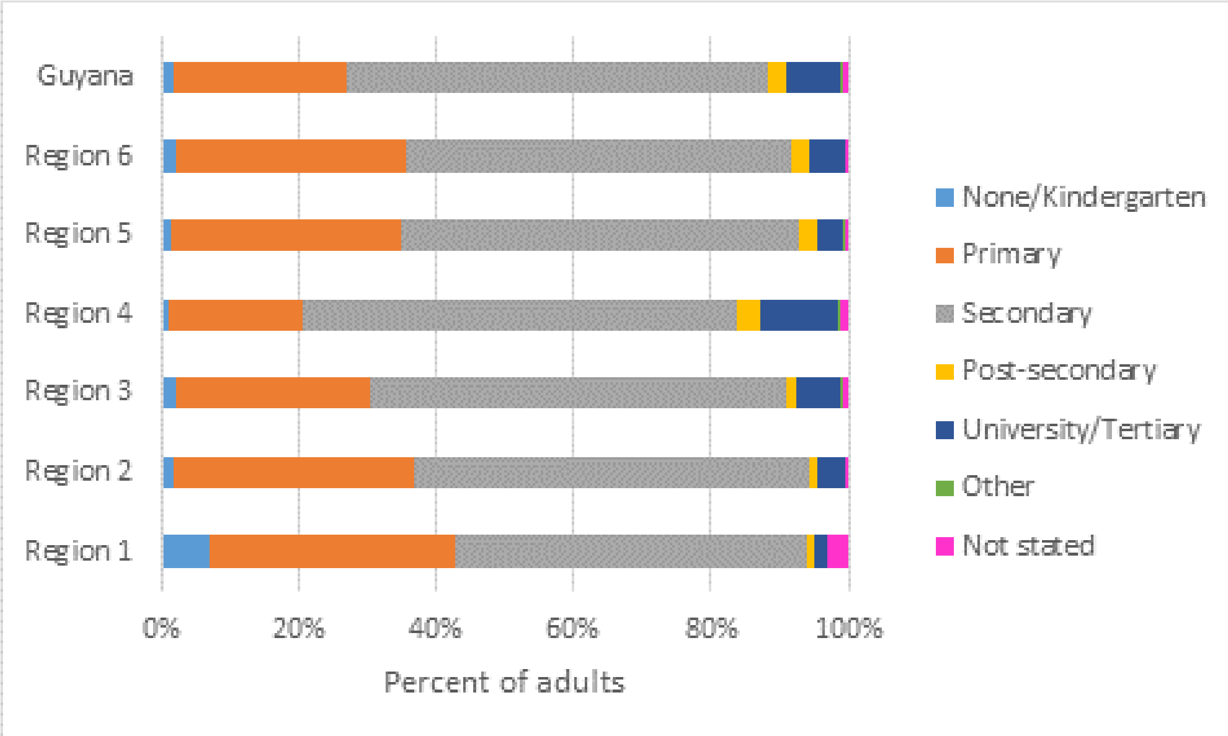


Source: BSG 2012

Figure 9.1-4: Adult Literacy Rate by Gender, 2012

Educational Attainment

Guyana has made progress in achieving universal primary education, but the education system still faces issues regarding access to education at the secondary level and quality issues across all levels of schooling. The percentage of children in Guyana attending secondary school was estimated at 84.5 percent in 2014 (World Bank 2016). Data from the 2012 census indicate that the majority of adults in Guyana at the time had attained the secondary level as their highest level (Figure 9.1-5). Of the coastal regions, educational attainment was highest in Region 4.



Source: BSG 2012

Figure 9.1-5: Highest Educational Attainment Level, 2012

The levels of primary education for the indigenous population are typically lower than for non-indigenous groups of the population. In Amerindian communities, the attendance rate at primary schools has been reported to be 50 percent lower than the average for Guyana (Minority Rights Group International 2008). Further, only 53 of every 100 students in indigenous communities complete secondary school (UNICEF 2017). This is partly attributable to a shortage of infrastructure, utilities, qualified teachers (Ministry of Education 2014), and financial constraints of families (UNICEF 2017). Standardized teaching methods and curricula are not aligned to indigenous culture and values, and this also contributes to lower-than-average attendance rates. While access to education in Amerindian communities continues to be limited, the stated government policy is to provide indigenous children with the same educational opportunities available to the rest of the population (Minority Rights Group International 2008). The Government of Guyana has made several interventions to bridge the gap in education quality between hinterland and indigenous communities and those of the coastland. Among the interventions are the implementation of “smart” classrooms in indigenous schools, internet access for students and teachers, remote and distance training of teachers, and the piloting of teaching in indigenous languages (Government of Guyana 2021; News Room Guyana 2021).

In addition to initiatives to promote education among Indigenous Peoples in Guyana, the country has a number of regulatory undertakings aimed at improving inclusivity in the education system, including: disability, gender, rural location, and poverty. In the 2010 Persons with Disabilities Act, the 2014 Education Bill, and the 2014–2018 education sector plan, promoting inclusivity for people with disabilities centered around providing substantive and high-quality special education in an unrestrictive and enabling environment (UNESCO 2021). Gender, location, and poverty disparities have been similarly addressed at the regulatory levels. The National Policy on Women 2006, the 2014 Education Bill, and the 2008–2013 education strategic plan all focus on reducing sex stereotyping in education material and offering males and females the same access to teacher training programs (UNESCO 2021). Specifically, the 2014 Education Bill and the 2014–2018 education sector plan allow for flexible schooling options, such as remote learning, for students in remote or sparsely populated areas. The latter is also significant for minimizing absenteeism due to rainy seasons, low water levels that prevents travel by boat, and times when students must stay home to help harvest crops (UNESCO 2021). Additionally, poverty, which is often linked to rural living, was addressed in the 2014–2018 education sector plan by aiming to reduce the costs of education for poor families to enable them to keep their children in school. The Ministry of Education offered measures including providing free textbooks and uniforms and implementing school feeding programs as a way to alleviate the financial stressors of education (UNESCO 2021).

Educational Attainment in Region 2, Region 3, and Region 4

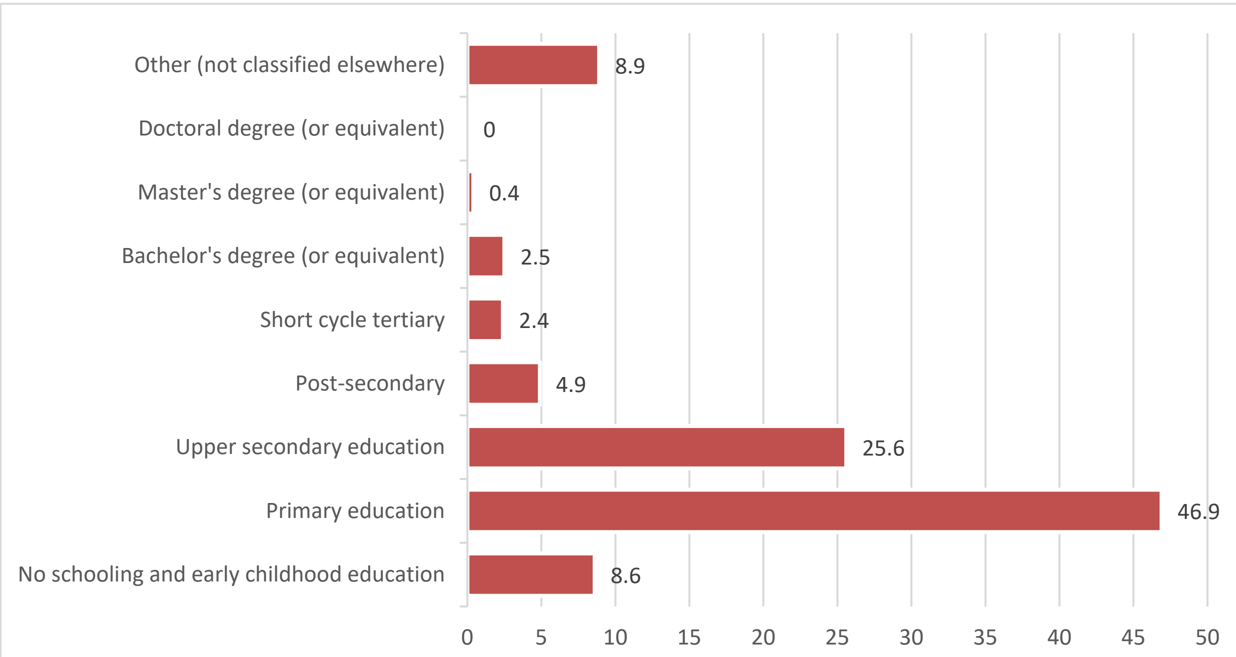
As a whole, Guyana's Ministry of Education is engaging in efforts to enhance educational attainment throughout the country as demonstrated by its education inclusivity initiatives. The Ministry's undertakings manifest in different forms in each region, and there has been noteworthy progress in Region 2, Region 3, and Region 4.

In Region 2, for example, Guyana's Ministry of Education distributed the "Because We Care" cash grant to school-aged children. The grant is intended to lessen the financial burden of education on families by providing the parents of school-aged children with $15,000 GYD in addition to $4,000 GYD school supplies and uniform stipends. The initiative demonstrates the country's commitment to enhancing educational attainment in Region 2 (Guyana Chronicle 2021).

The Guyana Secondary Education Improvement Project (GSEIP), a $52 billion GYD project funded by the World Bank, allocated a portion of funds towards Region 3 and Region 4 to enable them to construct new and advanced secondary schools. Both regions are a focus of the GSEIP because the highest populations are concentrated in the coastal regions, thus serving the highest proportion of students and schools in the country. Specifically, Region 4 has approximately 42 percent of the country's total population, while Region 3 has around 14 percent (Ministry of Education 2021). Resulting from the population proportions, the two regions combined also account for nearly 30 percent of the country's secondary school population and over 40 percent of the population living in poverty in Guyana (NationNews 2021). The additional secondary schools will help the regions alleviate some of the population stressors on the education system while simultaneously providing students with greater access to valuable tools and knowledge. For example, the buildings are being outfitted with resources to better serve students with disabilities, provide modern vocational training such as Clothing and Textiles, and labs in Information Technology, Biology, Chemistry, and Physics, among other educational resources (Stabroek News 2020).

Educational Attainment in the Direct Area of Influence

The 2021 household socioeconomic survey found that primary and secondary education attainment were dominant among the 402 Direct AOI survey respondents as the highest level of education attained, while post-secondary and university education were the highest level attained for only a small fraction of respondents, a trend that is consistent with national education levels. The breakdown of educational attainment level in the Primary and Secondary Study Areas can be found on Figure 9.1-6.



Source: 2021 household socioeconomic survey

Figure 9.1-6: Educational Attainment in the Primary and Secondary Study Areas

Results from the Tertiary Study Area followed similar trends, with 22 of the 25 respondents indicating either primary or secondary as the highest level of educational attainment. The remaining three respondents reported attaining a tertiary/university-level education.

9.1.3. Existing Conditions and Baseline Studies (Economic)

9.1.3.1. Economic Overview

Guyana was reclassified by the World Bank from a lower middle-income country to an upper middle-income country in 2016 (World Bank 2016) and continues to hold this status (World Bank 2021). Guyana's economy grew by 43.5 percent in 2020, up from 5.4 percent growth in 2019. This increase was due mainly to the country's first year as an oil-producing nation. However, not all sectors of the economy grew in 2020, as outputs of sugar, rice, gold, and fishing declined (Bank of Guyana 2021), and economic activity across the country was negatively impacted by the coronavirus disease 2019 (COVID-19) pandemic. Although gross domestic product (GDP) grew by 43.5 percent overall, non-oil GDP actually contracted by 7.3 percent by the end of 2020, compared to a 4.3 increase in the same period in 2019.

Guyana's main sectors by contribution to GDP in 2020 are summarized in Table 9.1-5.

Table 9.1-5: Economic Sectors and Contribution to Gross Domestic Product at Current Basic Prices in 2020

Sector	Percent of GDP
Agriculture, Fishing, and Forestry	18.13%
Mining and Quarrying (including petroleum and gas)	29.17%
Wholesale and Retail Trade	5.2%
Transportation and Storage	2.97%
Construction	7.15%
Manufacturing	4.56%
Public Administration	6.55%
Information and Communication	2.29%
Financial and Insurance Activities	4.04%
Education	3.06%
Other Services	0.23%
Health and Social Services	1.74%
Electricity and Water	0.86%
Real Estate	8.31%

Source: Bank of Guyana 2021

Note: Percentages do not add to 100 percent (likely in part due to rounding) but have been verified by the Consultants to be as-reported in the referenced source.

Guyana relies heavily on trade, with exports totaling $558.79 billion GYD ($2.794 billion USD) in 2020, up from $338.47 billion GYD ($1.692 billion USD) in 2019 (Bank of Guyana 2021). The main export products for the country are sugar, rice, bauxite, gold, forest products, and—as of 2020—crude oil (FAO 2015; Bank of Guyana 2021). In 2020, exports of sugar, timber, and other goods declined by 13.4 percent, 17.9 percent, and 37 percent, respectively. Oil exports began in 2020, amounting to 26.6 million barrels (4.3 million cubic meters [m^3]) over the year, valued at approximately $222.376 billion GYD ($1.112 billion USD).

The investment climate and financial infrastructure in Guyana is still maturing, and the country has faced challenges in attracting investments and diversifying the economy. According to the World Bank, the overall business regulatory framework remains complex and cumbersome. A challenging regulatory environment for businesses particularly affects micro-, small-, and medium-sized enterprises, which account for most businesses in Guyana (World Bank 2016). In 2020, as in recent prior years, Guyana ranked 134 out of 190 world economies for ease of doing business (World Bank 2020).

The economic importance of the petroleum and gas sector— a sector that is particularly important for the coastal areas (i.e., where the potential for socioeconomic impacts from the sector are higher, as compared to the rest of the country), as well as the mining and wholesale/retail trade sectors (which are important sectors for the country as a whole)—are described in further detail below.

9.1.3.2. Petroleum, Gas, and Support Services

Oil production in Guyana commenced in December 2019, and Guyana became an oil-exporting nation in 2020. The oil reserves of Guyana are estimated at 9 billion barrels (1.4 billion m^3) of oil equivalent resource, with still unexplored and potentially undiscovered additional reserves; offshore oil exploration activities are ongoing.

Categorized as part of the Mining and Quarrying sector (described further below), the “Petroleum & Gas & Support Services” sector expanded substantially in 2020 (Bank of Guyana 2021). This was the first full year of crude oil production, amounting to over 27 million barrels (4.3 million m^3) in 2020, compared to just over 427,000 barrels (68,320 m^3) in 2019. Oil production averaged 74,300 barrels (11,888 m^3) per day over the year, peaking at 120,000 barrels (19,000 m^3) per day in December 2020. Overall, the sector contributed more than $180.39 billion GYD ($901.95 million USD) to the national GDP in 2020, representing 17 percent of total GDP at basic prices, compared to 1.9 percent in 2019.

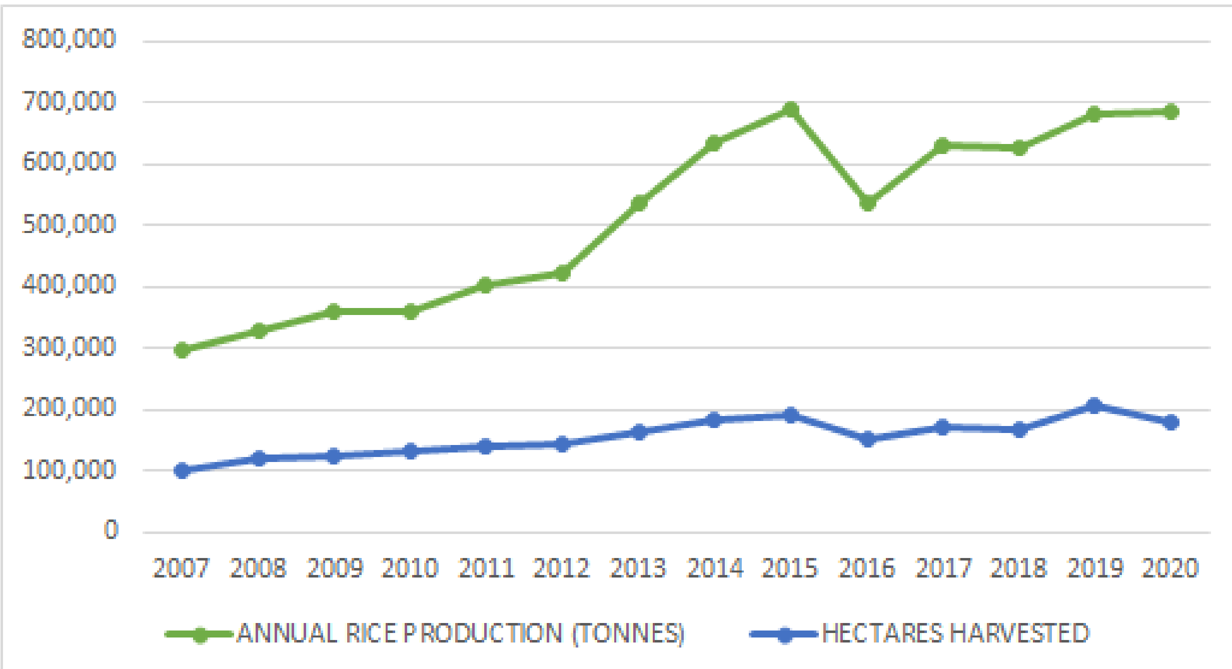
In 2019, the Bureau of Statistics anticipated that as a result of the oil and gas sector, GDP may increase up to 13 times and the GYD will appreciate in value against the USD once daily production reaches 1 million barrels of oil per day (160,000 m^3 per day; Bureau of Statistics 2019, pers. comm.). In addition to impacts on GDP through fiscal revenue, there will also be opportunities to boost economic growth through increased foreign direct investment in supporting goods and services, which will present the country with opportunities to diversify production and trade. Nonetheless, the economy’s increased dependence on natural resources will also increase its vulnerability to commodity price fluctuations and could reduce the competitiveness of other sectors (IDB 2017).

9.1.3.3. Agriculture

According to the Private Sector Commission (PSC), Guyana has a relatively strong agricultural sector and is the only net exporter of food in the Caribbean. In 2020, the agriculture sector (including sugarcane, rice, other crops, and livestock) grew by 4.5 percent over the prior year, compared to a 0.3 percent increase between 2018 and 2019, and a 14.7 percent decline between 2017 and 2018. The increase in 2020 was attributed to higher outputs of sugarcane, rice, and other crops (Bank of Guyana 2021). The agriculture sector represented 16.2 percent of Guyana’s GDP at basic prices in 2020, down from 17 percent in 2019, 18.3 percent in 2018, and 21.4 percent in 2017. This follows a general downward trend of the contribution of the agriculture sector to national GDP over the past decade (Bank of Guyana 2021). The Ministry of Agriculture is currently drafting a revised National Agriculture Strategy for 2020 to 2025 that will take into consideration the burgeoning oil and gas sector and its interaction with agriculture (Ministry of Agriculture 2016, pers. comm.).

Rice

In 2020, rice production increased by 0.7 percent to 687,427 tonnes, up from 682,081 tonnes in 2019 (Figure 9.1-7). This increase is linked to a 4.4 percent increase in the hectares of rice production, although there was also a 3.5 percent decrease in yield per hectare due to various diseases that affected the second crop in 2020 (Bank of Guyana 2021). In 2018, rice production was notably lower at 626,684 tonnes; this low production was attributed to poor weather conditions, paddy bug infestation, fewer hectares harvested, and lower investments in the sector (Bank of Guyana 2018). The main export markets for Guyana's rice are the European Union, Caribbean Community (CARICOM), Mexico, West African countries, and Latin America (Bank of Guyana 2019).



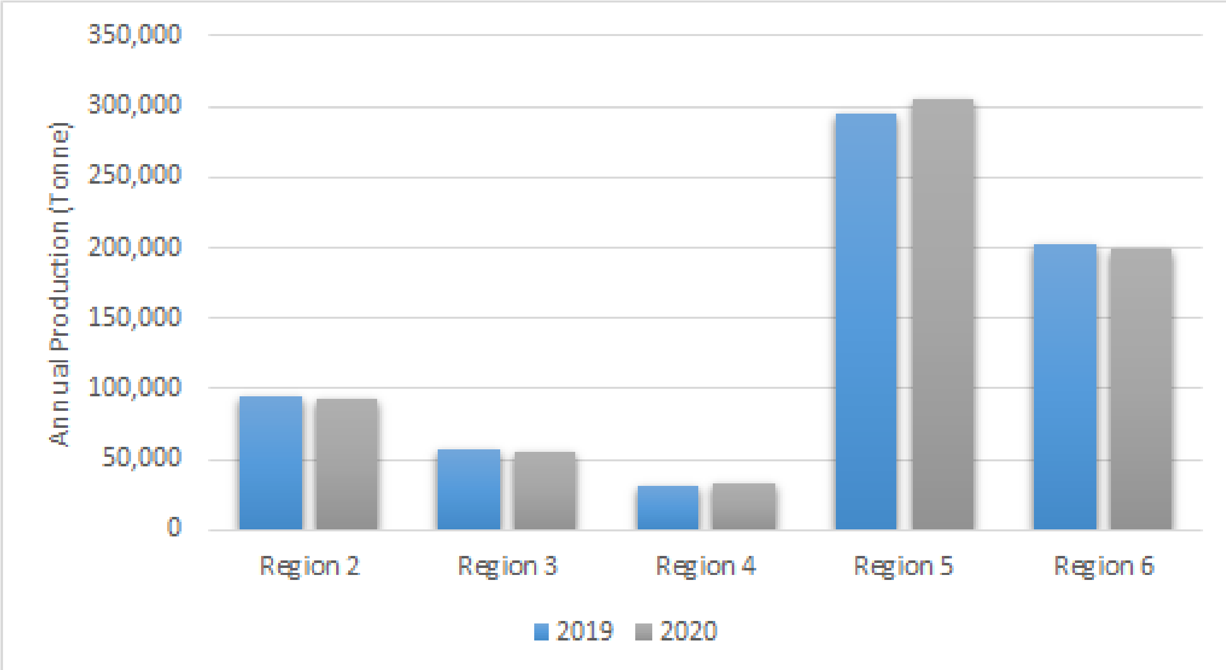
Sources: Ministry of Agriculture 2018; Bank of Guyana 2019; Guyana Rice Development Board 2021, pers. comm.

Figure 9.1-7: Annual Rice Production and Hectares Harvested, 2007–2020

Rice is especially important in several coastal NDCs, where it is cultivated for both commercial and subsistence use (ERM/EMC 2018), and rice fields dominate the landscape in many coastal areas in these regions (Figure 9.1-8). Many communities have reported that the heavy flooding across Guyana in 2021 had a significant negative impact on local rice farming.

Figure 9.1-8: Rice Field in Region 2 Pomeroon-Supenaam

Rice farming is the predominant agricultural activity in the coastal areas of Regions 2, 3, 5, and 6. In 2016, rice production accounted for an estimated 85 percent of the overall economy in Region 2, and 55 to 60 percent in Region 3 (Guyana Rice Producers' Association 2016, pers. comm.). Region 5 had the largest rice industry, with more than 80,000 hectares harvested in 2018 compared with approximately 28,800, 15,400, 7,000, and 40,000 hectares harvested in Regions 2, 3, 4 and 6, respectively. Consequently, annual rice production is highest in Region 5. Between 2019 and 2020, rice production was relatively stable across all of these regions, with a slight increase in production in Region 5 (Figure 9.1-9).



Source: Guyana Rice Development Board 2021

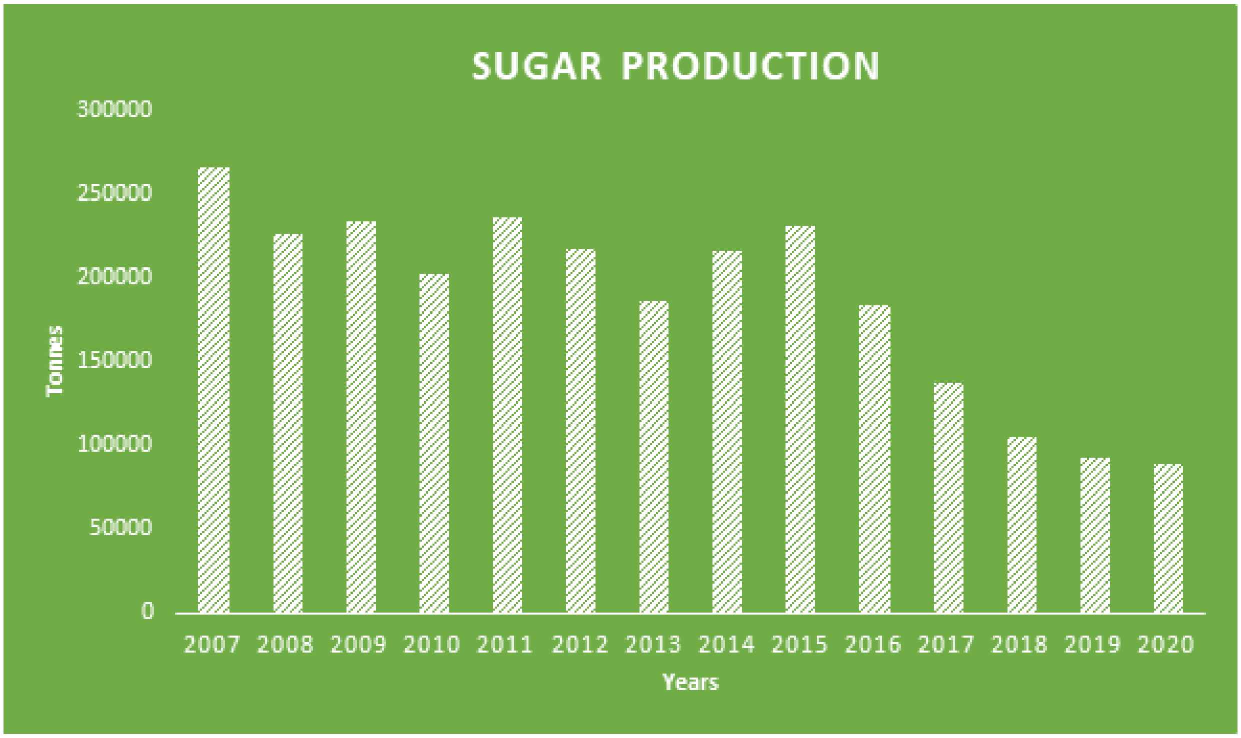
Figure 9.1-9: Annual Rice Production in Regions 2 through 6

According to the president of the Guyana Rice Producers' Association, industrial rice production requires the ability to precisely control water levels in the rice fields. The rice growers in coastal Guyana achieve this by operating two separate systems of canals, one dedicated to irrigation and another dedicated to drainage. The irrigation canals convey fresh water from water conservancies or rivers via gravity to the rice fields. The rice fields are contained within a dike system that has separate gates for irrigation and drainage systems. The fields drain to a separate network of canals constructed to provide general drainage to the surrounding coastal landscape (Guyana Rice Producers' Association 2016, pers. comm.). These canals drain to the Atlantic Ocean via manually operated mechanical sluice gates (locally called *kokers*; Figure 9.1-10) or by pump stations installed along the coastline. The drainage canals are generally constructed at or very near sea level to achieve the gradient necessary for drainage of the surrounding landscape. Therefore, the drainage canals are tidally influenced and the kokers control inflow from the sea. This system helps ensure that the rice fields remain upgradient of tidally influenced water in the drainage canals and prevents salt water from intruding into the fields (Guyana Rice Producers' Association 2016, pers. comm.; ERM/EMC 2018).

Figure 9.1-10: Sluice Gate (Koker) in Charity (Region 2) at High Tide

Sugar

In 2020, sugar production declined to 88,890 tonnes, down from 92,232 tonnes in 2019, 183,491 tonnes in 2016, and 231,076 tonnes in 2015 (Figure 9.1-11). Sugar production in 2020 represented the lowest quantity of sugar produced over the last decade. This outcome in 2020 compounded declines in prior years and can be attributed to mechanical failures in two factories, unfavorable weather conditions, and the effects of the pandemic, which affected worker turnout (Bank of Guyana 2021).



Sources: Ministry of Agriculture 2018; Bank of Guyana 2021

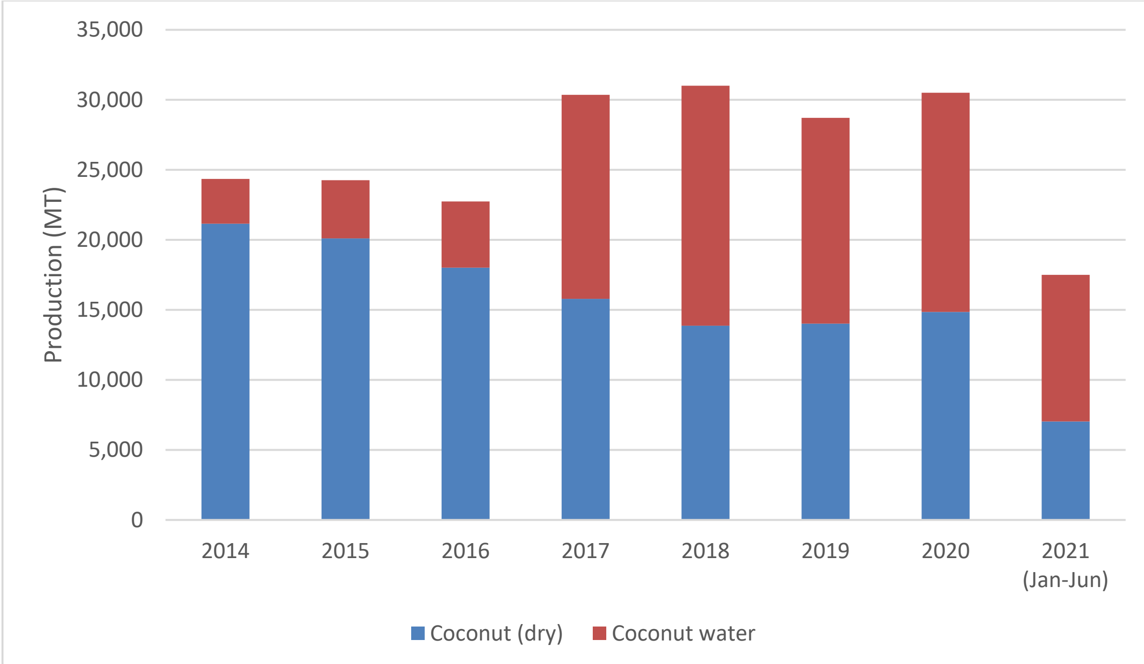
Figure 9.1-11: Annual Sugar Production, 2007–2020

As production levels were reduced, the value of sugar, as indicated by its average export price, increased by 4.5 percent in 2020. This increased value somewhat offset the 17.1 percent decline in export volumes, although export earnings still declined from $5,810.2 million GYD ($29.1 million USD) in 2019 to $5,036.9 million GYD ($25.2 million USD) in 2020. Overall, the average export price for sugar was $77,685 GYD ($388.3 USD) per tonne in 2020, compared to $74,362.2 GYD ($371.8 USD) per tonne in 2019, $72,899.2 GYD ($364.5 USD) per tonne in 2018, and $92,566.1 GYD ($462.8 USD) per tonne in 2017 (Ministry of Agriculture 2018; Bank of Guyana 2021). Guyana's Demerara sugar is exported to markets in the European Union, United States, and CARICOM countries. Commercial farms growing sugarcane are found primarily along the coastal areas in Regions 4 and 6 (Figure 9.1-12; ERM/EMC 2018).

Figure 9.1-12: Aerial View of Sugar Plantations

Coconut

The coconut industry in Guyana has grown in recent years (Figure 9.1-13) and shows potential for continued growth due to high international demand for products such as coconut oil and coconut water. As of 2020, approximately 24,000 hectares of coconuts were being cultivated (up from 10,000 hectares in 2015), and the National Agricultural Research and Extension Institute (NAREI) estimates that acreage dedicated to coconut cultivation could quadruple from 2015 existing conditions by 2025 (Stabroek News 2018).



Source: Ministry of Agriculture 2021a
MT = metric tonnes

Figure 9.1-13: Annual Production of Coconuts and Coconut Water, 2014–2021

In 2016, a Coconut Festival was held in Guyana through a collaborative effort of the Ministry of Business,[3] the Ministry of Agriculture, the International Trade Centre, and the Caribbean Research and Development Institute to build awareness of the coconut industry and to promote investments (NAREI 2017). Following this, a Coconut Board was convened by the International Trade Centre to focus on the development of Guyana's coconut industry and promote collaboration with the government and private sector operators (NAREI 2019, pers. comm.).

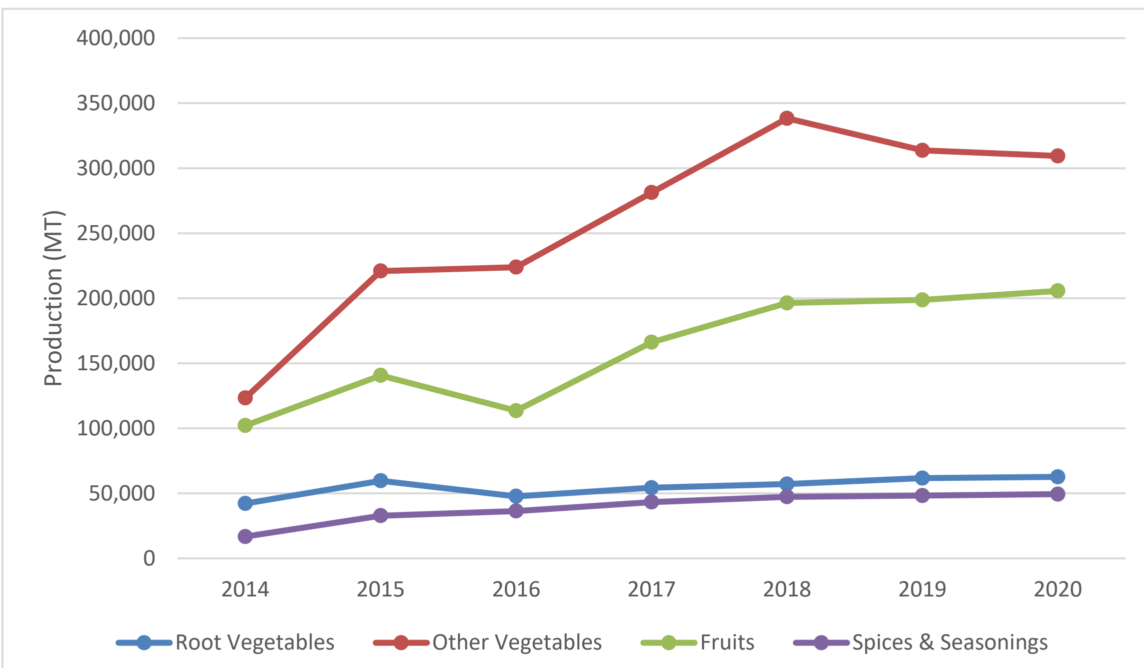
Within the agricultural sector, the coconut industry ranks third after rice and sugar in terms of acreage; coconut is grown primarily in the coastal regions, including along the Pomeroon River and the Essequibo Coast in Region 2. According to news media articles, the amount of land in the Pomeroon area being converted to coconut cultivation is increasing (Guyana Chronicle 2016; Stabroek News 2016). In 2017, coconut production was 136,603 tonnes, of which 9,068 tonnes were exported. Value-added coconut products exported in 2017 included coconut choka, grated coconut, coconut water, and crude coconut oil (Ministry of Agriculture 2018). In 2021, coconut cultivation in Region 2 was affected by massive flooding across the region. The coconut industry is active in all six of the coastal regions (ERM/EMC 2018), but none have been specifically identified within the Direct AOI. In most cases, coconut farming is conducted for both subsistence and commercial reasons and ranges in reported importance by stakeholders from low to essential (ERM/EMC 2020a). There are instances where the expansion of coconut estates has resulted in the clearing of large swathes of mangrove forests, as is the case at the

[3] Now the Ministry of Tourism, Industry and Commerce

mouth of the Pomeroon River. However, coconut farming also supports Guyana's sea defense along sea dams through vegetative stabilization of the earthen coastal seawall.

Other Cash Crops

Non-traditional crops (i.e., crops other than sugar cane and rice) grown in Guyana include tubers such as cassava, sweet potato, and eddo; vegetables such as bora, eggplant, cabbage, cucumber, pumpkin, plantains, squash, tomatoes, and okra; spices such as hot peppers, eschallot, and ginger; and fruits such as avocado, banana, cherry, lime, orange, papaya, mango, passionfruit, watermelon, and pineapple. Data from the Ministry of Agriculture (2021b) show that production for all crop categories has generally increased over recent years. Growth in root vegetables and spices/seasonings has been more modest, whereas fruits and non-traditional crops have shown more substantial increases in production (Figure 9.1-14). Among fruits, papaya has shown the highest level of growth (1,104 percent) since 2014, along with orange (448 percent) and mango (217 percent). Increases in vegetables during this period include pumpkin (395 percent), eggplant (359 percent), and bora (208 percent), while sweet potatoes (323 percent) and ginger (475 percent) production also grew significantly.



Source: Ministry of Agriculture 2021b
MT = metric tonnes

Figure 9.1-14: Production of Other Cash Crops, 2014–2020

Similar to coconut farming, cash crops are grown in all six of the coastal regions (ERM/EMC 2018). In some cases, farmers use the sea defense walls for agricultural purposes for subsistence and small-scale commercial sale. In Region 1, cassava is a primary staple in the diet, and villages that grow cash crops typically only sell them within their own villages (as transportation challenges restrict access to other markets). In many villages, cash crops are a primary source of both income and subsistence, supplementing fishing activities (ERM/EMC 2018).

In May to August 2021, Guyana experienced unprecedented flooding in all regions of the country. The floods severely impacted the cash crop growing areas of Regions 5 and 6. The floods destroyed crops and produce, and extensive and prolonged flooding in some areas will affect future production of cash crops (especially in areas already challenged by saline intrusion). In Region 1, livestock rearing has also been negatively impacted by flooding. NDCs in Region 5 reported a delay in the resumption of farming in some communities due to damaged farmland and lack of capital (ERM 2021). The COVID-19 pandemic has also affected farmers due to reduced purchasing power, less spending in communities, and lower demand for produce from farmers.

Value-added Agricultural Products

According to various interviewed stakeholders, establishing manufacturing operations to develop value-added products such as pepper sauce, beverages, and canned fruit are priorities at both community and strategic policy levels (Pomeroon Women's Agro-Processors Association 2016, pers. comm.; Private Sector Commission of Guyana 2016, pers. comm.; Ministry of Agriculture 2016, pers. comm.; West End Agricultural Development Society 2016, pers. comm.; Ministry of Agriculture 2016, pers. comm.). Several agricultural co-ops in Regions 2 and 3 have achieved varying levels of success in producing and marketing such products. National-level agencies such as the Ministry of Agriculture and the PSC emphasize the importance of developing markets for such products to provide better stability and security to farmers. However, there are a number of challenges associated with this, including high energy costs, difficulty locating or establishing markets for products, maintaining quality control and standards, packaging and labeling, and obtaining financing for start-up costs.

The private sector, through the Guyana Manufacturing and Services Association (GMSA), in partnership with the Ministry of Business[4], has been executing the *UncappeD* initiative, which has provided the opportunity for large and small agro-producers and processors from across the country to showcase their products at national-level expos and regional marketplace events. Several other related initiatives are also underway, including an Inter-American Development Bank (IDB)-supported project to improve the quality of national infrastructure, which would assist agro-processors. Many of these initiatives were reduced or suspended in 2020 in response to the COVID-19 global pandemic. However, the GMSA has established a web portal to facilitate information sharing and communication, connecting products and service providers with potential clients nationally, regionally, and internationally. Currently focused on the agro-processing sector, the GMSA plans to expand the portal to include the forestry and wood products and services sectors in subsequent phases.

The Ministry of Agriculture is pursuing other initiatives including the creation of a research arm of the Guyana Rice Development Board to explore options for value-added rice products, encouraging blending of wheat flours with locally manufactured flours (cassava, sweet potatoes,

[4] Now the Ministry of Tourism, Industry and Commerce

rice), and establishment of a milk pasteurization plant in partnership with private operators (Ministry of Agriculture 2016, pers. comm.).

In August 2021, the Ministry of Agriculture invested $26 million GYD ($130,000 USD) in the Guyana Marketing Corporation in the form of three all-terrain vehicles and two refrigerated trucks. The Guyana Marketing Corporation also launched its one-stop shop to better support farmers and marketers in marketing their produce (Parris 2021). Also in 2021, the U.S. Agency for International Development announced a partnership with local entity Guyana Economic Development Trust to launch an Economic Development Incubator and Accelerator (EDIA) for Guyanese agro-processors. The EDIA will address the technology base of agriculture processing in Guyana (Stabroek News 2021).

9.1.3.4. Fisheries and Aquaculture

Marine Fisheries

There are four main types of marine fisheries in Guyana (Ministry of Agriculture 2013), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place. Table 9.1-6 summarizes the characteristics of these fisheries. Tuna, such as yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), have also been identified as a potential oceanic target species of commercial interest (Isaac and Ferrari 2017); however, the industrial tuna fishery in Guyana is small, as described in Section 8.2, Marine and Coastal Biodiversity.

Table 9.1-6: Primary Characteristics of Marine Fisheries in Guyana

Type of Fishery	Species	Gear	Depth
Industrial	Seabob, shrimps, and prawns	Trawls	Primarily from 13–16 meters but can occur from 0–75 meters
Semi-industrial	Red snapper and vermillion snapper	Fish traps and lines	Edge of continental shelf
Artisanal	Mixed fish and shrimp	Gillnets, drift seines, fyke nets/Chinese seines, and others (e.g., Cadell line)	0–28 meters
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

According to data from the PSC and the Ministry of Agriculture, fishery yields have generally declined since 2013, including the following annual trends:

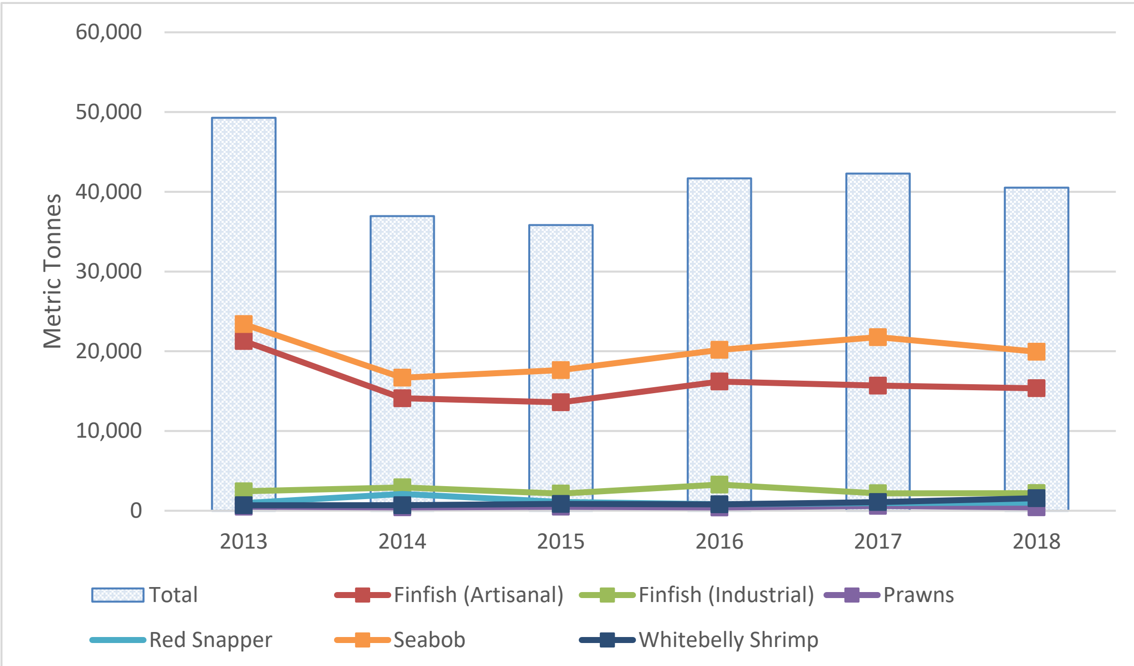
- Fishery yields declined between 2014 and 2015. The PSC attributes this to El Niño-related weather phenomena, while the Ministry of Finance characterizes this as part of a longer-term decline caused by unsustainable overfishing, including illegal fishing by foreign vessels (Ministry of Finance 2015).

- The sector recovered in 2016 with growth in both fish and shrimp outputs. Fish output improved by 20.5 percent, and (total) shrimp output grew by 9 percent. However, prawn output fell by 17.8 percent (PSC 2017).
- In 2017, production continued with a very modest 1 percent overall increase. Shrimp and fish catch decreased by 6.2 percent and 1.2 percent, respectively, while prawn catch increased by approximately 4 percent between 2016 and 2017, and small shrimp catch grew by 8.9 percent (Bank of Guyana 2018).
- Fish catch continued to decline in 2018 with a 6.2 percent reduction compared with 2017 (Bank of Guyana 2019). These changes were attributed to market challenges arising from rigorous international certification requirements and an intrusion of sargassum seaweed (Bank of Guyana 2019).
- In 2019, fish catches increased by 21.4 percent, largely due to growth in local demand. However, shrimp catches were reduced by 25.1 percent, associated with the intrusion of sargassum seaweed (Bank of Guyana 2019).
- Fish catch in 2020 showed a marked reduction of 17.1 percent compared to 2019, attributed to COVID-19 restrictions and related changes in demand for fishery products. Additionally, shrimp catch decreased by 14.3 percent due to weather conditions and an extended closed season for shrimp fishing (Bank of Guyana 2021).
- In general, during the COVID-19 pandemic, many companies working in the fishing industry have reduced the number of staff working on a given day. Fisheries plants were closed between April and August 2020 as a result of COVID-19 restrictions, and a reduced number of vessels went out to sea (resulting in lower fishing production) throughout the year (Ministry of Agriculture 2021, pers. comm.).

According to the Fisheries Department, reasons for decline in fish catch can generally be attributed to either the depletion or the migration of stock. The Fisheries Department has a program of reviewing stock assessments of seabobs and bycatch to further understand recent trends (Department of Fisheries 2016, pers. comm.). Fishing interests and the Fisheries Department personnel also acknowledged the prevalence of illegal fishing by both foreign and domestic vessels, but did not specifically implicate illegal fishing in the decline of stock in recent years (Guyana Association of Trawler Owners and Seafood Processors 2016, pers. comm.; Ministry of Agriculture 2016, pers. comm.; West End Agricultural Development Society 2016, pers. comm.; Fisherfolk in Lima 2016, pers. comm.). Some media reporting suggested that there had been an increase in fish catch in 2021, but specific data confirming this reporting were not available.

Fishing catches for 2013 to 2018 are shown on Figure 9.1-15. The data indicate a declining trend for artisanal finfish, prawn, and seabob shrimp catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. In the last decade, the contribution of the fishing subsector to Guyana’s national GDP peaked at $25.76 billion GYD ($128.8 million USD) in 2014 (3.3 percent of GDP at basic prices) and subsequently declined to

$11.45 billion GYD ($57.5 million USD) in 2020 (1.1 percent of GDP at basic prices; Bank of Guyana 2021).



Source: Ministry of Agriculture 2018, Ministry of Agriculture on Fisheries Production 2019, pers. comm.
Note: Whitebelly is a species of shrimp.

Figure 9.1-15: Commercial Fisheries Catch Volumes, 2013–2018

Bycatch of endangered turtles, sharks, and rays as a result of fishing operations represents a recognized challenge for the industry and is the subject of increasing targeted study (Kolmann et al. 2017; Garstin and Oxenford 2018).

Prawns and Shrimp

Within the fishery sector, the prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 73 meters water depth (40 fathoms; Guyana Rice Producers' Association 2016, pers. comm.).

The industrial seabob shrimp sector continues to be an important commercial fishery, and industry leaders are currently in the process of applying for Marine Stewardship Council certification (an internationally recognized voluntary process used to assess and certify the sustainability of wild-capture marine and freshwater species). The seabob fleet currently operates under a voluntary management plan (the only fishery-specific management plan for fisheries operating in Guyana's territorial waters) (Guyana Rice Producers' Association 2016, pers. comm.). The season for seabob production typically lasts for approximately 6 weeks, although if production is low, it can be extended for up to 10 weeks. In 2020, the seabob fishery was extended to 8 weeks (Ministry of Agriculture 2021, pers. comm.).

Fishing Livelihoods

Fishing is important to Region 1 and all of the coastal NDCs in Regions 2 through 6, providing direct employment and income for numerous fisherfolk and indirect employment for numerous others in supporting services. As evidenced through research conducted in 2018 and 2019, the importance of fishing to local communities, as well as the scale of fishing activities varies across regions. For example, one of the largest landing sites in Region 6 is Complex 66, where up to 200 vessels land during peak fishing seasons; a typical small landing site, like Rose Hall in Region 6, may only have four vessels that operate routinely (Department of Fisheries 2019, pers. comm.). Table 9.1-7 provides information on the estimated size of the vessel fleets at various coastal landing sites across Regions 1 through 6. These sites were selected as they provide a good representation of the entire coastline.

Table 9.1-7: Estimated Size of Artisanal Vessel Fleet at Selected Coastal Ports

Region	Port	Approximate Number of Vessels During Peak Season
Region 1	Smith's Creek	6
	Waramuri	20
Region 2	Charity	100
	Hampton Court	15
	Lima	30
Region 3	Zeeburg	30
	Windsor Forest	12
	La Grange	8
Region 4	Ogle	30
	Riverview (Unity)	30
Region 5	Mahaicony Bridge	15
	Rosignol	40
	Bushlot	40
Region 6	Rose Hall	4
	Albion	70
	Complex 66	200

Source: Department of Fisheries 2019, pers. comm.

Drift seines and fyke nets (also referred to in Guyana as Chinese seines) are the most frequently used gear type. In general, small artisanal vessels characterized by having engine sizes of less than 40 horsepower and using fyke nets are used in daily fishing trips. Fishing tends to occur along the coastlines at "pens" located near landing sites; for example, one vessel exclusively using fyke nets at the Ogle landing site was reported to make daily trips to pens located between 2 and 4 kilometers offshore from the landing site. Other small artisanal vessels use drift seines. These vessels frequently make daily trips and focus on fishing along the coastline near respective landing sites, but may stay at sea for up to 8 days. For example, fishing vessels from the Hampton Court landing site (Region 2) travel along the Essequibo Coast, while vessels from the Bushlot landing site (Region 5) target the Region 5 coastline. Smaller vessels typically do not travel more than 12 kilometers from shore, where fishing occurs at depths ranging from 2 to 31 meters (Department of Fisheries 2019, pers. comm.).

Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. For example, most of the vessels at the Charity landing site (Region 2) spend approximately 18 days at sea per trip fishing along the Essequibo Coast, frequently traveling as far east as the Waini River in Region 1. Larger artisanal vessels at the Rosignol (Region 5) and Complex 66 (Region 6) landing sites travel along the coastlines of Regions 5 and 6; in addition, some vessels are also licensed to fish in Surinamese waters. Larger vessels are reported to travel up to 25 kilometers from shore with fishing at depths of up to 28 meters.

Table 9.1-8 provides an overview of the commercial fishing communities identified as part of the late 2017 and early 2018 field work by the Consultant team.

Table 9.1-8: Estimated Size of Commercial Fishing Communities in Coastal Regions

Region	NDC Name	Fishing Community
Region 1	Morawhanna	3 boats/1 person
Region 2	Charity/Urasara	20 persons
Region 3	Wakenaam (island)	60 persons
Region 4	Georgetown City	20 boats
	Better Hope / La Bonne Intention	35 boats
	Enmore/Hope	20 boats
Region 5	Hamlet/Chance	30 boats
	Profit/Rising Sun	60 boats
	Bath/Woodley Park	12 boats
	Zeelust/Rosignol	175 boats
Region 6	Macedonia/Joppa	100 persons

Source: ERM/EMC 2018

Data obtained during informal engagement with fisherfolk in 2018 suggest that the economies of Regions 5 and 6 are generally more dependent on commercial fishing than those coastal NDCs in other regions (ERM/EMC 2018).

A large percentage of fish captured using artisanal methods is sold to third parties. Sale prices are subject to short-term fluctuations. According to the fisherfolk interviewed as part of the Liza Phase 1 post-permitting marine fish study (ERM 2018), the 2019 to 2020 Participatory Fishing Study (ERM/EMC 2020b), and the 2021 Participatory Fishing Study (EMC 2021), the price of fish is seasonally influenced. Interviewees commented that the prices generally decline during the rainy season due to higher catches and increased supply; seasonal variability also affects the productivity of fishing trips. The catch price for many species was significantly lower in 2021 compared to 2018; according to some community sources, this could be attributed to reduced spending power in communities as a result of economic slowdown during the COVID-19 pandemic.

9.1.3.5. Mining and Quarrying

The mining and quarrying sector (excluding “petroleum, gas and related support services,” described separately) is an important sector for Guyana and has accounted for approximately 13 to 15 percent of national GDP in recent years (2017 to 2020; Bank of Guyana 2021). In 2020, faced with the challenges of operating during the COVID-19 pandemic, this sector contributed $128.8 billion GYD ($640 million USD) to GDP at basic prices (12.2 percent of GDP), representing a decline from $142.7 billion GYD ($713.5 million USD; 14.8 percent of GDP) in 2019. Mining and quarrying products include gold, bauxite, diamonds, and stone.

The mining sector contributed more than 40 percent of exports in 2020. Most notably, raw gold and bauxite equated to 37.8 percent and 2.8 percent, respectively, of export totals in 2020 (BSG 2021). This represented a reduction of 26.9 percent compared with 2019 due to lower production of bauxite, gold, and diamonds. This decline was due to a decrease in the export volume, which outweighed a rise in the export price (Bank of Guyana 2021).

The mining sector employs between 12,000 and 18,000 persons, which accounts for 4 to 6 percent of the total labor force (GOINVEST 2021).

Mining in Guyana was severely impacted by the May 2021 floods. Region 7 is the small- and medium-scale gold mining capital of Guyana and was financially impacted because of flooding effects. Mining ceased as mines were flooded and the multiplier effects of the activity dwindled (Kaieteur News 2021a). In July 2021, President Ali stated that over 50 percent of mining operations were affected, with mining areas cut off due to infrastructural damages, estimating that lost production amounted to approximately $23 billion GYD ($115 million USD) and $1 billion GYD ($5 million USD) in damages to mining infrastructure (Kaieteur News 2021b).

9.1.3.6. Other Sectors

Wholesale and Retail Trade

Wholesale and retail trade fell by approximately 29 percent in 2020. According to the Bank of Guyana, the combined impacts of reduced import levels for consumer goods (-11.9 percent) and the precautionary measures implemented by the Guyana National COVID-19 Task Force to address the spread of the coronavirus by restricting non-essential business activity were responsible for the significant decline in this sector (Bank of Guyana 2021).

The COVID-19 pandemic in 2020 and 2021 is reported to have had a significant impact on local businesses and commerce in Region 1 communities, with prices for food and basic commodities increasing while local residents’ income and purchasing power have declined. Local shops and businesses have also closed, reducing supply. This has affected the ability of many households to access necessary food and supplies, and increased food insecurity (Region 1 Communities 2021, pers. comm.). As a result, many families report having to access savings and/or loans in order to subsist since the start of the pandemic.

Manufacturing

The manufacturing sector recorded weakened output of 8.6 percent due to contractions of 3.7 percent, 5.7 percent, and 10.8 percent, respectively, in the sugar processing, rice milling and other manufacturing subsectors in 2020 (Bank of Guyana 2021). The most important manufactured products in terms of volume continued to include laundry soap, detergent, paints, putty, whitewash, oxygen, and acetylene, as well as edible goods including rice, sugar, and rum (PSC 2015). Guyana's manufacturing sector also benefited from increased demand as a result of the COVID-19 pandemic, most notably for the country's production of plastic sinks, pharmaceuticals, tablets, nitrogen gas, oxygen, and detergents (Bank of Guyana 2021). Many of the country's manufacturing facilities are located in coastal areas (ECLAC 2005).

Tourism

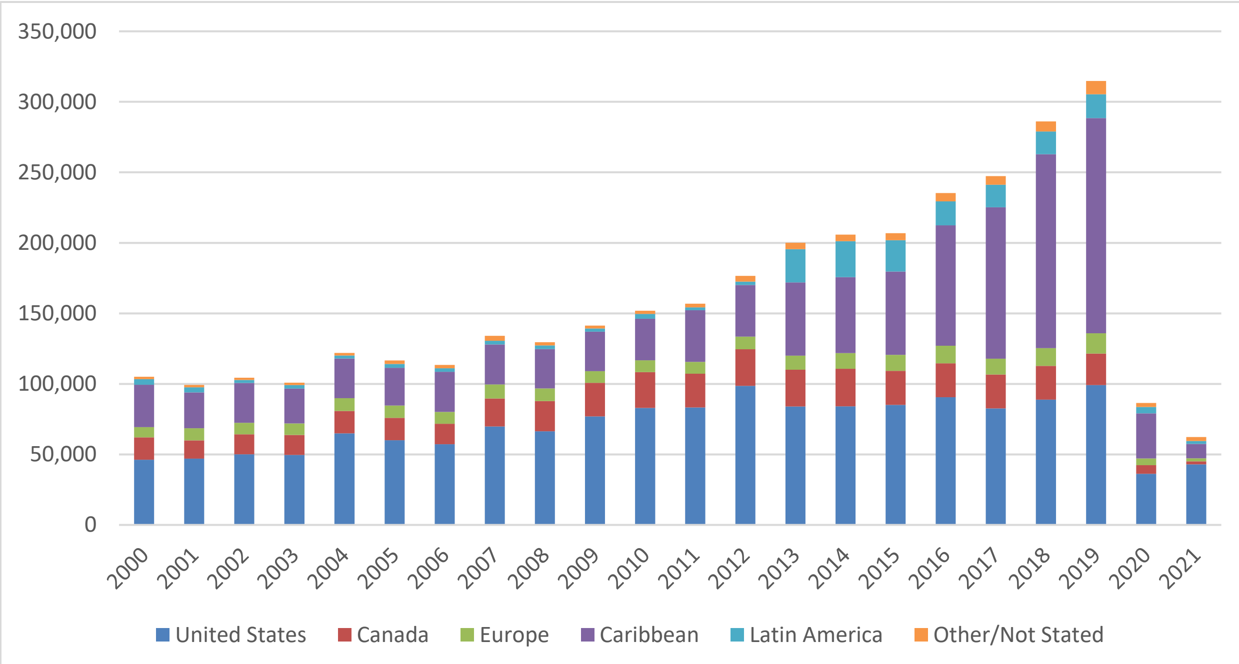
According to the World Travel and Tourism Council (2021), tourism directly contributed 10.4 percent of the country's GDP in 2019, although this declined to only 5.5 percent in 2020 during the COVID-19 pandemic. Although most tourism infrastructure (e.g., hotels) is located in the more populated townships such as Georgetown, Linden, and Berbice, many of Guyana's tourist attractions are located in the country's hinterland. These attractions offer nature, culture, and adventure-based experiences such as trips to waterfalls and Amerindian villages. These trips range from same-day to multiple-night excursions. In 2020 and 2021, the COVID-19 pandemic has had a significant impact on tourism in Guyana, as in other parts of the world. In Region 1, community-based tourism is reported to have largely stopped during the pandemic, although some communities have embraced this period as an opportunity to implement new projects and facilities intended to support the local tourism industry.

Guyana is not a popular destination for cruise ships, and the country receives only a few small ships each year. The country does not have the berthing capacity for large cruise ships (Department of Tourism 2016, pers. comm.).

Sediment deposition from the mouth of the Amazon River along Guyana's coast means that there are few beach offerings for tourists. The highly turbid water along the coast also likely contributes to the relatively small numbers of tourists that visit Guyana relative to other locations in the region with clearer water. Some tourism occurs at the Shell Beach Protected Area (SBPA) during the marine turtle nesting season, but this is limited because infrastructure and systems have not yet been established to facilitate travel or provide convenient accommodations. In general, however, Guyana is thought to have considerable ecotourism potential, and development of tourism infrastructure at the country's protected areas, including SBPA in Region 1, is considered a key part of the Protected Areas Commission's current strategic plan (PAC 2014).

Data from the Guyana Tourism Authority (2021) indicate that the number of international visitors to Guyana had tripled since the early 2000s, prior to the onset of the COVID-19 pandemic and related travel restrictions in 2020 and 2021 (Figure 9.1-16). Between 2015 and 2019, the number of international visitors increased by 34 percent overall (Guyana Tourism Authority

2021). The largest number of visitors originates from the United States and the Caribbean, with smaller numbers from Canada, Europe, and Central and South America.



Source: Guyana Tourism Authority 2021

Note: 2021 data include arrivals in January through June 2021.

Figure 9.1-16: Annual International Visitors to Guyana, 2000–2021

Before the COVID-19 pandemic suspended tourism in the country, the majority of visitors consisted of Guyanese expatriates returning to visit family; visitor numbers therefore peaked during the summer vacation (July and August) and key holidays (e.g., Christmas in December). However, the Guyana Tourism Authority has been increasing its efforts to raise Guyana's profile as a nature- and adventure-based tourism destination. In 2018, these activities included the launch of a "Destination Guyana" website and a social media strategy (Guyana Tourism Authority 2018); hosting several tourism agency trips to familiarize tour guides with Guyana; and securing representation in core tourism markets such as the United States, Canada, the United Kingdom, and Germany (Ministry of Business 2019). In 2019, Guyana was awarded the "Best Ecotourism Destination" at the ITB Travel and Trade Show Berlin (Stabroek News 2019).

As with the tourism sector globally, the Guyana tourism industry was impacted by the global COVID-19 pandemic in 2020, resulting in a decline in both visitor numbers and revenue from the industry. More generally, according to representatives of the Department of Tourism, increases in tourism in recent years have been attributed to increased regional sporting tournaments in the Georgetown area, particularly cricket events, which have attracted visitors from across the Caribbean and internationally. During major events such as the Cricket World Cup, increased traffic congestion has been observed in the Georgetown area (Department of Tourism 2016, pers. comm.).

According to personnel from the Department of Tourism in 2019, the oil and gas sector may be a catalyst to Guyana's tourism sector. The discoveries of oil and gas have raised Guyana's profile internationally, increasing exposure in potential tourism markets and attracting international events. Furthermore, tourism sector operators have anticipated increased business travel associated with the oil and gas sector, which has increased interest in upgrading existing services such as accommodations, and establishing new services such as flights on new or underserved routes (Department of Tourism 2019, pers. comm.).

Most of the major tourist attractions are located in Georgetown, such as museums, the zoo, parks, public gardens, and the Stabroek Market. Georgetown and surrounding areas are known for their many historic buildings, which date from the late eighteenth century through the mid-nineteenth century, when Guyana was first a Dutch colony and then an English colony (National Trust of Guyana 2018). Guided tours of Georgetown's historic buildings and sites are available, as are guided tours of the Essequibo River, the El Dorado Rum Factory, the Georgetown City Centre, and other attractions.

In 2019, the Department of Tourism reported a new Development of Regional Tourism Bodies project that aims to integrate regional and local authorities in tourism planning at the regional level. Regional initiatives will depend on the available resources, particularly beaches and waterfront infrastructure and development (Department of Tourism 2019, pers. comm.). Local tourism and recreation is important to the local economy in the coastal NDCs in Regions 2 through 6, including those outside Georgetown. Some regions are less dependent on tourism (e.g., Region 2), with their coastline and beaches being frequented by ten or fewer locals daily. Other regions have economies that are more established and well-linked to local tourism. Region 3 and 4, specifically Best/Klien/Pouderoyen and Haslington/Grove, respectively, are known for their eco-tourism, with diverse bird species and protected mangroves. Regions 5 and 6, on the other hand, have beaches or other recreational areas (e.g., horse tracks) frequented by hundreds weekly (ERM/EMC 2018).

Some NDCs are looking to invest in local tourism and expand its economic return. For example, Rose Hall Town Council (Region 6) has control over a long stretch of beach that is frequented daily by 20 to 50 persons and hundreds on weekends, and is seeking development of further tourism opportunities.

Informal Economy

Regarding specific economic sectors in Guyana, domestic workers (i.e., people who work within the scope of a residence) are considered to work in the informal economy. When surveying sector employment, it can be difficult to access domestic workers, so reliable statistics about the rate of domestic work in Guyana is uncommon. However, it is known that many Guyanese domestic workers also engage in other income-generating activities. To help address the challenges faced by domestic workers and by Guyana trying to account for that subset of the population, the country ratified International Labour Organization (ILO) Convention No. 189, creating decent work for domestic workers. In the Convention, domestic workers are to be covered by labor legislation, minimum wage, overtime, paid leave, and social security

(ILO 2017). Despite ratification of the ILO Convention No. 189, domestic workers often work without pay or protections, resulting in their roles being considered non-wage activities.

Indigenous Peoples may also engage in livelihoods outside of wage-based employment. The majority of Indigenous Peoples in Guyana work in a range of income-generating activities, including processing crops, fishing, producing crafts, small-scale trading and bartering, and day labor. However, on average in Guyana, less than 10 percent of households in Amerindian communities have members with a full-time, salaried job. As such, indigenous land use and customary indigenous economics may be considered a non-wage activity in Guyana despite being a productive undertaking (Griffiths and Anselmo 2010). Amerindian communities in Region 3 and Region 4 are described further in Section 9.9, Indigenous Peoples.

9.1.3.7. Labor Force Profile

Labor Force Statistics

The most recent iteration of the Guyana Labour Force Survey provides data for the first quarter of 2021 (BSG 2021). Results indicate that as of the first quarter of 2021, the unemployment rate was 15.6 percent (46,480 persons), compared to 12.8 percent, 13.4 percent, and 14.7 percent in the same quarter in 2020, 2019, and 2018 respectively (BSG 2020b, 2020a, 2019). As of the first quarter of 2021, Guyana's working-age population (aged 15 and above) was 581,594 persons, of which approximately 72.1 percent were based in rural areas. Women accounted for 52.5 percent, and men represented approximately 47.5 percent of the working-age population. However, men represented 60.3 percent of the total labor force.[5]

Among the working-age population, participation in the labor force[6] was higher among men than women (64.9 percent versus 38.7 percent) and slightly higher in urban areas (53.2 percent) compared to rural areas (50.3 percent). The employment-to-population ratio was 43.2 percent, with a significant difference between the rate of men (56.3 percent) and women (31.3 percent) (BSG 2021).[7] In the first quarter of 2021, approximately 35.9 percent of youth (aged 15 to 24) were not in education, employment, or training; this percentage has been relatively consistent since data reporting began in 2017 (BSG 2018a, 2018b, 2019, 2020a, 2020b, 2021).

Type of Employment

The private sector accounts for 65 percent of employment, with the public sector and not-for-profit organizations accounting for 23 percent and 12 percent, respectively. More women than men are employed in the public sector. As of the first quarter of 2021, the majority of employed persons worked in either the wholesale and retail trade sector (16 percent), or the public administration and defense sector (13.4 percent). Recent growth in the public administration and defense sector has been offset by a 35 percent decrease in employment in agriculture, forestry, and fishing, which has dropped from the largest single employment sector

[5] The labor force is defined as the sum of employed persons and unemployed persons.
[6] The labor force participation rate is defined as a percentage of the working age population.
[7] The employment-to-population ratio is defined as the proportion of a country's working age population that is employed.

in Guyana's economy in 2017 to the third largest employment sector. Table 9.1-9 presents employment in Guyana by economic sector for 2012 compared to results from the final quarter of 2017 (BSG 2018b) and the first quarter of 2021 (BSG 2021). These data are based on International Standard Industrial Classification, wherein oil and gas activities are captured under the "mining and quarrying" sector.

Table 9.1-9: Employment in Guyana by Economic Sector in 2012, 2017, and 2021

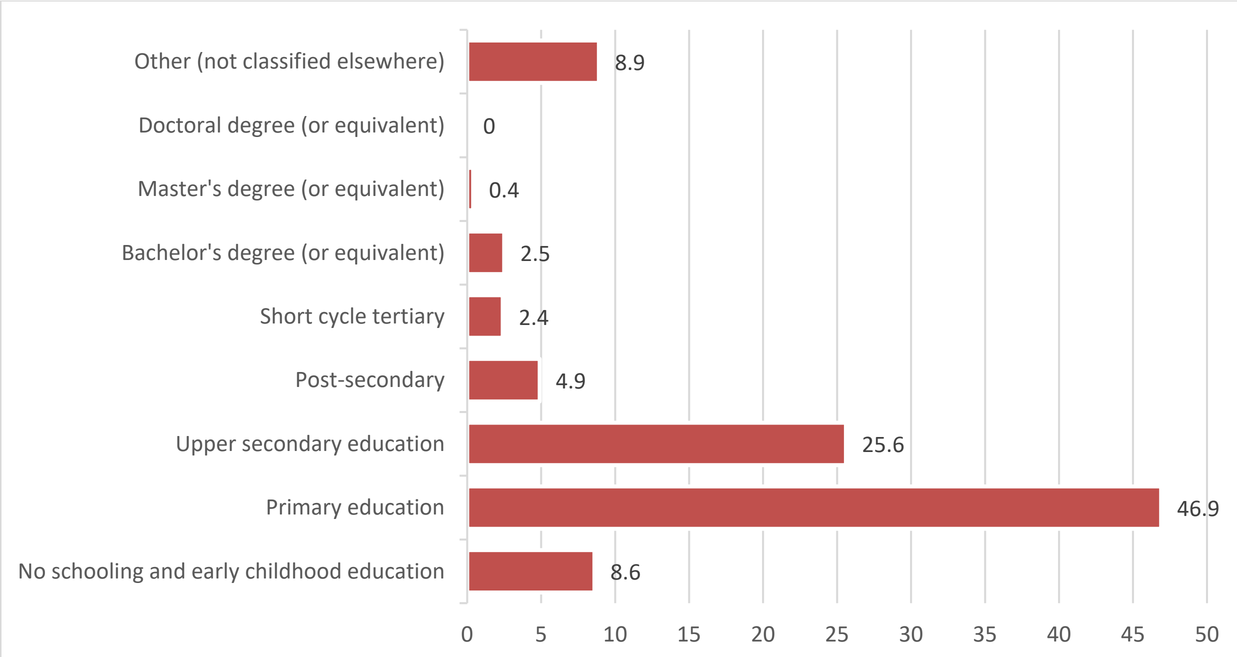
Economic Sectors	2012	2017 [a]	2021 [b]
Agriculture, forestry, and fishing	17.5	18.9	12.2
Wholesale and retail trade	15.4	16.1	16.0
Public administration and defense	7.2	9.3	13.4
Construction	10.4	7.7	10.2
Manufacturing	8.6	8.4	10.1
Transportation and storage	7.7	7.3	6.9
Education	5.3	6.3	4.2
Mining and quarrying	8.2	4.2	4.6
Administrative and support services	3.7	4.3	5.0
Accommodation and food service activities	2.8	4.4	5.1
Human health and social work activities	2.7	1.2	0.8
Activities of households as employers	2.3	2.8	3.4
Other service activities	2.7	2.6	3.3
Financial and insurance activities	1.3	1.2	1.0
Professional, scientific, and technical services	1	0.97	1.1
Water supply, sewerage, and waste management	0.5	1.24	0.6
Information and communication	1	0.84	1.0
Electricity, gas, steam, and air conditioning	1	0.82	0.6
Activities of extraterritorial organizations	0.2	0.8	0.1
Arts, entertainment, and recreation (not statistically significant)	0.6	0.5	0.5
Real estate activities (not statistically significant)	0.1	<0.1	0.1
Not classifiable by economic activity	0.3	<0.1	<0.1

Source: BSG 2016, 2018b, 2021

[a] Results from the Guyana Labour Force Survey for the final quarter of 2017
[b] Results from the Guyana Labour Force Survey for the first quarter of 2021

As of the first quarter of 2021 (Figure 9.1-17), approximately 48.2 percent of workers were classified as informally employed. Of this total, approximately 54 percent were men and 39 percent were women; and approximately 51 percent and 41 percent identified as rural and urban residents, respectively (BSG 2021).[8] Informal employment is characterized by a low level of organization, and labor relations have no contractual arrangements or formal guarantees (BSG 2018b).

[8] Source data do not add to 100 percent. Coefficient of variation for informal worker statistics ranges from 2.62 percent to 5.35 percent (BSG 2021).



Source: BSG 2021

Note: Results for “Masters or equivalent” and “Doctoral or equivalent” categories were not considered statistically significant.

Figure 9.1-17: Percentage Share of Working Age Population by Education Completed, First Quarter 2021

9.1.3.8. Economic Summary within Project Area of Influence

Economic Activity

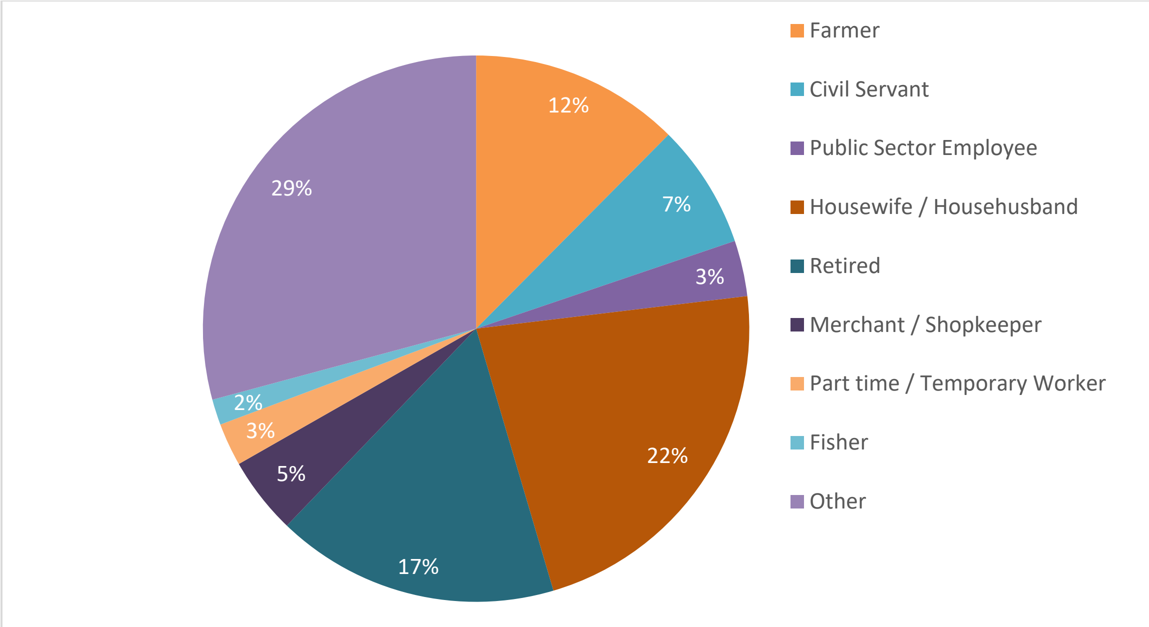
As the Project is not expected to impact Region 2 other than potential impacts on fishing activity by residents of Region 2 (which is discussed previously in Section 9.1.3.4, Fisheries and Aquaculture), regional specific economic activity details provided below focus on Regions 3 and 4.

Regions 3 and 4 both engage in agricultural activities as the primary forms of economy. In Region 3, agriculture is largely centered around rice farming, sugar cane, and coconuts (Ministry of Local Government and Regional Development 2022d). In 2018, Region 3 harvested 15,400 hectares of rice, accounting for nearly three percent of total hectares harvested in Guyana in 2018. Rice production accounted for approximately 55 to 60 percent of overall economy in Region 3 in 2016 (Guyana Rice Producers’ Association 2016, pers. comm.). Additionally, the Guyana Sugar Corporation released the average production range over the past 10 years for Region 3’s sugar estates. The Wales Estate and the Utivlugt Estate have produced an average of 21,843 and 20,000 tonnes of sugar per year over a 10-year period, respectively (GuySuCo Undated_a, Undated_b). Moreover, coconut production in the region has been bolstered by the Ministry of Agriculture’s Hope Coconut Industries Limited (HCIL) project of establishing additional coconut seedling nurseries to help decentralize quality coconut planting in the country. The addition of the four nurseries, established in Wakenaam, Leguan, Canal 2, and Corentyne, has increased HCIL's production capacity to approximately 48,000 coconut seedlings per year (Kaieteur News 2022).

In addition to agriculture, Guyana's commercial and administrative activities are concentrated in Region 4, largely due to the presence of country's capital city, Georgetown, and the associated port, the Port of Georgetown (UNICEF 2017). Georgetown is situated on the northern coast of Guyana, and the port serves as a major source of imports for food, clothing and textiles, and hardware, among other items, and export goods including sugar, rice, bauxite, rum, and lumber. The Port of Georgetown also serves approximately 466 container ships, 265 tankers, 112 break bulk ships, and 3 cruise ships per year (Shipping Association of Guyana 2022). In general, ports are considered economic catalysts, serving an important role for coastal and hinterland areas. As major economic hubs, ports provide important employment and generate socioeconomic benefits and wealth (Dwarakish and Salim 2015). The Port of Georgetown provides a similar benefit to the economy.

Outside of the port-based economy, Region 4's main agricultural outputs include sugar, livestock, fruits and ground provisions, and manufacturing (textiles, clothing, etc.) (Guyana Lands and Surveys Commission 2022). Regarding manufacturing, the Coldingen and Eccles estates in Region 4 are two of four notable industrial estates in the country. The estates create items ranging from furniture, footwear, and windows to chemicals and pharmaceuticals. The Coldingen estate, dating back to 1997, operates on approximately 14 hectares of land and employs around 300 people. The primary activities of the estate are seafood processing, wood processing, furniture making, and textiles. Similarly, the Eccles estate provides jobs for nearly 750 people and also engages in wood-processing, furniture manufacturing, and pharmaceutical services (Luken and Small 2019).

Of the surveyed households in the Primary and Secondary Study Areas, 22 percent of respondents reported primary occupations as housewives or househusbands, while 17 and 12 percent indicated primary occupation as retired and farmer, respectively. Civil servants, public sector employees, fisherfolk, and merchants/shopkeepers were each the stated primary occupations of less than 10 percent of respondents, and nearly 30 percent indicated other (Figure 9.1-18).



Source: 2021 household socioeconomic study

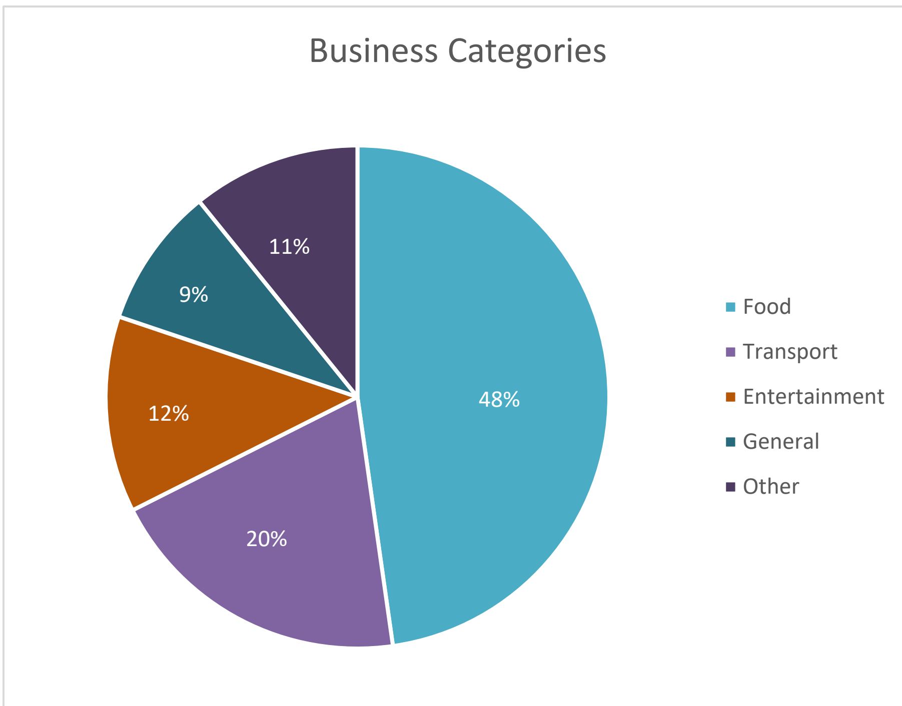
Figure 9.1-18: Reported Occupations in Primary and Secondary Study Areas

The reported primary occupations of households in the Tertiary Study Area deviated slightly from those of the Primary and Secondary Study Areas. Nearly 40 percent of respondents indicated other, while 30 percent reported being a housewife or househusband as their primary occupation. Farmer, civil servant, and retired followed, with 13, 8, and 8 percent, respectively. Approximately 4 percent of households indicated working as a merchant/shopkeeper.

Employment by Sector

Among the Primary and Secondary Study Areas, agriculture, fishing, and forestry comprise the largest proportion of state employment among the 2021 household socioeconomic survey respondents, with over 50 percent of the 234 respondents indicating one or more of these sectors as their primary employment. Construction, wholesale and retail trade, health and social services, and other or other services accounted for 40 percent of the stated primary employment among respondents. Other categories, such as public administration, electricity and water, transportation and storage, education, financial and insurance activities, and information and communication, accounted for the remaining 10 percent of stated employment. Oil and gas, despite being a dominant economic force in Guyana, was the stated primary employment for only two respondents in the Direct AOI, both of whom reside in the Stanleytown to Vreed-en-Hoop area. Respondents in the Tertiary Study Area followed similar trends, with the majority of households indicating agriculture, fishing, and forestry and other or other services as their primary forms of employment (2021 household socioeconomic survey).

In addition to the primary employment sectors recorded in the 2021 household socioeconomic survey, the 2021 business socioeconomic survey also explored the functioning of local businesses in the Primary, Secondary, and Tertiary Study Areas. Of the 150 surveyed business owners in these three study areas, 111 respondents provided information about the category of their business. Approximately 48 percent of these respondents indicated owning and/or working in the “Food” category. In this context, the “Food” category predominantly refers to markets, including shopping markets, food stalls, and super markets. The “Transport” category, referring to automobile service stations, parts shops, and gas stations, was the stated business category for 20 percent of the respondents. The “Entertainment” category, referring to sports stores, bars, restaurants, cultural facilities, and computer stores, was the stated business category for 12 percent of the respondents. The “General” category, referring to general stores, beauty stores, and money transfer services; and the “Other” category, referring to furniture stores, clothing stores, real estate agencies, and pharmacies, were the stated business categories for 9 percent and 11 percent of respondents, respectively (Figure 9.1-19). Over 90 percent of the business survey respondents indicated that female staff comprise at least 40 percent of their workforce.



Source: 2021 business socioeconomic survey

Figure 9.1-19: Percentage Share of Business Categories in the Primary, Secondary, and Tertiary Study Areas

As depicted on Figure 9.1-20, over half of the surveyed businesses with physical storefronts reported having clients arriving at their location by foot. A slightly lesser amount (46 percent) reported receiving clients via car, and only one business reported receiving clients by bicycle.

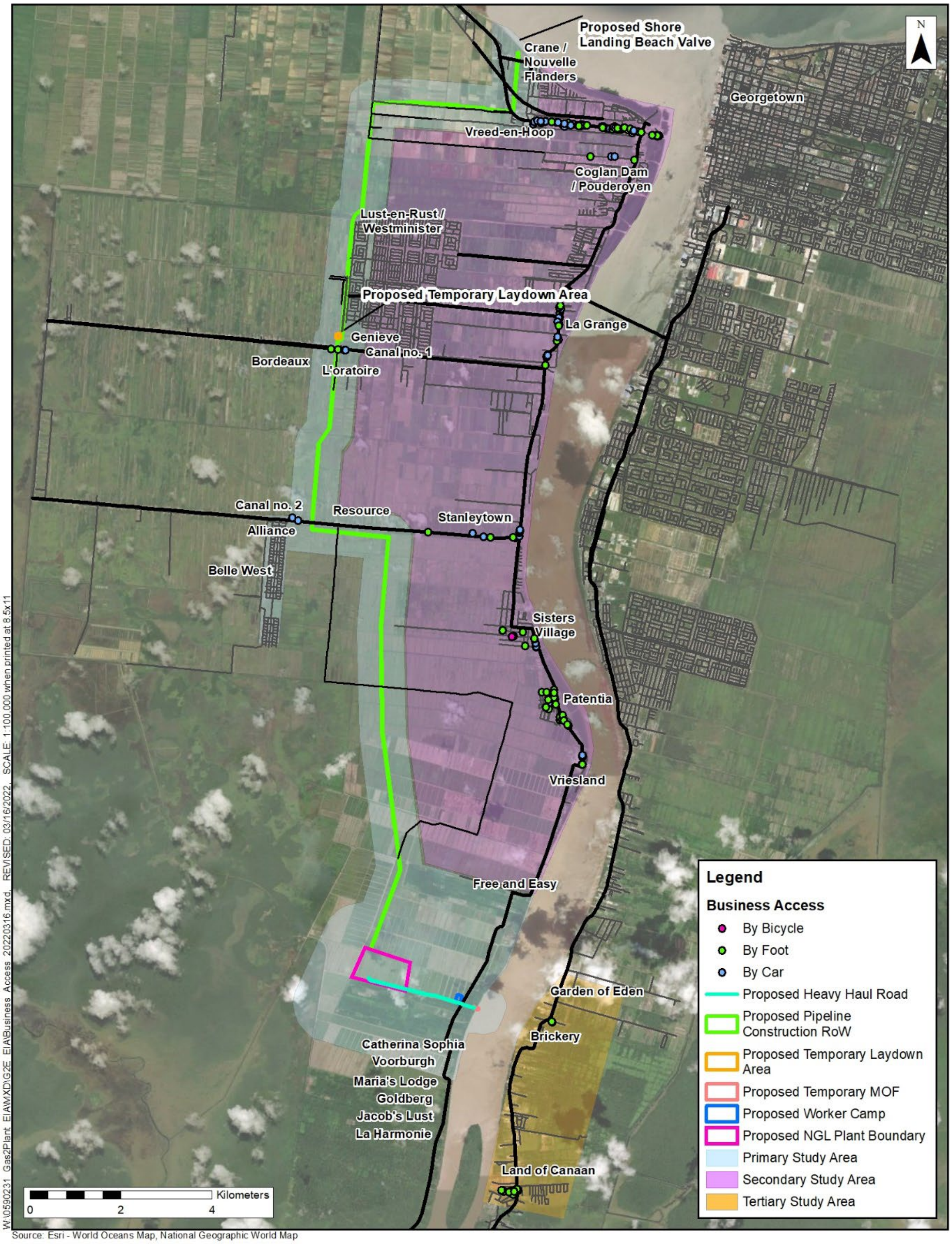


Figure 9.1-20: Reported Means of Access to Businesses

When asked about challenges to their operations, business owners reported a broad scope of issues, many of which were correlated to their respective annual sales volumes. Respondents representing businesses whose estimated annual sales volume was less than $1 million GYD expressed challenges pertaining to competition, financial instability, brand recognition, maintenance costs, costs of goods, and distance from populated areas. Of the eight business respondents whose estimated annual sales volume was less than $1 million GYD, one business reported neighbors as a challenge while another reported a challenge with unlicensed shops in the area. The remaining six indicated there being no challenges to their operations. Businesses in the $6 to $10 million GYD annual sales volume range reported drainage, distance from populated centers, and competition as significant challenges. Competition, cost, and accessibility of raw materials, price increases, available space, and estate closures were the dominant reported challenges for businesses in the $11 to $15 million GYD annual sales volume range. Challenges relating to competition and transportation of materials were the primary reported challenges for the $51 to $60 million GYD and over $100 million GYD annual sales volume businesses, respectively.

The results of the 2021 business socioeconomic survey indicate that the majority of respondents believe the Project will have multiple positive impacts. Out of 150 respondents, nearly three-quarters indicated they are expecting benefits to their business from the Project (Figure 9.1-21). Nearly every respondent from this group identified an increase in sales or business as the most likely benefit. Other expected benefits included improved infrastructure, such as roads, reduced electricity costs, and better job opportunities leading to higher economic power in local communities.

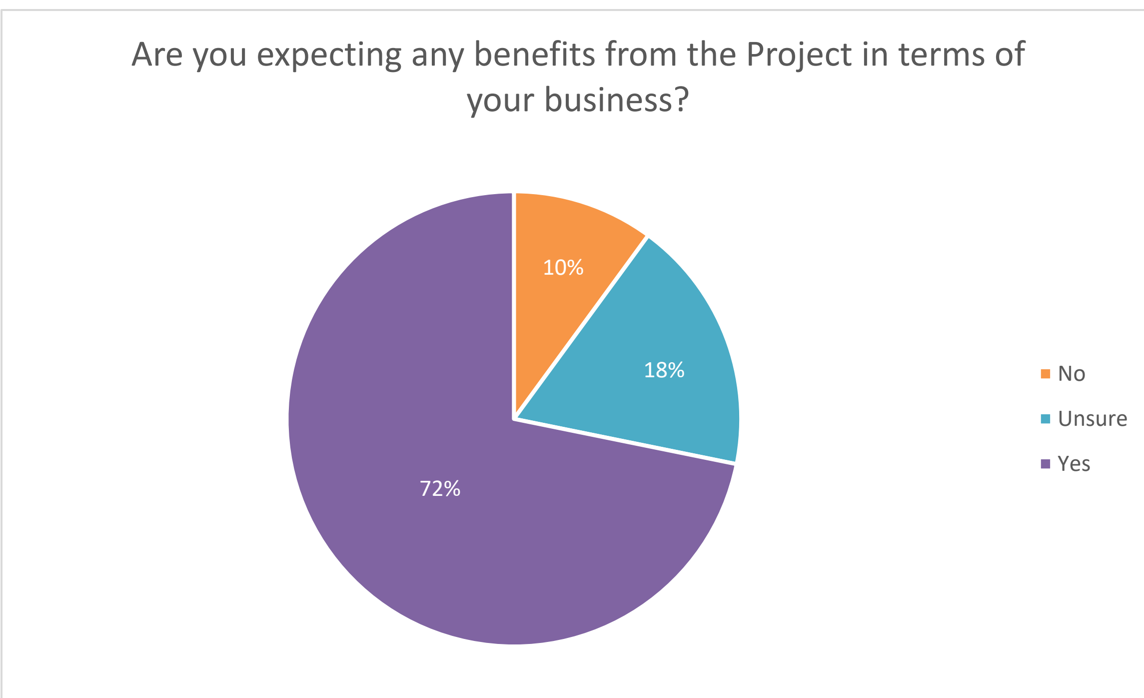


Figure 9.1-21: Business Survey Respondent Expectations of Benefits from the Project

Fishing Activity

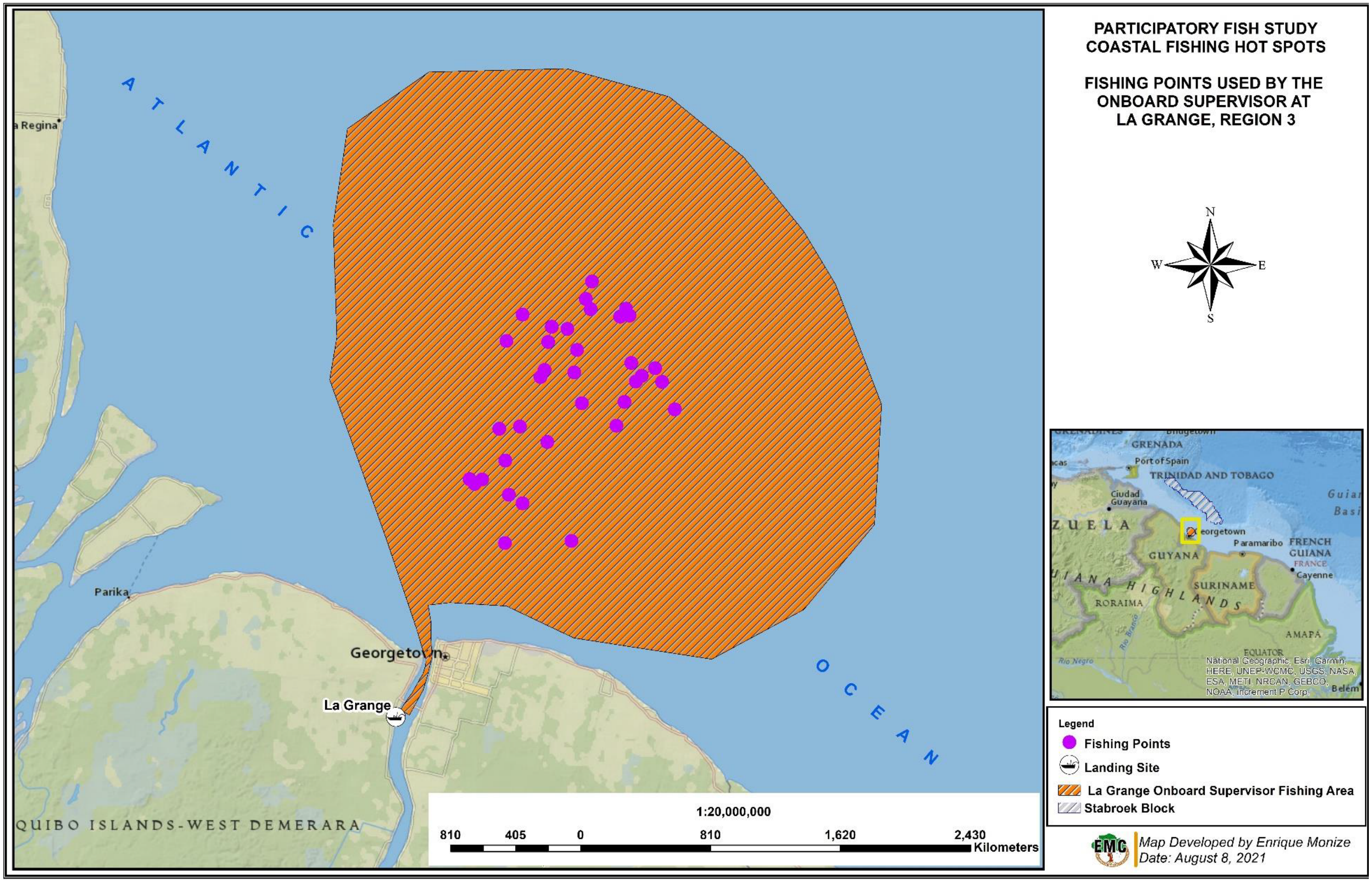
In the Direct Onshore AOI, approximately 35 percent of surveyed households reported fishing in canals and other areas. Of these, most responses indicated that fishing occurred for recreation and/or household consumption. Conversely, nearly 70 percent of 25 households in the Tertiary Study Area engage in fishing.

Fishing activity within the Direct Offshore AOI is informed by the Participatory Fishing Study quarterly report from August 2021 (EMC 2021). Data on fishing practices from study participants at the La Grange landing site (within the Secondary Study Area) suggest the main fishing area for this landing site is north of the mouth of the Demerara River (Figure 9.1-22). All fishing points remained within the fishing area as mapped below with the closest and farthest points from shore located 16.5 and 47.3 kilometers from the mouth of the Demerara River (EMC 2021).

At the La Grange landing site, the fisherfolk use only Cadell lines for commercial fishing and it is the only such landing site in the country. Fisherfolk estimate that six vessels regularly operate from this landing site, most of which are outboard cruisers fitted with 15 horsepower engines. Fisherfolk traverse along the Demerara River to access fishing grounds along the Region 3 and 4 coastlines. Fisherfolk from the La Grange landing site fish about 1 to 25 kilometers offshore at depths of 7 to 27 meters. Fishing trips last from 2 to 16 hours with soak times of approximately 1 to 1.5 hours. Two to three fishing trips are conducted by each vessel per week (EMC 2021).

Fishing activity from other landing sites selected for the Participatory Fishing Study along the Guyanese coast (including Region 2) generally does not appear to occur within the Project's Direct Offshore AOI (EMC 2021).

According to representatives from the Department of Fisheries, although there are no landing sites near Crane - where the offshore pipeline will make its shore crossing, in the past there have been fish pens and fish bands established in this area. Some fisherfolk are also known to use Chinese seines in this area (Department of Fisheries 2022, pers. comm.).



Source: EMC 2021

Figure 9.1-22: Fishing Points Used by the La Grange Onboard Supervisor

9.1.4. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on socioeconomic conditions. The relevant planned Project activities and the associated potential impacts of these activities on socioeconomic conditions are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.1.4.1. Relevant Project Activities and Potential Impacts

The Project will not have any direct impact on the administrative divisions, population distribution, or education systems described in Section 9.1.2, Existing Conditions and Baseline Studies (Social). The Project is not expected to cause a significant influx to the area and, as such, is not expected to cause noteworthy population shifts or impacts to education systems (i.e., by overburdening schools). The anticipated lack of impact on schools is further supported by the anticipated general demographic of workers who will be supporting the Project, as most are not expected to bring families who require educational resources.

Therefore, this section focuses on assessment of potential Project impacts on economic conditions in the Project AOI, as described in Section 9.1.3, Existing Conditions and Baseline Studies (Economic). In general, the planned Project activities that could affect economic attributes of the Project AOI are broadly relevant to economic development, employment and business growth, and existing livelihood activities.

With respect to increased employment and economic development, the Project will have direct and indirect potential impacts resulting from employment of Guyanese nationals and use of local companies to supply various goods and services. The local workforce and local suppliers will also benefit from capacity-building training programs currently being undertaken (and planned to be continued) by EEPGL. There will also be revenue generation and increased tax revenues for the government as a result of the Project.

Project activities could have short-term impacts during the Construction stage as a result of the presence of the offshore pipeline installation vessels and the associated marine exclusion zones that will be in place during construction. The continued presence of some portion of the offshore pipeline exclusion zone within the nearshore area will limit anchorage, trawling, and the placement of fish nets and pens, which could have long-term impacts on fishing livelihoods during the Operations stage. Potential impacts on fishing livelihoods as a result of unplanned events (e.g., collisions between Project vessels and non-Project vessels) are discussed in Chapter 10, Unplanned Events. The Project may also have potential impacts on agricultural livelihoods within the Direct AOI at a relatively small scale; these are discussed in Section 9.6, Land Use and Ownership.

Receptors of potential economic impacts include the general Guyanese population; the general population of Regions 2, 3, and 4 - specifically Georgetown and the communities and individuals within the Direct AOI; local businesses; and fishing vessel operators in the Offshore Project AOI.

Table 9.1-10 summarizes the planned Project activities that could result in potential impacts on socioeconomic conditions.

Table 9.1-10: Summary of Relevant Project Activities and Key Potential Impacts—Socioeconomic Conditions

Stage	Project Activity	Key Potential Impacts
Construction	Project hiring and workforce training	• Direct hiring of Guyanese nationals for a limited number of positions • Hiring of Guyanese nationals by Project contractors and subcontractors • Labor force enhancements (increase in experience, capacity, and skills of local workers) • Greater gender disparity considering a majority of the construction roles are likely to be filled by males • Unmet expectations for employment
	• Project worker spending • Project capacity building programs for prospective local suppliers • Project procurement of select goods and services	• Contributions to GDP and increased sales tax revenues • Increased local business activity and growth • Competition with other local businesses for qualified workers • Unmet expectations for direct benefits for businesses
	• Establishment of safety exclusion zones around major Project installation vessels during offshore pipeline installation • Transit of Project vessels between the offshore pipeline corridor and shorebases in Georgetown and in Guyanese waters between the offshore pipeline corridor and shorebase in Trinidad and Tobago	• Temporary disruption of fishing activities due to presence of Project vessels

Stage	Project Activity	Key Potential Impacts
Operations	• Limited local employment (direct and indirect) • Project worker spending • Project capacity building programs for prospective local suppliers • Project procurement of select goods and services	• Labor force enhancements • Contributions to GDP and increased sales tax revenues • Increased employment • Increased local business activity and growth • Increased demand for services and infrastructure, potentially leading to increased cost of living and/or procurement challenges for other companies
	• Establishment of permanent exclusion zone along portion of nearshore pipeline corridor	• Long-term disruption of fishing activities due to presence of nearshore fishing exclusion zone
Decommissioning	Limited local employment (direct and indirect)	• Direct hiring of Guyanese nationals for a limited number of positions

9.1.4.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluation Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors; frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for socioeconomic conditions (Table 9.1-11). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for socioeconomic conditions sensitivity are provided in 9.1-12.

As described above, socioeconomic conditions is a complex resource. For the purpose of assessing the significance of potential impacts on this resource and the various receptors, separate discussions are provided for the following components, with the assessment focusing on the specific potential impacts that are relevant to each component:

- Economic Development
- Employment and Business Growth
- Existing Livelihoods

Table 9.1-11: Definitions for Intensity Ratings for Potential Impacts on Socioeconomic Conditions

Criterion	Definition
Intensity	**Negligible**: The changes do not bring about a perceptible increase in cost of living or economic competition, or any loss of livelihood or employment.
	Low: There is a small but perceptible increase in cost of living, economic competition, and/or unmet expectations for some individual households or businesses, or the changes impact some individual receptors' ability to engage in their current livelihood(s) at the same level of productivity.

Criterion	Definition
	Medium: Increased cost of living, economic competition and/or unmet economic expectations is evident for receptors at the group, community, or sector level or the changes impact some receptors' ability to engage in their current livelihood(s) at the same level of productivity, and/or cause a loss of working days. The changes impact up to an entire sector within a community in this way.
	High: Increased cost of living, economic competition and/or unmet economic expectations is widespread and uncontrolled and results in chronic hardship for households and/or small and medium-size businesses, or the changes cause the receptors to cease their current livelihood activities for an extended period of time, or indefinitely. The changes impact up to an entire sector within a region in this way.

Table 9.1-12: Definitions for Resource Sensitivity Ratings for Potential Impacts on Socioeconomic Conditions

Criterion	Definition
Sensitivity	**Low**: The local and regional economies are highly diversified and not highly dependent on any one sector. The workforce is highly skilled, would not experience major challenges in shifting to different occupations, and is well positioned to benefit from the Project. Or the receptor can easily adapt to the change without assistance or can shift to alternate livelihood opportunities without impacting ability to subsist and/or earn income.
	Medium: The local and regional economies are somewhat diverse and dependent on a few key industrial sectors that are not all natural resources-based. Alternate economic opportunities, including from the Project, are possible, but the workforce may require additional training to be able to pursue such opportunities, or the receptor may adapt to the change or shift to alternate livelihood activities with assistance and with some disruption to ability to subsist and/or earn income.
	High: The local and regional economies are highly dependent on one or a few industrial sectors that are largely natural resources-based. There are few alternate economic opportunities in the area and/or the workforce does not have the skills to shift to pursue alternate economic opportunities, or the receptor cannot adapt to the change without difficulty and cannot easily transition to alternate livelihood activities. Impacts on current livelihood activities will pose a threat to the receptor's ability to subsist, earn income, and maintain current quality of life.

9.1.4.3. Impact Magnitude Ratings—Socioeconomic Conditions

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to socioeconomic conditions is provided in Table 9.1-13.

Economic Development

Contributions to GDP and Tax Revenue Generation

Guyana's first full year as an oil-exporting nation in 2020 was marked by a 43.5 percent growth in real GDP, although non-oil real GDP contracted 7.3 percent. As such, development of the oil and gas sector represents a critical point in Guyana's development trajectory, and the government has pledged to use funds accrued from the sector for development of the country's infrastructure, including investments in health, education, agriculture, and power for domestic and industrial use (in alignment with Guyana's Green State Development Strategy) (DPI Guyana 2018; Oil Now Guyana 2018). GDP is projected to grow by 47.5 percent in 2022 as a result of the oil and gas sector, specifically brought on by Liza Phase 1 and Liza Phase 2 production (King 2022).

The Project has the potential to impact economic conditions as it is expected to facilitate more energy independence as well as more reliable and less carbon-intensive power generation (as compared to the current fuel oil-fired power sources). Improved electrification at a national scale is typically linked to improvement of economic growth and overall growth in GDP. Economic conditions can also be impacted positively by local hiring for a limited number of new full-time positions, contracted workers, local Project procurement, and Project worker spending.

In addition to direct expenditures and employment, the Project will also likely generate induced economic benefits as other non-Project-related businesses benefit from direct Project purchases. Worker spending and increased purchasing power by locals with additional income will likely expand spending in the local area. This will generate more local value-added tax. These beneficial "multiplier" impacts will occur throughout the Project life.

Considering the factors above, potential economic development benefits and impact on the economy are expected to be **Positive**, and as such a magnitude rating is not assigned.

Labor Force Enhancements

While there may be some short-term challenges in relation to workforce cost of living and competition for some sectors as a result of the Project's Construction stage workforce demands, and as the oil and gas sector adds jobs more generally (i.e., increased demand for workers and services exerts upward pressure on salaries in some sectors), it is expected that the availability of a more robust employment situation with higher than average wages will result in a positive outcome over the longer term. These conditions should contribute to reduced emigration of tertiary educated and otherwise qualified workers from the country. This should provide a more qualified workforce for all sectors of the economy over the medium to long term.

The long-term impacts to the labor force should therefore be **Positive** overall; Guyana is known for having a large percentage of the tertiary-educated population emigrate from the country primarily to Organisation for Economic Co-operation and Development nations (World Bank 2016, 2000; Guyana Chronicle 2015). Provided that a more robust employment environment can be demonstrated, an increase in high-skilled, high-paying jobs associated with the oil and gas sector should contribute to the attenuation of this phenomenon, creating a larger pool of advanced workers for all areas of the economy. EEPGL's ongoing capacity-building and training initiatives will continue to focus on developing a more qualified workforce and enhancing the capacity of local suppliers to serve a larger and more diverse clientele, rather than focusing only on the immediate needs of the oil and gas sector.

The creation of employment opportunities for residents of Guyana will contribute positively to economic conditions by generating additional income taxes, increasing household purchasing power, and generating increased sales tax revenue. The Bureau of Statistics anticipates that Guyanese as a whole will become wealthier as a result of the oil and gas sector, and this offers the potential to result in improved quality of living. For example, as people become wealthier, they are likely to be interested in owning their own home, resulting in an increase in the number of households (Bureau of Statistics 2019, pers. comm.). This impact is considered to be **Positive** and, as such, a magnitude rating is not assigned.

Employment and Business Growth

Increased Employment

At the close of 2021, the total workforce supporting EEPGL's activities (including direct employees and contractors) amounted to more than 6,300, more than half of whom (over 3,500 workers) were Guyanese. The number of Guyanese workers in 2021 increased by 55 percent from the 2,338 Guyanese workers in 2020, representing a doubling of the percentage increase from the 1,898 workers in 2019. Roles held by Guyanese employees cover a range of skill levels and professions, including but not limited to entry-level positions, apprentices, equipment operators, administrators, skilled trades, supervisors, professional personnel (e.g., engineers, lawyers, scientists), and managerial staff.

The Project will have limited direct local employment during the Construction stage, as most employment opportunities will arise through EEPGL's construction contractors for the onshore pipeline and NGL Plant construction. As a result, only modest increases in total direct employment by EEPGL, including an increase of EEPGL's office staff (for all EEPGL activities), are expected. EEPGL intends to continue hiring Guyanese nationals in alignment with its Local Content Plan, which outlines EEPGL's strategy and multi-tiered approach to building Guyanese workforce and supplier capabilities in conjunction with strategic investments in the local community.

As discussed in Chapter 5, Project Description, during the Construction stage there will be an estimated peak of approximately 500 construction worker positions, of which between 25 and 50 percent are expected to be Guyanese. It is expected that a majority of the Guyanese workforce will comprise individuals already residing in either Region 3 or Region 4. During the Operations and Decommissioning stages, there will be approximately 40 and 50 full-time equivalent (FTE) workers, respectively, who will likely reside predominantly either in Region 3 or 4. Employment will contribute to the improvement of livelihoods and economic wellbeing of workers and their families.

While employment is one of the primary indicators of sustainable economic development, a majority of the employment during the Project will be during the Construction stage and on a contracted basis. Therefore, beyond ensuring appropriate capacity to perform work or deliver services to EEPGL and its contractors, EEPGL is committed to capacity-building that is designed to strengthen local workers' and entrepreneurs' skills and employability, providing employment and livelihood benefits over the longer term.

This impact is considered to be **Positive** and, as such, a magnitude rating is not assigned.

Increased Local Business Activity

In addition to direct or indirect employment of Guyanese for the Project workforce, the Project will promote the indirect employment of workers through its procurement of select local goods and services. Local and foreign workers that are off-shift are also expected to spend a portion of their salaries in the Project AOI (specific locations depend upon a series of factors including where local workers reside, how they commute, where foreign workers are housed, and how the Project limits or restricts worker movements during off-hours). It is likely that workers will spend money within the Project AOI on food, transportation, and entertainment. This increase in business for these local service providers could potentially lead to increased incomes for Guyanese outside of the Project workforce, additional hiring, and continued investment in these local businesses, allowing for further growth.

EEPGL's activities will engage local suppliers and thus strengthen local workers' and entrepreneurs' skills and employability. The increased skill development will deliver long-term employment and livelihood benefits.

In terms of local procurement, the majority of EEPGL's (and subcontractors') suppliers supporting in-country work scopes are Guyanese-owned (over 880 unique Guyanese-owned suppliers used in 2021, up from 806 in 2020). This increase in Guyanese suppliers is representative of an overall continuous increase in local business activity as oil and gas operations have expanded in Guyana (creating more opportunities) and as Guyanese businesses have built capacity and developed their capabilities to service the industry. Business with Guyanese-owned suppliers amounted to $44 billion GYD ($219 million USD) for 2021, a 37 percent increase from 2020. In February 2021, Stabroek Block co-venturers ExxonMobil, Hess Corporation, and CNOOC Limited launched the Greater Guyana Initiative (GGI). GGI represents a partnership between the Stabroek Block co-venturers and the Government of Guyana to promote capacity building and workforce development to support the broader economy.

As part of its efforts to optimize local content during prior development projects, including the Liza Phase 1 and Liza Phase 2 Development Projects, EEPGL and its contractors have implemented a range of training programs for workforce and local business-capacity building, which covered professional, technical, and health and safety training.

In addition, during 2021 alone, more than 3,000 tender notifications were shared with the local community. Guyanese companies also benefited from support provided through the Centre for Local Business Development (CLBD), which aims to help local businesses become globally competitive. For example, to date more than 29 companies have benefited from the CLBD's ISO Mentorship Program.

It is anticipated that these capacity-building efforts will contribute to improved employment and business opportunities for participants over the long term. Similarly, a range of government capacity-building programs on topics such as waste management, oil spill response, protective species observer training, marine turtle telemetry and tracking, gas and power, energy literacy, local content, etc., have been conducted in support of the Liza Phase 1, Liza Phase 2, and

Payara Development Projects, and these should contribute to enhanced administrative efficiency that will further facilitate business activity in Guyana. As part of the Project, EEPGL intends to continue on the same course with its workforce development, supplier, and government capacity-building efforts.

This impact is considered to be **Positive** and, as such, a magnitude rating is not assigned.

Increased Cost of Living and Economic Competition

Potential adverse impacts of the Project on economic conditions associated with planned Project activities could include potential cost of living increases due to a higher demand for some goods and services, either through direct Project procurement or through Project worker purchases (see Section 9.3, Social Infrastructure and Services, for potential impacts on social infrastructure and services, including potential impacts on cost of housing and lodging). Additionally, increased competition for skilled workers, support services, and semi-skilled labor during the Construction stage could result from EEPGL and its contractors' hiring and procurement activities. This could present a potential adverse impact for other companies and sectors that may not be able to pay salaries comparable to those of the oil and gas sector. With the expansion of job opportunities in the oil and gas sector, it is likely that other sectors and the economy overall during the initial years of the Project's life cycle will need to adjust to wider economic changes, which may include upward pressure on salaries.

The Project's relatively small direct workforce during all stages of the Project compared to the national workforce (i.e., 3,500 direct and contractor Guyanese workers supporting EEPGL's other activities as of the end of 2021, in addition to the approximately 300 Guyanese Project direct and indirect workers represents less than 1 percent of the working age population; BSG 2021) suggests that Project-induced increases in cost of living and competition are expected to be limited. However, the Project's demand for workers with specific types of skills and experience (e.g., machine operators, general construction workers) may disproportionately affect some categories of workers more than others during the Construction stage.

Of the 111 businesses within the Direct AOI who identified their category of business in the 2021 business socioeconomic survey, 48 percent belonged in the food category, including food markets, food stalls, and restaurants. It is likely that these businesses may compete for Project-related business, including worker spending. For businesses partaking in the 2021 business socioeconomic survey, competition was already listed as a primary challenge across all sizes of business. While an increase in demand is generally positive and healthy competition is normal, if the demand is less than anticipated or focused on a few vendors only, the induced increase in competition could lead to degradation of social cohesion.

Although oil-and-gas sector activity has seen rapid growth in in recent years, there is little evidence of changes in cost of living specific to the industry other than anecdotal accounts. As the Guyanese economy continues to evolve, however, there could be a future perceptible increase in prices and competition for workers for some receptors. The contribution of the Project is expected to be a small part of this change at the macro level; however, increased cost of living and economic competition will likely be evident for individual receptors within the

Project AOI and potentially at the sector level (e.g., construction sector). However, the construction sector was the fourth largest sector in 2021, representing 10.2 percent of employment in Guyana in 2021 (BCG, 2021) so the limited amount of local Project workers for the Construction stage is not likely to impact the entire sector. Therefore, the intensity of the potential impact is rated as **Low**. Project-related salaries and economic activity will decrease after the Construction stage as a result of a limited workforce in the Operations and Decommissioning stages, so the intensity of impact will decrease to **Negligible** for these stages. The impact will occur throughout the Project life cycle, yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact within the Direct AOI is rated as **Small**.

Unmet Employment and Business Opportunity Expectations

Specific to the Project AOI, of the 436 respondents of the 2021 household socioeconomic survey who responded to the question of whether or not they would expect themselves or members of their household to receive employment from the Project, 312 respondents (over 71 percent) answered in the affirmative. The number of those in the Direct AOI with Project-related employment expectations exceeds the number of anticipated available positions for Guyanese at all stages of the Project. Of the 149 business respondents within the Direct AOI who were asked a similar question in the 2021 business socioeconomic survey related to expectation of Project benefits for their business, 72 percent answered in the affirmative.

Furthermore, as noted in Section 9.1.3.8, Economic Summary within Project AOI, approximately 51 percent of participants of the 2021 household socioeconomic survey in the Direct AOI listed themselves as having occupations considered unemployed or underemployed.

Out of 150 business respondents to the 2021 business socioeconomic survey, nearly three quarters indicated they are expecting benefits to their business from the Project, including an increase in sales or business as the most likely benefit. Other expected benefits included improved infrastructure such as roads, reduced electricity costs, and better job opportunities leading to higher economic power in local communities. These pre-existing expectations, if not met, could lead to a degree of resentment regarding the Project and degradation of social cohesion (as assessed in Section 9.2, Community Health and Wellbeing).

Considering the potential is evident for unmet economic expectations for more than a few individuals or businesses throughout the Direct AOI, the intensity of the potential impact related to unmet expectations for individual employment is likely to be **Medium** at the early stages of the Project, decreasing to **Low** in the later stages of the Construction stage, when jobs have been filled and the nature and scale of opportunities become better understood by the communities. Similarly, it is likely that expectations related to business opportunities will remain higher as the Project ramps up into the early parts of the Construction stage and then will decrease for the later Construction stage. By the time of the Operations and Decommissioning stages, as local communities and businesses become more familiar with the Project’s benefits and opportunities, the intensity will decrease to **Negligible**. However, unmet expectations for receptors will likely occur more than occasionally for up through the early Construction stage, yielding a frequency designation of **Continuous** for all stages and a duration of **Medium-term** (because as noted above, unmet expectations and misperceptions will lesson as Project opportunities are realized). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact across the Direct and Indirect AOIs is rated as **Small**.

Greater Gender Disparity in Construction Stage

Among the working age population in Guyana, participation in the labor force (employed and unemployed) was higher in 2021 among men than women, 64.9 percent versus 38.7 percent, respectively (BSG 2021). The employment-to-population ratio, which is the proportion of the country's working age population that is employed, was 43.2 percent in 2021, with a significant difference between the rate for men (56.3 percent) and women (31.3 percent) (BSG 2021). According to various reports by international agencies, gender mainstreaming within Guyana has generally not been successful to date (ILO 2018) and there is also clear gender inequality in access to the labor force and income broadly as a result of structural inequality (CANARI 2021). Women and vulnerable populations in Guyana have the propensity to benefit less from employment opportunities. Within the Direct AOI, 130 survey respondents self-identified as vulnerable, while an additional 310 and 314 households indicated the presence of children and elderly, respectively.

Given the local context and the number of people considered vulnerable in the Direct AOI, as well as the prevalence of the perception that jobs on large construction works and in operations of industrial facilities are typically occupied by men, it is very likely that women will not have equal access to Project employment opportunities with Guyanese businesses unless they are directly targeted for recruitment. Furthermore, according to 2020 data, a female employee's average hourly salary in Guyana was approximately 30 percent less than a man's and the female unemployment rate was 16.5 percent compared to 12.3 percent for men (UNWomen 2020).

While EEPGL is committed to improving gender equity and has various initiatives in place that may benefit the Project,[9] it is unclear how many of the locally available positions during the Construction stage (where the quantity of positions is substantially higher than Operations and Decommissioning stages) will either improve gender equity in local employment or further contribute to the existing gender disparity.

Considering that inequitable employment opportunities will only impact some individual receptors, the intensity of the potential impact is rated as **Low.** It will occur throughout the Project life cycle, yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact within the Direct AOI is rated as **Small**.

[9] One example is the EEPGL-supported and CLBD-initiated women-focused entrepreneurship program: Accelerate-Her. In late 2021, 35 women were shortlisted to participate in a series of workshops and skills development programs. Some of the women-represented businesses were from the construction sector.

Existing Livelihoods

Limitations on Fishing in Offshore and Nearshore Areas

Few potential adverse impacts on existing livelihoods related to deepwater fishing are expected as a result of planned Project activities. Current fishing activities (both industrial and artisanal) rarely occur as far offshore as the seaward end of the offshore pipeline; according to various members of the industrial and artisanal fishing community as well as the Fisheries Department, the existing offshore marine safety exclusion zones associated with the Destiny and Unity Floating Production, Storage, and Offloading (FPSO) vessels, which will not change as a result of the Project, are expected to continue to have little or no impact on existing fishing activity (ERM 2018, pers. comm.). However, there will be new temporary marine safety exclusion zones associated with the major installation vessels during offshore pipeline installation in the Construction stage. These zones will move with the major installation vessels along the offshore pipeline route. It is anticipated that these temporary marine safety exclusion zones during the Construction stage may impact commercial vessels that operate in deeper waters and artisanal fisherfolk vessels that operate in shallower waters – in particular in the nearshore offshore pipeline segments and at the shore landing site.

There may also be Project interactions with fisherfolk associated with support vessels transiting between the offshore pipeline corridor and shorebases in Georgetown during Construction. Considering the small number of operators that will likely be impacted by the temporary safety exclusion zones or support vessel movements, and the ability for EEPGL to provide information in advance about EEPGL operations, potential impacts to livelihoods as a result of the temporary marine safety exclusion zones during the Project's Construction stage have an intensity rating of **Low**. Situations resulting in the inability of fishing vessels to use the relatively small area of ocean that will be affected, especially considering the zones will move with the Project vessels as the pipeline is laid, will be **Episodic**. The potential for such situations will extend only during offshore pipeline construction, which is anticipated to last approximately 12 months, and are therefore considered to be **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact within the Offshore Indirect AOI is rated as **Small**.

The highest potential for Project interactions with fisherfolk will be associated with the nearshore segment of the offshore pipeline construction activities. As noted in Chapter 5, Project Description, the nearshore area in the vicinity of Crane will be temporarily disturbed by offshore pipeline burial in this area, as well as the completion of the pipeline shore crossing. Various construction equipment (e.g., pipeline barge, crane barge, horizontal directional drilling [HDD] rig) will be present in the area for the limited amount of time it takes for the offshore pipeline to be tied in to the onshore pipeline. The area along the beach and the in-water area around the offshore pipeline corridor will be demarcated as a safety exclusion zone, within which artisanal fishing will be prohibited. In regard to the extent to which the area is used or traversed for fishing and/or as a landing site, the Fisheries Department has stated that fishing activities occur in the general area in both the nearshore and offshore environments and that there are fish net systems and pens in the nearshore and far offshore environments that could be affected by

Project activities (Department of Fisheries 2022, pers. comm.). The interaction with Project vessels and related construction activities will impact some individual receptors' ability to engage in their current livelihood(s) at the same level of productivity in this particular area over a certain period of time, and the intensity is thus rated as **Low**. Situations resulting in the inability of artisanal fishing vessels to continue normal operations as a result of the construction activity (including the Project safety exclusion zone which will move with the construction activity) will be **Continuous** and will extend more than a week but less than a year (**Medium-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Small** in the Construction stage.

It is anticipated that the safety exclusion zone for a portion of the nearshore pipeline segment will remain in place throughout the Operations stage, resulting in the prohibition of any fishing activity in that area to prevent accidental damage to the pipeline in shallower waters. This exclusion zone could prevent more than a few individuals (e.g., a group of fisherfolk from a specific community; seasonal fisherfolk) from engaging in their current livelihood(s) at the same level of productivity for an extended period of time. Considering the geographic extent of the permanent exclusion zone has yet to be determined, a conservative approach is taken and the intensity is rated as **Medium**. Situations resulting in the inability of artisanal fishing vessels to continue normal operations as a result of the permanent safety exclusion zone will be **Continuous** and will extend more than a year in the Operations stage (**Long-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Medium** during the Operations stage.

9.1.4.4. Sensitivity of Resource—Socioeconomic Conditions

Based on the sensitivity rating definitions in Table 9.1-12, the resource sensitivity for the Project's potential positive impacts relate to economic development is considered **Medium**.

With respect to employment and business growth, receptors in the Direct AOI are considered to have a **High** level of sensitivity given that most income generating activity within the area is natural resources based. There are few alternate economic opportunities in the area, and many of the population may lack the skills to shift to pursue alternate economic opportunities as provided by the Project.

With respect to economy and livelihood impacts, artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential temporary fishing disruption impacts from Project activities and are thus considered to have a **Medium** level of sensitivity to such impacts. Industrial fisherfolk are generally better able to adapt to these types of impacts, as they have a better ability to use alternate fishing locations during the period of temporary impacts. However, as a conservative measure and in recognition of the variability in ability to adapt across the sector, industrial fisherfolk are considered to also have a **Medium** level of sensitivity to potential impacts on fishing activity.

9.1.4.5. Pre-mitigation Impact Significance—Socioeconomic Conditions

As discussed above, the potential impacts on economic development and increased employment, worker spending, and business activity that will result from Project employment, procurement, and worker spending are considered to be **Positive**. As described in Chapter 3, EIA Approach and Impact Assessment Methodology, this assessment does not develop significance ratings for positive impacts.

Assuming implementation of the embedded controls listed in Table 9.1-13, the intensity ratings for potential Project impacts for increased cost of living and economic competition, unmet expectations, gender disparity and limitations, and disruptions to fishing activities are **Low**. This results in pre-mitigation magnitude ratings of **Small** for these potential impacts**.**

Coupled with sensitivity ratings of **Medium** (fisherfolk and receptors within Georgetown) and **High** (for individual receptors within the Direct AOI), the pre-mitigation impact significance for socioeconomic conditions ranges from **Minor** to **Moderate**.

9.1.5. Impact Management and Monitoring Measures

Based on the **Minor** to **Moderate** significance of potential socioeconomic conditions, various mitigation measures are proposed in addition to the embedded controls that are taken into account in the pre-mitigation impact significance ratings.

In terms of managing expectations related to employment and business opportunities, EEPGL will proactively communicate the Project's limited direct staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers; and will do the same for the number and types of jobs expected to be contracted during the Construction stage. EEPGL will augment stakeholder engagement and recruitment efforts to specifically target households and businesses within the Direct AOI with communications material related to Project employment and business opportunities to proactively manage expectations. These efforts will decrease the significance of potential impacts on unmet employment and business opportunity expectations to **Minor**.

EEPGL will develop contract language for pipeline and NGL Plant contractors encouraging recruitment and training of women for various Project-related construction roles. This effort may help with improving gender disparity during the Construction stage, and the significance of this potential impact is therefore reduced to **Minor**.

EEPGL will also develop contract language for pipeline and NGL Plant contractors to advertise the types of goods and services they will procure locally (within the Direct AOI) and the bidding process for ensuring transparency, which should help to decrease rates of unhealthy local competition driving up the cost of living as a result. These efforts will decrease the significance of potential impacts related to increased cost of living and economic competition to **Minor**.

As a mitigation measure to address the potential for adverse impacts on fishing activities, the Project intends to issue notices to mariners via the Maritime Administration Department (MARAD), as well as via the Trawler's Association and fishing co-ops for major marine vessel movements, including movements of major installation vessels. Notices will aid other marine users so they can avoid areas where concentrations of Project vessels and/or safety exclusion zones may be present. The Project will also continue to communicate major vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators, including those vessels known to operate in the vicinity of the offshore pipeline corridor who might not ordinarily receive Notices to Mariners and, where possible, communicate Project activities to those individuals to aid them in avoiding Project vessels through the stakeholder engagement process. This will allow fishing boat operators to adjust their fishing locations if needed to avoid these offshore locations with higher densities of Project vessels. With implementation of this mitigation measure, the significance of potential impacts on industrial fisherfolk is considered to be reduced to **Negligible** during the Construction stage. However, the geographic extent to which the permanent exclusion zone along the nearshore portion of the offshore pipeline corridor will extend is currently unknown. If it should extend into deeper waters where trawlers may be active, this could have longer-term impacts on where and how they fish and therefore, the significance remains conservatively at **Minor** during the Operations stage.

Many of the artisanal craft engaged in subsistence fishing activities do not carry radios, may use remote ports, and/or may not receive notices of increased vessel activity issued by the Project through the channels described above. Accordingly, this mitigation measure is likely to be somewhat less effective for artisanal fisherfolk. For this reason, while the same mitigation measure described above will be applied to address potential impacts on artisanal fisherfolk, including regular engagement on Project-related activities where they are informed of Project activity, the significance of potential impacts is maintained at a rating of **Minor**.

In relation to the Project Safety Zone around the nearshore area of the offshore pipeline, EEPGL will not only utilize Notices to Mariners, but also will proactively engage with nearshore artisanal fisherfolk in advance of construction and advertise a cut-off date for all fisherfolk to remove fishing equipment from the nearshore project exclusion zone. It is assumed this cut-off date will also apply throughout the Operations stage as the exclusion zone will remain in effect to prevent accidental damage to the pipeline in shallower waters. This will allow the fisherfolk time to relocate their fishing activities to another area so the restrictions in the nearshore segment will be less likely to impact their livelihoods in the longer term, as they will have time to adjust. The significance of potential impacts as a result of the permanent exclusion zones in both the Construction stage and Operations stage is thus reduced to a rating of **Minor**.

Table 9.1-13 summarizes the management and monitoring measures relevant to socioeconomic conditions.

Table 9.1.13: List of Management and Monitoring Measures

Embedded Controls
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable.
Work with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities in alignment with Guyana's Local Content policy.

Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.
Mitigation Measures
Notices to Mariners are issued through the MARAD for their communication with the public, and information is provided to the Department of Fisheries for their distribution to stakeholders (including associations, co-ops, and fisherfolk) within the fishing industry in country, regarding movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
Proactively communicate the Project’s limited direct staffing requirements as a measure to reduce the magnitude of potential population influx to Region 3 and Georgetown from job seekers; also advertise the number and types of jobs expected to be contracted during the Construction stage.
Augment stakeholder engagement and recruitment efforts to specifically target households and businesses within the Direct AOI with communications material related to Project employment and business opportunities in an effort to proactively manage expectations.
Develop contract language for pipeline and NGL Plant contractors encouraging recruitment and training of women for various Project-related construction roles.
Develop contract language for pipeline and NGL Plant contractors to advertise the types of goods and services they will procure locally (within the Direct AOI) and the bidding process for ensuring transparency.
Proactively engage with nearshore artisanal fisherfolk in advance of construction and advertise a cut-off date for all fisherfolk to remove fishing equipment from the Nearshore Project Exclusion Zone.
Monitoring Measures
Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis; disaggregate by gender.
Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis, including within the Direct AOI.
Monitor frequency of engagement with stakeholders, including fisherfolk, communities within the Direct AOI, vulnerable groups, and Indigenous populations.

9.1.6. Assessment of Residual Impacts

As described above, there are mitigation measures proposed to address potential impacts on socioeconomic conditions. Accordingly, the residual impact significance ratings are reduced to **Negligible** (for impacts on industrial fishing livelihoods) and **Minor** (for employment and business growth and artisanal fishing livelihoods). The impacts on economic development as well as increased employment, worker spending and increased local business activity remain **Positive**.

Table 9.1-14 through Table 9.1-16 summarize the assessment of potential pre-mitigation and residual impact significant for the assessed potential impacts on socioeconomics.

Table 9.1-14: Summary of Potential Pre-Mitigation and Residual Impacts—Economic Development

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction and Operations	Labor force enhancements Contributions to GDP and tax revenue generation Worker spending	Medium	Not rated (Positive)	Positive	None	Positive

Table 9.1-15: Summary of Potential Pre-Mitigation and Residual Impacts—Employment and Business Growth

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Increased employment Increased Local Business Activity	High	Not rated (Positive)	Positive	None	Positive
	Increased cost of living and economic competition	High	Medium	Moderate	Develop contract language for construction contractors to advertise the types of goods and services they will procure locally and the bidding process for ensuring transparency.	Minor

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	Greater gender disparity in Construction stage	High	Medium	Moderate	Develop contract language for pipeline and NGL Plant contractors encouraging recruitment and training of women for various Project-related construction roles	Minor
	Unmet employment and business opportunity expectations	High	Medium	Moderate	Proactively communicate the Project's limited direct staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job seekers; advertise the number and types of jobs expected to be contracted during the Construction stage. Augment stakeholder engagement and recruitment efforts to specifically target households and businesses within the Direct AOI with	Minor

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
					communications material related to Project employment and business opportunities in an effort to proactively manage expectations.	
Operations Decommissioning	Increased employment Worker spending Increased local business activity	Medium (Georgetown population) High (Direct AOI population)	Not rated (Positive)	Positive	None	Positive
	Increased cost of living and economic competition	High	Negligible	Negligible	None	Negligible
	Unmet employment and business opportunity expectations	High	Negligible	Negligible	None	Negligible

Table 9.1-16: Summary of Potential Pre-Mitigation and Residual Impacts—Existing Livelihoods

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Industrial Fisherfolk—impacts on fishing livelihoods as a result of temporary disruption of fishing activities due to presence of Project vessels	Medium	Small	Minor	Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones	Minor
	Artisanal Fisherfolk—impacts on fishing	Medium	Small	Minor		Minor

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	livelihoods as a result of temporary disruption of fishing activities due to presence of Project vessels				Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners	
Construction	Artisanal Fisherfolk—impacts on fishing livelihoods as a result of nearshore and shore landing construction	Medium	Medium	Moderate	Proactively engage with nearshore artisanal fisherfolk in advance of construction and advertise a cut-off date for all fisherfolk to remove fishing equipment from the Nearshore Project Safety Zone	Minor
Operations	Artisanal Fisherfolk—long-term disruption of fishing activities due to nearshore safety exclusion zone	Medium	Medium	Moderate	Continuous engagement with nearshore artisanal fisherfolk regarding permanent safety exclusion zone	Minor

9.2. Community Health and Wellbeing

This section presents an overview of community health and wellbeing in Guyana and in the vicinity of the Project (including Region 3 and Region 4), and considers how the health and wellbeing of individuals and communities may be affected by the Project.

9.2.1. Baseline Methodology

The understanding of existing conditions (Section 9.2.2, Existing Conditions and Baseline Studies) is based on a combination of desktop (secondary) and field-based (primary) research as described in Section 9.1, Socioeconomic Conditions. Desktop studies drew on publicly available data provided by government entities and other stakeholders, and other relevant data received from public sources. Field-based research included household surveys conducted in the vicinity of the Project, as described in Section 9.1, Socioeconomic Conditions.

Due to the availability of health data at a national and regional level in Guyana, this section focuses on national and regional profiles; community-specific data are not publicly available. Furthermore, in many cases, health-related data from recent years are not available in the public domain. However, the 2021 household socioeconomic survey conducted in the vicinity of the Project included questions pertaining to community health and wellbeing, and findings from these questions are discussed herein.

Recent data sources, including data on COVID-19, have also been incorporated, where available; however, not all statistics and/or reports are regularly updated and recent sources are not available for all indicators.

This section also incorporates information obtained directly from stakeholder engagement and key informant interviews conducted between 2017 and 2022 with members of national, regional, and local governments; civil societies and non-governmental organizations; local community members; and other stakeholders for the Project and past EEPGL projects. Additional detail regarding stakeholder engagement can be found in Chapter 6, Stakeholder Engagement.

Study areas for socioeconomic resources, as referenced in this section, are defined and illustrated in Section 9.1, Socioeconomic Conditions, including:

- Direct AOI
  - **Primary Study Area**[10]: This Study Area includes communities and households within 500 meters of the onshore pipeline corridor; within 1 kilometer of the NGL Plant boundary and/or temporary MOF; within the area extending from the Demerara River immediately north of Free and Easy village, south and west to the NGL Plant and temporary MOF; plus the area encompassing settlements in the Belle West housing scheme;

[10] The socioeconomic Primary Study Area includes the Direct AOI for biophysical components, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

  - **Secondary Study Area**: This Study Area includes communities and households located between the Primary Study Area and the Demerara River.
- Indirect AOI
  - **Tertiary Study Area**: This Study Area includes the communities on the East Bank of the Demerara River immediately across from the temporary MOF.
  - **Regional Study Area**: This Study Area includes the remainder of Region 3 plus Regions 2 and 4 (the balance of the Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology). The communities that were engaged and/or studied in the Regional Study Area include Georgetown, Santa Aratak, and Pakuri.

The combined socioeconomic Study Areas are equivalent to the Onshore Indirect AOI as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

In Section 9.2.3, Impact Prediction and Assessment, the identification and assessment of potential impacts on community health and wellbeing has been conducted in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology.

In assessing the potential community health and wellbeing impacts of the Project, the World Health Organization's definition of *health* was applied: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO 2006). Factors that affect health are commonly called "determinants of health," which are defined by the International Finance Corporation (IFC) as "individual, social and environmental, and institutional factors that are directly, indirectly, or cumulatively affected by the proposed project" (IFC 2009), as described in Table 9.2-1.

Table 9.2-1: Determinants of Health

Categories of Determinants of Health	Examples of Specific Health Determinants
Individual factors: Genetic; biological; lifestyle; behavioral; and/or circumstantial, of which some can be influenced by proposals and plans	Gender; age; dietary intake; level of physical activity; tobacco use; alcohol intake; personal safety; sense of control over own life; employment status; educational attainment; self-esteem; life skills; stress levels; etc.
Social factors: Community, economic and/or financial conditions	Access to social and health-related services and community; social support or isolation; housing; income; distribution of wealth; sexual customs and tolerance; racism; attitudes to disability; trust; sites of cultural and spiritual significance; local transport options available; etc.
Environmental factors: Physical	Quality of air, water, and soil; access to safe drinking water and adequate sanitation; disease vector breeding places; land use; urban design
Institutional factors: The capacity, capabilities and jurisdiction of public sector services	Availability of services, including health, transport, and communication networks; education and employment; environmental and public health legislation; environmental and health monitoring systems; laboratory facilities; etc.

9.2.2. Existing Conditions and Baseline Studies

This section describes the existing community health and wellbeing characteristics of the Project AOI.

9.2.2.1. Health Status

According to the Ministry of Health, health outcomes in Guyana have steadily improved over recent decades (Persaud 2013). From 2000 to 2016, there was a 0.9 percent increase in personal healthcare access and quality. As of 2017, life expectancy for all births had increased from 69 years for females and 62.4 years for males in 1990 to 72.2 years for females and 66.4 years for males (IHME Undated). The crude death rate[11] decreased from 6.6 per 1,000 persons in 2003 to 6.1 per 1,000 persons in 2011 (Persaud 2013). The leading causes of mortality in 2017 were chronic diseases (including cardiovascular and cerebrovascular diseases), cancers, diabetes, and hypertension (IHME Undated). Road injuries, interpersonal violence, and self-harm were the most prevalent causes of injury in 2017 (IHME Undated).

Burden of Disease

As with many other developing countries, Guyana is undergoing an epidemiological transition whereby non-communicable diseases are beginning to replace communicable diseases as the leading causes of illness and mortality, although communicable diseases are still prominent in the disease profile. This shift is largely due to trends toward more sedentary occupations and lifestyles, as well as unhealthy diets and habits such as tobacco and alcohol use. Prior to the COVID-19 onset in 2020, non-communicable diseases were the most significant public health challenge facing Guyana (Ministry of Finance 2018; WHO 2018). In 2019 (the most recent year for comprehensive health data in Guyana), the cause of death by non-communicable disease increased to 69.7 percent, marking an increase of more than 2.3 percent since 2015 (World Bank 2021a).

Non-communicable Disease

The most common non-communicable diseases and causes of illness/mortality in 2013 were diabetes, cardiovascular diseases, heart diseases, hypertension, cancers, chronic lung diseases, gastroenteritis and liver disease, accidents, violence-related injuries, and mental illnesses (Persaud 2013). The disease profile was similar in 2017, with the most common mortality-causing non-communicable diseases being heart diseases (ischemic and hypertensive), stroke, diabetes, chronic kidney diseases, and cirrhosis. Specifically, in 2017 compared to 2007, there were 32 percent more deaths from hypertensive heart disease, 31.5 percent more deaths from chronic kidney disease, 17.8 percent more deaths from stroke, 16.6 percent more deaths from ischemic heart disease, and 10.3 percent more deaths from diabetes (Ministry of Finance 2018; WHO 2018).

[11] The crude death rate is the number of deaths occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013b).

Obesity is on the rise in the country, along with other forms of malnutrition. Although Guyana is considered self-sufficient for food, the population's access to, and use of, the right types of food to maintain health are of concern. This has led the Ministry of Agriculture to develop the Guyana Food and Nutrition Security Strategy 2011–2020 Plan (Ministry of Agriculture 2011). This plan aims, among other goals, to integrate agricultural practices with improved food security and nutrition (Ministry of Health 2013a). According to the Ministry of Health, in 2013, 6.2 percent of the population had been diagnosed with diabetes, with an estimated incidence rate of 4,000 new cases annually. Type 2 (non-insulin dependent) diabetes accounted for 92 percent, with Type 1 (insulin-dependent) making up the other 8 percent (Persaud 2013). As of 2018, incidence of diabetes was continuing to increase (Ministry of Finance 2018).

Hypertension is also on the rise, with a 2013 prevalence rate of 9 percent of the population over 30 years old, and with an estimated 16,000 new cases reporting annually. Hypertension is the major contributing cause of strokes for persons over 40, as well as for heart attacks, disability, and other health issues affecting productivity of working-age adults (Persaud 2013). As of 2018, incidence of hypertension was continuing to increase (Ministry of Finance 2018).

The impact of COVID-19 on health and wellbeing in all parts of Guyana has been significant. According to a study on COVID-19 impacts on households (UNDP 2020), approximately 21.8 percent of the households who took part in the survey skipped meals during the pandemic. Skipping meals was reported to be more prevalent among female-headed households. As of late 2021, 10.9 percent of the households interviewed had experienced lack of access to medications, treatments, and therapies (UNDP 2020).

Communicable Disease

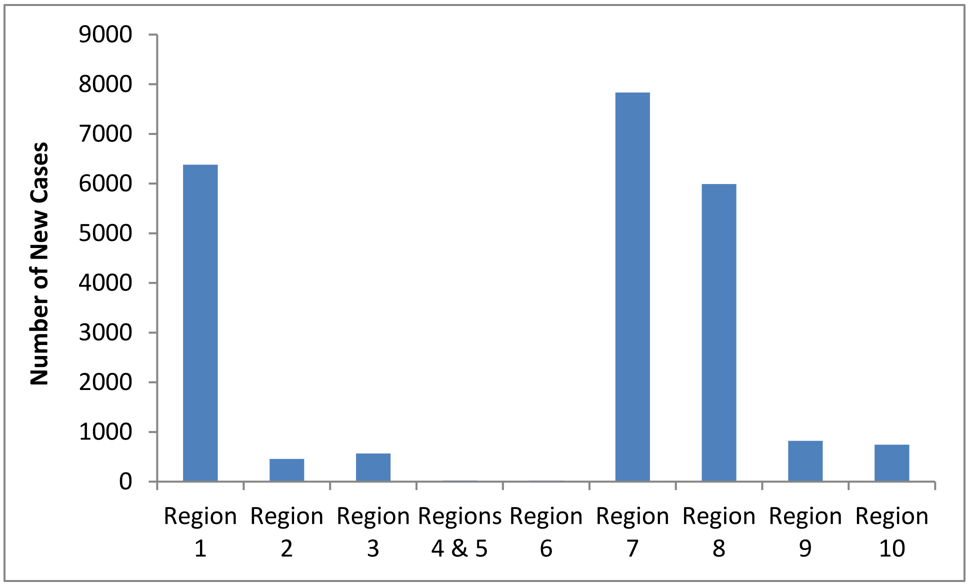
Communicable diseases also continue to impact productivity, quality of life, and wellbeing in Guyana, particularly in the hinterland regions. This is due to a number of interrelated factors including poverty, nutritional deficiency, and inadequate access to health services. In 2012, the most common communicable diseases were malaria (31,876 cases), tuberculosis (TB) (725 cases), and human immunodeficiency virus (HIV) (8,263 cases out of 106,492 tested) (Persaud 2013). In 2016, communicable, maternal, perinatal, and nutritional conditions accounted for 20 percent of all mortality in Guyana (WHO 2018).

Malaria is found in much of Guyana and is most prevalent in Regions 1, 7, and 8. Malaria control efforts, such as distribution of insecticide-treated bed nets in Regions 1, 7, 8, 9, and 10, and indoor residual spraying,[12] have been ongoing in these regions for decades. After an initial reduction in malaria prevalence in the early 2000s, the number of cases increased from 2007 to 2012. Data indicate a correlation with mining activities in the hinterland areas, and the country's Central Vector Control Service now sends mobile teams to work directly with populations residing in mining camps (USAID 2014). There was a decrease in 2013, with figures released by the Ministry of Health showing that in 2013, there were 23,489 reported cases of malaria,

[12] Indoor residual spraying involves coating the walls and other surfaces of a house with an insecticide that has residual activity (i.e., continues to work over several months, killing mosquitos on contact with the sprayed surfaces) (Centers for Disease Control and Prevention 2019).

compared to 31,876 for the previous year (Persaud 2013). In 2019, malaria cases increased to 18,826 cases, an increase of 10.4 percent from 2018 (Rios 2021).

Figure 9.2-1 shows the number of reported new malaria cases for each region in 2019, the most recent year for which data broken down by region are available. As in prior years, Regions 1, 7, and 8 exhibit the highest number of malaria cases.



Source: Malaria Atlas Project 2021

Figure 9.2-1: Malaria Incidence by Region, 2019

Dengue fever, chikungunya, lymphatic filariasis, and Zika are also locally transmitted in Guyana (i.e., they are present in the community and passed from Guyanese to Guyanese). Unlike malaria, transmission of these diseases tends to be common in populated and urbanized areas.

Lymphatic filariasis and soil-transmitted helminthiasis continue to be problematic in Guyana, leading to deformity, malnutrition, and social stigma in impacted populations. In 2017, lymphatic filariasis was the tenth most common cause of disability from illness in Guyana (IHME Undated). Efforts to combat these diseases include mass drug administration campaigns and improvements in sanitation in endemic areas.

TB continues to be a priority health concern in Guyana. It was nearly eradicated in the 1980s, but saw a resurgence in the 1990s due to its association with the HIV/Acquired Immunodeficiency Syndrome (AIDS) epidemic. In 2020, the country had a TB incidence rate of 79 per 100,000, following a decade of fluctuation from 2010 to 2019 (WHO 2022; Knoema 2020). For comparison, the global incidence in 2020 was 127 per 100,000 (World Bank 2021b). The estimated burden of TB in Guyana in 2020 is shown in Table 9.2-2.

In 2020 the number of adults living with HIV in Guyana was estimated at 8,700, and the prevalence rate in the population aged 15 to 49 was 1.4 percent for men and 1.3 percent for women (UNAIDS 2021; Table 9.2-3). Progress has been made in addressing the HIV epidemic in the country, with a significant reduction in HIV incidence (per 1,000 population) since 2003; however, between 2008 and 2017, AIDS mortality (per 1,000 population) increased from 0.11 to 0.15, before levelling at 0.14 in 2018 and 2019, and increasing slightly again in 2020 (UNAIDS 2021).

Table 9.2-2: Estimates of Tuberculosis Burden in Guyana, 2020

Estimates of TB Burden [a]	Number	Rate (per 100,000 population)
Total incidence (includes HIV+TB)	620 (470–790)	79 (60–100)
HIV-positive incidence	110 (45–200)	14 (5.7–26)
HIV-negative TB mortality	98 (86–110)	12 (11–14)
HIV-positive TB mortality	41 (16–76)	5.2 (2.1–9.7)

Source: WHO 2022

[a] Ranges represent uncertainty intervals.

Table 9.2-3: Estimates of HIV and AIDS Number and Prevalence in Guyana, 2020

Category	Number Living with HIV [a]		Category	Rate (per 100,000 population) [a]
Total adults and children	9,000 (8,100–10,000)		—	—
Adults (aged 15 and over)	8,700 (7,900–9,700)		Adults aged 15-49	1.3 (1.2–1.5)
Women (aged 15 and over)	4,400 (4,000–4,900)		Women aged 15-49	1.4 (1.3–1.6)
Men (aged 15 and over)	4,300 (3,800–4,900)		Men aged 15-49	1.3 (1.1–1.4)
Children (aged 0 to 14)	<500 (<500–<500)		—	—

Source: UNAIDS 2021

[a] Ranges represent uncertainty intervals.

Maternal and Child Health

Guyana has made improvements in maternal and child health in recent years, but did not achieve the Millennium Development Goal targets of reducing child mortality rates by two-thirds, and maternal mortality ratio by three-quarters between 1990 and 2015 (UNDP 2011). Over the period 2015 to 2030, Guyana is working toward achieving the targets for the Sustainable Development Goals for maternal and child health (UNDP Undated). This includes reducing maternal mortality to less than 70 per 100,000 live births. In 2018, Guyana's maternal mortality ratio was estimated at 116.7 per 100,000, a significant improvement from 229 per 100,000 in 2015 (Green State Development Strategy 2019). Sustainable Development Goal targets also include ending preventable deaths of newborns and children under 5 years of age, reducing neonatal mortality to at least as low as 12 per 1,000 live births, and reducing under-age-5 mortality to at least as low as 25 per 1,000 live births. Guyana's neonatal mortality rate was 20.8 per 1,000 live births and under-age-5 mortality was 20.8 per 1,000 live births in 2018 (Green State Development Strategy 2019).

The crude birth rate[13] declined from 22.8 per 1,000 persons in 2003 to 17.7 per 1,000 persons in 2011, and the infant mortality rate declined from 17 to 15.1 per 1,000 live births during this same period (Persaud 2013). However, marked disparities exist in rural and hinterland areas. In 2014, the rate of under-age-5 mortality in rural areas (48 per 1,000 live births) was more than four times the rate in urban areas (11 per 1,000 live births) (BSG et al. 2015).

The primary causes of infant death at birth include premature birth and respiratory distress, both of which are preventable, with the secondary causes being congenital deformity and birth defects that are not preventable (Persaud 2013). According to interviews with health workers in late 2017 and early 2018, home deliveries are common in many remote areas due to the lack of ambulance services and general access to transportation to neighboring healthcare facilities. In some remote healthcare facilities, the lack of basic medical supplies means that health workers must rely on rudimentary equipment to perform births (e.g., scalpel to cut umbilical cords, no electricity) (ERM/EMC 2018).

According to the Canal Polder representatives, teenage pregnancy is not prevalent in the Direct AOI within Region 3, but substance abuse is common (Canal Polder NDC 2021a, pers. comm.). According to Goed Fortuin representatives, the area of La Harmonie has a prevalence of teenage pregnancy for girls as young as 15 years and old (Goed Fortuin NDC 2021, pers. comm.).

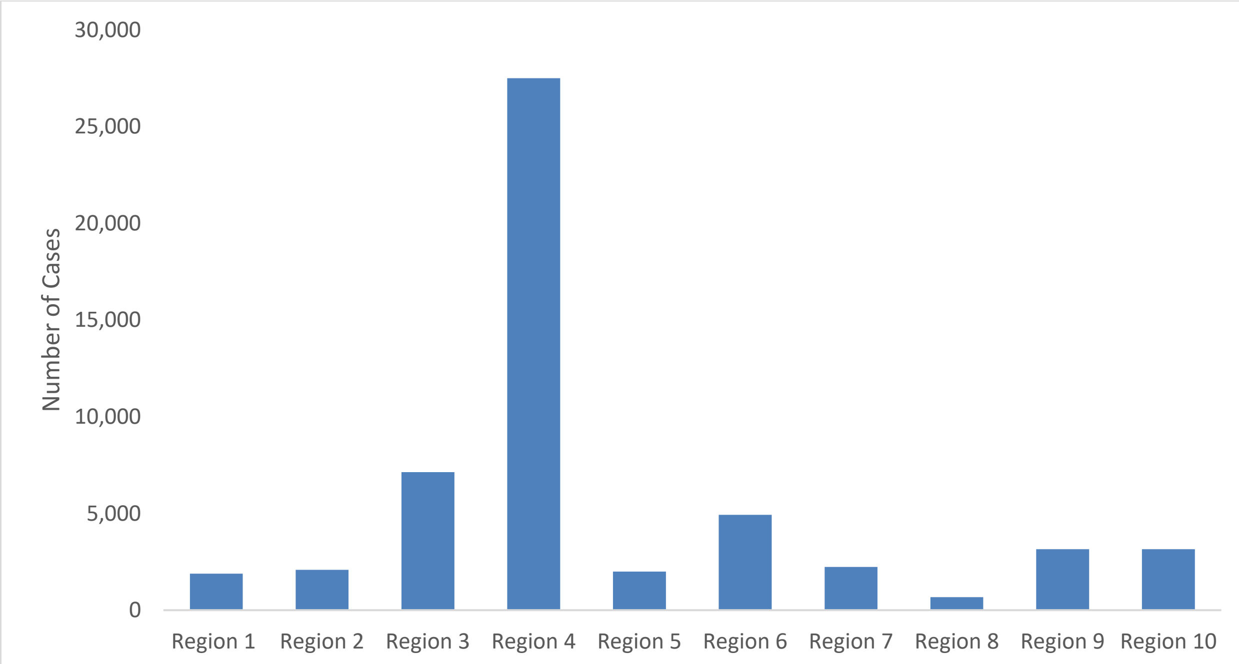
Mental Health

Guyana reports a relatively high suicide rate at the national level. Since 2008, the crude suicide rate has shown a generally increasing trend from 29.98 deaths per 100,000 people in 2008, to a high of 40.28 in 2019 (the most recently available annual data; WHO 2021). In 2019, Guyana marked the second-highest country-level suicide rate (WHO 2021), and suicide was the third major cause of death in the 15 to 44 age group (Green State Development Strategy 2019). According to Guyana's Chief Medical Officer, rates are particularly high in Regions 2, 3, and 6, with the most common method being ingestion of poisons such as pesticides. No single reason is pinpointed for this phenomenon, but the shortage of mental health workers and the stigma associated with mental illness—leading to untreated depression—are thought to be contributing factors, as well as the ease of access to pesticides and other toxic agricultural substances (Ministry of Public Health 2016, pers. comm.).

COVID-19

Guyana has been responding to the global COVID-19 pandemic since March 2020, when the virus appeared in the Guyanese population. Infection rates and deaths have since increased. As of 20 January 2022, the country had recorded 1,111 deaths from COVID-19 and a total of 54,736 cases (Ministry of Health 2022). The regional breakdown of cases is illustrated in Figure 9.2-2.

[13] The crude birth rate is the number of live births occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013a).



Source: Ministry of Health 2022

Figure 9.2-2: Guyana COVID-19 Cases by Region (20 January 2022)

The pandemic has impacted all regions of the country, including the most populous Region 4. All regions, including hinterland regions, have seen periods of rise and decline. In 2020, the pandemic posed a particularly serious threat to the regions mostly inhabited by Indigenous Peoples, requiring extensive lockdowns in villages and communities. The Infectious Diseases Hospital and other COVID-19-related medical facilities are described in Section 9.2.2.2, Healthcare System.

The impact of the pandemic on the healthcare system of Guyana has been significant and has necessitated additional funding to the health sector for focused interventions. The challenges of the pandemic are stretching the country's public health system (World Bank 2020). Interventions have included the establishment of a specialized hospital for serious COVID-19 cases and upgrades to regional and secondary hospitals. In 2020, approximately 15 percent of the national emergency budget ($51.7 billion GYD or $258.5 million USD) was allocated to the health sector (Stabroek News 2020). In 2021, $53.5 billion GYD ($267.5 million USD) was identified for ongoing response to COVID-19 and its effects. The budget also provided $750 million GYD ($3.75 million USD) for the procurement of COVID-19 vaccines, medical supplies, test kits, sanitizing materials, personal protective equipment, and the roll out of an immunization program.

The Government of Guyana also sought and received funding from the World Bank for a project to address COVID-19 impacts on the health sector. The Guyana COVID-19 Emergency Response Project is funded by an International Development Assistance credit of $1.586 billion GYD ($7.93 million USD). The project objectives include the prevention, detection, and response to the threat posed by COVID-19 and the strengthening of national systems for public health preparedness (World Bank 2020).

9.2.2.2. Healthcare System

The Ministry of Health is responsible for setting national policy, regulation, and standards; building and refurbishing healthcare facilities; and financing the employment of doctors, nurses, and emergency response workers. At the regional level, the Regional Health Authorities have the autonomy to assess, plan, and implement health services and manage the facilities for a defined population in a defined geographic area, including day-to-day management of the facilities and employment of all other staff working in the health sector. The country’s main framework for health is the Health Vision 2020, which sets the strategy and overall planning for the health sector (Ministry of Health 2013b).

Government health spending is low compared to that of other Latin American and Caribbean countries, averaging $46,000 GYD ($230 USD) per capita compared to an average of $137,000 GYD ($685 USD) for the region (World Bank 2020). Out-of-pocket health expenditures represent 32.4 percent of overall expenditure, and concerns about access to health care for vulnerable populations have been highlighted (World Bank 2020). In the 2021 budget, $53.5 billion GYD ($267.5 million USD) was allocated to healthcare (DPI Guyana 2021). The healthcare system in the country is highly decentralized, with RDCs and Regional Health Authorities managing, financing, and providing health services. However, the system continues to have a number of challenges related to human resources capacity and infrastructure capacity, which is especially acute in remote areas, such as Region 1.

The Ministry of Health established priorities in 2013 for the national healthcare system to increase financial and technical support to improve the following (Persaud 2013):

- Family health (child, adolescence, women, men, elderly);
- Disease eradication and mental health;
- Violence, accidents, and injury rates;
- Healthcare facilities at all levels (community centers to city hospitals);
- Nutrition and food security; and
- Access to health for frontier, migrant, remote, and vulnerable populations.

Healthcare Facilities

Healthcare facilities in the two regions of the Project’s Indirect AOI are summarized in Table 9.2-4. In addition to these facilities, there is one National Ophthalmology Center and one National Psychiatric Hospital in the country, both located in Region 6.

Table 9.2-4: Healthcare Facilities in Regions 3 and 4

Region	Regional Hospital	District Hospital	Diagnostic Center	Health Center	Health Post
Region 3	1	2	1	17	22
Region 4	1	1	1	39	7

Source: Ministry of Health 2020

There are plans to expand and enhance the medical facilities in Region 3 in 2022 (CMO, pers. comm.). These intended expansions will address the emerging trends of diseases in the region and the anticipated increase in population as a result of planned developments.

In addition to using healthcare facilities, individuals are known to self-treat using natural at-home remedies. According to representatives from Goed Fortuin, in the Direct AOI there are persons who grow wild plants to use for medicinal purposes at the household level (Goed Fortuin NDC 2021, pers. comm.). According to representatives from Toevlugt Patentia, plants are grown and used for diabetes and blood sugar / blood pressure relief at the domestic scale but not for commercial use or sale (Toevlugt Patentia NDC 2021, pers. comm.).

According to Guyana's Chief Medical Officer, one of the biggest health system shortfalls for Guyana is unreliable emergency care services. This includes the lack of a functioning air ambulance system, which is needed to adequately respond to mining injuries in the country's interior and to the large number of vehicle accident-related injuries. There are also shortages of blood at times, and capacity in hospitals is inadequate. The public hospital in Georgetown once had 900 beds, but due to fires and dilapidation over the years, this has been reduced to 450 (Ministry of Public Health 2016, pers. comm.). In 2012, there were 28 hospital beds per 10,000 people in the country, up slightly from 25 beds per 10,000 people in 2003 (Persaud 2013; ERM/EMC 2018). The most common reasons for clinic visits were hypertension, diabetes, antenatal, and family planning. Medical supplies, including medicines, are in short supply and those provided to village health centers from larger cities (such as Mabaruma and Georgetown) are typically close to, if not past, the expiration date.

The Infectious Diseases Hospital, commonly called the COVID Hospital, was commissioned at Liliendaal, Georgetown, in July 2020 to serve as the premier institution for the quarantining and isolation of persons who have been infected with COVID-19 and other infectious diseases (Newsroom Guyana 2021). The hospital has a capacity of 200 beds and an intensive care unit capacity of 40 beds. As of 20 January 2022, there were approximately 815 new COVID-19 cases in the country with 16 persons hospitalized at the Infectious Diseases Hospital (Ministry of Health 2022). In 2020, the Ministry of Health aimed to expand the capacity of the hospital by adding 10 intensive care unit beds and 50 regular ward beds; the second floor of the hospital has been re-fitted with piped oxygen to prepare for additional patients. The government is in the process of expanding COVID-19 capacity at the regional hospitals, and plans to close services at selected hospitals across the country to provide additional COVID-19 treatment facilities, should the need arise, as well as to use a field hospital (a donation from Qatar) to boost the country's COVID-19 response capacity (Village Voice News 2021).

Health Human Resources

Retention of healthcare professionals in Guyana is a challenge, as in many other developing countries with high emigration rates of skilled workers to developed countries. The most recent available statistics from the World Bank indicate that there were eight physicians and 10.4 nurses per 10,000 people in the country in 2020 (World Bank 2020). Guyana's Health Human Resource Action Plan for Guyana 2011–2016 aimed to address this issue.

9.2.2.3. Quality of Life

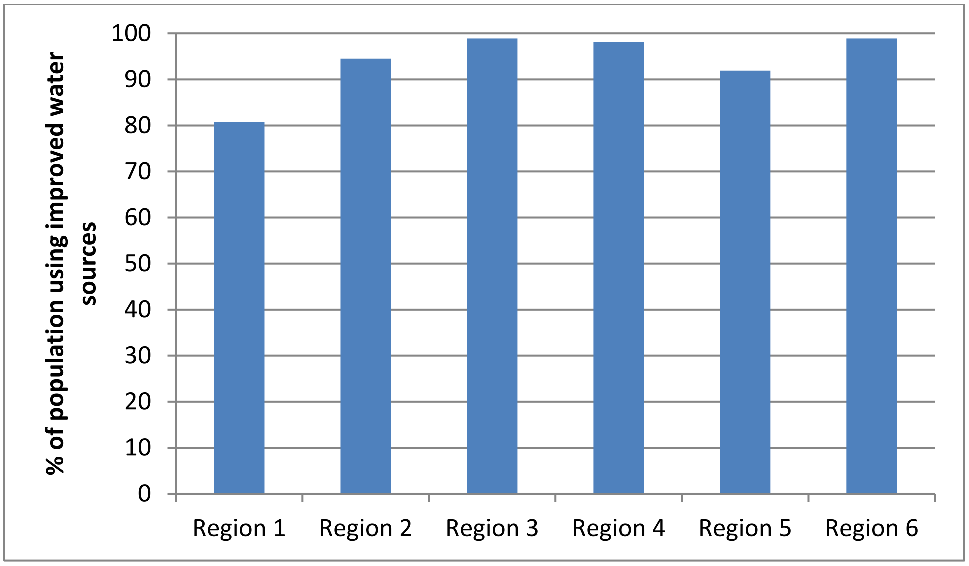
According to a Socioeconomic Impact Assessment of COVID-19 on households in Guyana (UNDP 2020), which was prepared in December 2020, the pandemic was hindering access to basic goods and services. One in ten respondents to the study claimed to be unable to access medical services or treatments when needed. The study found that respondents did not visit health facilities for the following reasons: 35 percent said health facilities lack supplies; 26 percent said they are too busy; 23 percent said they have no money or resources; and 22 percent were unwilling to travel to health facilities.

Water and Sanitation

According to the most recent Guyana Multiple Indicator Cluster Survey (MICS),[14] 94 percent of Guyana's population had sustainable access to improved drinking water sources[15] as of 2014, and 95.4 percent used an improved sanitation facility[16] (UNICEF 2014). According to the Green State Development Strategy, 96 percent of the population is noted as having access to potable water (Green State Development Strategy 2019). Figure 9.2-3 shows the percentage of the population with access to improved sources of drinking water, by coastal region, in 2014. However, while access to improved water sources has improved over the years, wastewater and sanitation coverage and infrastructure in the country are limited, thus hampering efforts to improve health conditions (World Bank 2016).

In 2012, approximately 97 percent of the population in both urban and rural areas used an improved drinking-water source (as compared to 83 percent in rural areas in 2000). However, an assessment conducted by multilateral partners in 2014 points out that the quality of water supply services is hindered by decaying distribution networks, with 50 percent to 70 percent of wastewater going unaccounted for at the national level (and more than 70 percent in Georgetown) (World Bank 2016).

[14] The MICS program was developed by the United Nations Children's Fund and serves as an international household survey program to collect internationally comparable data on a wide range of indicators on the situation of children and women.
[15] Improved water sources refer to any of the following types of supply: piped water into dwelling, compound, yard, to neighbor, or to public tap/standpipe; tube well/borehole; protected well; protected spring; and rainwater collection. Bottled water is considered an improved water source only if the household is using an improved water source for handwashing and cooking.
[16] An improved sanitation facility is defined as a facility that flushes or pour-flushes to a piped sewer system, a septic tank, a pit latrine, a ventilated improved pit latrine, or a pit latrine with slab.



Source: UNICEF 2014

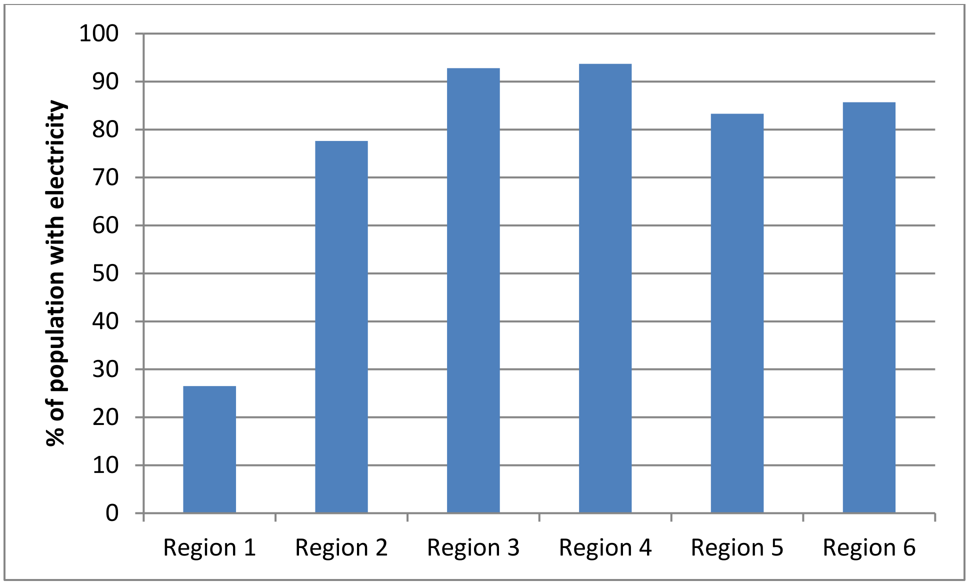
Figure 9.2-3: Percent of Population with Access to Improved Water Sources by Region, 2014

Guyana Water Inc. (GWI) has established wells in Koboremo, Kamwatta, and Toko, and rehabilitated water catchment areas in Matthew's Ridge and Mabaruma in Region 1. New wells were also established at Silver Hill, Waikabra, and Hill Foot in Region 4. New water treatment plants are planned for several locations in Region 4, including Diamond, Timehri North, Bladen Hall, Sparendaam, and Sophia (Guyana Chronicle 2018).

Additional information regarding water and sanitation infrastructure can be found in Section 9.3.2.3, Water and Sanitation.

Electricity

Results of the MICS indicate that an estimated 91.2 percent of the coastal population and 56.2 percent of the interior population have access to electricity. Figure 9.2-4 shows the percent of the population with electricity in each of the coastal regions in 2014.

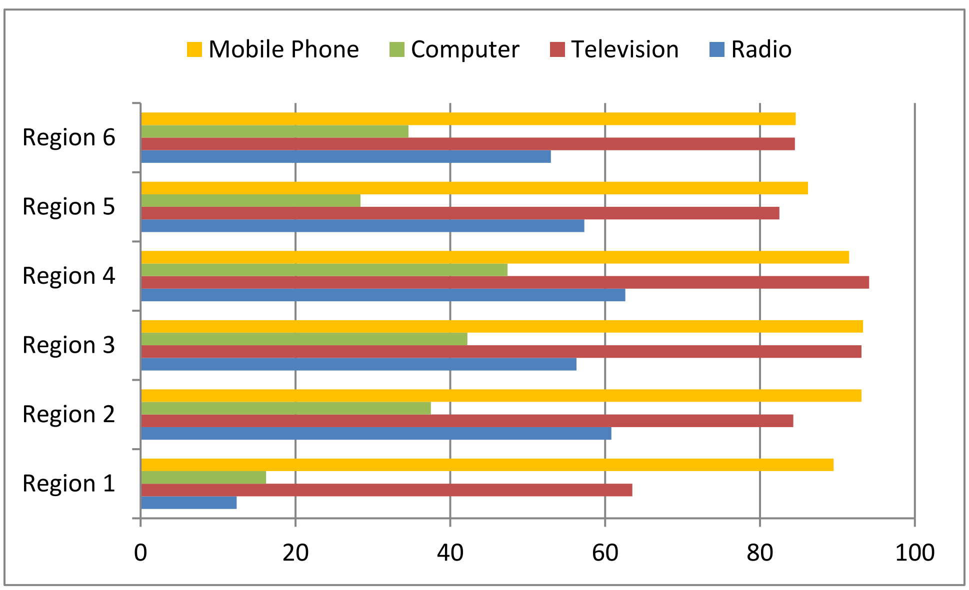


Source: UNICEF 2014

Figure 9.2-4: Percent of Population with Electricity by Region, 2014

Telecommunications

Mobile telephone coverage is quite comparable among coastal regions, and an average (across the coastal regions) of 88.6 percent of households in the country has at least one member with a mobile phone. There is more disparity in other forms of telecommunications, with Region 1 in particular showing lower levels of access to computers, television, and radio, relative to other regions (Figure 9.2-5).



Source: UNICEF 2014

Figure 9.2-5: Household Access to Telecommunications, 2014

The 2021 household socioeconomic survey in the Project vicinity found that approximately 80 percent of the 439 respondents to the question of primary mode of communication chose *cell phone* or *Wi-Fi*, while another 15 percent chose *landline*. In addition, nearly 78 percent of surveyed households indicated having at least one television in their home, and about 42 percent responded similarly for radios.

9.2.2.4. Natural Hazards

Guyana is not threatened by many natural hazards, but due to its low-lying coastal plain, the coastal areas of Regions 1 to 6 face severe risk of flooding. The INFORM[17] risk profile for the country (Inter-Agency Standing Committee and the European Commission 2020) identifies flooding, tsunami, drought and epidemic as being the primary natural risks at the country level.

The World Bank (2016) estimates that Guyana is one of the countries most vulnerable to global climate change due to its low-lying coastal areas, as many areas lie below mean sea level and a high percentage of the population and critical infrastructure are located along the coast. In addition, Guyana’s marine fisheries and food security have exhibited a high degree of vulnerability to climate-related effects (Ding et al. 2017). Both changes in rainfall patterns and predicted sea-level rise associated with climate change pose significant threats to the Guyanese population and its livelihoods. As such, the country invests consistently in the construction and maintenance of sea and river defense infrastructure, as well as a system of reclaimed lands, drainage and irrigation canals, pumping stations, and conservancy dams to protect agriculture, economic activities, and settlements in the vulnerable coastal areas. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems. Additional discussion of climate change is provided in Section 7.6, Air Quality, Climate, and Climate Change.

Despite the investment in climate change resiliency, floods continue to threaten public safety and infrastructure along the coast. One of the worst flooding crises occurred in 2005, when torrential rains caused many rivers and water conservancies in the coastal plain to overflow, causing severe flooding in Regions 1, 2, 3, 5, and 6. The floods resulted in the direct or indirect deaths of 19 people from either drowning, acute dehydration, or succumbing to an outbreak of leptospirosis that occurred in the aftermath of the flooding (PAHO 2005). More recently, in March 2018, floodwaters breached the sea defense network in the West Coast Demerara area, damaging local businesses and homes and forcing the temporary evacuation of some residents. Annual flood damage in Georgetown was estimated in 2019 to be $1.3 billion GYD ($6.5 million USD) (Guyana Times 2019).

In 2021, heavy rains in May and June resulted in serious flooding. Reports to date have indicated severe flooding in regions 10, 7, 6, 5, and 2 (CDEMA 2021). More than 36,000 households have suffered from the flooding across 300 communities in all 10 regions of the country. In the short-term, the flood’s economic impact has included loss of livestock and agricultural production, cessation of mining activities, and the loss of mining equipment in mining regions.

[17] INFORM is a collaboration of the Inter-Agency Standing Committee and the European Commission.

9.2.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on community health and wellbeing. The relevant planned Project activities and the associated potential impacts of these activities on community health and wellbeing are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

This section focuses on community health and wellbeing and does not discuss worker health and safety, which is outside of the scope of this EIA. EEPGL is committed to protecting the safety, security, and health of its employees, its contractors, and the public, to achieve a work environment where nobody gets hurt. Consistent with this commitment, the Project will employ a robust and effective management system to protect its Project workforce. EEPGL will implement its operations integrity management system (OIMS), designed to manage occupational risks to Project workers. Additional information regarding EEPGL's occupational safety and health program is provided in the Project Environmental and Socioeconomic Management and Monitoring Plan (ESMMP; EIA Volume III—Management Plans).

9.2.3.1. Relevant Project Activities and Potential Impacts

The Project will involve a range of activities within the Onshore Direct AOI[18] and Indirect AOI that could potentially impact community health and wellbeing across the aforementioned determinant of health categories (Table 9.2-1). Shifts in demographic patterns, including the influx of foreign workers or the spatial concentration of working-age populations, have the potential to cause changes in disease transmission patterns, impact public safety, and increase the burden on medical and health infrastructure. Additionally, perceived risks and impacts associated with the oil and gas sector (specifically the NGL Plant and onshore pipeline) can also contribute to anxiety for some stakeholders; this concern has emerged through stakeholder engagement activities to date, including community engagement in Regions 3 and 4 in 2021 regarding the Project. Table 9.2-5 summarizes the planned Project activities that could result in potential impacts on community health and wellbeing. Relevant receptors vary depending upon the potential impact being considered and include the general population of Georgetown and its vicinity; the general population throughout the Direct AOI; and individuals and families located in the immediate vicinity of the onshore Project components (essentially, the Primary Study Area).

[18] For socioeconomic resources, the onshore component of the Direct AOI includes the communities within the immediate vicinity of the Project's onshore components as well as the communities between the Project's onshore components and the Demerara River (these correlate with the Primary and Secondary Study Areas, respectively, as described in detail in Section 9.1.1, Baseline Methodology [Socioeconomic Conditions]).

Table 9.2-5: Summary of Relevant Project Activities and Key Potential Impacts—Community Health and Wellbeing

Stage	Project Activity	Key Potential Impacts
Construction	Project worker presence; potential project use of medical and health services; temporary restriction of access to road segments; noise from equipment and activities; traffic on public roads; presence of onshore natural gas facilities	• Increased risk of communicable disease transmission within communities • Interaction between workers and community, resulting in potential impacts on social cohesion • Overburdening of medical and health services • Temporary restriction of access to medical/healthcare facilities • General nuisance from increased noise, potentially causing stress on mental health • Increased risk of physical and mental health concerns as a result of public safety issues, such as crime, increased traffic, reduced access to social infrastructure and services • Public anxiety over presence of onshore natural gas facilities, primarily related to the perceived risk of an emergency event
Operations	Presence of onshore natural gas facilities; noise from NGL plant operations	• Public anxiety over presence of onshore gas facilities, primarily related to the perceived risk of an emergency event • General nuisance from increased noise, potentially causing stress on mental health
Decommissioning	Noise from decommissioning activities	• General nuisance from increased noise, potentially causing stress on mental health

Several potential impacts with potential indirect impacts on community health and wellbeing are addressed through assessment of potential impacts on other resources. A summary of the additional potential impacts covered elsewhere in the EIA is presented in Table 9.2-6.

Table 9.2-6: Potential Impacts Discussed in Other EIA Sections and Scoped out of the Community Health and Wellbeing Impact Assessment

Potential Impact	Relevant EIA Section
Project-related discharges to water (altering water chemistry and turbidity) in marine and riverine systems	Section 7.4, Water Quality
Air quality emissions from Project sources	Section 7.6, Air Quality, Climate, and Climate Change
Waste generation, storage, and disposal	Section 7.7, Waste Management Infrastructure Capacity
Local job creation, contributing to positive physical and mental health outcomes	Section 9.1, Socioeconomic Conditions
Increased road traffic	Section 9.4, Transportation
Increased marine traffic	Section 9.4, Transportation
Hydrocarbon spills from Project vessels operating nearshore or offshore	Chapter 10, Unplanned Events
Marine, river, or vehicle accidents involving non-Project individuals	Chapter 10, Unplanned Events
Risks due to gas infrastructure fires or explosions	Chapter 10, Unplanned Events

9.2.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity), and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for community health and wellbeing (Table 9.2-7). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for community health and wellbeing are provided in Table 9.2-8.

As described above, community health and wellbeing is a complex resource. For the purpose of assessing the significance of potential impacts on this resource and its receptors, separate discussions are provided for the following community health and wellbeing components, with the assessment focusing on the specific potential impacts that are relevant to each component:

- Individual and social determinants of health and wellbeing
- Physical determinants of health and wellbeing
- Institutional determinants of health and wellbeing

Table 9.2-7: Definitions for Intensity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Intensity	**Negligible**: No discernible change occurs in health status of the population. The anticipated incidence of a health-related risk at an individual level is very rare.
	Low: Changes to health status occur in some individuals and households, but changes are minor, temporary, and reversible without medical or public health intervention. The anticipated incidence of a health-related risk at an individual level is rare.
	Medium: Changes to health status occur at the population level, but are reversible over time or with medical or public health intervention. The anticipated incidence of a health-related risk at an individual level is occasional.
	High: Profound and measurable changes occur in health status at the population level. Some health impacts may be severe or permanently debilitating, requiring medical or public health intervention or other forms of assistance for treatment and recovery. The anticipated incidence of a health-related risk at an individual level is frequent.

Table 9.2-8: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Sensitivity	**Low**: The population does not have many areas of health vulnerability. Individuals and households have the personal resources and capacity to protect and promote health. The community is well equipped with resources and infrastructure to provide routine medical and health care and address medical and health emergencies. There is a predominant absence of concern regarding the impact of the Project on personal wellbeing.
	Medium: The population has multiple areas of health vulnerability due to environmental or social factors. Portions of the population face socioeconomic challenges that act as barriers to health protection and promotion. There are shortfalls in local medical and health resources and infrastructure that compromise the ability to provide timely and appropriate medical and health care in some situations. The population contains a moderate proportion of individuals who express concerns regarding the impact of the Project on their wellbeing.
	High: The population has many areas of health vulnerability due to environmental or social factors. A large portion of the population is disadvantaged, and this acts as a barrier to protecting and promoting health. Adequate medical health resources and infrastructure are lacking, often not allowing for timely and appropriate medical and health care. The population contains a significant proportion of individuals who express concerns regarding the impact of the Project on their wellbeing.

9.2.3.3. Impact Magnitude Ratings—Community Health and Wellbeing

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to community health and wellbeing is provided in Table 9.2-9.

Individual and Social Determinants of Health and Wellbeing

Communicable Disease Transmission and Effects on Social Cohesion

This section examines the potential for the increased risk of communicable disease transmission for individuals within communities (in both worker camp and no worker camp scenarios). It also examines potential impacts on familial and community social cohesion[19] as a result of interactions between workers and community members, as well as public safety. There is a wide range of illnesses and disabilities already present in the population, comprising a baseline prevalence rate. However, as individuals value their health, even a small increase in the prevalence rate of a disease or disability attributed to the Project can be considered significant.

Population shifts caused by the influx of workers from other parts of the country or foreign countries have the potential to cause changes in transmission patterns of some communicable diseases, particularly if workers originate from countries or regions with higher rates of diseases that are transmitted through person-to-person contact, such as TB, sexually transmitted infections, and COVID-19. Social cohesion within communities, especially smaller and more vulnerable populations, can also be affected by the presence of a large workforce originating from outside of the community area. This can cause strain in familial relationships and tension among community members who may have differing viewpoints on the presence of the workforce.

Guyana has a lower rate of TB incidence than the global average (79 cases per 100,000 people in 2021 versus the global average of 127 cases), but has a higher rate than most developed countries (WHO 2022; World Bank 2021b). Guyana's rate of HIV prevalence (1.4 percent in 2020) is comparable to the global average (WHO 2022). Various reports over the years, including from sources such as UNAIDS, the Caribbean Investigative Journalism Network, and academic journals, suggest that Georgetown has a relatively high prevalence of prostitution but sexually transmitted disease rates at a community level are unknown.

Additionally, COVID-19 is currently affecting people in Guyana (and elsewhere) with resulting impacts on relationships and health services. As a result of the pandemic, widespread changes to business operations, inter-regional and international travel, and social interactions have been instituted in Guyana and abroad. In 2020, nearly 22 percent of households that participated in a COVID-19 impacts survey indicated skipping meals during the pandemic. Similarly, 10.9 percent of responding households had experienced lack of access to medications, treatments, and therapies (UNDP 2020). In addition to resource complications caused by the pandemic, Guyana has experienced increased infection rates and deaths since 2020. As of 23 January 2022, the country had recorded 1,134 deaths from COVID-19 and a total of 57,227 cases (Ministry of Health 2022).

The Project will require approximately 500 onshore construction workers during the peak of the Construction stage and approximately 40 workers and 50 workers during the Operations stage and Decommissioning stage, respectively. EEPGL will optimize the use of local content to the extent practicable, so it is likely that a significant portion of the onshore positions will be filled by individuals currently residing in Guyana (likely in Region 3 and the east bank of Region 4 vicinity).

[19] Social cohesion refers to the strengths of relationships in communities and the sense of solidarity amongst families and communities.

If the worker camp scenario is implemented, housing for up to 150 workers (presumed to be primarily foreign) will lessen the potential for increases in communicable disease transmission and social cohesion effects within communities, but only if the worker camp is operated in a "closed" arrangement (which will limit the degree to which workers are allowed to socialize outside of the camp during off-work hours). If the worker camp is constructed, but has no restrictions on workers' movements outside of working hours, the potential for interaction between community members and workers will likely be higher than it would be if such restrictions are in place.

Assuming for the purpose of the EIA that 50 percent of workers are local hires (exact percentage to be determined during contracting), in the worker camp scenario, there could be up to an additional 100 workers (either foreign or not from the local area) during the peak of the Construction stage who will require temporary housing or lodging within Georgetown and/or Region 3. There could also be approximately 250 Guyanese workers (again assuming 50 percent local hire for the purpose of the EIA) who will be commuting to the work sites from their homes in Georgetown and other Region 3 communities. These workers also will likely have the opportunity to engage in activities during off-work hours within the Direct AOI that could result in higher rates of communicable disease transmission, as well as impacts on community social cohesion. Considering that some community leaders have noted a baseline prevalence of substance abuse in the Direct AOI, this could lead to negative interactions between community members and the workforce, which could degrade social cohesion.

Potential communicable disease transmission risks will vary according to the workforce's primary countries of origin; however, as an embedded control, regardless of worker origin, the Project will establish a worker health-screening program and take precautions to avoid internal and external communicable disease risks, including COVID-19. Although the effects of COVID-19 have been significant in Guyana, stringent control and prevention methods are in place for the EEPGL workforce and these will be employed for the Project workforce. In addition to the Project's COVID-19 worker policy, Guyana emphasizes general safe COVID-19 practices for the country at large. Such practices have previously included wearing a face mask, keeping physical distance of at least 6 feet between people, and washing hands or using hand sanitizer (Ministry of Health 2022). However, acknowledging the transmissibility of COVID-19 and its ability to continue spreading despite preventative measures, bringing new members into a community during the pandemic will create inherit risks to community members with which workers interact.

Given the size of the Project workforce (up to 500 workers) in comparison with the receiving communities within the Direct AOI, the intensity of potential impacts related to increased rates of communicable disease transmission and effects on social cohesion under a "no worker camp" scenario is rated as **Medium** during the Construction stage. Should the Project proceed with a "closed" worker camp alternative, the intensity of potential impacts related to increased rates of communicable disease transmission and effects on social cohesion is rated as **Low**, considering the decreased workforce that will potentially interact with neighboring communities within the Direct AOI. Under a worker camp scenario with no restrictions on worker movements during off-work hours, the intensity of potential impact would likely be decreased relative to the "no worker camp" scenario, but conservatively the intensity could still be as much as **Medium**.

During the Operations and Decommissioning stages, the permanent workforce will be 40 and 50, respectively, and will likely be predominantly Guyanese. Interactions with the local community are likely to be normalized throughout the Operations stage, and workers are eventually likely to be regarded as community members. Therefore, the intensity is rated as **Negligible** during the Operations and Decommissioning stages.

Foreign workers will move through the Direct AOI and Indirect AOI and interact with community members primarily before and after workdays, yielding a frequency designation of **Episodic** during all stages. Regardless of the intensity or frequency of foreign workers coming to Guyana, expatriate labor will constitute some portion of the Project workforce for the life of the Project, so the duration of the impact is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of worker interaction resulting in increased communicable disease transmission and effects on social cohesion is considered to be **Negligible** (if the worker camp is employed in a "closed" fashion) to **Small** (if the worker camp is not used and/or is not "closed") during the Construction stage and **Negligible** during the Operations and Decommissioning stages.

Public Anxiety over Presence of Natural Gas Facilities

This section examines the potential for an increase in public anxiety as a result of the Project. Oil and gas represents the newest sector in Guyana's economy, and concerns exist among those living in coastal communities about oil and gas activities and their perceived potential impact on livelihoods and the environment. The onshore Project components—specifically the NGL Plant and the onshore pipeline—has the potential to create anxiety in particular with those located in the Direct AOI, who will have the most interaction with the Project. Certain vulnerable sub-populations (e.g., rural farmers who are concerned about the onshore pipeline crossing their agricultural land, people with existing mental health or anxiety type disorders, etc.) may be more concerned about these perceived impacts (e.g., pipeline leaks, gas explosions) than others and may experience an associated increase in anxiety levels.

Potential changes in health and wellbeing that can be attributed to Project-related anxiety are expected to be reversible, as more Project information will continue to be made available to mitigate these concerns. Recognizing that this impact is driven by perception of risk, and perceptions may affect a wider area or range of people than that which could potentially be affected by potential physical health impacts, the geographic extent of potential anxiety-related impacts is predicted to be larger than that of other community health-related impacts (i.e., across portions of the Indirect AOI, and not only within the Direct AOI). Therefore, the intensity of potential impacts related to public anxiety over the presence of natural gas infrastructure is rated as **Medium** for the Construction and Operations stages. These impacts are predicted to occur on an **Episodic** basis over the life of the Project (**Long-term**). As such, the magnitude of potential impacts related to public anxiety is considered **Small** during the Construction and Operations stages.

Physical Determinants of Health and Wellbeing

Impacts on Public Safety

This section examines potential impacts on public safety as a result of the presence of the Project workforce and/or influx into the Project area. Rapid population change and, in particular, the introduction of transient populations is often perceived as contributing to increased rates of crime. Criminal activity in Georgetown (including petty theft and armed robberies) is common. Most robberies are noted to be crimes of opportunity, stemming from inadequate police presence and poor police response (OSAC 2020). In general, excessive alcohol use is associated with increased crime, including assault and criminal damage. The influx of Project workers to the Georgetown area and Region 3 is not expected to contribute significantly to an increase in local crime rates given that the number of workers who may become targets for crime is a small portion of Georgetown's population.

The presence of Project traffic on public roads has the potential to impact community health and wellbeing; on average, during the Construction stage, the Project anticipates approximately 16 to 30 daily one-way trips for onshore pipeline construction activities and approximately 28 to 64 daily one-way trips for NGL Plant construction activities. During the Operations stage, the Project anticipates approximately 280 daily one-way trips to/from the NGL Plant. Construction stage workers will be transported to the NGL Plant and onshore pipeline construction areas in buses. This increased traffic activity has implications for local drivers on the roads, including a potential increase in the risk of vehicular accidents (see Chapter 10, Unplanned Events). Increases in road traffic (movement of materials and personnel), in particular during the Construction stage, through community areas can result in a number of mental health and wellbeing impacts for other road users, such as:

- Reduction in real or perceived road safety;
- Driver delay;
- Community separation;
- Intimidation and fear; and
- Reduction in pedestrian amenity (places in a town or village where pedestrians meet to socialize and/or mingle).

Construction activities and equipment may also temporarily impede access to canals and other areas used for recreation, household activities, or cultural resources. Such lack of access can impact physical health and mental health. For example, if individuals who normally use the canal for bathing or washing clothes no longer have access, this could impact their personal hygiene and mental wellbeing. For those who use roads, canals, or land to access or participate in cultural, spiritual, or recreation activities, this could result in frustration or stress. However, only approximately 20 respondents of the 2021 household socioeconomic survey in the Direct AOI claimed to use the canals for these purposes.

Given the Project workforce's anticipated limited interaction with the community during the Construction stage, the intensity of potential impacts on public safety (i.e., as a result of criminal activity) is rated as **Low**. The intensities of potential mental health and wellbeing impacts as a result of Project traffic and temporary access constraints are also rated as **Low** during the Operations stage, considering the number of daily one-way trips and their potential to impact receptors at an individual level. The intensities of traffic and access constraint-related impacts are expected to be **Negligible** during the Construction stage, based primarily on the limited number of Construction stage vehicle trips resulting from the decision to mobilize contractors via buses.

These impacts are predicted to occur on an **Episodic** basis over the duration of the Construction stage. This stage will last longer than 1 year, so duration is considered **Long-term**. As such, the magnitude on public safety and mental health is rated as **Small** during the Construction and Operations stages and **Negligible** during the Decommissioning stage.

General Nuisance from Increased Noise, Potentially Causing Stress on Mental Health

During the Construction stage, onshore construction activities such as HDD, trenching, and backfilling will generate noise emissions within the Direct AOI, and some of these activities will occur in relatively close proximity to communities. Excessive or persistent noise exposure can have a detrimental impact on mental and/or physical health.

An embedded control for the Project is that the Project will perform onshore construction activities only during the day to the extent practicable. This will decrease the intensity of potential impacts, in that noise impacts during nighttime hours are more likely to lead to stress and associated mental or physical health issues. The assessment of potential noise-related impacts (see Section 7.5, Sound and Vibration) analyzed potential noise and vibration impacts for a range of scenarios, during both daytime and nighttime—where applicable, and concluded that the residual impact significance of noise at potential residential structures during the Construction and Operations stages will range from **Negligible** to **Moderate**. This assessment was based on comparison of modeled noise levels at potential residential structure locations to thresholds assigned to various significance levels. On the basis of the residual impact significance ratings assigned for impacts on sound resources, the intensity of potential noise-related impacts on mental or physical health is rated as up to **Medium** during the Construction stage and up to **Medium** during certain intermittent activities in the Operations stage, considering that the number of receptors who may be exposed to higher levels of noise (including at night) is greater than a few individuals. However, these levels of impact on mental health during the Construction stage will be limited to a few days for given individual, and only infrequent exposure for a few individuals during the intermittent Operations scenarios. Decommissioning activities will be almost entirely limited to activities at the NGL Plant site. The nature of noise emission from a decommissioning operation will be similar in nature to those associated with NGL Plant construction activities (for which a **Negligible** significance was determined).

Institutional Determinants of Health

Restricting Access to Healthcare

This section discusses the Project's potential to restrict access to healthcare and health services. Restrictions to access for other resources (e.g., recreation, livelihoods, transportation) are covered in other sections. Coupled with disparities between the population and available health services, the nature of the Construction stage may have implications for local community members' abilities to access health resources. It is possible that construction equipment and general construction activities may occasionally require the temporary blockage of roads and access points through communities (particularly in areas such as Polder and Canal 1 roads that lead east to the main road), which could in turn restrict access to healthcare in portions of the Direct AOI—either for emergency or routine needs. Such temporary restrictions on access to health services could provide significant challenges for local populations.

While the incidences of temporary restrictions to physical access to health resources are expected to be infrequent and limited in time, it is possible that this will affect individuals occasionally. On this basis, the intensity of potential impacts of restricting access as a result of construction activity is rated **Low** during the Construction stage. These impacts are not expected to occur during Operations or Decommissioning stages, as no road closures are anticipated during these stages. These impacts are predicted to occur on an **Episodic** basis over the duration of the Construction stage (**Long-term**). As such, the magnitude of potential impacts relating to restricting access to healthcare is rated as **Small** during the Construction stage.

Overburdening of Medical and Health Services

This section discusses the Project's potential to overburden medical and health services and create an indirect impact on non-Project users of these services. As an embedded control, the Project will have a dedicated medical clinic at the NGL Plant site to treat workers for minor medical issues. In the event of a more serious illness or injury that cannot be handled by the Project's dedicated medical professionals, workers will be medically evacuated to a healthcare facility in Georgetown, depending on the type of medical issue. In the event a worker requires medical evacuation/referral, Project-dedicated medical professionals will be available to support the referral. While these provisions will limit the degree to which Project needs will increase the burden on Georgetown-based medical and health services, Project use of Guyanese healthcare facilities could potentially compromise availability and access for the local population. For its offshore projects, EEPGL currently uses a designated local, private Guyanese clinic supported by an international medical provider, as well as hospitals in Georgetown, in the event of work-related and non-work-related medical and health emergencies. However, for the most part, these hospitals are relied upon only for initial evaluations or, in the case of life-threatening emergencies, stabilization before evacuation of foreign workers out of country to another facility.

There are approximately 13 medical facilities in Georgetown (United Kingdom Government 2021), and workers' use of these facilities (which would occur primarily in situations where the Project-dedicated medical clinic at the NGL Plant site are not able to manage the case) will be unlikely to create overburdening. However, for workers supporting the onshore pipeline construction, there may be instances where workers use local facilities in Region 3. Region 3 is characterized by an already overburdened and sparse local health infrastructure, with only three facilities located in the Direct AOI: one regional hospital and two health centers (Ministry of Health Undated). The aforementioned health facilities serve multiple communities and, with the addition of a significant number of onshore Project construction workers, the potential exists for the burden on these facilities to increase beyond their capacity to address needs.

The COVID-19 pandemic has itself contributed to overburdening of health resources in Guyana. The impact of the pandemic on the healthcare system of Guyana has been significant and necessitated additional funding to the health sector for focused interventions. The challenges of the pandemic are stretching the country's public health system (World Bank 2020). Interventions have included the establishment of a specialized hospital for serious COVID-19 cases and upgrades to regional and secondary hospitals.

Although the local Guyanese medical facilities are likely overburdened because of limited availability and the COVID-19 pandemic, the Project's reliance on the facilities will be limited, primarily due to the inclusion of Project-dedicated medical resources. As such, the intensity of this potential impact is rated as **Low**. Situations resulting in Project use of existing medical and health facilities will be **Episodic**, but the potential for such situations will extend across the Construction stage resulting in a duration of **Long-term**. Consequently, the magnitude of potential impacts related to Project overburdening of medical and health services is rated as **Small**.

9.2.3.4. Sensitivity of Receptors—Community Health and Wellbeing

The Guyanese population is in an epidemiological transition, whereby the burden of illness has begun to shift from communicable disease to non-communicable (chronic) diseases and injury. However, communicable diseases, including HIV/AIDS, TB, pneumonia, and others (including, more recently, COVID-19), still make up a considerable burden of illness in the country. This transition is characteristic of many developing countries as they experience demographic changes, including lower fertility rate and longer life expectancy, as well as improvements in health and sanitation systems. In general, urban populations typically have higher health status than rural populations. They typically have better access to health services and higher levels of immunization coverage, and are less likely to suffer from some communicable diseases, such as malaria and soil-transmitted helminths (parasitic worms). However, densely populated urban settings, such as Georgetown, are typically disproportionately affected by other types of communicable diseases such as dengue fever, HIV/AIDS, and TB. Communities within Guyana also tend to be tight-knit, with a generally strong level of social cohesion. As such, based on the sensitivity rating definitions in Table 9.2-8, the sensitivity of the population in the Direct AOI and Indirect AOI with respect to potential increased transmission of communicable disease and effects on social cohesion is considered **Medium**.

Public anxiety related to perceived impacts from oil and gas operations in general has been evident for a number of years in Guyana, and anxiety related to perceived risks from the Project in particular was evident in isolated instances during community engagement conducted to support the EIA. Public anxiety is anticipated to decrease as the local population's understanding of the Project—and in particular the system of embedded controls to prevent unplanned events—increases. The level of public anxiety will likely also decrease with time as the public experiences the actual impacts from planned activities (which may be less than current expectations of impacts for many of the more concerned individuals). For example, local farmers may be less apprehensive regarding potential impacts on their livelihoods as they realize that the presence of the onshore pipeline is not affecting their agricultural activities. Continued disclosure of Project-related activities, as well as continuous engagement with the community and targeted engagement with certain vulnerable populations including the agricultural communities in Regions 3 and 4, will help to reduce the levels of anxiety over a shorter timeframe.

Georgetown residents generally have relatively high levels of literacy and multiple means of accessing information on the Project and the country's developing oil and gas sector on a continual basis, which will help to reduce anxiety related to limited understanding of Project risks. Georgetown residents are also relatively well positioned to experience potential socioeconomic benefits of the Project, which will serve to counteract anxiety related to the Project. However, as there may be some residents in the Direct AOI who may still have concerns and anxieties regarding the potential impact of the Project on their health and wellbeing, through a conservative approach, the sensitivity of the population relative to this potential impact is considered **Medium**.

The Guyana Police Service is responsible for maintaining security and order in the greater Georgetown area. Georgetown tends to have high-crime hotspots, where Guyana Police Service officials experience challenges ensuring sufficient presence to address law enforcement needs. Within the Direct AOI, police presence and ability to respond may be more constrained due to there being only two police stations within the Direct AOI (LaGrange and Wales). The sensitivity of the Georgetown population and those in the Direct AOI to public safety-related risks from the Project, such as crime resulting from population influx, is therefore considered **Medium**.

With respect to potential impacts on mental and physical health as a result of noise-related nuisance during the Construction stage, groups such as children, the elderly, and those with physical or mental disabilities are considered vulnerable population groups. Of the 440 respondents in the 2021 household socioeconomic survey within the Direct AOI, 130 households (29.5 percent) responded that the household includes individuals who are considered for the purpose of this EIA as "vulnerable" (e.g., physical disability, internally displaced, female-headed household); 310 respondents (70.5 percent) claimed to have children below the age of 18 in their household; and 239 respondents (54.3 percent) claimed to have households that include persons over 65 years of age. When a large proportion of a target population is disadvantaged or vulnerable, this can present a barrier to protecting and promoting health. Based on the sensitivity rating definitions in Table 9.2-8, the resource sensitivity for physical determinants of health, including mental and physical health as a result of noise-related nuisance in the Direct AOI, is therefore considered **High**.

Georgetown has a high concentration of medical and health facilities relative to other parts of Guyana, although emergency care capacity and health-related workers are generally considered limited in supply throughout the country. Guyana's emergency medical system is currently in transition, with a relatively new ambulance system responding to emergencies (established in 2014), no air ambulance, and a deficit of hospital beds required to adequately serve the population, although a new infectious diseases hospital has been established (Ministry of Public Health 2016, pers. comm.). Adequate medical health resources and infrastructure in the Direct AOI are generally lacking, often not allowing for timely and sufficient medical and health care. Based on the sensitivity rating definitions in Table 9.2-8, the resource sensitivity for institutional determinants of health, including restricted access to and overburdening of medical and health services, is therefore considered **High**.

9.2.3.5. Pre-Mitigation Impact Significance—Community Health and Wellbeing

Assuming implementation of the embedded controls listed in Table 9.2-9, the intensity ratings for potential Project impacts on community health and wellbeing in the Construction stage will range from **Negligible** to **Medium**. This results in pre-mitigation magnitude ratings in the Construction stage ranging from **Negligible** (for communicable disease / social cohesion under a "closed" worker camp scenario) to **Small** (for communicable disease / social cohesion under a no-worker camp or non-closed worker camp scenario, public anxiety, public safety, and overburdening of and access restrictions to health services) to **Medium** (for noise-related nuisance).

Coupled with sensitivity ratings of **Medium** (for communicable disease / social cohesion, public anxiety, and public safety) and **High** (for noise-related nuisance and overburdening of and access restrictions to health services), the pre-mitigation impact significance for community health and wellbeing ranges from **Minor** (for communicable disease / social cohesion under a no-worker camp or non-closed worker camp scenario, public anxiety and public safety) to **Moderate** (for overburdening of and access restrictions to health services) to **Major** (for noise-related nuisance).

Although the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, suggests that communicable disease / social cohesion under a "closed" worker camp scenario would yield a pre-mitigation significance rating as **Negligible**, the risk remains of workers leaving the camp and/or those workers who do not reside in the camp interacting with communities to an extent that could result in increased communicable disease transmission and/or effects to social cohesion. Therefore, the potential impact has been assigned a **Negligible to Minor** pre-mitigation significance.

9.2.4. Impact Management and Monitoring Measures

Given the **Negligible** and **Minor** significance ratings of potential impacts on community health and wellbeing for communicable disease transmission / social cohesion, public anxiety, and public safety, mitigation measures are not required. That said, EEPGL will work closely with police and other public safety authorities as needed to address concerns regarding Project linkages to these types of potential impacts. With particular respect to public safety concerns, EEPGL will require Project workers to adhere to a worker code of conduct. This code of conduct will also help alleviate risk of communicable disease transmission and degradation of social cohesion, especially if coupled with a worker camp that is closed (e.g., restrictions on worker extracurricular activities within local communities during off-work hours). EEPGL will also implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to Project vehicle movements.

With respect to public anxiety concerns, EEPGL's ongoing stakeholder engagement programs within the Direct AOI and other type of ongoing training will continue to provide a means of informing the community about the Project; this is expected to shorten the timeframe over which public anxiety about perceived Project risks will decrease. EEPGL will also continue to refine and implement its Stakeholder Engagement Plan (SEP; EIA Volume III—Management Plans), which includes measures for continued engagement with communities aimed at increasing awareness of the nature of the Project and the measures in place to prevent accidents. Although this sensitivity is expected to decrease over time as the country becomes more accustomed to the presence of the oil and gas industry and once the pipeline and NGL Plant are operational, it may not be possible to completely alleviate concerns across the entire population.

With respect to potential impacts on community health and wellbeing related to overburdening of medical facilities due to Project use (pre-mitigation significance rating of **Moderate**), EEPGL has reduced the potential impact through the embedded control of having trained medical personnel at the medical clinic at the NGL Plant site to minimize reliance on medical infrastructure and facilities in Guyana. A recommended mitigation measure to supplement this control is for the Project to use a dedicated medical provider (with a dedicated ambulance) to complement the services of the local, private medical clinic used by the Project to avoid overwhelming the local medical infrastructure. On the basis of this mitigation measure being in place, the intensity of the potential impact will be reduced, resulting in a residual impact significance rating of **Minor**.

Given the **Moderate** pre-mitigation significance rating of potential impacts on community health and wellbeing related to restricting access to healthcare and medical facilities as a result of construction, a recommended mitigation measure is for the Project to develop—as part of detailed construction planning—a traffic and access management plan to allow for alternative routing for pedestrians and vehicles during construction, to the extent required based on construction plans. Providing alternative access will limit movement restrictions for non-Project road users, including pedestrians and vehicles, who may require access to necessary healthcare and medical facilities in routine and emergency events. On the basis of this mitigation measure being implemented, the intensity of the potential impact will be reduced, resulting in a residual impact significance rating of **Minor**.

Given the **Major** pre-mitigation significance rating of potential impacts on community health and wellbeing related to nuisance from increased noise, potentially causing stress on mental health, a recommended mitigation (as noted in Table 7.5-14) is to make reasonable efforts to communicate with the residents in the respective structures ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts. Furthermore, during that communication, EEPGL will share how affected persons can use the community feedback mechanism to discuss any nuisance or stress related to elevated noise levels. Advance warning and notification of noise-related impacts and the ability to vent grievances typically reduces mental stress that is associated with the nuisance. On the basis of this mitigation measure being implemented, the intensity of the potential impact will be reduced, resulting in a residual impact significance rating of **Moderate**.

Table 9.2-9 summarizes the management and monitoring measures relevant to this resource.

Table 9.2-9: List of Management and Monitoring Measures

Embedded Controls
Provide health-screening procedures for Project workers to reduce risks of transmitting communicable diseases.
Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD boring).
Develop and implement a SEP that includes measures for continued engagement with communities aimed at increasing awareness of the nature of the Project and the measures in place to prevent accidents.
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) prior to onset of Project activities. Take measures to promote the CGM being well publicized and understood by the public.
Monitor grievances received and resolved by the CGM; adjust the CGM and other management measures on an ongoing basis, as appropriate, based on feedback received.
Mitigation Measures
Require Project workers to adhere to a worker code of conduct, which will address off-duty social interactions and considerations.
Use a dedicated medical provider (with access to a dedicated ambulance) to complement the services of the local, private medical clinic used by the Project to avoid overwhelming the local medical infrastructure
Prior to initiation of onshore construction activities, prepare a traffic and access management plan to provide secondary means of access for vehicles and pedestrians to eliminate restrictions of public movement.
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to Project vehicle movements.
Monitoring Measures
Track number and types of complaints received and resolved via the Project CGM; adjust the CGM and other management measures on an ongoing basis, as appropriate, based on feedback received. Disaggregate the data by location of complainant (e.g., community, Georgetown, other location).
Monitor average time for processing and resolution of grievances.
Track percentage of grievances resolved.
Monitor noise levels during onshore construction activities near sensitive receptors.
Test for communicable diseases through standard medical screening / surveillance protocols.
Monitor frequency of stakeholder engagement, including canal users; households within the Direct AOI, especially those in closest proximity to the onshore pipeline (during Construction) and the NGL Plant (in all stages); and vulnerable households.

9.2.5. Assessment of Residual Impacts

As described above, no mitigation measures are proposed to address potential impacts on community health and wellbeing for noise-related nuisance, anxiety, and communicable disease transmission / effects to social cohesion.

With respect to temporarily restricting access to health and medical resources and potential overburdening of medical/health resources, the recommended mitigations to prevent such restrictions through construction management plans, and through the use of dedicated medical resources for the Project will decrease the residual significance ratings to **Minor**.

With respect to public safety, EEPGL will implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to Project vehicle movements, which will decrease the residual significance ratings to **Negligible**.

Table 9.2-10 through Table 9.2-12 summarize the assessment of potential pre-mitigation and residual impact significant for the assessed potential impacts on community health and wellbeing.

Table 9.2-10: Summary of Potential Pre-Mitigation and Residual Impacts—Individual and Social Determinants of Health

Stage	**Potential Impact**	**Sensitivity**	**Magnitude**	**Pre-Mitigation Significance Rating**	**Proposed Mitigation Measures**	**Residual Significance Rating**
Construction	Increased risk of communicable disease transmission within communities Interaction between workers and community, resulting in potential effects to social cohesion	Medium	Worker Camp "Closed": Negligible Worker Camp Not Used or No Restrictions: Small	Worker Camp "Closed": Negligible to Minor Worker Camp Not Used or No Restrictions: Minor	Require Project workers to adhere to a worker code of conduct, which will address off-duty social interactions and considerations.	Worker Camp "Closed": Negligible Worker Camp Not Used or No Restrictions: Minor
Construction	Public anxiety over presence of onshore natural gas facilities, primarily related to the perceived risk of an emergency event	Medium	Small	Minor	None	Minor
Operations	Public anxiety over presence of onshore natural gas facilities, primarily related to the perceived risk of an emergency event	Medium	Small	Minor	None	Minor

Table 9.2-11: Summary of Potential Pre-Mitigation and Residual Impacts—Physical Determinants of Health

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction Operations	Increased risk of physical and mental health concerns as a result of public safety issues, such as crime, increased traffic, reduced access to social infrastructure and services	Medium	Small	Minor	Prior to initiation of onshore construction activities prepare a traffic and access management plan to provide secondary means of access for vehicles and pedestrians to eliminate restrictions of public movement. Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to Project vehicle movements.	Negligible

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	General nuisance from increased noise, potentially causing stress on mental health	High	Medium	Major	None Communicate with the residents in the respective structures ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts Share details related to the community feedback mechanism	Moderate
Operations	General nuisance from increased noise, potentially causing stress on mental health	High	Medium	Major		Moderate
Decommissioning	General nuisance from increased noise, potentially causing stress on mental health	High	Negligible	Negligible	None	Negligible

Table 9.2-12: Summary of Potential Pre-Mitigation and Residual Impacts—Institutional Determinants of Health

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Overburdening of medical and health services	High	Small	Moderate	Use a dedicated medical provider (with access to a dedicated ambulance) to complement the services of the local, private medical clinic used by the Project to avoid overwhelming the local medical infrastructure	Minor
Construction	Temporary restriction of access to medical/healthcare facilities	High	Small	Moderate	Prior to initiation of onshore construction activities, prepare a traffic and access management plan to provide secondary means of access for vehicles and pedestrians to eliminate restrictions of public movement.	Minor

9.3. Social Infrastructure and Services

This section presents an overview of social infrastructure and services in Guyana, with a focus on the vicinity of the Project (including Region 3 and Region 4), and considers how individuals and communities using these social infrastructure and services may be affected by the Project. Potential impacts related to road and marine transportation are covered in Section 9.4, Transportation.

9.3.1. Baseline Methodology

The understanding of existing conditions (Section 9.3.2, Existing Conditions and Baseline Studies) is based on a combination of desktop (secondary) and field-based (primary) research. Desktop studies used publicly available information, including the Guyana national census[20] and reports by government, NGO, and multilateral institutions. Field-based research included household socioeconomic surveys conducted in the vicinity of the Project, as described in Section 9.1, Socioeconomic Conditions.

9.3.1.1. Study Areas

Four separate study areas are referenced in the discussion of socioeconomic resources; together, these comprise the combined Onshore Direct AOI and Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology. The study areas are referred to throughout Chapter 9, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, and are described below (Figure 9.1-1):

- Direct AOI
  - **Primary Study Area**[21]: This study area includes communities and households within 500 meters of the onshore pipeline corridor, within 1 kilometer of the NGL Plant boundary and/or temporary MOF; within the area extending from the Demerara River immediately north of Free and Easy village, south and west to the NGL Plant and temporary MOF; plus the area encompassing settlements in the Belle West housing scheme.
  - **Secondary Study Area**: This study area includes communities and households located between the Primary Study Area and the Demerara River.
- Indirect AOI
  - **Tertiary Study Area**: This study area includes the communities on the East Bank of the Demerara River immediately across from the temporary MOF.

    The communities that were engaged and/or studied in the Tertiary Study Area include Brickery, Garden of Eden, and Land of Canaan.

[20] The most recent national census was undertaken in 2012 (BSG 2012).
[21] The socioeconomic Primary Study Area includes the Direct AOI for biophysical components, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

- **Regional Study Area**: This study area includes the remainder of Region 3 in addition to Regions 2 and 4 (the balance of the Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology).

  The communities that were engaged and/or studied in the Regional Study Area include Georgetown, Santa Aratak, and Pakuri.

The combined socioeconomic study areas are equivalent to the Onshore Indirect AOI as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

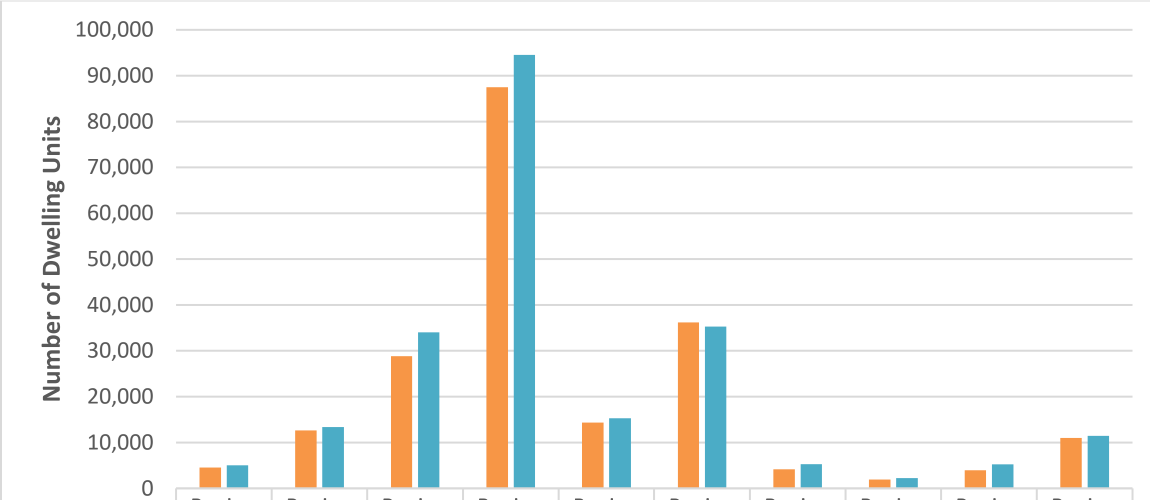
In Section 9.3.3, Impact Prediction and Assessment, the identification and assessment of potential impacts on social infrastructure and services has been conducted in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology.

9.3.2. Existing Conditions and Baseline Studies

This section describes existing conditions for social infrastructure and services in the Project AOI. The section addresses the following social infrastructure and services: housing, lodging, water and sanitation, power, telecommunications infrastructure, educational facilities, and security facilities. Medical infrastructure and services are addressed in Section 9.2, Community Health and Wellbeing. Ground and marine/river transportation infrastructure are addressed in Section 9.4, Transportation.

9.3.2.1. Housing

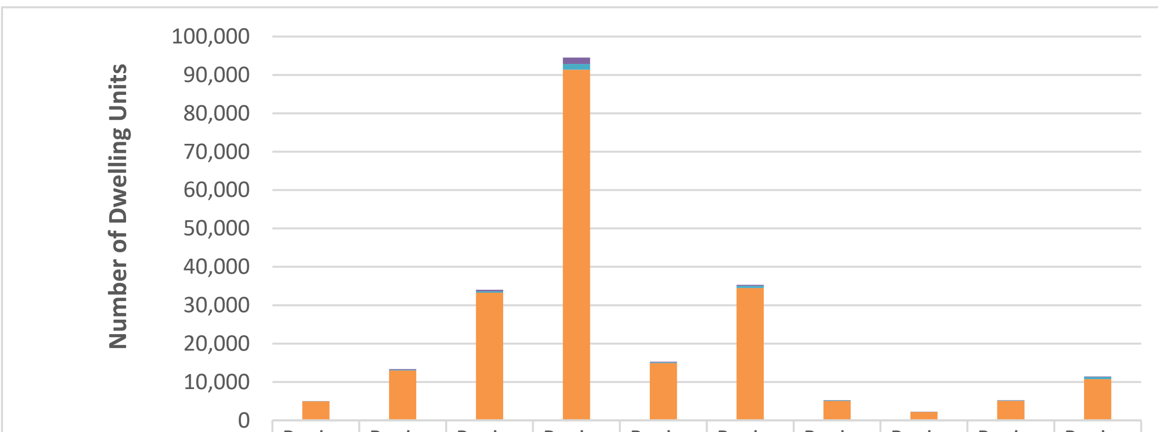
According to the 2012 census results (BSG 2012), a total of 221,741 dwelling units were recorded in the country, which was an increase of 8.1 percent compared to the 2002 census results. Regions 3, 4, and 6 contain the largest proportion of the population and, as expected, recorded the highest number of dwelling units in both the 2002 and 2012 census years. Figure 9.3-1 shows the number of dwelling units by region. According to the 2012 data, 214,999 of the total 221,741 dwelling units were occupied, suggesting that only 3 percent were either vacant or closed dwelling units, compared to 8.8 percent in the 2002 census. Occupancy rates were high for all ten administrative regions according to the 2012 census (see Figure 9.3-2).



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
2002	4,556	12,629	28,819	87,475	14,347	36,189	4,173	1,933	3,963	11,013
2012	5,042	13,368	34,042	94,531	15,274	35,297	5,266	2,227	5,257	11,437

Source: BSG 2012

Figure 9.3-1: Regional Distribution of Dwelling Units: 2002 and 2012



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Closed Dwellings	57	203	411	1,663	166	221	107	31	104	127
Vacant Dwellings	44	158	362	1,497	205	589	138	13	64	582
Occupied Dwellings	4,941	13,007	33,269	91,371	14,903	34,487	5,021	2,183	5,089	10,728

Source: BSG 2012

Figure 9.3-2: Number of Occupied, Closed, and Vacant Dwelling Units: 2012

Detached houses are the most common type of housing in all regions and a majority of homes in the coastal area are owned by their occupants, as indicated by the 2012 census. However, the census data indicate that Regions 3 and 4 have a higher proportion of rented and unrecognized tenure homes, which is consistent with data obtained during the ecosystem services fieldwork conducted in late 2017 and early 2018 (ERM/EMC 2018). In addition, according to an IDB study on the housing sector of six Caribbean countries, Guyana had—at the time—a housing deficit of 20,000 units for the low-income category (IDB 2016b).

Approximately 74 percent of the 433 respondents to the housing questions within the 2021 household socioeconomic survey conducted in the vicinity of the Project indicated that they have resided within the Wales Estate Area for over 10 years. Only 20 of the 433 respondents indicated they had recently arrived (i.e., within the past 6 months). In terms of the type of tenure, respondents provided a range of answers, predominantly *lease*, *own*, or *rent*. Only 22 respondents indicated they use their land with no formal agreements. Section 9.6, Land Use and Ownership, provides further details on this aspect.

According to a 2020 housing market study, Guyana's residential real estate prices have been rising, particularly in the capital city of Georgetown, following the discovery of oil in 2015. In line with the growing demand for housing, commercial banks' housing loans have increased, prompting an increase in household debt (Chow 2020). It should be noted that this study concluded that a thorough analysis of the housing market in Guyana is challenging in view of the limited availability of data and the limited duration of the study.

Georgetown Housing Market

Georgetown has a population density of 104.4 people per square kilometer (km^2) as compared with the six coastal regions (which have a combined population density of 9.6 people per km^2) and the four hinterland regions (which have a combined population density of less than 1 person per km^2) (IDB 2016b). According to several realtors based in Region 4, the residential market in Georgetown is mainly comprised of nuclear families with children; up to 70 percent of the residences are rentals. The realtors indicated that households with multi-generational families and extended families are not common in Georgetown. The main constraints to home ownership identified were low incomes, high mortgage interest rates, and low availability of preferred locations. In the more affluent areas of Georgetown, where gated communities and secure homes are available, single-family home values currently range from $50 million to $70 million GYD ($250,000 to $350,000 USD) (Jewanram Realty 2019, pers. comm.; Carol Comes 2019, pers. comm.; Reid's Realty 2019, pers. comm.).

In 2019, local realtors stated that the residential market in Georgetown is small, and that since oil was discovered in 2015, there have been increases in both demand and prices of purchased and rental homes and apartments in Georgetown. Shortages are reported in the rental markets at price points between $50,000 and $85,000 GYD per month ($250 to $425 USD per month) and in the home-buying markets at price points ranging from $15 million to $40 million GYD ($75,000 to $200,000 USD) in Georgetown. Increased investments in executive housing, apartment complexes, and office spaces that may be linked to the oil and gas sector have been observed by realtors (Jewanram Realty 2019, pers. comm.; Carol Comes 2019, pers. comm.; Reid's Realty 2019, pers. comm.).

Informal Settlements

Informal housing settlements increased in the 1980s and 1990s due to housing supply constraints, causing many people to occupy vacant parcels (IDB 2016a). The former Ministry of Communities (now the Ministry of Local Government) has worked in recent years to regularize some informal settlements, particularly in the Georgetown area, by providing services such as paved streets, drainage, septic tanks, and water supply. If informal settlement sites are not suitable for regularization to permanent neighborhoods, they are moved to other locations (Ministry of Communities 2016; IDB 2016a, 2016b). In 2016, there were 216 recorded informal settlements in the country, of which 154 had been brought under the regularization program (IDB 2016a).

9.3.2.2. Lodging

In Guyana, lodgings include hotels, guesthouses, and resorts—the latter of which are located mainly in hinterland areas. Accommodation capacities are relatively small and occupancy rates tend to be low. In addition, there are several small-scale lodgings that are not graded or certified (IDB 2015). According to data from the Guyana Tourism Authority, accommodation capacity in Guyana had been steadily increasing as of 2017, with room capacity increasing by more than 90 percent in 2017 (3,338 rooms) as compared with 2006 (1,716 rooms). The majority of visitors in Guyana stay in private homes and hotels. However, the data from the Guyana Tourism Authority suggest the number of visitors staying in private homes declined from 2015 to 2017, while there were increases in visitors staying in hotels, guesthouses, and apartments. The number of visitors to Guyana staying in resorts also declined across this period. This could be related to the number of reported business travelers, which increased from 15,543 in 2012 to 24,855 in 2017 (GTA 2018).

The tourism sector in Guyana, including the hotel and lodging segment, was severely affected by the COVID-19 pandemic (Ragobeer 2020). However, the decline in tourist room occupancy of established hotels during the pandemic was offset by the oil and gas sector (including EEPGL and service companies), which booked entire venues for their workers for the duration of 2020 and 2021.[22]

In Region 3, a three-star hotel in Vreed-en-Hoop called the Aracari Resort has 52 rooms. Approximately 17 kilometers southwest of the proposed NGL Plant, a commonly visited eco-resort / nature reserve called Arrowpoint Nature Resort is located in the rainforest and titled lands of the Santa Aratak Amerindian Reservation. This eco-resort is reached by boat along Kamuni Creek, a tributary to the Demerara River approximately 16 kilometers upriver from the proposed temporary MOF. The small resort of eight rooms is popular with domestic and international tourists and is not a common lodging choice for business travelers.

[22] Lodging data presented in this section includes data from 2019 and selected updates for 2020. Due to the significant impacts of the COVID-19 pandemic on the tourism and hospitality sector (including hotels) in 2020, occupancy and other data from 2019 is expected to be more representative of future conditions during planned Project construction and operation.

Many respondents to the 2021 household socioeconomic survey mentioned local guest houses or rooms for rent in their communities. However, in most cases, residents were unable to specifically identify a location or name for these accommodations.

A list of the most commonly frequented hotels in Region 4 and their capacities as of 2019 is presented in Table 9.3-1.

Table 9.3-1: Room Numbers at Principal Hotels in Region 4, 2021

Name of Lodging	Number of Rooms
Alpha Guest House	35
Guyana Marriott Hotel	197
Princess Hotel	191
Pegasus Hotel Guyana	134
Tower Suites	74
Regency Suites	40
Grand Coastal Hotel	43
Sleepin International Hotel	56
Sleepin International Hotel and Casino	152
Brandsville Hotel	34
Brittany’s Hotel	39
Cara Lodge	34
K & VC International Ltd.	40
King’s Plaza Hotel	33
Ocean View Hotel	44
Park Vue Hotel	32
Tropical View International Hotel	32

Source: GTA 2021, pers. comm.

Georgetown and Area Hotels

Most hotels in Georgetown offer similar basic amenities, including Wi-Fi, restaurants, bars, fitness centers, swimming pools, ensuite bathrooms, free parking, laundry services, and television. In addition, some also provide business centers and conference facilities. However, there is significant variability in the daily rates for the hotels between international and non-international brands; the former offer additional services and generally have higher ratings and prices. The majority of accommodation capacity is centralized in Region 4, particularly in Georgetown, where several major internationally branded hotels are located.

From April to May 2019, a team of consultants commissioned by EEPGL requested feedback from 14 hotels in Region 4 on the facilities they offer and general demand forecasting, including any perceived influence from the increased activity in the oil and gas sector, and received responses via questionnaire from seven hotels: Pegasus Hotel Guyana, Regency Suites, Grand Coastal Hotel, Brandsville Hotel, Cara Lodge, El Dorado Inn, and Kanuku Suites. Based on the responses, the Pegasus Hotel Guyana and Grand Coastal Hotel reported average capacity rates of more than 70 percent. Disaggregated data on the origins of their guests are not available, but they indicated that a majority are foreigners.

The room rates at the Pegasus Hotel Guyana were the highest among the hotels that provided feedback. At the time of the 2019 survey, daily room rates varied from $39,000 to $50,000 GYD ($195 to $250 USD) at the Pegasus Hotel Guyana and $14,000 to $27,800 GYD ($70 to $139 USD) at the Grand Coastal Hotel.

The Pegasus Hotel Guyana is expanding, with the construction of a 200-suite hotel, conference centers, and executive office space that was initially expected to be operational by early 2021. However, construction was delayed by the availability of construction materials due to the impacts of the COVID-19 pandemic.

The Grand Coastal Hotel indicated that there are no current plans for expansion.

The remaining five responding hotels reported average capacity rates (pre-COVID-19) that fluctuate from 40 to 70 percent based on the season. In particular, the Brandsville Hotel indicated that capacity rates vary based on peak seasons for business travel. Seasons and availability of rooms also influence the room rates. The majority of the guests at these hotels are reported to be foreigners. Cara Lodge, Brandsville Hotel, and El Dorado Inn all reported changes in vacancy rates and origin of guests over the last 2 to 3 years that they suggested could be linked to the oil and gas sector. Regency Suites reported lower vacancy rates, but this was attributed to the facilities they provide. Of the hotels surveyed, only Regency Suites has disaggregated data on the origins of the guests, with approximately 25 percent of guests being Guyanese, 30 percent from CARICOM countries, and the remaining 45 percent from other foreign countries. At the time of the survey, Regency Suites reported the lowest daily room rates at $11,400 GYD ($57 USD) and also offered options for permanent housing. In addition, Cara Lodge, Kanuku Suites, Brandsville Hotel, and Regency Suites indicated that works expansion and upgrades were planned or underway as of 2019 (Kanuku Suites 2019, pers. comm.; Cara Lodge 2019, pers. comm.; Brandsville Hotel 2019, pers. comm.; El Dorado Inn 2019, pers. comm.; Regency Suites 2019, pers. comm.).

The Marriott Hotel is popular with both Guyanese visiting Georgetown and travelers affiliated with the oil and gas sector. To address accommodation needs associated with the COVID-19 pandemic, workers from EEPGL and service companies are currently occupying much of the hotel. According to TripAdvisor.com, the average price range for a standard room at the Marriott is between $48,000 and $100,000 GYD ($240 and $500 USD) (TripAdvisor 2021).

In 2020, the Government of Guyana through the Guyana Office for Foreign and Local Investment published a call for the Expression of Interests for the construction of hotels in Guyana. In November 2020, agreements were signed for the development of four hotels in Region 4. Among the intended hotel projects are an $18 billion GYD ($90 million USD) Hilton Garden Inn at Houston/Mc Doom (East Bank Demerara), a Delta Hotels Marriott near the Cheddi Jagan International Airport, an H-Towers luxury hotel in New Providence (on the East Bank), and a SureStay Plus Hotel by Best Western (in the city center) (Papannah 2020).

According to GO-Invest, these investments were being prioritized by the government in 2021 (Guyana Times 2021).

9.3.2.3. Water and Sanitation

Official data on water usage in Guyana is difficult to obtain, but the United Nations estimates that irrigation use takes up a significant portion, followed by municipalities (FAO 2021). A 2021 household socioeconomic survey by the Consultants found that 111 of the approximately 440 survey respondents stated that they use the canals in and around the Primary and Secondary Study Areas for various purposes, including domestic use for water (particularly in drought or dry seasons), agriculture, fishing, transportation, and personal use (bathing, swimming, recreation). Figure 9.3-3 shows the households where reported canal users reside, based on survey responses.

Of the 59 survey respondents who reside in the Primary Study Area, 19 claimed to not use the canals for any purpose. Five of these responding canal users indicated multiple uses of the canal; the most frequently reported other uses in the Primary Study Area were transportation (8 respondents), fishing (13 respondents), personal and household (5 respondents), agriculture (5 respondents), and domestic (4 respondents). It was noted by a few households in La Harmonie and Free and Easy communities that they use the canal for transportation to and from school and farming areas. For personal and household use, respondents in the area use the canals for swimming, bathing, and water for household chores.

According to the Canal Polder NDC representatives (Canal Polder NDC 2021b, pers. comm.), residents use both canals and the Conservancy Dam area for swimming, fishing, family outings, boating, and jet skiing, although it should be noted that boating is illegal in the Conservancy Dam area. In the Goed Fortuin area, there are fisherfolk who use the koker areas and associated canals for boat landing purposes. This is also the case at the kokers of Schoonard and Meer Zoorgen. The canals are also used throughout the Direct AOI for the planting of religious flags by Hindu devotees. The Goed Fortuin NDC (Goed Fortuin NDC, 2021, pers. comm.) has noted an increased use of the canals in their NDC area for religious worship, which has resulted in the relocation of some fishing activities away from these areas.

Only 14 of the 32 respondents in the portion of the Primary Study Area along the pipeline corridor (including at the pipeline canal crossing areas) report using the canals. The reported uses include agriculture, fishing, domestic use, and personal use. There was no mention of transportation uses.

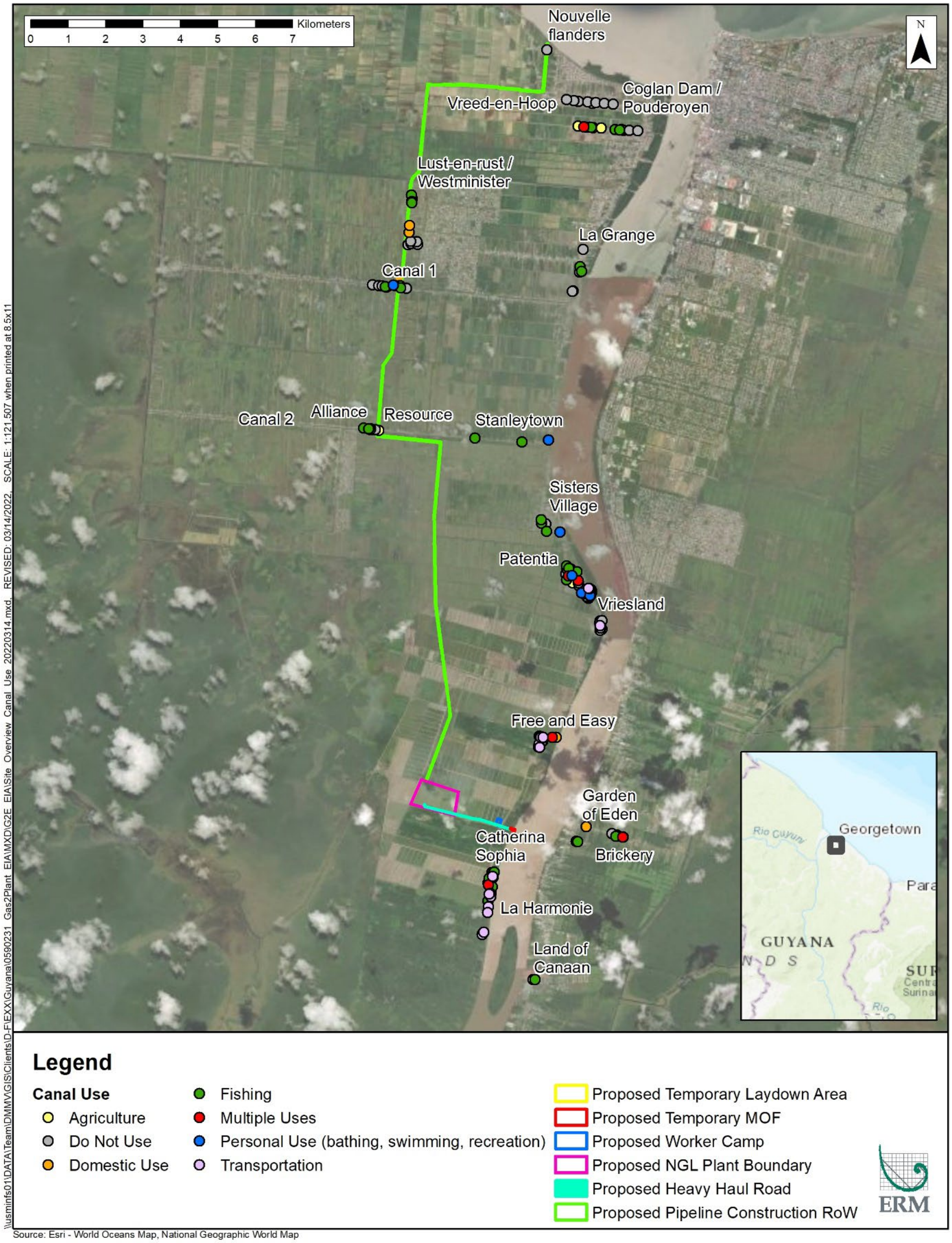


Figure 9.3-3: Canal Users and Primary Uses

Potable Water

Most potable water is obtained from the deeper aquifers that underlie Georgetown and the coastal plain. GWI, a commercial public enterprise, distributes water in five service areas along the coast, and has a separate program to serve communities in the hinterlands. GWI derives 90 percent of its water from groundwater sources and the remaining 10 percent from surface water sources (GWI Undated_a). Groundwater is extracted from 250 wells and is processed in 28 water treatment plants (GWI 2020). The former Ministry of Communities[23] and GWI have established several new wells in the hinterland regions, including in communities in Regions 1 and 9. New wells were also established in Region 4. In addition, GWI is working to increase access to treated water in Region 1 and intends to establish several water treatment plants in Georgetown (Guyana Chronicle 2018).

In rural areas not served by GWI, domestic water is obtained from a mix of groundwater, surface water, and rainwater sources. Rainwater is often used for potable water in households, while river water is typically used for cleaning and other non-potable uses. The Food and Agriculture Organization estimated that in 2012, 98 percent of the population had access to improved water sources (FAO 2015).

Businesses that use large quantities of water, such as beverage bottling and food processing plants, generally have their own wells to meet their needs (FAO 2015).

The results of the 2021 household socioeconomic survey in Region 3 found that 88 percent of the 436 respondents have connections to a main water line, while 6 percent use rainwater; five respondents claimed to use rivers or canals for their water needs. Those five respondents were in three different communities across the survey area. According to Canal Polder NDC representatives (Canal Polder NDC 2021b, pers. comm.), the water from the Conservancy Dam is commonly used by households who siphon freshwater with pipes for domestic use such as washing and gardening.

Agricultural-Use Water

Declared Drainage and Irrigation Areas (areas with fully developed drainage and irrigation systems) are found in Regions 2, 3, 4, 5, and 6. In these regions, irrigation is conducted via gravity flow from surface water resources trapped by shallow earthen dams known as “conservancies.” These are located in the upper stream catchment areas and store water at elevations higher than those of the surrounding fields. In other schemes, water is pumped from rivers into the irrigation canals. In addition, there are several engineered conservancies that supply water to agricultural lands in coastal regions. The Tapakuma Conservancy serves Region 2 and has been designed to provide irrigation to about 12,000 hectares (29,650 acres). During times of water shortage, this conservancy is supplemented by pumping from the Pomeroon River (FAO 2015). The Boeraserie Conservancy supplies Region 3, the East Demerara Water Conservancy supplies Region 4, and the Mahaica-Mahaicony-Abary / Agricultural Development Authority supplies water to Region 5.

[23] Now Ministry of Local Government

The National Drainage and Irrigation Authority of the Ministry of Agriculture has responsibility for the maintenance and delivery of the irrigation water supply throughout the country. This authority works with the conservancies' boards, water users associations, farmer groups, and local government bodies to maintain irrigation and drainage systems in an operational and efficient manner.

According to Canal Polder NDC representatives (Canal Polder NDC 2021b, pers. comm.), the water from the Conservancy Dam supplies rice farmers with water in outlying areas (Nismes, La Retraite Canal and sugar estate), and water from the canals is also used for agricultural purposes.

Sanitation

In addition to potable water, GWI provides sanitation services in Georgetown. Wastewater collection is provided through sewerage systems in central Georgetown, and in the Tucville-Stevedore housing schemes, servicing approximately 60,000 residents plus a non-residential population of approximately 200,000 persons. GWI has plans to construct two wastewater treatment facilities for each of these sewerage systems (i.e., central Georgetown and Tucville-Stevedore; GWI Undated_b).

Approximately 88 percent of respondents in the 2021 household socioeconomic surveys in Region 3 claim to use flush toilets while approximately 12 percent of respondents across a variety of communities use latrines. According to the Canal Polder NDC representatives (Canal Polder NDC 2021b, pers. comm.), some of the squatting areas in Cameron Dam, Belle West housing scheme, and along the Conservancy Dam are prone to flooding and this causes the pit latrines to overflow.

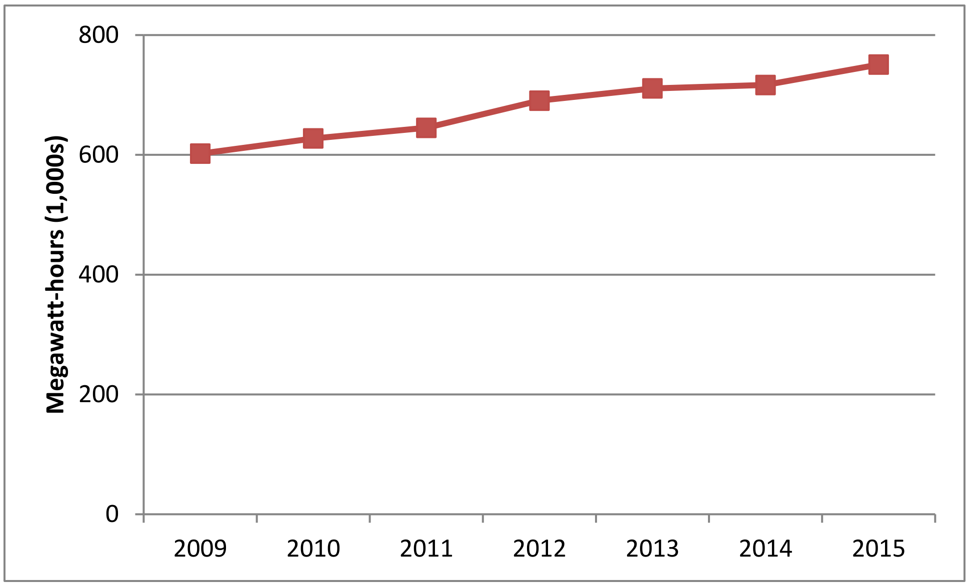
Power

Most of the electricity in the coastal plain of Guyana is generated, transmitted, and distributed by the state-owned utility Guyana Power & Light. However, due to poor reliability, many users also have their own diesel generators. Coastal areas that are not serviced by Guyana Power & Light include the Region 2 area west of Charity, and Region 1. Most areas of the hinterlands do not have centralized electricity supply, and the government has implemented a number of hinterland energy development projects in recent years, including solar system installations and feasibility studies for hydropower and wind projects (GPL 2011). According to the Guyana Energy Agency, a number of renewable energy projects are planned, including photovoltaic plants at Legaun and Mahdia. A 400-kilowatt solar farm was commissioned in 2021 at Mabaruma in Region 1 (Ragobeer 2021).

The PSC of Guyana has noted that the high cost of electricity in Guyana is a major challenge for businesses. During ecosystem services field work commissioned by EEPGL in late 2017 and early 2018, this was raised as an issue by representatives of agricultural processing associations as well as local community leaders (Canal Polder NDC 2021b, pers. comm.; Pomeroon WAPA 2016, pers. comm.; Private Sector Commission of Guyana 2016, pers. comm.; ERM/EMC 2018).

According to the PSC, hydroelectricity development should be a major priority for the country. The plan for the 165-megawatt Amaila Falls hydroelectric plant was cancelled in 2015 due to delays and the potential for cost overruns (Private Sector Commission of Guyana 2016, pers. comm.).

Figure 9.3-4 shows the total electricity generation output in Guyana in thousands of megawatt-hours from 2009 through 2015.



Source: Ministry of Finance 2015

Figure 9.3-4: Electricity Generation in Guyana, 2009–2015

Although Guyana has significant potential for hydroelectric, solar, and biomass-fueled electricity generation, in 2020, 92 percent of its installed generation capacity was thermal, relying on expensive imported heavy oil and diesel fuels and making average electricity prices among the highest in Latin America and the Caribbean (U.S. Department of Energy 2020). Of the remaining installed capacity, 7 percent was biomass-based, using bagasse (sugarcane fibers remaining after cane juice is extracted) as fuel to generate power at Guyana Sugar Corporation's sugarcane factories, and 1 percent was solar. There are plans to enhance the generation capacity of the factories such that excess power is available and can be exported to the national electrical grid, and the government is working toward a strategy to diversify Guyana's energy mix with renewable energy technologies focused on wind, solar, and small hydroelectric (GEA 2016; ClimateScope 2017).

During 2017 and 2018, the government implemented a Green Public Sector Programme, which saw the installation of a combined capacity of 3.02 megawatts of solar photovoltaic systems on the rooftops of 175 public or government buildings, and 65 solar-powered, light-emitting diode streetlights (GEA Undated). Solar farms are planned for other areas in the hinterlands including Port Kaituma and Matthew's Ridge in Region 1 (GEA Undated). In January 2019, a $1.6 billion GYD ($8 million USD) low-cost loan was approved by the Abu Dhabi Fund for Development and the International Renewable Energy Agency for the installation of a 5.2-megawatt grid-connected solar photovoltaic system in Guyana (DPI 2019b). In June 2019, Norway approved the release of $16 billion GYD ($80 million USD) to fund 30-megawatt solar farms with storage in hinterland communities (DPI 2019a). Further, in 2019, private developer Guyana Wind Farm Inc. indicated intentions to establish the Hope Beach Wind Farm at Hope, East Coast Demerara in Region 4. In June 2021, the company submitted its EIA to the EPA (OilNOW 2021). The wind farm will comprise four turbines, which are intended to supply 13 megawatts of power to the national grid (Ramroop 2019).

Approximately 88 percent of respondents in the 2021 household socioeconomic survey are tied to the main electricity line, while 3 percent report being without any supply of electricity and 9 percent rely on a generator or another source of power.

9.3.2.4. Telecommunications Infrastructure

The majority of households in the coastal regions have access to mobile phone service. There were 658,800 mobile connections in Guyana in January 2021, yielding a mobile connection rate of 83.6 percent of the population (Datareportal.com 2021). The lack of 4G network access, a previous major barrier to increased business investment in Guyana, was addressed in 2016 with the installation of the country's first 4G network. In addition, the government has signaled its intention to prioritize the economic liberalization of Guyana's telecommunications market to encourage greater investment in the sector (Guyana Chronicle 2019).

Internet service in Guyana consists of two major communications companies and a number of smaller companies providing broadband and satellite services. The services are more available on the coast, with lower availability in the hinterlands. The internet penetration rate as of 2021 was 37.3 percent with 294,300 users (Datareportal.com 2021). Internet users in Guyana increased by 1,442 between 2020 and 2021. The Government of Guyana has embarked on a number of programs to address internet inequity in the country, including the national eGovernment Programme, which developed a Digital Governance Roadmap for Guyana (e-Governance Academy 2018).

9.3.2.5. Educational Facilities

Table 9.3-2 shows the number of nursery, primary, secondary, and post-secondary schools in each of the coastal regions. The majority of post-secondary institutions (technical schools, colleges, and universities) are found in Georgetown. Educational facilities in the vicinity of the Project are shown on Figure 9.3-5.

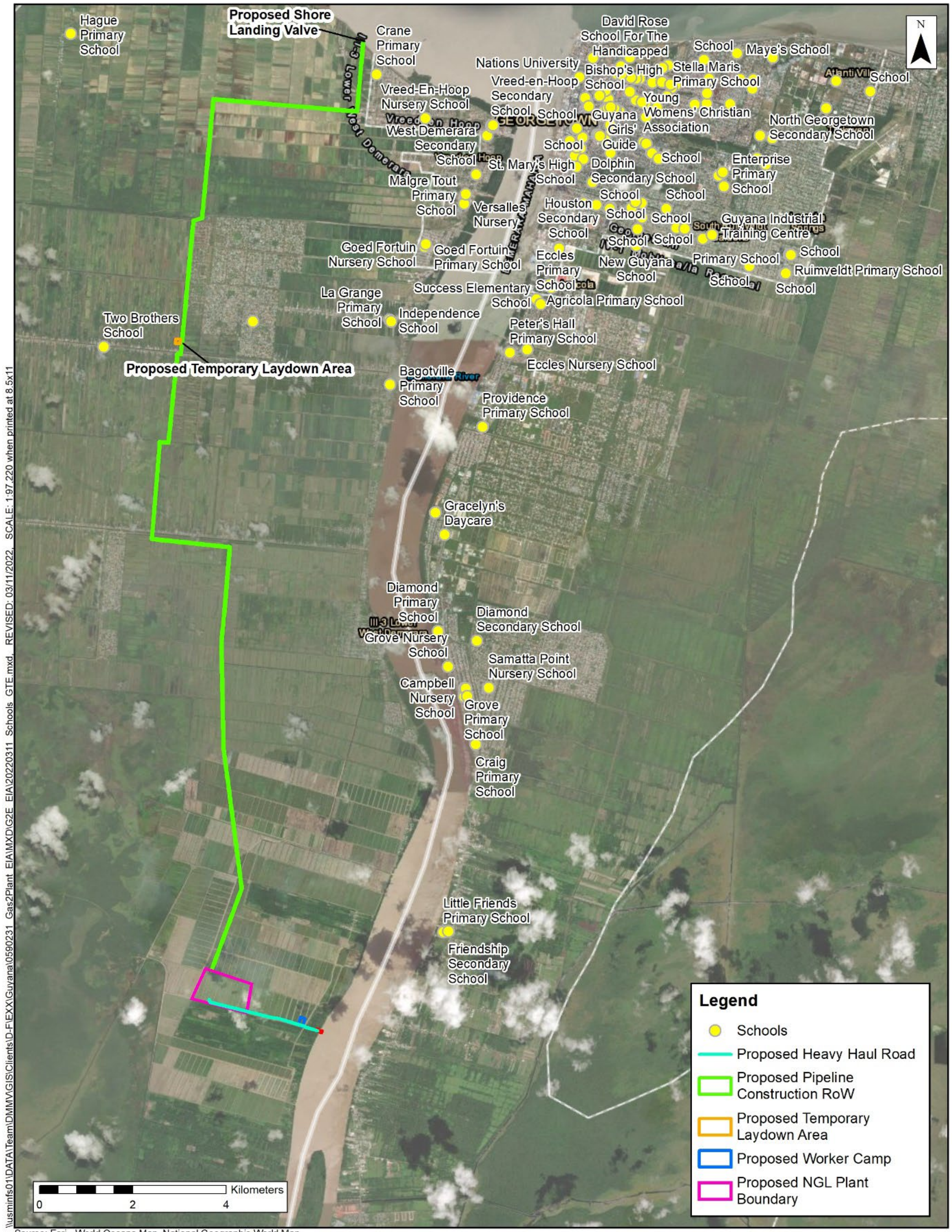
Table 9.3-2: Number of Educational Facilities in Guyana's Coastal Regions

	Nursery	Primary	Secondary	Technical/ Vocational	Special Schools	College/ University
Region 1	17	53	3	0	0	0
Region 2	36	42	8	1	0	0
Region 3	45	58	13	1	0	0
Region 4	58	55	48	10	2	15
Region 5	31	30	7	3	0	0
Region 6	57	56	18	2	0	2

Source: Ministry of Education 2018a,b,c, pers. comm.; Ministry of Education Undated

The distribution of schools in the coastal regions compared with other areas reflects population trends along the coast. Schools are found all along the coast of Regions 3, 4, 5, and 6, which are the most populated regions.

At the tertiary level, the country has one national public higher education institution, the University of Guyana. The university has two campuses in the country, the Turkeyen Campus in Region 4 and the Tain Campus in Region 6, both of which offer undergraduate and graduate programs. In addition, through its Institute of Distance and Continuing Education, the university offers extramural classes and online programs in Regions 2, 4, 6, and 10. Approximately 40,000 students (including both local and international) have graduated from this institution. For the academic year 2020 to 2021, the University of Guyana had a student population of 10,000 (University of Guyana 2021).



Source: Esri - World Oceans Map, National Geographic World Map

Figure 9.3-5: Educational Facilities in Vicinity of Project

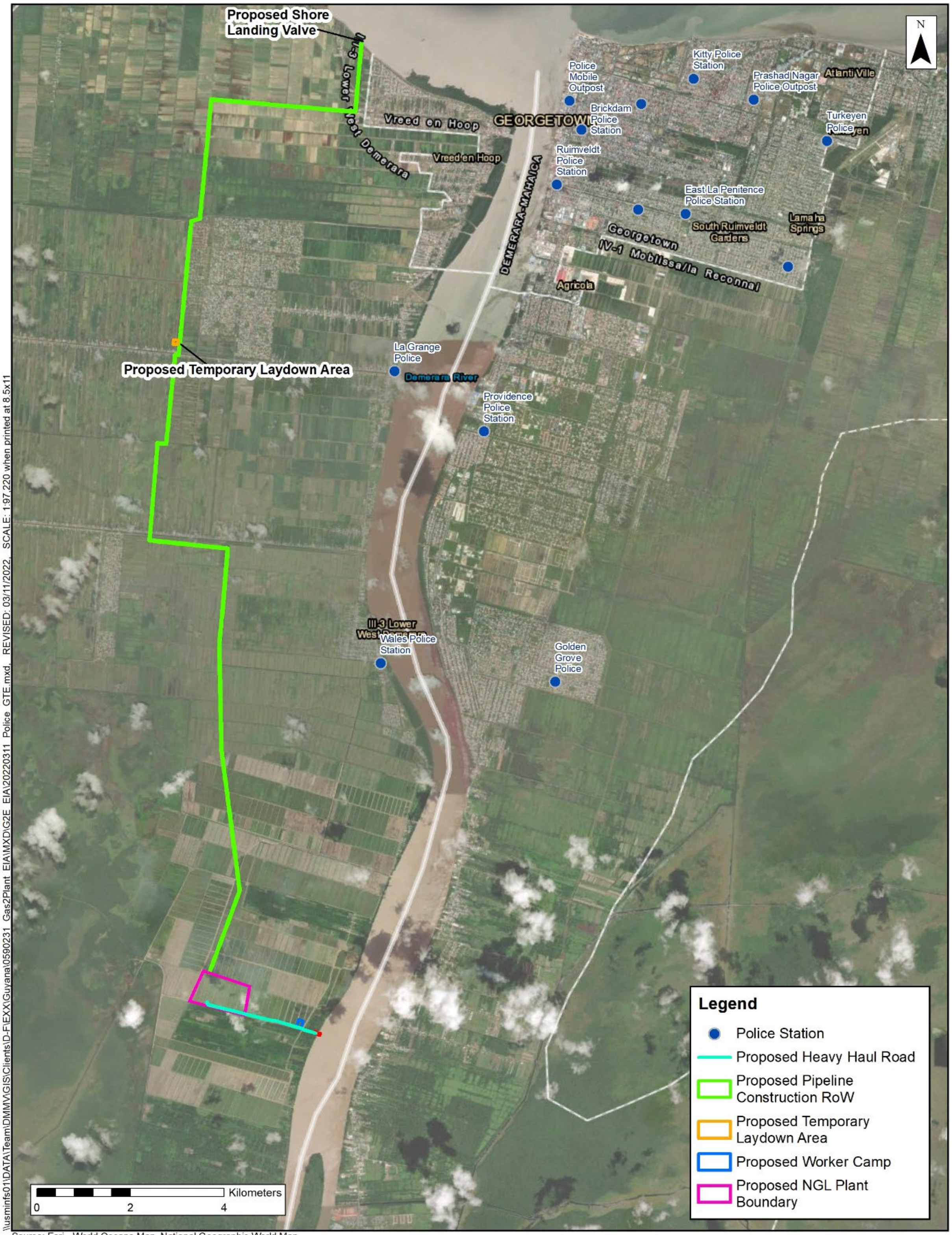
9.3.2.6. Security Facilities

The Guyana Defense Force is the military service of Guyana and has land, sea (Coast Guard), and air (Air Corps) units responsible for defending the territorial integrity of Guyana. In terms of internal security, the Guyana Police Service operates as a semiautonomous agency under the Ministry of Home Affairs. The Guyana Police Service has seven geographic policing divisions, each with its own headquarters, stations, and outposts, as summarized in Table 9.3-3.

Table 9.3-3: Policing Divisions in Guyana

Division	Geographic Area	Headquarters Location	Number of Stations	Number of Outposts
A	City of Georgetown and the East Bank of the Demerara River, including the Cheddi Jagan International Airport, Timehri, 40 kilometers (25 miles) from Georgetown	Brickdam, Georgetown	9	7
B	County of Berbice but excluding Kwakwani	Coburg Street, New Amsterdam	12	5
C	County of Demerara, east of the Demerara River but excluding A Division	Cove & John, East Coast Demerara	8	4
D	County of Demerara, west of the Demerara River and a portion of the East Bank of the Essequibo River	Leonora, West Coast Demerara	6	1
E & F	Upper Demerara including the area surrounding the bauxite holdings of Linden, Ituni, and Kwakwani, and the interior	Rabbit Walk, Eve Leary, Georgetown	30	6
G	Essequibo Coast including the islands of the Essequibo and Pomeroon Rivers	Anna Regina, Essequibo Coast	6	0

Figure 9.3-6 shows the total reported police stations in the vicinity of the Project (locational data were not available for the interior outpost locations).



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Source: Esri - World Oceans Map, National Geographic World Map

Figure 9.3-6: Locations of Police Facilities in Project Vicinity

9.3.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on social infrastructure and services. The relevant planned Project activities and the associated potential impacts of these activities on social infrastructure and services are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.3.3.1. Relevant Project Activities and Potential Impacts

In general, the planned Project activities that could affect social infrastructure and services within the Onshore Direct AOI[24] and Indirect AOI relate to the presence of the Project workforce in Regions 3 and 4. This includes the potential for an influx of job-seekers to the Georgetown area and, construction activities with the potential to affect the canals used by local households within the Onshore Direct AOI. Table 9.3-4 summarizes the Project activities that could result in potential impacts on social infrastructure and services.

Table 9.3-4: Summary of Relevant Project Activities and Key Potential Impacts—Social Infrastructure and Services

Stage	Project Activity	Key Potential Impacts
Construction	Construction of onshore pipeline, including trenching, backfillingfor pipeline installation	• Accidental damage to underground utilities • Erosion and sedimentation into canals, affecting usability for households • Temporary loss of canal access due to construction activities, preventing household use
	Project-related worker presence in Region 3 and Region 4 (Georgetown area), including potential for induced influx of job-seekers to Georgetown area	• Increased demand or use of lodging, leading to reduced availability and/or increased housing cost • Increased demand or use of housing and utilities, leading to reduced availability and/or increased cost
Operations	Project-related worker presence in Region 3 and Region 4 (Georgetown area), including potential for induced influx of job-seekers to Georgetown area	• Increased demand or use of lodging, leading to reduced availability and/or increased housing cost • Increased demand or use of housing and utilities, leading to reduced availability and/or increased cost

[24] For socioeconomic resources, the onshore component of the Direct AOI includes the communities within the immediate vicinity of the Project's onshore components, as well as the communities between the Project's onshore components and the Demerara River (these correlate with the Primary and Secondary Study Areas, respectively, as described in detail in Section 9.1.1, Baseline Methodology [Socioeconomic Conditions]).

Stage	Project Activity	Key Potential Impacts
Decommissioning	Project-related worker presence in Region 3 and Region 4 (Georgetown area), including potential for induced influx of job-seekers to Georgetown area	• Increased demand or use of lodging, leading to reduced availability and/or increased housing cost • Increased demand or use of housing and utilities, leading to reduced availability and/or increased cost

Potential impacts related to availability of emergency medical and health services as a result of the Project are assessed in Section 9.2, Community Health and Wellbeing. Potential impacts related to transportation, including transportation infrastructure, are assessed in Section 9.4, Transportation.

The Project will be completing a series of road and bridge upgrades as part of early works activities approved separately by the EPA, which should contribute to a positive outcome for road and bridge users within the Direct AOI; however, as discussed in Chapter 5, Project Description, these early works activities are not in scope for this EIA.

The Project will be providing its own power sources during the Construction stage and will source power for the NGL Plant from the third-party power plant during the Operations stage. The primary purpose of the Project is to provide natural gas for local energy generation. The Government-planned third-party power plant will provide additional electricity supply and is expected to increase the reliability of electricity service to Guyana users; therefore, the Project is expected to contribute to an overall net **Positive** impact on power availability and reliability. The Project will also provide its own telecommunications and security infrastructure and services; therefore, it will have no impact on these components of social infrastructure and services. In terms of educational facilities, most of the onshore construction workers are anticipated to be Guyanese workers already present in the country; the anticipated construction period is not long enough for the portion of foreign workers that will be involved to bring their families into Guyana, and the number of long-term Operations stage workers is relatively small (i.e., approximately 40 to 50 FTE workers, the majority of which will be Guyanese). Accordingly, the Project is not expected to result in a measurable increase in demand for educational facilities. For these reasons, the Project is not expected to have an impact on these types of social infrastructure and services, and they are not further discussed in this section.

9.3.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for social infrastructure and services (Table 9.3-5). Sensitivity is defined on a resource-specific basis for all receptors, and the definitions for social infrastructure and services are provided in Table 9.3-6.

For the purpose of assessing the significance of potential impacts on this resource, separate discussions are provided for the following social infrastructure and services components, with the assessment focusing on the specific potential impacts that are relevant to each of these three social infrastructure and services types:

- Lodging
- Housing and utilities
- Water and sanitation

For the purposes of social infrastructure and services, receptors are defined as leisure and business travelers to Guyana (specifically Georgetown); individuals who own, rent, or seek housing in Georgetown and the Direct AOI; and individuals within the Direct AOI who rely on canals for household or personal use.

Table 9.3-5: Definitions for Intensity Ratings for Potential Impacts on Social Infrastructure and Services

Criterion	Definition
Intensity	**Negligible**: No discernible changes in the availability, quality, and/or cost for lodging, housing, or utilities. There is no effect on canals that prevent their access and/or use.
	Low: Limited increases in demand for lodging or housing are perceptible, causing slight changes in the availability, quality, and/or cost of these resources and services, including associated utilities. There is limited and temporary loss of access to or usability of canal(s) for a limited number of households.
	Medium: Increases in demand for lodging or housing are evident and lead to frequent and widespread shortfalls in availability or quality or measurable increases in cost of lodging, housing, and utilities. There is limited and temporary loss of access to or usability of canal(s) over a wide area or for an entire community.
	High: Increases in demand for lodging or housing are sufficient to cause conditions of chronic shortage and inflated costs for lodging, housing, and utilities. There is permanent, long-term loss of access to or usability of canal(s) at the community level.

Table 9.3-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Social Infrastructure and Services

Criterion	Definition
Sensitivity	**Low**: Existing services have excess capacity, and receptors have the resources and capability to seek alternative lodging or housing options or accommodate the potential increase in price, including for utilities. Individuals can find alternative sources of water and sanitation options to provide for their household and personal needs in lieu of canal use.
	Medium: Existing services have minimal excess capacity, and receptors have limited resources or capability to seek alternative lodging or housing options or accommodate the potential increase in price, including for utilities. Individuals have limited options aside from canals for their personal and household use.
	High: Existing services have little or no excess capacity, and receptors have no resources or capability to seek alternative lodging or housing options or accommodate the potential increase in price, including for utilities. Individuals have no options aside from canals for their personal and household use.

9.3.3.3. *Impact Magnitude Ratings—Social Infrastructure and Services*

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to social infrastructure and services is provided in Table 9.3-8.

Lodging

The only Project component with the potential to affect lodging is the presence of the onshore and offshore Project workforces. The presence of Project workers has the potential to increase demand for lodging in the Georgetown area. The receptors that could experience an impact from the increase in demand are leisure and business travelers to Guyana, specifically those staying within Georgetown and the vicinity.

The workforce will peak at 800 workers during the Construction stage, remain at approximately 40 FTE workers during the Operations stage, and rise only slightly to approximately 50 workers during the Decommissioning stage. During the Operations stage, the percentage of Guyanese workers will increase over time, as Guyanese workers are trained and can assume more responsibilities.

The offshore construction workforce, which will peak at approximately 300 workers (of which a majority are estimated to be foreign), will likely be housed on offshore vessels and only require lodging in the Georgetown area for short periods of time (i.e., on the order of 1 night per month) to facilitate their rotation schedules in / out of Guyana. The onshore construction workforce will peak at approximately 500 workers (approximately 100 for the onshore pipeline and approximately 400 for the NGL Plant). EEPGL will optimize the use of local content to the extent practicable, so it is likely that a significant portion of workers will be Guyanese. It is assumed that the majority of the Guyanese workforce will be sourced from those that already reside in areas in / around Georgetown and/or Region 3, or within commuting distance, so that temporary lodging will not be required for these workers. The foreign portion of the onshore construction workforce however, will require temporary lodging.

As discussed in Section 5.3.5.1, Worker Camp, the Project is considering alternatives to accommodate the foreign onshore workforce during the Construction stage. One alternative is to house the workers in existing lodging (likely in the Georgetown area), and another alternative is to establish a worker camp near the proposed temporary MOF, with the capacity to accommodate 150 workers. The exact number of workers requiring housing will be determined during the contracting stage; however, for the purposes of this assessment, a scenario is assumed whereby 50 percent of the onshore workforce at peak requires housing. Therefore, the Project will create a lodging demand for up to 250 full-time onshore workers, or approximately 7,500 nights per month; and up to 300 offshore workers at 1 night per month per worker, or approximately 300 nights per month, for a collective total (at peak) of approximately 7,800 nights per month. Should the worker camp alternative be implemented to accommodate 150 workers, the combined peak lodging demand will decrease to approximately 3,300 nights per month.

In early 2022, members of the Consultants team conducted an updated housing and accommodation demand survey to better facilitate an assessment of the potential impacts of EEPGL's operations on the local lodging and housing markets in and around Georgetown. EEPGL and seven onshore and offshore support companies provided existing and forecast data (through the end of 2022) on housing purchases, housing rentals, and lodging demand. These data represent anticipated demand by staff and workers for all of EEPGL-related activities across Guyana, so the data are not specific to any one EEPGL projects.

The demand for hotel lodging in 2022 had increased by at least 20 percent for EEPGL and the support companies who participated in a similar 2019 survey. Considering that several support companies did not provide their data in time for the writing of the EIA, an assumption was made for the EIA that the 2019 demand for lodging from those companies has also increased by 20 percent. Therefore, the anticipated number of workers from EEPGL and 11 of its support companies requiring hotel rooms each month (actual data for seven companies and estimated data for four companies) was updated to approximately 900, with a majority requiring only one night per booking and an average stay of 2.5 nights per booking (i.e., the total demand was close to 2,000 nights/rooms per month).

The average stay for the offshore workers supporting EEPGL's offshore development project activities, which make up a majority of EEPGL's historical lodging demand across their projects to date (more than 700 rooms per month), is 1 night per month. The remainder of the lodging demand is for company management and staff visiting Georgetown for a short duration, usually no more than 5 nights per stay and typically one trip per month. During 2020 and 2021, EEPGL used several hotels (including the Marriott, Grand Coastal, and Cara Lodge) as staging areas for crew changes and isolation prior to going offshore to ensure safe operations during the COVID-19 pandemic; however, this is considered atypical.

At peak workforce conditions during the Construction stage, the demand (existing plus additional Project forecast) is estimated at 335 full-time rooms per month without the worker camp and 185 full-time rooms per month with the worker camp (Table 9.3-7).

Table 9.3-7: Summary of Demand Scenarios for Lodging (Construction Stage)

Demand Scenario	Total Workers	Average Nights Per Month	Average Full-time Rooms per Month	Total Full-time Rooms per Month
Existing demand	900	2.5	75	75
Project forecast demand (peak scenario, no worker camp)	250	30	250	260
	300	1	10	
Project forecast demand (peak scenario, worker camp)	100	30	100	110
	300	1	10	

In terms of supply, EEPGL applies a vetting process for lodging options against EEPGL's health, safety, and security criteria, and several hotels in Georgetown are considered "approved" for use by Project-related personnel (although EEPGL approval status does not apply to EEPGL's primary support companies). The hotels (some of which are EEPGL-approved) most commonly rented by EEPGL staff and many of its primary support companies include Guyana Marriott Hotel, Grand Coastal Hotel, Pegasus Hotel Guyana, Ramada Georgetown Princess Hotel, Kings Hotel and Residences, Cara Lodge, and Herdmanston Lodge. As discussed in Section 9.3.1, Baseline Methodology, there are few commercial hotel lodging options in Region 3 near the Project area that can accommodate large numbers of workers. Although Region 2 is considered part of the Onshore Indirect AOI, lodging options in this region were not assessed given their distance from the Project area and the relatively low likelihood of their being used by the Project workforce.

The 2021 household socioeconomic survey (as described in Section 9.1.1, Baseline Methodology [Socioeconomic Conditions]) included questions about guest houses and availability of accommodations in the Project area. Many survey respondents (both household and commercial) mentioned local guest houses or rooms for rent in houses within their communities. However, in most cases, residents were unable to specifically identify a location or name for these accommodations, and further information on their suitability to house workers was not available. For the purposes of this assessment, the Consultants operated on the premise that while such local accommodations and guest houses may be suitable for some workers, they will not be able to house a large workforce and, therefore, have not been included in the capacity count.

The estimated total demand (ranging from 110 full-time rooms per month to 260 full-time rooms per month, depending on where a worker camp is implemented) constitutes approximately 9 percent to 20 percent of the 1,250-bed capacity of the principal hotels in Region 4 (as shown in Section 9.3.1, Baseline Methodology [Social Infrastructure and Services], Table 9.3-1) and the Aracari Hotel in Region 3. This does not consider the 200-bed expansion of the Pegasus Hotel in Georgetown, which is expected to come online at some time during 2022. Although the aforementioned approved Georgetown hotels typically used by EEPGL and its primary support companies represent a total of 577 rooms (out of the 1,250 rooms), they reported average capacity rates (pre-COVID-19) that fluctuated from 40 to 70 percent based on the season. Several of these hotels also reported no change in occupancy rates as a result of the oil and gas sector.

Considering the information presented above, potential impacts on non-Project-related users of lodging (leisure and business travelers to Guyana, specifically Georgetown) as a result of Project-related demand or use of lodging are expected to be limited to Georgetown and Region 3. There is enough existing capacity in Georgetown-based lodging, and the support companies and their workers supporting the Project construction may take advantage of a wider range of lodging opportunities, including the potential to rent or buy houses (as discussed below and/or to use lodging other than the aforementioned principal hotels. On this basis, the intensity of the potential impacts on lodging is rated as **Low** for the Construction stage (when Project workforces will be at the highest levels). This intensity is expected to decrease to **Negligible** during later stages of the Project, as the number of Project-required workers seeking lodging will decrease substantially. Project-related demand for lodging will occur on a regular basis throughout the various Project stages, each of which will last more than 1 year in aggregate, yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this impact is rated as **Small** for the Construction stage, and **Negligible** for the Operations and Decommissioning stages.

Housing and Utilities

Project workers and those seeking Project-related work have the potential to increase demand for housing and utilities in the Georgetown area, as well as possibly in Region 3. This assessment was conducted independently from the lodging assessment (i.e., it assumes the lodging option described above is not used for any of the Project workforce and the entire workforce demand is taken up by housing rentals or purchases).

As noted in the assessment of potential impacts on lodging, the Project will require up to approximately 500 onshore construction workers during the peak of the Construction stage and approximately 40 workers and 50 workers during the Operations stage and Decommissioning stage, respectively. EEPGL will optimize the use of local content to the extent practicable, so it is likely that a significant portion of the onshore positions will be filled by individuals currently residing in Guyana (likely in Region 3 and the Georgetown vicinity). It is not known at this time how the contractors selected for the onshore pipeline and NGL Plant construction will choose to house their workers and, in particular, whether they will choose to rent or buy houses (as opposed to using hotels and other temporary lodging, as described in the lodging section). To the extent that contractors choose long-term housing rentals or purchases, it is likely that such housing would accommodate more than one worker per residence.

Accommodation and housing data collected from EEPGL and its primary supply companies during the above-referenced 2022 updated survey found that in 2022, these companies had approximately 242 active long-term rentals in the Georgetown area: 111 houses and 131 apartments. These rentals were primarily for expatriate staff living and office space, with a few guesthouse rentals specifically dedicated to offshore, rotational workforce (in lieu of hotels). These reflect rentals only, with only one EEPGL major support company (representing less than 1 percent of the total workforce) indicating in 2019 that they expected to purchase several homes by 2024. However, the 2022 survey results indicated that EEPGL and the seven support companies who provided data for 2022 had no intention of purchasing real estate for housing, but instead intended to rely on rentals and temporary lodging.

Despite indications from some realtors during the 2019 survey that there was a shortage of availability within the Georgetown housing market, there were no significant concerns expressed by EEPGL or its major support companies related to the number and availability of rental houses. However, one support company noted in the 2022 updated survey, a measurable increase in competitiveness and price within the real estate/accommodations market since 2019 due to an increase in demand and slow and moderate supply. Only two of the support companies who provided data for the 2022 survey had Guyanese staff (11 in total) who relocated to the Georgetown vicinity from other regions as a result of their work with EEPGL. This was an increase in only four workers since the 2019 survey. In general, there has been no indication of a large-scale influx of workers from other parts of Guyana to Georgetown in search of oil and gas sector jobs over the past several years.

In terms of supply, and as noted in the existing conditions from 2012 census data (BSG 2012), there were approximately 1,500 vacant dwellings (out of 95,000 total recorded dwellings) in Region 4 and 360 vacant dwellings (out of 34,000 total recorded dwellings) in Region 3. Although these data are dated, new houses have been built over the past decade, and population shifts have likely occurred, it reflects what local realtors stated in 2019 interviews about the relatively small residential market in the Georgetown area. Furthermore, realtors stated that since oil was discovered in 2015, there have been increases in both demand and prices of purchased and rental homes and apartments in Georgetown.

Data from the 2021 household socioeconomic survey conducted by the Consultants suggest that a variety of houses are available in the Project area for rentals. Furthermore, as discussed in the lodging section, many respondents in the Direct AOI, including Canal 1, Lust-en-Rust, Crane, and Westminster, commented that they know of rentals and guest accommodations in their immediate neighborhoods. These data suggest that available housing opportunities and rental accommodations for job seekers or Project workers from outside the Project area exist.

Some induced population influx from other regions of Guyana may occur, as job seekers move to the Georgetown area seeking direct or indirect employment from the Project, but this number to date has reportedly been insignificant. However, any future influx, including influx into Region 3, is expected to be limited and short-term in nature, given EEPGL's continuous efforts to communicate all workforce requirements for their ongoing projects to stakeholders; this will include the Project's limited workforce requirements in the Operations stage.

Considering that the Project workforce is not expected to affect demand for new housing structures to be built, impacts on demand for utilities are not expected. Furthermore, while demand for housing rentals by local companies doing business with foreign companies like EEPGL could drive up pricing for housing in general within various local markets, it is not likely to impact the price of electricity utilities generated, transmitted, and distributed by the state-owned utility company. Other utilities, such as potable water and sewage, are also controlled by commercial and state entities and are not likely to be impacted. Therefore, utilities are not further included in the impact assessment.

Given the lack of quantitative, recent data on rental housing stock and supply in the Georgetown and Region 3 areas (which is considerably difficult to obtain, as discussed in Section 9.3.1, Baseline Methodology [Social Infrastructure and Services]), a conservative approach was taken for the assessment of the intensity of the potential impact on housing availability and price, specifically with respect to non-Project-related individuals who may be seeking to rent or buy housing in Georgetown and Region 3. Should the Project proceed with the worker camp, which can accommodate up to 150 workers, the intensity of the potential impacts on housing is rated as **Low** during the Construction stage. However, if the entire onshore foreign workforce at peak (125 to 500 people, assuming 50 to 75 percent are expected to be Guyanese already with their housing needs met) is to be housed (either individually or in small groups) in communities near the Project area or within daily commuting distance, and they are not lodged in hotels, the intensity of impact on housing is rated as **Medium** during the Construction stage.

By the time of the Operations and Decommissioning stages, EEPGL's primary supply companies will have completed their Project-related work and will no longer require housing rentals (or purchases) within Georgetown and the vicinity; therefore, the intensity will decrease to **Negligible**, as it is anticipated that Operations and Decommissioning will employ 40 and 50 workers, respectively, of which a majority will be Guyanese.

Project-related demand for housing will occur on a regular basis throughout the Project life cycle, yielding a frequency designation of **Continuous** for all stages and a duration of **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on housing is considered to be **Small** (if the worker camp is used) to **Medium** (if the worker camp is not used) during the Construction stage and **Negligible** during the Operations and Decommissioning stages.

Water and Sanitation

As described in Chapter 5, Project Description, EEPGL will provide water and sanitation for its workforce as follows:

- Offshore pipeline: use water and sanitation facilities available on the work vessels;
- Onshore pipeline: provide bottled water and portable toilets;
- NGL Plant: provide an on-site groundwater well for domestic water supply, bottled water for potable water supply, and wastewater treatment facility at the NGL Plant for sanitary wastewater.

As described in Section 7.1, Geology and Hydrogeology, there is adequate groundwater and available bottled water to meet the Project's Construction and Operations stage water consumption demands.

However, construction activities in and around the canals in the Direct AOI could affect water and sanitation in local communities. The receptors that potentially could experience impacts on water and sanitation are canal users and other households in the Direct AOI who rely on canal use for water and sanitation needs. Data obtained through the 2021 household socioeconomic survey completed by the Consultants (as described in Section 9.1.1, Baseline Methodology [Socioeconomic Conditions]) found that approximately 25 percent of the approximately 440 respondents in the Primary and Secondary Study Areas use the canals for various purposes. While only a small number of respondents claim to use the canals and rivers for potable water (as opposed to being connected to a public water line or using rainwater), the stated use of the canals for other water and sanitation needs (clothes and dish washing, gardening, bathing, swimming, and recreation) was close to 13 percent in the Direct AOI.

Various Project onshore pipeline construction activities have the potential to impact access to canals and/or quality and quantity of the water in canals. In addition, potential construction-related damage to underground utilities, including water and sewage pipelines, could occur. It is also possible that construction equipment may temporarily block access to canals and rivers at various points during the Construction stage.

A number of additional embedded controls will reduce the potential for impacts on canals adjacent to the onshore pipeline corridor. EEPGL will require construction contractors to locate, identify, and flag existing underground utilities to prevent accidental damage during onshore pipeline construction. Temporary erosion controls along the pipeline construction right-of-way (RoW) will be installed and remain in place until construction is completed and disturbed areas are revegetated or otherwise stabilized. Any dewatering conducted to facilitate onshore pipeline installation will take place by implementing methods to reduce excessive transport of sediments into adjacent canals. During construction, stormwater will be managed to minimize potential erosion that could affect canals near the onshore pipeline corridor. Stormwater will be collected and routed, if feasible, to existing canals.

Considering the above embedded controls, the intensity of potential impacts on water and sanitation is rated as **Low** during the Construction stage. Project-related temporary impacts on canals and resulting water and sanitation will occur throughout the Construction stage but at irregular intervals, resulting in a frequency designation of **Episodic**. In aggregate, the onshore pipeline construction will occur over more than 1 year, yielding a duration of **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on water and sanitation is considered to be **Small** during the Construction stage. There will be no ground-disturbing activities during the Operations and Decommissioning stages with the potential to impact canals currently being used by communities. Accordingly, the intensity of the potential impacts for these stages is rated as **Negligible**.

9.3.3.4. Sensitivity of Receptors—Social Infrastructure and Services

Lodging

The receptors that potentially could experience impacts on lodging are leisure and business travelers to Guyana, specifically those staying within Georgetown and the vicinity. Based on the accommodations survey conducted by the Consultants, existing lodging options, especially those most frequented by EEPGL and its primary support companies, appear to have excess capacity (30 percent or more) during peak periods; this will potentially improve in the coming years, considering current ongoing hotel expansion efforts, many of which are due to open in 2022 after the delay due to the COVID-19 pandemic.

Leisure and business travelers typically have the ability to respond to capacity constraints when booking their travel through hotel-specific and other online booking platforms. In Guyana, a majority of the hotels listed in Table 9.3-1 are included on the most popular hotel online booking platforms. This instant access to capacity, price, and comparison of hotel amenities allows travelers to either adjust travel dates or hotel preferences. Business travelers also typically have the ability to absorb increases in price as a result of capacity constraints, while leisure travelers may have less ability, especially domestic travelers. However, based on the receptor sensitivity rating definitions in Table 9.3-6, the sensitivity of travelers to this potential impact is individual-traveler dependent and, accordingly, a conservative approach is taken, and a **Medium** level of sensitivity to increased demand and/or price for lodging is assigned.

Housing and Utilities

The receptors that potentially could experience impacts on housing availability and price (and any associated changes in utility pricing, which are not anticipated) are those individuals who own, rent, or seek housing in the Direct AOI (specifically in Georgetown and portions of Region 3). Considering there are reports of shortfalls of housing, and the current existing capacity of the housing rental market by area or community within Region 3 and Georgetown is also unknown, a conservative approach is taken, and the population is considered to have a **Medium** level of sensitivity to increased demand for housing and associated price increases for rentals and purchases.

Water and Sanitation

The 2021 socioeconomic survey (household level) conducted by the Consultants found that 30 percent of all respondents (which includes at least 35 individuals within the Direct AOI) were considered vulnerable households, and many of those also self-identified as canal users. Therefore, a conservative approach is taken, and the potential users who could be affected by impacts on canal access/use within the Direct AOI are considered to have a **Medium** level of sensitivity.

9.3.3.5. Pre-mitigation Impact Significance—Social Infrastructure and Services

Lodging

Assuming implementation of the embedded controls listed in Table 9.3-8, the intensity ratings for potential Project impacts on lodging will range from **Negligible** to **Low**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small.** Coupled with sensitivity ratings of **Medium**, the pre-mitigation impact significance for lodging ranges from **Negligible** (worker camp used) to **Minor** (worker camp not used).

Housing and Utilities

Assuming implementation of the embedded controls listed in Table 9.3-8, the intensity ratings for potential Project impacts on housing and utilities will range from **Negligible** to **Medium**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Medium.** Coupled with sensitivity ratings of **Medium**, the pre-mitigation impact significance for housing and utilities ranges from **Minor** (worker camp used) to **Moderate** (worker camp not used).

The assessments of potential impacts on lodging and housing each assume that all worker demand goes entirely to the specific resource being assessed (e.g., in the case of the lodging assessment, the workforce only stays in hotels). However, a scenario where a combination of housing and lodging is used could decrease the pre-mitigation impact significance for housing and utilities (under a no worker camp scenario) from **Moderate** to **Minor**.

As noted above in each scenario, utilization of the worker camp to accommodate 150 workers allows for a lower pre-mitigation impact significance for lodging and housing and utilities.

Water and Sanitation

Assuming implementation of the embedded controls listed in Table 9.3-8, the intensity ratings for potential Project impacts on water and sanitation will range from **Negligible** to **Low**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small.** Coupled with sensitivity ratings of **Medium**, the pre-mitigation impact significance for water and sanitation ranges from **Negligible** to **Minor**.

9.3.4. Impact Management and Monitoring Measures

For potential impacts on social infrastructure and services impacts, there are a number of embedded controls (see summary in Chapter 15, Commitment Register), which are accounted for in the pre-mitigation impact significance ratings. To supplement these embedded controls, additional mitigation measures are recommended below.

To address potential impacts on lodging, recommended mitigation measures include the following:

- The Project should proactively communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners across the Georgetown area, as well as any Region 3 hotels as they are identified. With this knowledge, hotels that have not traditionally been used by the Project workforce may be able to improve standards and be considered for future use. The Project workforce hotel room demand may thus be spread across a wider range of hotels and, therefore, decrease the intensity of the potential impact on both hotel room demand and potential resultant increases in price.
- The Project should continue to proactively manage messaging to stakeholders about the Project's limited workforce needs to reduce the potential for induced population influx.

To address potential impacts on housing, recommended mitigation measures include the following:

- To further understand the potential future demand for housing, EEPGL should require the onshore pipeline and NGL Plant contractors to complete a workforce housing survey to understand how many workers will require temporary housing and how the companies anticipate managing that need over the duration of the contract (e.g., number of local workers commuting to site from their homes, number of workers requiring Project-provided accommodations, number of homes to be rented / purchased [duration and location], number of hotel rooms [duration and location]).
- EEPGL should monitor housing prices (purchase and rental) for company-related transactions on a semiannual basis as an indicator of the company's potential impact on the availability and prices in the housing market. Should housing prices increase dramatically within the first year of data collection, EEPGL should work to meet workforce accommodation needs by the Project through lodging options and/or expansion of the worker camp.

No additional mitigation measures are required to address potential impacts on water and sanitation.

Table 9.3-8 summarizes the management and monitoring measures relevant to social infrastructure and services.

Table 9.3-8: List of Management and Monitoring Measures

Embedded Controls
Require construction contractors to locate, identify, and flag existing underground utilities to prevent accidental damage during onshore pipeline construction.
Implement soil erosion, stormwater runoff, and sedimentation control measures during soil disturbance (e.g., use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from construction areas, use of sediment basins and check dams to control water runoff).
Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Restore active agricultural areas to their pre-construction conditions, including replacing topsoil, to support continued agricultural use.
Dewater any trenches by first installing temporary drainage and use methods to prevent excessive transport of sediments into existing canals.
Manage stormwater to minimize potential erosion and excessive sediment transport into canals adjacent to the onshore pipeline corridor.
Collect stormwater and route, if feasible, to existing canals.
Mitigation Measures
Proactively communicate the Project's limited staffing requirements to reduce the magnitude of potential population influx to Region 3 and Georgetown from job seekers.
Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners.
Should housing prices increase dramatically within the first year of data collection (see monitoring measure below), make efforts to meet workforce accommodations needs by the Project through lodging options and/or expansion of the worker camp.
Require Project primary contractors to complete a worker housing survey to understand Project housing demands and requirements.
Monitoring Measures
Conduct routine inspections of erosion, stormwater runoff, and sedimentation control measures while bare soils are exposed.
Monitor housing prices (purchase and rental) for company-related transactions on a semiannual basis as an indicator of the company's potential impact on the availability and prices in the housing market.

9.3.5. Assessment of Residual Impacts

The mitigation measures proposed for lodging are not likely to impact the residual significance rating; therefore, it remains unchanged at **Negligible** to **Minor**.

The mitigation measures proposed for housing and utilities, whereby EEPGL better understands how the local workforce will be accommodated during the Construction stage and can recommend various scenarios to contractors (e.g., use a combination of local guest houses, housing rentals, housing purchase, long-term hotel use), should mitigate pressures on the housing sale and rental markets. These mitigations will decrease the residual impact significance to **Minor**.

As described above, no mitigation measures are proposed for to address potential impacts on water and sanitation. Accordingly, the residual impact significance ratings remain unchanged at **Negligible** to **Minor**.

Table 9.3-9 through Table 9.9-11 summarize the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on social infrastructure and services.

Table 9.3-9: Summary of Potential Pre-Mitigation and Residual Impacts—Lodging

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Accidental damage to underground utilities	Medium	Negligible	Negligible	None	Negligible
Construction	Increased demand or use of lodging, leading to reduced availability and/or increased cost	Medium	Small	Minor	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Minor
Operations	Increased demand or use of lodging, leading to reduced availability and/or increased cost	Medium	Negligible	Negligible	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Negligible
Decommissioning	Increased demand or use of lodging, leading to reduced availability and/or increased cost	Medium	Negligible	Negligible	Communicate EEPGL's health, safety, and security standards and requirements to interested hotel owners	Negligible

Table 9.3-10: Summary of Potential Pre-Mitigation and Residual Impacts—Housing and Utilities

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction (worker camp)	Increased demand or use of housing and utilities, leading to reduced availability and/or increased cost	Medium	Small	Minor	Proactively communicate the Project's limited staffing requirements to reduce the magnitude of potential population influx to Region 3 and Georgetown from job seekers Require Project primary contractors to complete a worker housing survey to understand Project housing demands and requirements	Minor
Construction (No worker camp)		Medium	Medium	Moderate		Minor
Operations	Increased demand or use of housing and utilities, leading to reduced availability and/or increased cost	Medium	Negligible	Negligible	None	Negligible
Decommissioning	Increased demand or use of housing and utilities, leading to reduced availability and/or increased cost	Medium	Negligible	Negligible	None	Negligible

Table 9.3-11: Summary of Potential Pre-Mitigation and Residual Impacts—Water and Sanitation

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Erosion and sedimentation into canals, affecting usability for households Temporary loss of canal access due to construction activities, preventing household use	Medium	Small	Minor	None	Minor
Operations	Erosion and sedimentation into canals, affecting usability for households Temporary loss of canal access due to construction activities, preventing household use	Medium	Negligible	Negligible	None	Negligible
Decommissioning	Erosion and sedimentation into canals, affecting usability for households Temporary loss of canal access due to construction activities, preventing household use	Medium	Negligible	Negligible	None	Negligible

9.4. TRANSPORTATION

Project implementation would require transport of personnel, materials, and equipment using road, river, and marine transportation. This section discusses baseline conditions and potential Project impacts on transportation infrastructure, function, and safety.

9.4.1. Baseline Methodology

The study areas for transportation resources, as referenced in this section, include:

- Marine and river transportation—The Demerara River from its mouth to the temporary MOF, and the open ocean between the mouth of the Demerara River and the offshore pipeline corridor;
- Onshore transportation—Principal roadways that will be used by the Project, including the East Bank of Demerara Public Road (EBD Public Road), West Bank of Demerara Public Road (WBD Public Road) and the Demerara Harbour Bridge; and
- Air transportation—Airports and heliports that will be used for Project logistics support.

The baseline for transportation was based on desktop and field data collection. Desktop activities included review of available information about transportation in the study area, particularly transportation analyses associated with previous EEPGL projects. Field data collection consisted of marine and onshore transportation counts. Limited information is publicly available regarding vessel and road traffic volumes, behaviors, and concerns. The field data collection conducted for this EIA reflects the conditions at the time of data collection only, and may not reflect transportation conditions throughout a given year.

9.4.2. Existing Conditions and Baseline Studies

This section describes Guyana's existing transportation infrastructure with particular focus on infrastructure and traffic (road and vessel) within the Project AOI. This section identifies road, river, and marine transportation infrastructure. Data were obtained from key informant interviews, reports, studies, and publicly available information.

9.4.2.1. Marine and Demerara River Vessel Traffic

Guyana relies on marine and riverine transportation for movement of freight and people. Guyana has approximately 1,000 kilometers of navigable rivers, which provide water access to most population and economic centers. The Port of Georgetown is the largest port in Guyana that provides access to river, coastal, and ocean transportation. MARAD is responsible for ensuring the safe and efficient operation of shipping activities in Guyana territorial waters.

Infrastructure

Marine and river transportation infrastructure within the Project AOI consists of waterways, coastal shipping channels, ports and quays, navigational aids in and near offshore oil exploration and development areas, and offshore shipping lanes. Representatives from MARAD have advised EEPGL that Jamaican and Trinidadian shipping lanes cross the Stabroek Block. Figure 9.4-1 shows the location of the identified shipping lane in the Stabroek Block, as indicated on the pilot chart for the Caribbean and Gulf of Mexico.

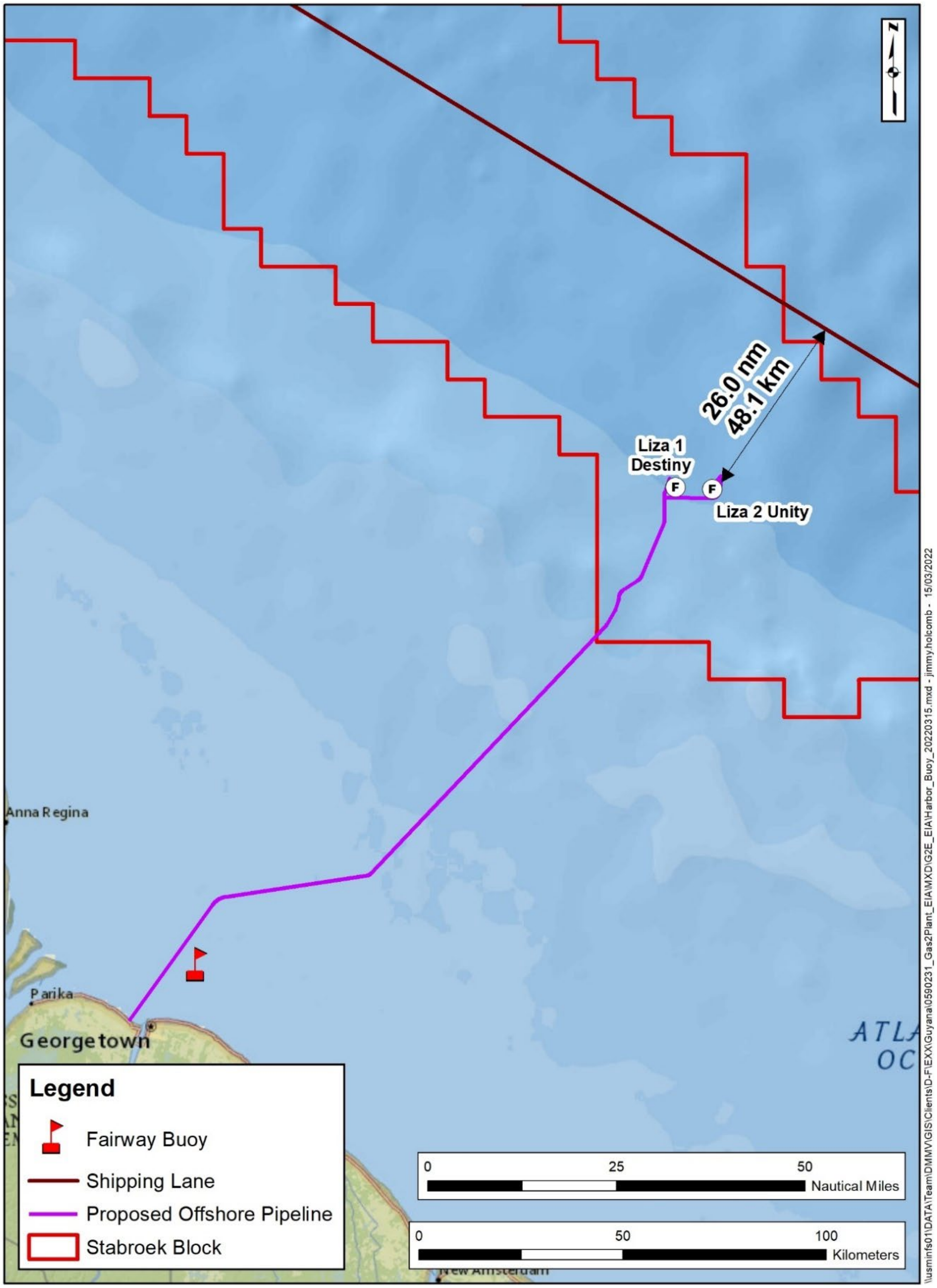
The Port of Georgetown is located at the mouth of the Demerara River and contains more than 40 separate wharves, including 6 primary cargo wharves ranging from approximately 127 to 247 meters long with depths alongside ranging from 4.8 to 7.4 meters, as well as four tanker berths, with depths alongside ranging from 3.1 to 6.7 meters (NGIA 2017). Other privately owned docks and portside facilities near Georgetown and the mouth of the Demerara River have staging areas or storage yards, although these facilities are congested and space is limited.

Vessels arrive in or depart from the Port of Georgetown in the vicinity of the Fairway Buoy, approximately 17 kilometers from the port (Figure 9.4-1). Departing vessels then proceed eastward or westward of the buoy depending on the destination port. Vessels entering Georgetown Harbour are guided by pilot vessels. The total number of vessels piloted by the Harbour Master in the Demerara River was approximately 1,200 per year in 2016 and 2017, and was consistent in volume throughout the year (Table 9.4-1).

A shipping channel is maintained on the lower Demerara River for the use of private, commercial, and military vessels (Figure 9.4-2). Pilotage is required to access the channel and is provided by the Harbour Master. The Demerara River channel has a dredged depth of 5.9 meters and has historically been dredged weekly to maintain this depth (MARAD Representatives 2018, pers. comm.). The Demerara Harbour Bridge, located 3.2 kilometers upstream from Georgetown, is a low-lying pontoon bridge with two central retraction sections that provide a 77-meter-wide opening for passage. The highest clearance available without retracting any section is 7.9 meters (NGIA 2017).

Table 9.4-1: Vessels Piloted by Harbour Master in the Demerara River in 2016 and 2017

Month	2017					2016				
	Cargo	Container	Tanker	Other	Total	Cargo	Container	Tanker	Other	Total
January	25	24	18	29	96	22	25	16	18	81
February	20	19	18	30	87	16	25	17	29	87
March	25	30	19	31	105	29	29	18	32	108
April	20	30	20	26	96	18	31	21	28	98
May	20	28	20	30	98	28	35	17	18	98
June	22	26	19	21	88	23	31	19	19	92
July	29	24	21	30	104	27	34	17	26	104
August	22	23	23	36	104	18	32	15	25	90
September	22	25	20	31	98	25	33	17	28	103
October	31	25	18	25	99	29	34	21	32	116
November	33	27	23	30	113	26	31	21	15	93
December	35	23	21	24	103	28	32	23	16	99
Total	**304**	**304**	**240**	**343**	**1,191**	**289**	**372**	**222**	**286**	**1,169**



km = kilometer; nm = nautical mile

Figure 9.4-1: Proximity of Offshore Pipeline to Offshore Shipping Lanes

Source: NAREI 2019, pers. comm.

Figure 9.4-2 Georgetown Harbour Navigation Channel

Fishing Industry

Fishing vessels comprise the largest share of vessel traffic in and near the Port of Georgetown and on the Demerara River. As described in Section 9.1, Socioeconomic Conditions, fisheries are of significant importance to Guyana's economy, particularly in coastal areas. Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. Deep-sea pelagic fishing commenced in 2016, and the Fisheries Department has stated that expanding deep-sea fishing is an important long-term objective for the fisheries sector. In addition, the Fisheries Department can license vessels to fish outside Guyana's territorial waters and is exploring how this industry can be developed (NAREI 2019, pers. comm.). Figure 9.4-3 depicts the primary fishing zones offshore Guyana, by fishery type, and the primary fishing ports or fish landing sites in Regions 1 through 6 (Guyana's coastal regions).

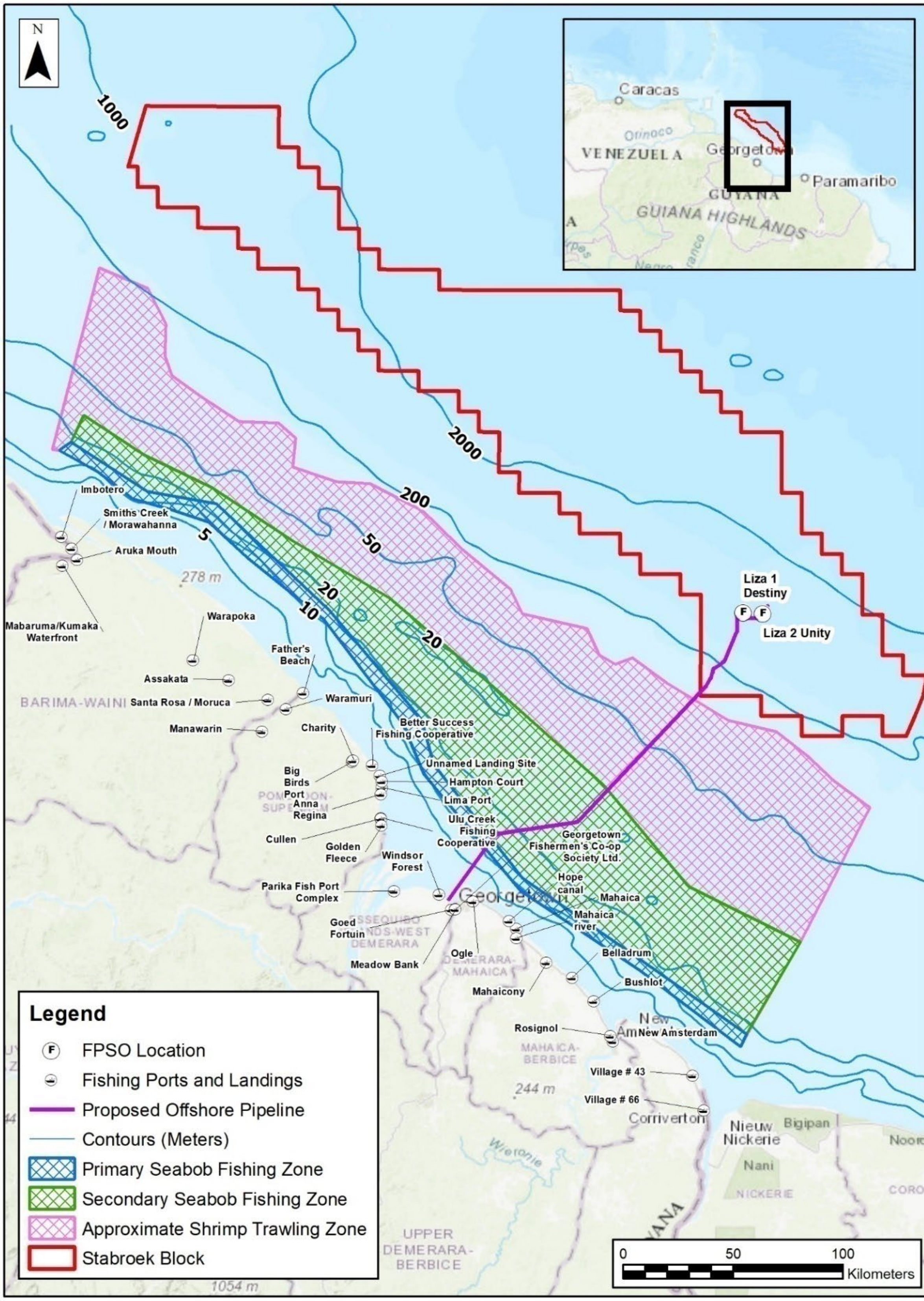


Figure 9.4-3: Fishing Zones and Main Fish Landing Sites and Ports

Passenger Services

The Transport and Harbours Department is responsible for the management of the national ferry service. The Department currently operates seven ferry vessels. Two of the ferries serve the "Northwest route," which travels between Georgetown (Region 4) and Guyana's northwestern coastal region (Region 1). Four ferries operate in the Essequibo River from several ports (also known as stellings) on either side of the Essequibo River, on Leguan and Wakenaam Islands, and at Bartica. A seventh ferry operates across the Moleson Creek at the Guyana-Suriname border (Guyana Chronicle 2021).

In addition to the national ferry service, many commercial vessels provide passenger and cargo transportation across the Demerara River between the Stabroek Market stelling in Georgetown (Region 4) and Vreed-en-Hoop stelling (Region 3) on the West Bank of the Demerara River, as well as between Regions 2 and 3 across the Essequibo River. These vessels are collectively and informally known as "speedboats" because they typically travel faster than government-managed ferries. Speedboats vary in size, power, and capacity, but can typically carry 13 to 30 passengers. Across the Essequibo River, speedboats operate at the same ports as the national ferry service and may also call at smaller informal landings as clients' demand and conditions warrant.

Speedboats are an important element in the transportation system between Georgetown and West Demerara. Speedboats serving the Demerara River crossing operate from 6:00 a.m. to 8:00 p.m. There are 58 speedboats registered with the Speedboat Association, of which 50 to 53 are operational on any given day (Gonsalves 2021, pers. comm.). Registered Demerara River speedboats generally share a common design, with a legal capacity of 33 passengers in a covered compartment, plus two crewmembers. Monitors at the Vreed-en-Hoop and Stabroek Market stellings record speedboat crossings and are meant to ensure that registered boats adhere to a set of rules developed by the Speedboat Association. The locations of the speedboat stellings on the Demerara River are shown on Figure 9.4-2. Rules and regulations for the safe operation of speedboats are developed by MARAD and enforced with the assistance of the Speedboat Association. The Speedboat Association has also developed and enforces a disciplinary system that requires registered speedboats to take turns, and also requires passengers to be seated and wearing a life vest before the boat casts off from the dock (Gonsalves 2018, pers. comm.).

During the morning rush period, at least five speedboats load simultaneously at Vreed-en-Hoop and discharge at Stabroek. Table 9.4-2 summarizes 2017 speedboat passenger volumes. Passenger volumes are substantially lower on Saturdays and Sundays. In 2017, approximately 590 school children commuted daily from Vreed-en-Hoop to Georgetown. This represented a 5 percent increase over 2016.

Table 9.4-2: 2017 Stabroek Market Weekday Speedboat Passenger Activity

Vessel Type	All Weekdays	Mondays
Average daily disembarkations	9,233	10,211
Rush hour (6:00 a.m. to 9:00 a.m.) disembarkations	5,225	5,808
Afternoon embarkations	1,815	ND

Source: Gonsalves 2018, pers. comm.

ND = no data

Vessel Traffic Counts

A 2-week study in February 2022 recorded vessel traffic in Georgetown Harbour and the Demerara River at five observation points shown on Figure 9.4-4. The observation points were located as follows:

- Location 1—Kingston Outfall drainage channel (near the mouth of the Demerara River)
- Location 2—Toolsie Persaud Lombard Street wharf
- Location 3—East end of Demerara Harbour Bridge
- Location 4—West end of Demerara Harbour Bridge
- Location 5—Garden of Eden, near Government of Guyana asphalt plants, across the river from the proposed temporary MOF site.

Observations were made on a 24-hour basis, recording the time of day, type of vessel observed, and direction of travel.

Table 9.4-3 and Table 9.4-4 summarize the vessel traffic recorded during this period. A total of 5,164 vessel observations were recorded, with observations ranging from 323 (Location 5) to 1,926 (Location 2) across the five locations. The average vessel movements per day ranged from 23 (Location 5) to 138 (Location 2). Many vessels were recorded passing by more than one observation point in the same movement. Vessel traffic occurred continuously throughout the 24-hour period, with 63 to 68 percent of the vessel traffic occurring between the hours of 8:00 a.m. and 8:00 p.m. for Locations 1 to 4 and 87 percent of the vessel traffic occurring between 8:00 a.m. and 8:00 p.m. for Location 5.

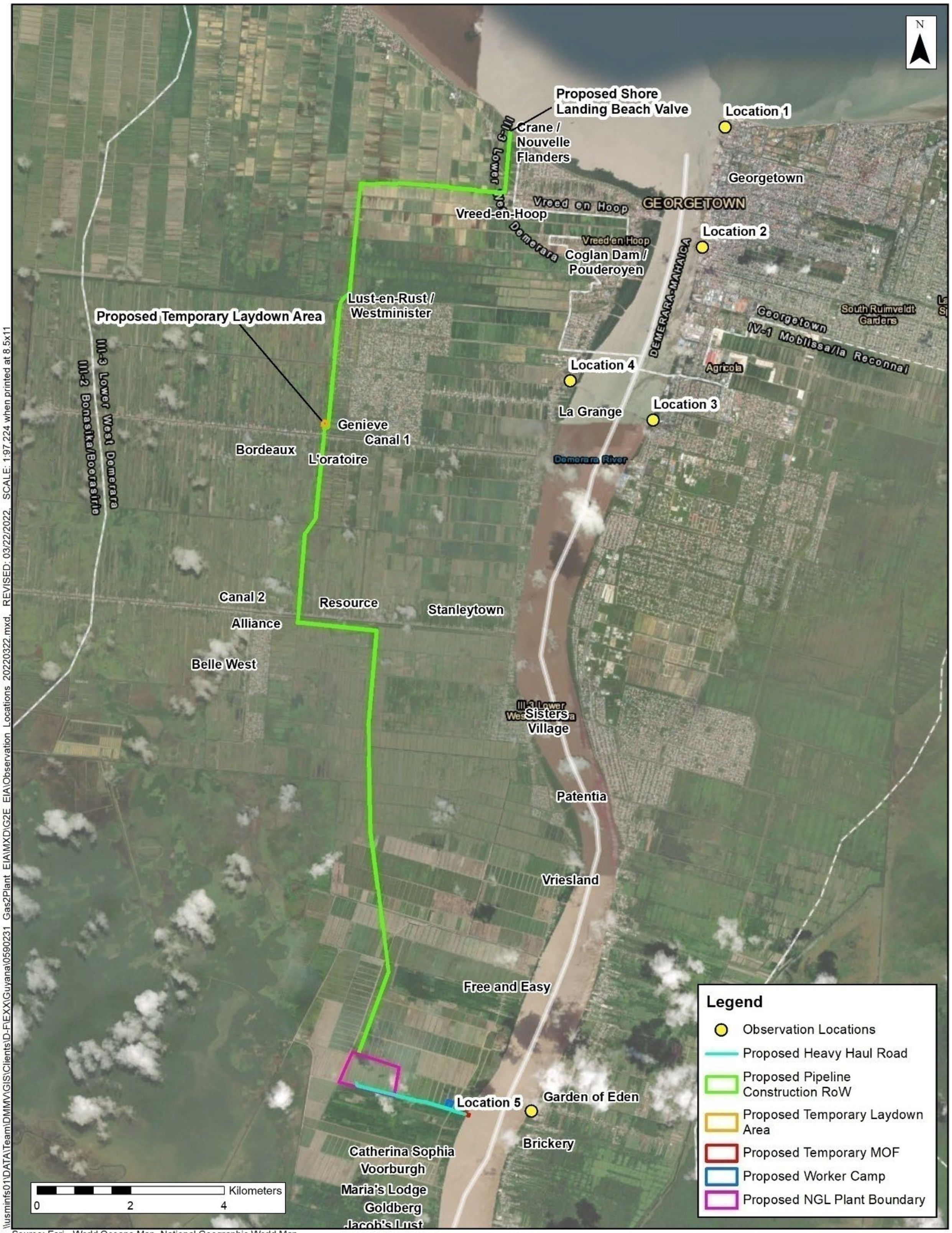


Figure 9.4-4: Vessel Traffic Count Locations, February 2022

Table 9.4-3: Vessel Traffic Recorded at Observation Points, 2–15 February 2022

	Observation Point				
Vessel Type	**Location 1 Kingston Outfall**	**Location 2 Toolsie Persaud Wharf**	**Location 3 Demerara Harbour Bridge East Bank**	**Location 4 Demerara Harbour Bridge West Bank**	**Location 5 Garden of Eden**
Cargo (bulk, container, roll-on/roll-off)	94	75	28	45	17
Tanker	35	38	28	26	9
Oilfield service vessel	122	108	2	1	1
Tug and barge	51	30	27	25	12
Tug alone	57	33	40	42	9
Trawler	172	234	45	39	2
Fishing vessel (other than trawler)	890	1,214	418	402	107
Government (Coast Guard, response vessel)	40	99	68	62	9
Pilot boat	103	73	7	3	1
Passenger (speedboat, ferry or other)	6	13	7	6	145
Research vessel	12	9	2	5	9
Other	5				2
Total	**1,587**	**1,926**	**672**	**656**	**323**

Table 9.4-4: Average Vessel Traffic Recorded at Observation Points, 2-15 February 2022, by Time Period

	Average Number of Vessels by Observation Point				
Time Period	**Location 1 Kingston Outfall**	**Location 2 Toolsie Persaud Wharf**	**Location 3 Demerara Harbour Bridge East Bank**	**Location 4 Demerara Harbour Bridge West Bank**	**Location 5 Garden of Eden**
12:01 a.m. to 4:00 a.m.	16	18	6	5	1
4:01 a.m. to 8:00 a.m.	17	21	8	8	2
8:01 a.m. to 12:00 p.m.	21	30	13	13	7
12:01 p.m. to 4:00 p.m.	25	33	11	11	7
4:01 p.m. to 8:00 p.m.	25	27	8	8	6
8:01 p.m. to 12:00 a.m.	9	9	2	2	1
Total Average Daily Vessel Traffic [a]	**113**	**138**	**48**	**47**	**23**

[a] Average vessel counts per time period may not total the total average daily vessel traffic due to rounding.

Fishing vessels, including trawlers, accounted for 67 to 75 percent of vessel movements observed at Locations 1 through 5 and 34 percent of vessel movements observed at Location 5. Cargo vessels and tankers combined comprised 6 to 11 percent of vessels movements at all locations. Offshore oilfield service vessels and pilot boats were prominent among the vessel counts in Georgetown Harbour (Locations 1 and 2). Government vessels (coast guard or response vessels) were observed at all locations, but constituted a higher proportion of traffic (about 9 to 10 percent) at the Demerara Harbour Bridge observation points (Locations 3 and 4), where vessels were being used in connection with ongoing bridge repairs.

Recorded vessel traffic at the observation point near the temporary MOF (Location 5) was about half the volume observed at the two Demerara Harbour Bridge observation points (Locations 3 and 4) and about 20 percent of the volume at Locations 1 and 2, with an average of 23 vessels passing the observation point daily. Almost 80 percent of this vessel traffic consisted of passenger boats and fishing vessels, and the other 20 percent included cargo ships, tankers, barges, tugs, and other vessels. Passenger boats included river tour boats as well as small private vessels.

The vessel counts presented herein do not include east-west speedboat movements across the Demerara River between the passenger terminals at Vreed-en-Hoop and the Stabroek Market. During morning and evening rush hours, there are as many as 15 speedboats travelling simultaneously east and west between these two commuter vessel terminals.

9.4.2.2. Onshore Vehicular Traffic

Road Network

Guyana's road network is one of the sparsest in South America, with approximately 3,990 kilometers of roads serving a country of 214,920 km^2, for a ratio of 0.018 kilometer of road per km^2, compared to a regional average of 0.17 kilometer per km^2 (IDB 2019). Approximately 80 percent of Guyana's roads are unpaved (IDB 2019).

Guyana's national road network includes six primary paved roads. These are primarily two-lane roads, but include four-lane segments of the EBD Public Road and East Coast Demerara Public Road. The road network is dependent on a system of bridges and culverts that provide crossings over a dense system of canals, drains, and sluices throughout the coastal lowlands.

The NGL Plant site will be about 1.9 kilometers west of the WBD Public Road and about 15 kilometers south of the Demerara Harbour Bridge (Figure 9.4-5). The WBD Public Road is the only connection for vehicular traffic between the southern West Bank Demerara communities (e.g., La Grange, Westminster, Nismes) and the Demerara Harbour Bridge, and experiences morning and evening congestion from commuter traffic. From the Demerara Harbour Bridge to Stanleytown Road, the WBD Public Road is on the order of approximately 7 meters wide in most locations, with each traffic lane occupying between 3 and 4 meters of paved surface. Shoulders on both sides of the road are narrow and generally unpaved. Parking on the shoulder or along the side of the road is common.

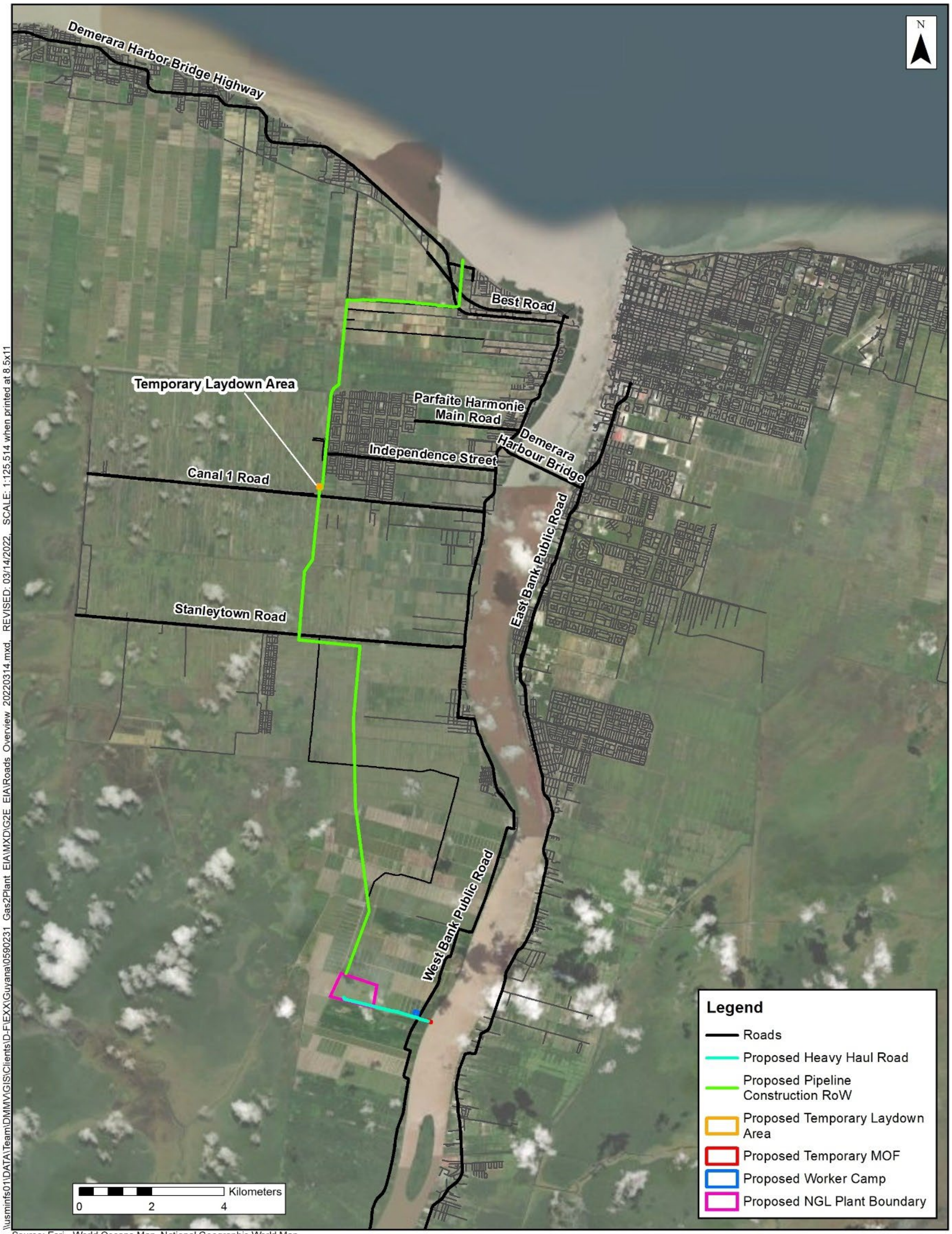
South of Stanleytown Road, the WBD Public Road makes two sharp turns within the settlement of Sisters Village and its width becomes variable (4 to 7 meters). South of the next settlement of Patentia, the road is primarily unpaved and provides reliable access only for dry season driving. This section of the WBD Public Road, extending south from Patentia to the proposed heavy haul road, is approximately 8 kilometers long, passes through three smaller settlements, and has six bridges (one concrete slab bridge and five wooden bridges) each with limited weight-bearing capacity for heavy truck loads.

Between the NGL Plant site and the coastline, the onshore pipeline will cross several local east-west roads. The local roads are part of a network of roads, canals, paths, and tracks that connect the settlements and properties west of the Demerara River. Close to the shoreline, the pipeline would cross two roads that parallel the shoreline, including the primary national road that parallels the coastline (Figure 9.4-5) between the Demerara and Essequibo Rivers.

One of the main shorebases (Guyana Shore Base, Inc.) is located south of greater Georgetown on the east bank of the Demerara River. The road route from this shorebase to the NGL Plant site follows the EBD Public Road south to the Demerara Harbour Bridge, crosses the Demerara Harbour Bridge, and then follows the WBD Public Road, which as described above is primarily unpaved south of Patentia. The EBD Public Road is the primary vehicular route between Georgetown and several large residential areas to the south, including Agricola, Republic Park, and Providence, and experiences severe congestion during the morning and evening commutes. Parking on the shoulder is common. Pedestrian overpasses were recently installed at several areas along the EBD Public Road to improve pedestrian safety and assist in reducing traffic congestion.

Vehicular travel across the Demerara River is possible only via the Demerara Harbour Bridge. The bridge has one travel lane in each direction, totaling approximately 9 meters of available roadway on the bridge, although the lanes narrow to approximately 3.5 meters in some locations. The bridge has a weight limit of 18 tonnes for general traffic and 22 tonnes for special crossings. In addition to overweight vehicles, vehicles wider than 2.3 meters or towing a trailer require prior permission from the Demerara Harbour Bridge Corporation.

Vehicular traffic is subjected to daily bridge closures to allow larger vessel traffic to pass through the bridge’s central section into and out of the Demerara Harbour. The daily closures typically last for 90 minutes and can create significant congestion on either side of the bridge, particularly when they coincide with regular commuting periods. Larger vessels that cannot fit under the existing span must queue until the bridge opens, creating vessel traffic congestion.



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Source: Esri - World Oceans Map, National Geographic World Map

Figure 9.4-5: Road Network in the Project Area

The Demerara Harbour Bridge has been in operation for approximately 40 years and is no longer able to efficiently service either present or estimated future traffic demands. The Government of Guyana has elected replacement of the heavily used bridge as a means of relieving congestion of both road- and river-based vessel traffic caused by the opening and closing of the retractor spans to allow large vessels to pass. In August 2021, the Ministry of Public Infrastructure issued a project summary evaluating replacement of the bridge, calling for the replacement bridge to span the Demerara River from Nandy Park to La Grange, slightly upstream of the existing bridge, and for the existing bridge to be closed and demolished once the new bridge is in operation. The replacement structure will be a fixed four-lane bridge with a vertical clearance over the channel of approximately 50 meters above the maximum tide level. The proposed design will connect to the main road network at the WBD Public Road and the Mandela to Eccles Road (MoPW 2021). Construction of the replacement bridge will likely require at least 2 years (Global Construction Review 2021).

Road Safety

A number of factors contribute to dangerous land transportation conditions in Guyana, including generally limited road maintenance, lack of streetlights, poor traffic law compliance and enforcement, narrow roads, and the variety of road users - including cars, large commercial vehicles, mini-buses, horse-drawn carts, bicycles, mopeds, scooters, motorcycles, stray dogs, free range livestock, and pedestrians (OSAC 2020).

Traffic Volumes and Level of Service

A traffic study performed in February 2022 (see Appendix Q, Gas to Energy Traffic Study: Vistro Report) examined the level of traffic congestion at intersections along the WBD Public Road from the coast south to Stanleytown Road (see Figure 9.4-6). The study characterized traffic flow and congestion using roadway Level of Service (LOS), a measure of road operation determined through measurement of velocity, travel time, density, maneuverability, vehicle disruption, convenience, and comfort of traffic. LOS is expressed in a range from A through F, as described in Table 9.4-5.

Table 9.4-5: Level of Service Definitions

Level of Service	Traffic Characteristics
A	Free flow
B	Not completely free flow, but driver can generally maintain the desired velocity
C	Stable flow, but the driver is affected when they want to freely choose the desired velocity
D	Flow begins to be unstable; driver has less freedom in choosing the velocity
E	Unstable flow; any obstacle causes traffic jams
F	Vehicle flow completely unstable; traffic jams occur

Source: TRB 2016

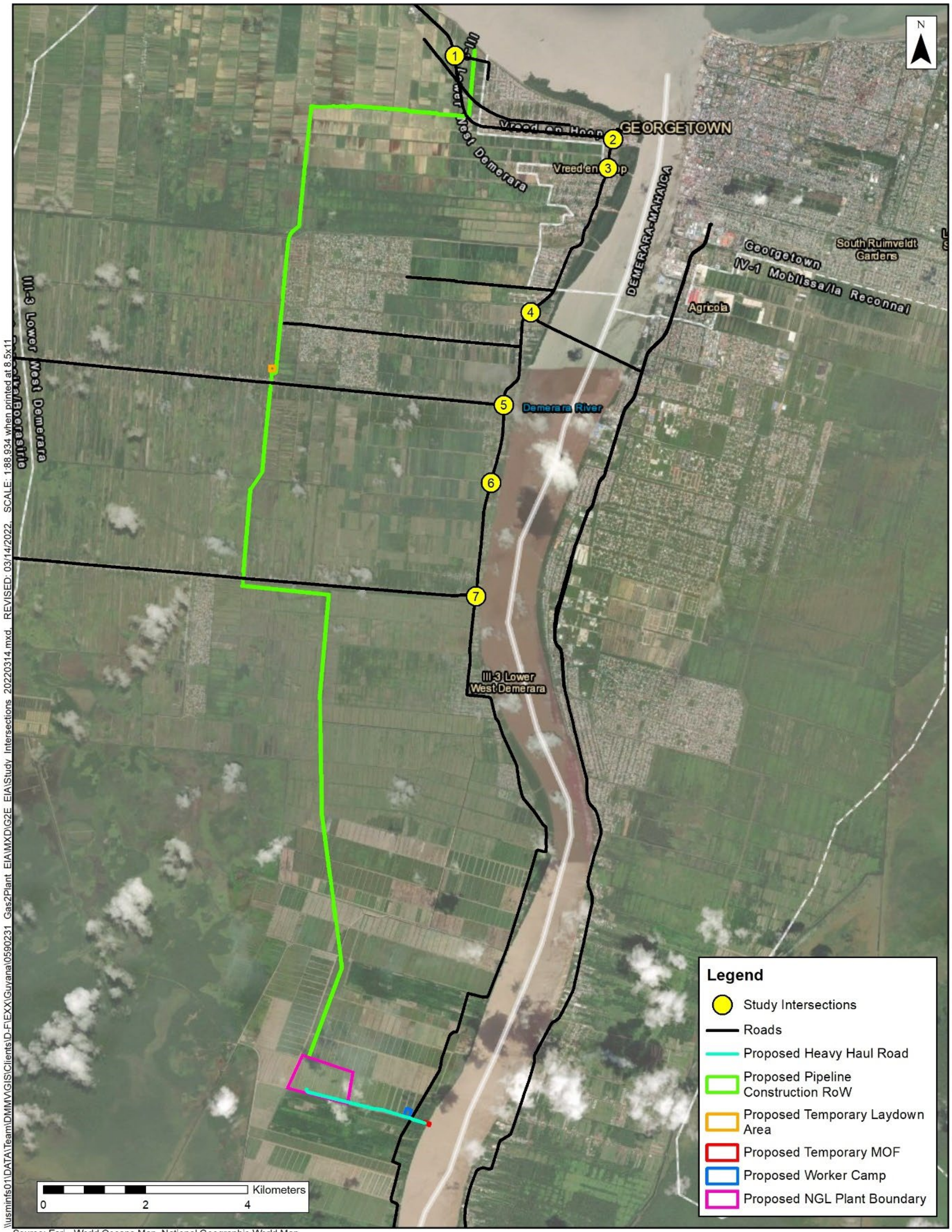


Figure 9.4-6: Intersection Analysis Locations

Table 9.4-6 presents the measured traffic volumes from the February 2022 study and the corresponding modeled LOS for the morning and evening peak traffic periods. The road system at the study intersections experiences notable traffic congestion during both the morning and afternoon peak hours. Traffic volumes and intersection turning movements were highest at the Demerara Harbour Bridge and at the intersection of West Demerara Highway with WBD Public Road and Stelling Road at Vreed-en-Hoop, resulting in unacceptable LOS (LOS F) at both intersections for both the a.m. and p.m. peak hours. The intersection of WBD Public Road with local roads at La Grange also experiences an unacceptable LOS (LOS F) for the a.m. peak hour. These LOS ratings indicate insufficient road capacity to accommodate existing traffic volumes. The morning peak hour volumes were higher for traffic moving towards the Demerara Harbour Bridge, while evening volumes were higher for traffic moving away from the bridge.

Table 9.4-6: Measured Traffic Volumes and Modeled LOS at February 2022 Study Intersections

Traffic Count ID	Location	a.m. Peak Hour		p.m. Peak Hour	
		Volume (vehicles per hour)	LOS [a]	Volume (vehicles per hour)	LOS [a]
1	West Demerara Highway at Shell Station Road and Crane Temple Road	955	D	992	C
2	West Demerara Highway at WBD Public Road and Stelling Road	2,045	F	2,061	F
3	WBD Public Road at Cogland Dam Road	1,481	E	1,603	E
4	WBD Public Road at Demerara Harbour Bridge	2,232	F	2,046	F
5	WBD Public Road at La Grange	1,057	F	1,181	F
6	WBD Public Road at Nismes	667	C	638	C
7	WBD Public Road and Stanleytown Road	606	C	612	C

Source: CARITRANS 2022

ND = no data

[a] See definitions of Level of Service A through F in Table 9.4-5.

9.4.2.3. Air Transportation Infrastructure

Air transportation in Guyana supports a variety of sectors including agriculture, tourism, and the extractive sectors. In 2011, Guyana ranked 131 out of 211 countries on the Air Connectivity Index (World Bank 2011), and in 2015 it ranked 49 out of 141 economies for the quality of its air transportation infrastructure (World Economic Forum 2015). In 2017 at the World Aviation Forum, Guyana was awarded for moving from 44.24 percent to 64.66 percent effective implementation of the Standards and Recommended Practices of the International Civil Aviation Organization (Stabroek News 2017). Compliance with the standards advances Guyana's efforts to be classified as a Federal Aviation Administration International Strategy Assessment Programme Category 1 country and facilitates direct flights to the United States.

Guyana's air transportation infrastructure comprises two international airports: CJIA and ECIA (also commonly referred to as Ogle Airport). In addition, nearly 100 aerodromes serve smaller towns and villages, principally in the Hinterland regions (IDB 2016). The CJIA and ECIA provide direct international flights to Caribbean, South America, Central America, and North America countries. In 2017, the most recent year for which data are available, 664,000 international passengers used Guyana's airports, representing a 6 percent annual growth rate from the prior year (GCAA 2018). Visitor (i.e., non-resident) arrivals have steadily increased over the past decade, from 156,910 in 2011 to 314,727 in 2019. The COVID-19 pandemic caused visitor numbers to drop sharply to 86,503 in 2020; numbers were at approximately 62,000 as of June 2021 (Guyana Tourism Authority 2021).

The CJIA is located at Timehri, approximately 40 kilometers south of Georgetown. The airport's existing terminal building has been operational since the 1970s; runways are short, and parking facilities are congested. From 2000 to 2012, passenger traffic at the CJIA increased 42 percent, from 384,000 to 544,000 (MoPW 2018). An expansion and modernization project started in 2013 and in 2021 was expected to be completed in 2022 (Stabroek News 2021). The expansion project includes extension of both runways, installation of an instrument landing system, construction of new departure and arrival terminals, passenger boarding bridges, new aircraft parking bays, and other improvements. Upgraded sections of the airport are currently in use, but expansion and renovation works are ongoing.

The ECIA is located approximately 6 kilometers from Georgetown. In late 2001, the government leased the management and operation of the aerodrome to a local consortium of airline operators: Ogle Airport Inc. The lease is for a minimum period of 25 years with extension periods of 25 years on request of the lessee. The objective of the lease is to ensure compliance with International Civil Aviation Organization standards and to enable ECIA to serve as a backup to CJIA in the event of an emergency, disaster, accident, or other unserviceable situation (GoG 2006). ECIA has developed into the nation's principal domestic air hub, providing commercial and cargo transport services primarily between Georgetown and the Hinterland regions. In 2009, ECIA received International Port of Entry certification and now serves direct flights to three CARICOM states: Barbados, Suriname, and Trinidad. ECIA is capable of handling small aircraft, such as business jets, and the ATR-72 operated by Leeward Islands Air Transport (ECIA 2019, pers. comm.). In 2018, ECIA's domestic operations/flight landings totaled 16,500 and international operations/flight landings totaled 2,100 (ECIA 2019, pers. comm.). ECIA is also the base of EEPGL's primary local helicopter contractor, Bristow.

9.4.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on ground, river, and marine transportation. The relevant planned Project activities and the potential impacts of these activities on transportation are identified, and the significance of potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

Project implementation will require transport of personnel, materials, and equipment using ground, river, and marine transportation. This section addresses potential Project impacts on transportation infrastructure and function. Because Project air transportation will be a limited number of helicopter flights to and from the pipeline corridor, this element of transportation is not discussed further, and the remainder of the section focuses on ground and river transportation.

9.4.3.1. Relevant Project Activities and Potential Impacts

Planned Project activities that will have a potential impact on ground and river transportation within the onshore Direct AOI[25] and Indirect AOI include Project-related movement of workers, materials, and equipment over public roads and on the Demerara River, and the use of port facilities for Project staging and shipping. Planned Project activities that will have a potential impact on marine transportation within the offshore Direct AOI include vessels moving workers, material, and equipment between shorebases and the proposed offshore pipeline work areas, the presence of pipeline installation vessels along the offshore pipeline route, and the exclusion zone that will be in place around major installation vessels during offshore pipeline installation. Table 9.4-7 summarizes Project activities that could result in potential impacts on transportation resources.

Table 9.4-7: Summary of Relevant Project Activities and Key Potential Impacts—Transportation

Stage	Project Activity	Key Potential Impacts
Construction: road traffic	• Movement of Project materials, supplies, and personnel on public roads within the onshore Indirect AOI, in particular on the WBD Public Road from the Demerara Harbour Bridge to the NGL Plant site and/or onshore pipeline right of way. • Installation of the proposed onshore pipeline across (under) public roads.	• Increased vehicle traffic on public roads within the onshore Indirect AOI, especially the WBD Public Road and the Demerara Harbour Bridge, with potential for congestion and delays. • Increased wear and deterioration of public road surfaces, resulting in increased maintenance and repair needs. • Traffic delays and blockages during onshore pipeline installation for the one instance in which the proposed onshore pipeline will be installed across a public road using open-cut methods.
Construction: river vessel traffic	• Movement of Project materials, supplies, equipment, and personnel on the lower Demerara River from shorebases on the Demerara River south to the temporary MOF.	• Increased river vessel traffic, resulting in potential for increased river congestion and navigational complexity.

[25] For socioeconomic resources, the onshore component of the Direct AOI includes the communities within the immediate vicinity of the Project's onshore components, as well as the communities between the Project's onshore components and the Demerara River (these correlate with the Primary and Secondary Study Areas, respectively, as described in detail in Section 9.1.1, Baseline Methodology [Socioeconomic Conditions]).

Stage	Project Activity	Key Potential Impacts
	• Offloading activities along the river bank at the temporary MOF. • Use of ports in the onshore Indirect AOI for receiving, staging, loading, and shipping Project materials, supplies, and equipment.	
Construction: offshore installation vessel presence and support vessel traffic	• Movement of Project materials, supplies, equipment, and personnel between shorebases and worksites along the proposed offshore pipeline corridor. • Presence of pipeline installation vessels and related exclusion zones along the offshore pipeline corridor.	• Temporary loss of vessel access to offshore areas during installation of the proposed offshore pipeline due to the presence of construction vessels, installation activity, or temporary exclusion zones. • Increased vessel navigation complexity during installation of the proposed offshore pipeline due to additional vessel movements between shorebases and offshore construction areas and the presence of offshore construction vessels at offshore construction areas.
Operations: road traffic	• Daily worker commuting on the WBD Public Road and other public roads in the onshore Indirect AOI. • Movement of Project products, fuels, consumables, supplies, and equipment on public roads for NGL Plant operations.	• Increased vehicle traffic on public roads within the onshore Indirect AOI, especially the WBD Public Road and the Demerara Harbour Bridge, with potential for congestion and delays. • Increased wear and deterioration of public road surfaces, resulting in increased maintenance and repair needs.
Operations: river and shorebase vessel traffic	• Occasional movement of Project materials, supplies, equipment, and personnel on the lower Demerara River from the mouth of the Demerara River south to the temporary MOF as needed.	• Increased river vessel traffic, resulting in potential for increased river congestion and navigational complexity.
Operations: offshore vessel traffic	• Movement of Project materials, supplies, and equipment between ports and worksites along the proposed offshore pipeline route when needed for pipeline maintenance or repair. • Occasional presence of vessels related to pipeline maintenance and repair along the offshore pipeline route when needed.	• Increased vessel navigation complexity during occasional maintenance or repair of the proposed offshore pipeline due to the presence of vessels along the offshore pipeline.
Decommissioning	• Project activities for decommissioning would be similar to those for construction, with movements of vehicles and vessels on public roads, the lower Demerara River, and offshore.	• Increased vessel and road traffic; possible hindrance to traffic, but less intense than Construction, due to the base case that the onshore and offshore pipeline will be decommissioned and left *in situ*.

9.4.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2 Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity), and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for impact intensity are used in lieu of the general intensity definitions, as is the case for transportation (Table 9.4-8). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for transportation are provided in Table 9.4-9.

For the purpose of assessing the significance of potential impacts on this resource, separate discussions are provided for the following transportation components, with the assessment focusing on the specific potential impacts that are relevant to each transportation type:

- Marine transportation
- River transportation
- Road transportation: Road function and congestion
- Road transportation: Infrastructure condition

Table 9.4-8: Definitions for Intensity Ratings for Potential Impacts on Transportation

Criterion	Definition
Intensity	**Negligible:** No discernible change in transportation activity, road congestion, road condition, or waterway congestion.
	Low: Increased transportation activity or road/river/marine infrastructure demand may be perceptible, but does not significantly impact the capacity of waterways or transportation infrastructure. Minor deterioration of road surfaces occurs in a few specific locations.
	Medium: Increased transportation activity or road/river/marine infrastructure demand is widely perceptible and noticeably reduces waterway or transportation infrastructure capacity, but impacts do not require a change in typical travel behavior by non-Project road/river/marine users. Road surfaces experience modest deterioration in limited locations, but roads continue to provide adequate passage for typical traffic.
	High: Increased transportation activity or road/river/marine infrastructure demand is significant and causes substantial delay or congestion on roads or waterways, to the point where drivers, vessel operators, or other users of infrastructure must consistently and frequently change their typical daily behavior. Road surfaces experience significant or widespread deterioration.

Table 9.4-9: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Transportation

Criterion	Definition
Sensitivity	**Low:** The receptor is accustomed to or specifically anticipates the type of road or vessel activity proposed by the Project; existing transportation activities can easily adapt to additional transportation activity with no outside assistance or mitigation.
	Medium: The receptor is not specifically accustomed to the type of road or vessel activity proposed by the Project. The receptor can adapt to additional transportation activity with outside assistance or mitigation.
	High: The receptor is poorly suited to accommodate the type of road or vessel activity proposed by the Project, and cannot fully adapt to increased transportation activity even with outside assistance or mitigation.

9.4.3.3. Impact Magnitude Ratings—Transportation

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description. The subset of these embedded controls with particular relevance to transportation is provided in Table 9.4-15.

Marine Transportation

Direct Project impacts on marine transportation will include increased vessel traffic in and near the Project's offshore Direct AOI. Many Project materials and components will likely originate in other CARICOM countries, as well as other countries in North America, South America, and Europe (Section 5.4.1.4, NGL Plant Construction Methods), resulting in vessel shipments from various overseas locations to shorebases within Georgetown Harbour during the Construction stage. In addition, offshore pipeline installation would require approximately two vessel round-trips weekly between shorebases in Georgetown Harbour and the offshore pipeline construction corridor.

As described in Section 9.4.2, Existing Conditions and Baseline Studies, Georgetown Harbour experiences a high volume of vessel traffic, including cargo, tanker, fishing, and passenger vessels. The 2022 vessel counts observed an average of 113 and 138 vessels per 24-hour period at two locations close to the mouth of the Demerara River (Table 9.4-4). The volume of Project-related vessel trips from various foreign locations to Georgetown Harbour will be limited to approximately 50 deliveries across the Project Construction stage; in combination with the two weekly vessel round trips between shorebases and the offshore pipeline corridor, this element of the Project would not substantially increase vessel traffic in the harbor.

Based on the minimal anticipated increase in vessel traffic relative to the current volumes of marine traffic in Georgetown Harbour, the impact intensity of increased vessel traffic in the vicinity of the offshore Direct AOI during offshore pipeline construction will be **Low**, with **Continuous** frequency due to the likelihood of regular vessel traffic, and a **Long-term** duration due to the Construction period of approximately 1 year.

Marine vessel transportation will also be potentially impacted by ongoing offshore pipeline installation work and vessel activity over the estimated 13-month period for offshore pipeline installation. Anchored pipelay barges and crane barges generally will remain within the offshore pipeline construction corridor, moving along the corridor as pipeline installation progresses. The estimated two weekly round-trips to the offshore work areas will provide materials and support. All non-Project vessels will need to navigate around the offshore work areas. Due to the extent of marine areas available to navigate around the offshore pipeline work areas, the impact intensity of the offshore work area on marine transportation for most of the offshore pipeline corridor will be **Low**, with **Continuous** frequency due to the continuous presence of working vessels within the work areas, and a **Long-term** duration due to the construction period of approximately 1 year. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on marine transportation within and near the Direct AOI would be **Small** for most of the offshore pipeline corridor.

In the case of pipeline installation activities in the nearshore segment, installation vessels will occupy the construction area for a longer time period, resulting in the exclusion zone for the nearshore portions of the offshore pipeline prohibiting non-Project vessel activity for up to approximately 3 months. This will result in an impact of **Medium** intensity, with a **Medium-Term** duration and **Continuous** frequency. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on marine transportation within and near the nearshore segment will be **Medium**.

The Operations stage will require only occasional vessel traffic related to offshore pipeline inspections and maintenance. The impact intensity on marine transportation during this stage will thus be **Negligible**, with **Episodic** frequency and **Long-term** duration, resulting in an impact of **Negligible** magnitude.

Decommissioning will likely have impacts similar to the Construction.

River Transportation

The Project will use the Demerara River as the primary transportation route for moving aggregate and sand, heavy equipment, NGL Plant modules, and other materials and supplies from shorebase locations in Georgetown Harbour to the proposed temporary MOF (Sections 5.4.1.5, Temporary Material Offloading Facility Construction Methods) during the Construction stage. Installation and operation of the temporary MOF will include river dredging to allow barges to travel from the main river channel to the temporary MOF pier, and to allow barge maneuvering at the temporary MOF (Section 5.4.1.5).

During the first year of NGL Plant construction, an average of 7 to 8 barge round-trips weekly between a shorebase on the east side of the Demerara River, north of the Demerara Harbour Bridge, to the temporary MOF. During the early stages of construction some of these vessels may come from upstream of the temporary MOF if local sand is delivered to the site. Such activity is uncertain, and the majority of barges will likely travel to the temporary MOF from the north. During the second year of NGL Plant construction, fewer barge trips would be needed, averaging 2 to 3 round-trips weekly between a shorebase on the east side of the Demerara River and the temporary MOF.

Vessel counts in February 2022 observed an average of 23 daily vessel movements at Garden of Eden, near the proposed temporary MOF (Table 9.4-4), primarily consisting of fishing vessels or private passenger vessels. About 12 percent of the February 2022 vessel observations were cargo vessels, tankers, or barges (Table 9.4-5). Project barge round-trips will add an average of one to two daily barge trips to the Demerara River in this area, increasing total vessel traffic by 5 to 10 percent, compared to existing conditions.

Project construction will also generate vessel traffic between a shorebase on the west side of the river, south of the Demerara Harbour Bridge, and a shorebase on the east side of the river, north of the bridge. An average of 1 to 2 vessels per week would make this shorter round trip (2 to 4 total trip movements per week). At the Demerara Harbour Bridge, a daily average of 47 (west bank) or 48 (east bank) vessel movements were observed. Project-related vessel traffic would thus represent a 0.6 to 1.2 percent increase in existing vessel traffic in this area.

The minimal increase in existing vessel traffic yields an impact of **Low** intensity based on the definitions in Table 9.4-8. The impact frequency is assumed to be relatively **Continuous** during the Construction stage, and duration will be **Long-term** due to the Construction stage being more than 1 year. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on marine transportation within and near the Direct AOI would be **Small**.

Operation of the NGL Plant is not expected to generate regular vessel traffic, yielding an impact of **Negligible** intensity, with **Episodic** frequency and **Long-term** duration, resulting in an impact of **Negligible** magnitude.

Decommissioning of the NGL Plant may require transport of decommissioned equipment from the NGL Plant site via river vessel. However, as the final details of decommissioning have not been established, a reliable estimate of vessel trips, if any, is not available. However, it is assumed that if river transportation of decommissioned equipment is required, the intensity of vessel traffic impacts will be no more than **Low**. The impact frequency is assumed to be relatively **Continuous** during the Decommissioning stage, and duration will be **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on marine transportation within and near the Direct AOI would be **Small**.

Ground Transportation

Road and bridge upgrades to the WBD Public Road will occur as part of early works activities (which have been approved separately by the EPA and thus do not form part of the Project). The early works include installation of temporary spans over five existing bridges, along with ramps to transition from the temporary spans to existing roadways, and reinforcement of roadways to support those ramps. Early works will also include upgrading, rehabilitation, and repair of approximately 5.5 kilometers of roads along the WBD Public Road from the village of Patentia south toward the NGL Plant site to provide improved access to the site. These improvements are expected to result in improved vehicular access for residents in this area, who currently only have dry-season vehicular access in some areas because of poor existing road conditions. As discussed in Chapter 5, Project Description, these early works activities are not in scope for this EIA, but will nonetheless provide an indirect benefit to community road users.

Project construction-related traffic could potentially have impacts on road function and condition. Project activities with the potential to affect road traffic include movement of workers and supplies during the Construction stage (for construction of the onshore pipeline and NGL Plant) and during the Operations stage (for transport of workers and equipment to the NGL Plant, and waste shipments from the NGL Plant).

The onshore pipeline will cross the WBD Public Road, Stanleytown Road, Canal 1 Road, and nine unnamed roads using HDD methods, allowing uninterrupted road use throughout construction (Table 5.4-1). Other public roads and most private roads will be crossed by open-cut methods, requiring temporary closure of the roads and the establishment of detours. Most open-cut road crossings will require only a few days to complete (Section 5.4.1.3, Onshore Pipeline Construction Methods). Accordingly, transportation impacts from pipeline installation across roads will result in impacts of **Low** intensity, with **Continuous** frequency (as the closure will be continuous during the crossing) and **Short-term** duration, resulting in an impact of **Small** magnitude.

Estimated Project traffic volumes on public roads during the Construction stage are summarized in Table 9.4-10. This table focuses on activities that generate frequent road traffic, and excludes equipment deliveries associated with one-time activities such as mobilization and demobilization of equipment for trenchless pipeline installation or pre-commissioning spreads. Traffic to and from the NGL Plant site will use the WBD Public Road. Buses carrying personnel are anticipated to originate on the east side of the Demerara River (assumed for the purpose of the EIA to be at the Cricket Stadium and comprising 75 percent of the workforce) or on the west side of the Demerara River, north of the NGL Plant site (assumed for the purpose of the EIA to be at the Sports Complex and comprising 25 percent of the workforce). Light vehicles and flatbed delivery trucks will generally originate in Georgetown. The waste disposal facilities that will be used by the Project are located within or south of Georgetown.

Table 9.4-10: Estimated Project Traffic Generation during the Construction Stage

Component	Average Daily Round-Trips	Vehicle Type	Notes
Onshore Pipeline: Personnel Transportation	4 to 6	Light vehicles	Assume two pipeline crews, with transport of workers by 25-person buses
	5 to 10 (2023) 2 to 4 (2024)	Buses	
NGL Plant: Personnel Transportation	10-15	Light vehicles	Assumes no worker camp, with transport of workers by high-capacity buses [a]
	5 to 10 (2023) 10 to 20 (2024) 2 to 3 (2025)	Buses	
NGL Plant: deliveries	1 to 2	Flatbed delivery trucks	
NGL Plant: Waste removal	<1 (2 to 3 per week)	Waste hauler trucks	

[a] If a worker camp is used at the NGL Plant site, bus trips to the NGL Plant site for personnel would be reduced to 2 to 7 round trips daily in 2023 and 7 to 17 round trips daily in 2024.

Traffic for personnel and supplies for onshore pipeline and offshore pipeline (associated with shore crossing HDD/pre-commissioning) installation will use the WBD Public Road and roads extending west to various points along the onshore pipeline corridor (Figure 9.4-5). Some of these roads have paved segments, but many are unpaved and some are tracks only. Some degree of construction access road development or improvement will likely be required along the onshore pipeline route, comprising a combination of soil stabilization and temporary hard-surfacing, with restoration following construction completion.

The baseline traffic study completed in support of the EIA found that intersections of the WBD Public Road at the West Demerara Highway, Cogland Dam Road, the Demerara Harbour Bridge, and La Grange already experience high levels of congestion and delay during morning and evening peak hours (Table 9.4-6). Intersections farther south at Nismes and Stanleytown Road experience moderate levels of congestion and delay. The buses and private vehicles transporting Project personnel are most likely to travel during peak hours, contributing to the existing baseline road congestion. If all workers other than supervisors are transported by bus, Project employee travel during the Construction stage will generate approximately 24 to 31 daily round-trips during 2023, approximately 26 to 45 daily round-trips during 2024, and approximately 16 to 24 daily round-trips during 2025, with trips likely occurring during the morning and evening peak hours. An additional 2 to 3 round trips would occur on a daily basis for deliveries and waste shipments, not necessarily during the morning and evening peak hours.

Given the baseline traffic volumes (Table 9.4-6), the anticipated additional Project vehicle trips will result in an increase in the peak hourly traffic on the order of 4 to 7 percent (using 2024 estimates) at the four intersections studied along the WBD Public Road during the Construction stage. On this basis, and recognizing that these intersections already have failing or near-failing LOS ratings, the intensity is considered to be **Low**. With a **Continuous** (daily) frequency and **Long-term** duration, this results in an impact of **Small** magnitude.

Project-related construction traffic, and especially heavy vehicle traffic (buses, delivery trucks, and waste hauler trucks) will contribute to wear and deterioration of the WBD Public Road and local roads used for transportation to the onshore pipeline worksites. As an embedded control, EEPGL will restore areas affected by Project construction activities, including repairs to key roads used by the Project (Section 5.4.1.6, Post-Construction Cleanup and Restoration). On the basis of this embedded control, the impacts of construction-related Project road traffic on road conditions will have **Negligible** intensity, resulting in an impact of **Negligible** magnitude.

Project traffic to and from the NGL Plant during the Operations stage will consist of personnel commuting trips (for an estimated 40 FTEs), visitors, chemical/water/waste transport, and product transport (i.e., various NGLs) (Table 9.4-11). All traffic will need to use the WBD Public Road. Additional traffic will be generated by the comprehensive maintenance that will occur on average once every 3 years and by other occasional repair and maintenance needs.

Table 9.4-11: Estimated Project Traffic Generation during the Operations Stage

Traffic Types	Average Daily Trips	Vehicle Type	Origin/Destination
NGL Plant workforce	1 to 2 round trips per day	Buses	Cricket Stadium or Sports Complex
Visitors	10 round trips per day	Light vehicles	Offices (Georgetown area)
Light vehicles	4 to 5 round trips per day	Light vehicles	Georgetown area
Deliveries	<1 (2 round trips per week)	Delivery trucks	Georgetown area
Waste removal	<1 (1 round trip per week	Waste hauler trucks	Georgetown area
Total	17 to 19 round trips per day	—	—

The total anticipated traffic generation of 17 to 19 round trips daily results in an increase in the peak hourly traffic on the order of 1 to 3 percent at the four intersections studied along the WBD Public Road. Recognizing that some of these intersections already have failing or near-failing LOS ratings, however, the intensity of impacts during the Operations stage on road congestion and condition is conservatively rated as **Low**. The impacts will be **Continuous** and **Long-term**, resulting in an impact of **Small** magnitude.

Decommissioning of the NGL Plant will likely have an impact similar to that of the Construction stage, although somewhat reduced as the base case is for the onshore pipeline to remain *in situ*. On this basis, the potential impact will likely have no more than a **Low** intensity, with **Continuous** frequency and **Medium-term** duration, resulting in an impact of **Small** magnitude

9.4.3.4. Sensitivity of Receptors—Transportation

Marine Vessel Traffic

Table 9.4-12 summarizes the sensitivity ratings assigned for the various types of receptors that could potentially experience marine transportation impacts from planned Project activities.

Table 9.4-12: Sensitivity Ratings for Receptors of Marine Transportation Impacts

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
Commercial cargo vessels	Includes all international and regional commercial cargo vessel activity making calls at Georgetown Harbour, as well as traversing the northern coast of South America. Project activities will occur in areas potentially used by commercial shipping organizations, and will require use of Georgetown Harbour.	Low	Georgetown Harbour is an active commercial port, where vessel traffic—such as Project-related traffic—is expected. Commercial vessels in international waters are expected to be able to safely navigate around other vessels (whether in transit or stationary).The offshore pipeline corridor is outside of the shipping channel that leads into Georgetown Harbour.
Commercial fishing vessels	Includes commercial fishing vessels (i.e., those who sell their product to local or international markets) that operate in Guyana coastal and offshore waters. These vessels may navigate near Project vessels, or may currently conduct fishing operations near the proposed offshore pipeline route.	Medium	Operators are likely to receive communications about Project activities, are accustomed to navigating in the context of commercial shipping activity in the vicinity of the Georgetown Harbour, and can alter their travel routes or fishing grounds to avoid offshore construction areas. Vessel operators would rely upon, and be sensitive to, loss of customary fishing grounds.
Subsistence fishing vessels	Includes individuals whose fishing activity is primarily or solely to feed themselves, their family, or their community, and not for commercial sales. These individuals generally operate near shore.	Medium	Subsistence fishing vessels are usually small, with limited ability to identify or avoid Project vessels. They are able to make modest adjustments in their customary routes based on observed vessel traffic. They may not receive notice of Project-related activities.

Demerara River Vessel Traffic

Table 9.4-13 summarizes the sensitivity ratings assigned for receptors that rely upon travel on the lower Demerara River and could potentially experience transportation impacts from planned Project activities.

Table 9.4-13: Sensitivity Ratings for Receptors of Demerara River Transportation Impacts

Receptor	Description of Receptor	Sensitivity Rating	Rationale for Rating
Commercial cargo and fishing vessels	Includes cargo and fishing vessels that travel on the lower Demerara River.	Medium	Operators are likely to receive communications about Project activities and are accustomed to navigating in the context of commercial shipping activity in the Demerara River and the Georgetown Harbour. They should be able to successfully navigate around Project-related cargo vessels, but would be sensitive to delays and are dependent upon their ability to safely navigate on the lower Demerara River.
Commercial passenger vessels	Includes ferry boats, speedboats, and river tour boats that carry	Medium	Commercial passenger vessel operators are likely to receive notice of Project-related vessel traffic, and most would have skills and vessel capacity to

Receptor	Description of Receptor	Sensitivity Rating	Rationale for Rating
	passengers across or up the lower Demerara River.		navigate in the context of increased river or marine vessel traffic. However, operators depend on their ability to travel along certain routes at scheduled times and would be negatively affected by activities that harm their ability to adhere to these schedules.
Subsistence fishing vessels	Includes individuals whose fishing activity is primarily or solely to feed themselves, their family, or their community, and not for commercial sales. These individuals may fish within or travel to home docks on the lower Demerara River.	Medium	Subsistence fishing vessels are usually small, with limited ability to navigate around Project vessels. They are able to make modest adjustments in their customary routes based on observed vessel traffic. They may not receive notice of Project-related activities.
Private passenger vessels	Includes individuals who use their own vessels for transportation on the Demerara River.	Medium	Private vessels are usually small, with limited ability to navigate around Project vessels, and may not receive notice of Project-related activities. They are able to make modest adjustments in their customary routes based on observed vessel traffic.

Onshore Vehicular Traffic

Table 9.4-14 summarizes the sensitivity ratings assigned for receptors that rely upon travel on public roads and could potentially experience transportation impacts from planned Project activities.

Table 9.4-14: Sensitivity Ratings for Receptors of Road Transportation Impacts

Receptor	Sensitivity Rating	Rationale for Rating
Current users of the WBD Public Road	High	The WBD Public Road is heavily traveled and the sole connecting road for numerous settlements west of the lower Demerara River. No alternate north-south routes are available.
Current users: local roads extending to the west from the WBD Public Road	High	Roads such as Independence Street, Canal 1 Road, and Stanleytown Road connect homes and settlements with the regional road network via the WBD Public Road. Alternate routes are limited or non-existent and residents rely on a limited road network for access to jobs, services, and the larger community.
Current road users: Demerara Harbour Bridge	High	The Demerara Harbour Bridge is the only vehicular travel route across the Demerara River in the Georgetown—Vreed-en-Hoop area. The closest additional bridge over the Demerara River is over 90 kilometers to the south in Linden, Guyana.
Current road users: West Demerara Highway and road network within Vreed-en-Hoop and nearby areas	Medium	The Vreed-en-Hoop area road network provides alternate routes for most destinations. Travelers are accustomed to relatively high existing traffic volumes on the major roadways.

Receptor	Sensitivity Rating	Rationale for Rating
Current road users: Georgetown road network	Medium	Travelers on the road network within Georgetown are accustomed to relatively high existing traffic volumes, as well as congestion and road safety risks in parts of Georgetown. Additional traffic will likely be viewed as incremental, but not a fundamental shift in conditions. The grid road network within Georgetown generally provides alternate routes.

9.4.3.5. Pre-mitigation Impact Significance—Transportation

Embedded controls are accounted for in the pre-mitigation impact significance ratings presented below.

Marine Transportation

The pre-mitigation intensity ratings for potential Project impacts on marine transportation range from **Negligible** to **Low**, yielding magnitude ratings ranging from **Negligible** to **Small**. Coupled with sensitivity ratings of **Low** to **Medium**, the pre-mitigation impact significance for marine transportation ranges from **Negligible** (commercial cargo vessels) to **Minor** (commercial and subsistence fishing vessels).

River Transportation

The pre-mitigation intensity ratings for potential Project impacts on river vessel transportation range from **Negligible** to **Low**, yielding magnitude ratings ranging from **Negligible** to **Small**. Coupled with sensitivity ratings of **Medium**, the impact significance for river transportation ranges from **Negligible** to **Minor**.

Road Transportation

The pre-mitigation intensity ratings for potential Project impacts on traffic congestion are rated as **Low**. This results in a pre-mitigation magnitude rating of **Small.** Coupled with sensitivity ratings of **Medium** to **High**, the pre-mitigation impact significance for road transportation with respect to traffic congestion ranges from **Negligible** to **Moderate**.

The pre-mitigation intensity of potential impacts of pipeline installation under roads is rated as **Low**, yielding a magnitude rating of **Small**.

The pre-mitigation intensity of potential impacts on road condition is rated as **Negligible**, yielding a magnitude rating of **Negligible**.

9.4.4. Impact Management and Monitoring Measures

Based on the **Negligible** to **Minor** significance of most transportation impacts, mitigation measures are not warranted. It is noted, however, that the limited significance of these potential impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitments Register). To address the potential traffic congestion impacts of a **Moderate** significance, the following mitigation measures are recommended:

- Maximize use of bus transportation to reduce the volume of vehicles movements associated with worker transportation.
- Schedule deliveries and, to the extent feasible, personnel transport, during non-peak traffic periods.
- Engage with community stakeholders to obtain local understanding of traffic flow and congestion within towns and settlements and to provide information on anticipated Project traffic.

Table 9.4-15 summarizes the management and monitoring measures relevant to transportation.

Table 9.4-15: List of Management and Monitoring Measures

Embedded Controls
Restore all roads to their pre-construction condition or better following completion of each contractor's component of the construction process (potentially including retention and handover of temporary bridge spans to the Government of Guyana, where appropriate).
Complete pipeline road crossings using trenchless methods where practicable. Where open-trench crossings are used, minimize the time of road closure to the extent practicable, and provide adequate detours.
Mitigation Measures
To address potential impacts on commercial and subsistence fishing vessel operators in the marine environment and Demerara River, proactively communicate plans for offshore pipeline construction, temporary safety zones, marine and river cargo transportation to fishing vessel operators, using community groups and other contacts established through EEPGL's ongoing work in the region.
Maximize use of bus transportation to reduce the volume of employee vehicles.
Schedule deliveries and, to the extent feasible, personnel transport, during non-peak traffic periods
Engage with community stakeholders to obtain local understanding of traffic flow and congestion within towns and settlements and to provide information on anticipated Project traffic.
Survey the WBD Public Road and other access roads to the onshore pipeline corridor to confirm that route geometrics are adequate for safe passage of buses and trucks.

9.4.5. Assessment of Residual Impacts

The mitigation measures proposed for road transportation would provide measures to mitigate road congestion during. Assuming implementation of these measures, the residual impact significance for potential traffic congestion impacts is reduced to **Minor**. Potential residual impact significance ratings for other potential impacts on transportation are unchanged.

Tables 9.4-16, 9.4-17, and 9.4-18 summarize the assessment of potential pre-mitigation and residual impact significance for the potential impacts on transportation.

Table 9.4-16: Summary of Potential Pre-mitigation and Residual Impacts—Marine Transportation

Stage	Potential Impact	Sensitivity	Magnitude	Pre-mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Increased vessel traffic	Low to Medium	Small	Negligible to Minor	Proactively communicate plans for offshore pipeline construction, temporary safety zones, marine and river cargo transportation to fishing vessel operators, using community groups and other contacts established through EEPGL's ongoing work in the region	Negligible to Minor
	Presence of offshore pipeline work vessels	Low to Medium	Small to Medium	Minor to Moderate		Minor to Moderate
Operations	Vessel traffic for pipeline inspections and maintenance	Medium	Negligible	Negligible		Negligible

Table 9.4-17: Summary of Potential Pre-mitigation and Residual Impacts—River Transportation

Stage	Potential Impact	Sensitivity	Magnitude	Pre-mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Increased vessel traffic	Medium	Small	Minor	Proactively communicate plans for offshore pipeline construction, temporary safety zones, marine and river cargo transportation to fishing vessel operators, using community groups and other contacts established through EEPGL's ongoing work in the region	Minor
Operations	Increased vessel traffic	Medium	Negligible	Negligible		Negligible
Decommissioning	Increased vessel traffic	Medium	Small	Minor		Minor

Table 9.4-18: Summary of Potential Pre-mitigation-and Residual Impacts—Road Transportation

Stage	Potential Impact	Sensitivity	Magnitude	Pre-mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Road access/use disturbance due to onshore pipeline crossing using open-cut methods	High	Low	Moderate	Where open-trench crossings are used, minimize the time of road closure to the extent practicable, and provide adequate detours	Minor
	Increased road traffic and congestion	High	Small	Moderate	See Section 9.4.4, Impact Management and Monitoring Measures	Minor
	Increased wear and deterioration of road surfaces	High	Negligible	Negligible	None	Negligible
Operations	Increased road traffic and congestion	High	Small	Moderate	See Section 9.4.4	Minor
	Increased wear and deterioration of road surfaces	High	Small	Negligible	None	Negligible
Decommissioning	Increased road traffic and congestion	High	Small	Moderate	See Section 9.4.4	Minor
	Increased wear and deterioration of road surfaces	High	Negligible	Negligible	None	Negligible

9.5. CULTURAL HERITAGE

“Cultural heritage” is an umbrella term for many heritage-related resources defined by international organizations as well as national laws and regulations. Through Guyana’s National Trust Act, No. 7 (Chapter 20:03) of 1972 (National Trust Act), the National Trust is tasked with the protection of national monuments of cultural heritage significance. A monument is defined in the National Trust Act as “any building, structure, object or other work of man or of nature whether above or below the surface of the land or the floor of the sea within the territorial waters of Guyana and any site, cave or excavation.” Under section 15 of the law, the National Trust is given the authority to designate a national monument if it is determined to be “in the interest of the public that any monument should be preserved on account of the historic, architectural or archaeological interest attaching to it or its national importance.”

Cultural heritage can be both tangible and intangible (e.g., oral histories), and tangible cultural heritage can be both portable (i.e., objects) and non-portable (i.e., sites). Tangible cultural heritage includes properties and sites that possess archaeological (prehistoric or historic in character), cultural, artistic, or religious significance. It can also include locations with unique natural environmental features that are important local cultural values. Non-portable, tangible cultural heritage, the type typically most susceptible to impacts from infrastructure development projects, can be further subdivided into archaeological, architectural, and living heritage sites. Archaeological sites are areas where human activity has measurably altered the earth (e.g., canals, mounds) or deposits of physical remains are found (e.g., artifacts). Archaeological sites can be prehistoric or historic, and can be underwater or terrestrial. Architectural sites include standing buildings, bridges, dams, and other structures of historic or aesthetic significance. Living heritage consists of resources of traditional, religious, or cultural significance. Living heritage sites can include archaeological resources, sacred sites, sacred structures, and prominent topographical features essential for the preservation of traditional cultures.

9.5.1. Baseline Methodology

A cultural heritage study was performed in support of the Project EIA. The objective of this study was to identify any cultural heritage sites within the Project’s Area of Potential Effects (APE; see Section 9.5.1.3, Historic Architectural Survey Field Methods, for definition) that may be adversely affected by the Project’s construction and operation activities. The assessment of these sites focused on identifying previously recorded and previously unidentified archaeological sites, intangible cultural heritage resources, and historically significant architectural resources.

9.5.1.1. Approach and Scope

The cultural heritage baseline study completed for the Project EIA is intended to describe any cultural heritage that could potentially be impacted by the Project, including archaeology, structures, and the cultural landscape. The objective is to establish a cultural heritage baseline intended to support the protection and preservation of existing cultural heritage from potential adverse impacts of the Project's activities. Fieldwork for this study consisted of a combination of pedestrian and windshield surveys. When appropriate, shovel testing of identified and accessible high-probability[26] landforms was conducted.

9.5.1.2. Background Research

Prior to the start of fieldwork, the Consultants conducted a background assessment of available material relevant to the archaeology of the region immediately surrounding the Direct AOI. The background research was intended to identify previously recorded sites, historic structures, and completed studies within a 3-kilometer-wide area along the approximately 27-kilometer-long onshore pipeline corridor. In addition, this research included a 3-kilometer area surrounding the other Project onshore facilities (i.e., the NGL Plant and the temporary MOF site).

Background research incorporated peer-reviewed book chapters, journal articles relevant to the region, historical maps, and personal communications with local Guyana residents familiar with the regional landscape. This was done to establish a cultural context for the broader region and include major prehistoric and historic periods, and significant archaeological phases, as well as to learn about potential resources that have not been previously documented.

With respect to the offshore components of the Project, the Consultants relied upon prior geophysical studies conducted by EEPGL in or around the offshore Direct AOI (i.e., as part of previous EEPGL offshore development projects and the Fiber Optic Cable project). No additional reference material describing previously identified cultural resources (e.g., shipwrecks) was identified.

9.5.1.3. Historic Architectural Survey Field Methods

In the context of historic properties, an APE is defined as the geographic area or areas within which an undertaking may result in changes to the character or use of historic properties, if any such properties exist. Such changes may result in direct impacts (e.g., physical damage to a site) or indirect impacts (e.g., a change in the viewshed of the historic setting of a site). For the purpose of this EIA, the Indirect or "visual" APE for historic structures is defined as historic structures that will be visible from the Project footprint, up to a distance of 1 kilometer away. The field survey therefore focused on what will actually be visible from the Project footprint during construction or operation activities. While structures farther than 1 kilometer from the Project footprint could be visible from the Project footprint, any changes to the viewsheds of these structures at this distance would be minimal given the dense nature of vegetative land cover in the area. Any vegetative clearance will remove modern vegetative overgrowth, and thus not alter the character of the historic landscape or the historic viewshed.

The Consultants surveyed properties 50 years or older in the Indirect APE, including buildings, engineering structures such as bridges and canals, cemeteries, monuments, and other sites that had the potential to contain significant historic value. The age of resources was estimated

[26] High-probability landforms are areas that were assessed as having a high likelihood of containing significant cultural resources. These areas are generally identified by distinct landforms and deposits that have been shown in other similar surveys to contain archaeological sites, that environmentally could have served as optimal locations for habitation, or that have experienced limited disturbance.

based on architectural styles and materials, supplemented with information from historical maps, aerial photographs, and available architectural resources. The boundaries of resources were defined to encompass the buildings and structures themselves and other elements of the built environment in their immediate vicinity. Digital photographs were taken to record the structures' overall appearance and details. When access to a property was not granted, observations were limited to a windshield survey and photographs were taken from the nearest public road or from the pipeline survey corridor.

9.5.1.4. Archaeological Survey Field Methods

Shovel Testing

The APE for archaeological resources is limited to the footprint of potential construction impacts (i.e., where potential ground-disturbing activities are planned). While the standard width of the construction RoW for the pipeline will be 22.9 meters wide, a 30-meter-wide corridor was surveyed for archaeological features in all accessible portions of the survey corridor. This survey corridor width was designed to encompass the area of construction impacts while providing sufficient coverage to accommodate minor route revisions and small shifts in workspace and facility locations. The archaeological survey area also included—to the extent accessible—additional work spaces along the onshore pipeline corridor, such as HDD work areas and temporary staging areas. Finally, the survey area included accessible portions of the proposed NGL Plant site and a portion of the proposed heavy haul road corridor leading to the proposed temporary MOF. Hand-held global positioning system (GPS) units, with sub-meter accuracy, were used to navigate to survey areas, track progress, and record results.

Standard archaeological survey methods were used during the field study. When possible, the entire surveyed area was subjected to systematic pedestrian reconnaissance along transects spaced 15 meters apart (two transects within the nominal 30-meter-wide inventory corridor). At times, these transects were confined to mud dams surrounded by canals. Prior to the start of fieldwork, and in addition to pedestrian reconnaissance and surface inspection, the Consultants designed a plan for the incorporation of shovel testing outlined in the following approach:

- In previously disturbed areas (e.g., fallow fields) with poor ground surface visibility (less than 25 percent), shovel tests would be excavated at staggered intervals every 100 meters along each of the survey transects, or through a combination of pedestrian survey and/or judgmental shovel testing, at the discretion of the lead archaeologist.[27]
- High-probability landforms (e.g., terraces) would be subjected to judgmental shovel testing.
- In locations where ground surface visibility exceeded 25 percent, judgmental shovel tests would be excavated at the discretion of the lead archaeologist.

[27] Judgmental shovel testing consists of shovel testing done in random locations outside of a systematic grid pattern or survey design. Such tests are commonly used to target high-probability landforms or specific site locations, or as a means of obtaining insight into the subsurface stratigraphy of a study area. In many cases, judgmental shovel testing may be employed to supplement pedestrian survey of areas with high ground surface visibility and/or severely disturbed deposits (e.g. agricultural fields), if it is deemed necessary.

- Areas with greater than 20 percent slope would not be shovel tested as they are considered unlikely to have supported human habitation.
- Shovel tests would be excavated until subsoil was reached or to a depth of 1 meter. All soil recovered from shovel tests would be screened through ¼-inch (6.4 millimeters) wire mesh. If artifacts were encountered, even in cultivated fields or other areas with good surface visibility, additional shovel tests would be excavated at intervals ranging from 5 to 15 meters (depending on site size) to delineate the site. This would be done until two consecutive negative shovel tests were excavated in all cardinal directions from positive tests or until the limits of the survey corridor were reached. All artifacts encountered during shovel testing would be collected for laboratory analysis. Site boundaries and locations of individual archaeological features would be recorded with a GPS. Shovel tests would be backfilled upon completion of the excavation process.

General field conditions were photographed and documented with digital media. Notes on landforms, setting, ground surface visibility, and disturbances were recorded using ArcGIS Field Maps. Additional details that include observations regarding soil stratigraphy (e.g., Munsell color, texture) were also described.

A concerted effort was made to determine the location, extent, and condition of any previously recorded sites within the survey area. None were identified within the proposed Project footprint during background research, but one prehistoric ceramic scatter site, Recht-door-Zee, was recorded west of the proposed onshore pipeline corridor, between Canal 1 and Canal 2 in Versailles Estate. No evidence of the site extending into the survey corridor was observed during the survey.

No significant archaeological sites or cultural materials were encountered during the course of the survey within the NGL Plant site or along accessible portions of the onshore pipeline survey corridor. Three *Ceiba pentandra* trees, or silk cotton trees as they are locally known, important to coastal oral traditions, were noted either within or in the immediate vicinity of the Direct AOI of the proposed onshore pipeline (see Figures 9.5-1 and 9.5-2). Furthermore, two archaeological sites were also recorded during the field survey, but are located well away from the Direct AOI.

Limitations

The cultural heritage baseline survey had a number of limiting factors that restricted the types of data that were collected. These limiting factors were a product of the conditions of the terrain and included the degree of previous disturbance and development along the survey corridor, general geographic and natural conditions specific to each survey area that produced safety limitations to access, and access permission restrictions to portions of the study area. As a result, these factors limited the survey methods that could be employed. Given the extent and depth of disturbance encountered and the nature of the archaeological landscape that exists along the entirety of the corridor, some judgmental shovel tests were excavated, but pedestrian survey was determined to be the most appropriate approach for most of the onshore pipeline corridor and for the NGL Plant site.

9.5.2. Existing Conditions

Little is known about the archaeology of Region 3, an economically developed region of Guyana that has become a major agricultural hub and housing district. Cultural phases have been defined by multiple researchers since the 1960s. Table 9.5-1 summarizes the previously documented cultural heritage sites of Region 3. With the exception of III-3:1, Recht-door-Zee, all of these sites are located more than 5 kilometers away from the Project footprint.

Table 9.5-1: Documented Sites of Region 3

Number/Name	Type	River
III-2:1 Leonora	ceramic	Demerara
III-2:2 Stewartville	ceramic	Demerara
III-3:1 Recht-door-Zee	ceramic	Demerara
III-3:2 Sand Hills	stone tool	Demerara
III-3:3 Santa Mission	ceramic	Demerara

9.5.2.1. Existing Conditions of Region 3 – Essequibo Islands, West Demerara

In 1884, Estate Manager William Russell reported an artificial raised field behind Plantation Leonora that bore a striking resemblance to the mounds found at the back of Plantation Enmore, Plantation Mon Repos, and others. This led to the conclusion that similar mounds and mound adaptations may have been dispersed across the coast along the previous shoreline that stretched from the Canje River to the west bank of the Demerara River. None of the sites along the west bank are known to have been fully investigated, but several researchers have discussed the known findings. For instance, Roth (1924) discusses artifacts recovered from Sand Hills in Region 3 that include stone implements such as adzes, axes, and celts that were recovered from the site; they are currently housed at the Walter Roth Museum of Anthropology.

In 1977, a mound associated with several sherds of prehistoric ceramic was encountered during clearing activities on the Versailles Estate. Upon its discovery, cultivation activities were halted and pottery collected. The site (Recht-door-Zee) was later excavated by Williams in 1978 and 1979, and further excavations were conducted by Wishart in 1982 (Wishart 1982). Recht-door-Zee was identified as being associated with the Abary phase, as defined by Evans and Meggers (1960), based on pottery typology and a bead recovered from the site. More recent characterizations of Guyana's major archaeological phases place it in the expansive Horticultural Period as defined by Plew (2005) and Plew and Daggers (in press 2022) that lasts from 3500 before present (BP) to the present, and the Formative period as defined by Williams (2003). Recht-door-Zee appears to date to after 800 BP, and was a significant trading location along the Amazon-Orinoco Communications Corridor (Plew Undated; Williams 2003; Wishart 1982). The site is known for a significant ceramic assemblage that seemingly encapsulates multiple ceramic traditions found in the lower Aruka River and displays elements of Koriabo influence, a contemporary tradition of the Abary phase (Evans and Meggers 1960; Plew 2005; Williams 2003). In addition, excavations have revealed construction of wattle and daub houses at the site (Plew 2005; Wishart 1982). Located south of Canal 2, the site is approximately

2.5 kilometers west of the Project footprint and is the only recorded archaeological site in the vicinity of the Project footprint. However, it does not fall within the Project APE.

Sites with similar reported features have been identified at Stewartville, and a habitation/ceramic site was investigated within the vicinity of Santa Aratak Mission. Table 9.5-2 presents the significant archaeological phases over time in Guyana as they are currently understood. These phases have been defined by three different sets of researchers. Evans and Meggers (1960), working with the limited information available to them at the time, were able to define several significant archaeological phases, represented on the left side of the table. Williams (1998), and later Plew (2005), devised subsequent chronologies that aimed to further organize the archaeological phases of Guyana as well as complement those previously defined. These are represented in the table by the two right columns. Each phase described is given a time span expressed in “Before Present” or BP.

Other common sites in the region are associated with Dutch colonial rule and are commonly encountered along the banks of the Demerara River. Such sites are typically represented archaeologically by deposits of old colonial bottles, as the river served as a major port while Guyana remained a colony.

Table 9.5-2: Major Archaeological Phases of Guyana

Cultural Phases	**Northwest**	**Northwest/Iwokrama**
Evans and Meggers 1960	Williams 1998	Plew 2005
	Paleo-Indian Pre-7500 BP	
	Archaic 7500–3500 BP	
Alaka Phase 2600–1500 BP	Early Formative 3500–740 BP	Horticultural Period 3500 BP–Present
Mabaruma 1500–350 BP; Abary 750–400 BP; Koriabo 600–300 BP	Formative Period 740–200 BP	
Taruma ?? – 100 BP; Rupununi 300–100 BP; Wai 150 BP–Present	Late Formative Post 200 BP	

9.5.2.2. Terrestrial Archaeology Existing Conditions and Results

A field survey of the proposed onshore Project footprint took place between November 2021 and February 2022. Figure 9.5-1 shows the currently proposed onshore pipeline alignment and the location of the cultural resources survey corridor (the latter divided into the portion that was field surveyed and the portion that was inaccessible at the time of the survey). As noted above, given the conditions of the terrain and nature of the landscape, the majority of the route was investigated via pedestrian survey. Significant disturbance was observed throughout the APE, deeming extensive shovel testing unwarranted. No previous cultural heritage surveys are known to have been undertaken within the vicinity of the Project's construction footprint and one known cultural heritage site located on the Versailles estate, Recht-door-Zee (Figure 9.5-1), had been previously investigated (Plew Undated 12; Plew 2005; Wishart 1982).

The Direct AOI is situated within an historic landscape that has been occupied and continuously modified since at least the start of Dutch colonization in the late 16th century, and most likely by peoples who inhabited the region prior to contact. Crossing multiple housing development areas, canals, and modern and historic plantations, the landscape is most accurately characterized as a large, historic, human-designed landscape composed entirely of archaeosediments that are continuously being reformed (Waters 1992).[28] The Project footprint is located within four primary types of anthropogenic landscapes: canals and mud dams, active agricultural fields, historic/abandoned agricultural fields, and residential neighborhoods.

Areas of the Project footprint that follow or cross canals and/or mud dams are heavily disturbed, and in many instances, are continuously being reformed. The canals are routinely dredged and mud dams are constructed or reconstructed from the dredged sediment material in response to erosion caused by annual rainy seasons. Mud dam deposits tend to be thick (more than 1 meter) and composed of heavy, extremely plastic, clays. Virtually nowhere along these areas has been left undisturbed, even along neglected or abandoned areas, leaving little in way of surviving archaeological deposits. North of Canal 2, many of the dams and canals are routinely maintained, as they still support active agricultural fields. To the south, many areas have been neglected or abandoned in recent years.

[28] As defined by Waters (1992:33), archaeosediments are "those sediments created by intentional or unintentional human activities. Archaeosediments include mounds or earthworks composed of intentionally excavated natural sediments and soil, trash accumulated in pits, byproducts of construction, such as berms adjacent to canals, accumulations of shells in heaps, and middens are a combination of chemically altered natural sediments, accumulated organic and inorganic refuse, and sediment brought onto the site on the soles of feet and clothing."

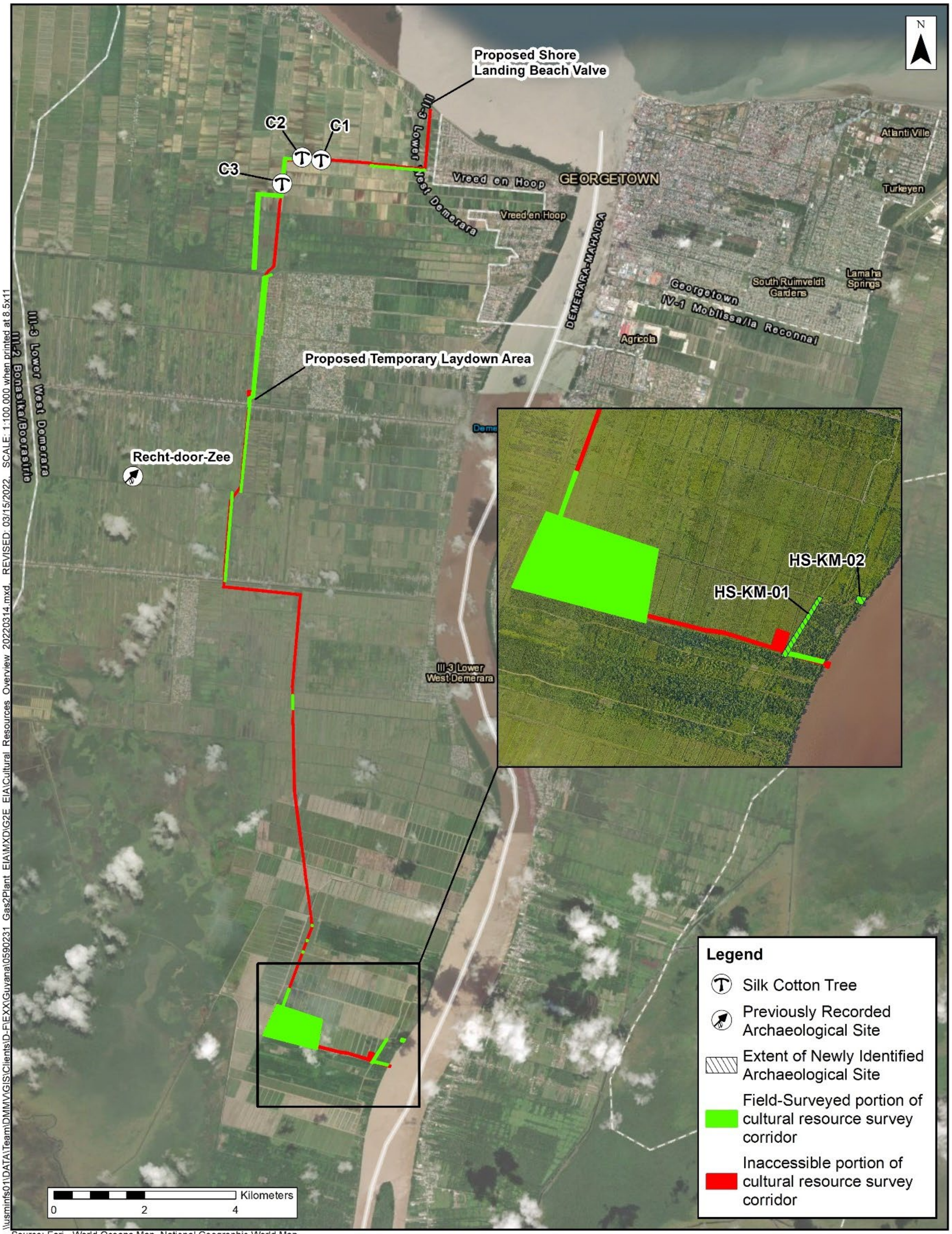


Figure 9.5-1: Project Footprint Cultural Heritage Survey Overview

Active rice fields are the dominant form of agricultural disturbance along the onshore pipeline corridor north of Canal 2. Rice fields are repeatedly planted, flooded, harvested with heavy machinery, and burned. Examples of such fields currently being farmed are located between Crane Seawall and Cogland Dam (SKP[29] 0.2–0.3, SKP 0.4–1.1, and SKP 1.2–1.5), Cogland Dam and La Parfaite Harmonie (SKP 1.6–5.8), and La Parfaite Harmonie and Canal 1 (SKP 7.5–10.2). South of Canal 1 (SKP 10.5–12.2) plots of pineapple plantations and rice fields occupy the landscape. At the time of the survey, a stretch of farmland between SKP 5.8 and SKP 7.2, immediately north of La Parfaite Harmonie, appeared to no longer be used for agriculture, but still displayed evidence of significant disturbance from years of cultivation. Between SKP 12.3 and the housing development around Canal 2 at SKP 14.3 are pineapple plantations and what appeared to be fields not actively used at the time of the survey. Although agricultural development is part of the landscape's historic nature, the disturbance to these areas through varying and consistent agricultural activities since as far back as Dutch colonial rule, which has continued into modern day, appears to have resulted in an overall lack of intact archaeological deposits.

Small portions of the onshore pipeline corridor cross residential areas that include the area between Crane Seawall and Cogland Dam (SKP 0.1–1.6), La Parfaite Harmonie (SKP 7.2–9.6), and the housing developments around Canal 1 (SKP 10.2–10.4) and Canal 2 (SKP 14.3–14.4). Although limited, these areas have been so thoroughly developed that essentially no intact archaeological deposits remain.

Although archaeological resources and deposits were not observed in these areas, two *Ceiba pentandra* trees, or silk cotton trees as they are known locally, were identified in or near the proposed Project footprint at the Cogland Dam section near SKP 3.8 (designated C1) and SKP 4.3 (designated C2); a third silk cotton tree was identified to the south of this area within the proposed Project footprint near SKP 5.7 (designated C3). These trees are associated with deep spiritual beliefs in the region. See section 9.5.2.3, Silk Cotton Trees, for further detail (see Figure 9.5-2).

[29] SKP as used in this section refers to the distance in kilometers along the onshore pipeline cultural resources survey corridor, measured from the proposed shore landing beach valve location (e.g., SKP 1.2 = 1.2 kilometers along the cultural resources survey corridor from the proposed shore landing beach valve location).

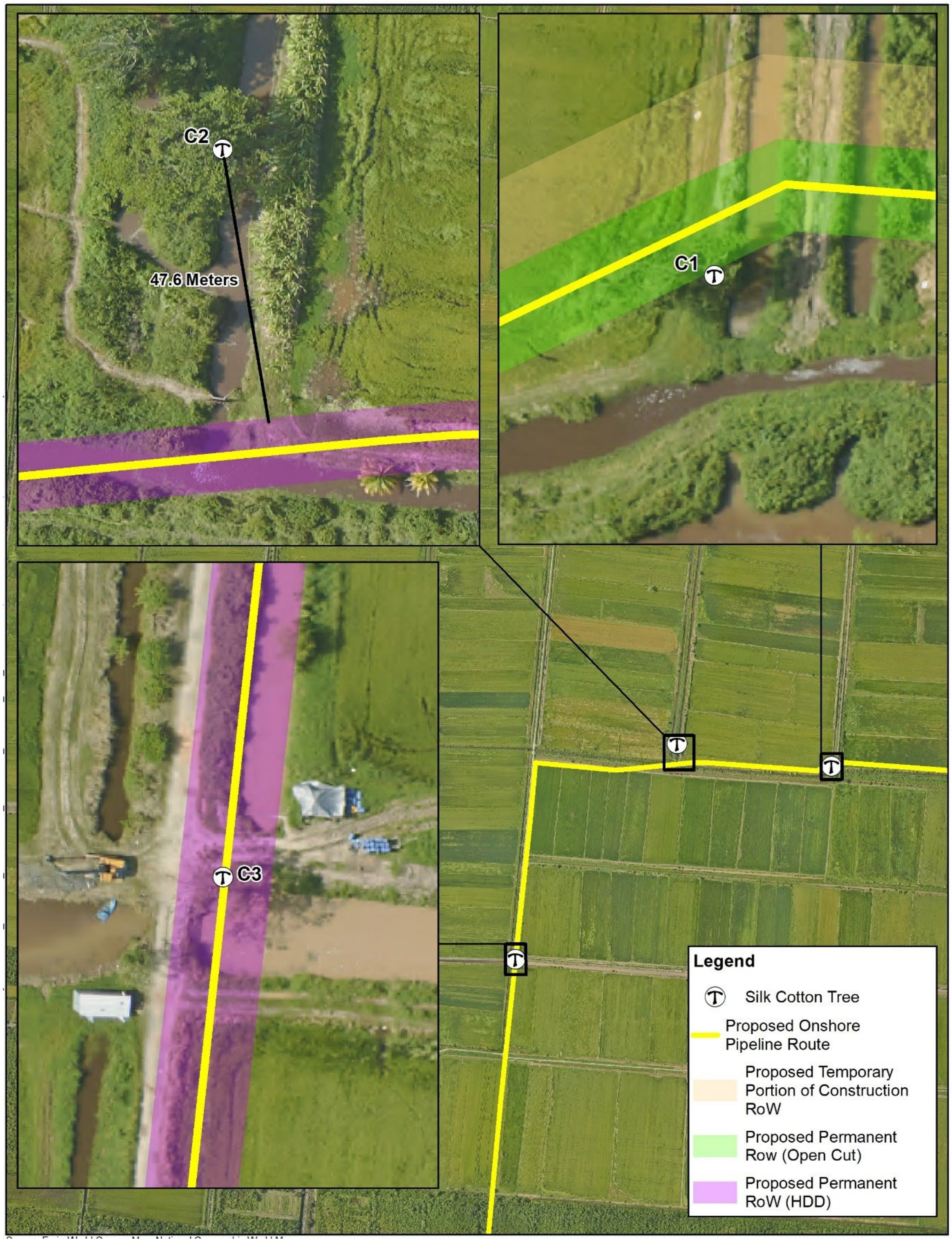


Figure 9.5-2: Locations of Identified *Ceiba pentandra* "Silk Cotton" Trees in or near the Direct AOI

The historic nature of the landscape is more easily viewed south of Canal 2 (KP 144-254), where abandoned sugarcane plantations extend from Canal 2 to the NGL Plant site. Some of these areas (e.g., portions of the Wales Estate) were still actively harvested until as recently as 2015, but have since been abandoned. These areas are heavily overgrown with vegetation and relict sugarcane plants, making surveying challenging, but given the longevity of these plantations, little intact archaeological material is likely to be present.

Areas not occupied by canals have been significantly disturbed by agricultural activities. Although many of these activities are historic in nature (e.g., the historic sugar plantations within the Wales Estate), other areas are still actively cultivated for rice (e.g., the area between Cogland Dam and Crane Seawall, or the locations south of Cogland Dam). The segment of pipeline planned between Canal 2 and the NGL Plant crosses areas of previous sugar cane plantations. Much of this has been abandoned and heavily overgrown. Canals and mud banks along much of this portion of the route, particularly in Wales Estate, are not being maintained as regularly as other areas far to the north. As a result, these areas have become extremely overgrown and are difficult to survey.

East of the proposed NGL Plant site, set along the bank of the Demerara River, is the proposed temporary MOF site, which will be connected to the NGL Plant site by the proposed heavy haul road. The proposed heavy haul road will extend east of an existing, north-south oriented access road for a distance of approximately 350 meters through what was, at the time of the survey, dense forest to the point where it will connect with the proposed temporary MOF. This portion of the proposed heavy haul road footprint was surveyed for approximately 300 meters before the presence of a canal prevented further progress. In addition to a pedestrian reconnaissance along this area, a judgmental shovel test was excavated in this area.

Along the north-south access road located north of the proposed heavy haul road, a low-density ceramic sherd scatter was identified. This site (designated HS-KM-01) consists of ten ceramic sherds that date to the historic colonial periods. Some fragments appeared to be derived from early Dutch-era bottles and vessels, while others consisted of historic whiteware that may date to British rule in the 19th century. The presence of non-local laterite indicates that the road has undergone improvement at some point in time. All of the sherds were encountered on the surface of the road and, given the presence of laterite, the materials were likely transported from a different location and were secondarily deposited. Given the location of the site in the road, a shovel test was not completed, but it is highly improbable any intact archaeological deposits associated with the site are present in this area.

Recent clearing activities on the proposed NGL Plant footprint have allowed for systematic survey of the area. Transects in this area were restricted to mud dams that ranged from 12 to 115 meters apart. Areas between large gaps in transects were typically covered by survey of multiple spur transects branching off each transect. These spurs had been cleared for geotechnical investigation purposes, affording significant survey coverage of the proposed NGL Plant footprint. While the entire landscape of the NGL Plant site consists of an historic anthropogenic landscape, its use into the modern era has reduced the degree to which any historic character remains. No cultural materials, either prehistoric or historic, were encountered on the proposed NGL Plant site.

An additional site (designated HS-KM-02), was encountered along the shore of an access canal north of the proposed temporary MOF location. During low tide, a series of historic bottle and vessel sherds, along with bricks, were observed protruding out of the bank. Further investigation of the area indicated the presence of ruins of a possible historic canal wall, additional Dutch or other colonial-era materials, and the potential foundations of a structure. Unfortunately, due to time constraints posed by the tides, thick forest vegetation, the hazardous conditions of the mudflats where most of the materials were observed, and the location of the site outside the proposed Project disturbance footprint, fully delineating the site was not possible. HS-KM-02 is more than 600 meters away from the closest proposed Project component, i.e., the temporary MOF location. However, its presence indicates the type of archaeological materials that could potentially be encountered along the shoreline of the Demerara River in the area that will be disturbed during construction of the temporary MOF.

*9.5.2.3. Silk Cotton Trees (***Ceiba pentandra***)*

The *Ceiba pentandra* tree, the largest tree species found in Guyana, is most commonly referred to among Guyanese as the silk cotton tree. These trees are associated with strongly held spiritual beliefs that are often associated with the Dutch and dark spirits. *Ceiba pentandra* is the most commonly occurring species of the *Ceiba* genus, which comprises 18 different species, and is found throughout much of South America, Central America, and the Caribbean, as well as in Southeast Asia, Africa, and other parts of the world. Known to reach heights of 70 meters, they have distinctive spines along the trunk and branches (Tareau et al. 2022).

Ceiba pentandra is known throughout the world by a variety of local and indigenous names that include: kapok tree, silk cotton tree, white silk cotton tree, kabu-kabu, and kapuk, among many other titles, but is hereinafter referred to as the silk cotton tree when referring to them in Guyana, as that is the name used locally (Tareau et al. 2022; Flora & Fauna Web 2021). Found most commonly in Guyana's interior, silk cotton trees are also present throughout the coastal environment of Region 3 where the Project is located.

Silk cotton trees hold a place of great spiritual significance in Guyana and are an integral element to the creation myths of the Akawaio, Makusi, and Arawak peoples. In these stories, a creator, using pieces of the silk cotton tree's wood or bark, formed all humans and animals (de Goeje 1943; Roth 1915; Tareau et al. 2022). Such spiritual significance is not unique to Guyana, and exists in some form throughout much of Central and South America. For instance, Cano and Hellmuth (2008) explain that *Ceiba* trees held great cosmic significance for the Maya of Central America, who believed that a great *Ceiba* tree served as the axis of the world. Another Mayan belief pertained to the tree's connection to the heavens, with five trees connecting the physical earth to the spiritual underworld. Mayans believed that souls ascended through a great *Ceiba* tree to the heavens made up of the tree's branches (Cano and Hellmuth 2008; Lans 2008). In Trinidad and Tobago, African slaves historically revered these trees, and ceremonies are still often conducted today before a tree is cut down or destroyed (Lans 2008). Similar myths and legends are known throughout Paraguay, Argentina, and the countries of Amazonia, often centering around creation and connection between the physical and spiritual worlds (Tareau et al. 2022).

In Guyana, the Arawak believe silk cotton trees are inhabited by spirits that imbue them with the power to move at nighttime (Guyana Chronicle 2012a; Tareau et al. 2022). Around Region 3, and throughout the country, many beliefs are associated with the Dutch, as the fraught history of slavery and historical sugarcane production and colonial rule (1580–1782; 1784–1803) is still plainly visible on much of the landscape. Some local traditions maintain that silk cotton trees are markers for the locations of fallen Dutch soldiers (Figure 9.5-1). In some cases, these beliefs are so prevalent that people have been known to wrap chains around these trees to trap those spirits from escaping (Daggers 2022, pers. comm.). People are known to carry out religious ceremonies around these trees and present gifts such as cigarettes, rum, fruit, and the blood of fowl cocks that have been offered as sacrifices to the resident spirits (Guyana Chronicle 2012b).

Such beliefs have been known to have repercussions for past development projects. A well-known case of such an instance occurred in the village of Perseverance, Mahaicony, where a planned road had to be divided into two lanes to avoid disturbance of a local silk cotton tree known to the community as the “Dutchman Tree” because it is believed to be haunted (Rutherford 2013). In general, these trees are often met with a significant amount of apprehension and fear by many Guyanese who believe cutting down such a tree will result in the offender’s quick demise (Guyana Chronicle 2012b).

Essentially, these trees embody a mix of tangible and intangible cultural heritage that are deeply rooted in Guyanese beliefs and oral traditions, particularly around the coast. Even younger, more recently planted trees are typically treated with reverence and caution.

9.5.2.4. Historic Structures Existing Conditions and Results

As described above, the Indirect APE for historic structures was defined as structures that will be visible from the Project footprint, up to a 1-kilometer buffer around the Project footprint. The architectural reconnaissance survey within this buffer focused on structures meeting these criteria. Digital photographs of representative structures assessed as being 50 years or older within each neighborhood were taken from the public road. Prior to the survey, the Consultants conducted a background research of the Project area and the APE. No previously recorded historic architectural resources were identified in this background research. However, three historic neighborhoods on the West Bank of the Demerara River fell within the APE. These include Crane Village, La Parfaite Harmonie, and Nismes.

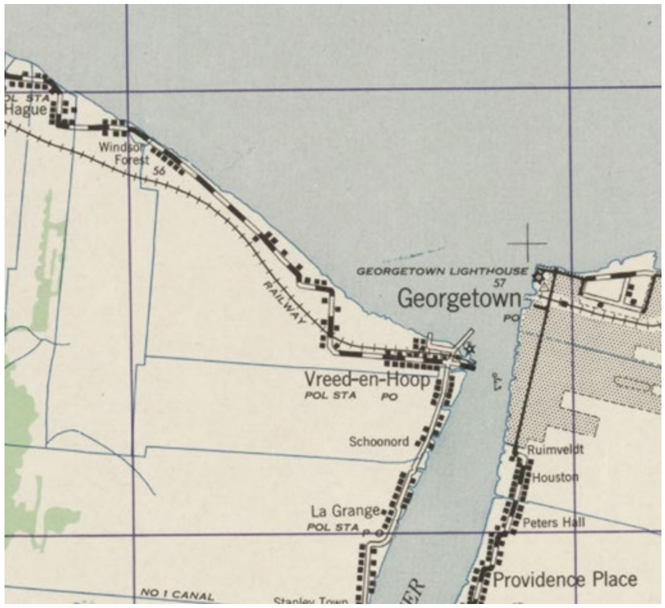
Crane Village is located to the north of Vreed-en-Hoop and extends approximately 0.8 kilometer to the shore. The surrounding area is a mixture of rural and residential, with the Atlantic Ocean to the north, cultivated agricultural fields to the west and south, and residential and commercial development to the east and southeast. The onshore pipeline in this area will run from north to south, approximately 0.3 kilometer west of the residential community. The racial composition of the neighborhood includes Afro-Guyanese, Indo-Guyanese, Latin Americans, and Amerindians.

Crane Village is a residential community of approximately 10,000 inhabitants situated within the larger Vreed-en-Hoop Village, which includes several other smaller communities. Vreed-en-Hoop was named after the sugar cane plantation of the same name first seen on historical maps dating back to 1798 (University of Amsterdam Library 2022). The plantation was first owned by Erve J. Lespinasse, followed by Jonas Fileen from 1817 to 1826, and British politician and merchant Sir Jones Gladstone from 1828 until 1839. Vreed-en-Hoop was the site of pioneering experiments in sugar processing via vacuum pan technology by Thomas Dodson in 1832. The technology was subsequently passed rapidly through the wider Caribbean sugar economy (Ortega 2014). Data collected from slave registers show that 472 enslaved people worked at Vreed-en-Hoop in 1832 (UCL 2022a). Gladstone divided and sold the estate when reports of the working conditions on the plantation, years after the Slavery Abolition Act of 1833, were published in Britain (Beckert and Desan 2018).

The residential community was officially established in 1978; however, it is believed to have been in existence since the late 1800s or early 1900s, at the time when the Vreed-en-Hoop and other plantations in the area were operating (Figures 9.5-3 and 9.5-4). The neighborhood developed in two phases. Phase I is located closer to the main road, and was built by the residents themselves, who took turns building each other’s houses. Phase II is located in the northern half of the neighborhood and was built in 1992 as a residential development (housing scheme) for military families (Dhanraj 2017). Phase II introduced an almost grid-like pattern in the neighborhood defined by internal streets, while Phase I was an open area upon which residences were built. The built environment within the community includes large, mid-sized, and modest residences; a primary school; a nursery school; a large playfield; a youth center building; a mosque; three churches and a mandir.[30]

The Consultants observed three types of historic dwellings within Crane Village: colonial family houses; one-room buildings; and mid-century, pre-independence family houses. Examples of the historic dwellings observed within Crane Village can be found in Appendix R, Cultural Heritage Photolog.

[30] Hindu temple



Source: Army Map Service 1944

Figure 9.5-3: Detail View of a 1943 Topographic Map Depicting Vreed-en-Hoop Village, Main Roads, and Railway

Source: Google Earth 2022

Figure 9.5-4: Crane Village and Vreed-en-Hoop

La Parfaite Harmonie is located on the West Demerara Bank, approximately 3 kilometers from the Demerara River and extends 2.3 kilometers to the west. The residential neighborhood is laid in a grid defined by internal streets, and is situated between Canal 1 to the south and an unnamed smaller canal to the north. The neighborhood was built on four abandoned plantations running parallel to each other: La Parfaite Harmonie, Westminster, Onderneeming, and Recht-door-Zee. The surrounding areas consist of cultivated and abandoned agricultural fields in all cardinal directions.

La Parfaite Harmonie takes its name after a plantation originally owned by John Daly. The estate is first shown on a historic map dating back to 1798 under Plantation Number 1 (University of Amsterdam Library 2022). Daly transferred the plantation to his children, Thomas and Anne De Saint Felix in 1826. Data collected from slave registers show that 101 enslaved people worked at this plantation in 1826 and 89 in 1832 (UCL 2022a and 2022b).

The residential neighborhood first developed in the southern portion circa 2002 and rapidly expanded north as one of the largest housing schemes in the country. Dwellings in this neighborhood were built after 2002, and thus are not considered historic under the Guyana National Trust guidance (Figure 9.5-5).

Source: Google Earth 2022

Figure 9.5-5: La Parfaite Harmonie Location in 2002 before the Housing Scheme (Left) and in 2021 after the Housing Scheme (Right)

Nismes is located on the West Demerara Bank. It is bordered by the Demerara River to the east, Canal 1 Polder neighborhood to the north, and Canal 2 Polder neighborhood to the south, and extends about 11 kilometers west to Vauxhall Canal. Residential development within Nismes is concentrated along the canals and near the Demerara River along Old Road, while the interior consists of forested areas and agricultural fields with a limited number of access dirt roads. The onshore pipeline in this area will run 3.8 kilometers from north to south within Nismes, at a distance of approximately 4.7 kilometers west of the Demerara River, along an existing irrigation trench. The neighborhood has a population of approximately 1,500 habitants, who are predominantly Afro-Guyanese.

Like most of the villages on the West Bank, Nismes takes its name from a sugar plantation of the same name. The plantation was operating in the early 20th century, but apparently became uneconomical to manage due to its limited size, and ceased sugar production. Nismes contains a significant amount of “backlands” between Canal 1 Polder and Canal 2 Polder. These lands were used to produce coffee, sugar, fruits, citruses, root vegetables, and grains in the 1960s and 1970s (Clarke 2012). Several pedestrian and vehicular bridges are located along the canals, and these were used by the residents to access the fields.

The onshore pipeline corridor will potentially be in the line-of-sight of several structures at the intersection of the corridor with Canal 1. An historic bridge located 81 meters east of the corridor and a cluster of historic structures, in fair condition approximately 341 to 420 meters east of the corridor, were identified within the Indirect APE (Table 9.5-3). Photographs of the resources can be found in Appendix R, Cultural Heritage Photolog.

Table 9.5-3: Historic Structures within APE at Nismes—Canal 1

Resource Type Description	Latitude /Longitude	Distance and Bearing from Onshore Pipeline	Photographs
Bridge	6°45'53.34"N/ 58°14'30.59"W	81 meters east	10
One-Room Building	6°45'51.12"N/ 58°14'19.66"W	420 meters east	5
One-Room Building	6°45'51.01"N/ 58°14'20.06"W	409 meters east	7
Bungalow	6°45'51.11"N/ 58°14'20.41"W	398 meters east	6
One-Room Building	6°45'51.38"N/ 58°14'21.14"W	374 meters east	8
One-Room Building	6°45'51.43"N/ 58°14'22.23"W	341 meters east	9

Pipeline construction activities will also potentially be in line-of-sight of structures at the intersection with Canal 2. Several historic structures, in fair condition, were identified within the Indirect APE in this area (Table 9.5-4). Photographs of the resources can be found in Appendix R, Cultural Heritage Photolog.

Table 9.5-4: Historic Structures within APE at Nismes—Canal 2

Resource Type Description	Latitude/Longitude	Distance and Bearing from Project	Photographs
Mid-size dwelling with additions	6°43'48.95"N/ 58°14'47.79"W	85 meters east	11
Mid-size dwelling with additions	6°43'48.95"N/ 58°14'47.21"W	97 meters east	11,12

The dominant architectural form in villages on the West Bank of the Demerara River is vernacular wood dwellings on stilts. For centuries, wood was the main material used for construction in Georgetown and the surrounding area, due to it being a local material that was easily accessible and inexpensive. This is no longer the case today, and new construction usually uses concrete and cement blocks. The residential dwellings in the area range from smaller, make-shift structures, to mid-size residences. There are few examples of larger homes. This architectural form (vernacular wood dwellings on stilts) is a symbol of Guyanese domestic architecture and ties in with its distinctive Caribbean and European influence, which is unique to

Guyana in South America, the only English-speaking South American country. The influence of the Dutch, Spanish, French, and British on the architecture of Guyana is apparent in the civic, public, and other government buildings in Georgetown, as well as in the domestic architecture of the area.

Georgetown is situated at 2 meters below sea level, so flooding is frequent, hence the necessity for dwellings to be raised to a minimum of 2 meters. The city uses a system of seawalls, dams, canals, trenches, and kokers to control the water level. Stilt and pier foundations are preferred and more suitable than continuous foundations due to the coastal plains' alluvial soils. This design prioritizes ventilation and creates a dry and shaded outdoor space adequate for the tropical climate of Guyana.

A stilted dwelling's lower level is typically used for domestic chores and shelter for animals, and might also include an outdoor shower and toilet. Some dwellings feature multi-purpose mud stove/ovens, which are used for cooking. A staircase leads to the upper level's living quarters, either on the short side of the dwelling, or running parallel to the façade. The stairs are either straight flights or have intermediate landings, and might be covered with metal shed roofs or uncovered. Roof types include front-gabled and side-gabled roofs made of corrugated metal or standing seam metal panels. Some are steeply pitched for rainwater run-off and might feature some decorative elements such as finials on the roof ridge at each gable end or Victorian-esque cornice detailing. The walls are typically enclosed with ship-lap wood board siding.

Fenestration is an important functional feature and decorative element in Guyanese vernacular architecture. Windows on the dwellings include jalousie windows, wooden shutters, French windows, and paned, double-hung, Georgian sash windows. Demerara windows are popular in the surrounding area and are a key indicator of age. They are a sloping, top-hung shutter developed in the country's colonial era, and are ideal for the tropical climate. However, these windows are mostly featured in larger buildings in downtown Georgetown and not in the residential areas in the immediate vicinity of the Project. Instead, domestic dwellings of middle-class residences in the vicinity of the Project feature full-length galleries with glass or wooden slatted jalousie windows and paned wooden frame windows. Later additions and enclosures are common and clearly visible through the difference in material and/or fenestration. Further modifications include raising the structure by an extra few meters and the replacement of the original wooden stilts with cement blocks.

9.5.2.5. Underwater Cultural Heritage

Aside from geophysical surveys conducted by EEPGL in support of its prior offshore projects, no underwater cultural heritage surveys are known to have been undertaken within the vicinity of the offshore portion of the Direct AOI. Accordingly, the assessment of existing underwater cultural heritage is based on a review of relevant prior EEPGL-sanctioned studies. Specifically, the Consultants reviewed results for the following geophysical surveys conducted in support of EEPGL's prior offshore projects, all of which are in the vicinity of the offshore Direct AOI:

- 2016 Environmental Baseline Survey Report, conducted by Fugro for the Liza Development area (Fugro 2016), overlapping with the PDAs for Liza Phase 1 Development Project and

Liza Phase 2 Development Project (both of which overlap the seaward extent of the offshore pipeline); and

- 2020 Geophysical Route Survey, conducted by International Telecom for the Fiber Optic Cable Project (the cable corridor of which overlaps a significant portion of the offshore pipeline's corridor from the Stabroek Block to the shore landing).

2016 Liza Development Area Survey

In 2016, EEPGL retained Fugro Marine Geoservices, Inc. (Fugro) to conduct a geophysical and remote sensing survey of the seafloor within the Liza Phase 1 PDA to identify the occurrence of any potential cultural resources that had the potential to impact or be impacted by the placement of planned subsea equipment for the Liza Phase 1 Development Project (Fugro 2016).

Remote sensing surveys employ various instruments that use high and/or low frequency sound waves to collect information from the seafloor. This survey used several of these including:

- Multi-beam echo sounders, which collect bathymetric data via a wide band of high-frequency sound waves and can detect abnormal shapes (which could potentially include objects of cultural interest) against the surrounding landscape (both automated underwater vehicle [AUV] mounted and hull-mounted instruments were used);
- Side-scan sonars (SSS), which employ high-frequency sound waves to collect textural data from the seafloor and provide high resolution images of objects on the seafloor surface (AUV-mounted instrument was used); and
- Sub-bottom profilers, which collect data on subsurface sediments and objects beneath the seafloor via low frequency sound waves that are capable of locating buried shipwrecks beneath the seafloor surface (both AUV-mounted and hull-mounted instruments were used).

The model types of the remote sensing instruments used and the settings employed for each instrument are provided in Table 9.5-5. The survey was divided into three areas: the Main AUV Survey Area; the Upper Slope and Outer Shelf Reconnaissance Area (USOS Survey Area); and the Skipjack Survey Area. These are shown on Figure 9.5-6.

Table 9.5-5: 2016 Liza Development Geophysical Survey Remote Sensing Instruments and Survey Settings

Type of Instrument	Model	Survey Settings	Hull- or AUV-Mounted	Survey Areas in which Equipment was Used
Multi-beam echo sounders	Kongsberg EM2040 bathymetric system	Frequency of 200 kHz swath coverage of 150 degrees	AUV-mounted	• Main AUV Survey Area • USOS Survey Area (where possible) • Skipjack Survey Area
	Kongsberg EM302 bathymetric system	Frequency of 30 kHz	Hull-mounted	• USOS Survey Area
SSS	EdgeTech model 2200 full-spectrum system	Dual frequencies of 105 kHz and 410 kHz	AUV-mounted	• Main AUV Survey Area • USOS Survey Area (where possible) • Skipjack Survey Area
Sub-bottom profilers	EdgeTech model DW-106 full spectrum system	Frequency range of 1 kHz to 10 kHz	AUV-mounted	• Main AUV Survey Area • USOS Survey Area (where possible) • Skipjack Survey Area
	EdgeTech 3300 full spectrum system	Frequency range of 1 kHz to 10 kHz	Hull-mounted	• USOS Survey Area
Underwater Digital Camera	Prosilica Allied Vision GE4000	35 millimeter digital imagery, approximately 8 meters (approximately 26 feet) above seafloor	AUV-mounted	• As needed for ground-truthing in all survey areas

kHz = kilohertz

The Consultants assessed Fugro's remote sensing survey methodology, including the remote sensing equipment and instrument settings employed and the results produced, according to internationally recognized standards. The Consultants found that the methods used by Fugro and the survey results are sufficient to provide existing cultural heritage data for the area of potential impact, as the methodology and quality of data produced met the guidelines and requirements for nearshore and offshore remote sensing cultural surveys as defined by the U.S. Bureau of Ocean Energy Management and Historic England. Together, these guidelines help frame "internationally recognized practices" for remote sensing surveys designed to locate and assess cultural heritage (BOEM 2017; Historic England 2013).

Within the Main AUV Survey Area (which overlaps with the northern extent of the offshore pipeline), the low-frequency and high-frequency SSS survey identified 73 sonar contacts (designated UD01 through UD073); these were assessed further as potential marine hazards and/or cultural resources.

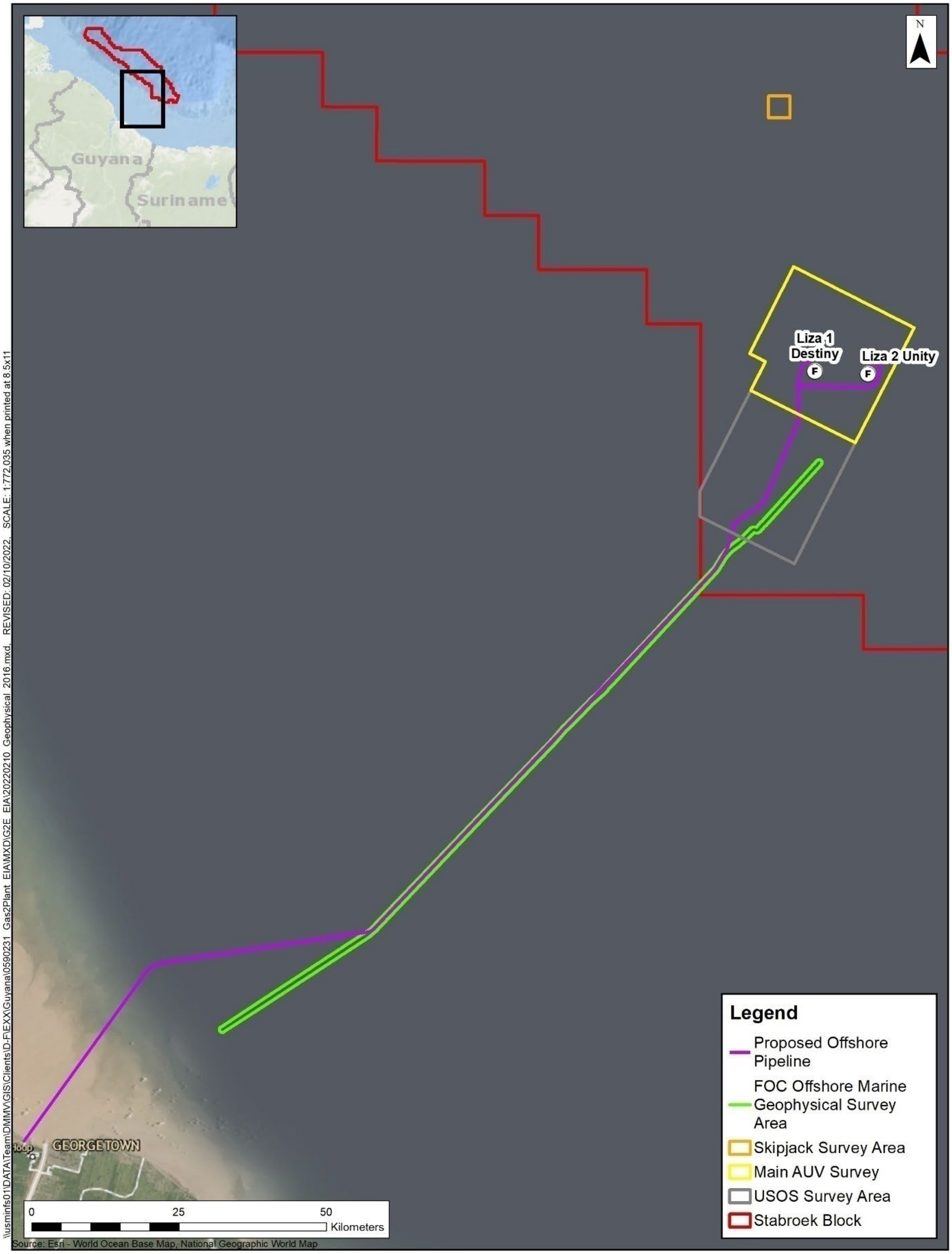
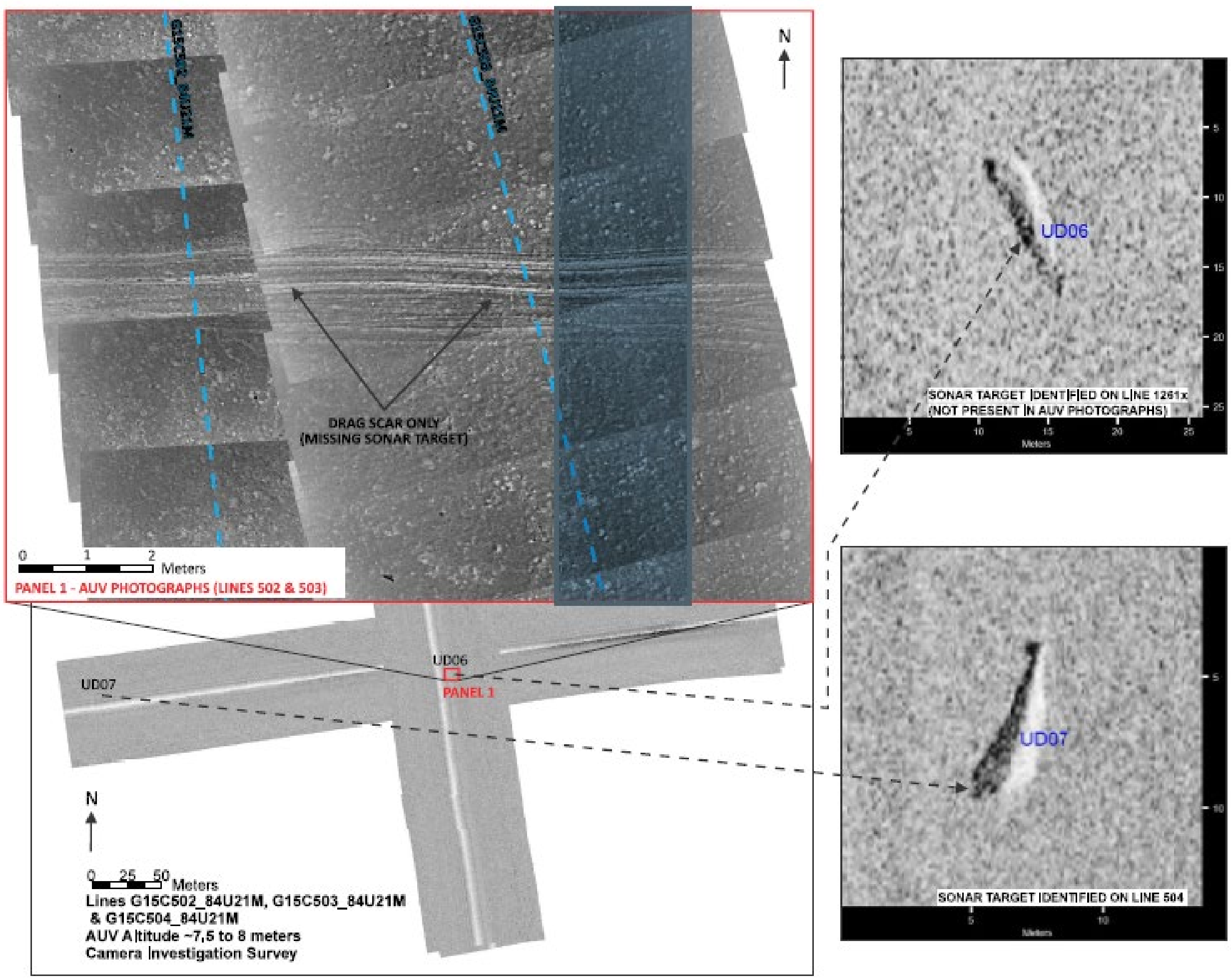


Figure 9.5-6: Extents of Prior Geophysical Surveys in Vicinity of Offshore Direct AOI

One contact (UD06) was initially considered to be a possible vessel and thus was subjected to follow-up surveys using high-frequency SSS and digital photography. During this second inspection, however, UD06 could not be located, although the seafloor at its previously recorded location showed signs of the object having moved downslope (drag scars). A follow-up survey identified contact UD07, which was interpreted as being the same contact (see Figure 9.5-7). This indicates that the object is not culturally sensitive because, even if it were a cultural resource, it no longer maintains its original context (greatly diminishing its potential research value).



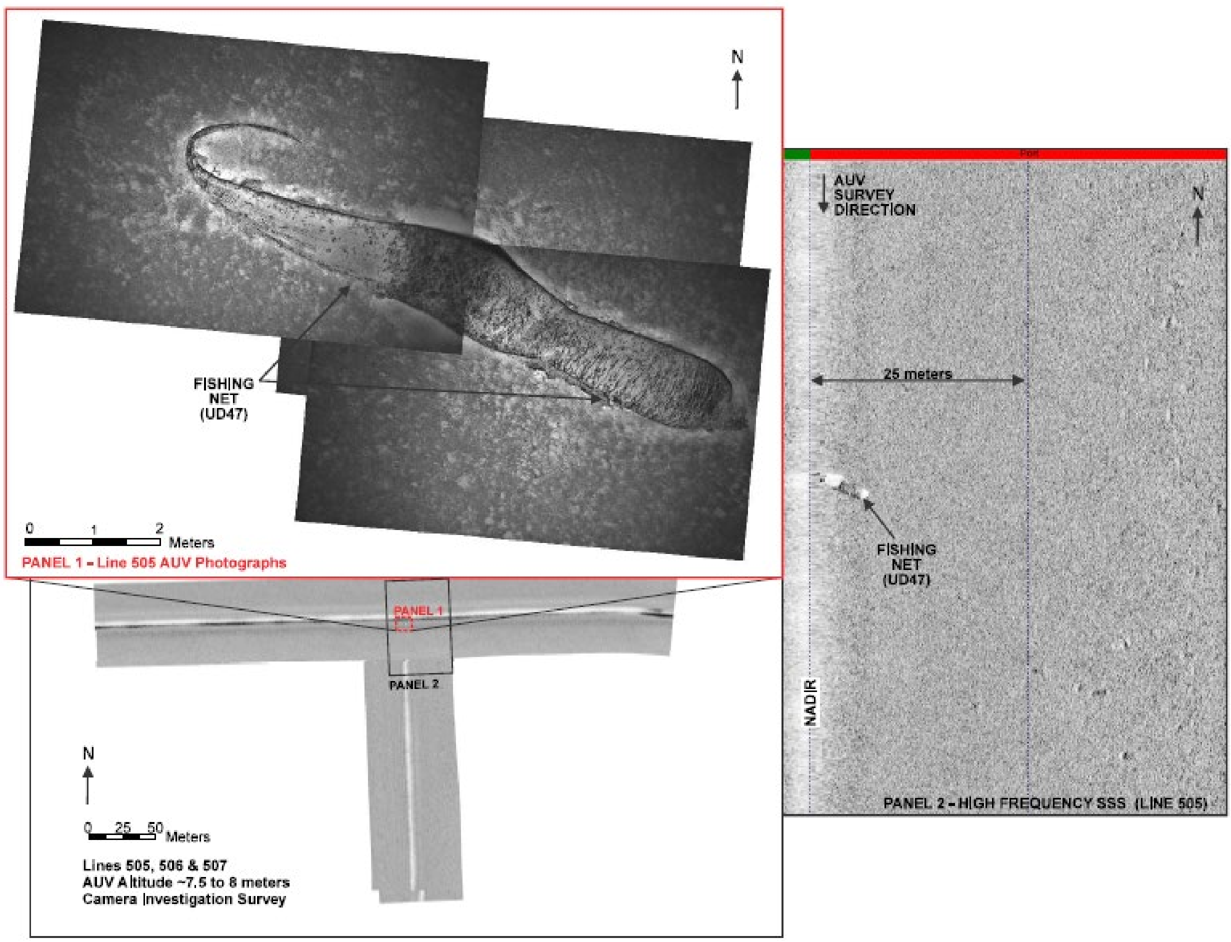
Source: Fugro 2016

Figure 9.5-7: AUV High-Frequency SSS Data and Photographs Showing Interpreted Movement of Sonar Contact UD06 (UD07 Presumed to be New Position of Same Contact)

Contact UD047 was also initially considered to be a potential vessel, but upon second inspection was identified as likely being a fishing net (see Figure 9.5-8). The remaining 71 contacts in the Main AUV Survey Area were judged to be geologic features (e.g., rock clusters or formations) or manmade debris (e.g., debris associated with previous well development projects or cable-laying efforts) of no significant cultural value. Figure 9.5-9 shows examples of modern debris from three of the contacts (UD08, UD011, and UD021), such as discarded chain or cable coils.

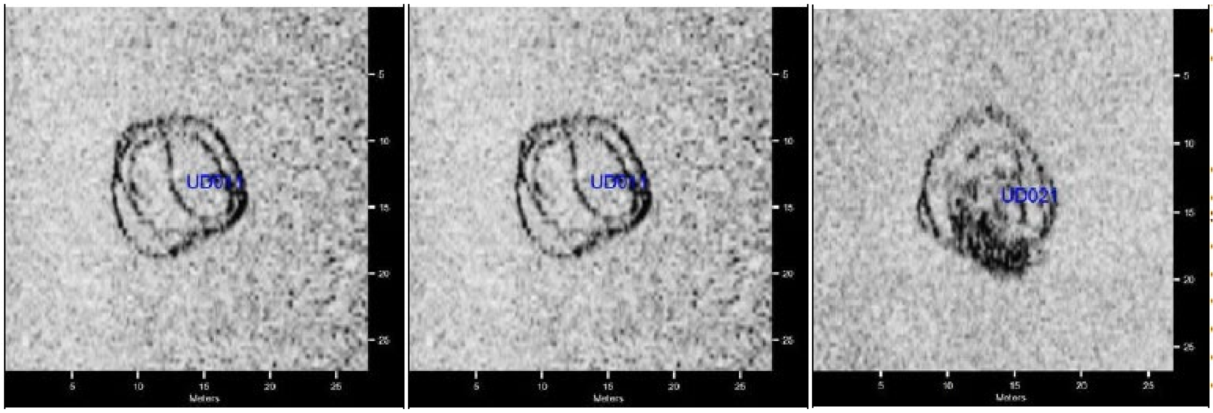
After reviewing the SSS imagery and data collected, the Consultants concluded that the 73 SSS contacts are likely modern debris, fishing nets, chain or cable coils, or geological features of no significant cultural value.

Additionally, an unidentified subsea cable has been mapped across the Liza Development area (see Figure 9.5-10). With respect to cultural heritage, the subsea cable does not have any cultural significance.



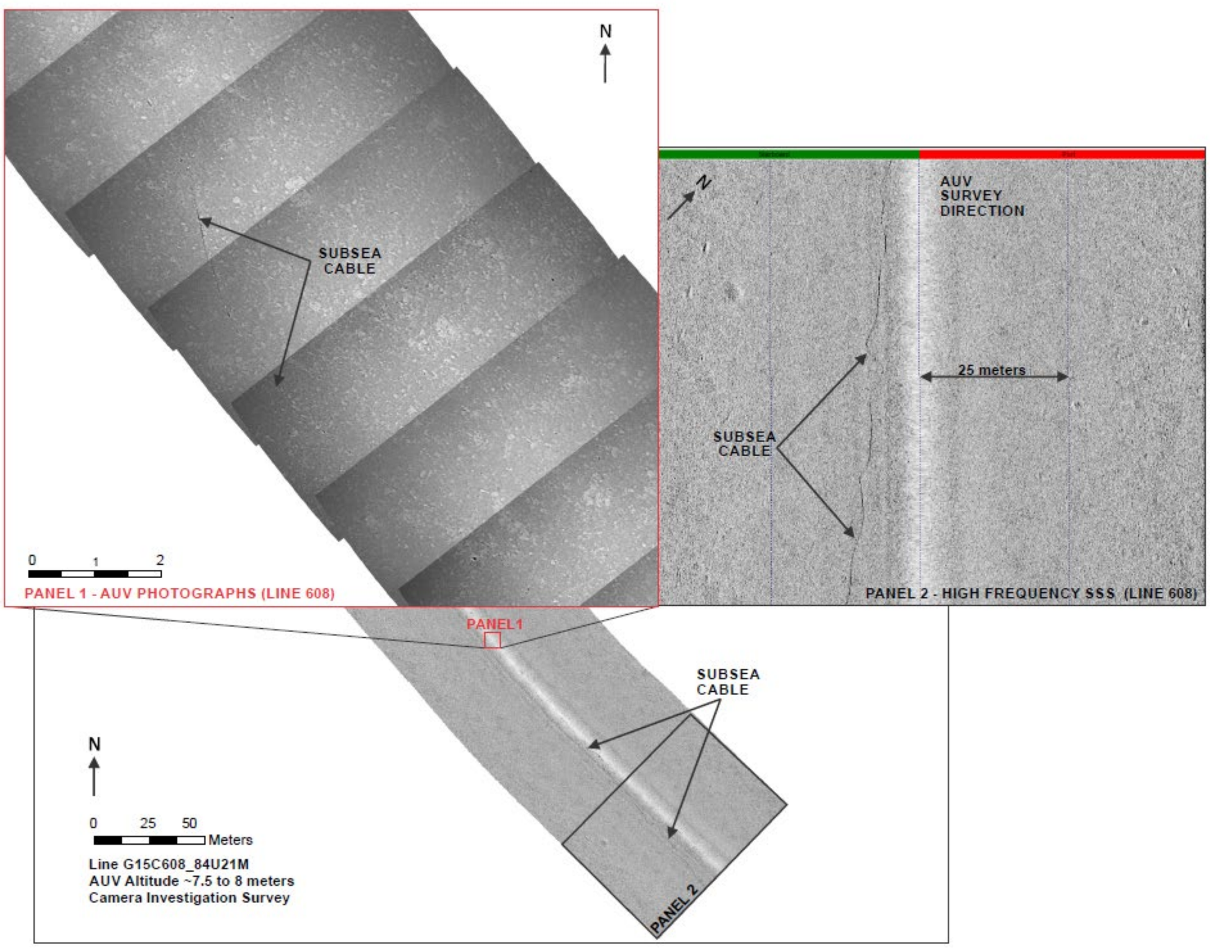
Source: Fugro 2016

Figure 9.5-8: AUV High-Frequency SSS Data and Photograph Showing Sonar Contact UD047 and Corresponding Photograph of Fishing Net



Source: Fugro 2016

Figure 9.5-9: SSS Contacts UD08, UD011, and UD021 Found within the Main AUV Survey Area



Source: Fugro 2016

Figure 9.5-10: AUV High-Frequency SSS Data and Photographs Showing Unidentified Subsea Cable

Remote-sensing efforts in the USOS Survey Area revealed no discernable objects, either geological or manmade in origin, and thus Fugro concluded that there are no cultural concerns for the USOS Survey Area. The Consultants concur with this conclusion.

2020 Geophysical / Routing Study for Fiber Optic Cable Project

A geophysical survey was conducted in early 2020 to gather field data to finalize the route for EEPGL's proposed Fiber Optic Cable Project (Stantec 2020). The width of the survey corridor was 500 meters in shallow depths (15-meter to 1,000-meter water depth) and 2 to 3 times water depth in deeper depths (>1,000 meters), centered on the preliminary proposed cable route (Figure 9.5-6). Equipment used and data collected included:

- Multi-beam echo sounders with GPS to obtain bathymetric data along the proposed route
- SSS to visualize the seabed
- Sub-bottom profiler to visualize soil layers beneath seabed
- Ultra-short baseline acoustic positioning system for towfish tracking
- Magnetometer to determine the locations of in-service cables and other seabed infrastructure
- Seabed sampling equipment

No seabed debris or shipwrecks were identified along the survey route, and no submarine cable crossings were encountered. Seabed scars attributed to trawl fishing were encountered at the beginning of the shallow water sections of the survey. The scars were up to 1 m in depth. Pockmarks were also observed, and some were assumed to be caused by fishing gear making contact with the seabed (International Telecom 2020).

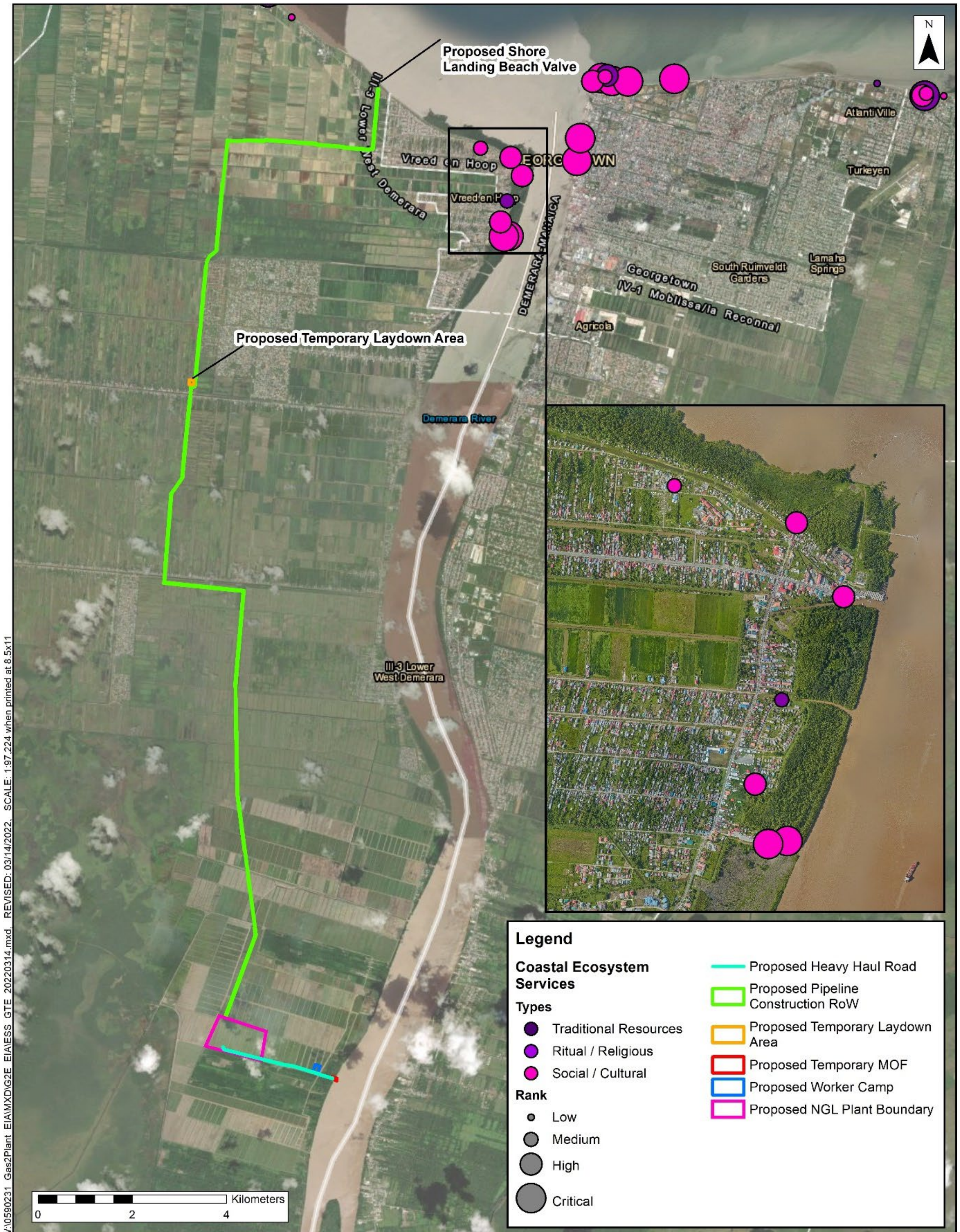
9.5.2.6. Coastal Cultural Heritage

Data obtained from the National Trust of Guyana in 2019 provided records of approximately 136 heritage sites in Georgetown, comprising monuments, public buildings, schools, gardens, places of worship, and markets, among others (National Trust of Guyana 2019, pers. comm.). There were no new additions to the cultural sites list in 2020 or 2021 (National Trust of Guyana 2021, pers. comm.). Several archaeological sites have been identified along the Guyana coast, including shell mounds, seashell deposits, quarries, pollen sections, tool/implements, and ceramic/pottery sites (i.e., scatters) as shown in Table 9.5-6 (National Trust of Guyana 2019, pers. comm.). These sites are of significant cultural value to both the people of Guyana and researchers, as they offer insight into the material culture of Indigenous Peoples inhabiting the land before, during, and after contact with Europeans. However, only two of the ceramic/pottery sites on the maps are shown to be located near the shoreline.

Table 9.5-6: Archaeological Sites on the Guyana Coast

Region	Number of Sites	Type of Sites
1	68	Shell mounds, seashell deposits, ceramics, tools/implements, quarries
2	12	Shell mounds, ceramics
3	5	Ceramics
4	17	Ceramics, shell mounds, pollen sections
5	13	Ceramics
6	21	Ceramics, pollen sections, petroglyphs

As part of the late 2017 and early 2018 ecosystem services engagement fieldwork by members of the Consultants team, coastal communities from Regions 1 through 6 were engaged about known archeological sites as well as any locations of ecosystem services with cultural significance to each community (e.g., Hindu prayer flag locations, burial and cremation sites). In 2019, members of the Consultants team reengaged members in the same communities to validate the ecosystem services data collected in 2017 and 2018. Figure 9.5-11 shows an excerpt from the coastal ecosystem services map prepared based on the 2019 validation exercise, showing the locations of identified cultural coastal ecosystem services in the vicinity of the Project footprint (the nearest of which is approximately 2 kilometers away). These sites include those classified as “ritual/religious” and “social/cultural,” both of which are categorized under the “cultural” category of ecosystem services.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 9.5-11: Cultural Coastal Ecosystem Services Identified in 2019 the Vicinity of the Project Footprint

9.5.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on cultural heritage. The relevant planned Project activities and the associated potential impacts of these activities on cultural heritage are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.5.3.1. Relevant Project Activities and Potential Impacts

Planned offshore Project activities that have the potential to adversely impact underwater cultural heritage located on or beneath the seafloor include the installation of the offshore pipeline and associated subsea components (e.g., PLETs).

Planned onshore Project activities that have the potential to adversely impact terrestrial cultural heritage include ground disturbance associated with the construction of the onshore pipeline, the NGL Plant, and ancillary structures (e.g., temporary MOF, heavy haul road), and the presence of aboveground Project components during the Operations stage (i.e., with respect to viewshed impacts that could affect historic structures). There would be no anticipated additional cultural heritage impacts during the Decommissioning stage, as any resources that could be impacted during the Decommissioning stage would—if present in the Project footprint—already have been disturbed during the Construction or Operations stages.

Table 9.5-7 summarizes the planned Project activities that could result in potential impacts on cultural heritage.

Table 9.5-7: Summary of Relevant Project Activities and Potential Key Impacts—Cultural Heritage

Stage	Project Activity	Key Potential Impact
Construction	Installation of the offshore and onshore pipeline; construction of the NGL Plant, heavy haul road, and temporary MOF	• Damage to underwater cultural heritage sites (if present). • Damage to terrestrial tangible (archaeological) cultural heritage sites (if present). • Damage to intangible cultural heritage. • Change in viewsheds associated with historic structures.
Operations	Presence of aboveground Project features (NGL Plant)	• Change in viewsheds associated with historic structures.

9.5.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2 Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for cultural heritage (see Table 9.5-8). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for cultural heritage sensitivity are provided in Table 9.5-9.

As described above, cultural heritage includes a combination of tangible and intangible resources. For the purpose of assessing the significance of potential impacts on cultural heritage, separate discussions are provided for the following cultural heritage components, with the assessment focusing on the specific potential impacts that are relevant to each of these four cultural heritage types:

- Underwater Cultural Heritage
- Terrestrial Tangible (Archaeological) Cultural Heritage
- Intangible Cultural Heritage
- Historic Structures

Table 9.5-8: Definitions for Intensity Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Intensity	**Negligible**: No discernible change in the physical condition, setting, or accessibility of cultural heritage sites.
	Low: A small part of a cultural heritage site is lost or damaged, resulting in a loss of scientific or cultural value; setting undergoes temporary or permanent change that has limited impact on the site’s perceived value to stakeholders; stakeholder access to the site is temporarily impeded.
	Medium: A significant portion of a cultural heritage site is lost or damaged, resulting in a loss of scientific value; setting undergoes permanent change that permanently diminishes the site’s perceived value to stakeholders; site become inaccessible for the life of the Project to stakeholders.
	High: Entire cultural heritage site is damaged or lost, resulting in a nearly complete or complete loss of scientific or cultural value; setting is sufficiently impacted to cause the site to lose all, or nearly all, cultural value or functionality; site becomes permanently inaccessible to stakeholders.

Table 9.5-9: Definitions for Resource Sensitivity Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Sensitivity	**Low**: Site is not specifically protected under local, national, or international laws or treaties; site can be moved to another location or replaced by a similar site, or is of a type that is common in surrounding region; site has limited or no cultural value to local, national, or international stakeholders and/or site has limited scientific value or similar information can be obtained at numerous sites.
	Medium: Site is specifically or generally protected by local or national laws, but laws allow for mitigated impacts; site can be moved or replaced, or data and artifacts recovered in consultation with stakeholders; site has considerable cultural value for local and/or national stakeholders and/or site has substantial scientific value but similar information can be obtained at a limited number of other sites.
	High: Site is protected by local, national, and international laws or treaties; site cannot be moved or replaced without major loss of cultural value; legal status specifically prohibits direct impacts or encroachment on site and/or protection zone; site has substantial value to local, national, and international stakeholders and/or site has exceptional scientific value and similar site types are rare or non-existent.

9.5.3.3. Impact Magnitude Ratings—Cultural Heritage

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to cultural heritage is provided in Tables 9.5-10 through 9.5-13.

Underwater Cultural Heritage

Based on the geophysical surveys described above, no underwater cultural heritage features that could be impacted by the Project have been identified, meaning that the anticipated intensity of potential impacts on underwater cultural heritage is **Negligible**. While there is a portion of the offshore pipeline RoW for which geophysical survey is ongoing as of the writing of this EIA (see Figure 9.5-5), this survey will be completed prior to initiation of offshore pipeline installation. It is possible that cultural heritage resources could be identified during this survey. Further, it is possible that cultural remains not identified during the geophysical survey could be encountered during offshore pipeline installation (these are referred to as “chance finds”). These could include, but are not limited to, shipwrecks or associated artifact scatters. It is conservatively assumed that the intensity of impact on a previously unidentified underwater cultural heritage resource could be as high as **Medium** if seabed-disturbing activities took place in the location of such a resource. If this were to occur, and depending upon the Project stage, the Project would most likely relocate the subsea infrastructure to the extent practicable.

If the resource could not be avoided, any disturbance to underwater cultural heritage resource as a result of Project activities would have a **Long-term** duration. On the basis that a cultural heritage resource that could not be avoided would be lost permanently, the impact frequency is considered **Continuous**. Considering the information presented above, the anticipated magnitude of potential impacts on underwater cultural heritage is **Negligible** (on the assumption that geophysical survey will identify no cultural resources in the disturbance area, any such resources could be avoided if they are identified, and no chance finds are encountered). However, considering the possibility an as-of-yet unidentified cultural heritage site is identified within the Project disturbance area and cannot be avoided, the magnitude rating could be as high as **Medium**. These potential impacts would be limited to the Construction stage, as seabed areas would be disturbed during the Operations stage, and any seabed areas disturbed during Decommissioning would already have been disturbed during the Construction stage.

Terrestrial Tangible (Archaeological) Cultural Heritage

As discussed above, the entirety of the terrestrial portion of the Project construction footprint is an historic landscape composed of archaeosediments. While portions of these landscapes have their foundations as far back as colonial Dutch rule, most of these deposits have been continuously disturbed through routine canal and mud dam maintenance, agricultural activities, or modern housing and infrastructure development. Accordingly, undisturbed terrestrial archaeological deposits that date back to the precolonial periods have a very limited potential to exist anywhere within the proposed Project construction footprint, and no significant archaeological sites were encountered within the areas surveyed during the course of the field investigation.

One prehistoric site, Recht-door-Zee, has been identified approximately 2.5 kilometers from the proposed onshore pipeline corridor, but the area in which ground disturbance will occur during the Construction stage does not cross the site's known boundaries.

One low-density historic ceramic sherd scatter (designated as HS-KM-01) (10 individual artifacts identified) was identified adjacent to the proposed heavy haul road, dispersed across the surface of an existing access road. These sherds were generally isolated and widely spaced apart, and appear to have been derived from colonial period activities. However, the presence of laterite in the road, a material not local to the region, indicates that the road had been modified using imported material, and the associated sherds were therefore likely redeposited from somewhere else. As such, it is unlikely an undisturbed archaeological deposit in the area is associated with these artifacts and thus it is likely the site holds little to no significant research potential.

An additional site (designated as HS-KM-02) was identified along the mudflats of the Demerara River during low tide. This site is associated with the Dutch colonial period and consists of eroding bricks from a possible modified canal wall, historic jar and bottle fragments that date to roughly the seventeenth or eighteenth century, and a possible foundation within the jungle setting behind the possible modified canal wall. Although this site is not within the Direct AOI, as it lies approximately 650 meters to the north of the area to be disturbed as part of the temporary MOF construction, it is worth noting as the kind of site or intact archaeological deposit that may be encountered as a chance find during temporary MOF construction. As the Project is currently designed, the site will not be impacted by Project activities.

On the basis that no terrestrial cultural heritage features that could be impacted by the Project have been identified, the anticipated intensity of potential impacts on terrestrial cultural heritage is **Negligible**. However, because there are portions of the onshore pipeline RoW for which field-based surveys could not be completed (see Figure 9.5-1), it is possible that chance finds could be encountered during onshore construction activities. It is conservatively assumed that the intensity of impact on a previously unidentified terrestrial cultural heritage resource could be as high as **Medium** if ground disturbance activities took place in the location of such a resource. If this were to occur, a cultural heritage specialist would need to analyze the resource, delineate the cultural heritage site, and, depending on the cultural heritage specialist's assessment of the significance of the site, potentially excavate the portion of the ground disturbance area prior to further disturbance as a means of recovering and preserving the data that would otherwise be lost.

If the resource could not be avoided, any disturbance to a terrestrial cultural heritage resource as a result of Project activities would have a **Long-term** duration. On the basis that a cultural heritage resources that could not be avoided would be lost permanently, the impact frequency is considered **Continuous**. Considering the information presented above, the anticipated magnitude of potential impacts on terrestrial cultural heritage is **Negligible** (on the assumption that no chance finds will occur and/or any chance finds could be avoided if they are identified). However, considering the possibility an as-of-yet unidentified terrestrial cultural heritage site is identified within the Project disturbance area and cannot be avoided, the magnitude rating could be as high as **Medium**. These potential impacts would be limited to the Construction stage, as any areas disturbed during either the Operations or Decommissioning stages would already have been disturbed during the Construction stage.

Intangible Cultural Heritage

Intangible cultural heritage is often difficult to see on the physical landscape, as it typically comprises cultural elements that have no physical presence (e.g., oral histories, traditional skillsets). Occasionally, however, tangible cultural elements are the physical embodiment of intangible cultural elements. Such is the case with silk cotton trees in Guyana. Strong spiritual beliefs are associated with these trees and they are an important part of the cultural landscape.

Three silk cotton trees were identified during the field survey as being located along the proposed onshore pipeline corridor. All of these trees are located near the Cogland Dam portion of the pipeline. The first tree (designated as C1) is located adjacent to survey KP 4.1 along the edge of a farm road on the north side of the canal. This tree is located at the approximate edge of the temporary construction RoW (as well as the permanent RoW), and thus would be impacted by Project construction activities if the pipeline is installed using open trenching at this location. The second tree (designated as C2) is approximately 400 meters to the west of C1, and is situated roughly 50 meters north of the edge of the permanent RoW at survey KP 4.5. Potential Construction stage impacts to C2 will be avoided, because of the distance of this tree from the permanent RoW. The third tree (designated as C3) is located within the proposed permanent RoW, approximately 750 meters south of C2 at survey KP 5.4. As with C2, potential Construction stage impacts to C3 will be avoided because this segment of the pipeline will be installed by HDD, and because EEPGL has committed to preserving this tree rather than removing it (as would normally be done for large woody vegetation in the permanent RoW).

These three trees, though not confirmed to be archaeological in nature, are tangible markers of intangible cultural heritage, important to local oral traditions associated with local residents. Little is written about these beliefs or the practices associated with them, but the connections to Dutch Colonial rule and spiritual beliefs make these trees and their associated context in the cultural landscape significant. The intensity of impact to these trees could be **High** if they are disturbed by Project construction activities (i.e., either through removal or damage during open trenching or removal from the permanent RoW for HDD segments). If the trees are avoided by the Project (e.g., through use of HDD vs open trenching and through avoiding removal of the trees from the permanent RoW), the intensity of impact will be **Low,** on the basis that the resources would not be impacted, but access to the resources could be temporarily limited during the Construction stage.

Any limitation to access of the trees would be **Continuous** during the time period when construction is active in the vicinity of each tree; these time periods will be well less than a year (but possibly more than a week) in duration in each instance, yielding a duration no more than **Medium-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact is rated as **Small** on the basis that the two trees within the pipeline RoW (C1 and C3) can be avoided through the use of HDD vs. open trenching (which has been identified as an embedded control below) and through avoiding removal of the trees from the permanent RoW. The potential impacts will be limited to the Construction stage, as any disturbance of the trees will occur during the Construction stage, and—based on the commitment to avoid removal of the trees as part of Operations stage maintenance—no additional disturbance will occur during the Operations and Decommissioning stages.

Alternatively, if C1 cannot be avoided via HDD, the tree would be destroyed and removed during the Construction stage. As the tree would be permanently removed under this scenario, this would be a **Continuous** and **Long-term** impact. The magnitude of this impact under this scenario would thus be **Large**.

Historic Structures

Three neighborhoods with potentially impacted historic structures were identified within the APE of the proposed onshore pipeline corridor: Crane Village, La Parfaite Harmonie, and Nismes. The onshore pipeline corridor will pass within approximately 0.3 kilometer of Crane Village; however, the pipeline construction activities will generally not be visible from the residential neighborhood due to the distance and presence of visual impediments within the viewshed of the residences. Although La Parfaite Harmonie neighborhood is located on a historic landscape associated with plantations that were active during British rule, the area has been heavily altered with the development of residential subdivisions from 2002 to the present; accordingly, the structures present in the neighborhood are not historically or architecturally significant.

The onshore pipeline corridor will pass within the boundaries of Nismes and will cross Canal 1 and Canal 2. Five residential structures of potential historical significance were identified at Canal 1 within the APE and two residential structures with potential historical significance were identified within the APE at Canal 2. The onshore pipeline corridor will be near the structures; however, it will not significantly impact the viewshed of these resources due to the distance from the structures, the presence of existing buildings, mature vegetation and other visual impediments, and the fact that the pipeline will be installed using HDD at these locations. One bridge structure at Canal 1 was identified within the corridor and falls within the direct APE of the Project. The Project will involve possible structural upgrade to the existing bridge or the construction and use of a temporary bridge during the Construction stage. The existing bridge structure is not confirmed to be historically significant and is a common example of such structures in the area. Many bridges of the same architectural quality can be found along Canal 1 and Canal 2, and around the West Bank area at large. As with the other structures, the pipeline will be installed using HDD at this location, so there will be no visual impact on the resource.

Considering the above information, the intensity of potential impacts to the referenced historic resources is considered to be **Negligible** during the Construction stage. The viewshed impact would be **Continuous** during the time period when construction is active in the vicinity of the historic structures, but these time periods would be less than a year in duration in each instance, yielding a duration no more than **Medium-term**.

During the Operations stage, the only Project features that will be visible will be those associated with the NGL Plant. No historic structures were identified within the APE of the NGL Plant site. Accordingly, the intensity of potential viewshed impacts on historic structures associated with the presence of Project facilities during the Operations stage is rated as Negligible. These Project facilities would be present on a **Continuous** basis for the full Project life cycle (**Long-term)**.

Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact is rated as **Negligible** for both the Construction and Operations stages. The potential impacts would be limited to the Construction stage, as there will be no visible Project components during the Operations stage, and the base case for the Decommissioning stage would not involve aboveground activities.

9.5.3.4. Sensitivity of Resource—Cultural Heritage

Based on the sensitivity rating definitions in Table 9.5-10, the resource sensitivity for cultural heritage is considered **Low** for the underwater cultural heritage, terrestrial tangible (archaeological) cultural heritage, and historic structures components, and **Medium** for the intangible cultural heritage component.

These ratings are based on the findings of the survey, but should the Project encounter chance finds during construction activities, the sensitivity ratings could be higher, depending on the nature of the encountered resource. Depending on the nature of the specific resources encountered, shipwrecks and/or submerged archaeological sites could be specifically protected by national laws such as Guyana's National Trust Act of 1972, or international conventions such as the 2001 United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage and could possess research and cultural value.

Terrestrial archaeological resources and historically or culturally significant structures are also protected under Guyana's National Trust Act of 1972. As such, any previously unidentified cultural resource could have a higher sensitivity rating.

9.5.3.5. Pre-mitigation Impact Significance—Cultural Heritage

Assuming implementation of the embedded controls listed in Tables 9.5-11 through 9.5-14, the intensity ratings for potential impacts on cultural heritage from planned Project activities range from **Negligible** to **Medium**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Medium.** Coupled with sensitivity ratings of **Low** (for the marine cultural heritage, terrestrial tangible (archaeological) cultural heritage, and historic structures components), and **Medium** (for the intangible cultural heritage component), the pre-mitigation impact significance for cultural heritage ranges from **Negligible** to **Minor**.

9.5.4. Impact Management and Monitoring Measures

9.5.4.1. Underwater Cultural Heritage

As discussed in Section 9.5-2, Existing Conditions—Cultural Heritage, most of the planned seabed disturbance area for the Project has been subjected to geophysical surveys to assess the presence of any underwater cultural heritage, and the as-of-yet unsurveyed portions of the disturbance area will be surveyed prior to initiation of seabed disturbance activities. On the assumption that any resources identified during the future survey activities will be avoided if they are identified, this increases the level of certainty that planned Project activities will not disturb significant underwater cultural heritage. However, the possibility of a chance find during offshore construction activities exists. For this reason, a Chance Find Procedure is recommended as a mitigation measure to be adopted and implemented by the Project during offshore construction activities, and this Chance Find Procedure is included in the Environmental and Socioeconomic Management and Monitoring Plan in Volume III of the EIA. In the event of a chance find, the Chance Find Procedure requires temporary cessation of Project activities, assessment of such a find by a cultural heritage specialist, and development of a treatment plan for significant chance finds in consultation with the National Trust of Guyana and other cultural heritage stakeholders, as appropriate.

Considering the implementation of the measures outlined in the Chance Find Procedure, the magnitude of the impact would be expected to be reduced to no more than **Small**, as activities would be adjusted/curtailed upon discovery of a previously unidentified cultural resource. This would reduce the residual impact significance rating to **Negligible**.

Table 9.5-10 summarizes the management and monitoring measures relevant to this component of cultural heritage.

Table 9.5-10: List of Management and Monitoring Measures—Underwater Cultural Heritage

Embedded Controls
Prior to initiation of seabed disturbance, conduct a seabed survey to assess the presence of potential underwater cultural heritage resources. If any potential cultural heritage resources are found, adjust the layout of Project features to avoid such resources or subject the resources to assessment by a cultural resources specialist and, as warranted, consult with the National Trust of Guyana prior to disturbing such resources.
Mitigation Measures
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.

9.5.4.2. Terrestrial Tangible (Archaeological) Cultural Heritage

Despite the historic character of the landscape, modern development has likely destroyed any significant archaeological deposits or sites that may be present within the Project's onshore construction footprint. Based on this, and on the results of field surveys, the Consultants have concluded that no archaeological resources of significant cultural value are likely present within the planned area of disturbance. However, as with underwater cultural heritage, the possibility of a chance find during onshore construction activities exists. For this reason, a Chance Find Procedure is recommended as a mitigation measure to be adopted and implemented by the Project during onshore construction activities.

The banks of the Demerara River are known to have frequent deposits of historic Dutch bottles. The illicit trade of these historic artifacts has become a major contributor to the livelihood of those who dive for bottles. This has become a concern for the heritage industry particularly in controlling damages to such sites, and managing illicit trade of cultural material. Furthermore, areas adjacent to the river are generally considered a high-probability location for potential prehistoric resources. Given the proximity of the temporary MOF construction area to the Demerara River, it is recommended that initial ground disturbance at the temporary MOF location should be conducted with the presence of an archaeological monitor.

Considering the implementation of the measures outlined in the Chance Find Procedure, the magnitude of the impact would be expected to be reduced to no more than **Small**, as activities would be adjusted/curtailed upon discovery of a previously unidentified cultural resource. This would reduce the residual impact significance rating to **Negligible**.

Table 9.5-11 summarizes the management and monitoring measures relevant to this component of cultural heritage.

Table 9.5-11: List of Management and Monitoring Measures—Terrestrial Tangible (Archaeological) Cultural Heritage

Mitigation Measures
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.
Have an archaeological monitor is present when initial ground disturbance work occurs at the temporary MOF site.

9.5.4.3. Intangible Cultural Heritage

Three silk cotton trees, though not confirmed to have terrestrial archaeological value, are significant to the cultural landscape and local oral traditions (see Section 9.5.2.3, Silk Cotton Trees (*Ceiba pentandra*). Currently, C1 and C3 are located within the Project's permanent RoW, while C2 is outside the permanent RoW. As embedded controls, the Project plans to avoid C3 by completing the associated pipeline segment via HDD, and by avoiding removal of the tree from the permanent RoW (woody vegetation is typically removed from the permanent RoW, even for HDD segments). With respect to C1, EEPGL is currently assessing whether it is possible to complete the associated pipeline segment using HDD techniques rather than open-cut techniques. If HDD techniques are used for this segment, the same embedded control of avoiding removal of the tree from the permanent RoW will be applied. If this pipeline segment is completed using open-cut techniques, the tree will likely require removal. As a mitigation measure for this scenario, before removing the trees, it is recommended that the National Trust be notified of the intent to discuss the resource and the cultural ramifications of its removal. Furthermore, local community leaders should be consulted regarding the tree's spiritual significance.

As described above, segments of the onshore pipeline corridor have not been subjected to pedestrian survey due to access limitations. A recommended mitigation measure for these segments is that a vegetation specialist should examine any areas not previously surveyed for potential silk cotton trees, prior to initiation of ground disturbance. If any silk cotton trees are identified, the avoidance or removal of these trees should be addressed in the same manner as discussed for C1 through C3.

As an additional mitigation measure, it is recommended that the Project maintain a high-visibility exclusion fence around these trees during construction and maintain a 10-meter buffer around the trees and have an archaeological monitor is present on site when construction activities are taking place in the immediate vicinity of each tree. Finally, considering their presence may be an indication of the potential for historic artifacts or burials, as well as their importance to local beliefs, the Consultants recommend—in addition to implementation of the Chance Find Procedure recommended for all onshore activities—an archaeological monitor should be present in any instance where a silk cotton tree is removed.

Under the scenario where disturbance of silk cotton trees is avoided, while the additional mitigation measures recommended above will reduce the potential for an unforeseen impact (e.g., disturbance of a potential burial site, inadvertent physical impact to the tree during construction activities), the magnitude of the impact would remain unchanged, as the intensity rating is based on reduced access to the tree during construction. Accordingly, the residual impact significance is maintained at **Minor**.

Under the scenario where a silk cotton tree is planned to be disturbed (e.g., if C1 cannot be avoided via HDD), the mitigation measure of notifying the National Trust, consulting with community leaders, and ensuring that an archaeological monitor is present when work occurs near the tree, will not change the magnitude, as the resource will be completely lost. However, the objective of this mitigation measure is to confirm that the specific resource is not specifically protected under national law, is of a type that is common in the surrounding region, has limited or no specific cultural value to stakeholders, and/or has limited scientific value or similar information can be obtained at numerous sites. Under the premise that this would be confirmed through consultation with the National Trust and community leaders, the sensitivity of the specific resource could be reduced to **Low**, reducing the significance to **Moderate**.

Table 9.5-12 summarizes the management and monitoring measures relevant to this component of cultural heritage.

Table 9.5-12: List of Management and Monitoring Measures—Intangible Cultural Heritage

Embedded Controls
Use HDD techniques wherever practicable to avoid physical disturbance of silk cotton trees.
Where HDD techniques are used for a segment where a silk cotton tree falls within the permanent RoW, avoid removal of the tree from the permanent RoW.
Mitigation Measures
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.
Maintain a high-visibility exclusion fence around silk cotton trees during construction activities and preserve a 10-meter buffer around the trees during construction activities in the vicinity of the trees.
Have an archaeological monitor present when work occurs in a segment of the onshore pipeline corridor where a silk cotton tree is present in the temporary or permanent RoW.
If a silk cotton tree is planned to be disturbed, notify the National Trust, consult with the community leaders, and have an archaeological monitor present when work occurs near the tree.
For segments of the onshore pipeline corridor that have not been subjected to pedestrian survey, have a vegetation specialist examine the segments for potential silk cotton trees, before initiating ground disturbance. If any silk cotton trees are identified, address the avoidance or removal of these trees in accordance with the embedded controls and other mitigation measures listed above.

9.5.4.4. Historic Structures

Potential impacts on historic structures within the APE of the Project would be limited to potential viewshed alterations visual disturbances. Based on the fact that portion of the onshore pipeline corridor in which historic structures are present in the APE will be installed via HDD, the intensity of such impacts is characterized as **Negligible**. As such, no mitigation measures are proposed in relation to historic resources.

Table 9.5-13 summarizes the embedded controls and monitoring measures relevant to this resource.

Table 9.5-13: List of Management and Monitoring Measures—Historic Structures

Embedded Controls
Use HDD to install onshore pipeline crossings at Canal 1 and Canal 2.

9.5.5. Assessment of Residual Impacts

Considering the implementation of the mitigation measures described above, the residual impact significance ratings will decrease to **Negligible** for underwater cultural heritage, terrestrial tangible (archaeological) cultural heritage, and historic structures. In the case of intangible cultural heritage, the residual impact significance is dependent on whether a tree is disturbed or removed. If disturbance and removal can be avoided, the residual impact significance will remain **Minor**. If disturbance or removal is planned, the residual significance can be reduced to be **Moderate**, contingent on confirmation with the National Trust and community leaders that the specific resource is not specifically protected under national law, is of a type that is common in the surrounding region, has limited or no cultural value to stakeholders, and/or has limited scientific value, or similar information can be obtained at numerous sites.

Table 9.5-14 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on cultural heritage.

Table 9.5-14: Summary of Potential Pre-Mitigation and Residual Impacts—Cultural Heritage

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Underwater cultural heritage—damage from Project activities disturbing the seabed	Low	Negligible to Medium [a]	Negligible to Minor [a]	Chance Find Procedure	Negligible
	Terrestrial (archaeological) cultural heritage—damage from Project ground-disturbance activities	Low	Negligible to Medium [a]	Negligible to Minor [a]	Chance Find Procedure; Archaeological monitor at temporary MOF site	Negligible
	Intangible cultural heritage—damage to silk cotton trees (HDD/no tree removal scenario)	Medium	Small	Minor	Exclusion fencing around silk cotton trees; Chance Find Procedure; Have an archaeological monitor present for work in areas near silk cotton trees	Minor
	Intangible cultural heritage—damage to silk cotton trees (open-cut / tree removal scenario)	Medium	Large	Major	Notify the National Trust, consult with community leaders, and have an archaeological monitor present when work occurs near the tree.	Moderate [b]
	Historic structures—viewshed impact from Project activities	Low	Negligible	Negligible	None	Negligible
Operations	Historic structures—viewshed impact from Project features	Low	Negligible	Negligible	None	Negligible

[a] Higher end of magnitude/significance range is associated with the potential presence of unidentified cultural heritage resources (i.e., “chance finds”).
[b] Residual rating is contingent on confirmation with the National Trust and community leaders that the specific resource is not specifically protected under national law, is of a type that is common in the surrounding region, has limited or no cultural value to stakeholders, and/or has limited scientific value or similar information can be obtained at numerous sites.

9.6. LAND USE AND OWNERSHIP

9.6.1. Baseline Methodology

9.6.1.1. Study Areas

Study areas for socioeconomic resources, as referenced in this section, are defined and illustrated in Section 9.1, Socioeconomic Conditions, including:

- Direct AOI:
  - **Primary Study Area**[31]: This study area includes communities and households within 500 meters of the onshore pipeline corridor, within 1 kilometer of the NGL Plant boundary and/or temporary MOF; within the area extending from the Demerara River immediately north of Free and Easy village, and south and west to the NGL Plant and temporary MOF, plus the area encompassing settlements in the Belle West housing scheme.
  - **Secondary Study Area**: This area includes communities and households located between the Primary Study Area and the Demerara River.
- Indirect AOI:
  - **Tertiary Study Area**: This study area includes the communities on the East Bank of the Demerara River immediately across from the temporary MOF.

    The communities that were engaged and/or studied in the Tertiary Study Area include Brickery, Garden of Eden, and Land of Canaan.
  - **Regional Study Area**: This area includes the remainder of Region 3, plus Regions 2 and 4 (the balance of the Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology).

    The communities that were engaged and/or studied in the Regional Study Area include Georgetown, Santa Aratak, and Pakuri.

The combined socioeconomic study areas are equivalent to the Onshore Indirect AOI as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

9.6.1.2. Baseline Studies

Baseline research has included a secondary (desk-based) review of available information about land use and ownership. Research has focused on the Primary Study Area as this includes lands that will be directly affected by planned activities during the Construction and Operations stages. Information about current land use activities has also been derived from aerial photos and field reports from biophysical study teams, as well as publicly available reports and resources relevant to the Primary Study Area.

[31] The socioeconomic Primary Study Area includes the Direct AOI for biophysical components, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

The Consultants conducted socioeconomic surveys in Region 3, as described in Section 9.1, Socioeconomic Conditions. Surveys were conducted in December 2021 and included residents and businesses in the Primary Study Area and Secondary Study Area. Some survey questions were included to help characterize local residents' land use activities including questions related to livelihoods, land use, fishing, agriculture, and other activities. The household surveys also inquired about land ownership, as reported by the survey respondents; individual responses have not been cross-checked with legal registries, but provide an important indication of ownership status from the perspective of current residents.

9.6.1.3. Limitations

The Guyana Lands and Survey Commission (GLSC) and National Industrial and Commercial Investments Ltd. (NICIL) are responsible for land acquisition and access related to the proposed Project. At the time of writing, registered land ownership, surveys, parcel plans, or official records of land titles or tenures have not been provided to the Consultants. This information is therefore not reflected in this analysis.

Based on aerial images and field-based reports from biophysical studies, the Consultants understand that approximately three residential structures are within 100 meters of the proposed heavy haul road. At the time of writing—and in respect of ongoing engagement of these residents by the Government of Guyana, and pending confirmation of the planned government-led land acquisition processes—these residents had not been included in the 2021 socioeconomic household surveys or other primary research efforts. Assumptions regarding these residences are identified in the relevant sections.

9.6.2. Existing Conditions and Baseline Studies

9.6.2.1. Land Ownership

National Context

There are three types of land tenure in Guyana (GLSC 2013):

- **Public lands** include state-owned land and government land. State lands are held by the people of Guyana and may be licensed, permitted, or leased for various purposes including agriculture, forestry, and mining. Government lands have been granted to the Government of Guyana by the state, to be developed for public purposes such as healthcare, schools, land development schemes, etc. Combined, public land is estimated to account for between 76 percent (GLSC 2013) and 85 percent of all land in Guyana (GLSC 2018; Khemraj 2019).
- **Private (freehold) lands** are bought and sold in the freehold market, and are held under either a "certificate of title" or "transport of property". Transactions are recorded by the Land

Registry or Deeds Registry, respectively.[32] Private lands are estimated to account for between 2 percent (Khemraj 2019) and 10 percent (GLSC 2013) of all land in Guyana.[33]

- **Amerindian lands** are held under communal title. Amerindian lands are collectively owned by the respective indigenous group and are not subject to transfer or sale. Combined, Amerindian lands account for approximately 14 percent of lands in Guyana (Khemraj 2019; GLSC 2013).

On the coastal plain, most of the cultivated lands are held as sugar estates under the Guyana Sugar Corporation (GuySuCo) or as rice plots. Sugar estates consist of both private and leasehold (lands leased by the state) tenure. Most rice fields under 6 hectares have been converted to freehold tenure, while the larger plots are under leasehold, administered by the GLSC or other designated authorities (FAO and GLSC 2017). Forest and mineral resources are owned by the state, and tenure in these sectors are in the form of limited term concessions from the Guyana Forestry Commission and the Guyana Geology and Mines Commission, respectively.

Leases of government-owned lands are issued by the GLSC or other designated authorities. Freehold titles are recorded by two separate agencies: the Deeds and Commercial Registries Authority and the Land Registry. The Deeds and Commercial Registries Authority is responsible for administering the laws enacted by Parliament affecting land (DCRA Undated). The Land Registry was established to simplify land registration and provide security of tenure to owners of titled public lands (Land Registry Undated).

According to a study of the land registration system in Guyana conducted by the IDB, the country's dual property registration systems (title registration and deed registration) have regulations that overlap and conflict, and are considered complex and bureaucratic. The systems are also considered ineffective in managing and enforcing rights. As a result, a large number of land owners do not register their properties or do not keep their ownership rights up to date (IDB 2010). However, in recent years, the capacities of the Deeds and Commercial Registries Authority and Land Registry have improved to enable better execution of their legal mandates. In addition, the GLSC is working to regulate land to provide security of tenure on public lands.

Primary Study Area

The onshore pipeline traverses approximately 25 kilometers from the offshore pipeline shore landing (near the community of Crane) to the NGL Plant site. Along this route, the onshore

[32] A property can be registered as a certificate of title or a transport depending on the date that the property was established. Titles were issued under the British system of land/property law, whereas transports were issued under the Roman Dutch system.

[33] This breakdown of public, private, and Amerindian land is not well documented. In particular, the combined area of private land is unknown and may be as low as 1 to 2 percent of total land area. In regard to Amerindian land, the estimated 14 percent excludes areas under dispute or awaiting demarcation (GLSC 2013).

pipeline will intersect private and public lands. There are no Amerindian lands in the Primary or Secondary Study Areas.[34]

The onshore pipeline and temporary construction areas will intersect with private and public land parcels between the shore landing and the NGL Plant. Information about specific parcels along the onshore pipeline route was not available at the time of writing, although private landownership is expected to be found in populated areas (e.g., the community of Crane, near Canal 1, and near Canal 2).

The NGL Plant, heavy haul road, and temporary MOF are located within the Wales Development Area, on lands owned by Guyana's NICIL and formerly held by GuySuCo. These Project components are located in an area known as Plantation Rhynstein, and NICIL has indicated that there are no private lands or occupancy permissions in the area. The land was transferred from GuySuCo to NICIL in 2017.

Self-Reported Land Ownership

The 2021 household survey asked participants to identify their land ownership or other form of tenure. Figure 9.6-1 and Figure 9.6-2 illustrate land tenure responses from the household survey. Highlights from the Primary Study Area (including the onshore pipeline corridor[35] and South Wales[36] residents) include:

- Nearly all survey participants (152 responses) reported that the residence in question is their primary residence. The only exception was one residence in the village of Free and Easy.
- Most survey respondents claim to have lived in their homes for more than 10 years (51 percent of survey respondents along the onshore pipeline corridor, and 79 percent in South Wales).
- The form of land ownership or tenure was variable.
  - Along the pipeline corridor, 83 percent of respondents reported that they own or lease their land, and 16 percent indicated they have an informal agreement with responses indicating that these agreements are generally with family members or other known individuals. One respondent indicated they act as a caretaker for a family property.
  - In Free and Easy, 17 of 27 respondents (63 percent) indicated that they own their land. Seven residents reported having informal agreements with family members, one person had a rental agreement, and two residents indicated that they have no agreement to use the land.

[34] The Santa Aratak title lands are approximately 4.8 kilometers from the NGL Plant, and are the nearest Amerindian lands to the Project. Santa Aratak is further described in Section 9.9, Indigenous Peoples.

[35] This portion of the Primary Study Area includes residents of Crane, Nouvelle Flanders, Lust-en-Rust, Westminister, Canal 1 (including Bordeaux, Genieve, and L'oratoire), and Canal 2 (including Resource and Alliance). The household survey includes responses from 83 residents adjacent to the proposed onshore pipeline corridor, and 52 residents in the South Wales area.

[36] For the purposes of this report, the area of "South Wales" refers to settlements in the vicinity of the proposed NGL Plant site, heavy haul road, and temporary MOF, inclusive of communities known locally as Free and Easy, Catherina Sophia, Voorburgh, Maria's Lodge, Goldberg, Jacob's Lust, and La Harmonie.

- Between Catherina Sophia and La Harmonie, 10 of 25 residents (40 percent) indicated that they own their properties, 7 residents (28 percent) have an informal agreement, and 8 residents (32 percent) reported having no agreement, unknown agreements, or being on state-owned lands.

Between Free and Easy and Catherina Sophia, the Consultants have identified four residential structure within 500 meters (three of which are located within approximately 200 meters) of the proposed temporary MOF and heavy haul road. These residents were not included in the 2021 household survey and have not been engaged by the Consultants to date. However, aerial images and field reports indicate the presence of residential structures, household gardens, small crops, livestock, and outbuildings (described further in Section 9.6.2.2, Land Use). Information provided to EEPGL by NICIL in March 2022 indicated that these residences are located on land owned by NICIL and are not covered by a recognized land tenure or agreement permitting residency or land use.

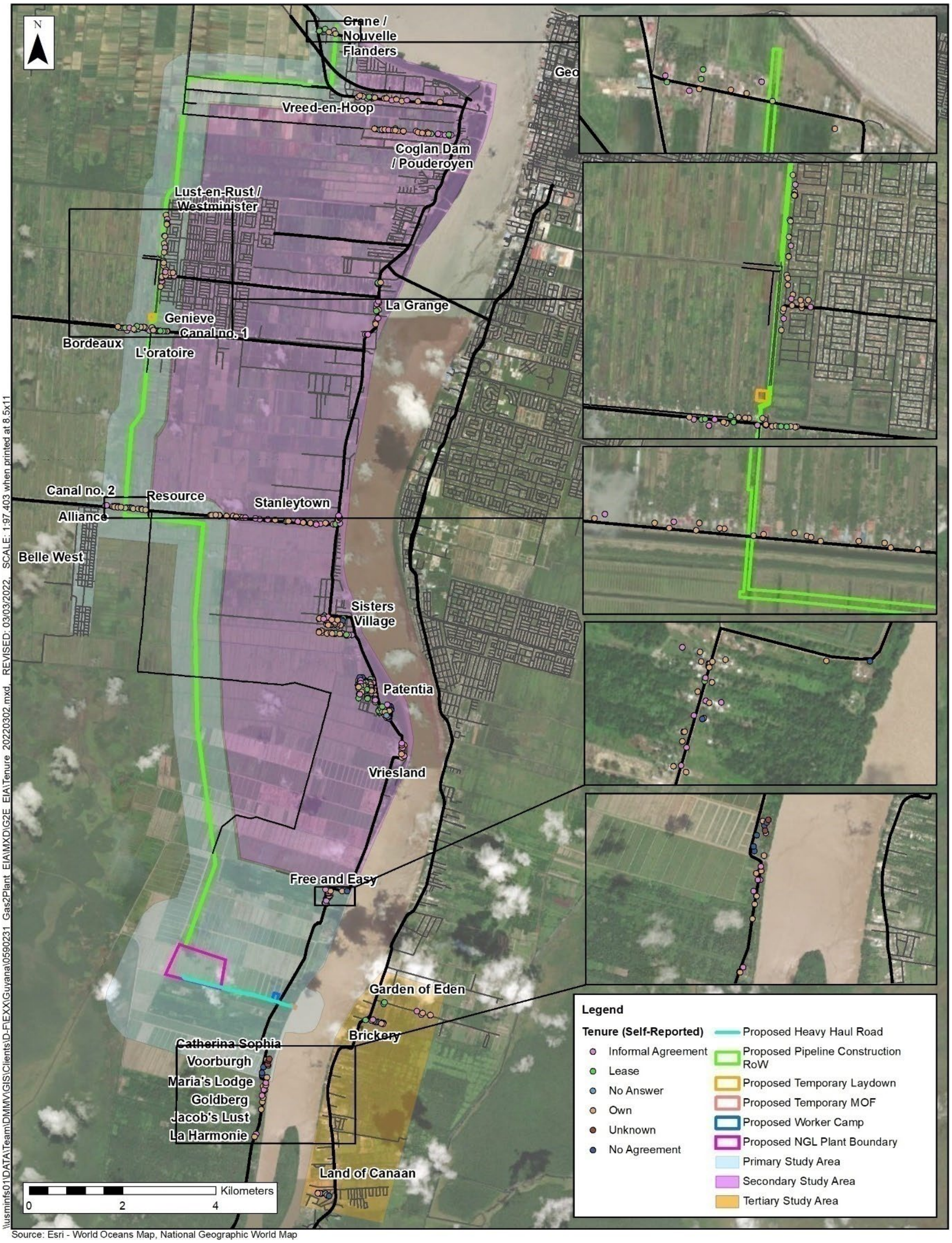
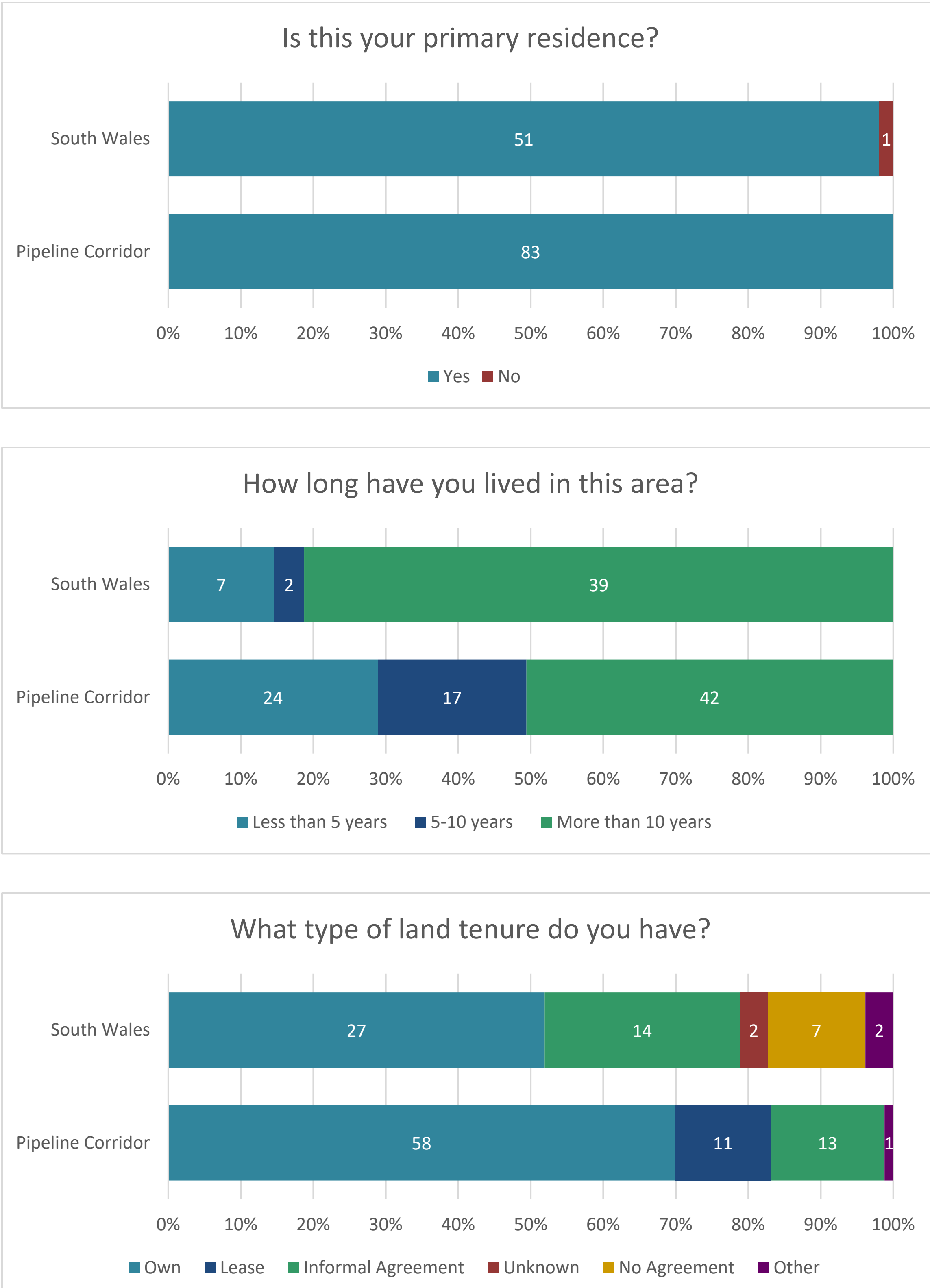


Figure 9.6-1: Self-Reported Land Tenure (Household Survey, Dec. 2021)



Note: Values within chart indicate number of responses. Categories not shown had a value of zero.

Figure 9.6-2: Land Ownership Responses (Household Survey, Dec. 2021)

9.6.2.2. Land Use

National and Regional Context

Guyana's 215,000 km^2 of land area can be broadly divided into four ecoregions:

- The coastal plain stretches 440 kilometers from the Corentyne River in the east to Waini Point in the west and ranges from approximately 5 to 65 kilometers wide along the coast. Home to the majority of Guyana's population, this low-lying land (1.4 meters below mean high tide level, on average) accounts for less than 8 percent of the country's land area.
- The hilly sand region is a largely vegetated zone dominated by white, sandy soils and undulating terrain lying inland from the coastal zone. This zone ranges from approximately 150 to 250 kilometers wide, is largely forested, and contains most of the country's mineral deposits.
- The interior highlands extend from the hilly sand region to the country's southern borders. The highlands are part of the pre-Cambrian Guiana Shield and also contain mineral deposits. This zone makes up the largest portion of land in the country.
- The interior savannas consist of two main savanna complexes: the Rupununi Savannas and the Intermediate Savannas. In Regions 9 and 10, respectively, the Rupununi Savannas cover 15,540 km^2 and the Intermediate Savannas cover more than 5,180 km^2.

Guyana is a sparsely populated country. In addition to accommodating most of the population and built infrastructure, the coastal plain is also the main agricultural region for the country (FAO 2015). In 2018, agricultural lands represented 6.4 percent of the total land area in Guyana (World Bank 2021). These lands are below sea level and, with two wet seasons each year, are vulnerable to both inundation from the sea and intense rainfall runoff. Coastal areas are typically protected from the sea by mangrove forests and manmade concrete and earthen dykes.

Figure 9.6-3 shows land use patterns for the coastal areas of Guyana. In the coastal plain, agriculture is dominant throughout Regions 2, 3, 4, 5, and 6 and occurs to a lesser extent in Region 1. The main crops are sugar, rice, and coconut plantations, interspersed with smaller-scale establishments of cash crops, non-traditional crops, and livestock. In the hilly sand region, the predominant land use is forestry and mining.

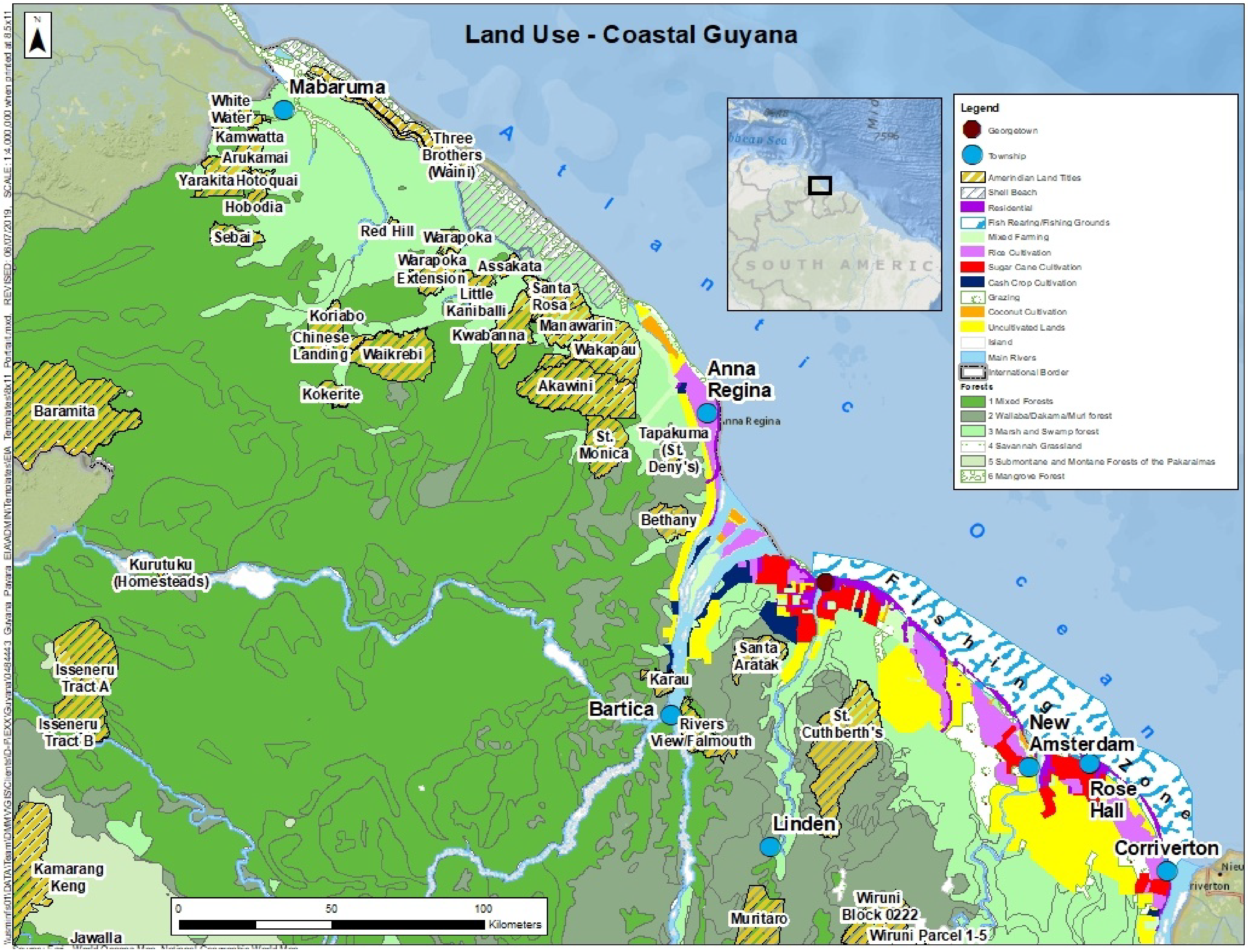


Figure 9.6-3: Land Use and Land Cover in Coastal Guyana

Guyana has a National Land Use Plan (GLSC 2013) that guides the GLSC in land management and administration. The GLSC plans to revise this plan to include oil and gas sector considerations and is implementing a *Mainstreaming Sustainable Land Development and Management* project (FAO and GLSC 2017), which will strengthen institutional and human capacities for participatory and integrated land use planning (Guyana Lands and Surveys Commission 2019, pers. comm.; Ministry of Communities 2019, pers. comm.).

Region 3 Land Use

The low coastlands, hilly sand and clay, and forested highlands of Region 3 provide favorable conditions for agriculture - namely rice, although sugar cane and coconut are cultivated to a lesser extent. Residents in Region 3 also use the land to raise cattle for beef and dairy (Ministry of Local Government and Regional Development 2022). In 2018, 15,400 hectares of rice were harvested in Region 3, accounting for nearly 8.5 percent of total hectares harvested in Guyana that year. Sugar cane cultivation, though not as significant as rice output, was a notable agricultural element of Region 3. Region 3's sugar estates, the Wales Estate and the Uitvlugt Estate, historically produced an average of 21,843 and 20,000 tonnes of sugar per year, respectively, over a 10-year period (GuySuCo Undated_a, Undated_b). However, sugar production and export began declining in 2011—largely due to the loss of preferential prices for sugar in European markets—and culminated with the closure of multiple GuySuCo estates between 2016 and 2017 (Singh 2021).

Coconut production in Region 3 has been bolstered by the Ministry of Agriculture's efforts to establish coconut seedling nurseries to decentralize coconut crops in the country. The addition of four nurseries established in Wakenaam, Leguan, Canal 2, and Corentyne has increased production capacity to approximately 48,000 coconut seedlings per year (MOA 2022).

Region 4 Land Use

Growth of the oil and gas sector in Guyana has influenced demand for and value of land, specifically in the Georgetown area in Region 4 (Guyana Lands and Surveys Commission 2019, pers. comm.). In addition to serving as the country's commercial and infrastructure center, Region 4 also uses land for agricultural purposes including sugar and coconuts. The majority of Guyana's sugar estates are located in Region 4, including the Enmore, Blairmont, Rosehall, Albion, and Skeldon estates. The average output of each estate varied from $261,000 to $3.8 million GYD ($1,250 to $18,098 million USD)) from 2011 to 2016. Similar to Region 3, sugar production has significantly declined with the closure of GuySuCo's sugar estates in 2016 and 2017. Outside of corporate sugar production, there were approximately 1,210 private sugar cane farmers in Region 4 as of 2017 (Singh 2021).

As part of the Ministry of Agriculture's coconut production development initiative, coconut nurseries have also been established in Region 4. One such nursery is near Mon Repos, where 30 mother palms (i.e., palm trees that display prolific bearing habits, pest and disease resistance, and are located in a favorable growth habitat) are located. Using the 30 mother palms, Region 4 plans to develop coconut nurseries in Victoria, Friendship, and Helena #2 (Kundun et al. 2021).

Primary Study Area - Overview

The profile of land use in the Primary Study Area is based on the Consultants' observations in the field, analysis of aerial photos, reports by household survey participants, and data derived from biophysical surveys conducted for the Project. Further detail is provided for each segment of the Primary Study Area in the subsequent sections.

Land Use Profile of the Primary Study Area

Figure 9.6-4 shows the distribution of land uses across the Primary Study Area. More than half of lands are classified as fallow agriculture (2,337 hectares, or 56 percent of the Primary Study Area), including former sugar fields that are now typified by swamp, high vegetation (e.g., bamboo), and forested areas. Active agriculture is also prevalent, including rice fields (536 hectares, or 13 percent) and fallow sugarcane / rice fields that are now used for small-scale mixed crops (522 hectares, or 12 percent). In regard to the distribution of various land uses, the following is noted:

- In general, rice farming occurs throughout the northern portion of the Primary Study Area, around the shore crossing (near the communities of Crane and Nouvelle Flanders) and west of the Westminister / Lust-en-Rust housing scheme.
- Small-scale mixed crops are found north of Canal 1, and between Canal 1 and Canal 2.
- Human habitation exists in a few locations, including residential areas, housing schemes, and informal settlements. This includes residences near the shore crossing, the western edge of the Westminister / Lust-en-Rust housing scheme, along Canal 1 and Canal 2, and the Belle West housing scheme (on Canal 2, west of the onshore pipeline corridor).
- In the South Wales area, the community of Free and Easy is a residential area and there are informal settlements in the vicinity of the temporary MOF and heavy haul road (as noted above), and along the Demerara River in the southeast corner of the Primary Study Area.

Figure 9.6-5 illustrates the breakdown of the 4,193-hectare Primary Study Area based on type of land use.

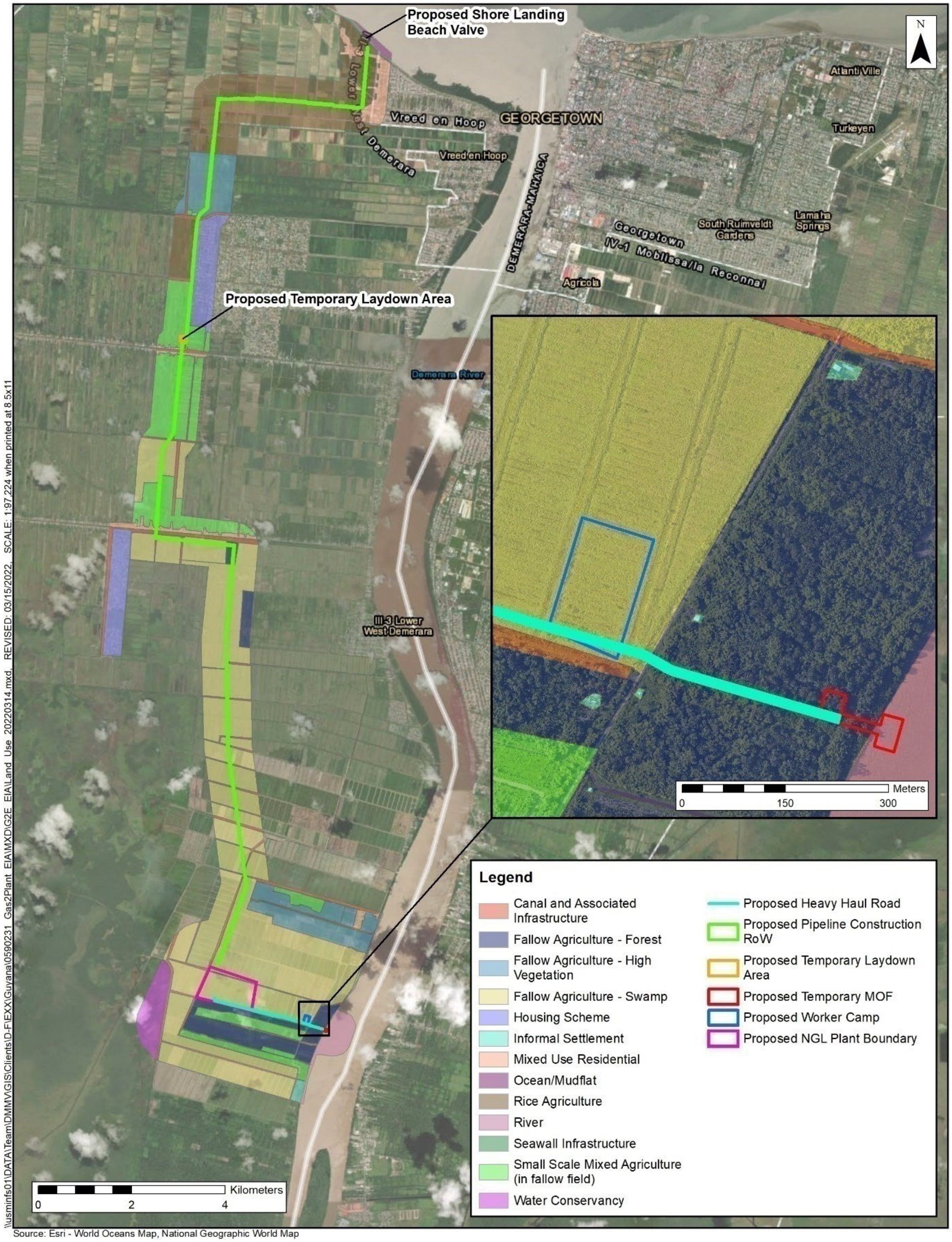


Figure 9.6-4: Land Use in the Primary Study Area

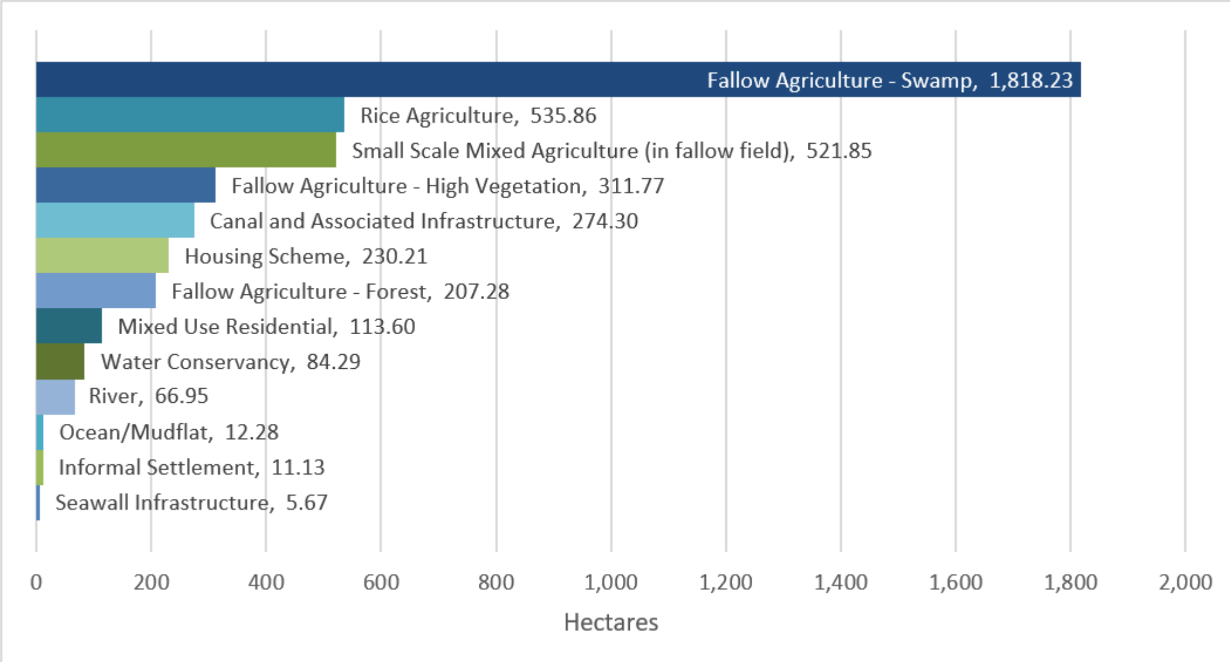


Figure 9.6-5: Land Use Profile of Primary Study Area (hectares)

Vegetation Profile of the Areas of Disturbance

Within the Primary Study Area, the vegetation survey results (Section 8.3, Terrestrial Biodiversity) provide a detailed estimation of vegetation types (indicative of land use) for the proposed onshore components of the Project, including the footprint of temporary[37] and permanent surface disturbance. Results are illustrated on Figure 9.6-6, and highlights for "All Infrastructure"—inclusive of temporary and permanent surface disturbance, as well as HDD (underground) crossings (collectively referred to below as the Project Footprint)—are summarized below:

- The majority of the Project Footprint (67 percent) comprises a combination of grasslands, shrublands, and swamps that are not currently subject to cultivation, residential purposes, or other types of active land use.
- Agriculture is the next most prominent land use. Active agricultural fields (rice and pineapple) represent 15 percent of the Project Footprint. This includes 18 hectares of active rice fields, representing a small portion of rice cultivation in the broader region and 3 percent of rice fields in the Primary Study Area. This area also includes 3.2 hectares of active pineapple cultivation, representing less than 1 percent of non-rice cropland in the Primary Study Area. In addition to areas under active cultivation, inactive/fallow fields (formerly rice or sugarcane) represent 7 percent of the Project Footprint.
- Forests of varying types and maturity (including early succession bamboo and palm forests) are the next most prominent land use. With 9.1 hectares of forests across the Project

[37] Temporary surface disturbance includes construction areas that will be restored following the completion of construction activities.

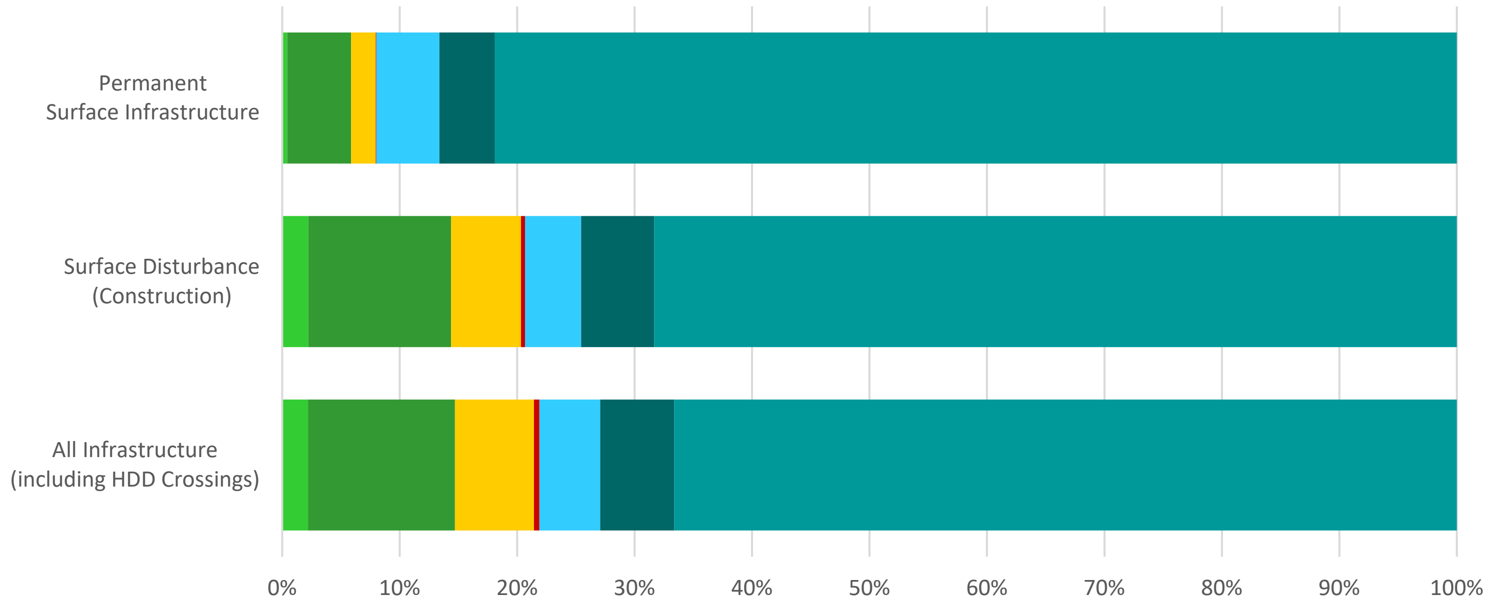
Footprint, affected forests represent 6 percent of the Project Footprint and 4 percent of forests in the Primary Study Area. More mature secondary growth and riparian forests represent less than 0.5 hectare of the Project Footprint.

- Residential areas, roads, and buildings represent approximately 0.7 hectare, or less than 0.5 percent of the Project Footprint.
- Water (primarily existing canals and drainage channels) and earthen dams account for 7.4 hectares, or 5 percent of the Project Footprint.

Buildings

Based on aerial photo analysis, there are 34 buildings within 25 meters of the proposed onshore pipeline, and 153 buildings within a distance of between 25 and 100 meters from the proposed onshore pipeline. This includes residential and other types of buildings of varying age and condition.

In the southern portion of the Primary Study Area, three buildings are located within 100 meters of the proposed heavy haul road.



	All Infrastructure (including HDD Crossings)	Surface Disturbance (Construction)	Permanent Surface Infrastructure
Active Agriculture (Pineapple)	3.17	3.08	0.44
Active Agriculture (Rice)	18.02	16.82	5.52
Inactive Agriculture (Sugarcane)	9.69	8.25	2.13
Roads, Residential Areas, Buildings	0.67	0.47	0.06
Water and Dams	7.44	6.60	5.45
Forests (Note 1)	9.09	8.63	4.80
Grasslands, Shrublands, Swamp, and Coastal Vegetation (Note 2)	95.96	94.53	83.19

Notes: (1) Includes Bamboo Forest, Early Successional Bamboo/Palm Forest, Early Successional Forest/Swamp, Riparian Forest (Mangrove Associated Species), and Modified Secondary Forest. (2) Includes Herbaceous/Grassland, Herbaceous/Grass Swamp, Shrubland/Swamp, Shrubland/Grass, and Coastal Strand Vegetation (Mangrove Associated Species).

Figure 9.6-6: Land Use Profile—Areas of Project Footprint (hectare)

The following sections describe specific portions of the Primary Study Area in further detail, from north (shore crossing) to south (NGL Plant). These descriptions are based on the vegetation survey results and aerial photo analysis, complemented by findings from the household survey.

Shore Crossing

Land use near the shore crossing includes a mix of residential and cultivated land (Figure 9.6-7). The rocky shoreline is accessible, and Hindu flags indicate that people visit the shore for prayers and funereal ceremonies. Livestock freely graze on the seawall. Access to the seawall is via a pedestrian bridge, approximately 300 meters east of the shoreline crossing.

Atlantic shoreline

Prayer flag on shoreline

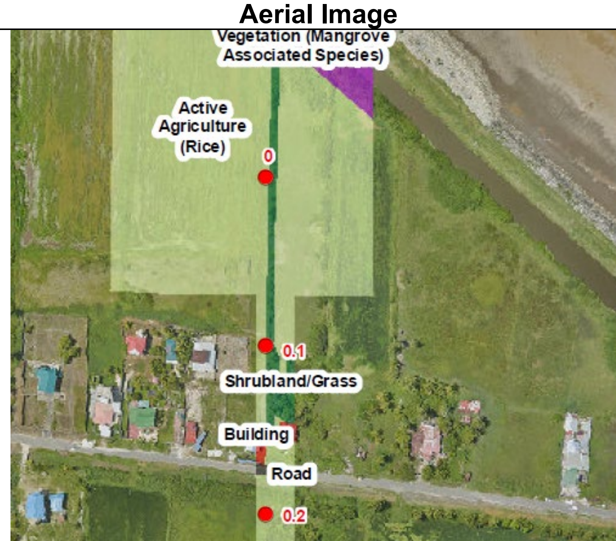
Grazing on seawall

Seawall with pedestrian bridge

Figure 9.6-7: Land Use Images near Shore Crossing

Actively cultivated rice fields are present at the shore crossing, adjacent to the seawall (Table 9.6-1). A paved road runs roughly perpendicular to the proposed onshore pipeline at this location; a cluster of homes and buildings are located approximately 250 meters inland from the seawall. Two buildings are situated within approximately 30 meters of the onshore pipeline construction RoW; one appears to be abandoned, and the other is newly constructed. A cluster of 5 to 6 buildings is present adjacent to (and west of) the onshore pipeline construction RoW, within 30 to 100 meters of the proposed pipeline route.

Table 9.6-1: Land Use Examples—Shore Crossing

Description	Aerial Image
Location: shore crossing Project Footprint: • Active agriculture (rice)	
Location: approx. 100 to 200 meters from shore crossing Within Project Footprint: • 1 building (new construction) • 1 abandoned building • Public road Within 100 meters of Footprint: • Cluster of buildings west of pipeline	

Note: Location estimates based on pipeline kilometer points (KPs) as shown in Chapter 5, Project Description. The images shown above can be viewed in more detail, including relevant legends and scale, in Appendix M, Pipeline Alignment and Vegetation Mapbook.

The Consultants surveyed 11 households near the proposed shore crossing, including residents of Crane and Nouvelle Flanders. Of those surveyed, two homes identified farming (rice and vegetables) and livestock rearing (poultry) on their land. Other homes in the area declined to participate in the household survey.

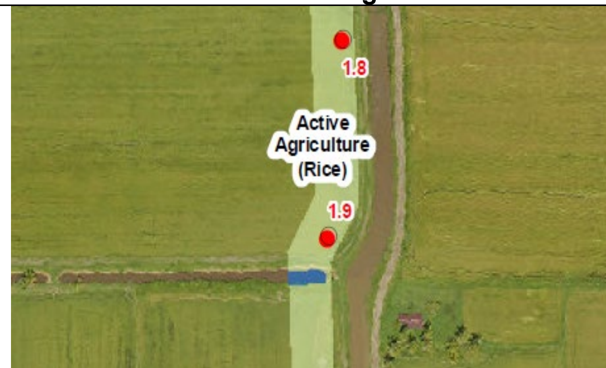
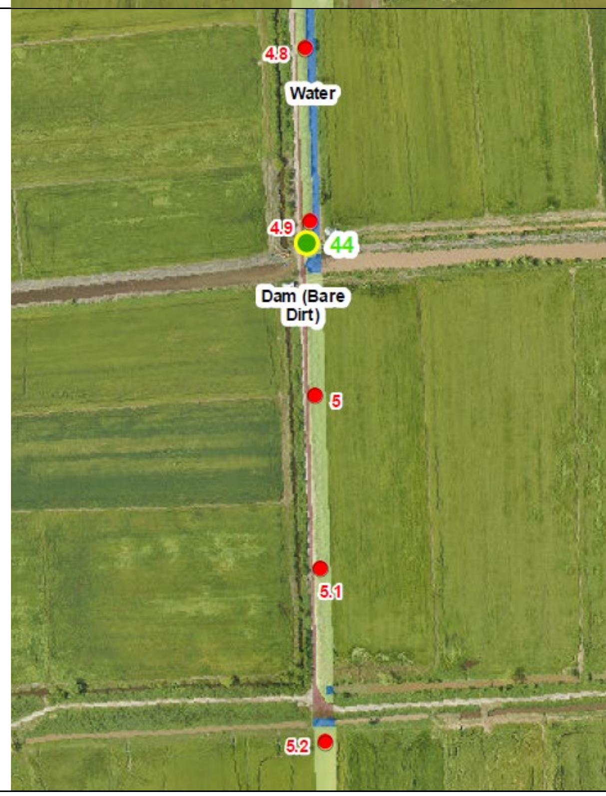
North of Canal 1

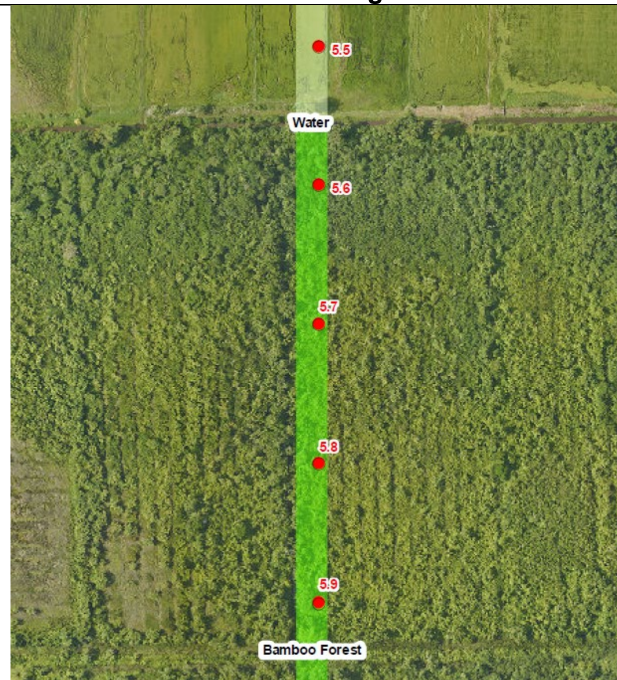
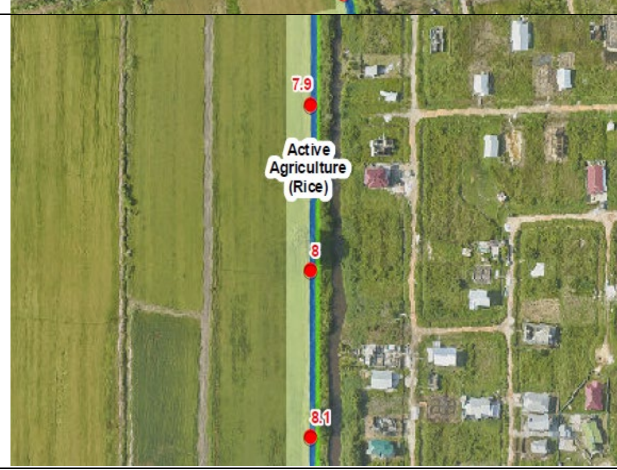
Between the shore crossing and Canal 1, the onshore pipeline will pass through active rice fields for approximately 5.5 kilometers, including regular crossings of the canals that irrigate these fields. Other features in this area include a non-residential building and an agricultural access road (Table 9.6-2). Approximately 5.6 kilometers from the shore crossing, the environment transitions to bamboo forest for approximately 1.4 kilometers before intersecting with Canal A northwest of the community of Westminister / Lust-en-Rust). At this point, the pipeline corridor will intersect the road access to a small settlement; aerial photos indicate that small-scale crops are grown at this settlement.

After crossing Canal A, the onshore pipeline will travel parallel to the western perimeter of the community of Westminister / Lust-en-Rust, through an area of existing rice fields (approximately 2.5 kilometers of active rice fields).

During the household survey, the Consultants engaged with 27 residences along the western perimeter of the Westminister / Lust-en-Rust housing scheme. None of the residents surveyed identified farming or active croplands associated with their homes, although the lands adjacent to this housing scheme are actively cultivated for rice and other crops. Reported use of the canals included fishing and provision of household water (discussed further in Section 9.3, Social Infrastructure and Services).

Table 9.6-2: Land Use Examples—North of Canal 1

Description	Aerial Image
Location: approx. 1.9 km from shore crossing Within 100 meters of Project Footprint: • 1 building (non-residential)	
Location: approx. 4.9 to 5.2 km from shore crossing Within Project Footprint: • Dirt road used to access fields (only available access) • Water (canals) on either side of road Note: green marker labeled "44" indicates a vegetation survey point.	

Description	Aerial Image
Location: approx. 5.5 to 6.9 km from shore crossing Within Project Footprint: • Transition from active agriculture (rice) to bamboo forest	
Location: Canal A, approx. 7.0 km from shore crossing Within Project Footprint: • Local road Within 100 meters of Project Footprint: • Cluster of buildings, suspected informal settlement • Bridge • Small-scale crops	
Location: west of Westminister / Lust-en-Rust housing scheme, approx. 7.1 to 9.1 km from shore crossing Within Project Footprint: • Active rice fields Within 100 meters of Project Footprint: • Residences on the west perimeter of Westminister / Lust-en-Rust	

Note: Location estimates based on pipeline KPs as shown in Chapter 5, Project Description. The images shown above can be viewed in more detail, including relevant legends and scale, in Appendix M, Pipeline Alignment and Vegetation Mapbook.

Canal 1 to Canal 2

Approximately 300 meters north of Canal 1 (9.6 kilometers from the shore crossing), the active cultivation shifts from rice to pineapple (Table 9.6-3). Residences, local businesses, and local access roads line the north and south sides of Canal 1.

Table 9.6-3: Land Use Examples—Canal 1

Description	Aerial Image
Location: north of Canal 1, approx. 9.6 to 9.9 km from shore crossing Within Project Footprint: • Active pineapple fields • Residences along Canal 1 (north side) • Local roads	
Location: south side of Canal 1, approx. 10.0 km from shore crossing Within Project Footprint: • Residences along Canal 1 (south side) • Local roads • Active pineapple fields • Inactive sugarcane fields	

Note: Location estimates based on pipeline KPs as shown in Chapter 5, Project Description. The images shown above can be viewed in more detail, including relevant legends and scale, in Appendix M, Pipeline Alignment and Vegetation Mapbook.

After crossing Canal 1, the onshore pipeline will continue south through actively farmed pineapple fields (bordered by inactive sugarcane fields) for approximately 800 meters, after which point the existing land use includes a mixture of bamboo/palm forest and inactive sugarcane fields for approximately 2.8 kilometers. Pineapple fields resume approximately 250 meters north of Canal 2 (Table 9.6-4). The Canal 2 Road runs along the north side of the canal and is lined with residential homes (Figure 9.6-8). The Alliance/Resource canal divides residences in this area—locally known as the Resource and Alliance communities—and the canal is crossed by the proposed onshore pipeline route. Established homes are immediately adjacent to the Alliance/Resource canal.

After crossing Canal 2, the onshore pipeline will turn east, running parallel to the canal through swamp and early successional forest areas for approximately 1.7 kilometers. A single residence is located south of Canal 2 in the vicinity of the onshore pipeline route (between the canal and the onshore pipeline route); it is accessible by a footbridge from the Canal 2 Road (Table 9.6-4; Figure 9.6-8).

Table 9.6-4: Land Use near Canal 2

Location: north side of Canal 2, approx. 13.6 to 13.9 km from shore crossing Within Project Footprint: • Active pineapple fields • Residences along Canal 2 (north side) • Local roads • Canal dividing Alliance and Resource communities • Inactive fields Within 100 meters of Project Footprint: • Residences along north side of Canal 2 Road (Alliance and Resource communities)	
Location: south side of Canal 2, approx. 14.6 km from shore crossing Within 100 meters of Project Footprint: • Residence and other structures, accessed by pedestrian bridge across Canal 2	

Note: Location estimates based on pipeline KPs as shown in Chapter 5, Project Description. The images shown above can be viewed in more detail, including relevant legends and scale, in Appendix M, Pipeline Alignment and Vegetation Mapbook.

Roadside along Canal 1

North side of Canal 1

Residences along Canal 2

Resource/Alliance Canal (Canal 2)

Residence on south Side of Canal 2

Crops Grown near Belle West housing scheme
(location unknown)
(Source: Bacchus 2022)

Figure 9.6-8: Land Use Images near Canal 2

During the household survey, the Consultants engaged with 26 residents along Canal 1 near the proposed onshore pipeline RoW. Five of these residents identified as farmers and reported crops of fruit and root vegetables such as cassava. Five other residents reported rearing poultry on their properties. Residents also reported using canals for fishing and swimming.

Near Canal 2, the Consultants engaged with 19 residents, including those living in the Alliance and Resource areas. Seven respondents identified as farmers, although 12 indicated that they cultivate crops at some scale, including fruits and vegetables. Livestock rearing was reported by seven households, primarily in reference to poultry, but also some sheep, goats, and cattle.

Recent media reports have highlighted concerns that agricultural lands leased to and actively cultivated by local farmers based in the Belle West housing scheme will be removed as a result of the Project (Bacchus 2022). The location(s) of the referenced agricultural lands to be removed are not known by the Consultants, nor is it clear if the referenced lands are north and/or south of Canal 2. The Canal 2 crossing is approximately 500 meters east of the Belle West housing scheme. Vegetation surveys indicate that the former agricultural fields along the route have been inactive for a number of years and now comprise a mix of swamp, early successional forest, and bamboo forest. Bacchus (2022) reports the following:

- Lands were leased to approximately 75 farmers in June 2019. Individual farmers hold between 2 and 5 acres. Most individuals are former sugar workers.
- Participating farmers understood the lease to be valid for 20 years and invested accordingly to establish permanent/perennial crops and livestock.
- The lease was rescinded in September 2020 and lessees were given notice to vacate the lands by October 2021.

As of February 2022, Bacchus (2022) reported that affected farmers had not vacated the leased lands and were seeking legal advice.

South of Canal 2

After turning south from Canal 2, the onshore pipeline route travels approximately 9.2 kilometers through the former GuySuCo sugar estate, now comprising a mix of bamboo, early successional forest, and swamp areas, as well as inactive sugarcane fields. There is no known human habitation in this area, and access to the low-lying lands is limited to travel along canals.

South Wales (including NGL Plant Site and Temporary MOF)

As the onshore pipeline route reaches the proposed NGL Plant site, the vegetation transitions to shrubland and swamp. This area continues to comprise former sugarcane fields within the GuySuCo sugar estate. There is no known human habitation in this area, and overland access is limited. Vegetation types along this section of the onshore pipeline route (approximately 9.2 kilometers in length)—and in the vicinity of the NGL Plant site, proposed heavy haul road, and temporary MOF—are detailed in Appendix M, Pipeline Alignment and Vegetation Mapbook.

The proposed location of the heavy haul road and worker camp are also typified by shrubland and swamp, transitioning to more established forest (secondary forest and mangroves) as the proposed heavy haul road footprint approaches the proposed temporary MOF site. Parallel to the river, an overland track (WBD Public Road) connects a number of residences near the proposed heavy haul road and temporary MOF, and extends south to the settlement of Catherina Sophia and north to Free and Easy.

Through the household survey, the Consultants engaged with 25 residents between Catherina Sophia and La Harmonie, the majority of whom (60 percent, or 15 respondents) identified as farmers. Crops include a range of fruits and vegetables, and livestock include poultry, sheep, goats, and cows. These residents reported a high level of canal use (92 percent, or 23 respondents) including fishing, domestic water, travel, and transportation of produce from fields.

The Consultants also surveyed 27 residents of the Free and Easy community, located approximately 2.3 kilometers northwest of the proposed NGL Plant site. Seven respondents identified as farmers, although 18 reported growing crops (including cassava and other vegetables, and fruit). Ten homes reported livestock rearing, including poultry, pigs, and other species. Reported canal use is also high in Free and Easy, supporting activities such as fishing, domestic water, travel, and transportation - including access to farmlands.

The Consultants have identified four residences within 500 meters (three of which are located within approximately 200 meters) of the intersection of the WBD Public Road and the proposed heavy haul road. As of the writing of the EIA, these residents had not yet been engaged by the Consultants; direct engagement was delayed in respect of ongoing engagement of these residents by the Government of Guyana, and pending confirmation of the planned government-led land acquisition processes. However, based on observations it is evident that household structures in this area range from corrugated metal buildings (Figure 9.6-9) to more established structures that appear to be constructed of concrete and timber. A limited number of non-residential outbuildings are also present. Based on aerial images and field reports, local land use appears to include household gardens, small crops, and livestock.

Figure 9.6-9: Residence Examples near Temporary MOF

9.6.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on land use and ownership. The relevant planned Project activities and the associated potential impacts of these activities on land use and ownership are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.6.3.1. Relevant Project Activities and Potential Impacts

Planned Project activities that result in a change in how people use the land (for livelihoods or other activities), and/or a change in land occupancy or ownership status, are broadly relevant to the assessment of potential impacts on land use and ownership. This assessment focuses on onshore (i.e., land-based) activities across all Project stages. Related impacts are assessed in Section 9.1, Socioeconomic Conditions (including potential impacts on fishing livelihoods), Section 9.2, Community Health and Wellbeing (including noise-related nuisance for local residents), and Section 9.8, Ecosystem Services (including potential impacts on use of canals and the Demerara River).

Potential impacts considered in this section include:

- Physical displacement or relocation;
- Change in land ownership or status of existing tenure (if not associated with physical displacement or relocation);
- Reduced access to land and natural resources, including potential economic displacement; and
- Change in quality of agricultural harvests.

Table 9.6-5 summarizes the planned Project activities that could result in potential impacts on land use and ownership.

Table 9.6-5: Summary of Relevant Project Activities and Key Potential Impacts—Land Use and Ownership

Stage	Project Activity	Key Potential Impacts
Construction	Onshore pipeline installation; construction of the NGL Plant, heavy haul road, and temporary MOF	• Physical displacement or relocation • Change in land ownership or status of existing tenure • Reduced access to land and natural resources • Change in quality of agricultural harvests
Operations	Onshore pipeline RoW maintenance	• Change in land ownership or status of existing tenure • Reduced access to land and natural resources

No potential impacts on land use or ownership are identified during the Decommissioning stage as the buried onshore pipeline will be decommissioned and left in situ, and decommissioning activities at the NGL Plant will occur within the NGL Plant boundaries and will not affect land owners or land users.

9.6.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for land use and ownership (Table 9.6-6). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for land use and ownership sensitivity are provided in Table 9.6-7.

Table 9.6-6: Definitions for Intensity Ratings for Potential Impacts on Land Use and Ownership

Criterion	Definition
Intensity	**Negligible**: No perceptible change in the household assets, livelihoods, or wellbeing of residents and/or land users.
	Low: Perceptible change in the household assets, livelihoods, or wellbeing of residents and/or land users, for some individuals, but without altering livelihood practices or productivity.
	Medium: Perceptible change in household assets, livelihoods, or wellbeing of residents and/or land users is evident at the group- or community-level. Changes could affect receptors' ability to engage in their current livelihood(s) at the same level of productivity.
	High: Changes result in chronic hardship for residents, land owners, and/or their respective communities, including changes that require receptors to change or cease their current livelihood activities for an extended period of time, or indefinitely.

Table 9.6-7: Definitions for Resource Sensitivity Ratings for Potential Impacts on Land Use and Ownership

Criterion	Definition
Sensitivity	**Low**: Land users are not dependent on the resource for their livelihoods or wellbeing, or alternative areas/resources are readily available and accessible.
	Medium: The resource is important, but not critical, to the livelihoods and wellbeing of land users. The availability or quality of the resource can be replaced or re-established over time.
	High: Land users are highly dependent on the resource for their livelihoods or wellbeing and have little ability to cope with a change to resource availability or accessibility. Or, the resource may be less critical, but is difficult or impossible to replace or re-establish.

9.6.3.3. Impact Magnitude Ratings—Land Use and Ownership

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to land use and ownership is provided in Table 9.6-9.

Physical Displacement or Relocation

The socioeconomic Primary Study Area includes population nodes at various locations between the Atlantic Coast and the temporary MOF on the Demerara River. The primary population nodes are located in the following areas:

- The shore crossing is adjacent to a cluster of residences in the community of Crane.
- The onshore pipeline corridor runs immediately west of the Westminister / Lust-en-Rust housing scheme.
- The onshore pipeline corridor crosses populated areas at Canal 1 and Canal 2.
- East of the NGL Plant, the heavy haul road and temporary MOF sites are proximate to four dwellings that comprise an informal settlement in the South Wales area along the existing overland track that comprises the WBD Public Road.

Construction of the onshore pipeline will involve a combination of open-cut (19.95 kilometers) and HDD (4.94 kilometers) construction methods. One suspected residential property is intersected by the planned onshore pipeline route, near the road approximately 175 meters south of the shore crossing; this property will not be maintained as residential, and any residents will be relocated. Other than this instance, the onshore pipeline is not expected to result in the removal or relocation of existing residences or residents.

Construction of the NGL Plant and ancillary facilities (including the heavy haul road and temporary MOF) will displace up to four dwellings currently located within 500 meters of these facilities, and will also result in the displacement of the existing residents. Based on information provided by the National Industrial and Commercial Investments Limited (NICIL), these dwellings are located on land currently owned by NICIL and are not covered by a recognized land tenure or agreement permitting residency or land use. Regardless, the displacement and relocation of these persons—and the loss of any assets or improvements associated with their use of the land in this area[38]—is recognized as a Project impact.

The Government of Guyana, through NICIL, will be responsible for any land acquisition and relocation of existing residents, including the Crane property and the persons currently living near the proposed heavy haul road and temporary MOF, and will engage directly with the affected persons to establish the relocation process and any available compensation and/or relocation assistance. Guyanese law allows for the Government of Guyana to acquire land through compulsory acquisition, which can lead to expropriation and forced evictions.

[38] Assets or improvements may include dwellings, sheds, other buildings, fences/pens, gardens, crops, docks/wharves, irrigation channels, crops, and/or other livelihood, employment, and income-generating resources.

The relocation of the four households is expected to be an event of **High** intensity for the affected persons, as relocation could represent a lasting adverse change to their security of housing, livelihood, and overall wellbeing. Although relocation will be a one-time event, the consequence will be **Continuous** and **Long-term**. In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of potential impacts of physical relocation on affected persons is considered to be **Large.**

Change in Land Ownership or Status of Existing Tenure

In addition to physical displacement or relocation (discussed above), the Project may also result in a change in the nature of land ownership or tenure for all or part of a property, parcel, or land use area. Most notably, a permanent right-of-way (RoW) will be established for the operation and maintenance of the onshore pipeline. Although it is intended to support pipeline operation and maintenance, the permanent RoW (as well as a larger temporary RoW encompassing the permanent RoW) will be established during the Construction stage. Land use in the permanent RoW will be restricted, and growing crops or construction of any structures will not be permitted in the permanent RoW. Creation of the RoW may result in changes to existing private property boundaries and/or the details of licenses, leases, permits, or other tenures related to the use of affected public lands.

Information about specific private properties or public land tenures that will be affected by the Project was not available at the time of writing. However, the onshore pipeline permanent RoW will be approximately 12 meters wide (as described in Chapter 5, Project Description)[39]. Although the onshore pipeline is approximately 25 kilometers long—from the shore crossing to the NGL Plant—it only crosses populated areas in the vicinities of Crane, Canal 1, and Canal 2. Notably, the populated areas at Canal 1 and Canal 2 will be crossed by HDD, avoiding or reducing the physical disturbance of individual properties, although any rights or restrictions associated with the permanent RoW will still be in effect.

This impact assessment considers potential changes to the nature of land ownership (e.g., the rights afforded by a “Certificate of Title” or “Transport of Property”) or to a registered license, lease, permit, or other tenure that allows for use of public lands. In the absence of specific information about private properties or other land tenures, this assessment relies on the general context of the area in order to evaluate this potential impact. Thus, considering the populated areas proximate to the onshore pipeline, potential impacts on existing land ownership or tenure could be experienced in the following areas:

- At the shore crossing near Crane, where there are existing residences and active agricultural activities (mainly rice farming);

[39] The onshore pipeline will require an approximately 23-meter-wide temporary construction RoW during the Construction stage. This temporary RoW will be expanded in certain designated areas, primarily to accommodate the additional area needed to construct HDD crossings beneath some features such as roads and canals. However, the temporary construction RoW will not result in additional changes to land ownership or tenures as affected lands will be restored to pre-disturbance condition. Therefore, this assessment focuses on the permanent RoW, which will be in place throughout the Operations stage.

- Between Crane and Canal 1 (including adjacent to the Westminister / Lust-en-Rust housing scheme), where active rice farming is evident;
- North and south of Canal 1, and north of Canal 2, where active pineapple farming is evident.

Given the uncertainties described above, the potential impact is considered **Low** in intensity. The permanent RoW will largely follow (or be installed within) existing canals, which will minimize impacts on areas that may otherwise be designated as private property or subject to an agricultural tenure. Impacts will be limited to any properties or tenures directly intersected by the permanent RoW, and will not extend more broadly through the community. Any changes in land ownership will be **Continuous** and **Long-term**, as they will be in effect for the life of the Project. In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impact on land ownership and tenure is considered to be **Small.**

Reduced Access to Land and Natural Resources

The Primary Study Area has a long agricultural history. Although many of the large-scale sugarcane and rice fields are now fallow or overgrown, small areas of crops have been identified at various points along the onshore pipeline route. These crops are generally located in proximity to populated areas near Crane / Nouvelle Flanders, Westminister / Lust-en-Rust, Canal 1, and Canal 2. The most common crops are rice and pineapple, although other types of vegetable farming have also been reported during the 2021 household socioeconomic surveys and in local media reports (as discussed in Section 9.6.2.2, Land Use). Grazing occurs in the Primary Study Area; although no communal grazing areas have been identified, areas reportedly used for grazing livestock include the sea wall, fallow sugarcane fields, and along roadsides and dams.

Agricultural activities (crops and livestock) are the most significant land uses in the Primary Study Area, and are therefore the focus of the assessment in this section.[40] The Project's use of land during the Construction and Operations stages will reduce access to affected land for agricultural or other purposes. This loss of access could result in temporary and/or permanent economic displacement for people who may depend on these lands for their livelihoods, employment, and/or income-generating activities. Considering the onshore pipeline route, this impact is relevant to:

- Rice fields north and south of Crane
- Rice fields west of Westminister / Lust-en-Rust
- Pineapple/mixed crops north and south of Canal 1
- Pineapple/mixed crops north of Canal 2

[40] No formal recreational areas have been identified in the Primary Study Area, although local residents are known to use the beach on the Atlantic Coast for recreation and cultural/religious activities. The Project's potential impact on recreational and cultural use of the shoreline is assessed in Section 9.8, Ecosystem Services. Transportation networks also intersect the Primary Study Area, and potential impacts on local roads and traffic are assessed in Section 9.4, Transportation. An extensive network of canals and drainage channels exists throughout the region, and potential impacts on use of canals are addressed in Section 9.3, Social Infrastructure and Services, and Section 9.8, Ecosystem Services.

Additionally, an approximately 2-kilometer-long stretch of small-scale mixed crops has been identified south of the proposed NGL Plant and heavy haul road (as shown on Figure 9.6-4). Although these crops are not within the proposed footprint of temporary or permanent Project infrastructure, they may be a source of livelihood for some or all of the four households near the heavy haul road and temporary MOF who will be physically displaced, as described in the discussion of *Physical displacement or relocation* impacts, above. It is unknown at this time where these individuals will be relocated, or what assistance they may be provided to support relocation. If they are users of these crops (and dependent on the crops for livelihoods), and if they are relocated substantially farther away from these crops (so that reasonable access is not maintained), then the loss of access to these crops would constitute economic displacement for the affected persons. There are also indications of subsistence sugarcane farming and cattle grazing on and/or near the NGL Plant site (Chapter 5, Project Description). The construction of the NGL Plant and heavy haul road will involve vegetation clearance and infrastructure construction, thereby removing this area from agricultural/grazing use for the life of the Project.

Construction Stage

Surface disturbance during the Construction stage (including construction of the onshore pipeline, NGL Plant, ancillary facilities, and temporary construction areas[41]) will affect an estimated 16.82 hectares of active rice farming, 3.08 hectares of active pineapple/mixed crops farming, and 8.25 hectares of inactive sugarcane fields. The remainder of the surface disturbance area is mostly associated with grasslands, shrublands, swamps, bamboo, palm, early successional forests, and other vegetation, much of which is found in overgrown (inactive) fields.

Combined, the affected rice and pineapple farming areas amount to an estimated 19.89 hectares, representing approximately 14.4 percent of the total surface disturbance during the Construction stage. However, if the permanent onshore pipeline RoW (discussed below for the Operations stage) is excluded, the temporary construction areas will remove access to 11.29 hectares of existing rice fields, and 2.64 hectares of pineapple/mixed crops.

The total number of land users affected, and degree of dependency on agricultural activities, is not known at the time of writing. However, it is expected that this change will represent a perceptible change for multiple households and/or land users along the onshore pipeline route, and could affect their ability to engage in their current livelihood(s) at the same level of productivity; thus, the impact is considered to have a **Medium** intensity.

For the mixed crops identified south of the proposed NGL Plant and heavy haul road, the potential loss of access to croplands resulting from physical displacement would be more significant, and could result in chronic hardship for affected farmers. Under the conservative assumption that the households to be physically displaced are users of these crops *and* will be relocated sufficiently distant from these crops to effectively amount to economic displacement, this impact is thus considered to have a **High** intensity. Similarly, at or near the NGL Plant site,

[41] Temporary surface disturbance includes construction areas that will be restored following the completion of construction activities.

the loss of lands used for subsistence sugarcane farming and cattle grazing could also amount to economic displacement for affected farmers (regardless of physical displacement scenarios), and this impact is also considered to have a **High** intensity.

Temporary construction areas will be restored to pre-construction condition, but as the change will persist for more than a year, this impact is considered to be **Continuous** and **Long-term**. For the presumed economic displacement of residents from crops near the NGL Plant and temporary MOF, the impact will also be **Long-term**, as it would be a permanent change initiated during the Construction stage. Based on the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the loss of access to land and natural resources (and potential economic displacement) is considered to be an impact of **Medium** magnitude for affected farmers along the onshore pipeline route, and an impact of **Large** magnitude for potentially displaced farmers near the NGL Plant and temporary MOF.

Operations Stage

The surface area affected by the approximately 12-meter-wide, permanent onshore pipeline RoW during the Operations stage is significantly smaller than the surface disturbance during the Construction stage. The permanent RoW will remove 5.52 hectares of existing rice fields and 0.44 hectare of existing pineapple/mixed crops. It will also remove 2.13 hectares of currently inactive sugarcane fields from potential future agricultural use. Combined, this will amount to 8.09 hectares of active or fallow agricultural fields that will be removed from potential future agricultural use to accommodate the operation and maintenance of the onshore pipeline RoW.

The total number of land users affected by the permanent RoW, and degree of dependency on agricultural activities, is not known at the time of writing. The relatively narrow, linear nature of the permanent RoW should reduce the impact on any single farmer or landowner and avoid chronic hardship for a person, household, or community, and the design and routing of the RoW has aimed to reduce impacts on actively cultivated fields. Considering that the permanent RoW will follow existing canals and/or drainage channels (or be constructed in them) in many areas, it is expected that this change will still represent a perceptible change, but should not significantly alter farmers' abilities to engage in their current livelihood(s) at a similar level of productivity. Accordingly, this impact is conservatively considered to be a **Low** intensity. The permanent RoW restrictions will be in place for the duration of the Operations stage; therefore, the impact is **Continuous** and **Long-term**, resulting in an impact of **Small** magnitude during the Operations stage.

Change in Quality of Agricultural Harvests

In addition to the evaluation of physical displacement and reduced access to land described above, this assessment considers a potential impact related to a change in the quality of agricultural crops harvested from the Primary Study Area. This could result as an indirect effect of potential changes related to soils, water quality or availability, and/or dust deposition. These changes could conceivably extend beyond the Project footprint to affect adjacent areas.

As noted in the preceding section, actively farmed land is at various locations along the onshore pipeline corridor between the shore crossing and Canal 2, including plots of rice, pineapple, and mixed vegetable crops. Figure 9.6-4 shows the distribution of these land uses in the Primary Study Area, within 500 meters of the onshore pipeline.

Section 7.2, Soils, evaluates the potential that the Project could contribute to loss of, or damage to, agricultural soils. This section concludes that, with embedded controls—including restoration of agricultural areas to their pre-construction conditions to support continued agricultural use—the potential impact will be **Negligible** in intensity. Section 8.4, Freshwater Biodiversity, contemplates changes to the water quality of canals through sedimentation and erosion (as a result of riparian habitat disturbance) and concludes that the intensity of impact will be **Negligible** in the areas proximate to active farming where riparian vegetation consists of intensively managed herbaceous vegetation. Based on the conclusions of these sections, changes to agricultural harvests in areas adjacent to the onshore pipeline are not expected to occur as a result of changes to soils, water quality, or water availability.

Construction activities could generate dust through vegetation clearing, earthworks, and movement of equipment and vehicles on unpaved surfaces. Dust emissions from construction areas could be deposited on nearby crops, and could adversely affect crop growth or productivity. The distribution of dust deposition will be influenced by prevailing weather conditions, including wind and precipitation. As described in Section 7.6, Air Quality, embedded controls that will be in place for dust management include, among others, good industry practices to minimize dust emissions. Dust levels will be actively monitored so that additional dust management measures can be implemented if required. Timely revegetation of disturbed areas will also be implemented following construction and will provide lasting dust management; success of revegetation efforts will also be monitored.

Dust deposition during the Construction stage has not been quantitatively modeled, but a semi-quantitative analysis has been conducted to assess areas along the onshore pipeline corridor where there could be concerns regarding potential dust impacts. Considering the proximity of rice, pineapple, and other crops to the onshore pipeline corridor, this is conservatively considered to be an impact of **Medium** intensity, as it has the potential to affect agricultural productivity and related livelihoods, but is not expected to result in chronic hardship. The frequency will be **Episodic**, as impacts will change as construction activities change in nature and location along the onshore pipeline corridor, and **Medium-term**, as dust emissions in a particular location may last for more than a week (but definitely less than a year). In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of the potential impact of dust deposition on agricultural harvests is considered to be **Small.**

9.6.3.4. Sensitivity of Resource—Land Use and Ownership

Based on the sensitivity rating definitions in Table 9.6-7, the resource sensitivity for land use and ownership will vary depending on the receptor. People living near the temporary MOF, or the shore crossing, are considered to have a **High** sensitivity to physical displacement or relocation impacts, as they may have insecure land tenure and little ability to cope with change related to relocation. Similarly, people living near the temporary MOF are also considered to have a **High** sensitivity to change in access to land and natural resources. For all other impacts and receptors, sensitivity to land use and ownership impacts is considered to be **Medium**.

9.6.3.5. Pre-mitigation Impact Significance—Land Use and Ownership

Assuming implementation of the embedded controls listed in Table 9.6-9, the intensity ratings for potential Project impacts on land use and ownership will range from **Low** to **High**. Impacts with **High** intensity include those related to physical and economic displacement. This results in pre-mitigation magnitude ratings ranging from **Minor** to **Major**. Coupled with sensitivity ratings of **Medium** (for most receptors proximate to the onshore pipeline, related to economic displacement) and **High** (for households subject to physical displacement or relocation), the pre-mitigation impact significance for land use and ownership ranges from **Minor** to **Major**.

9.6.4. Impact Management and Monitoring Measures

Three potential land use and ownership impacts are predicted to have a pre-mitigation significance of **Minor**; therefore, mitigation measures are not required for these potential impacts. It is noted, however, that these assessments are supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register; and Table 9.6-9). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

The impacts with higher pre-mitigation significance (**Moderate** to **Major**) are related to physical and economic displacement. To mitigate the impact, the recommended mitigation measure is for EEPGL to support the Government of Guyana to plan and implement a Resettlement and Livelihood Restoration Strategy in alignment with international standards, as described below.

Resettlement and Livelihood Restoration Strategy

The Government of Guyana is responsible for land acquisition, including the relocation of the residents currently living near the proposed heavy haul road and temporary MOF, and near Crane. EEPGL will support the Government of Guyana in this process with the intention that Project-related land acquisition, resettlement, and livelihood restoration activities and/or related support is aligned with internationally recognized good practice for resettlement as defined by IFC Performance Standard 5 (PS 5): Land Acquisition and Involuntary Resettlement.

The key commitments and steps involved in the land acquisition and resettlement process are outlined below, with the overall objective that the quality of life for all affected persons and households is maintained or improved in all cases. The scope of this process includes (1) the management of physical displacement and economic displacement, and (2) potentially affected persons or households regardless of the legal status of land or property tenure.

Key Commitments

- Avoid (or minimize if avoidance is not possible) displacement by exploring alternative project designs.[42]
- Avoid forced eviction.
- Provide for appropriate disclosure of information, as well as the informed consultation and participation of those affected.
- Seek negotiated settlements with those affected, to help avoid expropriation.
- Provide compensation for lost assets at their full replacement value, along with supportive measures to help those affected to improve (or at least restore) their livelihoods and standards of living.
- Provide those affected by physical displacement with resettlement support and security of tenure to prevent future eviction.
- Provide opportunities for those affected to derive development benefits from Project.

Process Steps

Table 9.6-8 provides a framework for a Resettlement and Livelihood Restoration Strategy in alignment with internationally recognized good practice for resettlement and livelihood restoration. EEPGL will support the Government of Guyana to further develop this framework including determination of roles and responsibilities and timelines. This process will apply to all documented occupants and land users, regardless of the nature or status of their land ownership or tenure.

Table 9.6-8: Resettlement and Livelihood Restoration Strategy Steps

Phase	Steps [a]
Phase 1 – Prepare Resettlement and Livelihood Restoration Strategy	1. Review the national legal framework, identify any gaps between national requirements/plans/actions and those of IFC PS 5, and determine how to bridge these effectively. 2. Prepare and implement an engagement plan with those affected and other stakeholders. Include a feedback mechanism to receive and resolve concerns related to resettlement. 3. Work with local authorities to establish and publicize a clear cut-off date for compensation planning purposes. Once in place, administer a census of affected people and households, a socioeconomic survey, and a detailed inventory of affected immoveable assets. 4. Determine who will be eligible for what kind of compensation entitlements, and prepare an entitlement matrix. Determine the specific types and amounts of compensation to be provided, including cash compensation rates and conceptual plans or designs for any replacement assets. 5. Design supportive measures, including those relating to livelihood restoration, vulnerable persons support, and any other appropriate assistance. Define monitoring and evaluation measures.

[42] The Project design has already minimized displacement through selection of the onshore pipeline route, location of the NGL Plant and ancillary infrastructure, and selection of construction methods (including HDD crossing of populated areas).

Phase	Steps [a]
	6. Develop an implementation plan, including team roles and responsibilities, work plan, schedule, and budget. 7. Prepare the Resettlement and Livelihood Restoration Strategy document, disclose it publicly, and finalize it considering comments received.
Phase 2 – Implement Strategy and Secure/ Access Land	1. Continue to engage with those affected. 2. Undertake individual household negotiations and sign individual resettlement agreements, using the survey results, as well as the eligibility, entitlements, and supportive measures defined in the Resettlement and Livelihood Restoration Strategy. 3. Finalize entitlement arrangements, including processes for compensation, plans/designs/construction of any replacement assets, purchase of any replacement lands, etc. 4. Finalize supportive measures, including implementation arrangements. 5. Deliver entitlements to those affected and secure/access land for Project use.

[a] The specific steps identified in this table are aligned with good practice as defined by IFC Performance Standard 5 (Land Acquisition and Involuntary Resettlement). The details of specific steps may be adjusted in a manner that is reasonable and practicable for the specific context of the Project, while maintaining the overall intent and objectives of good practice for resettlement and livelihoods restoration.

Table 9.6-9 summarizes the management and monitoring measures relevant to land use and ownership.

Table 9.6-9: List of Management and Monitoring Measures

Embedded Controls
Develop and implement a SEP that includes measures for continued engagement with communities, including potentially affected residents and landowners.
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) prior to onset of Project activities. Take measures to promote the CGM being well publicized and understood by the public, including potentially affected residents and landowners.
Use appropriate control measures to minimize dust arising from construction works (e.g., watering of roads or exposed surfaces during dry conditions).
Mitigation Measures
Support the Government of Guyana to develop and implement a Resettlement and Livelihood Restoration Strategy for resettlement (for physical displacement) and livelihood restoration (for economic displacement) through a process that aligns with IFC Performance Standard 5.
Undertake early liaison with the potentially affected users of agricultural lands prior to construction, as part of the stakeholder engagement plan, to inform them of the work activities and feedback/complaints procedure.
Based on the result of dust monitoring during onshore pipeline construction, develop additional mitigations, as needed.
Monitoring Measures
Monitor frequency of engagement with stakeholders communities, including local residents and farmers, proximate to construction areas.
Track number and types of complaints received and resolved via the Project CGM; adjust the CGM and other management measures on an ongoing basis, as appropriate, based on feedback received. Disaggregate the data by location of complainant (e.g., community, Georgetown, other location).
Monitor average time for processing and resolution of grievances.
Track percentage of grievances resolved.

Embedded Controls
During construction, monitor dust levels along portions of the onshore pipeline corridor with agricultural lands in close enough proximity to potentially be affected by dust emissions.

9.6.5. Assessment of Residual Impacts

EEPGL's support to the Government of Guyana to implement a Resettlement and Livelihood Restoration Strategy that is aligned with international standards is an important mitigation measure to manage potential impacts related to physical and economic displacement. However, given the uncertainty associated with the government-led land acquisition process at the time of writing, the assessment conservatively assumes that some **Moderate** significance residual impacts may persist. This includes the potential impacts related to physical displacement and reduced access to land and natural resources (and potential economic displacement) during the Construction stage. The residual significance of reduced access to land and natural resources related to construction of the onshore pipeline is conservatively maintained as **Moderate** due to the length of the onshore pipeline corridor and uncertainty about the number of potentially affected land users. The residual significance of other potential impacts are maintained as **Minor**.

Table 9.6-10 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on land use and ownership.

Table 9.6-10: Summary of Potential Pre-Mitigation and Residual Impacts—Land Use and Ownership

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Physical displacement or relocation	High	Large	Major	Resettlement and Livelihood Restoration Strategy	Moderate
Construction Operations	Change in land ownership or status of existing tenure	Medium	Small	Minor	None	Minor
Construction	Reduced access to land and natural resources (and potential economic displacement): *construction of onshore pipeline and temporary construction areas*	Medium (onshore pipeline)	Medium (onshore pipeline)	Moderate	Resettlement and Livelihood Restoration Strategy	Moderate
	Reduced access to land and natural resources (and potential economic displacement): *indirect effect of physical displacement or relocation*	High (NGL Plant and temporary MOF)	Large (NGL Plant and temporary MOF)	Major	Resettlement and Livelihood Restoration Strategy	Moderate
	Reduced access to land and natural resources (and potential economic displacement): *NGL Plant and heavy haul road*	High (NGL Plant and heavy haul road)	Large (NGL Plant and heavy haul road)	Major	Resettlement and Livelihood Restoration Strategy	Moderate
Operations	Reduced access to land and natural resources (and potential economic displacement): onshore pipeline RoW	Medium	Small	Minor	None	Minor
Construction	Change in quality of agricultural harvests	Medium	Small	Minor	Dust monitoring and adaptive management	Minor

9.7. Landscape, Visual Resources, and Light

This section describes existing conditions regarding landscape, visual resources, and light in the Project AOI and discusses potential impacts on these resources, including the potential impacts of artificial light from the Project.

9.7.1. Baseline Methodology

9.7.1.1. Landscape and Visual Resources

The methodology used in the landscape and visual resources assessment reflects good international industry practice and is generally consistent with the visual assessment methodology applied by the U.S. Forest Service's (USFS's) Scenery Management System (USFS system). This approach involves characterizing landscapes in terms of their scenic integrity (i.e., the degree of intactness and wholeness of the landscape character) and identifying key viewpoints (i.e., publicly accessible locations with important, valued, or sensitive views, often involving natural, historical, recreational, or cultural features) and visually sensitive resources. Scenic integrity is expressed in this system in terms of the following levels (USFS 1995):

- Very high—refers to landscapes where the valued landscape character is intact, with only minute—if any—deviations. The existing landscape character and sense of place is expressed at the "highest possible level."
- High—refers to landscapes where the valued landscape character "appears" intact. Deviations may be present, but must repeat the form, line, color, texture, and pattern common to the landscape character so completely and at such a scale that they are not evident.
- Moderate—refers to landscapes where the valued landscape character "appears slightly altered." Noticeable deviations must remain visually subordinate to the landscape character being viewed.
- Low—refers to landscapes where the valued landscape character "appears moderately altered." Deviations begin to dominate the valued landscape character being viewed.
- Very low—refers to landscapes where the valued landscape character "appears heavily altered." Deviations may strongly dominate the valued landscape character.
- Unacceptably low—refers to landscape where the valued landscape character being viewed appears extremely altered. Deviations are extremely dominant and borrow little if any form, line, color, texture, pattern, or scale from the landscape character.

The visual impact assessment process involves evaluating the extent to which the Project will alter the landscape character by introducing features among scenic attributes that change the overall scenic integrity, especially where they may affect visually sensitive resources and/or key viewpoints.

9.7.1.2. Light

No applicable standards for assessment of light impacts were identified. The IFC Performance Standards include light in their definition of "pollution" (i.e., in the context of a potential visual impact); however, no light emission standards have been established by the IFC.

9.7.2. Existing Conditions and Baseline Studies

9.7.2.1. Landscape and Visual Resources

The existing landscape character was characterized based on field observation within the Project AOI, documenting scenic integrity using photographs. The following four general landscapes were identified:

- Guyana shoreline and Atlantic Ocean
- Mixed residential, commercial, and agricultural areas
- Fallow agricultural land
- Demerara River

The landscape character of these landscapes and any identified key viewpoints are briefly described below. There are no designated public recreation areas, historic sites, or cultural sites within the Direct AOI.

Atlantic Ocean and Guyana Shoreline

The Atlantic Ocean near the pipeline shore landing location presents an expansive natural vista extending uninterrupted to the horizon. The pipeline shore landing will be just west of the community of Vreed-en-Hoop in an area of exposed (at low tide) mud flats that has been improved with a berm and rip-rap for sea defense (Figure 9.7-1). The scenic integrity of this landscape is moderate, based on the USFS system, as there are beautiful ocean views, but the shoreline has been modified with the sea defense features.

Key viewpoint:

- Pipeline shore landing west of Vreed-en-Hoop, especially the view of the ocean. The open ocean is considered a visually sensitive resource.

Figure 9.7-1: **View Facing Northeast from the Guyana Coastline near the Proposed Pipeline Shore Landing**

Mixed Residential, Commercial, and Agricultural Areas

After the shore landing, the onshore pipeline will traverse land with a mix of residential houses and commercial and institutional (e.g., places of worship) buildings, interspersed with active agricultural areas (primarily rice; see Figure 9.7-2) for the next approximately 14 kilometers. The buildings are generally low-rise (mostly one- and two-story buildings) in nature, with some built on stilts because of flooding concerns. Some of the communities near the pipeline route include the western edge of Vreed-en-Hoop, Onderneeming, Westminister, and La Parfaite Harmonie. These communities have been developed in two patterns:

- Linear pattern of low-density buildings, typically along roads and/or canal s (Figure 9.7-3); and
- Grid pattern of buildings, roads, and associated drainage canals, which stands out as the dominant visual character (Figure 9.7-4).

The scenic integrity of this landscape is low based on the USFS system, as it has been moderately altered by agricultural and clusters of mixed-use development.

Key viewpoints for these landscapes include:

- Pipeline crossing of the West Coast Demerara Public Road, as this is the most heavily trafficked road that will be affected by the Project;
- Pipeline crossing of Canal 1; and
- Pipeline crossing of Canal 2 (Figure 9.7-5).

No visually sensitive resources were identified for these landscapes.

Figure 9.7-2: Representative View of Rice Fields Present in the Vicinity of the Direct AOI

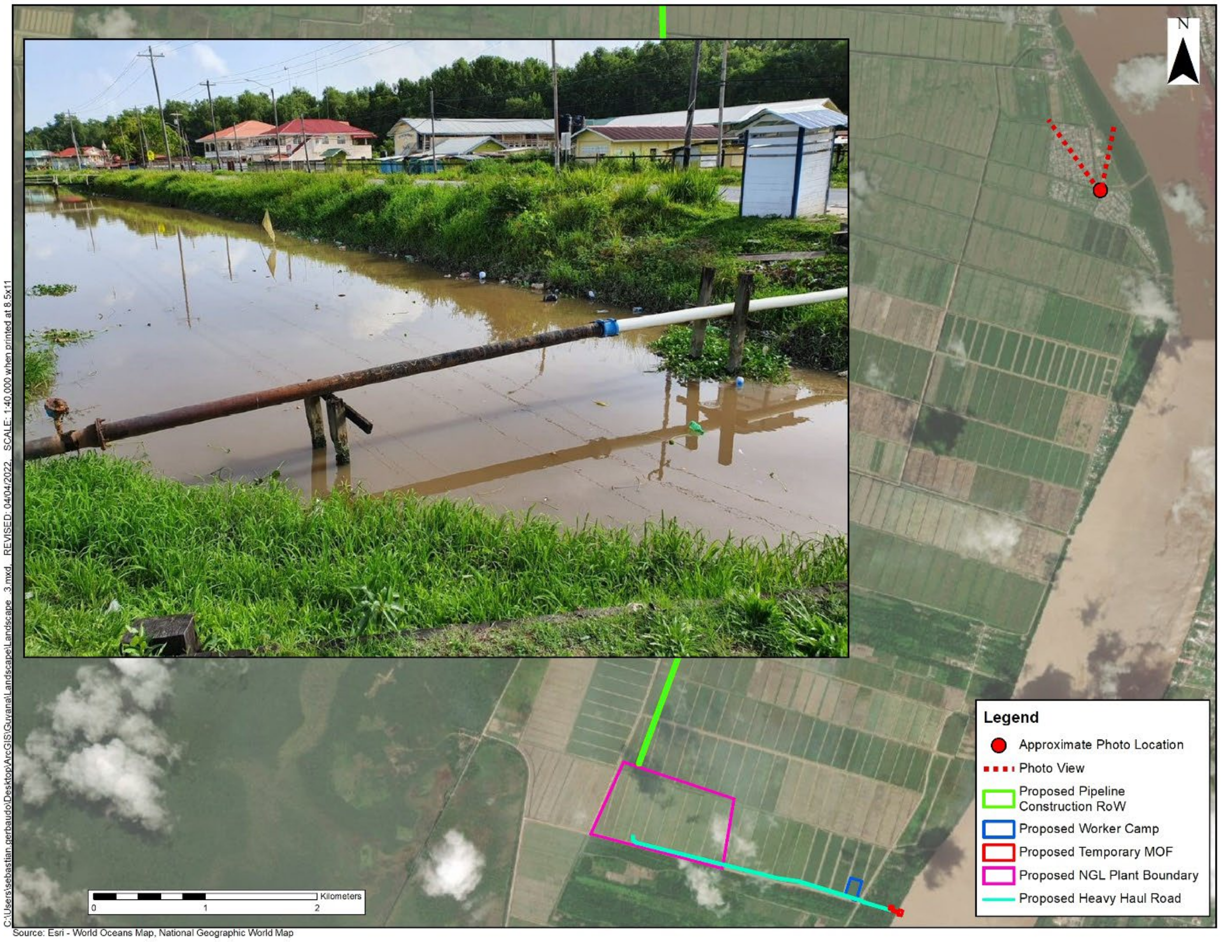


Figure 9.7-3: Representative View of Linear Development Pattern along Roads and Canals at Patentia—near the Direct AOI

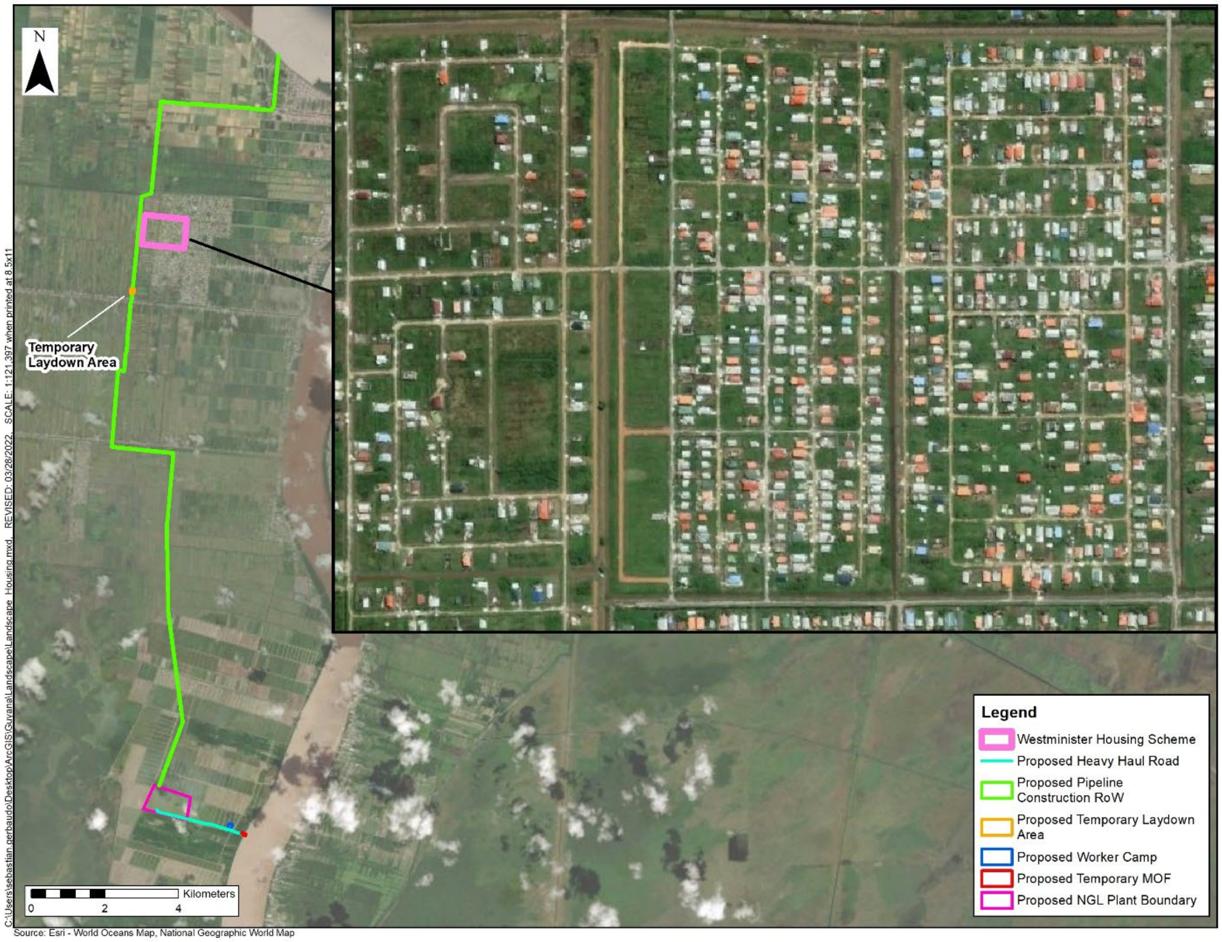


Figure 9.7-4: Representative Aerial View of a Grid Pattern Development in the Westminister Housing Area

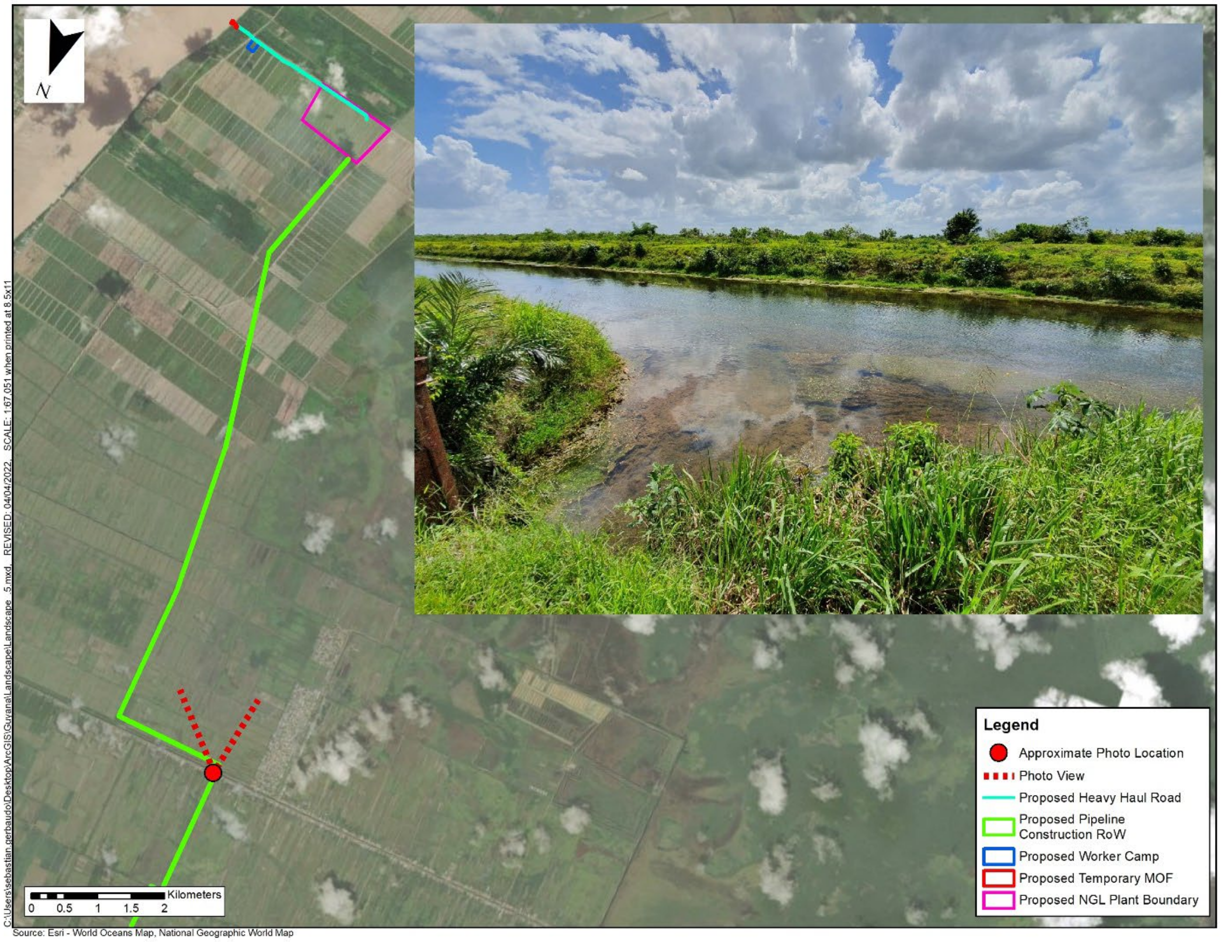


Figure 9.7-5: View of Canal 2 near the Proposed Pipeline Crossing

Fallow Agricultural Land

The last approximately 13 kilometers of the pipeline, as well as the NGL Plant, are located in the Wales Estate, which was the former GuySuCo sugar cane plantation. The landscape of this area is dominated by drainage ditches and fallow agricultural land, the latter of which is slowly converting from sugar cane to low grasses and shrubs (Figures 9.7-6 and 9.7-7). Some small trees and more mature vegetation have formed along the edges of the canals and other wetter areas.

The scenic integrity of this landscape is low based on the USFS system, as it reflects a moderately altered landscape that is now converting back to a more natural landscape through natural succession. No key viewpoints or visually sensitive resources were identified in this landscape.

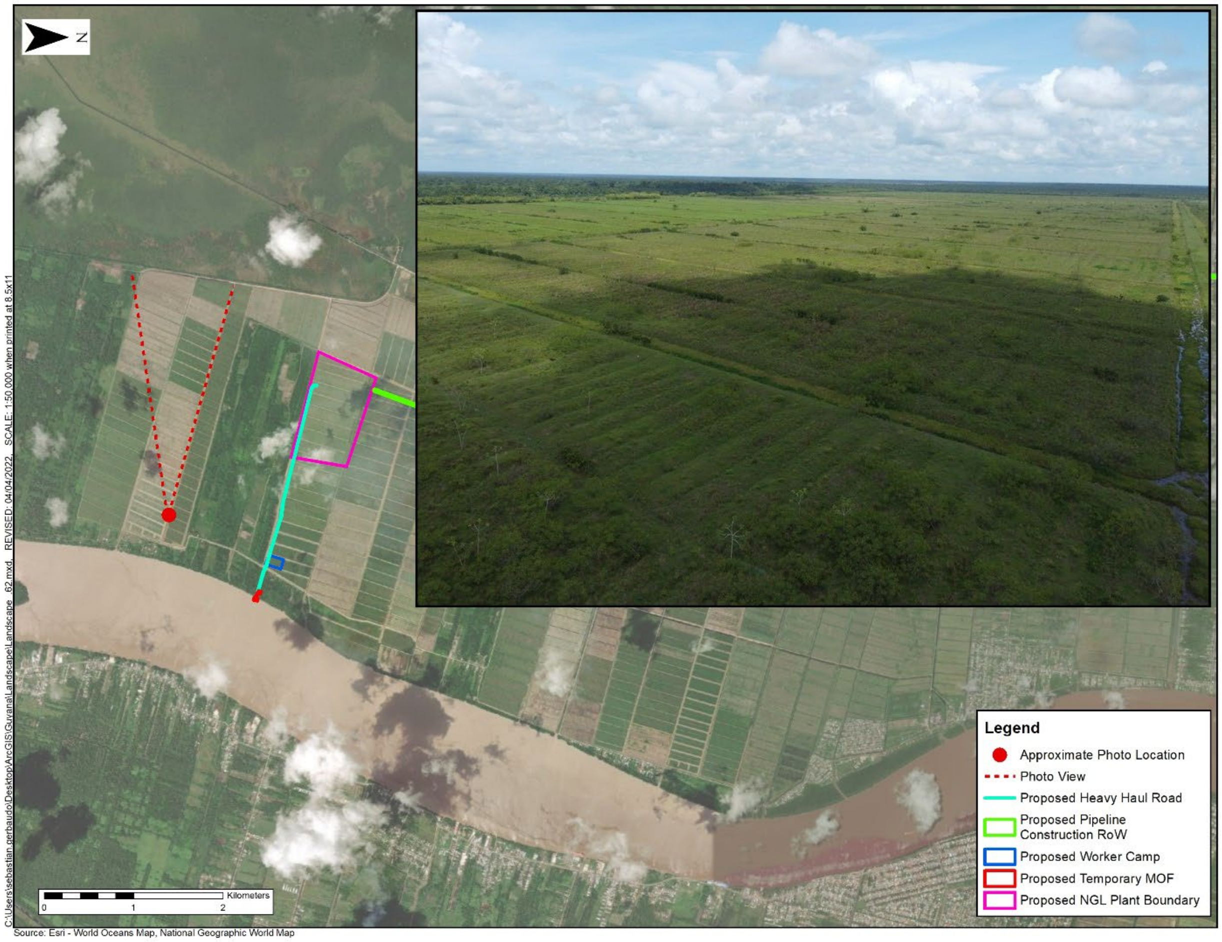


Figure 9.7-6: Representative Aerial View of the Fallow Agricultural Landscape in Relationship to Project Components

Figure 9.7-7: Representative Foreground View of Fallow Agricultural Landscape and Associated Canal

Demerara River

The Demerara River is a key landscape feature of the Project area, as it runs to the east of the onshore pipeline and the NGL Plant, and portions of it from the temporary MOF to its mouth are included in the Direct AOI. The shorelines of the Demerara River—in particular the portions closest to the river mouth—have been heavily modified with various commercial and industrial facilities, residential development, and sea defense structures. Additionally, the Demerara Harbour Bridge crosses the Demerara River approximately 16 kilometers downriver from the proposed temporary MOF location. This development is more significant along the East Bank, where it extends for more than 25 kilometers upstream from the mouth of the Demerara River to the Land of Canaan and even further south. The West Bank of the river is less intensively developed, but is still heavily modified for about 16 kilometers upstream from the river mouth, other than fringes of mangroves found at various locations along the shoreline.

The proposed temporary MOF is located in this landscape along a rural, agricultural, low-density residential area with some piers extending from the West Bank into the Demerara River (Figure

9.7-8). The scenic integrity of this landscape is moderate based on the USFS system, given its mostly natural character, but with some anthropogenic intrusion s (e.g., piers).

The principal key viewpoint for this landscape includes:

- From the river looking toward the West Bank of the Demerara River

The naturally vegetated shoreline along the West Bank of the Demerara River is considered a visually sensitive resource.

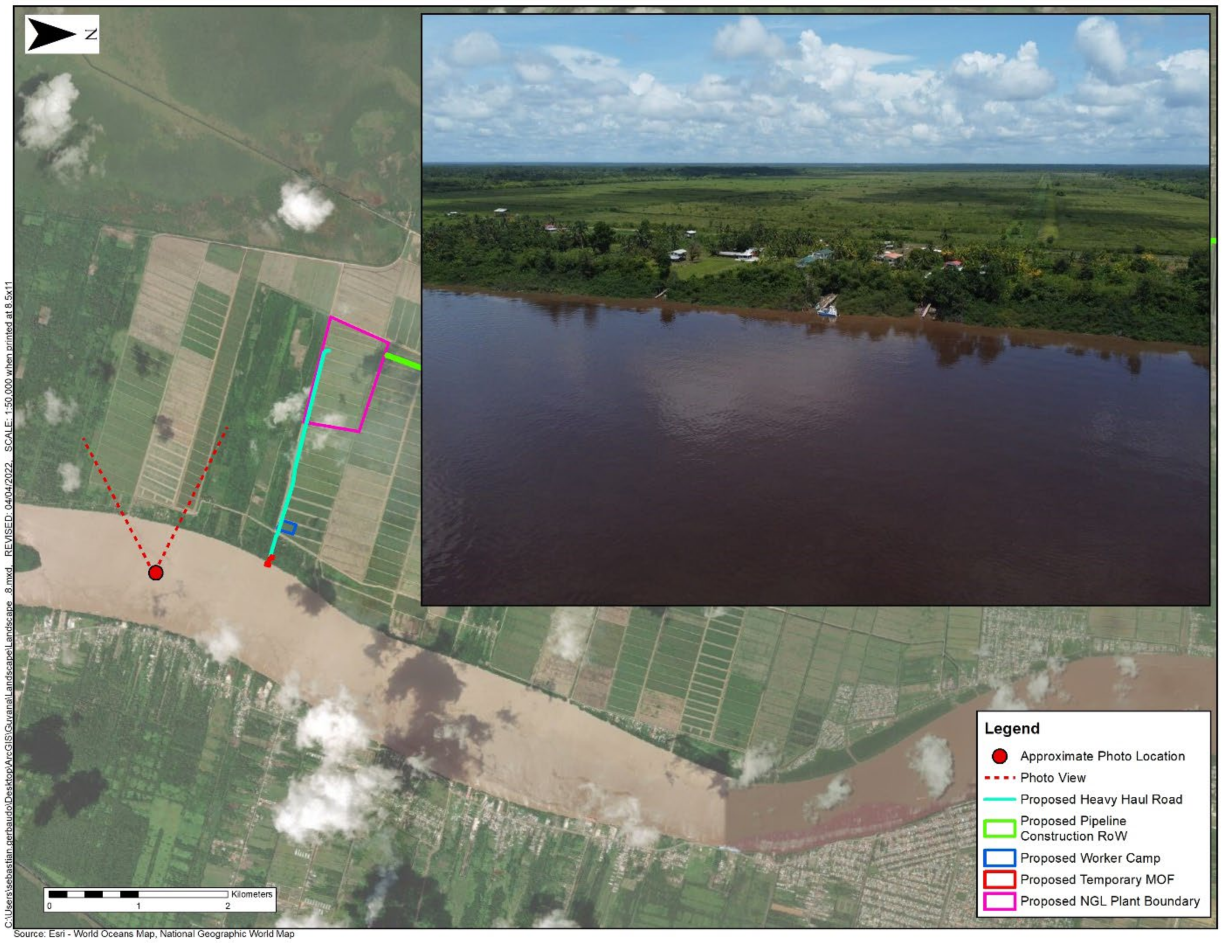


Figure 9.7-8: Representative Aerial View of the West Bank of the Demerara River near the Proposed Temporary MOF

9.7.2.2. Nighttime Light Conditions

No field measurements were conducted for the purpose of characterizing baseline nighttime visual conditions in the Direct AOI. For context, the Project Footprint will cross a variety of land uses—including undeveloped land and agricultural areas—with little to no anthropogenic light sources, as well as residential/commercial areas and transportation corridors with heavier concentrations of anthropogenic light sources.

9.7.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on the scenic and visual character of the surrounding landscape, as well as the impacts of artificial lighting on nighttime visual conditions. The relevant planned Project activities and the associated potential impacts of these activities on the scenic and visual character of the surrounding landscape are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.7.3.1. Relevant Project Activities and Potential Impacts

Table 9.7-1 summarizes the planned Project activities that could result in potential impacts on the scenic and visual character of the landscape in the vicinity of the Direct AOI.

Table 9.7-1: Summary of Relevant Project Activities and Key Potential Impacts—Landscape and Visual Resources

Stage	Project Activity	Key Potential Impacts
Construction	Construction of offshore pipeline; shore crossing; onshore pipeline; NGL Plant; and temporary MOF	Temporary alteration of scenic and visual character of landscape from key viewpoints and in sensitive visual landscapes (i.e., as a result of presence of construction equipment/ or activities), where present
Operations	Post-construction presence of offshore pipeline; shore crossing; onshore pipeline; NGL Plant; and temporary MOF	Ongoing alteration of scenic and visual character of landscape from key viewpoints and in sensitive visual landscapes, where present

9.7.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity), and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for landscape and visual resources (see Table 9.7-2) and nighttime visual conditions (see Table 9.7-3). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for landscape and visual resource sensitivity are provided in Table 9.7-4, and the definitions for nighttime visual conditions are provided in Table 9.7-5.

For the purpose of assessing the significance of potential impacts on this resource, separate discussions are provided for potential impacts on the surrounding landscape and nighttime visual setting from the following Project components:

- Offshore Pipeline
- Shore Crossing
- Onshore Pipeline
- NGL Plant
- Temporary MOF

Table 9.7-2: Definitions for Intensity Ratings for Potential Impacts on Landscape and Visual Resources

Criterion	Definition
Intensity	**Negligible**: No significant changes to scenic integrity at key viewpoints or visually sensitive resources, or scenic integrity change is perceptible at one or more key viewpoints or visually sensitive resources, but is not significant enough to result in a change in its scenic integrity level. [a]
	Low: Scenic integrity change occurs at one or more key viewpoints or visually sensitive resources, but is limited to a reduction of no more than one scenic integrity level.
	Medium: Scenic integrity change occurs at one or more of the key viewpoints or visually sensitive resources, and results in a reduction of two or more scenic integrity levels.
	High: Scenic integrity change occurs at one or more of the key viewpoints or visually sensitive resources, and results in a reduction of three or more scenic integrity levels.

[a] See Section 9.7.1, Baseline Methodology, for descriptions of scenic integrity levels.

Table 9.7-3: Definitions for Intensity Ratings for Potential Impacts on Nighttime Visual Setting

Criterion	Definition
Intensity	**Negligible**: No significant change to the nighttime setting at key viewpoints or visually sensitive resources, or the nighttime setting change is perceptible at one or more of the key viewpoints or visually sensitive resources, but the change is not significant enough to result in a change in its scenic integrity level. [a]
	Low: Nighttime setting change occurs at one or more of the key viewpoints or visually sensitive resources, but is limited to a reduction of no more than one scenic integrity level.
	Medium: Nighttime setting change occurs at one or more of the key viewpoints or visually sensitive resources, and results in a reduction of two or more scenic integrity levels.
	High: Nighttime setting change occurs at one or more of the key viewpoints or visually sensitive resources, and results in a reduction of three or more scenic integrity levels.

[a] See Section 9.7.1, Baseline Methodology, for descriptions of scenic integrity levels.

Table 9.7-4: Definitions for Resource Sensitivity Ratings for Potential Impacts on Landscape and Visual Resources

Criterion	Definition
Sensitivity	**Low**: Visually affected areas include landscape with scenic integrity levels [a] of Low, Very Low, or Unacceptably Low.
	Medium: Visually affected areas include landscapes with scenic integrity levels of Moderate
	High: Visually affected areas include landscapes with scenic integrity levels of Very High or High.

[a] See Section 9.7.1, Baseline Methodology, for descriptions of scenic integrity levels.

Table 9.7-5: Definitions for Resource Sensitivity Ratings for Potential Impacts on Nighttime Visual Setting

Criterion	Definition
Sensitivity	**Low**: Visually affected areas include nighttime settings with scenic integrity levels [a] of Low, Very Low, or Unacceptably Low.
	Medium: Visually affected areas include nighttime settings with scenic integrity levels of Moderate
	High: Visually affected areas include nighttime settings with scenic integrity levels of Very High or High.

[a] See Section 9.7.1, Baseline Methodology, for descriptions of scenic integrity levels.

9.7.3.3. Magnitude Ratings—Landscape, Visual Resources, and Light

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to landscape and visual resources, including the nighttime visual setting, is provided in Table 9.7-6.

Offshore Pipeline

The area west of Vreed-en-Hoop, especially the view of the ocean, is considered a key viewpoint, with the open ocean considered a visually sensitive resource. During the portion of the offshore pipeline installation within view of shoreline, a change to the scenic integrity of the landscape will be perceptible. Once installed, the offshore pipeline will be underwater and not visible from on the water or from onshore viewpoints. The scenic integrity of the ocean and shoreline landscape is rated as moderate, based on the USFS system, as there are beautiful ocean views, but the shoreline has been modified with the sea defense features.

For the period of time when offshore pipeline construction is occurring within view of the shoreline, the scenic integrity level may change by up to one level, but any such change will cease to exist post-construction. Accordingly, the intensity of the potential impacts from the offshore pipeline is rated as **Low** for the Construction stage and **Negligible** for the Operations stage. The scenic and visual impact will be **Continuous** during the period of pipeline installation (for the Construction stage) and for as long as the pipeline is present once installed (for the Operations stage). The impact for the Construction stage will be more than a week but less than a year for the Construction stage (**Medium-term**) and more than a year for the Operations stage (**Long-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment

Methodology, the magnitude of this potential impact from the offshore pipeline is rated as **Small** for the Construction stage and **Negligible** for the Operations stage**.**

The key viewpoint in the area west of Vreed-en-Hoop has a nighttime setting scenic integrity rating of moderate. Similar to the daytime shoreline landscape, the same open ocean views are present with limited existing artificial lighting. Light trespass from the City of Georgetown is present. Project construction would change the nighttime setting integrity level up to one level during construction activity. The intensity of the potential lighting impacts from the offshore pipeline is rated as **Low** for the Construction stage and **Negligible** for the Operations stage. The impact on the nighttime setting will be **Continuous** during pipeline installation (for the Construction stage) and for as long as the pipeline is present once installed (for the Operations stage). The impact for the Construction stage will be more than a week, but less than a year, for the Construction stage (**Medium-term**) and more than a year for the Operations stage (**Long-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact from the offshore pipeline is rated as **Small** for the Construction stage and **Negligible** for the Operations stage**.**

Shore Crossing

The offshore pipeline shore crossing has the potential to impact the scenic and visual character of the Guyana shoreline (a key viewpoint with a moderate scenic integrity rating, as noted above). EEPGL proposes to construct this section of the pipeline using HDD techniques, so the pipeline will not be visible. An aboveground beach valve station will be installed near the shore crossing, but this will be relatively low-profile and landward of the shoreline in a less sensitive visual location as compared to shoreline. There will be no significant changes to scenic integrity of the shore crossing area (as the installation will occur underground with no surface disturbance).

On this basis, the intensity of the potential impacts from the shore crossing during the Construction stage is rated as **Negligible** for an HDD approach. The scenic and visual impact will be **Continuous** during the period of shore crossing installation (for the Construction stage) and for as long as the pipeline is present once installed (for the Operations stage). The impact for the Construction stage will be more than a week but less than a year for the Construction stage (**Medium-term**) and more than a year for the Operations stage (**Long-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact from the offshore pipeline is rated as **Negligible** for both the Construction and Operations stages.

Impacts of the shoreline crossing on the nighttime visual setting would have the same intensity designations and impact ratings as the landscape and visual assessment. Security and safety lighting will be located on the aboveground equipment as necessary. Therefore, the potential nighttime setting impacts will be **Continuous** during the installation and also the Operations stage. Construction stage impacts on the nighttime setting will be **Medium-term** with the Operations stage experiencing **Long-term** impacts. The magnitude of potential impact from the shore crossing on the nighttime visual setting is rated as **Negligible** for both the Construction and Operations stages.

Onshore Pipeline

The onshore pipeline will be installed below ground either in an open trench—which will be backfilled and revegetated following pipeline installation, or via HDD—which will eliminate any visual character alteration along the respective segment. In either case, the pipeline equipment will not be visible once installed. For segments installed using open trenching, the construction RoW will be restored and revegetated, with the permanent RoW maintained (i.e., free of significant woody and other tall vegetation) throughout the Operations stage. This vegetative clearing in the permanent RoW will be visible within the landscape as a change in vegetation.

The onshore pipeline corridor will cross three key viewpoints, as follows:

- West Coast Demerara Public Road
- Canal 1
- Canal 2

The scenic integrity of this landscape is rated as low based on the USFS system, as it has been moderately altered by agricultural and clusters of mixed-use development. EEPGL plans to use HDD techniques to minimize visual impacts on these key viewpoints during both Construction and Operations stages, so there will be no change in visual character in these areas.

On the basis that the scenic integrity would not be expected to change by more than one level during construction (and only for open trenching segments), the intensity of the potential impacts from the onshore pipeline component during the Construction stage is rated as **Negligible** for HDD segments and **Low** for open trenching segments. The scenic and visual impact will be **Continuous** during the period of pipeline installation (for the Construction stage) and for as long as the pipeline is present once installed (for the Operations stage). The impact for the Construction stage will be more than a week but less than a year at any one segment for the Construction stage (**Medium-term**) and more than a year for the Operations stage (**Long-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of this potential impact from the onshore pipeline is rated as **Negligible** (HDD segments) to **Small** (open trenching segments) for the Construction stage and **Negligible** for the Operations stage.

Security and safety lighting for the onshore pipeline will only be present during the Construction stage, while the Project is installed below ground. The permanent RoW will not have lighting. Based on EEPGL's plans to use HDD techniques, impacts on the nighttime visual setting at these key viewpoints during the Construction stage will be limited to the area within and immediately surrounding the construction footprint.

Construction of the onshore pipeline would not change the scenic integrity of the nighttime visual setting by more than one level; therefore, the intensity of the potential impacts is rated as **Low** for both HDD and open trenching segments. The impact on the nighttime visual setting will be **Continuous** during pipeline installation. The duration of impacts for the Construction stage will be **Medium-term**. The magnitude of the potential impact from the onshore pipeline on the nighttime visual setting is rated as **Small** for the Construction stage.

Operation of the onshore pipeline would not involve any artificial lighting, and would not change the nighttime setting. As a result, operation of the onshore pipeline would have **Negligible** impact on the nighttime visual setting.

NGL Plant

The NGL Plant will be located in what is currently fallow agricultural land that was previously part of the GuySuCo Wales Estate. The construction and presence of Project features at the NGL Plant site will result in a change to the scenic and visual character of the landscape, by introducing an industrial character to an otherwise natural/agricultural area. The scenic integrity of this landscape at the NGL Plant site is rated as low based on the USFS system, reflecting a moderately altered landscape that is now converting back to a more natural landscape through natural succession. No key viewpoints or visually sensitive resources are identified in this landscape.

The intensity of potential impacts for the NGL Plant is rated as **Negligible** for the Construction stage, as construction activities will not be perceptible from key viewpoints in the vicinity of the NGL Plant site (e.g., WBD Public Road). Once the taller aboveground structures are in place during the Operations stage, it is expected that these will be visible from key viewpoints, but this would not be expected to change scenic integrity by more than one level—yielding an intensity of **Low**. The scenic and visual impact will be **Continuous** during the period of construction (for the Construction stage) and for as long as the NGL Plant aboveground facilities are present once installed (for the Operations stage). The impact for the Construction stage will occur for more than a year for the Construction stage (**Long-term**) and more than a year for the Operations stage (**Long-term**). Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of the potential impact from the NGL Plant is rated as **Negligible** for the Construction stage and **Small** for the Operations stage**.**

Construction of the NGL Plant would change the nighttime visual setting of the site (currently fallow agricultural fields) by introducing security and safety lighting (during both the Construction and Operations stages) into an otherwise natural/agricultural area with no current or past artificial lighting. The nighttime lighting integrity of this landscape at the NGL Plant site is rated as medium based on the USFS system, reflecting a landscape with limited viewers.

The intensity of potential nighttime setting impacts from NGL Plant construction is rated as **Low** and **Short-term**, because lighting will be perceptible primarily from key viewpoints in the vicinity of the NGL Plant site (e.g., WBD Public Road), and only during the Construction stage. The NGL Plant's taller aboveground structures will have safety lighting that is visible from the majority of the Study Area and from most identified key viewpoints. Facility safety lighting could also be visible from key viewpoints in the vicinity of the NGL Plant site (e.g., WBD Public Road). This lighting, and especially the safety lighting on taller structures, is expected to change the nighttime setting integrity by more than one level, yielding an intensity of **Medium**. The impacts of this lighting on the nighttime setting will be **Continuous** during the Construction stage and

Long-term for the life of the NGL Plant during the Operations stage. The magnitude of the potential impact from the NGL Plant is rated as **Small** for the Construction stage and **Moderate** for the Operations stage.

Temporary MOF

The temporary MOF will be constructed along the west bank of the Demerara River in a section that currently exhibits relatively natural shoreline vegetation. The Project will clear a small section of riverbank vegetation for the trestle portion of the temporary MOF, with the bulk of the temporary MOF pier structure extending into the water. This will introduce an industrial character to an otherwise relatively natural setting. The principal key viewpoint relevant to the temporary MOF is from the river looking toward the West Bank of the Demerara River. The naturally vegetated shoreline along the West Bank of the Demerara River is considered a visually sensitive resource. The scenic integrity of this landscape is rated as moderate based on the USFS system, given its mostly natural character, but with some anthropogenic intrusions (e.g., piers). The construction and presence of the temporary MOF will result in a change in scenic integrity, but not by more than one scenic integrity level, yielding an intensity of **Low**. The scenic and visual impact will be **Continuous** during construction (i.e., for the Construction stage) and for as long as the temporary MOF remains present during the Operations stage (it is understood that the Government of Guyana may use the temporary MOF for a period of time to support its other developments in the area). The temporary MOF will be in place for all of the Construction stage and a portion of the Operations stage, so the duration is considered **Long-term**. Following the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of the potential impact from the temporary MOF is rated as **Small** for the Construction stage and also the Operations stage, on the basis that the Government of Guyana may use the temporary MOF for other purposes during the initial years of the Operations stage.

The construction and presence of the temporary MOF will not change the scenic integrity of the nighttime visual setting by more than one level, yielding an intensity level of **Low**. The impact on the nighttime visual setting will be **Continuous** during the Construction stage and for as long as the temporary MOF remains present during the Operations stage. The magnitude of the temporary MOF on potential impacts on the nighttime visual setting is rated as **Small** for the Construction stage and any portion of the Operations stage when the temporary MOF remains present.

9.7.3.4. Sensitivity of Resource—Landscape, Visual Resources, and Light

Based on the sensitivity rating definitions in Table 9.7-3, the sensitivity of landscape and visual resources is rated as **Medium** for the ocean, shoreline, and section of the west bank of the Demerara River at the temporary MOF site; and **Low** for the landscape of mixed residential, commercial, and active and fallow agricultural land where the onshore pipeline corridor will be located. While the landscape at the NGL Plant site location is rated as low scenic integrity on the USFS scale, some elements of the NGL Plant infrastructure—because of their height—will be visible from several viewpoints in the area (e.g., nearby communities). Accordingly, the sensitivity of the resource with respect to the NGL Plant is rated as **Medium**.

Based on Table 9.7-5, the sensitivity of nighttime setting resources is also rated as **Medium** for the ocean, shoreline, and the section of the west bank of the Demerara River at the temporary MOF site; the sensitivity is **Low** for the landscape of mixed residential, commercial, and active and fallow agricultural land where the onshore pipeline corridor will be located. The nighttime visual setting at the NGL Plant site will be visible from the majority of the visual study area, and therefore is rated as **Medium** sensitivity.

9.7.3.5. Pre-mitigation Impact Significance—Landscape, Visual Resources, and Light

Assuming implementation of the embedded controls listed in Table 9.7-6, the intensity ratings for potential Project impacts on landscape and visual resources, along with the nighttime visual setting, will range from **Negligible** to **Low**. This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Small.** Coupled with sensitivity ratings of **Medium** (for the ocean and shoreline where the offshore pipeline and shore crossing will be located, the west bank section of the Demerara River where the temporary MOF will be located), **Low** (for the landscape in which the onshore pipeline corridor and NGL Plant site will be located), and **Medium** for the nighttime visual setting of the NGL Plant site. The pre-mitigation impact significance for landscape and visual resources ranges from **Negligible** to **Minor**, while the pre-mitigation impact significance for nighttime visual setting ranges from **Negligible** to **Medium**.

9.7.4. Impact Management and Monitoring Measures

Based on the **Negligible** to **Minor** significance of potential landscape and visual impacts, no mitigation measures are proposed. Based on the **Negligible** to **Medium** significance of potential nighttime setting impacts, lighting mitigation measures are proposed. It is noted, however, that the limited significance of potential landscape and visual impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). In particular, landscape, visual resources, and nighttime visual setting impacts are inherently reduced through the burial of the onshore pipeline and—in many areas with key viewpoints—use of HDD techniques. Nighttime visual setting impacts are mitigated through industry standard night sky light fixtures, on/off control measures, and use of the minimum required lighting intensity. As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

While viewpoints are limited in the area of the NGL Plant site and the scenic integrity of the landscape in this area is low, the presence of the NGL Plant aboveground structures will introduce a visual change to the fallow agricultural land that was part of the GuySuCo Wales Estate. However, it is noted that the Government plans to create a broader industrial development in this area, and the NGL Plant structures will therefore likely be congruent with the future visual landscape in the area.

Nighttime visual setting integrity is medium in the area of the NGL Plant; however, accepted mitigation measures will minimize the potential impact.

The temporary MOF will result in impacts on the relatively intact and natural West Demerara River shoreline in this area. However, the temporary MOF will be a temporary facility, and an embedded control associated with the temporary MOF's decommissioning includes the restoration of the disturbed shoreline by planting native vegetation.

Table 9.7-6 summarizes the management and monitoring measures relevant to landscape and visual resources.

Table 9.7-6: List of Management and Monitoring Measures

Embedded Controls
Use HDD techniques at major road and waterway crossings to help minimize visual impacts on key viewpoints during construction activities.
Subject to direction from the Government of Guyana regarding its desire to continue to use the temporary MOF after the Project Construction stage is complete, remove temporary MOF infrastructure as soon as feasible following completion of Project construction and attainment of stable operations (the temporary MOF will be removed prior to the 10-year design life of the structure being met), and revegetate disturbed areas in consultation with appropriate Guyanese authorities (e.g., NAREI).
Design and locate aboveground structures associated with the onshore pipeline (e.g., beach valve station) so as to minimize their visual profile and the degree to which they impact views of sensitive visual resources.
Implement industry-standard lighting practices, including (but not limited to): • Use the minimum lighting intensity necessary for health and safety. • Use directional lighting with full-cutoff features that direct light only to locations where it is necessary, while minimizing leakage into surrounding areas. • Use timers, motion sensors, or other features that activate lights only when necessary. • Use lights with lower color temperatures (i.e., closer to the yellow end of the spectrum).
Monitoring Measures
Conduct post-restoration vegetative cover monitoring along the onshore pipeline corridor.

9.7.5. Assessment of Residual Impacts

As described above, no mitigation measures are proposed to address potential landscape and visual resource impacts. Accordingly, the residual impact significance ratings remain unchanged at **Negligible** to **Minor**.

Table 9.7-7 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential landscape and visual impacts. Table 9.7-8 summarizes the same information for the nighttime visual setting.

Table 9.7-7: Summary of Potential Pre-Mitigation and Residual Impacts—Landscape and Visual Resources

Project Component	Affected Visual Resource / Key Viewpoint	Stage	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Offshore Pipeline	Ocean	Construction	Medium	Small	Minor	None	Minor
		Operation		Negligible	Negligible	None	Negligible
Shore Crossing	Shoreline	Construction	Medium	Small (trenching) Negligible (HDD)	Minor (trenching) Negligible (HDD)	None	Minor (trenching) Negligible (HDD)
		Operation		Negligible	Negligible	None	Negligible
Onshore Pipeline	Mixed Residential/ Commercial/ Agricultural	Construction	Low	Small (trenching) Negligible (HDD)	Negligible	None	Negligible
		Operation		Negligible	Negligible	None	Negligible
NGL Plant	Fallow Agricultural Land	Construction	Medium	Negligible	Negligible	None	Negligible
		Operation		Small	Minor	None	Minor
Temporary MOF	Demerara River	Construction	Medium	Small	Minor	None	Minor
		Operation [a]		Small	Minor		Minor

[a] While the Project does not plan to use the temporary MOF during the Operations stage, it is understood that the Government of Guyana may use the temporary MOF for a period of time after completion of Project construction to support its other developments in the area. Accordingly, the significance rating is applied to the Operations stage (recognizing that the temporary MOF will be removed prior to the 10-year design life of the structure being met).

Table 9.7-8: Summary of Potential Pre-Mitigation and Residual Impacts—Nighttime Visual Setting

Project Component	Affected Visual Resource / Key Viewpoint	Stage	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Offshore Pipeline	Ocean	Construction	Medium	Small	Minor	None	Minor
		Operation		Negligible	Negligible	None	Negligible
Shore Crossing	Shoreline	Construction	Medium	Negligible	Negligible	None	Negligible
		Operation		Negligible	Negligible	None	Negligible
Onshore Pipeline	Mixed Residential/ Commercial/ Agricultural	Construction	Low	Small	Negligible	None	Negligible
		Operation		Negligible	Negligible	None	Negligible
NGL Plant	Fallow Agricultural Land	Construction	Medium	Small	Minor	None	Minor
		Operation		Medium	Moderate	See Table 9.7-6	Minor
Temporary MOF	Demerara River	Construction	Medium	Small	Minor	None	Minor
		Operation [a]		Small	Minor	None	Minor

[a] While the Project does not plan to use the temporary MOF during the Operations stage, it is understood that the Government of Guyana may use the temporary MOF for a period of time after completion of Project construction to support its other developments in the area. Accordingly, the significance rating is applied to the Operations stage (recognizing that the temporary MOF is expected to be removed prior to the end of the Project's operational life cycle).

9.8. ECOSYSTEM SERVICES

Ecosystem services are typically defined as the benefits people obtain from the natural environment, including natural resources that reinforce basic human health and survival needs, support economic activities, and provide cultural fulfilment. Ecosystem services are categorized as provisioning, regulating, cultural, and supporting services, as defined below (Millennium Ecosystem Assessment 2005):

- Provisioning services: goods or products obtained from ecosystems such as food, fresh water, timber, fiber, and other goods;
- Regulating services: benefits obtained from an ecosystem's control of natural processes such as climate, carbon storage, waste absorption, water flow, disease regulation, pollination, and protection from natural hazards;
- Cultural services: non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment; and
- Supporting services: natural processes that maintain other services such as erosion control, soil formation, nutrient cycling, and primary productivity.

9.8.1. Baseline Methodology

9.8.1.1. Study Areas

Study areas for socioeconomic resources, as referenced in this section, are defined in Section 9.1, Socioeconomic Conditions, and illustrated on Figure 9.1-1. Study areas include:

- Direct AOI:
  - **Primary Study Area**:[43] This Study Area includes communities and households within 500 meters of the onshore pipeline corridor; within 1 kilometer of the NGL Plant boundary and/or temporary MOF; within the area extending from the Demerara River immediately north of Free and Easy village, south and west to the NGL Plant and temporary MOF; plus the area encompassing settlements in the Belle West housing scheme.
  - **Secondary Study Area**: This Study Area includes communities and households located between the Primary Study Area and the Demerara River.
- Indirect AOI:
  - **Tertiary Study Area**: This Study Area includes the communities on the East Bank of the Demerara River immediately across from the temporary MOF.

    The communities that were engaged and/or studied in the Tertiary Study Area include Brickery, Garden of Eden, and Land of Canaan.

[43] The socioeconomic Primary Study Area includes the Direct AOI for biophysical components, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

- **Regional Study Area**: This Study Area includes the remainder of Region 3, plus Regions 2 and 4. (the balance of the Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology).

  The communities that were engaged and/or studied in the Regional Study Area include Georgetown, Santa Aratak, and Pakuri.

The combined socioeconomic Study Areas are equivalent to the Onshore Indirect AOI as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

9.8.1.2. Baseline Studies

Coastal Ecosystem Services Study (Regions 1 through 6)

This assessment is informed by two distinct ecosystem services research efforts. In 2018 and 2019, a team of socioeconomic and biodiversity experts conducted an ecosystem services screening, scoping, and assessment exercise involving all 63 coastal neighborhood democratic councils (NDCs), CDCs, VCs, and TCs in Regions 1 through 6 (ERM/EMC 2020). This study remains the most comprehensive accounting of ecosystem services in coastal Guyana and provides information related to the coastal areas of the Indirect AOI, including the area in the vicinity of the pipeline shore crossing.

The study was conducted using a robust screening and scoping process[44] to identify and characterize a wide range of services across all four categories of ecosystem services. Identified services were subsequently prioritized based on the importance of the ecosystem service (considering intensity and scope of use, degree of dependence, and stakeholders' rating of importance) and the availability of alternatives (considering the existence of natural and/or manmade replacements, as well as accessibility, cost, sustainability, and preference for / openness to alternatives). Each ecosystem service was then rated as low, medium, high, or critical priority.

Ecosystem Services Focus Groups (Region 3)

To inform the understanding of existing ecosystem services in Region 3, the Consultants conducted a series of ecosystem services focus groups in December 2021. The Consultants facilitated these screening-level discussions to identify potential ecosystem services of importance to local residents. Much of the Primary and Secondary Study Areas are currently or formerly cultivated, including extensive rice and (former) sugarcane fields, and the information obtained from the focus groups highlighted the importance of agriculture and canal use, among other topics. The information obtained from of these focus groups was qualitative and was not used to develop priority ratings.

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[44] Screening sought to identify ecosystem services likely to be present in an area based on (1) whether a given habitat is believed to provide a service, and (2) whether people are believed to benefit from the service at local, national, and/or global levels. Scoping aimed to establish a list of beneficiaries; establish the value of the service to beneficiaries; identify and map habitats and resources that provide the service in the study area; and identify the condition and trends related to the service and natural resources. Screening and scoping were conducted by the study team, which included members of the Consultants team, other local experts, and members of the relevant NDCs, CDCs, VCs, and TCs.

Household Surveys (Region 3)

The Consultants also conducted 2021 household socioeconomic surveys in Region 3, as described in Section 9.1, Socioeconomic Conditions. Surveys were conducted in December 2021 and included residents and businesses in the Primary, Secondary, and Tertiary study areas. Some survey questions were included to help characterize local residents' use of ecosystem services in these areas, including questions related to livelihoods, land use, fishing, agriculture, and use of wild / natural resources for crafts, medicines, food, or other purposes. Examples include:

- What do you use this property for?
- Do you or anyone in your household fish? If yes: what is your reason for fishing, where do you fish, how do you fish, what type of fish do you typically catch, and what do you do with your catch?
- What crops do you grow, and where?
- Do you have livestock? If yes, where do they graze?
- How do you use the canals, if at all?
- Does anyone in your household engage in the following for home consumption or for sale? Options include: fruit/vegetable preserving /honey; wild plants / nuts / mushrooms; traditional crafts (pelts, baskets, use of mangroves); and traditional medicine (harvesting and production).

The complete household survey questionnaire is provided in Appendix O, Socioeconomic Surveys—Questionnaire.

9.8.2. Existing Conditions and Baseline Studies

The following sections describe the ecosystems services in the coastal portions of Regions 2, 3, and 4 (Section 9.8.2.1, Coastal Areas); the onshore pipeline corridor between the coast and Canal 1 (Section 9.8.2.2, North of Canal 1); the onshore pipeline corridor between Canal 1 and Canal 2 (Section 9.8.2.3, Canal 1 to Canal 2); and the area south of Canal 1 (which includes the remaining portions of the onshore pipeline corridor, NGL Plant site, and ancillary facilities; Section 9.8.2.4, South of Canal 2).

9.8.2.1. Coastal Areas

The ecosystem services study conducted in 2018 (and updated in 2019) provided a detailed examination of ecosystem services for the coastal portions of Regions 1 to 6. This study was led by the Consultants and involved the participation of community members to identify, prioritize, and describe ecosystem services, including specific resources and locations valued by the community. Figures 9.8-1 through 9.8-4 show the ecosystem services that study identified in the coastal areas of Regions 2, 3, and 4. Highlights from each region are summarized below; further details are available in the *Enhanced Coastal Sensitivity Mapping – Ecosystem Services Final Report (*ERM/EMC 2020).

Region 2

Region 2 comprises approximately 100 kilometers of coastline. Coastal NDCs include Anna Regina, Annandale/Riverstown, Good Hope/Pomona, Charity/Urasara, Evergreen/Paradise, and Aberdeen/Zorg-en-Vlygt.

The following ecosystem services were identified in the coastal portions of Region 2:

- **Provisioning services** include fishing, coastal agriculture, and aquatic transport. Fishing is the primary ecosystem service in the coastal areas of Region 2, including harvests of catfish, snapper, snook, and crabs. Commercial fishing and crabbing occurs in the Pomeroon River and at various locations along the coast. Ports, docks, shipyards, and ferries are important features in Riverstown, Supenaam, Riverside, and Vilvoorden; and the Big Bird Fish Complex in Charity serves as a landing site for large-scale artisanal fishing and processes fish for export. The seawall and coastal lands are also used for commercial and subsistence farming, including livestock and crop cultivation (including coconuts, bananas, plantains, and cash crops). Large-scale crop cultivation occurs on Tiger Island.
- **Regulating services** include mangroves, which provide shoreline protection as well as habitats for birds, crabs, and other wildlife. Tiger Island (a long island at the mouth of the Essequibo River, near the southern border of Region 2) was identified by the communities engaged in the ecosystems services study as a critical sea defense to erosion and flooding.
- **Cultural services** include recreation along the seawall and cricket matches on the beach. The shore is also valued by the region's Hindu population for cremation sites and religious activities.
- **Supporting services** include the natural process of soil formation, nutrient recycling, and accretion that benefit fishing and farming activities. The port at Supenaam is critical to the local economy, housing numerous ships offloading and loading their cargo. The primary wharves are located in Paradise and Vilvoorden, and there are various beach landing sites. Additionally, mangroves provide important habitats for biodiversity along the Pomeroon River.

Region 3

The Direct AOI is located within Region 3, including the pipeline shore landing near the community of Crane, the onshore pipeline corridor, the NGL Plant site, and ancillary facilities (as described in Chapter 5, Project Description). Region 3 includes the marine coastline between the Demerara and Essequibo Rivers, riverbanks of the Essequibo and Demerara Rivers, and islands in the mouth of the Essequibo River.

Coastal NDCs engaged in the 2018/2019 ecosystem services study (ERM/EMC 2020) included Wakenaam, Leguan, Mora/Parika, Hydronie/Good Hope, Greenich Park/Vergenoegen, Tuschen/Uitvlugt, Stewartville/Cornelia Ida, Hague/Blankenberg, La Jalousie/Nouvelle Flanders, and Best Klien/Pouderoyen.

The following ecosystem services were identified in the coastal portion of Region 3:

- **Provisioning services** include fishing and crabbing, and farming on the islands. The main commercial fish catch includes various types of catfish, snapper, bangamary, snook, mullet, and shrimp. Fishing occurs in coastal areas and within the Essequibo River. Crabs are caught during the spawning season (July and August) and throughout the year in the mangroves. Crop cultivation is practiced by many communities along the coast, ranging from subsistence farming of rice and other staples, to cash crops of coconuts and plantains for export markets. Freshwater from the river is drawn for irrigation of rice paddies and other crops on the islands. Livestock farming varies considerably between communities, although there is a general tendency to rear sheep and goats rather than cows. Near the rivers, speedboats, docks and shipyards are important for transport of passengers and goods.
- **Regulating services** include rocks, concrete structures, or earthen dams (ripraps) that protect the shoreline. Region 3's sea defense is further maintained by mangroves and coastal vegetation, which play a role in protecting inland areas from ocean water, wind, and flooding.
- **Cultural services** are centered around the shoreline, as members of the Hindu population use coastal shore access for praying and planting jhandi (prayer) flags, while local families recreate along the seawall. Coastal populations also use inland canals for prayer and swimming.
- **Supporting services** include the processes of nutrient recycling, soil formation, and accretion, which have contributed to the location of ports (e.g., Parika), wharfs (e.g., Parika and Vreed-en-Hoop), and dwellings.

As part of the 2021 household socioeconomic surveys, the Consultants engaged with 11 households near the communities of Crane and Nouvelle Flanders (i.e., in the vicinity of the proposed pipeline shore landing). Of these, two households reported growing crops (rice and vegetables), and two reported keeping livestock (poultry). All respondents have domestic water piped to the home. None reported fishing or use of canals for household, livelihoods, or recreational purposes.

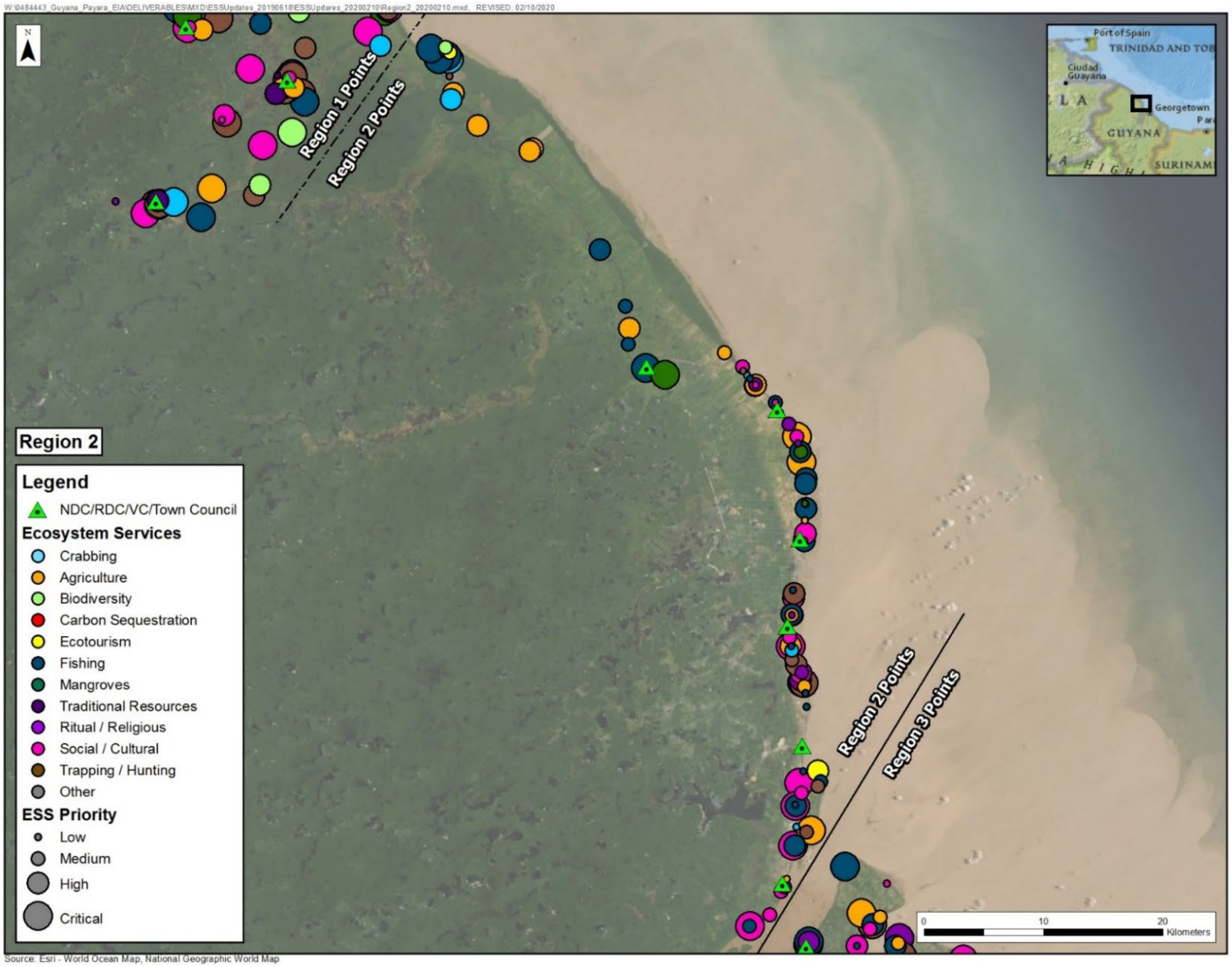
Region 4

Region 4 extends from the East Bank of the Demerara River to the West Bank of the Mahaica River. Coastal NDCs in Region 4 include Georgetown City, Industry/ Plaisance, Better Hope/La Bonne Intention (LBI), Beterverwagting/Triumph, Mon Repos/La Reconnaissance, Buxton/Foulis, Unity/Vereeniging, Haslington/Grove, and Enmore/Hope.

The following ecosystem services were identified in the coastal portion of Region 4:

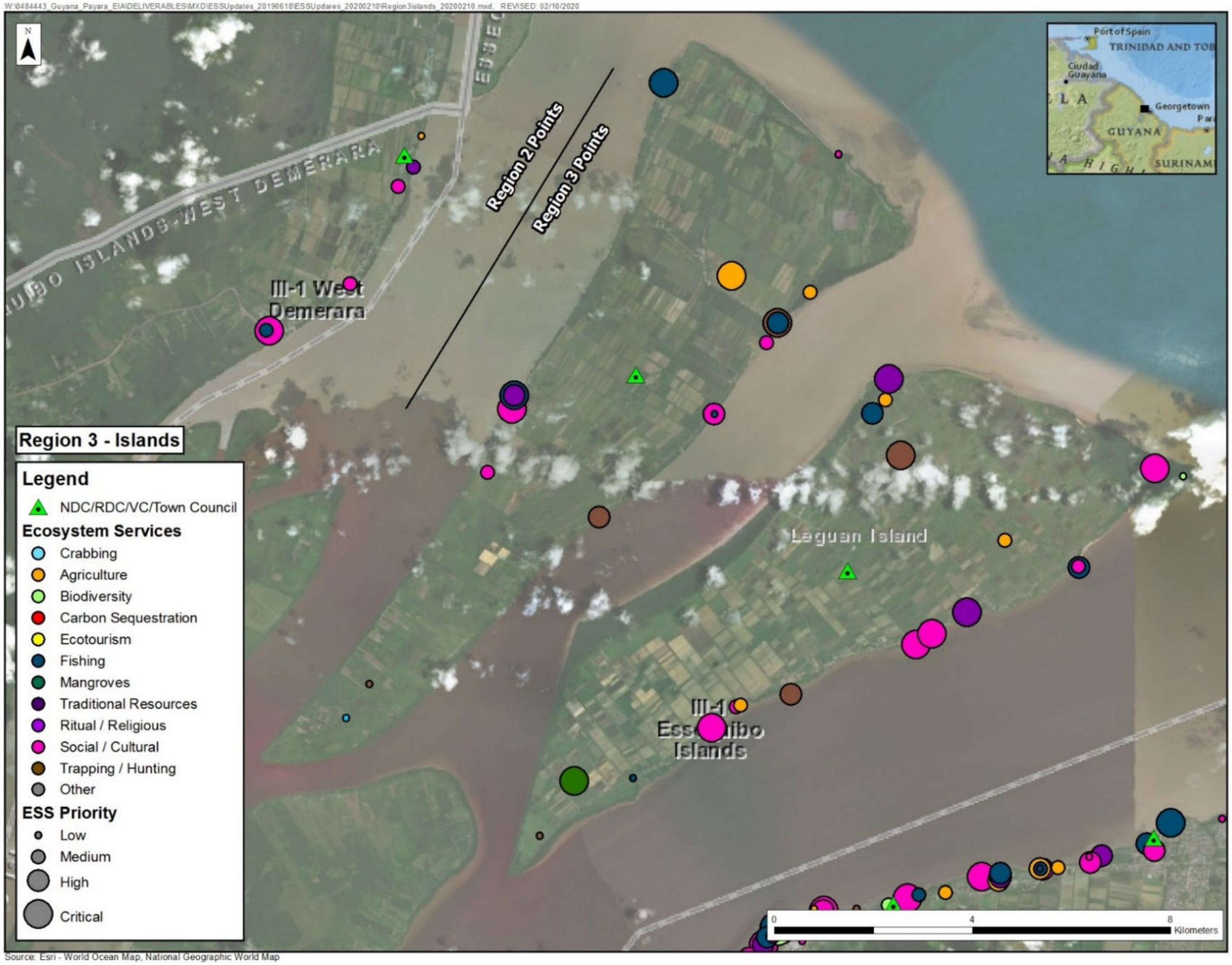
- **Provisioning services** include fishing, crabbing, agriculture and livestock farming, and water use. The most frequently caught types of fish include catfish, trout, paggy, snapper, bangamary, snook, mullet, shark, and shrimp. Fishing occurs at both a local and commercial level. Crabs are caught during the spawning season and throughout the year in the mangroves. Mangroves are important for biodiversity because they serve as nurseries and provide habitats for various marine species. Communities engage in subsistence farming of fruits and vegetables, while commercial farmers grow sugarcane, rice, coconuts, and cash crops. Livestock farming of sheep, goats, and other livestock increases with increasing distance east from Georgetown. Depending on the community, either potable water from groundwater or rainwater harvesting are major sources of water. Some water-based transportation occurs, though it is predominantly land-based along the coast. Based on the 2018-2019 ecosystems services study, harvesting of wild foods is rare in Region 4.

- **Regulating services** include rocks, earthen dams (ripraps), mangroves, and coastal vegetation that protect the shoreline. Region 4’s sea defense is further maintained by mangroves and coastal vegetation, which play a role in protecting inland areas from ocean water, wind, and flooding. Migrating mud flats provide productive grounds for mangrove growth and contribute to mangrove’s regulating services, including pollination, biodiversity, and fish abundance.
- **Cultural services** include shoreline activity from local community members who use the area for recreating, as well as the Hindu population who practice the tradition of bathing, praying, and planting jhandi (prayer) flags along the shoreline. Coastal populations also use inland canals for recreation and prayer.
- **Supporting services** are centered around the economic activity generated by Georgetown. The natural process of soil formation, nutrient recycling, and accretion have supported the location of the country’s largest port and its capital city to engage in important commercial activities. Mangroves also support biodiversity including roosting habitat for birds, and the 2018 to 2019 ecosystem services study noted that the area next to the Demerara Harbour Bridge is particularly important in this respect.



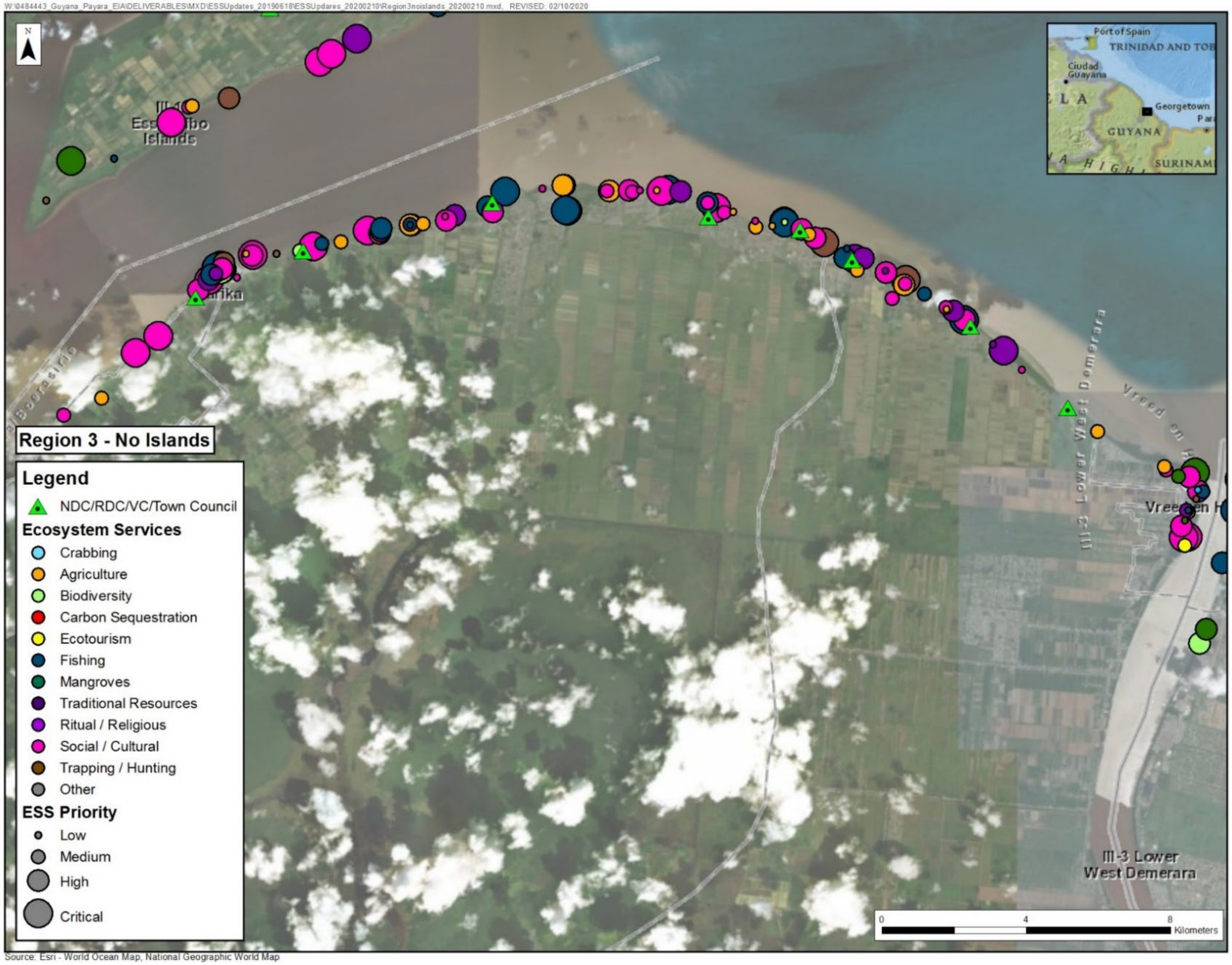
Source: ERM/ERC 2020

Figure 9.8-1: Region 2 Coastal Ecosystem Services Identified in 2018/2019 Study



Source: ERM/ERC 2020

Figure 9.8-2: Region 3 (Islands) Coastal Ecosystem Services Identified in 2018/2019 Study



Source: ERM/ERC 2020

Figure 9.8-3: Region 3 (Mainland) Coastal Ecosystem Services Identified in 2018/2019 Study

Source: ERM/ERC 2020

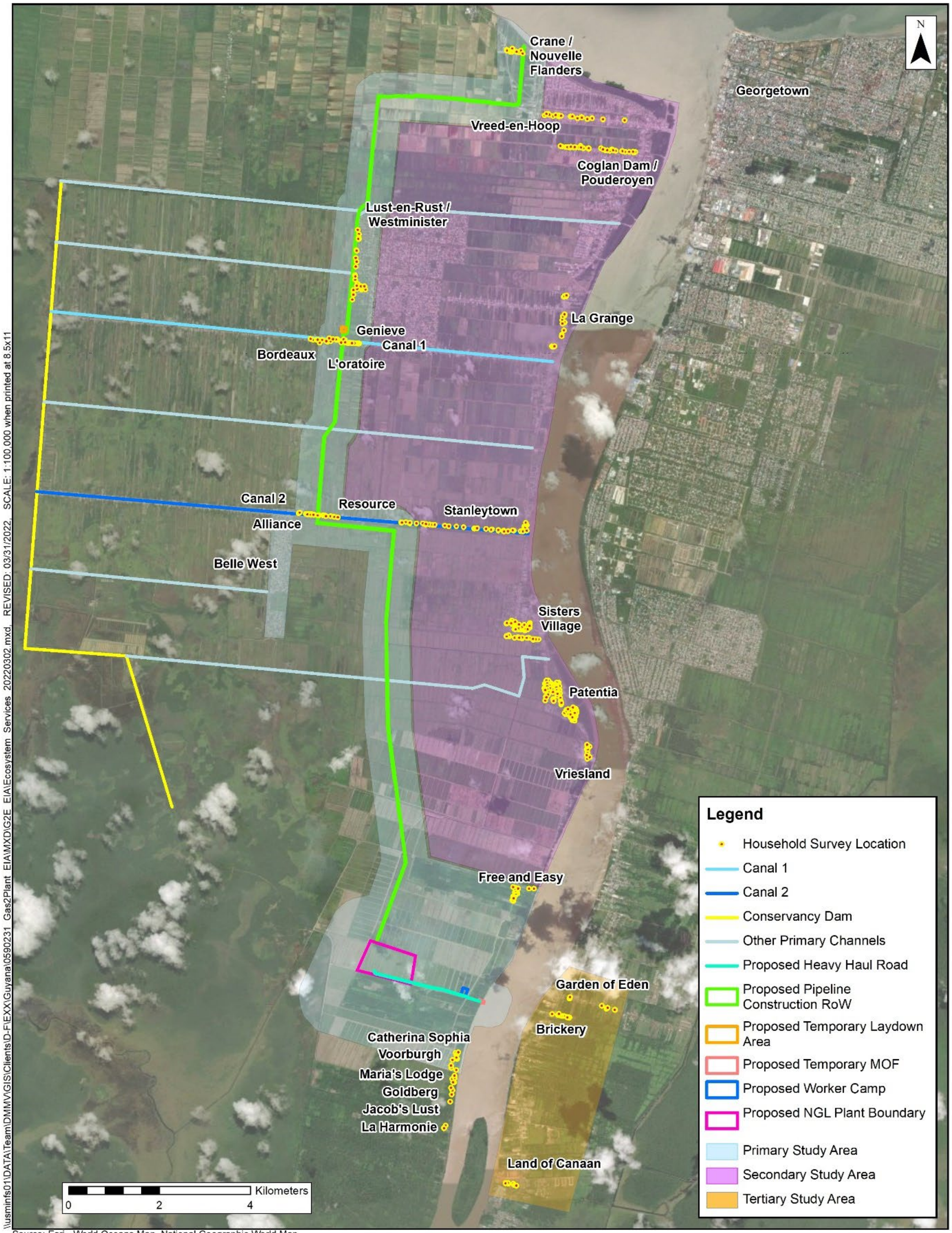
Figure 9.8-4: Region 4 Coastal Ecosystem Services Identified in 2018/2019 Study

9.8.2.2. North of Canal 1

The proposed pipeline shore landing is west of Vreed-en-Hoop, near the community of Crane. From here, the onshore pipeline will travel south and west, running east of a large housing scheme comprising the communities known as Westminister, Lust-en-Rust, Onderneeming, and Parfaite Harmonie before crossing Canal 1.[45] This housing scheme is within the jurisdiction of the Malgre Tout/Meer Zorgen NDC, headquartered in Goed Fortuin. Figure 9.8-5 illustrates the canal system.

The Consultants facilitated a focus group with the Malgre Tout/Meer Zorgen NDC in December 2021. This focus group was attended by five representatives of the NDC and included discussion of residents' use of the natural environment and ecosystem services in the NDC. Information presented in the following sections is derived from this focus group, unless attributed to the 2021 household socioeconomic survey.

[45] The area south of Canal 1 is covered in Section 9.8.2.3, Canal 1 to Canal 2.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 9.8-5: Canals and Communities in the Primary and Secondary Study Areas

Provisioning Services

Agriculture and Harvesting

The focus group participants reported that some residents cultivate rice (estimated at over 20 hectares within the NDC) and cash crops, for both personal use and sale. Some livestock rearing, including cattle and poultry, was reported. There are no designated grazing areas, but some animals are known to graze in open areas including vacant lots in Parfaite Harmonie (Malgre Tout/Meer Zorgen NDC 2021, pers. comm.).

No harvesting of wood or timber products is evident in this area North of Canal 1; lumberyards are available in the area, and most land has been cleared for cultivation or settlement. Some residents may obtain firewood from coastal mangroves, although the focus group participants noted that residents have a growing appreciation for the value of mangroves as sea defense. Some residents collect honey from hives in the area. Hunting or collection of other wild food products has not been reported, although some people are known to harvest birdseed and (unspecified) medicinal plants. Parrots and other birds may be caught for trade / sale and are noted to be captured in open areas adjacent to rice fields (Malgre Tout/Meer Zorgen NDC 2021, pers. comm.).

The Consultants surveyed 27 households in the areas known as Westminster and Lust-en-Rust, the westernmost settlements adjacent to the proposed onshore pipeline corridor. None of those surveyed reported growing crops, and only two households reported raising livestock (poultry).

Use of Water and Canals

Residents of the NDC catch fish for subsistence or sale. Fishing locations include the canals and farmlands connected to the Boerasirie Conservancy (discussed further in Section 9.8.2.3, Canal 1 to Canal 2). In addition to fish, crabs are often caught in mangroves (for household consumption and/or sale), and snails may be harvested from trenches and drainage areas. Farther from the Project, fishing is concentrated near the kokers (sluice gates) in Versailles, Goed Fortuin, and Malgre Tout, where approximately 30 local people use small boats to fish (Malgre Tout/Meer Zorgen NDC 2021, pers. comm.).

Canal waters are usually used for cropland irrigation. Households in the NDC generally have piped water provided to homes, although some residents are reported to occasionally use water from canals for washing, bathing, and watering plants, particularly during dry weather. Based on their proximity, residents of Westminister / Lust-en-Rust (i.e., the western end of the NDC) are most likely to use the canals for these purposes, as the water in the nearby canals originates in the Boerasirie Conservancy (Malgre Tout/Meer Zorgen NDC 2021, pers. comm.). Conservancy waters are noted to supply Canal 1, Canal 2, and connected canals.

In the 2021 household socioeconomic survey, all respondents stated that they have access to piped water for domestic use. Most respondents reported no use of the canals, although some (5 of 27) reported using them for fishing. Further information about canal use is provided in Section 9.3, Social Infrastructure and Services.

Travel and Transportation

In the more populated, eastern communities of the NDC, fisherfolk use boats to travel and fish in the waters of the Demerara River and Atlantic Ocean. Related economic activities are also important in the NDC, including boat building and repairs (in Versailles and Goed Fortuin) and transportation services (Malgre Tout/Meer Zorgen NDC 2021, pers. comm.).

Regulating Services

Shoreline protection provided by natural habitats (e.g., wetlands, beaches, etc.) is recognized by residents in the NDC as being valuable to protect crops, buildings, and recreation areas from the impacts of flooding and high wind and waves (Malgre Tout/Meer Zorgen NDC, 2021, pers. comm.). In the eastern part of the NDC, mangroves are located along the Demerara River and provide shoreline protection in this area.

Local predator animals aid in pest regulation, which is an advantage for crops and livestock rearing. Bats are present in the area, and there are mongooses in the vicinity of Parfaite Harmonie. Birds, bees, and other insects are also valued for their role in pollination of cultivated crops and wild plant species (Malgre Tout/Meer Zorgen NDC, 2021, pers. comm.).

Cultural Services

The NDC has a multi-ethnic population. Hindu households commonly use canals and waterways to erect flags during ceremonies; this occurs throughout the NDC. The riverfront along the Demerara River is valued for its natural aesthetics and waterfront views (Malgre Tout/Meer Zorgen NDC, 2021, pers. comm.). West of the Westminister/Lust-en-Rust housing scheme, the canals are used for swimming in various “blackas” (blackwater swimming holes).

Supporting Services

Mangroves along the Demerara River provide habitat for birds, crabs, and monkeys. Focus group participants emphasized the importance of bird habitat (Malgre Tout/Meer Zorgen NDC, 2021, pers. comm.).

9.8.2.3. Canal 1 to Canal 2

Two major canals, known as Canal 1 and Canal 2 (shown on Figure 9.8-5), transect the Primary and Secondary Study Areas in Region 3, as follows:

- The onshore pipeline will cross Canal 1 approximately 4.5 kilometers west of the main road in Bagotville.
- The onshore pipeline will cross Canal 2 approximately 4.5 kilometers west of the main road in Stanleytown, near the settlements known as Polder, Resource, Alliance, and Belle West. The onshore pipeline will turn east at Canal 2, before heading south to the NGL Plant site.
- The forested Boerasirie Conservancy is upstream (west) of this area and provides the source of freshwater for the canals.

The Canals Polder NDC comprises lands on either side of Canal 1 and Canal 2, broadly extending between the Demerara River and the Boerasirie Conservancy (Canals Polder NDC 2021, pers. comm.)[46]. The Consultants facilitated a focus group with the Canals Polder NDC in December 2021, attended by 11 representatives of the NDC, to discuss residents' use of the natural environment and ecosystem services. Information presented in the following sections is derived from this focus group, unless attributed to the 2021 household socioeconomic survey.

Provisioning Services

Agriculture and Harvesting

The primary use of land in the NDC is for agriculture (Canals Polder NDC 2021, pers. comm.), and the communities within the NDC identify as farming communities. Among the numerous canals, most non-residential land is currently or formerly cultivated. Rice, citrus, and pineapple are the primary crops throughout the NDC. Other crops include West Indian cherries, avocado, soursop, passionfruit, rambutan, cassava, and guava. Most farmers cultivate small plots with mixed produce. Sugar cane cultivation is currently minimal and has declined significantly since the closure of the former GuySuCo Wales Estate plantation.

Wild foods were also noted to provide important and enjoyable foods, including harvests of wild fruits such as jamun (also known as the Malabar plum or Java plum) and chiganet (also known as mess apple or rose plum), which generally cannot be found in commercial markets (Canals Polder NDC 2021, pers. comm.). Medicinal products may be gathered for personal use, including daisy team, carilla bush, and local herbs. Hunting is rare and usually occurs in the backlands outside of the NDC.

Livestock rearing occurs throughout the NDC. Poultry operations range from small, yard-based facilities to large, enclosed facilities with multiple layers. Larger farms are located in the western part of the NDC including Belle West. Cattle operations exist in the NDC, and cattle are typically pastured in former cane fields (Canals Polder NDC 2021, pers. comm.).[47] Some sheep and goats are reared on a small scale. There are no communal pasture areas, although farmers occasionally harvest grass from roadsides and along dams.

As there are few forested areas outside of the Boerasirie Conservancy, timber for building and/or firewood is usually procured from a sawmill. No notable use of other fibers was identified, although NDC representatives noted that people used to collect palm fibers to make hats and other woven products (Canals Polder NDC 2021, pers. comm.).

In the Primary Study Area, where the onshore pipeline corridor will cross Canals 1 and 2, the Consultants surveyed 45 households.[48] Of these, ten respondents reported growing household

[46] Adjacent to the Demerara River, the communities of Bagotville (east end of Canal 1) and Stanleytown (east end of Canal 2) are not part of the Canals Polder NDC.
[47] Cattle rearing is noted to be more prominent and to occur at a larger scale in the neighboring Belle Vue area, outside of the NDC.
[48] Survey respondents included residents of Alliance, Bordeaux, Canal 1, Canal 2, Genieve, L'Oratoire, and Resource.

crops, including fruit, vegetables, cassava root, and hay. Thirteen own livestock, primarily poultry, although four households reported sheep, goats, or cows.

Use of Water and Canals

Farmers rely on the canals for transporting produce. Boats are also used to access the Boerasirie Conservancy, which is not accessible by road. Freshwater from the Boerasirie Conservancy is used for domestic purposes such as washing, gardening, and bathing. In addition to domestic use, freshwater is used to supply rice fields and farmlands. Recreationally, residents use the canals for boating activities, fishing, and swimming.

Fishing, for personal and commercial use, occurs in the larger canals and upstream in the Boerasirie Conservancy. Catch species include food fish and aquarium fish, such as lukananie (peacock bass), patwa (black acara), hurie, yarrow, hassar (thorny catfish), and himara.

Of the 45 households surveyed in the Primary Study Area, all respondents reported having access to piped water for domestic use. Six households reported using the canals for fishing (primarily), as well as swimming and drainage. Further information about canal use is provided in Section 9.3, Social Infrastructure and Services.

Regulating Services

Upstream of the canals crossing the onshore pipeline corridor, the Boerasirie Conservancy wetlands provide water regulation. On the eastern side of the area, mangroves on the Demerara River prevent erosion, and protect water quality. Pollination by hummingbirds and bees is an important function for local farm environments.

Cultural Services

The Boerasirie Conservancy is visited by some residents for spiritual and aesthetic enjoyment, as well as recreation, including bird watching. Flags symbolizing religious and spiritual values are often placed in the main canals. Canals are also used by residents for swimming, fishing, family outings, and boating.

Supporting Services

The canals, former and current agricultural fields, and the Boerasirie Conservancy (upstream) provide habitat for a variety of birds, fish, and other wild animals in the area. On the eastern side of the area, mangroves on the Demerara River provide nursery habitats for a variety of species.

9.8.2.4. South of Canal 2

South of Canal 2, the largest populated area comprises the neighboring towns of Sisters Village, Patentia, Vriesland, and Vive-la-Force. The village of Free and Easy is approximately 4 kilometers south of Patentia and accessible by road, although the road is poorly maintained past Patentia. Scattered households are located farther south along the WBD Public Road, adjacent to the Demerara River and in the vicinity of the proposed temporary MOF.

The Toevlugt Patentia NDC covers settlements on the West Bank of the Demerara River between Canal 2 and Vriesland, including the communities of Sisters Village and Patentia (Toevlugt Patentia NDC 2021, pers. comm.). The Consultants facilitated a focus group with the Toevlugt Patentia NDC in December 2021, attended by 14 representatives of the NDC, to discuss residents' use of the natural environment and ecosystem services.

The village of Free and Easy is not within the jurisdiction of the NDC, nor are the households in the Catherina Sophia area. These settlements are located within the former GuySuCo Wales Estate and are not currently part of an NDC.

Information presented in the following sections is derived from the Toevlugt Patentia NDC focus group, unless attributed to the 2021 household socioeconomic survey (which included households in Free and Easy, Catherina Sophia, and nearby settlements).

Provisioning Services

Agriculture and Harvesting

Residents of the Toevlugt Patentia NDC pursue fishing, hunting, and agriculture for both subsistence and commercial purposes. Fishing of wild-caught river fish and hunting of ducks generally occurs in the canals and backlands, although efforts have declined since closure of the GuySuCo Wales Estate, and people have reportedly refocused their efforts outside of the NDC (Toevlugt Patentia NDC, 2021, pers. comm.). In addition to fishing, residents rear poultry, sheep, and goats, and there is medium-scale farming of cash crops in the backdam (inland farmlands).

Bee keeping and timber harvesting do not occur in the community (Toevlugt Patentia NDC, 2021, pers. comm.). Some residents use herbal remedies for various ailments; medicinal plants are found throughout the communities, but there is no designated area for cultivation.

The Consultants surveyed 165 households in Patentia and neighboring communities of Sisters Village and Vriesland; and 52 households in the southern part of the Primary Study Area (including Free and Easy, Catherina Sophia, and other settlements). Based on household survey results, crop cultivation and livestock rearing, detailed as follows, are more common in the more rural settlements in the south, compared with the more populous area near Patentia, where supplies and services are more accessible:

- Of the 52 households surveyed in the southern settlements, the majority (35) reported growing crops including cassava, plantains, corn, coconut, and pepper; and around half (26) raise livestock such as cows, sheep, goats, poultry, and pigs.
- Of the 165 households surveyed in and around Patentia, 18 grow domestic fruits and vegetables, including bananas, peppers, coconut, and mangoes; while 36 rear livestock, such as poultry, cows, sheep, and pigs.

Use of Water and Canals

Most households surveyed report having access to piped water for domestic purposes. For areas not served by water mains, the households use surface water flowing from the Boerasirie Conservancy (via canals) and/or collect rainwater. Freshwater from canals is also used for domestic and irrigation purposes, including irrigation of rice fields in La Retrait (Toevlugt Patentia NDC, 2021, pers. comm.).

On the Demerara River, boats transport people across the river on a limited basis. There is a boat service based locally, near the Wales police station. A small number of people are reported to use the canals for transportation purposes, including farmers' use of canals transport produce.

Similar to agriculture, household survey responses indicate that residents of Patentia and neighboring communities are less likely to fish compared with people living in the more rural southern settlements, detailed below:

- In the southern settlements, approximately half (23 of 52) of surveyed households reported fishing. Of these, most report fishing from a combination of canals and river areas. Most responses indicated that fishing occurred for recreation and/or household consumption, although two respondents report selling their catch in Vreed-en-Hoop. Canal use was also widespread among these settlements. Sixteen households identified using canals for fishing, and 21 use them for travel / transportation, including access to inland fields and the backdam. Other canal use includes water for irrigation, domestic water, and swimming. Seventeen households reported using a boat as their primary means of transport.
- Near Patentia, 38 of 165 (23 percent) surveyed households reported fishing in canals and other areas. Twelve households (7 percent) identified use of canals for other activities including transportation, recreation, and farming.

Regulating Services

Mangroves along the Demerara River serve as a natural sea defense. Pollinators like hummingbirds are important to the wellbeing of the local farms.

Cultural Services

The Demerara River shoreline is a significant area for local Hindu residents, who regularly use the riverside to bathe and conduct religious ceremonies. These activities are focused near the kokers (sluice gates). Recreationally, some residents are reported to traverse the area to access the Boerasirie Conservancy, west of the Project.

Supporting Services

The canals and farming lands provide habitat for a variety of birds, fish, and other wild animals in the area. Mangroves along the Demerara River serve as nursery habitats and also provide habitat for baboons.

9.8.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on ecosystem services. The relevant planned Project activities and the associated potential impacts of these activities on ecosystem services are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.8.3.1. Relevant Project Activities and Potential Impacts

Ecosystem services represent the benefits that people derive from natural ecosystems. Planned Project activities that could affect biophysical attributes of the Project AOI, or change the way people use or depend on ecosystems and natural resources, are relevant to the assessment of potential impacts on ecosystem services.

The identification of potential impacts on ecosystem services considers both biotic (i.e., flora and fauna) and abiotic (i.e., physical and chemical characteristics) components of the ecosystem. Potential impacts are generally characterized around the four types of services:

- **Provisioning services**, representing the goods or products obtained from ecosystems such as food, freshwater, timber, fiber, and other goods;
- **Regulating services**, being the benefits obtained from an ecosystem's control of natural processes such as climate, water flow, pollination, and protection from natural hazards;
- **Cultural services**, including non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment; and
- **Supporting services**, comprising natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

These four categories of services provide the framework for assessing potential impacts on ecosystem services. Considering these categories, Table 9.8-1 summarizes the ecosystem services that have been considered in this assessment, and provides a rationale for whether each service has been scoped in or out of the remainder of this assessment. If a service is not identified as present in the study area, or the planned Project components and activities are not expected to influence the availability or quality of a service, or an assessment of impacts is sufficiently provided by other sections of this EIA, then no potential impact is identified.

Table 9.8-1: Summary of Ecosystem Services Impact Scoping

Ecosystem Service	Status	Rationale	EIA Reference(s)
Based on the accompanying rationale, items with a solid marker (●) are included in the assessment of ecosystem services in this section; those with a white marker (○) are not assessed; and those with a semi-solid marker (◉) are assessed in other EIA sections.			
Provisioning Services			
Food: marine fish and shellfish	◉	Commercial and subsistence fishing occurs in the nearshore and offshore areas and may be affected by offshore and nearshore construction activities. The assessment of potential impacts on fish habitat and fish populations is provided in Section 8.2, Marine and Coastal Biodiversity, while potential impacts on fishing livelihoods are addressed in Section 9.1, Socioeconomic Conditions.	• 8.2 Marine and Coastal Biodiversity • 9.1 Socioeconomic Conditions
Food: freshwater fish	●	Local residents report fishing from the canals. Changes to canals and changes to access to canals could affect harvest of freshwater fish from these areas.	• 8.4 Freshwater Biodiversity
Food: crabs	●	Crabbing occurs in mangroves throughout the year. Construction of the shore crossing and temporary MOF could affect the crab harvest from affected areas.	• 8.2 Marine and Coastal Biodiversity • 8.5 Ecological Balance and Ecosystems
Food: wild meat	○	The 2021 household socioeconomic surveys and interviews in Region 3 indicated that hunting is rare and typically occurs outside the socioeconomic Direct AOI.	-
Food: wild plants and honey	○	The 2021 household socioeconomic surveys and interviews in Region 3 indicated that some residents harvest wild fruits, including jamun and chiganet, as well as a variety of medicinal plants and local herbs. Terrestrial vegetation surveys documented these and other edible and medicinal plants in and near the Direct AOI. These species are widely available and not particular to the Direct AOI, and loss of vegetation associated with the Project would not be expected to result in scarcity of these wild plants.	• 8.3 Terrestrial Biodiversity
Cultivated crops	◉	Construction of the shore crossing, onshore pipeline, NGL Plant, and ancillary facilities will affect lands that are currently and/or were formerly cultivated lands. The assessment of impacts on agriculture is addressed in Section 9.6, Land Use and Ownership.	• 9.6 Land Use and Ownership
Livestock farming	◉	Although no communal grazing areas are identified in the socioeconomic Direct AOI, areas reportedly used for grazing livestock, including the seawall, fallow sugarcane fields, and along roadsides and dams, are informally used for grazing. The assessment of potential impacts on grazing areas is addressed in Section 9.6, Land Use and Ownership.	• 9.6 Land Use and Ownership
Timber and wood products	○	Collecting timber and wood products is not common in the socioeconomic Direct AOI. The 2021 household socioeconomic surveys and interviews in Region 3 indicated that	-

Ecosystem Service	Status	Rationale	EIA Reference(s)
		lumberyards are widely available, forests are limited due to extensive cultivation (past and present), and residents are increasingly respectful of mangroves as sea defense.	
Biomass fuel	○	Use of biomass fuel has not been identified in the Primary Study Area.	—
Non-wood fibers and resins	○	Use of fibers and resins has not been identified in the Primary Study Area.	—
Freshwater for household use	●	Potential changes to canal networks could affect a source of freshwater used for domestic purposes.	—
Freshwater for irrigation	●	Potential changes to canal networks could affect a source of freshwater used for crop irrigation and household gardens.	—
Aquatic transportation	●	Potential changes to canal networks could affect the role of canals as a means for travel and transportation.	• 9.3 Social Infrastructure and Services • 9.6 Land Use and Ownership
Traditional resources and medicines	○	The 2021 household socioeconomic surveys and interviews in Region 3 indicated some use of medicinal plants and herbs identified in the Study Area, although no species were identified in stakeholder interviews as scarce or over-exploited. Loss of vegetation associated with the Project would not be expected to produce resource scarcity or result in significant impacts on traditional medicine use in the biophysical Direct AOI.	—
Regulating Services			
Global climate regulation (i.e., carbon sequestration)	○	The majority of land clearance will involve grasslands and fallow agricultural fields; secondary growth, mangroves, and riparian forests (valued for carbon sequestration) represent less than 0.8 hectare (combined) of the planned land clearance. Therefore, land clearance associated with the Project is not expected to influence carbon sequestration or global climate regulation processes. Potential impacts on marine carbon sequestration are assessed in Section 8.5, Ecological Balance and Ecosystems, and the Project's greenhouse gas emissions and potential impacts on global climate change are assessed in Section 7.6, Air Quality, Climate, and Climate Change.	• 7.6 Air Quality, Climate, and Climate Change • 8.3 Terrestrial Biodiversity • 8.5 Ecological Balance and Ecosystems
Regulation of water timing and flows	●	Potential changes to canal networks could affect natural and physical systems that regulate water flow.	• 7.1 Geology and Groundwater
Flood regulation	●	Potential changes to canal networks could affect flooding regulation.	—
Erosion regulation	◯	Potential changes to vegetation and canal networks could affect vegetation and ecosystems that regulate soil erosion. Soil erosion (including agricultural soils) is	• 7.2 Soils

Ecosystem Service	Status	Rationale	EIA Reference(s)
		assessed in Section 7.2, Soils. The assessment also identifies embedded controls to minimize erosion and reinstate natural erosion regulation, including stabilization, revegetation, and restoration of affected areas.	
Shoreline protection / mangroves / river defense	●	Construction of the shore crossing (coastal) and temporary MOF (Demerara River) could affect ecosystems that provide shoreline and riverside protection.	• 8.4 Freshwater Biodiversity • 8.5 Ecological Balance and Ecosystems
Pollination	○	Birds, bees, and other insects are valued for their role in pollination. Considering the widespread current and former cultivation of the Primary Study Area, the Project is not expected to alter habitat or affect birds, bees, or other insects to the extent that pollination would be influenced.	• 8.3 Terrestrial Biodiversity
Disease regulation	○	Considering the widespread current and former cultivation of the Primary Study Area, the Project is not expected to alter habitat in a way that would influence disease regulation.	• 8.3, Terrestrial Biodiversity
Pest regulation	○	Bats and mongooses are local predator species valued locally for pest regulation. Considering the widespread current and former cultivation of the Primary Study Area, the Project is not expected to alter habitat or affect predator species.	• 8.3, Terrestrial Biodiversity
Cultural Services			
Cultural, spiritual, or religious value of ecosystems	●	The shoreline is used for cultural, spiritual and/or religious activities, including by members of the Hindu population who access the coastal shore access for praying and placement of jhandi (prayer) flags.	• 9.5 Cultural Heritage
	◉	Two Ceiba (silk cotton) trees are identified along the proposed onshore pipeline RoW. These trees are important to coastal oral traditions, and are described further—along with an assessment of related potential impacts on intangible cultural heritage—in Section 9.5, Cultural Heritage.	• 9.5 Cultural Heritage
Tourism and recreation	●	Local residents are known to recreate along the seawall. Although specific use of the shore crossing has not been identified, the shore crossing is close to an access point used to access the waterfront.	—
Aesthetic value of natural landscapes	○	The affected landscape has been extensively modified by human presence and no areas of high aesthetic or visual quality (or inherently associated with natural landscapes) have been identified.	• 9.7 Landscape and Visual Resources
Non-use value of biodiversity	○	The affected landscape has been extensively modified by human presence. No notable non-use value of biodiversity (i.e., the inherent value of the existence of high biodiversity areas) is identified in relation to the onshore Project areas.	• 8.3 Terrestrial Biodiversity

Ecosystem Service	Status	Rationale	EIA Reference(s)
	◉	A variety of special status species are found in the Marine AOI, indicating value for biodiversity conservation. Potential impacts are assessed in Section 8.6, Special Status Species.	• 8.6 Special Status Species
Supporting Services			
Habitat provision	○	Section 8.2, Marine and Coastal Biodiversity, and Section 8.3, Terrestrial Biodiversity, consider potential impacts on biodiversity and habitats in the Project AOI.	• 8.2 Marine and Coastal Biodiversity • 8.3 Terrestrial Biodiversity
Primary production	○	The Project is not expected to affect primary production processes.	—
Nutrient cycling	○	The Project is not expected to affect nutrient cycling processes.	—
Water cycling	○	The Project is not expected to affect water cycling processes.	—
Soil formation	○	The Project is not expected to affect processes of soil formation and /or accretion.	—

Considering the interactions identified above, Table 9.8-2 further describes the planned Project activities that could result in potential impacts on ecosystem services, including activities during the Construction and Operations stages. During the Decommissioning stage, the onshore and offshore pipelines are planned to be left in situ, and decommissioning and removal of the NGL Plant and ancillary infrastructure are not expected to impact ecosystem services.

Table 9.8-2: Summary of Relevant Project Activities and Key Potential Impacts—Ecosystem Services

Stage	Project Activity	Ecosystem Service(s)	Key Potential Impacts
Construction	***Provisioning Services***		
	Installation of the offshore pipeline; construction of the shore crossing	Food: crabs	Change in the availability of crabs from mangroves due to nearshore and shore crossing construction activities
	Construction of the temporary MOF	Aquatic transportation	Change in use of Demerara River for travel and fishing
		Food: fish (freshwater)	
	Regulating Services		
	Filling and replacement of canals	Regulation of water timing and flows	Reduced water and/or flood regulation due to change in connectivity of canal network and local drainage
		Flood regulation	
	Construction of the shore crossing; construction of the temporary MOF	Shoreline protection / mangroves / river defense	Reduced shoreline protection (coastal and/or riverside) due to loss of mangroves and shoreline vegetation
	Cultural Services		
	Construction of the shore crossing	Cultural, spiritual, or religious value of ecosystems	Change in access to shoreline for cultural, spiritual, religious, or recreational activities
		Tourism and recreation	
Operations	***Provisioning Services***		
	Decommissioning of temporary MOF	Aquatic transportation	Change in use of Demerara River for travel and fishing
		Food: fish (freshwater)	

9.8.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2 Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors - frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for ecosystem services (Table 9.8-3). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for ecosystem services are provided in Table 9.8-4.

Table 9.8-3: Definitions for Intensity Ratings for Potential Impacts on Ecosystem Services

Criterion	Definition
Intensity	**Negligible**: No measurable change in the availability or function of the ecosystem service. Beneficiaries do not perceive a change in access to or quality of the ecosystem service.
	Low: Perceptible change in the availability or function of the ecosystem service. Beneficiaries may perceive a change in access to, or quality of, the ecosystem service, but change is unlikely to affect livelihoods or wellbeing.
	Medium: Perceptible change in the availability or function of the ecosystem service, which could adversely impact the livelihoods or wellbeing of beneficiaries. Localized impact (affects less than 20 households).
	High: Perceptible change in the availability or function of the ecosystem service, which could adversely impact the livelihoods or wellbeing of beneficiaries. Generalized impact (affects 20 or more households).

Table 9.8-4: Definitions for Resource Sensitivity Ratings for Potential Impacts on Ecosystem Services

Criterion	Definition
Sensitivity	**Low**: Beneficiaries are not dependent on the service for their livelihoods or wellbeing. Or, the ecosystem service is widely available and accessible to beneficiaries, and if the ecosystem service is lost or changed, its function can be quickly replaced or re-established.
	Medium: The ecosystem service is important, but not critical, to the livelihoods and wellbeing of beneficiaries. If the ecosystem service is lost or changed, its function can be replaced or re-established over time.
	High: Beneficiaries are highly dependent on the ecosystem service for their livelihoods or wellbeing and have little ability to cope with a change to the availability or function of the service. Or, the service is less critical, but is difficult or impossible to replace or re-establish.

9.8.3.3. Impact Magnitude Ratings—Ecosystem Services

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to ecosystem services is provided in Section 9.8.4, Impact Management and Monitoring Measures (Table 9.8-5).

Ecosystem services is a complex topic, as the resource is interconnected with other elements of the EIA. Potential impacts described in this section are based on the impact scoping summarized in Table 9.8-1, and related impacts are assessed in other chapters of the EIA.

Separate discussions are provided below for each of the six impacts identified in Table 9.8-2, including:

- Provisioning services:
  - Change in the availability of crabs from mangroves
  - Change in the use of canals
  - Change in the use of the Demerara River
- Regulating services:
  - Reduced water and/or flood regulation

  - Reduced coastal and/or riverside shoreline protection

- Cultural services:
  - Change in access to shoreline for cultural, spiritual, religious, or recreational activities

Change in the Availability of Crabs from Mangroves (Provisioning Service)

Harvesting of crabs is reported to occur seasonally in the nearshore area, and year-round in mangroves. Fishing livelihoods, including offshore and nearshore harvesting, are addressed in Section 9.1, Socioeconomic Conditions; the remainder of this assessment focuses on crabs obtained from mangroves.

Construction of the shore crossing has the potential to impact 0.29 hectare of coastal strand vegetation including mangrove-associated species. Construction of the temporary MOF has the potential to impact 0.06 hectare of riparian forest including mangrove-associated species. Therefore, changes to crab habitat and/or crab populations that could change the availability of crabs for harvesters is identified as a potential impact on this ecosystem service.

Crab habitat and crab populations have not been specifically identified in either of these locations (based on the results summarized in Section 8.2, Marine and Coastal Biodiversity, Section 8.4, Freshwater Biodiversity, and Section 8.5, Ecological Balance and Ecosystems). Therefore, the intensity of the Project's impact on the availability of crabs for harvesting in mangroves is considered to be **Negligible**. The potential impact will occur once, during the Construction stage, so the frequency is considered **Episodic**. Potential impacts are expected to last longer than a week but less than a year, so the duration is **Medium-term**. In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on the availability of crabs from mangroves is rated as **Negligible.**

Change in Use of Canals (Provisioning Services)

Throughout the Primary Study Area, the network of existing canals provides a source of freshwater for irrigating crops and household gardens, and the canals are occasionally used for domestic water (particularly during the dry season) as well as swimming and bathing. Canals provide a means for travel, including access to the "backdam" and fields that are not accessible by overland road; farmers use the canals to transport produce from their fields. Fishing occurs in the canals, as local residents report harvesting a variety of fish for food and/or aquarium trade from the channels. Reliance on the canals as a mode of transportation and a place for fishing is most pronounced in the South Wales communities.

Construction of the onshore pipeline will involve a combination of open-cut (19.95 kilometers) and HDD (4.94 kilometers) construction methods.

Backfilling canals will affect the canals west of the Westminister / Lust-en-Rust housing scheme, and between Canal 1 and Canal 2. Affected lands are subject to active rice and pineapple cultivation, and are adjacent to residential areas, as described in Section 9.6, Land Use and Ownership. All canals planned for backfilling are north of Canal 2. Therefore, residents of the

South Wales settlements—who exhibit a higher level of use of, and dependency on, canals—are unlikely to be affected by the planned canal filling and replacement.

Assuming that affected canals are replaced in the manner described above, livelihood and wellbeing impacts will be avoided for most beneficiaries. However, some localized impacts on livelihoods and/or wellbeing may be experienced by some beneficiaries after the reconfigured canal network is established; for example, a farmer may need to travel a different route through the canal network to access inland fields. Considering the above, the intensity of the potential impacts on the provisioning services provided by the existing canal network is determined to be **Medium**. For affected beneficiaries, this impact is expected to last for more than a week but less than a year, as the degree of hardship will decrease as new canal use patterns become established; the duration is thus considered **Medium-term**. Frequency is considered **Continuous**, as affected beneficiaries are generally understood to be regular canal users. Therefore, the magnitude of impacts on the provisioning services of affected canals is rated as **Medium.**

Change in Use of Demerara River for Travel and Fishing (Provisioning)

The Demerara River provides both a travel route (including access to the Amerindian village of Santa Aratak, discussed further in Section 9.9, Indigenous Peoples) and source of freshwater fishing. The Project may affect these provisioning services during in-river works and dredging associated with construction—and later decommissioning[49]—of the temporary MOF.

Construction activities will restrict access to areas actively subject to dredging activities, for a duration of approximately 1 year. The location of these activities will be dynamic in the river adjacent to the temporary MOF, and dredging vessels will navigate in a manner that allows other vessels to safely pass upstream and downstream. With an approximate river width of 1.2 kilometers, the majority of the river will continue to be navigable by non-Project vessels at any given time. Access restrictions during the Decommissioning stage will be smaller in scale and shorter in duration relative to the Construction stage. Impacts related to river traffic and river navigation are assessed in Section 9.4, Transportation, which concludes that the Project's impact on river navigation will be **Minor** in magnitude.

Construction of the temporary MOF and related dredging could also affect riverine fish as a provisioning service through potential changes in the accessibility of fishing grounds, quality of fish habitat, and/or health of fish populations. Specific fishing grounds in the Demerara River were not identified through the baseline studies (including through the 2021 household socioeconomic surveys or focus group discussions). Section 8.4, Freshwater Biodiversity, assesses multiple potential impacts on fish and fish habitat in the Demerara River, and concludes that the impacts of riverine biodiversity during construction is expected to range from **Small** to **Negligible** in magnitude.

The Demerara River is a primary river in Guyana, with links to Georgetown, the east bank of the Demerara River, and upstream to communities such as Santa Aratak, so the impact is

[49] The temporary MOF has an anticipated life of 10 years. Decommissioning of the temporary MOF will be undertaken by the Government of Guyana during the Operations stage of the Project.

determined to apply to the Indirect AOI. Considering the **Negligible**-to-**Low** magnitude of impact on river navigation and fish populations, the potential change to the Demerara River as a provisioning service is predicted to be **Low** in intensity. Changes to how people use the river will be noticeable, but are unlikely to affect livelihoods or wellbeing. For affected river users, the impact is expected to last for more than a week and less than a year, so the duration is **Medium-term**. The frequency is considered **Episodic**, as impacts will be focused on the active periods of the dredging cycle. Therefore, the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on the provisioning services of the Demerara River is rated as **Small**.

Reduced Water and/or Flood Regulation (Regulating)

As noted above, a network of existing, interconnected canals extends throughout the Primary Study Area (and throughout Region 3 more broadly). In addition to the provisioning services associated with freshwater, travel, and fishing, these canals are an integral part of the hydrological system and regulate the movement of water throughout the region. Upstream, the forests and wetlands of the Boerasirie Conservancy act as the source of most freshwater that feeds the canals between the Conservancy and the Demerara River. The canals were developed during the colonial period to support large-scale agricultural production, primarily sugarcane (Mullenite 2020).

Located in the backlands between the Demerara and Essequibo rivers, the Boerasirie Conservancy was established in its current form in 1950 and stores waters from the Boerasirie River. It feeds the irrigation canals that serve over 40,000 hectares of agricultural lands in Region 3 (Mullenite 2020). Downstream villages have historically relied upon the Boerasirie Conservancy. Early in its history, inefficient design and poor soil conditions made the conservancy inadequate for supporting both large-scale agricultural production and village settlements, as exhibited during periods of drought and erosion, although re-design and establishment of new inflows to the conservancy led to the success of the current water provision network (Mullenite 2020). In the present day, residential areas downstream of the conservancy include the Primary and Secondary Study Area communities, including, but not limited to, Canal 1, Canal 2, Westminister / Lust-en-Rust, and the settlements in the South Wales area.

Construction of the onshore pipeline will involve a combination of open-cut and HDD construction methods. Considering the water regulating services provided by canals, anychange to, the canal network is an important impact to consider, as it could influence the predictability or control of water networks in the local drainage system.

Section 7.1, Geology and Groundwater, considers potential impacts on the shallow water table and (indirectly) canal water levels as a result of dewatering during the Construction stage, and concludes that a change in water levels is expected to be within the range of natural variation (and therefore **Negligible** in intensity).

The Government's efforts will benefit from the water management and flood control expertise of the National Drainage and Irrigation Authority, and will be aligned with the Authority's efforts to support agricultural activities and improve resilience to extreme rainfall events associated with climate change (Ministry of Agriculture Undated). Accordingly, the potential intensity of the impact is considered to be **Negligible.** The potential impact is considered **Medium-term** and **Continuous**. In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on the regulating services provided by the canals is rated as **Negligible**.

Reduced Coastal and/or Riverside Shoreline Protection (Regulating)

As noted in Section 8.4, Freshwater Biodiversity, riparian areas and their associated vegetation enhance streambank stability and reduce erosion. Within the Direct AOI, the widest and most intact riparian vegetation zones are along the Demerara River; these zones support important nearshore and instream habitat, as well as ecologically significant mangrove species. Along the Atlantic coast (as described in Section 8.5, Ecological Balance and Ecosystems), the existing seawall and mangrove-associated species provide similar stability for the coastline, and the sea defense is also bolstered by a seawall. These coastal and riverside shoreline protections represent regulating ecosystem services.

Construction of the shore crossing has the potential to impact 0.29 hectare of coastal strand vegetation including mangrove-associated species along approximately 200 meters of the coastal shore frontage, although there will be no physical impact on the beach or seawall as this section of the shore crossing will be constructed using HDD methods. Construction of the temporary MOF has the potential to impact 0.06 hectare of riparian forest including mangrove-associated species along approximately 30 meters of river shore frontage. The Project construction could therefore impact the regulating service provided in terms of coastal and/or shoreline protection in these areas.

At both the shore crossing and the temporary MOF, construction will be conducted with an effort to minimize the footprint of activities and preserve coastal strand and riparian forest as much as practicable. Shoreline stability will be monitored during construction and will be reinforced as required to reduce erosion. After construction, pre-existing shoreline protection will be re-established through revegetation or armoring of disturbed areas, and may be supplemented by other forms of support and/or stabilization, if required.

Direct beneficiaries of this regulating service differ between the riverside (temporary MOF) and coastal (shore crossing) areas. For the former, there are few settlements in the South Wales area; as discussed in Section 9.6, Land Use and Ownership, there will be no residential dwellings within 300 meters of the proposed temporary MOF during the Construction stage. With a relatively small affected shoreline (approximately 30 meters) and no residential dwellings, the intensity of impact on riverside shoreline protection is determined to be **Negligible**. At the more populated coastal shore crossing, the existing shoreline protection benefits an estimated 10 to 14 homes immediately south of the shore crossing. Although the shore crossing has a larger population and longer affected shoreline (up to 200 meters), the potential impact is considered to be **Low** intensity, as the seawall provides added, engineered shoreline protection. Impacts on the seawall will be avoided (as the base-case construction scenario uses HDD to construct the shore crossing), or will be restored to a pre-construction condition.

Although the loss of shoreline vegetation will occur once, it will take some time to re-establish, so the frequency and duration are considered to be **Continuous** and **Long-term**. In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on shoreline protection as a regulating service is rated **Negligible** for the Demerara River (temporary MOF) and **Small** for the Atlantic coast (shore crossing).

Change in Access to Shoreline for Cultural, Spiritual, Religious, or Recreational Activities (Cultural)

Access to the coastal shore is valued by local residents. The beach is a place of prayer and religious rites for Hindu ceremonies (particularly common for Indo-Caribbean populations in Guyana and other Caribbean nations) and prayer flags have been observed on the beach near the shore crossing (as discussed in Section 9.6, Land Use and Ownership: Figure 9.6-7). These ‘jhandi flags’ are a core element of Hindu practice in Guyana. The triangular pieces of cloth—in various colors depending on the deity honored—are “consecrated by Hindu priests, transforming them into sacred objects of worship on par with…statues or images of Hindu deities” (Pillai 2021). Jhandi flags are erected following a puja (ritual) or prayer ceremony, provide a lasting symbol of devotion. The flag and bamboo pole are typically left in place to weather away, although a new flag may be later erected in the same location (Vertovec 1992). Although jhandi flags are often positioned at private homes and temples, they are also found in Guyana on the beach and near other waterbodies, including canals, where they may be representative of funereal rites or religious rituals involving water. In addition to religious and spiritual activities, the seawall is also used by local residents and families for recreation.

Construction of the shore crossing will temporarily restrict access to the beach near Crane. The shore crossing will be constructed using HDD, and there will be no excavation of the beach or seawall. However, while construction activities are underway, the beach will be used as a staging area for activities in the nearshore area, and access will be fully or partially restricted during these activities (up to approximately 3 months). Additionally, a footbridge east of the shore crossing may be temporarily inaccessible to the public while shore crossing construction is underway. These restrictions may impact the cultural service provided by the beach, if people are unable to access areas used for prayer and religious practices and/or recreational activities.

The beach area (and any existing jhandi flags or other artefacts) will be unaffected, although access to a segment of the beach will be temporarily hindered due to lack of access via the existing footbridge. Thus, the intensity of the impact on the cultural service provided by the shoreline is considered **Low**. The potential impact will be **Continuous** while the shore crossing is under construction. This will be for more than a week and less than a year, so the duration is **Medium-term**. In accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude of impacts on the cultural service provided by the coastal waterfront is rated **Small.**

9.8.3.4. Sensitivity of Resource—Ecosystem Services

Considering the sensitivity rating definitions in Table 9.8-4, the sensitivity of beneficiaries to changes in ecosystem services is specific to the type of service affected. Crabs are found in mangroves throughout Region 3, and beneficiaries are not dependent on this resource, so the sensitivity is considered **Low**. Similarly, beneficiaries of the Demerara River are identified to have a **Low** sensitivity due to the width of the river, relatively low volumes of vessels transiting near the proposed temporary MOF site (approximately 23 vessels per day[50]), and availability of road connections between Timehri and Georgetown.

The provisioning services provided by canals are more nuanced; although fishing in canals is considered replaceable and low dependency, the service provided by canals as a transportation route may be important to some livelihoods and takes longer to reinstate. Therefore, beneficiaries are conservatively considered to have a **Medium** sensitivity to change in the provisioning service of canals. Beneficiaries of shoreline protection and water/flood protection are also considered to have a **Medium** sensitivity due to the proximity of homes to the Atlantic shoreline near the shore crossing, and to canals more generally. Homes and fields cannot be relocated, and represent financial and emotional investment of homeowners. Finally, beneficiaries of the cultural service associated with the coastal shore are also considered to have a **Medium** sensitivity due to the importance of religious rites and the tangible representation provided by jhandi flags, noting that there are many alternative routes to access the waterfront.

9.8.3.5. Pre-mitigation Impact Significance—Ecosystem Services

Assuming implementation of the embedded controls listed in Table 9.8-5, the intensity ratings for potential impacts on ecosystem services from planned Project activities range from **Negligible** to **Medium.** This results in pre-mitigation magnitude ratings ranging from **Negligible** to **Medium.** Coupled with sensitivity ratings of **Low** and **Medium** (depending on the beneficiary), the pre-mitigation impact significance for ecosystem services ranges from **Negligible** to **Moderate**.

9.8.4. Impact Management and Monitoring Measures

Most potential ecosystem services impacts are predicted to have a pre-mitigation significance of **Negligible to Minor**; therefore, no mitigation measures are proposed for these potential impacts. It is noted, however, that the limited significance of potential ecosystem services impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

[50] Based on an observational study conducted in February 2022, an average of 23 vessels per day were observed on the river between the proposed temporary MOF site and the east bank of the Demerara River near Brickery. Nearly 80 percent of this vessel traffic consisted of passenger boats (including river tours and private vessels) and fishing vessels, and the other 20 percent included cargo ships, tankers, barges, tugs, and other vessels. Further information is provided in Section 9.4, Transportation.

The potential impact on the provisioning services provided by canals is predicted to have a pre-mitigation significance of **Moderate**, reflecting how integral the canal network is to the lives and livelihoods of local residents. Changes to the canal network are the responsibility of the Government of Guyana; however, EEPGL will work with the Government of Guyana to facilitate proactive engagement and communication with agricultural land owners and land users nearby to provide information about planned changes to the canal network, solicit input from stakeholders in advance, and address grievances if they arise. With this measure in place—and with the assumption that the functionality of the canal network will be restored or improved through the efforts of the Government of Guyana—the significance of this impact is expected to be reduced to **Minor**.

EEPGL is also committed to avoiding impacts on items and areas of cultural or spiritual value, including jhandi flags that may be found on the beach near the shore crossing. If such items are identified during pre-construction surveys, local stakeholders such as religious leaders will be engaged to determine an appropriate course of action. With this measure in place, the significance of this potential impact is reduced from **Minor** to **Negligible**.

Table 9.8-5 summarizes the management and monitoring measures relevant to ecological balance and ecosystems.

Table 9.8-5: List of Management and Monitoring Measures

Embedded Controls
Develop and implement a Stakeholder Engagement Plan that includes measures for continued engagement with communities, including informal settlements.
Implement a transparent, accessible, and consistent Community Grievance Mechanism prior to onset of Project activities. Take measures to promote the CGM being well publicized and understood by the public, including residents of informal settlements.
During dredging activities associated with the temporary MOF, conduct the dredging operation so as to maintain the ability for passenger vessels to pass up- and down-river of the temporary MOF.
Mitigation Measures
Work with the Government of Guyana to conduct proactive engagement and communication with agricultural land owners and land users near the onshore pipeline, to provide information about planned changes to the canal network, solicit input from stakeholders in advance, and address grievances.
Engage with residents and landowners near the shore crossing to proactively address potential concerns related to shoreline protection.
Prior to initiating construction activities at the shore crossing, identify jhandi flags or other religious or spiritual symbols within the affected area. Consult with local stakeholders (e.g., religious leaders) to determine an appropriate course of action if disturbance cannot be avoided.
Monitoring Measures
Monitor shoreline changes and/or erosion during and after construction of the shore crossing, and implement additional measures to stabilize shoreline if required.
Monitor frequency of engagement with stakeholder communities, including residents and land users.
Track number and types of complaints received and resolved via the Project CGM; adjust the CGM and other management measures on an ongoing basis, as appropriate, based on feedback received. Disaggregate the data by location of complainant (e.g., community, Georgetown, other location).
Monitor average time for processing and resolving grievances.
Track percentage of grievances resolved.

CGM = Community Grievance Mechanism

9.8.5. Assessment of Residual Impacts

Considering the mitigation measures described above, two potential impacts are expected to reduce in significance. The residual significance of all impacts is predicted to range from **Negligible** to **Minor**.

Table 9.8-6 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on ecosystem services.

Table 9.8-6: Summary of Potential Pre-Mitigation and Residual Impacts—Ecosystem Services

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Change in the availability of crabs from mangroves (Provisioning)	Low	Negligible	Negligible	None	Negligible
Construction	Change in use of canals (Provisioning)	Medium	Medium	Moderate	Engage with affected parties	Minor
Construction Operations	Change in use of Demerara River (Provisioning)	Low	Small	Negligible	None	Negligible
Construction	Reduced water and/or flood regulation (Regulating)	Medium	Negligible	Negligible	None	Negligible
Construction	Reduced shoreline protection (Regulating)	Medium (Atlantic coast)	Small (Atlantic coast)	Minor (Atlantic coast)	Engage with affected parties	Minor
			Negligible (Demerara River)	Negligible (Demerara River)	None	Negligible
Construction	Change in access to shoreline for cultural, spiritual, religious, or recreational activities (Cultural)	Medium	Small	Minor	Avoid disturbance of existing jhandi (prayer) flags	Negligible

9.9. Indigenous Peoples

This section presents an overview of Indigenous Peoples in Guyana and in the vicinity of the Project (including Region 3 and Region 4), and considers how Indigenous Peoples may be affected by the Project. Impacts on the broader population (including non-indigenous persons and communities) are considered and assessed in Sections 9.1 through 9.8.

In this section, Amerindian peoples are understood to be the Indigenous Peoples of Guyana. The terms “Amerindian” and “Indigenous” are thus used interchangeably.

9.9.1. Baseline Methodology

The understanding of existing conditions (Section 9.9.2, Existing Conditions and Baseline Studies) is based on a combination of desktop (secondary) and field-based (primary) research. Desktop research drew on publicly available information, including the Guyana national census[51] and reports by government, NGO, and multilateral institutions. Field-based research included household surveys conducted in the vicinity of the Project in Region 3, as described in Section 9.1, Socioeconomic Conditions.

Study areas for socioeconomic resources, as referenced in this section, are defined in Section 9.1, Socioeconomic Conditions, and illustrated in Figure 9.1-1. Study areas include:

- Direct AOI
  - **Primary Study Area[52]:** This study area includes communities and households within 500 meters of the onshore pipeline corridor; within 1 kilometer of the NGL Plant boundary and/or temporary MOF; within the area extending from the Demerara River immediately north of Free and Easy village south and west to the NGL Plant and temporary MOF; plus the area encompassing settlements in the Belle West housing scheme.
  - **Secondary Study Area:** This study area includes communities and households located between the Primary Study Area and the Demerara River.
- Indirect AOI
  - **Tertiary Study Area**: This study area includes the communities on the East Bank of the Demerara River immediately across from the temporary MOF.

    The communities that were engaged and/or studied in the Tertiary Study Area include Brickery, Garden of Eden, and Land of Canaan.
  - **Regional Study Area:** This study area includes the remainder of Region 3, plus Regions 2 and 4 (the balance of the Onshore Indirect AOI, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology).

[51] The most recent national census was undertaken in 2012 (BSG 2012).

[52] The socioeconomic Primary Study Area includes the Direct AOI for biophysical components, as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

The communities that were engaged and/or studied in the Regional Study Area include Georgetown, Santa Aratak, and Pakuri.

The combined socioeconomic study areas are equivalent to the Onshore Indirect AOI as defined in Chapter 3, EIA Approach and Impact Assessment Methodology.

9.9.2. Existing Conditions and Baseline Studies

9.9.2.1. National Context

The population of Guyana's Indigenous Peoples, referred to as Amerindians (a term defined in the Amerindian Act to represent Guyana's First People), numbered 78,492 as of the 2012 census. At this time, their population was on the rise, increasing by 12.8 percent between 2002 and 2012 (BSG 2012). According to the 2012 census, Amerindians comprised 10.5 percent of the national population and their numbers had nearly doubled since 1980 (Table 9.9-1).

Table 9.9-1: Distribution of Population by Ethnicity/Nationality Group (1980–2012)

Ethnicity / Nationality Group	Population				Percentage			
	1980	1991	2002	2012	1980	1991	2002	2012
Amerindian	40,343	46,722	68,675	78,492	5.3	6.5	9.1	10.5
African/Black	234,094	233,465	227,062	218,483	30.8	32.3	30.2	29.3
Chinese	1,864	1,290	1,396	1,377	0.3	0.2	0.2	0.2
East Indian	394,417	351,939	326,277	297,493	51.9	48.6	43.4	39.8
Mixed	84,764	87,881	125,727	148,532	11.2	12.1	16.7	19.9
Portuguese	3,011	1,959	1,498	1,910	0.4	0.3	0.2	0.2
White	779	308	476	415	0.1	0.04	0.06	0.06
Other	294	107	112	253	0.04	0.01	0.01	0.03
Total	759,566	723,671	751,223	746,955	100	100	100	100

Source: BSG 2012

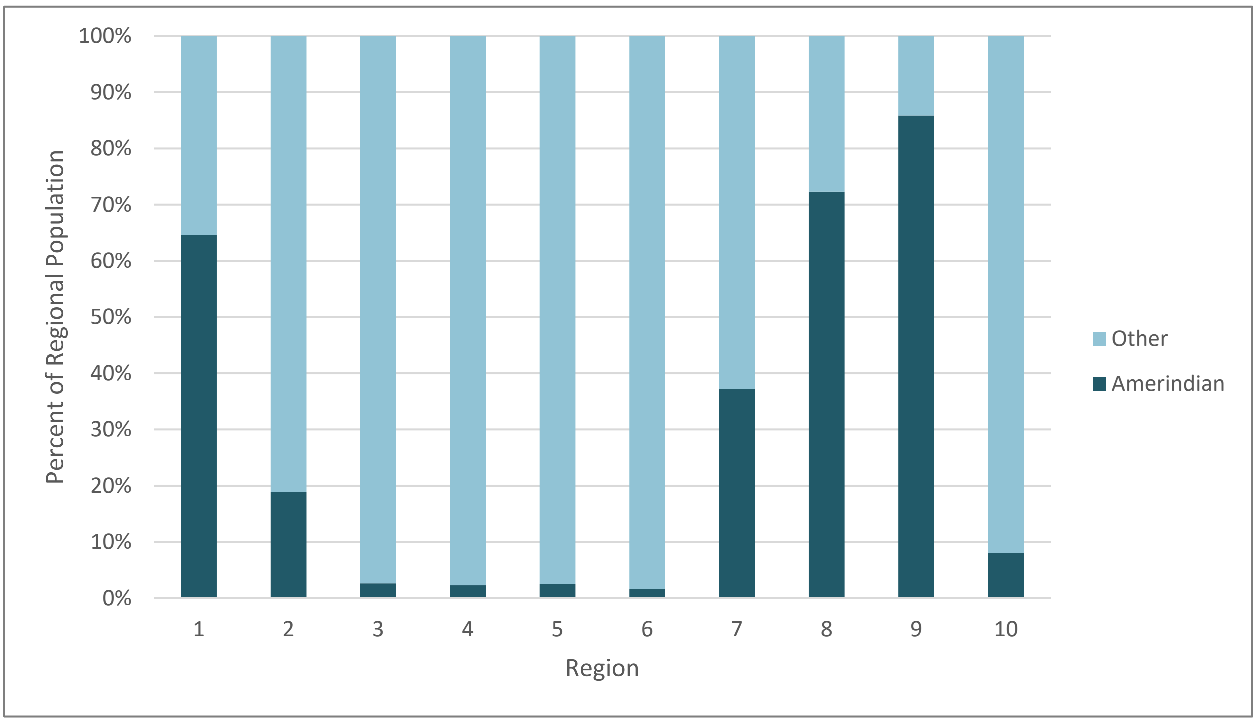
The majority of Amerindians live in the Hinterland Regions[53], where they made up between 37 percent and 86 percent of the regional population in 2012 (Table 9.9-2; Figure 9.9-1). Although the greatest numbers of Amerindians reside in Regions 1 and 9, there were over 6,000 Amerindian residents in each of Regions 2, 7, and 8 (Figure 9.9-2) as of the 2012 census. As the most populous region in Guyana, Region 4 reported over 7,000 Amerindian residents, representing 2.3 percent of the regional population. In Regions 3, 5, and 6, Amerindians also represented less than 3 percent of the population.

[53] Hinterland Regions include Regions 1, 7, 8, and 9.

Table 9.9-2: Percentage Distribution of Ethnicity/Nationality Group by Region (2012)

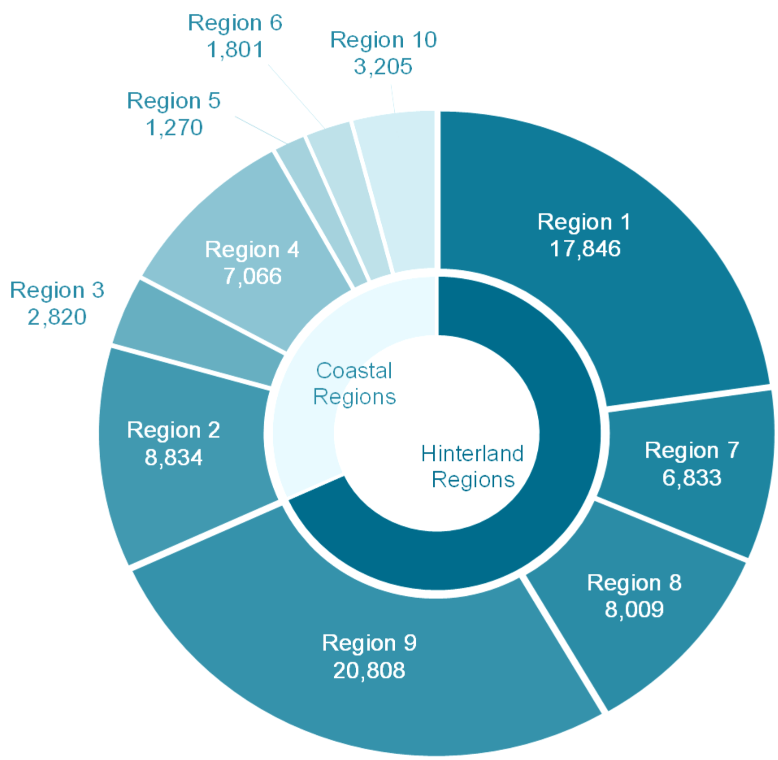
Ethnicity / Nationality Group	Region										
	1	2	3	4	5	6	7	8	9	10	Total
Amerindian	64.56	18.87	2.62	2.27	2.55	1.64	37.19	72.30	85.85	8.01	10.51
African/Black	2.30	12.58	21.13	40.56	33.06	21.32	11.62	7.75	1.46	49.02	29.25
Chinese	0.05	0.09	0.18	0.24	0.09	0.16	0.14	0.08	0.04	0.32	0.18
East Indian	1.71	44.57	59.55	35.02	54.66	66.03	8.54	2.55	1.04	2.82	39.83
Mixed	31.17	23.60	16.38	21.45	9.51	10.69	40.89	16.59	11.17	39.63	19.88
Portuguese	0.17	0.22	0.08	0.37	0.08	0.07	1.21	0.69	0.30	0.10	0.26
White	0.04	0.07	0.03	0.06	0.03	0.05	0.05	0.05	0.12	0.08	0.06
Other	0.01	0.00	0.05	0.03	0.01	0.02	0.36	0.00	0.02	0.03	0.03
Total	100	100	100	100	100	100	100	100	100	100	100

Source: BSG 2012



Source: BSG 2012

Figure 9.9-1: Amerindian Proportion of Population by Region, 2012



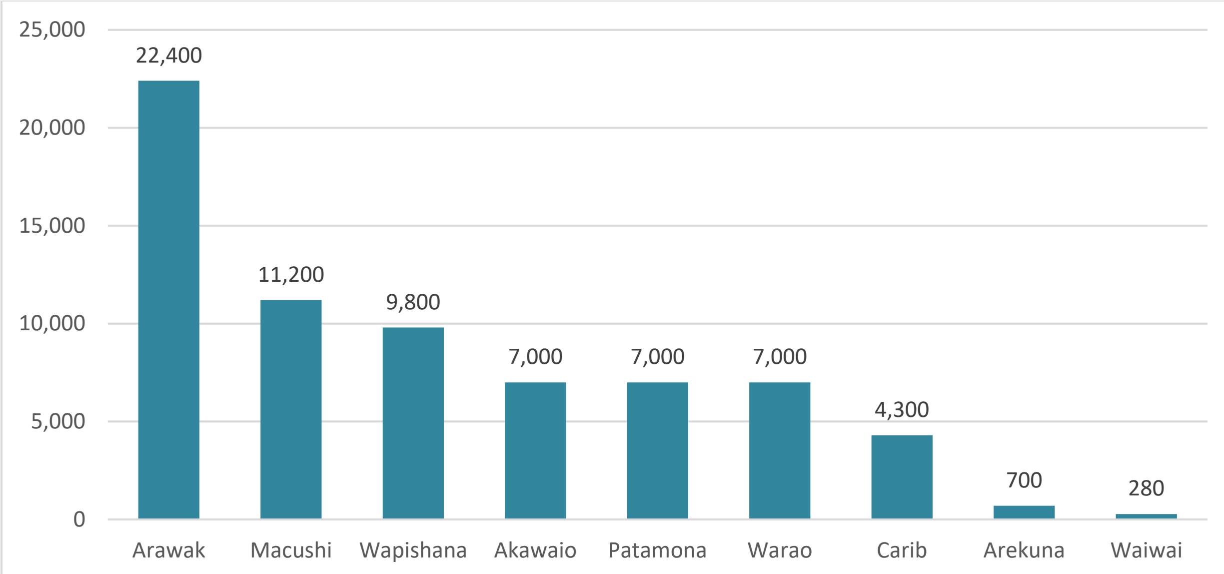
Source: BSG 2012

Figure 9.9-2: Amerindian Population by Region, 2012

Indigenous Groups

According to Minority Rights Group International (2018), there are nine main Amerindian groups in Guyana (Figure 9.9-3). Three of these groups reside in the coastal areas (the Carib, Warrau, and Arawak) while other groups inhabit the country's Hinterland Regions. Many of the Amerindians in the coastal area have culturally integrated with the general population and share many of the same livelihoods as the Afro- and Indo-Guyanese coastal populations. However, as a whole, the standard of living for the Amerindian population is lower than for the general population, particularly for those in remote areas where providing infrastructure and services is a challenge (Minority Rights Group International 2018).

Based on population estimates in 2007, the Arawak (Lokono) were the largest Amerindian group in Guyana, representing approximately 22,400 persons and 32 percent of the national Amerindian population (Figure 9.9-3). The Arawak originally settled along the Hosororo Creek Tributary of the Aruka River. They presently are found throughout Guyana's coastal belt, particularly in Regions 1 and 2, and are known for fishing and agriculture (Bollers et. al. 2019). Arawak communities are also found in other regions, including Region 3 and Region 4 (described further in Section 9.9.2.2, Regional Study Area).



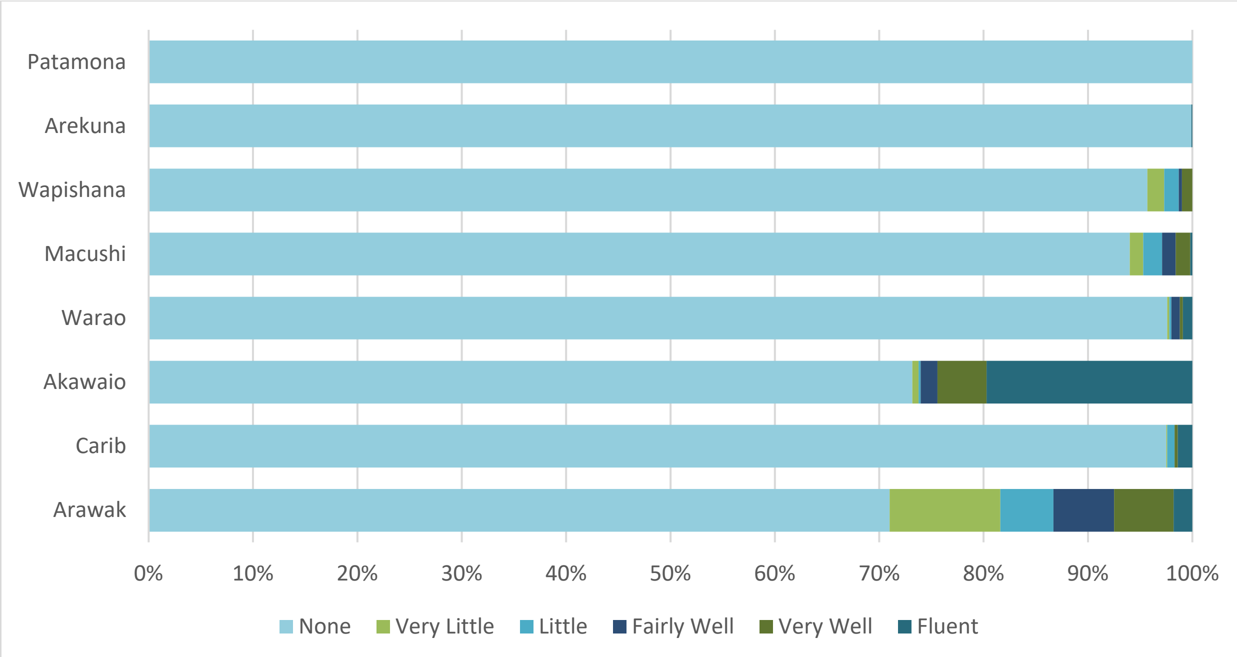
Source: Renshaw 2007

Figure 9.9-3: Populations of Amerindian Groups in Guyana, 2007

Language and Cultural Continuity

The use of traditional language has diminished and less than 0.3 percent of Indigenous Peoples in Guyana are reported to speak an indigenous language instead of English (Ministry of Health 2021). Low levels of indigenous language fluency are reported within Amerindian villages surveyed throughout the country (Figure 9.9-4; Bollers et. al. 2019). Arawak and Akawaio communities reported the highest levels of language proficiency, with 13.3 percent and 26 percent of respondents, respectively, reporting that they speak their indigenous language fairly well, very well, or fluently.

Other sources consider the same indigenous languages to be endangered. For example, nearly all speakers of Lokono (a member of the Arawakan language group), are noted to be over the age of 50 (UWI Undated). The state of the language is, in part, attributed to the Arawak's coastal territory and associated exposure to outside languages influences, relative to inland Indigenous Peoples in Guyana. A recent report by the Ministry of Health also noted that English has become the primary language used by Guyana's indigenous populations (Ministry of Health 2021), although the Consultants' experience indicates that Amerindian languages remain predominant in some communities, particularly in the Hinterland regions.



Source: Bollers et al. 2019

Note: Information for Wai Wai Amerindian group was not available.

Figure 9.9-4: Indigenous Language Fluency in Amerindian Villages, 2014

Amerindian culture and customs, such as religion, food, celebrations, and crafts, are generally still practiced in indigenous communities. However, a 2014 Inter-American Development Bank survey of indigenous communities in Guyana (Bollers et. al. 2019) found that more than 75 percent of respondents felt that loss of traditional folkways, culture, and customs were either "somewhat of a problem" or "a major problem."

Land Ownership

Land ownership is an important factor to Indigenous Peoples worldwide. In Guyana, the Amerindian Act of 2006 provides for "*the recognition and protection of the collective rights of Amerindian Villages and Communities, the granting of land to Amerindian Villages and Communities and the promotion of good governance within Amerindian Villages and Communities*."[54]

Under the Amerindian Act, land titling and land extensions are supported by the Amerindian Land Titling process, initiated in 2013. For a community to apply for ancestral (communal) lands, the Amerindian Act mandates that the community must have occupied the land for 25 years and have had a population of at least 150 persons for 5 years prior to application for the land. At the end of 2019, a total of 18 land title certificates had been issued, 21 demarcations completed, and 45 investigations (for new villages or extensions) completed

[54] Amerindian lands are categorized as either a "village" or a "community." The former refers to communally owned land with a title that is held by the Village Council; the latter indicates land that an indigenous community does not have a title to and thus does not own (Government of Guyana 2019).

(Chapman 2020). As of 2020, 18.8 percent of Guyana's landmass (40,279 km^2) was titled to Amerindian groups in Guyana (Chapman 2020).

In titled Amerindian villages, Indigenous Peoples are entitled to use land in traditional ways and make choices about the activities that reflect their land values (Bollers et al., 2019). Conversely, the absence of indigenous title in Guyana generally limits the rights of Indigenous Peoples to use their traditional lands. Figure 9.9-5 shows Amerindian titled lands in Guyana.

Indigenous Governance

Amerindian communities in Guyana are led by elected Toshaos (Amerindian leaders) and Village Councils (VCs). The role of VCs and Toshaos are described in the Amerindian Act. The VC is responsible for the good governance and well-being of the community and the promotion of the sustainable use, protection, and conservation of village lands and the resources on those lands under the provisions made in the Amerindian Act.

Although Toshaos are directly involved in VC affairs, they also play a more comprehensive leadership role in a community, including engagement of village residents (Ministry of Health 2021). According to the Amerindian Act, a Toshao is "responsible for ensuring good governance including accountability and transparency… and keeping peace and order in the Village" (Amerindian Act 2006). Toshaos and village councilors are elected every 3 years.

In addition to leading VCs, Toshaos also represent their villages on the National Toshaos Council. Established under the Amerindian Act, the National Toshaos Council is the legitimate authority representing all Amerindian villages in Guyana and functions as the key interlocutor on behalf of all of the indigenous communities. The National Toshaos Council comprises Toshaos from each Amerindian village and is administratively governed by an executive, meets biennially, and elects its 20-member executive function every 2 years. The primary objectives of the National Toshaos Council include the promotion of good governance and support for the general well-being of Amerindian villages, including strategies intended to address poverty, conservation, and other matters concerning natural resources as outlined in the Amerindian Act.

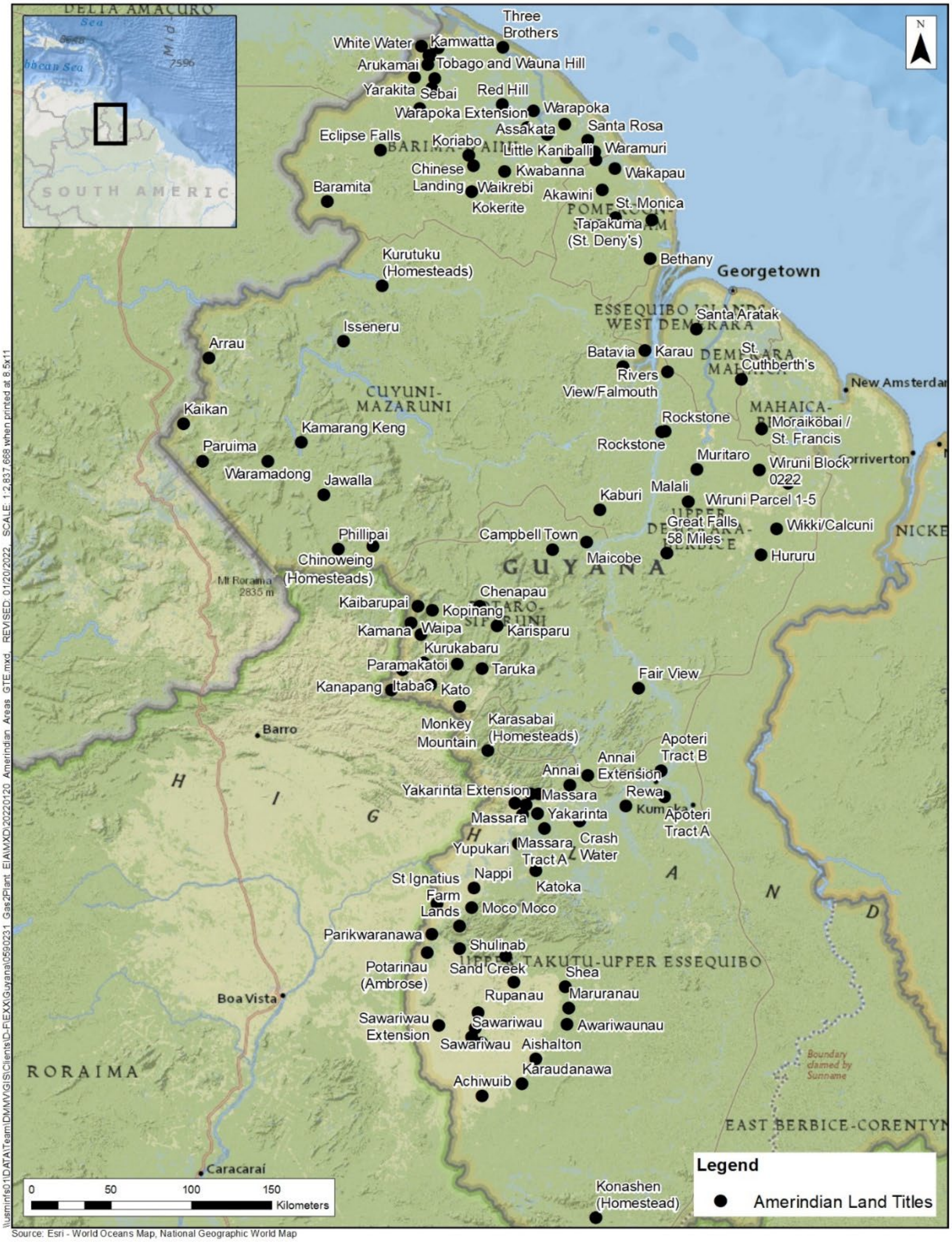


Figure 9.9-5: Amerindian Titled Lands in Guyana

9.9.2.2. Regional Study Area

This summary focuses on the administrative regions within the Regional Study Area in which Project activities would occur: Region 3 and Region 4.[55] Both regions rely on natural resources for subsistence and livelihoods, of which the main fortifications include coconuts, sugar cane, and beef and dairy farming (Reese 2012). Of the populations in each region, Amerindians constituted 2.6 percent of the population of Region 3 in 2012, and 2.3 percent of the population in Region 4.

The dominant indigenous group in both regions is the Arawak, who live in the titled areas of Santa Aratak village in Region 3, and Pakuri Village in Region 4 (Figure 9.9-6). In addition to these villages, Amerindian persons may also reside in communities throughout these regions.

Region 3: Santa Aratak Village

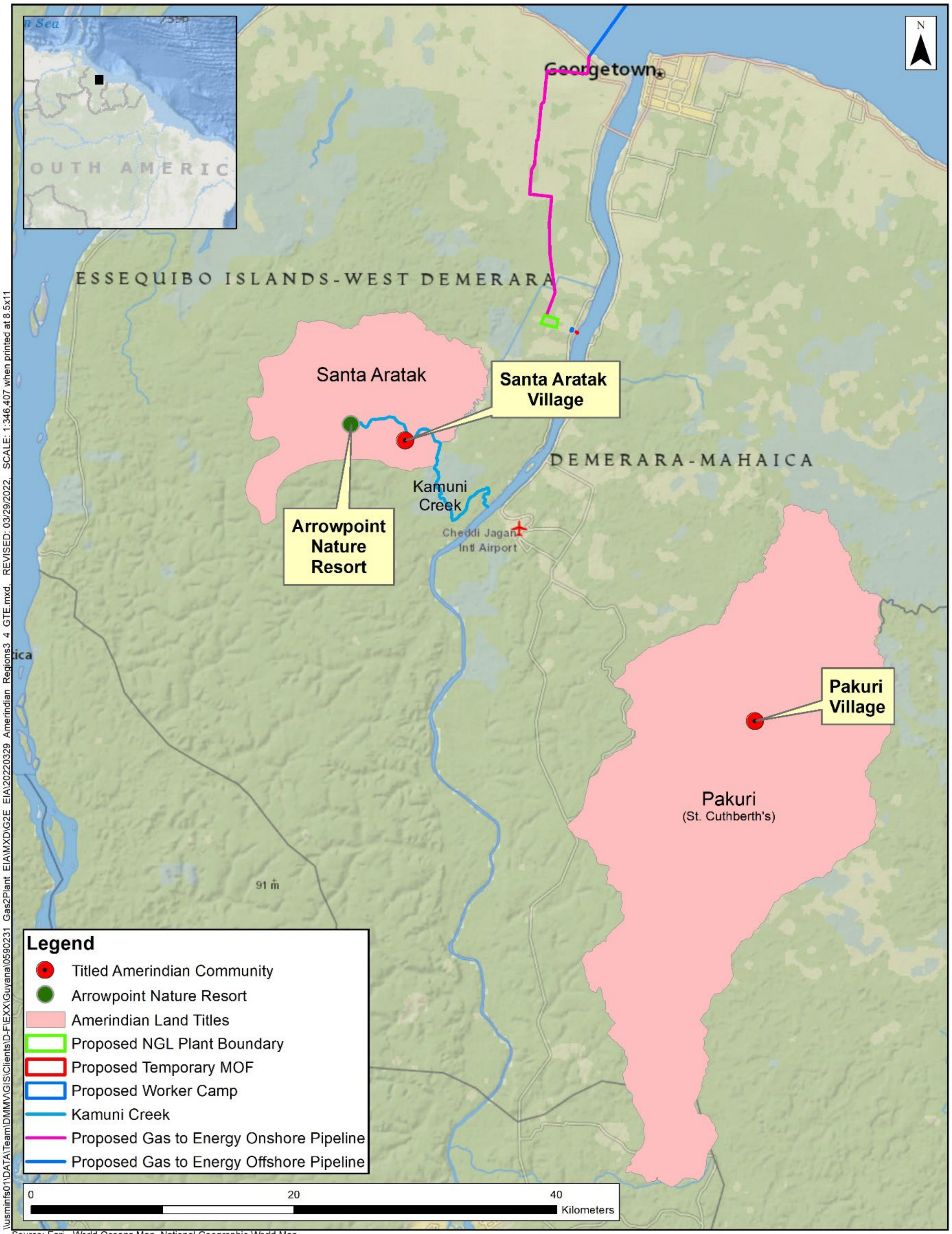
As a whole, Region 3 only has one Amerindian community within its border, the Santa Aratak village (also known as Santa Aratak Mission, Santa Arawak, or Santa Mission). Santa Aratak village is located approximately 14 kilometers southwest of the NGL Plant site, and is only accessible by boat via the Kamuni Creek tributary of the Demerara River. Boats typically depart from Timehri (near the Cheddi Jagan International Airport), from where it is approximately 1 hour by boat to Santa Aratak village. Upstream of the village is the Arrowpoint Nature Resource; visitors traveling by boat to the resort can stop at Santa Aratak to explore the village, learn more about the Amerindian culture, and purchase handicrafts from a local shop (Wilderness Explorers Undated).

The village is home to approximately 270 people, primarily of Arawak descent[56] (Santa Aratak 2022, pers. comm.) and sits within an Amerindian title area of approximately 174 km^2 of dense forest with open wetlands (APA Undated). There are more men than women in the community, as women often migrate to larger centers to support their children in accessing secondary and post-secondary education (Santa Aratak 2022, pers. comm.). In general, the population has declined from more than 1,000 persons 10 years ago, largely due to the lack of education and livelihood opportunities in the village (Santa Aratak 2022, pers. comm.). The current population is mostly young, with a small number of elders.

Most villagers speak English at home and in the community. There is only one fluent speaker of the Arawak language remaining in the community, although others can understand Warrau (Santa Aratak 2022, pers. comm.).

[55] Although Region 2 is also included in the Regional Study Area, Project activities will not occur in this region. Amerindians represent 18.9 percent of the Region 2 population. Amerindian villages in Region 2 include Bethany, St. Monica, Tapekuma (St. Denys), Akawini, Wakapau, and others. Potential socioeconomic impacts on residents of Region 2 are addressed in Section 9.1, Socioeconomic Conditions.

[56] Some residents identify as Machushi, Warrau, Wapishana, or other indigenous groups. There are fewer than five non-indigenous persons living in the community.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 9.9-6: Amerindian Titled Lands in Region 3 and Region 4

An average of four to five boats traverse Kamuni Creek daily, mostly carrying residents and sometimes tourists. There are two communally owned boats (capacities of 12 and 25 people) that transport members daily to Georgetown to sell produce, and each Friday to market to buy produce. Most residents also travel to hospitals in Georgetown and access healthcare services, including maternity care.

Local Economy and Livelihoods

For many years, farming has been the main livelihood for village residents, including cultivation of cassava (bitter), pineapple, eddo, plantain, coconut, cucumber, bora, peppers, pumpkin, and cabbage. However, farming in the village has declined significantly and this change is seen as a threat to the village's continuity. The migration of men from the village to seek work outside of the community is considered to be a driving factor in the agricultural decline (Santa Aratak 2022, pers. comm.).

Logging is presently the main primary economic activity. Men work in logging operations in the communally owned titled lands of the village or on privately owned concessions nearby. Logging is the main source of income for men, and approximately 60 percent of the local men are involved in logging (Santa Aratak 2022, pers. comm.). Lumber (primarily Greenheart and Kabukalli) is sold on the market, and the village receives a royalty for the extraction of logs from its titled lands. In addition to logging, a few men from Santa Aratak travel to other interior locations to work in gold mining activities (Santa Aratak 2022, pers. comm.).

Local unemployment is high among both men and women, but significantly higher among women, who are mainly engaged in unpaid care work. Some women are involved in handicraft production and activities related to the village's fledgling tourism activities. The sale of handicrafts has declined as a result of the global COVID-19 pandemic, leading to a decline in production and higher unemployment among women (Santa Aratak 2022, pers. comm.).

There are no known commercial livelihood activities related to wildlife. The community has a self-imposed ban on wildlife trapping as part of its efforts to conserve its biodiversity to offer an enhanced tourism product (Santa Aratak 2022, pers. comm.). In spite of setbacks related to the COVID-19 pandemic, tourism development is the livelihood focus of the village, and the community is actively collaborating with the Guyana Tourism Authority to improve its tourism offerings. The focus of the village's tourism product is cultural and heritage tourism; however, it sees conservations of its biodiversity as intricately linked to its culture (Santa Aratak 2022, pers. comm.).

The Santa Aratak community recognizes a need to resuscitate local agricultural activities, as this will be a benefit to local residents in many ways. Villagers currently obtain food from Georgetown, and rising costs of food products have been challenging. Agriculture is also seen as having several positive multiplier linkages with tourism, including the offerings of "farm-to-plate" dishes, demonstrations of the processing of cassava and making of cassava bread, and the harvesting of tibisiri (harvested for handicraft; Santa Aratak 2022, pers. comm.).

There are four small shops in the community that sell snacks, groceries, and kerosene.

Infrastructure and Services

Santa Aratak offers multiple public services including a health center, nursery and primary schools, a library, a guesthouse, and a craft center. The health center is staffed by a visiting doctor and dentist (monthly), and a full-time community health worker (Santa Aratak 2022, pers. comm.). There are some local projects intended to improve village infrastructure, including construction of a new lodge for visitors and a computer hub (Santa Aratak 2022, pers. comm.). Mobile phone service is noted to be unreliable, although the majority of households have mobile phones.

Local residents obtain water from a village well and the village has a water treatment system. Rainwater is also collected and used for domestic purposes (e.g., washing and bathing). Most residents also continue to drink the creek water and Kamuni Creek is considered to have traditional healing properties (Santa Aratak 2022, pers. comm.).

In addition to the two communally owned boats, the community also maintains two tractors for use in agriculture and logging (Santa Aratak 2022, pers. comm.). Most homes in Santa Aratak have solar panels (received through a government project a few years ago) and some residents also use personal generators. A small number of households do not have access to any form of electricity (Santa Aratak 2022, pers. comm.). Kerosene and natural gas are typically used for cooking and only around 2 percent of homes are estimated to use firewood for cooking purposes (Santa Aratak 2022, pers. comm.).

Ecosystem Services

Residents hunt wild meat, including labba and deer, for subsistence, although due to logging activities they need to travel further from the community to harvest animals. Fishing is conducted at Kamuni Creek. The village's forestry stock is being depleted by logging and there are no reforestation efforts; this poses a threat to the sustainability of both logging and hunting activities (Santa Aratak 2022, pers. comm.). No natural areas of the village are particularly known for spiritual value (Santa Aratak 2022, pers. comm.). However, the community has identified opportunities to develop cultural and heritage tourism and recognizes biodiversity as being intricately linked to its culture. Local biodiversity includes an abundance of monkeys and parrots (Santa Aratak 2022, pers. comm.).

The village members use the ite palm, harvested locally, for the straw for handicraft activities. Traditional medicines use turro and ite fruits, the capadulla plant, yarowballi, sweet broom, sand bitter, Congo pump, and Velvetleaf (Santa Aratak 2022, pers. comm.).

Central to the village, a Silk Cotton tree known as the "Kamaka Tree" is recognized as a living cultural heritage site (Santa Aratak 2022, pers. comm.). According to Arawak lore, the tree's roots are said to extend throughout the whole village and allow all other life in the community to flourish. In addition to the Kamaka Tree, villagers rely on locally available natural resources for tourism, building homes, and continuing to live a traditional way of life (Kaieteur News 2018). For example, the eta palm tree is used to make hand fans, jewelry boxes, tibisiri skirts, and fruit bowls, while the forest is logged for sale and building (DPI 2018).

Region 4: Pakuri Village

The Pakuri Village, formerly known as St. Cuthbert's Mission, is the only titled Amerindian community in Region 4, located near the border between Region 4 and Region 5. Sitting on the Mahaica River, the village is approximately 148 kilometers southeast of Georgetown and approximately 34 kilometers from the proposed NGL Plant. The village is accessible by both boat via the Mahaica River or overland from the Linden / Soesdyke Highway. Pakuri Village is home to approximately 1,200 Arawak people. In 2022, the village reported approximately 260 local households, and noted that the population has been relatively stable as many residents who leave the community (e.g., for schooling) return to live in the village (Pakuri Village 2022, pers. comm.).

Titled lands comprise 637 km^2 extending across portions of Region 4 and Region 5 (APA Undated), and are characterized as a combination of dense vegetation on their west side and savannah and shrub lands on their east side (Stabroek News 2004).

Local Economy and Livelihoods

Farming has generally been the main economic activity of Pakuri Village, including sorrel, ginger, red beans, watermelon, pumpkin, and pineapple (Pakuri Village 2022, pers. comm.). However, flooding in June and July 2021 decimated the farming activities of the village; many residents, mainly men, have since shifted to lumber and mining industries to generate incomes. A forestry concession is available for villagers to take part in lumber production; as of February 2022, the village reported that more than 15 local families depend on the lumber sector as their main livelihood activity (Pakuri Village 2022, pers. comm.). The Village Council is working with community members to reinvigorate the local economy after the flooding, and is pursuing options for transportation and marketing of produce from the village.

Acknowledging the adverse impact of increased rain and subsequent flooding on productive agriculture in the community, Guyana's Agriculture Minister declared that the village's farmers will receive assistance creating shadehouses (greenhouses), access to land, and farming tools and planting materials such as seeds, fertilizers, and chemicals to help continue incentivizing farming as a key part of Pakuri Village's economy (DPI 2021b).

In addition to agriculture and lumber, Pakuri Village, with the help of the Guyana Tourism Authority, is one of three Amerindian communities participating in an experimental community-owned and -led tourism framework. The framework is based on tourism being championed by local communities who have received training from the Guyana Tourism Authority in tour guiding, culinary creations, and services and deliveries. Pakuri Village hopes to continue enhancing tourism using this framework (Smith-Thomas 2021). In its efforts to improve its tourism offerings, the Village Council is constructing a seven-room guest house to accommodate overnight tourists in the village. The main tourism product of the village is biodiversity tourism—mainly birdwatching—and the village hopes to capitalize on its proximity to the Mahaica River, a bird and biodiversity hotspot of Guyana. The Village Council is also embarking on a handicraft initiative to enable women to participate further in the tourism activities of the village (Pakuri Village 2022, pers. comm.).

Infrastructure and Services

Pakuri Village has multiple public services, including schools and a health center. As of 2022, the village reported noteworthy enrollment numbers, with 30 teachers and with 44 students in nursery school, 154 in primary school, and 122 in secondary school (Pakuri Village 2022, pers. comm.). The village also offers a health center, staffed by nine full-time and part-time healthcare workers. In 2013, malaria, diarrhea, cancer, and cold/flu were the most commonly reported cases of illness and other health issues. In 2021, the village had more than 30 road-based vehicles, including one tractor.

The primary water sources in the village include piped water from a village well, river, and pond (Bollers et al. 2019; Pakuri Village 2022, pers. comm.). In 2021, the community received an $8.1 million GYD ($40,500 USD) upgraded and expanded water system, providing residents with safe potable water (DPI 2021a). McGill University's CARWIN program has highlighted the need for the water system upgrade grant, highlighting that although households in the center of the village can collect drinking water from a deep groundwater well with a solar-powered pump, those on the outskirts of the community typically collect their drinking water from creeks and, during the wet season, from rain water (McGill Undated). The Village Council is looking to improve water pressure and develop water pipelines to local homes (Pakuri Village 2022, pers. comm.).

Access to electricity is limited. Pakuri Village is outside of the electrical grid. More than 100 households rely on either personal generators or solar panels. For the homes that do not have access to personal electricity, the Village Council supplies electricity from a community generator that residents can access from 6 a.m. to 10 p.m. each day for a small fee (approximately $5,000 GYD [$25 USD] per month). However, access to electricity continues to hinder community development, as many low-income families cannot afford the access fee, although there are reduced rates and considerations for vulnerable village members, including pensioners (Pakuri Village 2022, pers. comm.). The available electricity in the community gives villagers access to cell services, TV signals, and satellite (Bollers et al. 2019).

9.9.2.3. Primary and Secondary Study Areas

No indigenous communities or indigenous lands are located within the Primary or Secondary Study Areas (as defined and illustrated in Section 9.1, Socioeconomic Conditions). A 2021 household survey conducted by the Consultants identified some persons of Amerindian descent within either the Primary or Secondary Study Area, comprising approximately 2 percent of survey responses (9 of 434 responses about ethnicity).

In the Primary and Secondary Study Areas combined, there were eight respondents who identified as having Amerindian ethnicity. Most were employed (63 percent) or worked in the home. Four of the respondents owned their land, one leased, and two had informal agreements (and one respondent did not know). The majority (63 percent) had lived in the area for more than 5 years, and others had moved to the area in the last 2 years. One respondent, located in the Primary Study Area, reported some farming and livestock activity. These characteristics, and other outcomes of the 2021 household survey, are included in the analysis provided in Sections 9.1 to 9.8.

9.9.3. Impact Prediction and Assessment

This section discusses the potential impacts of planned activities of the Project on Indigenous Peoples. The relevant planned Project activities and the associated potential impacts of these activities on Indigenous Peoples are identified, and the significance of each of these potential impacts is assessed in accordance with the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology. A pre-mitigation significance rating (i.e., considering the embedded controls included in the Project design) is provided for each potential impact. Any additional mitigation measures applied to supplement these embedded controls are described, and a residual significance rating (i.e., considering embedded controls and mitigation measures) is then provided for each potential impact.

9.9.3.1. Relevant Project Activities and Potential Impacts

Direct AOI

There are no indigenous communities or titled/asserted indigenous lands located within the Direct AOI. As such, potential impacts on Indigenous Peoples living within the Direct AOI are considered together with potential impacts on the general population of the area in Section 9.1, Socioeconomic Conditions, to Section 9.8, Ecosystem Services.

Indirect AOI

As described above, Santa Aratak and Pakuri are titled Amerindian villages within the Indirect AOI, located approximately 14 kilometers southwest and 34 kilometers southeast of the proposed NGL Plant, respectively.[57] In Region 3, the Santa Aratak community is accessed only by boat via Kamuni Creek, a tributary of the Demerara River. Boats travelling to the Arrowpoint Nature Resort typically depart from Timehri and stop in Santa Aratak for cultural activities and handicrafts. In Region 4, the community of Pakuri is accessible by boat (from the marine coast) or by road.

Construction of the Project will involve shoreline and river-based construction activities on the Demerara River to support construction of the temporary MOF. The temporary MOF will receive NGL Plant modules, heavy equipment, and large quantities of bulk aggregate required for construction of the NGL Plant; these products will be transported to the temporary MOF by barges that will generally originate from shorebases on the Demerara River, downriver of the temporary MOF. Construction of the temporary MOF will involve pile driving and construction of a pier structure that will extend into the river. Use of the temporary MOF will also require dredging to allow barges to maneuver between the main channel and the pier structure.

[57] As previously noted, a number of Amerindian villages are also located in Region 2, which is part of the Indirect AOI. However, no Project activities are planned to occur in Region 2. As such, specific or differential impacts on Indigenous Peoples in Region 2 are not expected. Potential socioeconomic impacts on residents of Region 2 more broadly are addressed in Section 9.1, Socioeconomic Conditions.

The Santa Aratak community uses the Demerara River for access to and from the community (via Kamuni Creek, more than 10 kilometers upstream of the proposed temporary MOF site), and Project-related activities in the river could therefore affect people living in Santa Aratak, including residents' access to / from the community and areas where they practice their livelihoods. However, the Project's onshore components and activities will be sufficiently distant from Santa Aratak and Pakuri so as to not be perceptible from these communities, and thus will not impact the physical or biological environment known to be subject to traditional or customary use by Indigenous Peoples in these communities.

Table 9.9-3 summarizes the planned Project activities that could result in potential impacts on Indigenous Peoples.

Table 9.9-3: Summary of Relevant Project Activities and Key Potential Impacts—Indigenous Peoples

Stage	Project Activity	Key Potential Impacts
Construction	Construction of temporary MOF including in-water infrastructure and river dredging; construction vessel movements between temporary MOF and downriver shorebases	• Interference with vessel traffic passing between Santa Aratak and downriver locations due to presence of dredging and Project construction vessels
Operations	Decommissioning of temporary MOF	• Interference with vessel traffic passing between Santa Aratak and downriver locations due to presence of Project decommissioning vessels

[a] The Project's use of the temporary MOF will cease during the Construction stage, but it is understood that the Government of Guyana may elect to use the temporary MOF for a period of time to support its own development projects in the area. The temporary MOF decommissioning will be removed prior to the 10-year design life of the structure being met and is therefore anticipated to occur during the Project's Operations stage.

9.9.3.2. Impact Assessment Methodology

As described in Section 3.3.6.2, Step 2: Evaluate Impacts, impact significance is characterized using a standardized approach that considers: (1) the magnitude of the potential impact (which is determined based on three factors: frequency, duration, and intensity); and (2) the sensitivity of the resource. General definitions for the magnitude factors of frequency, duration, and intensity are included in Chapter 3, EIA Approach and Impact Assessment Methodology. Where appropriate, resource-specific definitions for intensity are used in lieu of the general intensity definitions, as is the case for Indigenous Peoples (Table 9.9-4). Sensitivity is defined on a resource-specific basis for all resources, and the definitions for Indigenous Peoples are provided in Table 9.9-5.

Table 9.9-4: Definitions for Intensity Ratings for Potential Impacts on Indigenous Peoples

Criterion	Definition
Intensity	**Negligible**: No perceptible change in the livelihoods or wellbeing of Indigenous Peoples.
	Low: Perceptible change in the livelihoods or wellbeing of Indigenous Peoples for some individuals.
	Medium: Perceptible change in livelihoods or wellbeing of Indigenous Peoples is evident for an indigenous group or community. Changes could affect receptors' ability to engage in their current livelihood(s) at the same level of productivity.
	High: Changes result in chronic hardship for indigenous households and/or communities, including changes that require receptors to change or cease their current livelihood activities for an extended period of time, or indefinitely.

Table 9.9-5: Definitions for Resource Sensitivity Ratings for Potential Impacts on Indigenous Peoples

Criterion	Definition
Sensitivity	**Low**: Indigenous populations and/or communities have diverse livelihoods and economies, and robust socioeconomic and cultural networks. Local residents have multiple means/ routes of access to and from the community.
	Medium: Indigenous populations and/or communities have limited but well-established livelihoods and economies. Socioeconomic and cultural networks vary between individuals. Local residents have few means/routes of access to and from the community.
	High: Indigenous populations and/or communities have precarious livelihoods and relatively weak economies. Socioeconomic and cultural networks are fragile. Local residents have few means/routes of access to and from the community.

9.9.3.3. Impact Magnitude Ratings—Indigenous Peoples

The magnitude ratings discussed below reflect the consideration of all embedded controls included in the Project design; these are summarized in Chapter 5, Project Description, and the subset of these embedded controls with particular relevance to Indigenous Peoples is provided in Table 9.9-6.

Interference with Access to Santa Aratak

Santa Aratak is accessed from the Demerara River via Kamuni Creek. Changes to river access or navigability (e.g., between Santa Aratak and downriver locations such as Georgetown) could therefore affect access to the village, which could impact residents of Santa Aratak. A change in access to Timehri could also impact Santa Aratak residents connecting to road travel between Timehri and Georgetown or other locations on the East Bank of the Demerara River.

As described in Section 9.4, Transportation, the anticipated impact of the Project's planned activities on river access, navigation, and/or river transportation on the Demerara River is expected to be **Low** in intensity based primarily on the low percentage increase in existing river traffic that will be associated with the Project (estimated to be approximately 5 to 10 percent increase in total vessel traffic in the part of the river near the temporary MOF, as compared to existing conditions). Accordingly, the Project's potential impact on access to Santa Aratak village is also expected to be **Low** in intensity. The potential impact will persist for the duration of the Construction stage (during which dredging related to construction and the Project's use of the temporary MOF will cease, and after which Project construction vessel trips to the temporary MOF will be discontinued), representing a **Long-term** duration. During the Operations stage, the temporary MOF will be decommissioned. This will involve a limited amount of in-water activity—far less than that involved with the Construction stage; lasting more than a week, but less than a year (**Medium-term**). For both stages, potential interactions with vessels travelling to and from Santa Aratak will be **Episodic**. Following the methodology in Chapter 3, EIA approach and Impact Assessment Methodology, the magnitude of the impact for both stages is rated as **Small**.

9.9.3.4. Sensitivity of Resource—Indigenous Peoples

Based on the sensitivity rating definitions in Table 9.9-5, the sensitivity of Indigenous Peoples in Santa Aratak in relation to potential impacts of the Project is considered **Medium**. Santa Aratak has relatively strong social and transportation linkages to downstream communities in Region 3 and Region 4, and vessels regularly travel between the community and downriver locations, including regular travel to Georgetown to access markets and health services. Santa Aratak also has a well-established handicrafts market and connections to ecotourism, including Guyanese and international visitors travelling to the Arrowpoint Nature Resort. However, the only access to the village is by river.

9.9.3.5. Pre-mitigation Impact Significance—Indigenous Peoples

The Project's potential impact on access to Santa Aratak is expected to be **Small** in magnitude. Coupled with a sensitivity rating of **Medium**, the pre-mitigation impact significance for Indigenous Peoples is **Minor**.

9.9.4. Impact Management and Monitoring Measures

As potential impacts on Indigenous Peoples are expected to be of **Minor** significance, no mitigation measures specific to Indigenous Peoples are proposed. It is noted, however, that the low significance of potential Indigenous Peoples impacts is supported by a suite of embedded controls (see summary in Chapter 15, Commitment Register). As stated above, embedded controls are accounted for in the pre-mitigation impact significance ratings.

One of the embedded controls accounted for in the pre-mitigation significance ratings is EEPGL's commitment to ongoing engagement with Indigenous Peoples in Regions 1 through 6, including Santa Aratak, in accordance with the SEP (Volume III of the EIA).

Table 9.9-6 summarizes the management and monitoring measures relevant to Indigenous Peoples.

Table 9.9-6: List of Management and Monitoring Measures

Embedded Controls
Develop and implement a SEP that includes measures for continued engagement with communities, including Indigenous Peoples.
Implement a transparent, accessible, and consistent CGM prior to onset of Project activities. Take measures to promote the CGM being well publicized and understood by the public, including Indigenous Peoples—in particular in the Santa Aratak community.
During dredging activities associated with the temporary MOF, conduct the dredging operation so as to maintain the ability for passenger vessels to pass between the Santa Aratak community and downriver locations.
Monitoring Measures
Monitor frequency of engagement with stakeholders communities, including fisherfolk, within the Direct AOI, vulnerable groups, and indigenous populations.
Track number and types of complaints received and resolved via the Project CGM; adjust the CGM and other management measures on an ongoing basis, as appropriate, based on feedback received. Disaggregate the data by location of complainant (e.g., community, Georgetown, other location).
Monitor average time for processing and resolution of grievances.
Track percentage of grievances resolved.

9.9.5. Assessment of Residual Impacts

As described above, no mitigation measures are proposed to address potential impacts on Indigenous Peoples. Accordingly, the residual impact significance rating remains unchanged at **Negligible**.

Table 9.9-7 summarizes the assessment of potential pre-mitigation and residual impact significance for the assessed potential impacts on Indigenous Peoples.

Table 9.9-7: Summary of Potential Pre-Mitigation and Residual Impacts—Indigenous Peoples

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Construction	Interference with vessel traffic passing between Santa Aratak and downriver locations due to presence of dredging and Project construction vessels	Medium	Small	Minor	None	Minor
Operations	Interference with vessel traffic passing between Santa Aratak and downriver locations due to presence of Project decommissioning vessels	Medium	Small	Minor	None	Minor

10. UNPLANNED EVENTS

10.1. Introduction

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., accidents) but that has the potential to occur. Since such events are not planned, they are evaluated in a different manner from planned events—specifically, by evaluating the consequence/severity of a realistic scenario for an unplanned event and taking into consideration the likelihood that the event could occur.

The consequence/severity is assigned based on the sensitivity of the resource and the magnitude of the impact (determined as if it were an impact from a planned activity)—essentially equivalent to the manner in which a significance rating is assigned for an impact from a planned activity—and then using Figure 10.1-1 to determine the assigned consequence/severity.

		Sensitivity of Resource		
		Low	Medium	High
Magnitude of Impact	Negligible	Small	Small	Small
	Small	Small	Small	Medium
	Medium	Small	Medium	Large
	Large	Medium	Large	Large

Small Consequence/ Severity

Medium Consequence/ Severity

Large Consequence/ Severity

Figure 10.1-1: Consequence/Severity Determination for Unplanned Events

Likelihood reflects the probability of occurrence of the unplanned event. Three levels of likelihood are used: unlikely, possible, and likely, as defined in Table 10.1-1.

Table 10.1-1: Levels of Likelihood for an Unplanned Event Impact Assessment

Likelihood	Definition
Unlikely	Considered a rare event; there is a small likelihood that such an event would occur during the Project life cycle.
Possible	The event has a reasonable chance to occur at some time during normal operations of the Project.
Likely	The event is expected to occur at some point during the Project life cycle.

Once consequence/severity and likelihood are determined for a given risk to a resource from an unplanned event, the following risk matrix (Figure 10.1-2) is used to rate the risk to resources associated with unplanned events.

		Consequence/Severity		
		Small	Medium	Large
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

Figure 10.1-2: Risk Rating Matrix for Unplanned Events

For the purposes of the EIA, the following unplanned events are considered as having the potential to occur during the Project life, should a combination of standard and Project-specific safety controls fail concurrently:

- Marine or riverine fuel spill from:
  - Marine vessel collision
  - Marine vessel bunkering
  - Helicopter ditching (in the marine environment)
  - Riverine vessel collision
- Loss of integrity of offshore pipeline, resulting in a natural gas release
- Vessel collision with a third-party vessel, structure, or animal (non-spill-related):
  - Vessel collision with a third-party vessel or structure
  - Marine mammal strike by a Project vessel
  - Riverine mammal strike by a Project vessel
  - Marine turtle strike by a Project vessel
  - Rafting marine bird strike by a Project vessel (or helicopter)
- Onshore hydrocarbon release from:
  - Loss of integrity of onshore pipeline
  - Loss of integrity of natural gas liquids (NGL) processing plant (NGL Plant) facilities
- Untreated wastewater release at NGL Plant
- Vehicular accident

Other events not considered in the EIA include minor unplanned events (e.g., dropped objects, small hazardous material spills, on-site traffic accidents) that would have a credible potential to occur but would not significantly impact any resources outside the Project footprint. Risks from these types of minor events are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures, and are beyond the scope of the EIA.

As discussed previously, natural gas will be transported to the NGL Plant by pipeline, and NGLs will be sold to a third party; the base case is that these NGLs will be loaded onto tanker trucks at the NGL Plant and transported by truck to users in Guyana. Risks from tanker truck-related accidents are not addressed in this EIA because operation of these vehicles will be outside of the control of EEPGL and outside of the definition of the Project subject to EEPGL's Application for Environmental Authorisation.

10.1.1. Marine and Riverine Fuel Spill Scenarios

An offshore pipeline will be constructed in marine waters to transport the natural gas from the Liza Phase 1 (Destiny) and Liza Phase 2 (Unity) floating production, storage, and offloading (FPSO) vessels to shore. The construction of the offshore pipeline and new subsea tie-in infrastructure will involve the use of marine installation and support vessels and helicopters that use petroleum products for fuel. In the riverine environment (i.e., the Demerara River), vessels will be used to transport equipment, materials, and workers between shorebases and the temporary material offloading facility (MOF).

Multiple layers of control are in place with respect to these activities; however, if multiple controls fail, there is the potential for a fuel spill to occur. EEPGL categorizes hydrocarbon spills into three tiers:

- Tier I—Spill is small, the source of spill is under control, and EEPGL and its contractors would manage the response using local resources;
- Tier II—Spill is moderate, the source can be quickly brought under control, local response equipment is immediately available, and broader response would be managed in a coordinated manner using regional resources as needed; and
- Tier III—Spill is large and/or the source of the spill is not under control, and response would be managed in a coordinated manner with regional and internationally sourced resources.

For the scenarios considered, fuel could potentially be released into the environment in the form of marine diesel (vessels operating on the open ocean or in the Demerara River) or aviation fuel (helicopters transporting workers to/from offshore pipeline installation vessels). The scenarios considered are discussed below.

10.1.1.1. Collision between Project Marine Vessels or between a Project Marine Vessel and Third-Party Marine Vessel, Resulting in a Fuel Spill

The offshore pipeline construction and related subsea tie-in activities will involve a number of different types of vessels operating in the marine environment. This will include offshore installation vessels (subsea tie-in installation vessels, pipelay barges, etc.) and support vessels providing logistical support to these vessels. The major installation vessels will remain at sea during construction activities. The support vessels will transit between the Guyana shorebases and the offshore construction areas. There is a potential for collisions between these vessels and each other, and/or between these vessels and third-party vessels—either at sea or (in the case of support vessels) during the approach to / departure from shorebases in nearshore areas.

The potential for offshore vessel collisions (e.g., collisions between Project installation or support vessels, or between these vessels and a third-party vessel) to occur during the Project is limited by the following safety measures that will be put in place:

- The Maritime Administration Department (MARAD) will issue Notices to Mariners concerning safety at sea and the location of major installation vessels. EEPGL will also communicate major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners. Through a stakeholder engagement process, EEPGL will communicate Project activities, where possible, to those individuals to facilitate their avoidance of Project vessels. Marine safety exclusion zones with a 500-meter radius will be established around the major installation vessels. No unauthorized vessels will be allowed to enter these marine safety exclusion zones.
- With respect to installation of subsea tie-in infrastructure, a marine safety exclusion zone of 2 nautical miles (3.7 kilometers) will be maintained around the Destiny and Unity FPSOs. No unauthorized vessels will be allowed to enter these marine safety exclusion zones.
- EEPGL will use what is known as a Simultaneous Operations procedure (SIMOPs) to safely manage Project marine vessels performing work in the same vicinity of each other, which will include considerations for avoiding vessel collisions.
- Marine vessels will have industry-proven station-keeping systems to maintain stations in the offshore environment.
- EEPGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EEPGL will provide oversight of its contractors to verify that they implement management systems effectively and comply with EEPGL's requirements.
- Contractors are required to inspect their vessels regularly. The inspections will address marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability.
- In addition, vessels operating within the Georgetown Harbour or other coastal areas will be required to adhere to speed restrictions and navigation aids.

On the basis of the above safety controls, the limited number of marine vessels that will be involved in offshore Project construction activities and the limited timeframe for offshore construction, this event is considered **Unlikely** to occur during the Project.

10.1.1.2. Marine Vessel Bunkering System Failure

A variety of Project vessels will supply and support offshore construction activities. Fuel transfer from one vessel to another, a process known as bunkering, may be required at certain times to avoid unnecessary vessel refueling trips between the offshore pipeline construction areas and shorebases. A number of potential scenarios could lead to a fuel release during bunkering (e.g., loose hose couplings, hose or connection failure, valves or manifold leaks). To reduce the possibility and consequence of such a release, EEPGL or the operators involved in offshore bunkering operations will implement a series of controls (design-based and operations-based) in alignment with good international industry practice. Multiple automated safety features are designed into offshore supply vessels to minimize the risk of such releases (e.g., automated shut-off valves, alarms), and bunkering will be conducted by trained operations and maintenance crews. Additionally, all Project vessels will have robust emergency response plans in place to respond quickly in the event that a fuel release is detected. A release would likely be quickly detected and contained via either an automated and/or manual system. Considering the above controls, and the expectation that offshore bunkering will be extremely limited in frequency (estimated to be on the order of 15 times during the entire offshore pipeline installation campaign), this event is considered **Unlikely** to occur during the Project.

10.1.1.3. Helicopter Ditching

The Project will use helicopters for some crew changes on marine installation vessels. It is estimated that during offshore pipe installation, helicopter flights supporting the Project will be on the order of approximately two round-trip flights per week. Although aviation accidents are rare events, there is the potential for a helicopter to need to ditch at sea.

A ditching incident could be the result of a number of factors that may potentially include loss of power, severe weather, or bird strike. A helicopter ditching could potentially result in a spill of aviation fuel or lube oils from the helicopter and related potential localized environmental impacts. However, based on aviation industry experience, this is considered an **Unlikely** event.

10.1.1.4. Nearshore Collision between a Project Supply Vessel and Third-Party Vessel or Structure, or Grounding

There is a potential for collisions between support vessels and third-party vessels/structures in the Georgetown Harbour / Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Fuel oil or lubricating oil spills resulting from an event could potentially cause environmental impacts.

A number of controls will be implemented to prevent these types of vessel incidents from occurring. EEPGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EEPGL will provide active oversight over its contractors to verify that they are complying with its requirements. Contractors are required to regularly inspect their vessels, which addresses marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability. In addition, vessels operating within the Georgetown Harbour or other coastal areas will be required to adhere to speed restrictions and navigation aids.

MARAD has established a rigorous process for permitting all commercial vessels operating within Guyana's territorial marine waters. The application for this permit requires submission of numerous supporting documents and certifications as assurance that the vessel is equipped with the appropriate safety and navigation equipment, and that the crew is sufficiently trained in its operation to meet international standards for safe navigation and seamanship. The information required to complete this process is standardized under the relevant international treaties administered by the International Maritime Organization, and will support MARAD in regulating the operation of Project vessels to enhance maritime safety in Guyana's territorial marine waters

10.1.1.5. Marine and Riverine Fuel Spill Modeling

Factors Impacting Severity of Hydrocarbon Spills

Several factors impact the severity of hydrocarbon spills and the efficacy of available spill response options. These factors include the hydrocarbon properties, volume, and location of the spill, metocean conditions, and seasonal factors impacting the presence of wildlife (Dicks 1998).

Hydrocarbon products vary widely in their physical and chemical properties, as well as their potential impacts on marine organisms (Figure 10.1-3). Heavy oils have the potential to cause more significant and longer-term impacts, as they may persist along shorelines and cause smothering of intertidal plants and coral reef habitats. In contrast, light oils tend to be more toxic, but dissipate much more quickly through evaporation and dispersion, so they generally have less impact overall and their potential toxic impacts are likely to be localized and short-lived (ITOPF 2014; Dicks 1998).

Source: ITOPF 2014

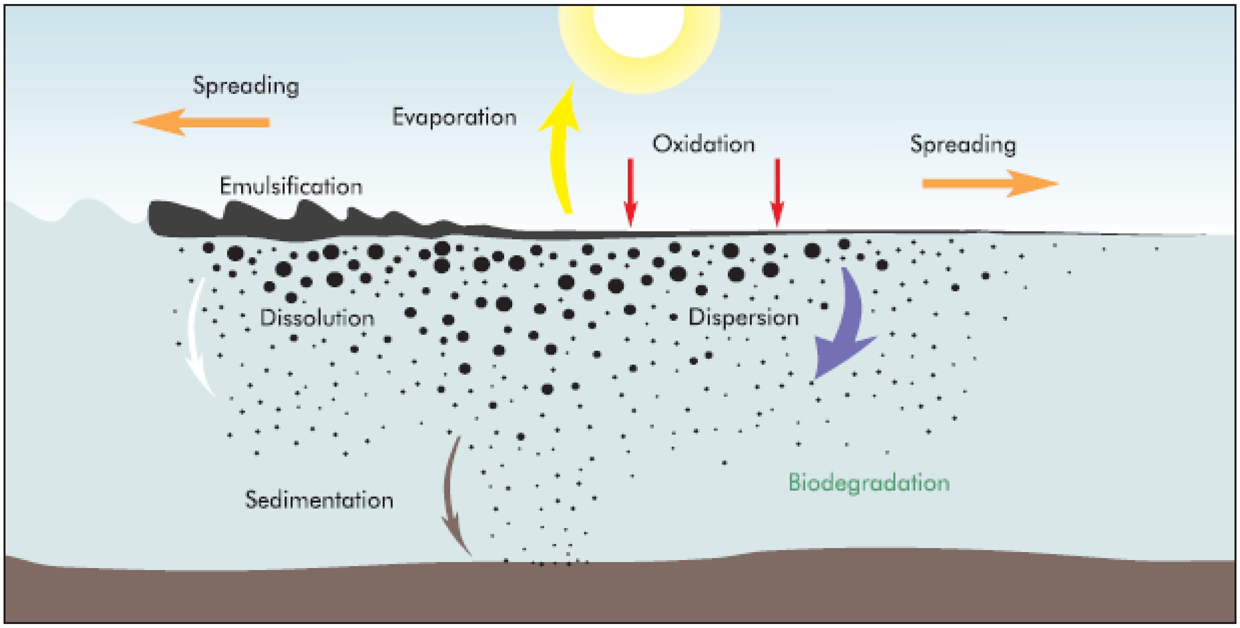
Figure 10.1-3: Typical Impacts on Marine Organisms across a Range of Oil Classes

The fuels that will be used by the Project during construction are on the "light" end of the above spectrum, with a specific gravity less than that of water. For a release to the water column, the fuel will float on the water surface.

Climate and weather can also impact the behavior of a hydrocarbon spill. For example, hydrocarbons become more viscous (i.e., flow less readily) at lower sea surface and air temperatures. In this case, the surface waters in the Project Area of Influence (AOI) are relatively warm, typically ranging from 24 to 30 degrees Celsius, which would result in the hydrocarbon remaining fluid, enhance evaporation of the lighter fractions (as discussed below), and improve spill response options.

Weathering Process

As soon as hydrocarbons are introduced into the ocean, advection and spreading begin immediately and result in a rapid increase of environmental exposure to hydrocarbons and their subsequent “weathering” processes (Figure 10.1-4). These processes include evaporation, dissolution, vertical dispersion, emulsification, and sedimentation. All of these processes are influenced by the specific composition of the introduced hydrocarbon. In addition, some components are degraded by photochemical oxidation induced by sunlight.



Source: ITOPF 2013

Figure 10.1-4: Weathering Processes Acting on Hydrocarbons in an Ocean Environment

These processes may result in vaporized hydrocarbon fractions and reaction products in the atmosphere, slicks and tar lumps on the ocean surface, dissolved and particulate hydrocarbon materials in the water column, and particulate fractions in the sediments. While physical and chemical weathering processes are occurring, biological processes such as biodegradation and bioaccumulation can also act on the hydrocarbons. Biodegradation involves the chemical breakdown of hydrocarbons to metabolites and ultimately to carbon dioxide, while bioaccumulation involves chemical uptake by larger organisms and the subsequent metabolism, storage, or discharge of the chemical.

Oil Spill Modeling Overview

Oil spill models have been in use for more than 30 years to support the development of oil spill response planning. Trajectory and fate models simulate oil transport and predict the changes the oil undergoes (i.e., its fate) as it interacts with water, air, and land. The models simulate spill events based on a characterization of the wind and hydrodynamic (marine currents) forces that influence oil transport. The model uses current data directly as surface oil moves with the speed and direction of the current. Wind data affect oil slicks at a range of 1 to 5 percent. Therefore, the SIMAP Model (RPS 2018b) estimated the wind drift to be 3.5 percent of wind speed. The model combines the magnitude and direction of the wind and current data inputs. The resulting predictions from the models can be used to quantify the potential consequences of a spill, which can then be used to guide response planning and prioritize response asset deployment. There are two principal modes in which oil spill models can be used:

1. **Stochastic** (statistical) mode, which examines *many potential releases* from the same point using the full range of historical data for wind and currents; and
2. **Deterministic** mode, which examines a *single potential release* using specific historical wind and hydrodynamic data selected from a range of historical data, or using forecasted wind and hydrodynamic data for an ongoing or future event.

Extreme weather events typically are considered qualitatively in oil spill modeling. The Project AOI is not in a seismically active area, so seismic events such as tsunamis did not factor into oil spill modeling. Accordingly, the oil spill modeling conducted for the purpose of this EIA was based on historical environmental (wind, wave, and current) and hydrodynamic data.

A typical approach to using oil spill models in oil spill response planning is to first apply the stochastic mode to determine the most likely trajectory for the spill scenarios of interest. The stochastic approach captures variability in the trajectory by simulating hundreds of individual spills (i.e., under different environmental [wind, wave, and current] and hydrodynamic conditions) and generating a map that is a composite of all of the predicted trajectories, thus providing a *probability footprint* showing the most likely path for a given spill scenario. Spill scenarios are typically modeled in stochastic mode to estimate probability that a specific area would be impacted by the spill, and timing of arrival of the spill at a particular area for each season or wind regime in the region.

Each stochastic model run results in a map showing the probability of a specified thickness of oil on the sea surface across the study area, and the minimum time of oil arrival across the study area. The areas and probabilities of oil contamination are generated by a statistical analysis of all the individual stochastic runs. It is important to note that a single run will encounter only a relatively small portion of this footprint. In addition, the simulations provide shoreline oil contamination data expressed in terms of minimum and average times for oil to reach shore, and the percentage of simulations in which oil is predicted to reach shore. Examples of stochastic maps are shown below in *Oil Spill Modeling Results*.

The specified thickness threshold on which the probabilities are based is chosen based on the purpose of the modeling or the types of impacts being considered, including ecological and socioeconomic impacts. Modeling is then used to determine the probability that oil would be present at a location in a thickness at or exceeding the designated threshold. For example, a surface slick thickness threshold can be based on the minimum thickness that can be mechanically recovered or on the minimum thickness that is thought to cause ecological or socioeconomic impacts. When applied in this way, a trajectory and fate model can quantify the likelihood of specific spill consequences, which is supportive of spill response planning and preparedness and environmental impact analysis.

Surface oil thickness thresholds are typically expressed in units of mass per unit area (e.g., grams per square meter [g/m^2]). Table 10.1-2 summarizes the range of thicknesses relative to their appearance on water.

Table 10.1-2: Oil Thicknesses (g/m^2) and Appearance on Water

Code	Description	Layer Thickness Interval (g/m^2)	Liters per Square Kilometer
1	Sheen	0.04–0.3	40–300
2	Rainbow	0.3–5.0	400–5,000
3	Metallic	5.0–50	5,000–50,000
4	Discontinuous True Oil Color	50–200	50,000–200,000
5	Continuous True Oil Color	200 +	200,000 +

Source: Bonn Agreement 2007

Oil spill modeling in the deterministic mode is used to predict where spilled oil from a single release would go and how quickly it would arrive at given locations. The trajectory of the spill is determined by the specific modeled wind and hydrodynamic conditions. The model predicts the spill pathway by calculating the movement of the oil for individual short increments of time (e.g., 1 hour) over the spill's duration, which cumulatively results in what is known as the *spill trajectory*. Knowing the distance traveled by the oil over a period of time also provides a prediction of the time of travel for the spill to reach specific areas. Consequences from the spill are determined by running the model within a geospatial framework so that interactions between the oil and elements of the environment (e.g., habitats) can be considered. Given an adequate definition of currents, winds, and the environment, a deterministic model can provide comprehensive predictions of the trajectory, fate, and effects of the oil.

Oil spill trajectory and fate models provide a quantifiable and consistent means to quantify spill consequences. A trajectory and fate model can also simulate the effects of spill response activities such as mechanical recovery, dispersant application, and *in situ* burning. Model simulations with and without spill mitigation measures can be used to calculate the effectiveness of different response strategies and equipment and can be used to help validate and improve spill response plans and contribute to a Net Environmental Benefit Analysis (NEBA) process. The NEBA process examines the benefit of using various spill response technologies against the effect of the oil spill itself prior to deploying the preferred technologies in a spill event.

Once individual spill events have been defined based on the selected criteria, a deterministic map for each event, showing the predicted trajectory and fate of the spilled oil, is generated. These deterministic maps can be generated for a range of spill scenarios and included in an Oil Spill Response Plan (OSRP) for use in planning responses to different scenarios. Examples of deterministic maps are shown below in *Oil Spill Modeling Results*.

Oil Spill Modeling Results—Marine Fuel Spill Scenarios

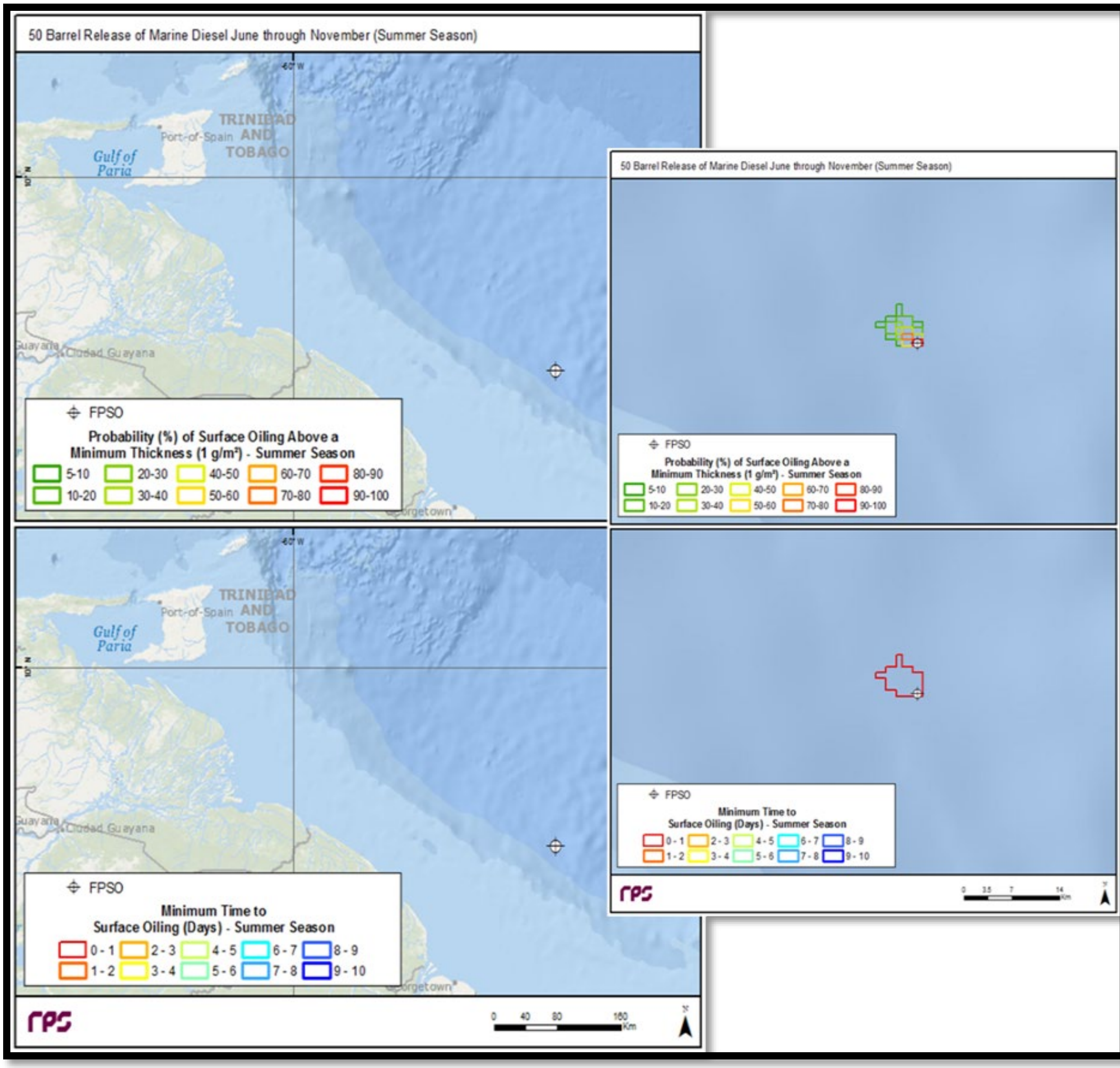
Oil spill modeling was conducted for two marine fuel spill scenarios (two different volumes at the same location). The modeled spill volumes (50 barrels and 250 barrels) were selected to represent a reasonable range of the size of a potential fuel release that could occur from a marine vessel supporting the Project (e.g., a supply vessel transiting between a shorebase and the offshore pipeline corridor). The SIMAP model system (RPS 2018b; RPS 2021a) was used to predict the probability of oil reaching 1 g/m^2 thickness on the sea surface across the model domain, taking into account the weathering profile of the oil (which would result in a proportion of the oil evaporating or dispersing into the water column). Spills were simulated taking into consideration the quantity of oil released, the type of oil and its characteristics (e.g., density), historical seasonal wind and current patterns, and water depth, among other factors.

Modeling was performed for the Jun–Nov season and the Dec–May season—representing the different prevailing oceanographic conditions between these periods. The modeling results are included in the OSRP (Volume III of the EIA) and are described below, including results for modeling under the stochastic (unmitigated) mode.

Marine Diesel Fuel Spill to Marine Environment—Stochastic Modeling Results (Unmitigated)

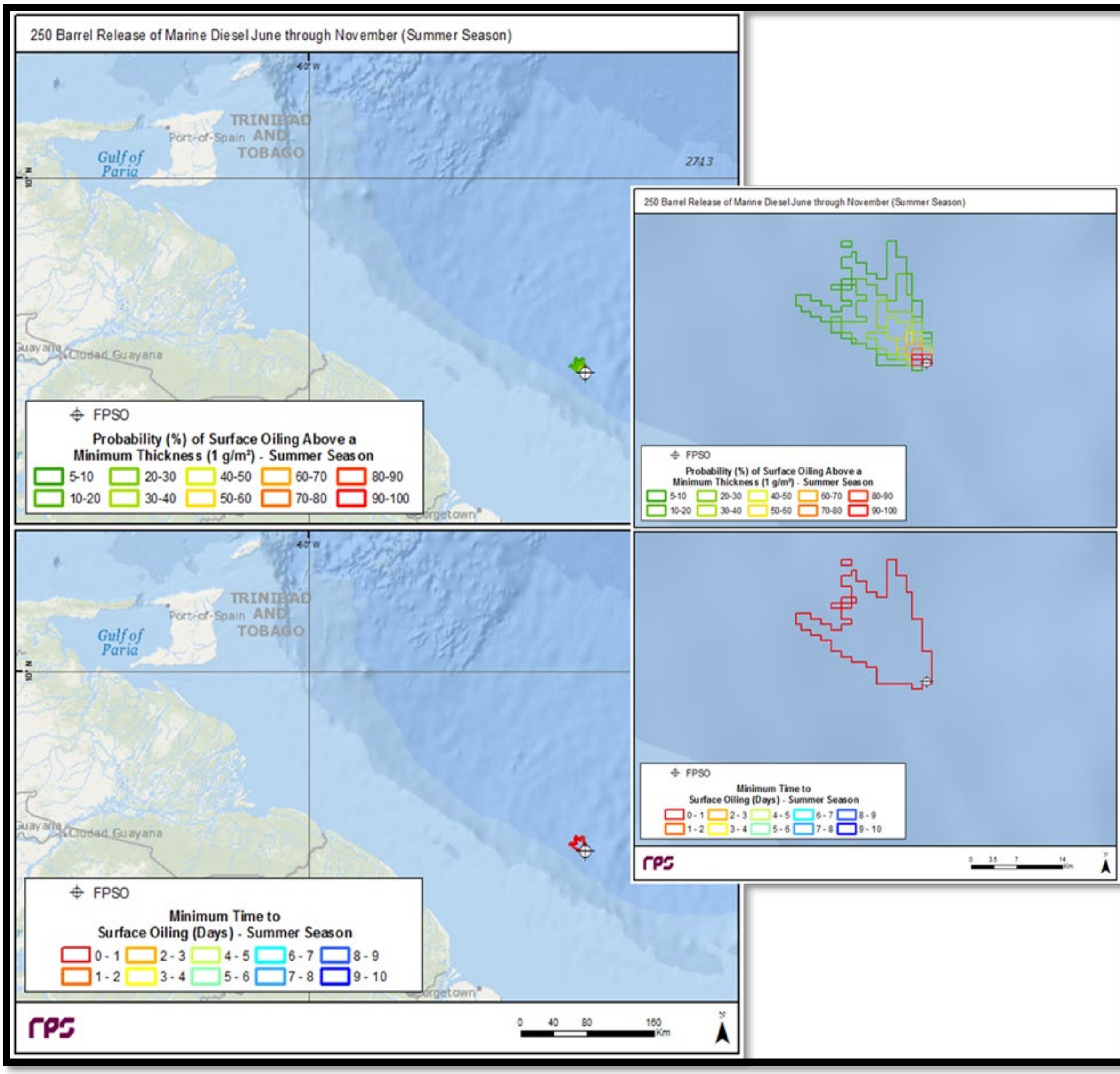
The SIMAP model was used to predict the probability of oil contamination on the water surface and shoreline for each of these fuel spill volumes occurring in each of the two aforementioned seasons—corresponding to seasonal wind regimes. Results from the SIMAP stochastic modeling are provided in maps depicting the probability and timing of oil contamination on the water surface and maps depicting the probability and timing of oil contamination on the shoreline. Figure 10.1-5a and Figure 10.1-5b provide the stochastic maps for the Jun–Nov period for a 50-barrel (8 cubic meters [m^3]) and 250-barrel (40 m^3) fuel spill, respectively. Figure 10.1-6a and Figure 10.1-6b provide the stochastic maps for the Dec–May period for a 50-barrel (8 m^3) and 250-barrel (40 m^3) fuel spill, respectively.

Surface oil is predicted to travel towards the northwest in all scenarios during both the Jun–Nov and Dec–May seasons.



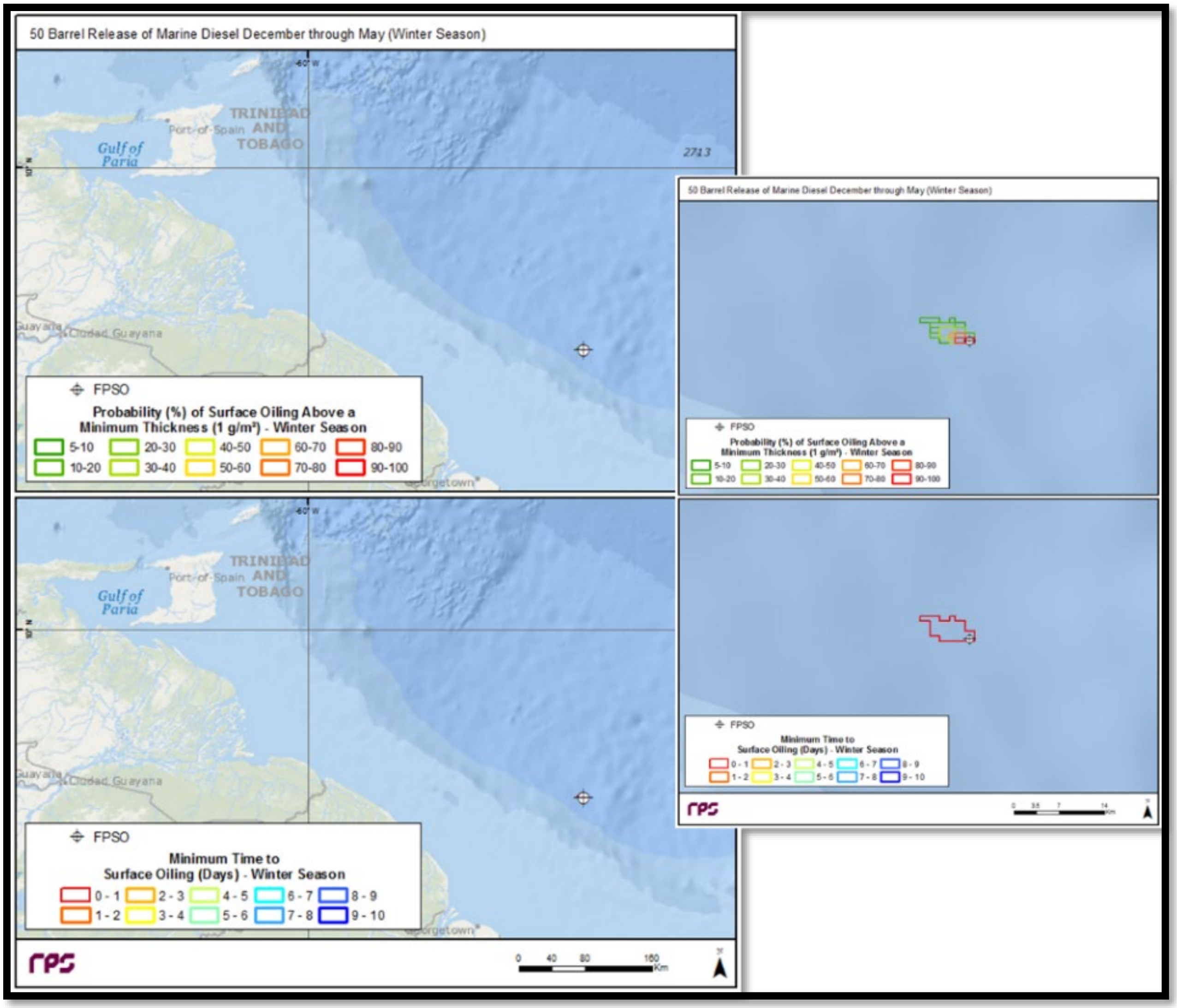
Note: Top Panel—Probability of surface oiling above a minimum thickness of 1 micrometer (µm). Bottom Panel—Minimum time for surface oil thickness to exceed 1 µm. Inset Panel—Detail.

Figure 10.1-5a: Proxy Stochastic Map for Predicted Surface Oiling and Timing from an Unmitigated 50-Barrel (8 m³) Surface Release of Marine Diesel (Jun–Nov)



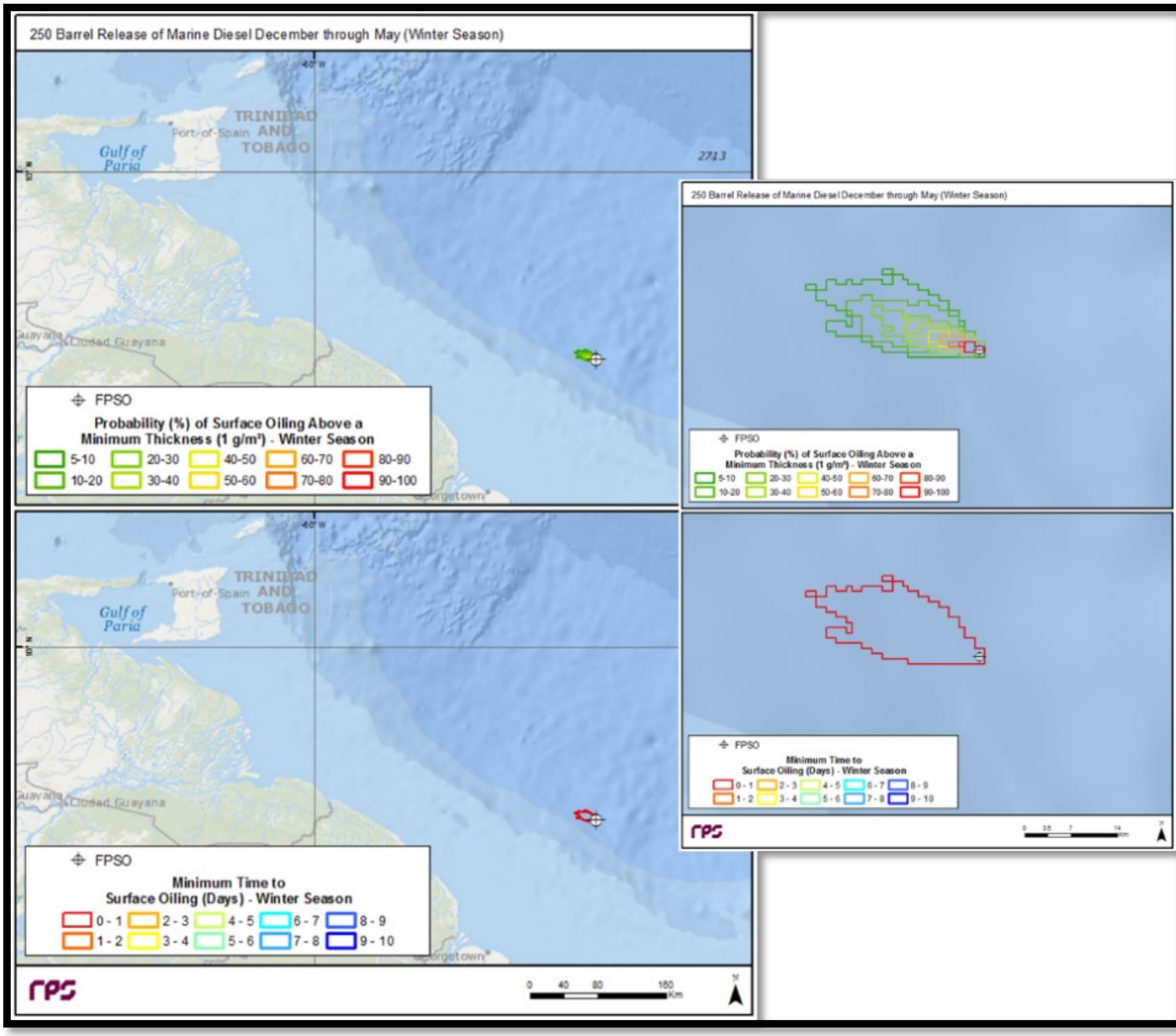
Note: Top Panel— Probability of surface oiling above a minimum thickness of 1 micrometer (µm). Bottom Panel—Minimum time for surface oil thickness to exceed 1 µm. Inset Panel—Detail

Figure 10.1-5b: Proxy Stochastic Map for Predicted Surface Oiling and Timing from an Unmitigated 250-Barrel (40 m^3) Surface Release of Marine Diesel (Jun–Nov)



Note: Top Panel—Probability of surface oiling above a minimum thickness of 1 micrometer (µm). Bottom Panel—Minimum time for surface oil thickness to exceed 1 µm. Inset Panel—Detail.

Figure 10.1-6a: Proxy Stochastic Map for Predicted Surface Oiling and Timing from an Unmitigated 50-Barrel (8 m^3) Surface Release of Marine Diesel (Dec–May)



Note: Top Panel—Probability of surface oiling above a minimum thickness of 1 micrometer (µm). Bottom Panel—Minimum time for surface oil thickness to exceed 1 µm. Inset Panel—Detail

Figure 10.1-6b: Proxy Stochastic Map for Predicted Surface Oiling and Timing from an Unmitigated 250-Barrel (40 m^3) Surface Release of Marine Diesel (Dec–May)

Marine Diesel Fuel Spill to Marine Environment—Deterministic Modeling Results (Unmitigated)

To supplement the stochastic modeling, a deterministic trajectory and fate simulation was run for each scenario to further assess a specific “worst-case” spill event that could potentially occur using the same combination of winds and current forcing used in the corresponding stochastic simulation from which it was identified. Different parameters or indicators can be used to identify the “worst case” (e.g., “time to reach the coast,” “oil volume to reach the coast,” “total length of oiled coastline,” “total water surface oiled”). For each of the marine diesel fuel spill scenarios, none of the simulations were predicted to reach shore. Accordingly, individual spill events simulated in each stochastic scenario were selected based on their rank according to the maximum water surface area oiled. Therefore, a single deterministic spill event ranked as the 95th percentile water surface area oiled was selected for these scenarios.

Modeled breakdowns of the mass balances for each deterministic scenario at the end of the simulations are presented in Table 10.1-3.

Table 10.1-3: Representative Worst-case Scenario Mass Balance at the End of the Simulation as Percent (%) of the Total Volume of Oil Released

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation
50-barrel (8 m^3) Marine Diesel Fuel Release—Jun–Nov Season	3.9	2.6	0.0	90.1	3.4
50-barrel (8 m^3) Marine Diesel Fuel Release—Dec–May Season	<0.1	29.8	0.0	65.5	4.6
250-barrel (40 m^3) Marine Diesel Fuel Release—Jun–Nov Season	1.1	20.5	0.0	75.2	3.2
250-barrel (40 m^3) Marine Diesel Fuel Release—Dec–May Season	0.0	29.9	0.0	65.5	4.6

Oil Spill Modeling Results—Riverine Fuel Spill Scenarios

Oil spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). The modeled spill volume (500 barrels) was selected to represent a reasonable estimate of the size of a potential fuel release that could occur from a riverine vessel supporting the Project (e.g., a barge transiting between a shorebase and the temporary MOF). Two spill locations were modeled in the Demerara River: one at the Demerara Harbour Bridge, and one at the temporary MOF. The SIMAP model system (RPS 2018b; RPS 2021a) was used, taking into account the weathering profile of the oil (which would result in a proportion of the oil evaporating or dispersing into the water column). Spills were simulated taking into consideration the quantity of oil released, the type of oil and its characteristics (e.g., density), historical seasonal wind and current patterns, and water depth, among other factors (Appendix S, ExxonMobil Demerara River Oil Spill Modeling).

Modeling was performed for environmental conditions corresponding to high river flow and low river flow conditions in the Demerara River. To account for tidal fluctuations in the river, screening was performed to select the tidal stage expected to result in the longest length of shoreline affected as a result of the spill. Based on this screening, the high river flow condition was modeled under a spring tide, and the low river flow condition was modeled under a neap tide. The modeling results are included in the OSRP (Volume III of the EIA) and are described below, including results for modeling under a deterministic (unmitigated) mode.

Marine Diesel Fuel Spill to Riverine Environment-Deterministic Modeling Results (Unmitigated)

Modeled breakdowns of the mass balances for each deterministic scenario at the end of the simulations are presented in Table 10.1-4. Figure 10.1-7a to Figure 10.1.7-c and Figure 10.1-8a to Figure 10.1-8c provide the deterministic maps at different time steps for a 500-barrel (80 m^3)

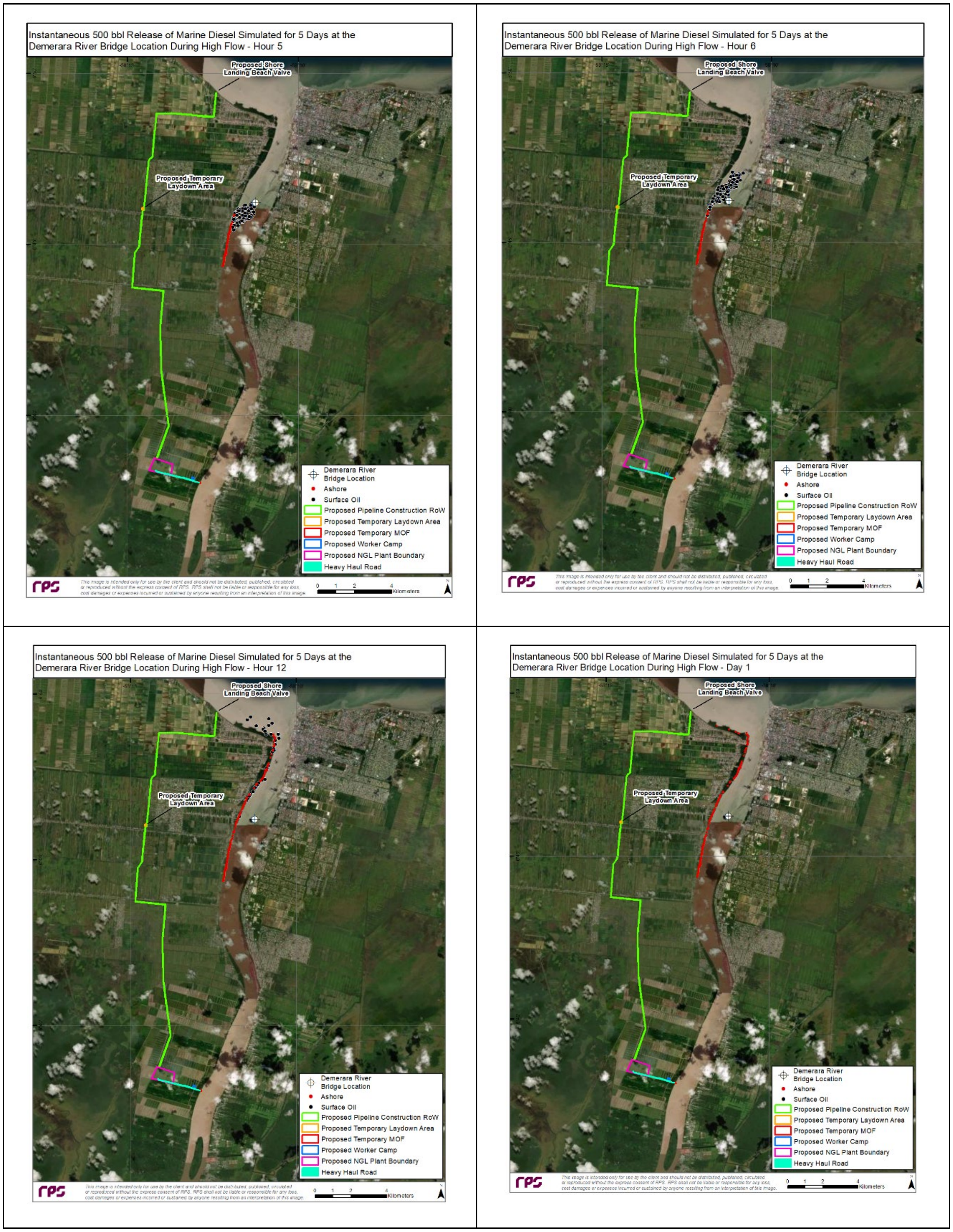
fuel spill at the Demerara Harbour Bridge under high river flow and low river flow conditions, respectively. Figure 10.1-9a to Figure 10.1.9-c and Figure 10.1-10a to Figure 10.1-10c provide the deterministic maps at different time steps for a 500-barrel (80 m^3) fuel spill at the temporary MOF under high river flow and low river flow conditions, respectively. Affected shorelines depicted on the figures are determined by the presence of any oil amount predicted to encounter a shoreline, regardless of a thickness threshold.

Table 10.1-4: Representative Worst-Case Scenario Mass Balance at the End of the 5-Day Simulation as Percent (%) of the Total Volume of Oil Released

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation	Sediment
Demerara Harbour Bridge Instantaneous 500-barrel (80 m^3) Marine Diesel Spill—High River Flow	0.0	5.1	19.2	75.2	0.5	<0.1
Demerara Harbour Bridge Instantaneous 500-barrel (80 m^3) Marine Diesel Spill—Low River Flow	0.0	7.8	20.9	70.1	1.2	<0.1
Temporary MOF Instantaneous 500-barrel (80 m^3) Marine Diesel Spill—High River Flow	0.0	0.1	30.5	69.1	0.3	<0.1
Temporary MOF Instantaneous 500-barrel (80 m^3) Marine Diesel Spill—Low River Flow	0.0	0.2	30.0	69.5	0.3	<0.1

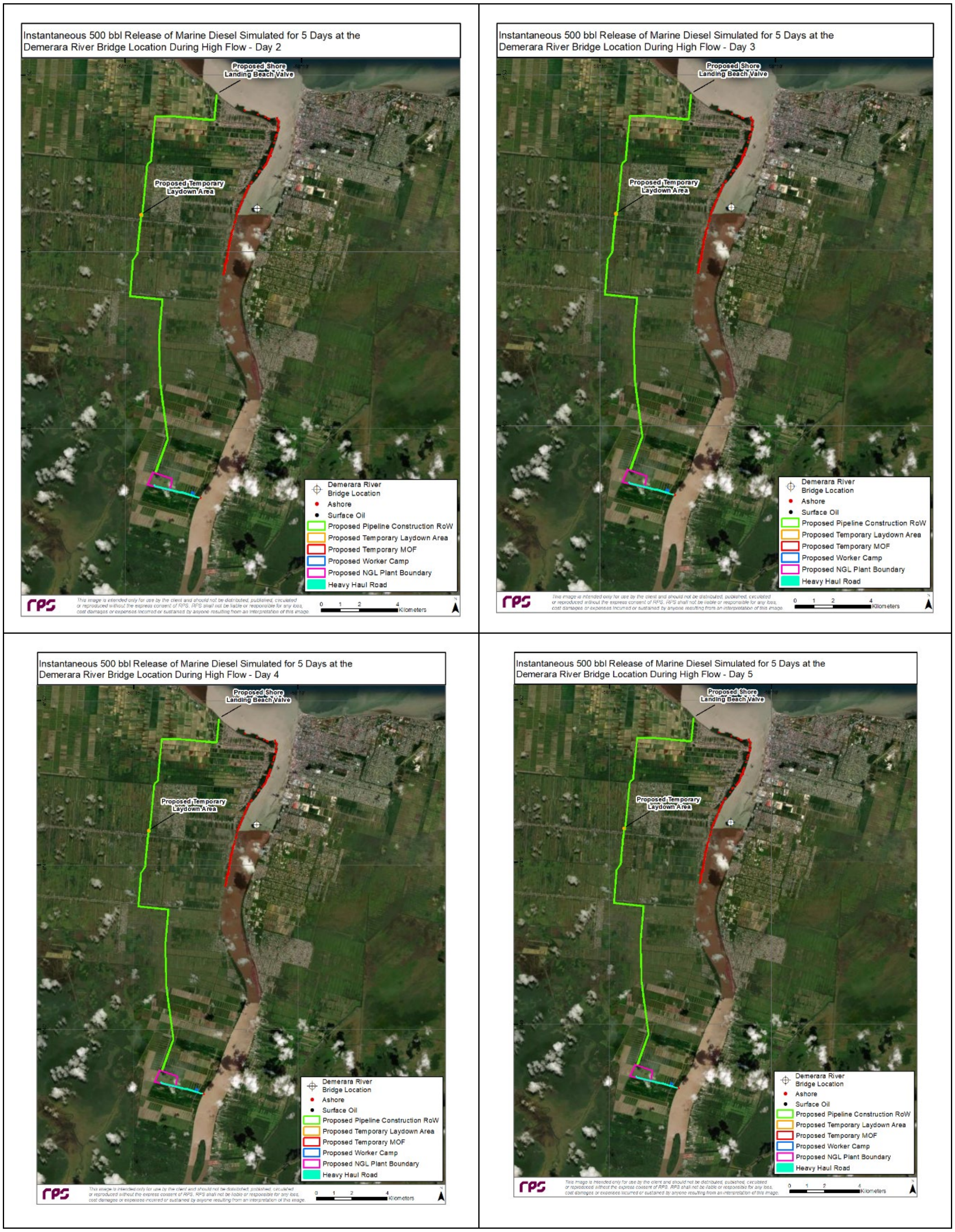
Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-7a: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Demerara Harbour Bridge (High River Flow Conditions)—Time Steps 1 Hour to 4 Hours



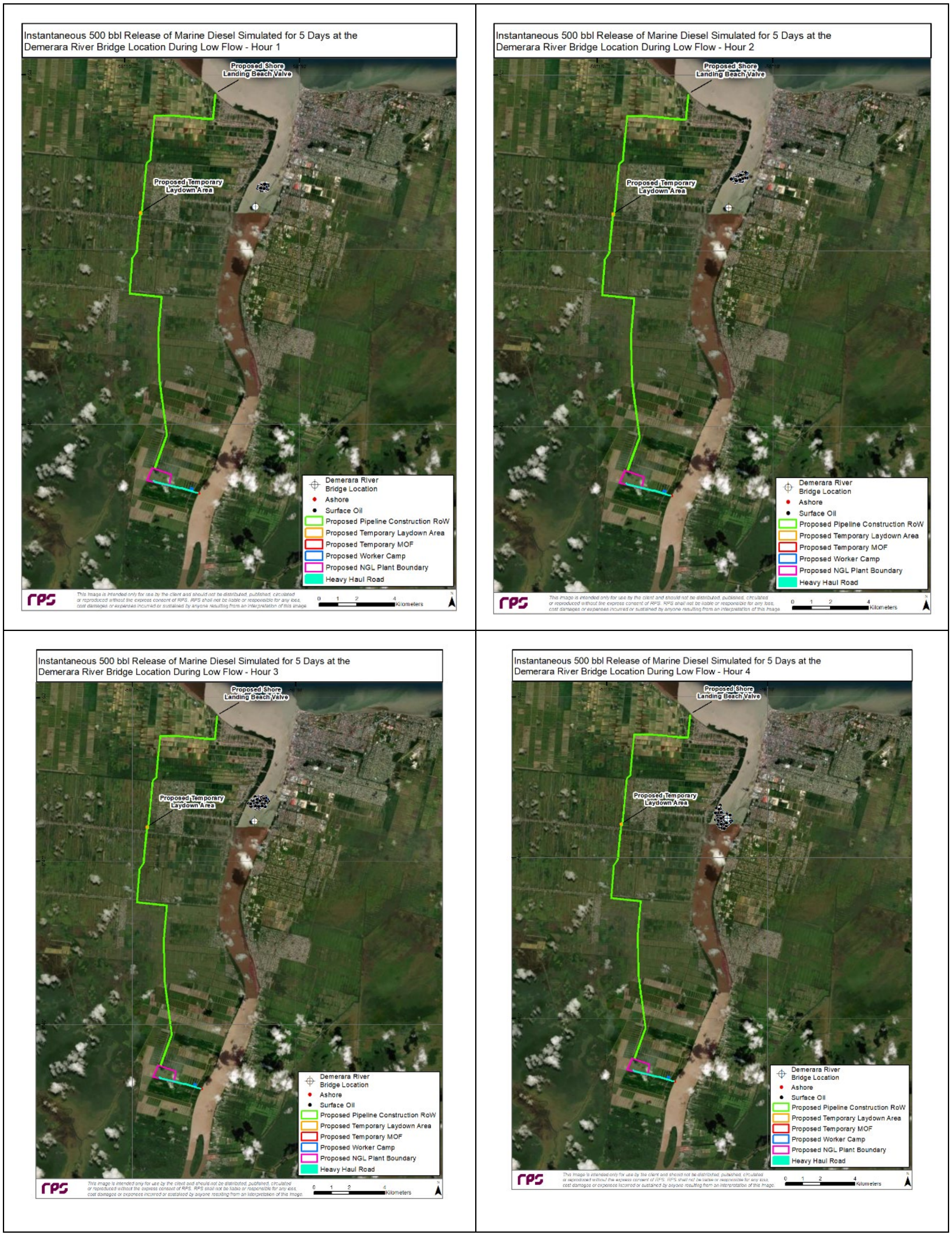
Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-7b: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Demerara Harbour Bridge (High River Flow Conditions)—Time Steps 5 Hours to 1 day



Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-7c: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Demerara Harbour Bridge (High River Flow Conditions)—Time Steps 2 Days to 5 Days

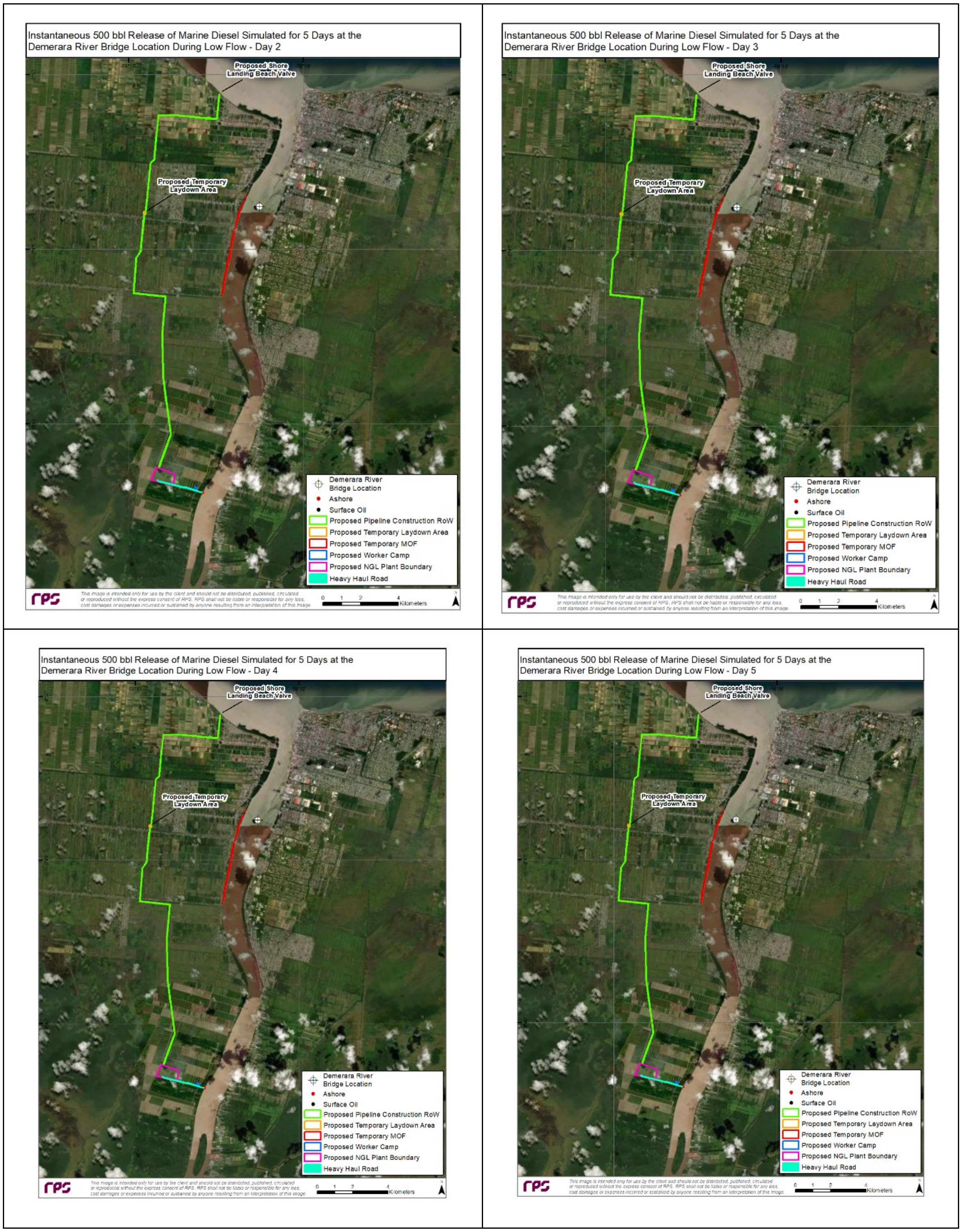


Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-8a: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Demerara Harbour Bridge (Low River Flow Conditions)—Time Steps 1 Hour to 4 Hours

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-8b: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Demerara Harbour Bridge (Low River Flow Conditions)—Time Steps 5 Hours to 1 Day



Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-8c: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Demerara Harbour Bridge (Low River Flow Conditions)—Time Steps 2 Days to 5 Days

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-9a: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Temporary MOF (High River Flow Conditions)—Time Steps 1 Hour to 4 Hours

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.9b: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Temporary MOF (High River Flow Conditions)—Time Steps 5 hours to 1 day

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-9c: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Temporary MOF (High River Flow Conditions)—Time Steps 2 Days to 5 Days

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-10a: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Temporary MOF (Low River Flow Conditions)—Time Steps 1 Hour to 4 Hours

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

Figure 10.1-10b: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Temporary MOF (Low River Flow Conditions)—Time Steps 5 Hours to 1 Day

Note: Surface oil droplets at the end of the indicated time period is displayed in black, and affected shoreline at the end of the indicated time period is displayed in red.

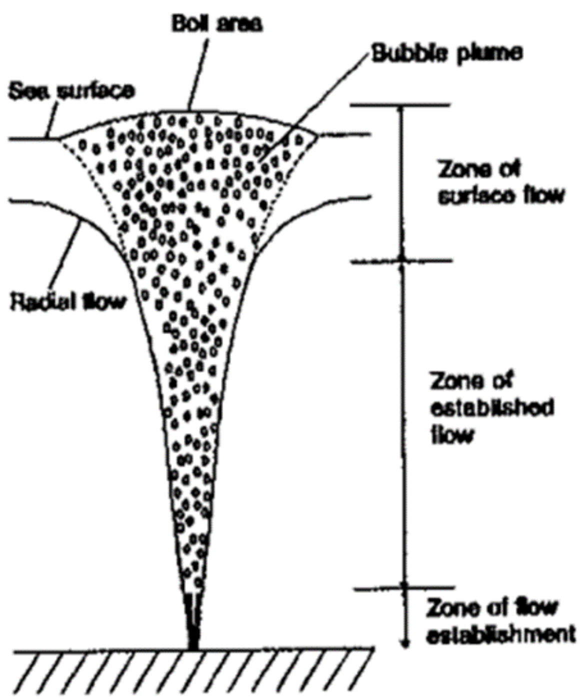
Figure 10.1-10c: Proxy Deterministic Map for Predicted Transport from an Unmitigated 500-Barrel (80 m^3) Surface Release of Marine Diesel Fuel at the Temporary MOF (Low River Flow Conditions)—Time Steps 2 Days to 5 Days

10.1.2. Loss of Integrity of Offshore Pipeline Resulting in a Natural Gas Release

An offshore pipeline will be installed from the Destiny FPSO Pipeline End Termination (PLET) to a shore landing point, with an infield pipeline from the Liza Unity FPSO tying-in to the PLET. From this point, the offshore pipeline will run approximately 200 kilometers to shore, where it will tie in with the onshore pipeline. There are a number of scenarios that could result in a loss of integrity and resulting release of natural gas from the offshore pipeline, including:

- Corrosion;
- Objects striking the pipeline; and
- A buildup of stress in the pipe wall, causing buckling.

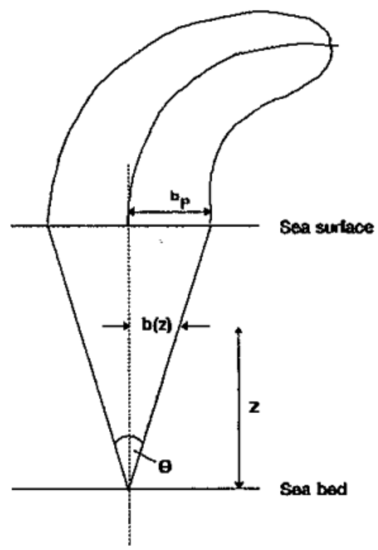
Unplanned gas releases from a subsea pipeline are discussed by the International Marine Contractor's association in their incident report Safety Flash 01/04. If an unplanned release of gas from damaged subsea pipelines occurs, the released gas will generate a gas plume that rises from the seafloor to the sea surface (Hissong et al. 2014). At the surface, the area of the gas release is directly proportional to the depth of water, as described in the publication Dispersion of Subsea Releases: Review of Prediction Methodologies (Rew et al. 1995) and shown on Figure 10.1-11. The boil area that is depicted in Figure 10.1-11 becomes the diameter of the release of natural gas.



Source: Rew et al. 1995

Figure 10.1-11: Schematic of Dispersion of Subsea Gas Releases

In the boil area, it is reasonable to assume that most of the natural gas will start to dissipate as a free gas. Therefore, almost all of the gas release will be limited to the area shown in Figure 10.1-12. The specific gravity of natural gas is less than 1, and it will therefore tend to disperse rapidly.



Source: Rew et al. 1995

Figure 10.1-12: Schematic of Dissipation of Subsea Gas Release at Sea Surface

Fire or explosion accidents can occur when the released gas disperses into the atmosphere and encounters ignition sources, which could have an adverse impact on human life and environment in the immediate vicinity of the fire. The consequences would likely be much less severe offshore than a release from the onshore pipeline because an offshore release would be extremely likely to be free-field[1], thereby negating the chance of an explosion. A release close to the FPSO (e.g., from a riser) could result in a fire onboard the FPSO.

At a location very close to land, the characteristics of a release would transition from those of a subsea release to those that would be closer in character to a release from the onshore pipeline, which is described in Section 10.1.2, Loss of Integrity of Offshore Pipeline Resulting in a Natural Gas Release.

To reduce the likelihood of a release, the offshore pipeline design and installation will vary depending on the pipeline depth. At a minimum, the pipeline will be laid in a trench, with sections closer to the nearshore area buried, which will reduce the likelihood of an external impact causing a release. The offshore pipeline will be constructed using international good practices, which will reduce the likelihood of stresses building up in the pipeline walls and thereby reduce the likelihood of buckling.

[1] Free-field is a modeling term used to describe a release that is into open space and not into confined or congested areas.

A leak would be quickly detected and isolated using emergency shut down valves, which will limit inventory loss and therefore the duration of any release event. The consequences are likely to be less severe offshore then a release from the onshore pipeline because it is extremely unlikely that there will be an ignition source to cause a fire, and the gas will passively disperse without affecting any resources.

On the basis of the above, a loss of integrity resulting in a release of natural gas from the offshore pipeline is considered **Unlikely**.

10.1.3. Vessel Collision with a Third-party Vessel, Structure, or Animal (Non-Spill-Related)

10.1.3.1. Vessel Collision with a Third-Party Vessel or Structure

Section 10.1.1.1, Collision between Project Marine Vessels or between a Project Marine Vessel and Third-Party Marine Vessel, Resulting in a Fuel Spill, and Section 10.1.1.4, Nearshore Collision between a Project Supply Vessel and a Third-Party Vessel or Structure, or Grounding, describe potential scenarios in which a Project vessel collision could occur with a third-party vessel or structure, resulting in a spill of fuel. This section addresses the potential for such a collision, but focuses on the potential non-spill related aspects. This section also addresses the potential for a Project vessel to collide with a marine animal, specifically focusing on marine mammals, marine turtles, and riverine mammals.

A variety of Project vessels will supply construction operations, and these vessels will transit between the Guyana shorebases and either the offshore pipeline corridor or temporary MOF. There is a potential for collisions between these vessels and third-party vessels/structures in the Georgetown Harbour / Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Damage to an impacted structure may require repairs, and in extreme cases, temporary closure of the structure; this has occurred before in Guyana (e.g., damage to and temporary closure of the Demerara Harbour Bridge).

A number of embedded controls will be in place to reduce the potential for a nearshore or offshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels or structures, or causing significant injury, is considered **Unlikely**.

10.1.3.2. Vessel Collision with a Marine Mammal

Collisions with vessels can injure or kill marine mammals. An incident such as this is extremely rare for slower-moving vessels. Marine mammals possess acute senses of hearing that they can use to detect approaching vessels, and they have the necessary swimming speed capability to avoid collisions. Unless large whales are extremely distracted by feeding or breeding (neither activity is expected in the waters of the Project AOI), the animals would be aware of the vessels and fast enough to move out of the way. Nevertheless, marine mammals are inherently vulnerable to vessel strikes when they surface to breathe or feed. This vulnerability increases in shallow, nearshore areas where opportunities to maneuver are reduced. Vessel speeds will be extremely low for major installation vessels (i.e., pipelay vessels, subsea tie-in installation vessels), greatly reducing the potential for marine mammal strikes by these vessels. The predominant source of potential risk will be the supply vessels transiting along the offshore pipeline corridor and between the offshore pipeline corridor and shorebases, or Project vessels transiting from foreign ports to Guyanese shorebases. The number of Project-related vessel trips between an overseas port and a Guyana shorebase is estimated at six trips (total) during the Construction stage. The frequency of Project-related vessel trips between a Guyana shorebase and the offshore pipeline corridor is estimated at approximately twice per week during the offshore portion of the Construction stage. Accordingly, the incremental increase in marine traffic will represent a relatively small increase in overall risk to marine mammals. However, the potential remains for individual dolphins or whales to collide with vessels transiting between the offshore pipeline corridor and shorebases during the Construction stage.

In the unlikely event of a collision, the severity of injuries typically depends on the size and speed of the vessel. The probability a collision will kill the animal increases about 8 times as speed increases from 7 to 18 knots (13 to 33 kilometers per hour) (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007; De Stephanis and Urquiola 2006). There are no reported incidents of collisions with whales by industry vessels (excluding tankers moving at high speeds) when mitigations are in place to slow for observed whales.

With respect to the potential for injury and mortality from vessels strikes, EEPGL will use the following embedded controls for the Project (see Section 5.6, Proposed Best Available Technology and Embedded Controls):

- Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface.
- Provide standing instruction to Project-dedicated vessel masters to reduce their speed within 300 meters of observed marine mammals, and not to approach the animals closer than 100 meters, when possible, to reduce probability of collisions. EEPGL-contracted vessels are trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such. Such vessels reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock. Vessels also slow to less than 5 knots (9.3 kilometers per hour) and are prohibited from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO when offloading and the 500-meter exclusion zone around pipe laying ships and FPSO during all other times.

Although the embedded controls noted above are expected to greatly reduce the possibility of a Project vessel striking a marine mammal, it is conservatively assumed that over the duration of the Project life cycle, such an event is **Possible**.

10.1.3.3. Vessel Collision with a Marine Turtle

Collisions with vessels can injure or kill marine turtles. Marine turtles tend to spend most of their time at sea at or near the sea surface, and do not possess the acute sense of hearing or the swimming speed that cetaceans use to avoid collisions. Marine turtles are inherently more vulnerable to vessel strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by the higher concentrations of turtles in the shallow nearshore areas. The planned Project activities will occur more than 100 kilometers away from the nearest portion of the Shell Beach Protected Area (SBPA), where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data).

There is very little potential for collisions with marine turtles to occur within the Project AOI, but the potential remains for individual turtles to collide with vessels transiting between the offshore pipeline corridor and shorebases. Hazel et al. (2007) investigated the influence of vessel speed on the probability of vessel strikes of large marine turtles. Avoidance ability is a combination of swimming speed and time from alert to approach. Loggerheads and other very large turtles can swim as fast as 24 kilometers per hour (13 knots). Therefore, they have the ability to avoid slower-moving vessels. The study showed (using a small recreational vessel) that the majority of turtles reacted in time to avoid slower vessels. Since larger vessels are also louder, the animals are able to sense their approach from even greater distances. Wirsing et al. (2008) studied the speed and maneuverability of adult loggerhead turtles to measure their speed and avoidance behavior. Both studies are consistent with adult turtles being aware and agile enough to easily avoid slower-moving vessels (less than 15 knots [27.8 kilometers per hour]). An incident of a slow-moving vessel colliding with a marine turtle is thus extremely rare, particularly in the open ocean. Of the more that 1,300 protected species detections recorded by EEPGL since Protected Species Observer observations began in 2015, only 17 have been marine turtles. The turtle telemetry studies conducted to date in support of EEPGL's offshore development projects further supports that marine turtles transiting along the Guyana Coast preparing to nest or re-nest will normally transit much closer to shore.

With respect to the potential for injury or mortality of marine turtles from vessel strikes, EEPGL will use the following embedded control for the Project:

- Provide standing instruction to Project-dedicated vessel masters to avoid marine turtles while underway, to reduce their speed within 300 meters of observed marine turtles (noting that such observations are inherently difficult), and to not approach the animals closer than 100 meters, when possible, to reduce probability of collisions. EEPGL-contracted vessels are trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such. Such vessels reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock. Vessels also slow to less than 5 knots (9.3 kilometers per hour) and are prohibited from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO and the 500-meter exclusion zone around major installation vessels during all other times.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking a marine turtle; accordingly, it is considered that such an event is **Unlikely**.

10.1.3.4. Vessel Collision with a Riverine Mammal

Collisions with vessels can injure or kill riverine mammals. As described in Section 8.2, Marine and Coastal Biodiversity, the American manatee (*Trichechus manatus*) and the neotropical otter (*Lontra longicaudis*) are the most likely riverine mammals to occur within areas affected by planned Project activities, and these species do not possess the acute sense of hearing or the swimming speed and agility that marine mammals rely on to avoid collisions. These species tend to spend most of their time near the water's surface.

The only portion of the Direct AOI where riverine mammals are likely to occur is the Demerara River. Planned Project activities in the Demerara River will include supply vessels traveling between shorebases and the offshore pipeline corridor, and between shorebases and the temporary MOF. Vessel speeds within the river will be low (an embedded control will be put in place to this effect), reducing the potential for collisions. The likelihood of a collision is low due to these factors; but these factors notwithstanding, the potential remains for individual riverine mammals to collide with vessels transiting Georgetown Harbour and the Demerara River. The potential for the greatest number of collisions to occur will be during the Construction stage, when vessel traffic will be at its peak.

The probability of a collision between a riverine mammal (predominantly manatees) and a vessel is primarily controlled by speed. Slow speeds (approximately 5 knots [9.3 kilometers per hour]) within rivers drastically reduce the possibility of collision with manatees. Laist and Shaw (2006) reported that in Florida, speed restrictions (approximately 5 knots [9.3 kilometers per hour]) are effective in significantly reducing collisions with manatees. Calleson and Frohlich (2007) documented that reducing boat speed allows the vessel and the manatee more time to detect the other and react accordingly to avoid a collision. Rycyk et al. (2018) documented tagged manatee behavior during boat approaches in Florida and concluded that faster boat speeds pose a greater risk of collision with manatees than slower boat speeds. Compared to fast approaches, slower passes allow the manatee more time to respond, and behavioral changes occur earlier relative to the time of the boat's closest approach.

With respect to the potential for injury or mortality from vessels strikes, EEPGL will use the following embedded controls for the Project (see Section 5.6, Proposed Best Available Technology and Embedded Controls):

- Provide awareness training to Project-dedicated marine personnel to recognize signs of riverine mammals at the sea surface.
- Provide standing instruction to Project-dedicated vessel masters to avoid riverine mammals while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions. EEPGL-contracted vessels are trained and instructed to slow when they observe a marine mammal, riverine mammal, marine turtle, or any floating debris or objects—as well as other vessels—and take corrective actions to alter course to avoid such.

Such vessels reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock.

The embedded controls noted above are expected to greatly reduce the possibility of a Project vessel striking a riverine mammal; accordingly, it is considered that such an event is **Unlikely**.

10.1.3.5. Collisions between Project Vessels/Helicopters and Marine birds

Rafting marine birds may suffer injury or mortality from collision with vessels transiting to and from the offshore pipeline corridor. However, rafters are not likely to be present in large aggregations in the offshore pipeline corridor because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for large aggregations of species that favor more calm and sheltered conditions. The EEPGL seismic surveys conducted in the Stabroek Block from 2015 through 2021 (RPS 2018a, 2019, 2020a, 2020b, 2020c, 2020d, 2020e, 2021b) have not documented any concentrations of rafting marine birds in the area during their survey periods. On the rare occasions that suitable conditions for rafting occur and marine birds are present in high enough concentrations to form rafts, individual marine birds could be susceptible to vessel strike and related injury or mortality. However, large marine bird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path.

Helicopters will be used as a form of transit to/from the major installation vessels, and could adversely impact marine birds through helicopter strikes of individuals flying near helicopters transiting around or in route to/from the installation vessels. Helicopter trips to and from the installation vessels are not expected to exceed more than two per week, so the potential for helicopter-bird interactions is expected to be low.

With respect to the potential for marine vessels colliding with rafting marine birds, EEPGL will use the following embedded control for the Project:

- Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting marine birds when transiting to and from the offshore pipeline corridor.

The embedded control noted above is expected to greatly reduce the possibility of a Project vessel striking rafting marine birds (that do not move out of the vessel's path on their own).

Given the low likelihood of vessels encountering rafting marine birds and the above embedded control, as well as the limited number of helicopter flights per day between the major installation vessels and shore, the likelihood of a vessel or helicopter interaction with a marine bird is considered **Unlikely**.

10.1.4. Onshore Hydrocarbon Release

There is the potential for an unplanned release of hydrocarbons from the onshore pipeline or NGL Plant. Potential scenarios for such a release are discussed in this section.

Det Norske Veritas GL's Process Hazard Analysis Software (PHAST) was used to model the consequence of fire and explosion hazards from several onshore release scenarios considered. PHAST is an industry-standard software tool that is used by companies and regulators around the world to model the potential consequences of hydrocarbon releases. It predicts the progress of a potential incident from the initial release to a far-field dispersion analysis, including modeling of pool spreading and evaporation, and flammable and toxic impacts. It calculates the release rate from an unplanned event and the total mass released through the specified orifice of the components based on the system pressure, available mass inventory, and time to isolation.

To get a close approximation of the release rate, the atmospheric expansion calculation within PHAST accounts for the expansion of fluids being released from the system to atmospheric conditions. Within PHAST, the cone (shell) model is used for jet fire modeling and assumes the shape of a jet flame as a frustum (i.e., lower part of the cone when cut horizontally) of a cone. The jet flame lengths and the subsequent thermal radiation hazard ranges are primarily driven by the release rate and the material.

Although there will be some hydrogen sulfide in the natural gas stream later in the life cycle of the Project, it is expected to be present then at a very low percentage of the stream composition and is likely to result in a concentration of less than 5 parts per million close to the fence, which is at a level that could potentially cause odor complaints, but below the concentration that can cause toxicological effects on humans. Accordingly, modeling to assess potential toxicity effects from hydrogen sulfide was not conducted.

Based on the safety protocols that will be put in place for both the onshore pipeline and NGL Plant, the onshore hydrocarbon release scenarios discussed below are considered **Unlikely** to occur.

10.1.4.1. Loss of Integrity of Onshore Pipeline

From the shore landing, the onshore pipeline follows a route that is approximately 25 kilometers in length to the NGL Plant, crossing through a mix of agricultural, residential, and light commercial land use. The onshore pipeline will be installed below ground (either via open trenching methods or via a horizontal directional drilling (HDD) bore) with a minimum cover depth of 1.22 meters. In sections installed using open trenching, a fiber optic cable (FOC)-based system will be installed in the same trench for communication and to detect leaks and/or third-party intrusion. The onshore pipeline will be coated with a three-layer polyethylene coating and dual-layer fusion-bonded epoxy to prevent external corrosion, and will be further protected from corrosion using an impressed current system. A monolithic isolation joint will be included at the pipeline shore landing area to isolate the offshore and onshore cathodic protection systems. The only aboveground components of the onshore pipeline containing natural gas will be an aboveground mainline valve (to be installed near the proposed shore landing beach valve).

The potential unplanned events considered included a full-bore rupture of the onshore pipeline or a leak in the pipeline. Small leaks are unlikely to create a sufficient amount of energy to move the earth surrounding the pipeline and therefore are unlikely to release natural gas to the air. Large leaks can propagate to full-bore ruptures and are therefore discussed together with full-bore ruptures in this section. A full-bore rupture would most likely create a crater around the release location. Therefore, this section deals with a full-bore rupture as the worst-case scenario for a loss of integrity of the onshore pipeline.

Onshore pipeline integrity failures are rare, especially on such relatively short lengths of pipeline as in the case of the Project. If a loss of integrity were to occur, the most likely causes would be a third party striking the line or corrosion of the pipe that ultimately led to a pipe wall failure. These potential causal factors are supported by data from Concawe, a pipeline operators association in Europe, and the Line Pipe Research committee of the American Gas Association (Concawe 2021; Eiber and Jones 1992; Jones et al. 1986). Both sources report that, of these two main mechanisms of failure, third-party line strikes are the most significant cause of failures on gas pipelines.

A line strike on the buried pipeline could occur as a result of a third party excavating in close proximity to the pipeline without knowing the exact location of the pipeline (e.g., during construction activities in close proximity to the pipeline). A third-party strike typically would present a source of ignition for the released gas, which could result in the immediate ignition of the gas and what is referred to as a jet fire[2]. If the release is not ignited immediately, a flammable gas cloud would be formed and this could ignite, causing either a flash fire[3] or explosion. An explosion would only be likely to occur if the gas is released into a congested space. A congested space can be defined as any space within which there is an obstruction to the free movement of a gas through the space. The most likely places where obstructions would be present near the onshore pipeline would be densely forested areas or thick undergrowth. The strength of the explosion would be correlated to the proportion of the gas cloud within the congested area. The higher the proportion of the gas cloud that is within a congested area, the stronger the resultant explosion would be. Consequently, open areas—such as that characterized by the onshore pipeline corridor—are unlikely to be conducive to an explosion in the case of a natural gas release from the onshore pipeline.

The Project will include a number of embedded controls to reduce the likelihood of a third-party line strike. These include the following:

- While the majority of the onshore pipeline corridor will pass through areas that correspond to Class 1 or Class 2 location classifications, as per American Society of Mechanical Engineers (ASME) B31.8, the onshore pipeline will be designed to a Class 3 location classification—which includes higher design factors, including increased wall thickness.
- Aboveground pipeline markers installed along the onshore pipeline corridor, indicating the location of the buried pipeline and including standard signage to not excavate in the area prior to contacting EEPGL.
- An FOC-based system installed along the pipeline at the time the pipeline is buried, to detect leaks and/or third-party intrusion the pipeline.

[2] A jet fire is a combustion of flammable material as it is being released from a pressurized process unit; the duration of the fire would depend on the amount of material available in the pipeline when released.
[3] A flash fire is a nonexplosive combustion of a flammable vapor cloud which is diffused in open air; the duration of a flash fire is typically relatively short (e.g., a few seconds), and depends on the mass of material in the cloud.

- For the aboveground valve near the shore landing, anti-cut / anti-climb perimeter fencing around the valve, with fiber optic intrusion detection, 24-hour-per-day closed-circuit television monitoring of the compound, and security lighting.

With respect to the potential corrosion causal factor, relevant embedded controls include the above-referenced external corrosion coating for the onshore pipeline, installation and monitoring of an impressed current cathodic protection system, and routine internal inspections for corrosion through the use of pipeline intelligent pigging tools.

Based on the embedded controls, a loss of integrity of the onshore pipeline resulting in a potential fire or explosion is considered **Unlikely**.

10.1.4.2. Loss of Integrity of NGL Plant Facilities

A series of potential scenarios involving a natural gas release from the NGL Plant facilities were screened using the above-referenced PHAST consequence modeling software tool to determine if they had the potential to impact any resources beyond the NGL Plant boundary. Those scenarios for which screening indicated no reasonable potential to impact resources beyond the NGL Plant boundary were not assessed further. Potential impacts for these scenarios would be limited to employees and contractors at the NGL Plant; these risks will be addressed through engineering assessments conducted during detailed Project design, and are beyond the scope of the EIA.

Natural gas recovered from the Destiny and Unity FPSO production operations will be processed at the NGL Plant to create a supply of methane/ethane for the third-party power plant and a supply of NGLs (propane, butane, and pentane) for local customers. The NGL Plant will receive the gas at a slug catcher, reduce the pressure of the gas stream through a pressure letdown facility, process the natural gas into the various target components, and then store NGLs temporarily on site in storage vessels (see Chapter 5, Project Description, for more details).

There will be numerous layers of protection to prevent a release of natural gas from the NGL Plant, including the following:

- Industry standard design standards (e.g., appropriate material selection, corrosion protection);
- Mechanical integrity programs as part of routine operations and maintenance;
- Overpressure protection;
- Isolation and blowdown system capabilities and procedures;
- Preventative maintenance programs (e.g., periodic vessel inspection, corrosion management);
- Emergency shutdown system;
- Process shutdown system; and
- Active and passive fire protection.

The details of these types of layers of protection will be developed during the detailed design of the Project. In the unlikely event that multiple layers fail, however, there is the potential that some of the scenarios analyzed have the potential to impact resources outside of the NGL Plant boundary. The types of events assessed for those scenarios with the potential to impact resources outside the NGL Plant boundary included a boiling liquid expanding vapor explosion (BLEVE), a flammable gas cloud, and a jet fire.

A BLEVE can be caused when the contents of a pressurized storage tank are heated by an external heat source such as a fire. The contents of the tank can start to boil, thereby increasing the pressure inside the tank until it exceeds the tank's design pressure, which can ultimately result in a failure of the vessel. At the point of failure, the tank can explode, creating an overpressure[4] and a fireball[5]. The overpressure from a BLEVE typically results in considerably more damage to the surrounding environment than the thermal radiation from a fireball, so the assessment is focused on BLEVEs. Such events are very rare in natural gas processing facilities, as evidenced by data in the International Oil and Gas Producers) Risk Assessment Data Directory, Report No. 434 (IOGP 2019). Several protection measures will be put in place to prevent such failures, such as pressure relief valves, firefighting systems, and industry-standard separation distances between storage vessels.

The screening assessment identified additional unplanned event scenarios that could result in explosions from other parts of the NGL Plant (i.e., other than storage vessels), but the potential extents of impact from these scenarios would likely be less significant than (and of a similarly low degree of likelihood as) a BLEVE; accordingly, these other potential explosion scenarios were not modeled.

Other types of natural gas releases from the NGL Plant could be caused by leaks from flanges or vessels, or operations and maintenance errors. Although significant releases are very rare, there is potential—if they did occur—for this to result in a jet fire or a flammable cloud, both of which could potentially impact resources outside of the NGL Plant boundary.

The potential natural gas releases that could impact resources outside the NGL Plant boundary were modeled using the PHAST software tool. The following events produced the largest potential impacts on resources outside of the NGL Plant boundary:

- Release of gas from the onshore pipeline, a pressurized propane storage bullet, piping upstream of the slug catcher, the deethanizer pump, the residue compressor outlet, or the methanol tank—resulting in a flammable cloud;
- Release and ignition of gas from the onshore pipeline, piping upstream of the slug catcher, the deethanizer pump, the residue compressor outlet, or the methanol tank—resulting in a jet fire; and
- Overpressure from a BLEVE of the pressurized propane storage bullet.

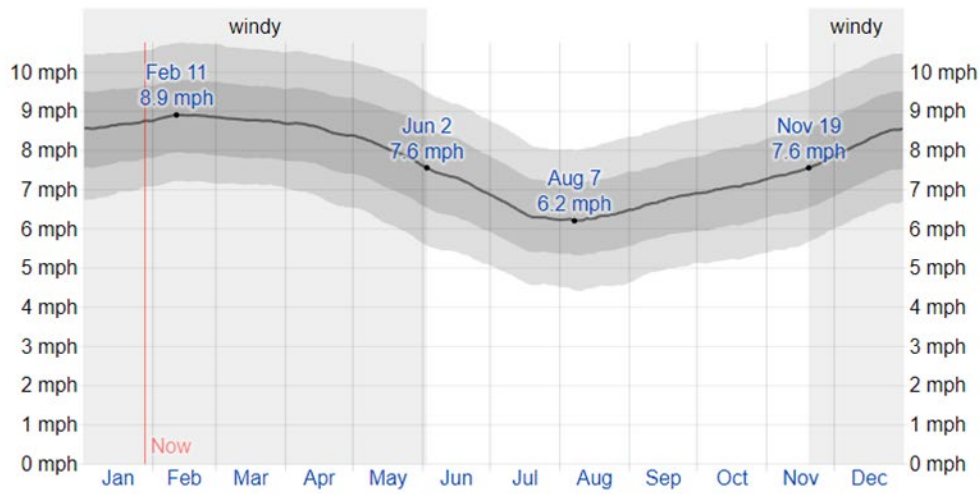
[4] Overpressure is the pressure caused by the shockwaves of an explosion.
[5] A fireball occurs when an instantaneous release of flammable material is ignited, resulting in a fire that is spherical and rises through the air due to the buoyancy of the hot combustion products.

10.1.4.3. Modeling of Hydrocarbon Releases

Factors Affecting Consequences of Hydrocarbon Releases

Several factors would affect the consequences of a hydrocarbon release. These factors include the physical and chemical properties of the hydrocarbon, the temperature and pressure of the release, the inventory available to be released, the types of terrain surrounding the release, and the meteorological conditions.

The meteorological conditions would affect the direction and concentration of a release. For any given release, wind speed, humidity, temperature, and atmospheric stability are the key parameters that determine how weather conditions affect the extent of the release. When modeling the release events, the weather conditions used in the modeling were taken from a review of publicly available data on weatherspark.com for Georgetown. Figure 10.1-13 depicts monthly average wind speeds for Georgetown based on data from 2014 to 2022.



The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind Speed (mph)	8.7	8.9	8.8	8.5	8.0	7.2	6.4	6.3	6.7	7.1	7.5	8.3

Source: weatherspark.com Undated
mph = miles per hour

Figure 10.1-13: Historical Average Wind Speeds for Georgetown

Based on the 90th, 50th, and 25th percentile wind speeds, Table 10.1-5 summarizes the wind speed and atmospheric stability conditions considered for consequence modeling. Three different wind speed / stability conditions were modeled for each event to assess potential consequences across a range of potential weather conditions. For each event modeled, the wind speed / stability condition predicted to result in the largest geographical area affected is presented below.

Table 10.1-5: Release Conditions Modeled

Percentile	Wind speed (meters/second)	Pasqual stability
90	10.5	B
50	7.8	B
25	4.5	B

The average annual atmosphere temperature is 27 degrees centigrade based on an average of monthly temperatures, and the average relative humidity is 72.5 percent. These parameters were used for all consequence modeling.

Wind direction data were used in the analysis to indicate the most likely direction of a release, but this parameter does not affect the extent of the release.

Modeling Results

Consequence modeling results are presented below in Figure 10.1-14 through Figure 10.1-25. The figures show predicted contours relative to specified endpoints for each type of event. These endpoints were selected based on guidance from the Centre for Chemical Process Safety (CCPS 1995), which is part of the American Institute of Chemical Engineers. The guidance from the CCPS is used by the oil and gas industry as a best practice for modeling potential consequences of onshore hydrocarbon releases. Table 10.1-6 summarizes the endpoints used and the corresponding contour color in the figures.

Table 10.1-6: Selected Consequence Modeling Endpoints

Flammable Cloud	Jet Fire (kW/m^2)	BLEVE (psi)
Upper flammable limit (red)	100 (purple)	3 (red)
Lower flammable limit (green)	37.5 (red)	2 (green)
Half flammable limit (blue)	12.5 (green)	0.3 (blue)
	4 (blue)	

kW/m^2 = kilowatt per square meter; psi = pounds per square inch

Table 10.1-7 through Table 10.1-9 summarize the potential consequences associated with the selected modeling endpoints.

Table 10.1-7: Flammable Cloud Radiation Consequences

Flammable Cloud	Consequences
Upper flammable limit	Highest concentration of gas where the area is still flammable
Lower flammable limit	Lowest concentration of gas where the area is still flammable
Half flammable limit	Lowest concentration of gas where there may still be very small flammable areas

Table 10.1-8: Jet Fire Radiation Consequences

Thermal Flux Level (kW/m^2)	Consequences
100	Expected fatality for all individuals within contour, inside and outside buildings
37.5	>90% chance of fatality inside and outside buildings; damage to process equipment
12.5	Significant chance of fatality; energy required for piloted ignition of wood
4	Causes pain after approximately 20 seconds exposure, and injury after 30 seconds exposure

kW/m^2 = kilowatt per square meter

Table 10.1-9: BLEVE Overpressure Consequences

Overpressure (psi)	Consequences
3	Steel frame buildings distorted and pulled away from foundations; threshold of damage to industrial machinery
2	Partial collapse of walls and roofs of houses
0.3	Safe distance (95% probability of no serious damage below this value); some damage to house ceiling and window glass broken

psi = pounds per square inch

Figure 10.1-14: Flammable Cloud from Onshore Pipeline Natural Gas Release

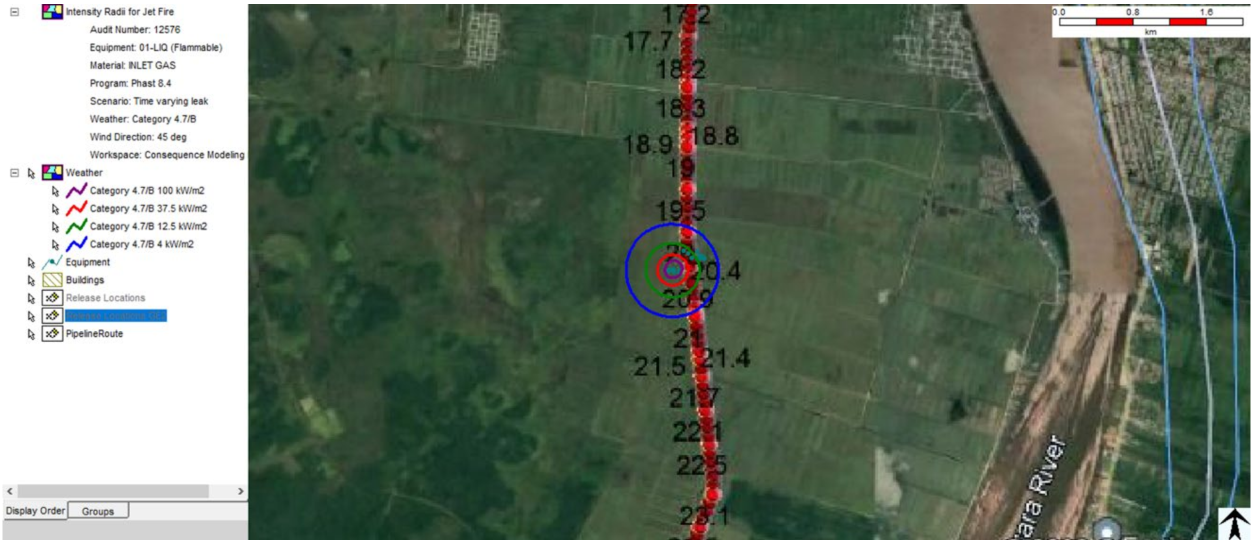


Figure 10.1-15: Jet Fire from Onshore Pipeline Natural Gas Release

Figure 10.1-16: Flammable Cloud from Piping Upstream of Slug Catcher Natural Gas Release

Figure 10.1-17: Jet Fire from Piping Upstream of Slug Catcher Natural Gas Release

Figure 10.1-18: Flammable Cloud from Outlet of Pump of Deethanizer Hydrocarbon Release

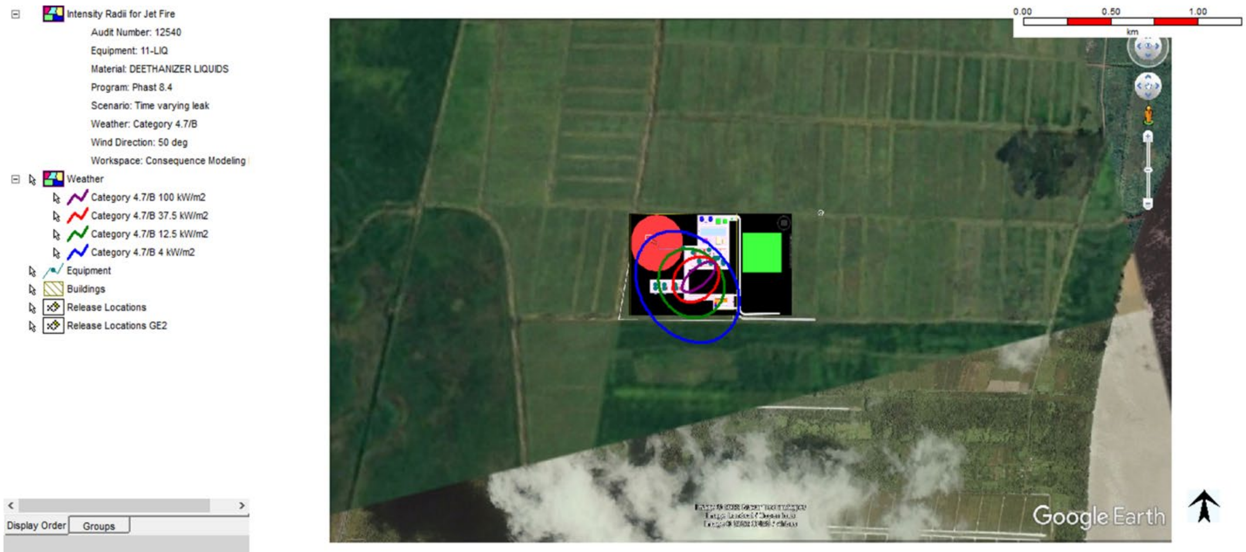


Figure 10.1-19: Jet Fire from Outlet of Pump of Deethanizer Hydrocarbon Release

Figure 10.1-20: Flammable Cloud from Outlet of Residue Compressor Hydrocarbon Release

Figure 10.1-21: Jet Fire from Outlet of Residue Compressor Hydrocarbon Release

Figure 10.1-23: Flammable Cloud from Propane Storage Bullet Release

Figure 10.1-23: BLEVE from Propane Storage Bullet Release

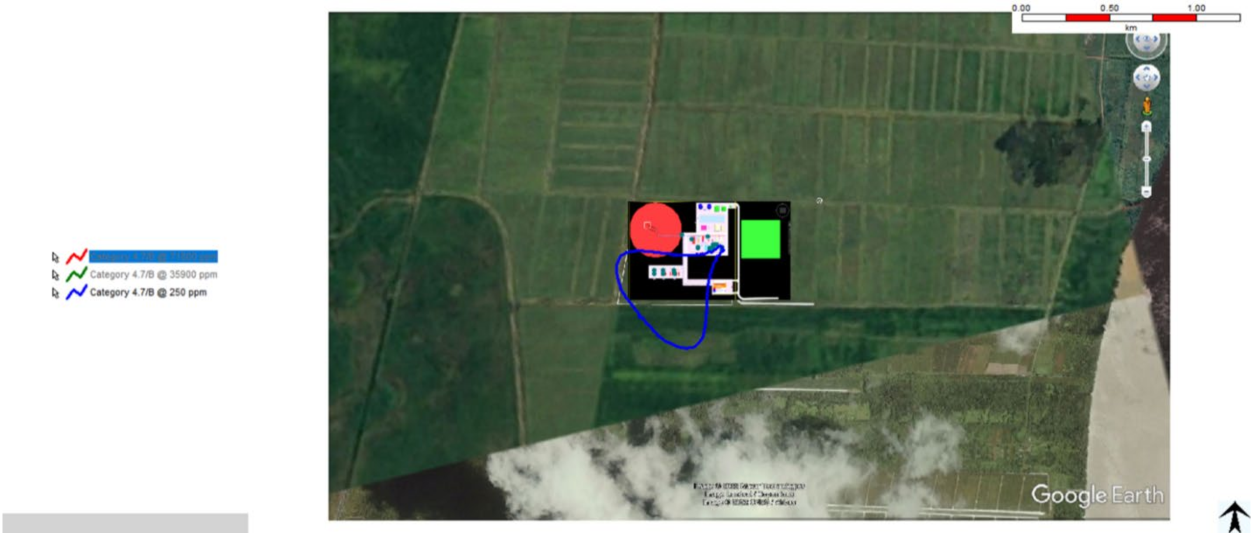


Figure 10.1-24: Flammable Cloud from Methanol Tank Release

Figure 10.1-25: Jet Fire from Methanol Tank Release

10.1.5. Untreated Wastewater Release at NGL Plant

The sanitary wastewater system will collect all domestic wastes from toilet facilities via manholes located near buildings and underground sloped piping. A modular “package” wastewater treatment plant (WWTP), described in Section 5.5.3.2, Operations Stage, will provide initial treatment of sanitary wastewater. Treated sanitary wastewater will be routed to the stormwater pond for monitoring and analysis prior to discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant.

A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. The preliminary design calls for injection of flocculants into the oily water streams prior to routing them to a Clarifier Tank. A skimmer will then send separated oil from the Clarifier Tank back to the process. The de-oiled water from the Clarifier Tank will then be sent to a Nutshell Filter or Dissolved Air Flotation Package for further treatment. Treated wastewater will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant.

An open drain system will collect rainwater from concrete, curbed areas of the NGL Plant. This includes the process, loading racks, flare, and substation areas. The water will be collected in an open drain header and drained to an oily water sump that is sized for the first flush (i.e., 15 minutes) of rainfall. The first flush of rainfall will be sent to the process WWTP, while subsequent water will be routed directly to the stormwater pond.

The stormwater pond will have a capacity of approximately 13,000 m^3, sized to accommodate non-process area runoff (approximately an average of 430,689 m^3 per year), process area stormwater runoff (i.e., rainwater after the initial 15-minute “first flush”), and treated (i.e., de-oiled) process wastewater (15 m^3 per hour). Water in the stormwater pond will be analyzed to ensure it meets specifications before being discharged to Demerara River either directly or via a canal adjacent to the NGL Plant site.

Based on the configuration described above, an untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent from the WWTP was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted (e.g., because of a high rainfall event or some other prior situation that prevented the stormwater pond contents from being discharged). In this situation, the potential exists that the effluent from the stormwater pond could be discharged to the Demerara River at constituent concentrations above treatment specifications. The key embedded controls that will reduce the likelihood of this situation occurring include the following:

- EEPGL will conduct routine maintenance and monitoring to maintain the performance of the WWTPs.
- The wastewater effluent from the WWTPs will discharge into the stormwater pond, which will contain uncontaminated stormwater runoff. Water in the stormwater pond will be monitored regularly to confirm compliance with discharge standards prior to discharge to the Demerara River.

Another situation that could result in untreated wastewater being released from the NGL Plant could occur if stormwater runoff from process areas overtops the open drainage system, in which case it could flow across unsealed surfaces and some of the water and contaminants could be absorbed by the ground. Water that is not absorbed would continue to flow until it reached a surrounding waterbody or was captured by another drain system at the NGL Plant site.

The key embedded controls that will reduce the likelihood of this situation occurring include the following:

- The open drain system will be sized to accommodate a 100-year rainfall event.
- The NGL Plant site will be graded so as to direct stormwater flow across the site into the stormwater pond.

While the embedded controls noted above would be expected to greatly reduce the likelihood of a release of untreated wastewater from the NGL Plant, the possibility of an extreme rainfall event that could result in either of the referenced scenarios is considered **Possible**.

10.1.6. Onshore Vehicle Accident

The Project will add additional vehicles to the public roadways during the Construction and Operations stages. During the Construction stage, workers will be transported using large-capacity buses, resulting in an estimated additional 30 to 50 round-trip vehicle movements per day at peak construction. During the Operations stage, the number of workers will be significantly reduced, but the estimated additional round-trip vehicle movements could be similar, on the conservative assumption that most employees drive alone to/from the NGL Plant each day.

Based on a baseline traffic study conducted at several intersections along the West Bank of Demerara Public Road in 2021 (see Section 9.4, Transportation), these estimated additional trips represent an incrementally small change with respect to existing traffic conditions in the vicinity of the Project. Nevertheless, the potential for a vehicular accident involving a Project-related vehicle during the Project life cycle is considered **Possible**.

10.1.7. Summary of Unplanned Events Interactions with Resources

Table 10.1-10 indicates which resources would potentially be impacted by the unplanned events considered above. The remainder of this chapter evaluates the risk of each of these potential impacts, considering the likelihood of the event and the potential consequence/severity of the event with respect to resultant impacts on the relevant resources.

Table 10.1-10: Resources Potentially Impacted by Unplanned Events

Resource	Marine or Riverine Fuel Spill	Loss of Integrity of Offshore Pipeline Resulting in Natural Gas Release	Vessel Collision with a Third-Party Vessel, Structure, or Animal (Non-spill Related)				Onshore Hydrocarbon Release		Untreated Wastewater Release at NGL Plant	Vehicular Accident
			Vessel Collision with a Third-Party Vessel or Structure	Marine Mammal Strike by a Project Vessel	Riverine Mammal Strike by a Project Vessel	Marine Turtle Strike by a Project Vessel	Loss of Integrity of Onshore Pipeline Resulting in Hydrocarbon Release	Loss of Integrity of NGL Plant Facilities Resulting in Hydrocarbon Release		
Onshore Geology and Groundwater									X	
Soils									X	
Sediments	X	X							X	
Water Quality	X	X							X	
Sound, Vibration, and Light							X	X		
Air Quality, Climate, and Climate Change	X	X					X	X		
Waste Management	X						X	X		
Protected Areas	X									
Marine and Coastal Biodiversity	X	X		X		X				
Terrestrial Biodiversity							X	X		
Freshwater Biodiversity	X				X				X	
Ecological Balance and Ecosystems	X	X					X	X	X	
Special Status Species	X	X		X	X	X	X	X	X	
Socioeconomic Conditions	X		X				X	X		
Community Health and Wellbeing	X	X					X	X		X
Social Infrastructure and Services	X						X	X		
Transportation	X		X							X
Cultural Heritage	X						X			
Land Use and Ownership	X						X	X		
Landscape and Visual										
Ecosystem Services	X									
Indigenous Peoples	X									

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10.1.8. Claims and Livelihood Remediation Processes

In the unlikely event of an oil spill unplanned event causing losses to stakeholders, EEPGL would establish a claims process and, depending on the nature of the unplanned event, a livelihood remediation program. The purpose of the claims process would be to provide compensation as appropriate for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required), would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the event. Eligible persons would be compensated as appropriate based on the magnitude of Project-related impacts they individually experienced, either in regard to human health or as a result of economic loss.

It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would consider establishing an independent implementation entity as soon as reasonably practicable after the event, to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts may potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support, as defined by the duration of impacts.

10.1.9. Embedded Controls and Mitigation Measures for Unplanned Events

Table 10.1-11 lists the embedded controls and mitigation measures relevant to the unplanned events described above.

Table 10.1-11: List of Embedded Controls and Mitigation Measures for Unplanned Events

Embedded Controls	Related Unplanned Event
Bury offshore pipeline in shallow water depths	Loss of integrity of offshore pipeline
Maintain marine safety exclusion zones to be issued through MARAD with a 500-meter radius around major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Vessel collision with a third-party vessel, marine fuel spill
Use leak detection systems for equipment, treatment, and storage facilities (fuel, chemical, etc.) on Project vessels in accordance with good international industry practice.	Marine or riverine spill
Maintain marine safety exclusion zones to be issued through MARAD with a 2-nautical-mile (approximately 12,150-foot) radius around FPSO, to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Vessel collision with a third-party vessel, marine fuel spill

Embedded Controls	Related Unplanned Event
Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.	Vessel collision with a third-party vessel, marine or riverine fuel spill
Use secondary containment for storage of bulk fuel, where practicable.	Marine fuel spill
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.	Vessel collisions with marine mammals, marine turtles, and riverine mammals
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting marine birds when transiting to and from the offshore pipeline corridor.	Vessel collisions with marine birds
Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters.	Vessel collisions with marine mammals and marine turtles
Require vessels to reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock and vessels also slow to less than 5 knots (9.3 kilometers per hour) and prohibit them from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO and the 500-meter exclusion zone around major installation vessels.	Marine fuel spill
Design the onshore pipeline to a Class 3 location classification under ASME B31.8.	Loss of integrity of onshore pipeline
Install aboveground pipeline markers along the onshore pipeline corridor, indicating the location of the buried pipeline and including standard signage to not excavate in the area prior to contacting EEPGL.	Loss of integrity of onshore pipeline
Install an FOC-based system along the pipeline at the time the pipeline is buried, to detect leaks and/or third-party intrusion the pipeline.	Loss of integrity of onshore pipeline
For the aboveground valve near the shore landing, install anti-cut / anti-climb perimeter fencing around the valve, with fiber optic intrusion detection, 24-hour per day closed-circuit television monitoring of the compound, and security lighting.	Loss of integrity of onshore pipeline
Apply external corrosion coating on the onshore pipeline.	Loss of integrity of onshore pipeline
Install and monitor an impressed current cathodic protection system along the onshore pipeline	Loss of integrity of onshore pipeline
Conduct routine internal inspections for corrosion through the use of pipeline intelligent pigging tools.	Loss of integrity of onshore pipeline
Use industry design standards for construction of Project infrastructure (e.g., appropriate material selection, corrosion protection)	Loss of integrity of offshore pipeline, onshore pipeline or NGL Plant Facilities
Implement mechanical integrity programs as part of routine operations and maintenance.	Loss of integrity of offshore pipeline, onshore pipeline or NGL Plant Facilities
As part of detailed design, complete an Escape, Evacuation, and Rescue Assessment, Dispersion Analysis, Fire and Explosion Hazards Assessment Study	Loss of integrity of offshore pipeline, onshore pipeline or NGL Plant Facilities

Embedded Controls	Related Unplanned Event
Install emergency shutdown systems to enable isolation and blowdown/depressurization of equipment.	Loss of integrity of NGL Plant Facilities
Provide active fire protection, including a pressurized ring main, with sufficient capacity to provide at least 4 hours of continued operation of fire pumps at maximum capacity.	Loss of integrity of NGL Plant Facilities
Install foam deluge systems in areas with potential for hydrocarbon fires.	Loss of integrity of NGL Plant Facilities
Provide overpressure protection for process equipment and piping to relieve excess pressure and safely dispose of hydrocarbons in the flare system.	Loss of integrity of NGL Plant Facilities
Provide structural fire proofing, where necessary, to reduce the risk of equipment and structures collapsing	Loss of integrity of NGL Plant Facilities
Configure spacing and layout of the NGL Plant to minimize the risk of fire and explosion, including consideration of detailed fire and explosion analysis studies and measures to minimize the accumulation and spread of flammable gases and liquids, minimize probability of ignition, and facilitate effective emergency response.	Loss of integrity of NGL Plant Facilities
Adhere to electrical classification of equipment to reduce the likelihood that equipment will ignite flammable gases or liquids	Loss of integrity of NGL Plant Facilities
Strategically place gas, smoke, and fire detection equipment to automatically initiate protection actions to isolate the source of a leak, minimize the possibility of ignition, and activate fire suppression systems and pumps.	Loss of integrity of NGL Plant Facilities
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Vessel collision with a third-party vessel, riverine fuel spill
Design the open drain system to accommodate a 100-year rainfall event	Untreated wastewater release
Grade the NGL Plant site so as to direct stormwater flow across the site into the stormwater pond	Untreated wastewater release
Conduct routine maintenance and monitoring to maintain the performance of the WWTPs	Untreated wastewater release
Discharge WWTP effluents into the stormwater pond, diluting the concentrations of constituents present in the wastewater effluents prior to discharge from the stormwater pond into the Demerara River.	Untreated wastewater release
Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in the Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles;	Vehicular accident

Embedded Controls	Related Unplanned Event
• Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	
Maintain an OSRP to facilitate an effective response to a marine or riverine fuel spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.	Marine or riverine fuel spill
Mitigation Measures	**Related Unplanned Event**
Issue Notices to Mariners to the Trawler’s Association and fishing co-ops via the MARAD for movements of major marine installation vessels to facilitate their avoidance of areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.	Vessel collision with a third-party vessel, marine fuel spill
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.	Vessel collision with a third-party vessel, marine fuel spill
Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.	Vessel collision with a third-party vessel
Implement the OSRP in the unlikely event of a marine or riverine fuel spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate PPE by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	Marine or riverine fuel spill
Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of a marine or riverine fuel spill.	Marine or riverine fuel spill
In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, provide appropriate restitution, consistent with governing contracts and applicable laws.	Vessel collision with a third-party vessel

PPE = personal protective equipment

10.2. Resource-Specific Risk Assessments

10.2.1. Geology and Groundwater

The unplanned events considered would not impact geological resources in Guyana. Accordingly, this section focuses on potential impacts on groundwater resources as a result of the unplanned events described in Section 10.1, Introduction [Unplanned Events]. As indicated in Table 10.1fill-10, the unplanned event with the potential to result in measurable impacts on groundwater includes the following:

- Untreated wastewater release at the NGL Plant

This event could impact groundwater resources primarily as a result of the infiltration of untreated wastewater through surface soils and into the shallow groundwater zone.

10.2.1.1. Untreated Wastewater Release at NGL Plant

The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. Effluents from both WWTPs will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant. An untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond overtops the pond and is released as overland flow across the site. If the water flows across unsealed surfaces, some of the water and contaminants will be absorbed by the ground and could then infiltrate into shallow groundwater. The infiltrating water could include dissolved contaminants such as nitrates, phosphates and other nutrients; metals; hydrocarbons; biodegradable organic matter; and pathogenic microorganisms.

As described in Section 7.1, Geology and Groundwater, the shallow groundwater bearing zone in the Project AOI is comprised of tens of meters of low-permeability silts and clays that comprise the upper geologic stratum in the Project AOI; this zone is not known to be used for groundwater extraction, but groundwater within these low-permeability silts and clays discharges to nearby canals. These silts and clays are underlain by the Upper Sand aquifer of the coastal artesian basin, which also has not historically been utilized extensively, and withdrawals ultimately ceased due to a high iron and salinity content.

The intensity of impact of an untreated wastewater release to groundwater would be a function of the amount of untreated wastewater that overflowed from the stormwater pond and the levels of contaminants within the overflow. It is possible that constituents could infiltrate into soils and increase levels in the shallow water-bearing zone, which could then discharge to canals and potentially contribute to human health impacts, but only over a localized area. Therefore, the intensity of potential impacts on groundwater resources is considered to be **Low**. The impact would be sustained for as long as elevated concentrations were present in canals at a level with potential to contribute to human health impacts, so the frequency is considered **Continuous**.

Advective-dispersive transport and natural attenuation processes would gradually restore conditions of the groundwater following the event; therefore, the duration is considered to be no more than **Medium-term**. For these reasons, the magnitude of this potential impact is rated as **Small**.

Consistent with the sensitivity ratings assigned for potential impacts on groundwater resources, a sensitivity rating of **Medium** is assigned on the basis that affected groundwater resources are a direct source of water discharging to canals that support diverse habitats.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, it is **Possible** that an untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset and—at the same time—the stormwater pond capacity is exhausted to the point that the pond is overtopped and its contents are released to the ground surface. Accordingly, the overall pre-mitigation risk of an untreated wastewater release at the NGL Plant impacting groundwater is considered **Minor** (Table 10.2.1-1).

As described in Section 10.1.8, Embedded Controls and Mitigation Measures for Unplanned Events, the Project has initiated a number of control measures to support the reliable operation of the NGL Plant wastewater system and to reduce the likelihood that the capacity of the stormwater pond is exhausted. In addition, a plan of action will be in place to facilitate a rapid response from the operator in the event of an upset in the wastewater treatment system. With implementation of these control measures, and considering that the shallow water table and low-transmissivity of the surficial soils would limit the rapid absorption of any release of untreated wastewater into the groundwater system, the intensity ratings for potential response/restoration-related impacts on groundwater would remain **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small** for an untreated wastewater release at the NGL Plant. In combination with the likelihood rating of **Possible** for an event, the residual risk to groundwater from this type of unplanned event is considered **Minor** (Table 10.2.1-1).

Table 10.2.1-1: Risk Ratings for Unplanned Event Impacts on Geology and Groundwater

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Untreated Wastewater Release at NGL Plant	Groundwater (shallow groundwater in the low-permeability silts and clays that overly the Upper Sands aquifer)—degradation of water quality	Possible	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.2. Soils

As indicated in Table 10.1-10, the unplanned event with the potential to result in measurable impacts on soils includes the following:

- Untreated wastewater release at the NGL Plant

This event could impact soils primarily as a result of the infiltration of untreated wastewater into surficial soils.

10.2.2.1. Untreated Wastewater Releases at NGL Plant

The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. Effluents from both WWTPs will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant. An untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond overtops the pond and is released as overland flow across the site. If the water flows across unsealed surfaces, some of the water and contaminants will be absorbed by surficial soils. The infiltrating water could include dissolved contaminants such as nitrates, phosphates and other nutrients; metals; hydrocarbons; biodegradable organic matter; and pathogenic microorganisms.

As described in Section 7.2, Soils, the onshore Direct AOI landscape is composed of a variety of soils developed from a variety of parent materials such as marine and fluvio-marine deposits with back-swamp organic soils. These soils are primarily composed of low-permeability clays and silts, and organic matter that is poorly to very poorly drained.

The intensity of impact of an untreated wastewater release to surficial soils would be a function of the amount of untreated wastewater that overflowed from the stormwater pond and the levels of contaminants within the overflow. A release of untreated wastewater to the environment is expected to be localized, likely with low levels of potential contaminants (as this would occur when the stormwater pond is full, likely due to excess uncontaminated stormwater content, which would dilute constituent concentrations). The surficial soils also have a relatively low permeability, so the rate of infiltration and absorption is expected to be low. Considering the intensity definitions in Section 7.2.3.2, Impact Assessment Methodology [Soils], the intensity of potential impacts on soils resources is considered **Low**. The impact would be sustained for as long as elevated concentrations were present in surficial soils at a level with potential to contribute to adverse impacts, so the frequency is considered **Continuous**. Natural attenuation and assimilation/degradation process would gradually restore conditions of the soils following the event; therefore, the duration is considered to be no more than **Medium-term.** For these reasons, the magnitude of this potential impact is rated as **Small**.

Considering the sensitivity definitions in Section 7.2.3.2, Impact Assessment Methodology [Soils], a sensitivity rating of **Low** is assigned on the basis that that effects to surficial soils within the NGL Plant site would result in only a minimal impact on users (as there would be no agricultural or other non-Project uses in the area that would be affected).

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, it is **Possible** that an untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset and—at the same time—the stormwater pond capacity is exhausted to the point that the pond is overtopped and its contents are released to the ground surface. Accordingly, the overall pre-mitigation risk of an untreated wastewater release at the NGL Plant impacting soils is considered **Minor** (see Table 10.2.2-1).

As described in Section 10.1.8, Embedded Controls and Mitigation Measures for Unplanned Events, the Project has initiated a number of control measures to support the reliable operation of the NGL Plant wastewater system and to reduce the likelihood that the capacity of the stormwater pond is exhausted. In addition, a plan of action will be in place to facilitate a rapid response from the operator in the event of an upset in the wastewater treatment system. With implementation of these control measures and considering that the shallow water table and low permeability of the surficial soils would limit the infiltration and absorption of any release of untreated wastewater into the soils, the intensity ratings for potential response/restoration-related impacts on soils would remain **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small** for an untreated wastewater release at the NGL Plant. In combination with the likelihood rating of **Possible** for an event, the residual risk to soils from this type of unplanned event is considered **Minor** (see Table 10.2.2-1).

Table 10.2.2-1: Risk Ratings for Unplanned Event Impacts on Soils

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Untreated Wastewater Release at NGL Plant	Soils (absorption of untreated wastewater containing nutrients and potential contaminants)—degradation of soil quality	Possible	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.3. Sediments

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on sediment quality include the following:

- Marine or riverine fuel spill
- Loss of integrity of offshore pipeline, resulting in a natural gas release
- Untreated wastewater release at the NGL Plant

10.2.3.1. Marine Sediment Quality

Marine Fuel Spills

In the unlikely event of vessel collisions, bunkering accidents, or helicopter ditching, an offshore or coastal spill of fuels and/or lubricating oils could occur. These fuels/oils would not sink or accumulate on the seafloor unless adsorption occurs with sediment; however, it is possible for these materials, once dispersed by wave action, to form droplets that are small enough to be kept in suspension and moved by the currents. The fuel/oil dispersed in the water column and their dissolved components (e.g., hydrocarbons) could adhere to fine-grained suspended sediments, which could then settle out and deposit on the seafloor. This is less likely to occur in open marine settings where the total suspended solids (TSS) concentrations are generally low (less than 10 milligrams per liter [mg/L]), and is not likely to result in measurable sediment contamination for small spills (NOAA 2020). However, based on environmental baseline survey sampling overseen by EEPGL between 2014 and 2019, some areas offshore Guyana have had TSS concentrations on the order of 50 mg/L, and studies in 2021 measured TSS concentrations on average of 70 mg/L within 35 kilometers offshore (see Section 7.4, Water Quality). The intensity of such an impact on marine sediments, if it were to occur, would be considered **Low**. On the basis that impacts would persist for as long as the spill remains unmitigated (although they would reduce significantly with time as the spilled fuel weathers), and because the impacts of an unmitigated fuel spill could—depending on volume of release—continue over more than a week, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Small**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine sediments from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a coastal spill is considered **Unlikely**, so the overall risk to marine sediments from an offshore or coastal fuel/oils spill would be **Minor**.

As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, the Project has several embedded controls in place to facilitate safe operation of marine vessels. A marine safety exclusion zone of 2 nautical miles (3.7 kilometers) will be maintained around the FPSOs during offloading, and a 500-meter radius will be maintained around major installation vessels. Additionally, MARAD will issue notices to mariners regarding locations of major installation vessels. All vessels will be equipped with spill response equipment and resources as specified in the OSRP (Volume III of the EIA). With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing spills (i.e., through the OSRP), the magnitude rating for potential impacts on sediment quality from a marine fuel spill would remain as **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to marine sediment quality from these types of unplanned events is maintained at **Minor** (Table 10.2.3-1).

Loss of Integrity of Offshore Pipeline

The integrity of the offshore pipeline could, in an unlikely event, be compromised to the extent that natural gas could be released to the ocean. This could occur due to corrosion, a strike from a foreign object, or from buildup of stress in the pipe wall causing it to buckle. The released gas from the offshore pipeline would likely generate a gas plume that rises from the seafloor to the sea surface. Potential fire or explosion could occur when the gas disperses into the atmosphere and encounters ignition sources. This could have an adverse impact if the leak occurred in an area in which humans or marine biota were present. However, most of the offshore pipeline is located sufficient far offshore that an atmospheric release would not result in such exposure.

Potential impacts on marine sediment quality from a natural gas release from the offshore pipeline are only expected for the portion of the pipeline that is buried, which is from the shore to approximately 45 kilometers off the coastline. In this shallow area, the pipeline will be buried with a minimum cover of approximately 1.2 meters. The released gas would disturb the sediment, causing the sediment to be re-suspended into the water column, transported and deposited onto the seafloor, where it could potentially accumulate to thicknesses sufficient to create a smothering effect for benthic organisms. The sediment impact would be limited to the sediment around the area of the pipeline that is compromised. Accordingly, the intensity of impacts on marine sediment quality from a loss of integrity of the offshore pipeline is considered **Low**. The impact on marine sediment quality would persist throughout the release (**Continuous**), but only to the point when the sediment around the area of the pipeline that has been compromised has been re-suspended/removed, so the duration is considered to be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine sediment quality from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a loss of integrity of offshore pipeline is considered **Unlikely**, so the overall risk to marine sediment would be **Minor**.

As described in Section 10.1.2, Loss of Integrity of Offshore Pipeline Resulting in Natural Gas Release, the Project will implement varying design and installation approaches depending on the pipeline depth. The pipeline will be buried in nearshore areas to reduce the potential for third-party strikes. Emergency shutdown valves will facilitate quick isolation of the pipeline in the event of an inventory loss. With implementation of these measures, the intensity ratings for potential response-related impacts on marine water quality from an offshore natural gas release from the pipeline would remain **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to marine water quality from these types of unplanned events is considered **Minor** (see Table 10.2.3-1).

Table 10.2.3-1: Risk Ratings for Unplanned Event Impacts on Marine Sediment Quality

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Fuel Spill	Marine Sediment Quality	Unlikely	Small	Minor	Implement OSRP in the event of a spill	Minor
Loss of Integrity of Offshore Pipeline	Marine Sediment	Unlikely	Small	Minor	None	Minor

10.2.3.2. Riverine Sediment Quality

Riverine Fuel Spills

In the unlikely event of a vessel collision between support vessels and third-party vessels / structures in the Georgetown Harbour / Demerara River area or nearshore grounding of a vessel, a riverine spill of fuels could occur. Similar to the marine environment, these fuels/oils would not sink or accumulate on the riverbed sediment unless adsorption occurs with sediment; however, it is possible for these materials, once dispersed by wave action, to form droplets that are small enough to be kept in suspension and moved by the currents. The fuel/oil dispersed in the water column and their dissolved components (e.g., hydrocarbons) can adhere to fine-grained suspended sediments, which can then settle out and deposit on the riverbed. Accordingly, the proportion of the spill that adheres to suspended sediments and settles on the riverbed can accumulate and result in temporary changes to sediment quality. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation.

Potential impacts on sediment quality from a riverine spill of fuels/oils are thus related to the TSS concentrations in the water column and the dissolved hydrocarbons (primarily monocyclic and polycyclic aromatic hydrocarbons) that could adsorb onto the solids. The TSS concentrations in the water column in the Demerara River are variable, with higher TSS concentrations in the wet season. In the 2021 to 2022 sampling, river TSS values ranged from around 15 to 700 mg/L (see Section 7.4, Water Quality). Persistence of contamination in the water column from an unplanned spill of fuels or lubricating oils would most likely be short-term in nature. The dissolved hydrocarbons are mostly light aromatics, and these concentrations can rapidly decline after a spill and are usually confined to an area near the origin of the spill (ITOPF 2014). Riverine fuel spill modeling performed in support of the EIA and the OSRP (see Section 10.1, Introduction [Unplanned Events], and the OSRP in Volume III of the EIA) shows that a fuel spill could extend upstream and downstream of the spill location. Based on these results, the intensity of impacts on sediment quality from a riverine fuel spill could be **Negligible** to **Low**. The impact on riverine sediment quality would persist as long as fuel constituents are present in the water column, so the frequency is considered to be **Continuous**. The hydrocarbons are expected to undergo many weathering and degradation processes once in the water column, so duration is considered to be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Negligible** to **Small.** Using the definitions for sensitivity rating presented in the assessment of potential impacts on riverine sediment from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a riverine spill is considered **Unlikely**, so the overall risk to riverine sediments from a riverine fuel spill would be **Minor**.

As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, the Project has several embedded controls in place to facilitate safe operation of vessels in the riverine environment. Vessels will observe local navigation procedures in and around the Georgetown Harbour and Demerara River and maintain safe distances. Additionally, Project-contracted vessels will reduce their speed to 5 knots (9.3 kilometers per hour) when in the Demerara River awaiting berth space to dock. With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing spills (i.e., through the OSRP), the magnitude ratings for potential impacts on water quality from a riverine fuel spill would likely be reduced to **Negligible**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to riverine sediment quality from these types of unplanned events is rated as **Minor** (Table 10.2.3-2).

Untreated Wastewater Release in the Demerara River

The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. Effluents from both WWTPs will be routed to the stormwater pond prior to analysis and discharge to the Demerara River potentially via a canal adjacent to the NGL Plant or directly into the river. An untreated wastewater release from the NGL Plant to the river could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond are released to the river.

Impacts on river sediment quality from untreated wastewater are difficult to predict and depend on the particulate component in the wastewater and the specific constituents in the discharge. The particulate component could be of sufficient size to settle onto the riverbed. If untreated wastewater continues to be discharged over time, a gradual buildup of these solids could occur and accumulate on the river bottom in localized areas. Similarly, the dissolved components could partition to particulate material in the water column, which could settle and accumulate on the river bottom in localized areas. On this basis, the intensity of impacts on riverine sediment quality from an unplanned wastewater release from the NGL Plant would be expected to range from **Negligible** to **Low**. On the basis that impacts would persist for as long as the treatment plant continues to not operate properly and the discharge continues, the frequency and duration are considered to be **Continuous**. The treatment plant operations would likely be corrected in a short period of time, but the duration is conservatively rated as **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Negligible** to **Small**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on riverine sediment from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, an unplanned release of wastewater from the NGL Plant is considered **Possible**, so the overall risk to riverine sediment from an offshore or coastal fuel/oils spill would be **Minor**.

As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, the Project has several embedded controls to reduce likelihood of untreated wastewater release. EEPGL will conduct routine maintenance and monitoring to maintain WWTP performance. With implementation of these embedded controls, the magnitude ratings for potential impacts on sediment quality from an untreated wastewater release would likely remain at **Negligible** to **Small**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Possible**, the residual risk to riverine sediment quality from an unplanned release of untreated wastewater from the NGL Plant is considered **Minor** (see Table 10.2.3-2).

Table 10.2.3-2: Risk Ratings for Unplanned Event Impacts on Riverine Sediment Quality

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Riverine Fuel Spill	Riverine Sediment Quality	Unlikely	Small	Minor	Implement OSRP in the event of a spill	Minor
Untreated Wastewater Release	Riverine Sediment Quality	Possible	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.4. Water Quality

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on water quality include the following:

- Marine or riverine fuel spill
- Loss of integrity of offshore pipeline, resulting in a natural gas release
- Untreated wastewater release at the NGL Plant

10.2.4.1. Marine Water Quality

Marine Fuel Spills

In the unlikely event of vessel collisions, bunkering accidents, or helicopter ditching, an offshore or coastal spill of fuels and/or lubricating oils could occur. Once spilled to the environment, these materials will undergo weathering processes, resulting in their partitioning into different phases (e.g., evaporated, entrained in water column) while at the same time experiencing dilution. Some of the spilled material would be removed from the water column entirely via evaporation. Additionally, transformation processes such as biodegradation and photo-oxidation would gradually reduce hydrocarbon concentrations in the marine environment following a spill. The proportion of the spill that mixes through the water column due to wave energy would be subject to rapid, high levels of dilution. Some light-weight constituents, especially aromatics, are soluble in water. The proportion of the spill that mixes through the water could therefore increase hydrocarbon concentrations in the water column and result in temporary changes to water quality.

Potential impacts on water quality from a marine spill of fuels or lubricating oils are thus related to contamination within the water column from dissolved hydrocarbon concentrations (primarily monocyclic and polycyclic aromatic hydrocarbons). Contamination in the water column from an unplanned spill of fuels or lubricating oils would most likely persist for a relatively short time. The constituents are mostly light aromatics; these concentrations can rapidly decline after a spill and are usually confined to an area near the origin of the spill (ITOPF 2014). Marine fuel spill modeling performed in support of the OSRP (Volume III of the EIA) shows the modeled extent of marine fuel spills for two spill-size scenarios during multiple seasons. Based on these results, the intensity of impacts on water quality from a marine fuel spill could be as much as **High**. The impact on marine water quality would persist as long as the fuel spill is present in the water, so the frequency is considered to be **Continuous**. The hydrocarbons are expected to undergo many weathering and degradation processes once in the water column, so duration of the impact is considered to be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium.** Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine water from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine spill is considered **Unlikely**, so the overall risk to marine waters from a marine fuel spill is rated as **Minor**.

As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, the Project has several embedded controls in place to facilitate safe operation of marine vessels. A marine safety exclusion zone of 2 nautical miles (3.7 kilometers) will be maintained around the FPSOs, and a 500-meter radius will be maintained around major installation vessels. Additionally, MARAD will issue notices to mariners regarding locations of major installation vessels. All vessels will be equipped with spill response equipment and resources as specified in the OSRP. With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing spills (i.e., through the OSRP), the magnitude rating for potential impacts on water quality from a marine fuel spill would likely be reduced to **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to marine water quality from these types of unplanned events is maintained at **Minor** (Table 10.2.4-1).

Loss of Integrity of Offshore Pipeline

The integrity of the offshore pipeline could, in an unlikely event, be compromised to the extent that natural gas was released to the ocean. This could occur due to corrosion, a strike from a foreign object, or from buildup of stress in the pipe wall causing it to buckle. The released gas from the offshore pipeline would likely generate a gas plume that rises from the seafloor to the sea surface.

Potential impacts on water quality from a natural gas release are not expected beyond the disturbance of the water column due to the released gas bubbles. The area impacted by these bubbles would be directly proportional to the depth of the water (shallow regions will result in a smaller area of disturbance, as the gas would surface quicker). Accordingly, the intensity of impacts on marine water quality from a loss of integrity of the offshore pipeline is considered **Low**. The impact on marine water quality would persist throughout the release (**Continuous**), but only to the point when the gas has escaped into the atmosphere. The natural gas is expected to rise rapidly through the water column, so the duration is considered to be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Negligible**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on marine water from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a loss of integrity of offshore pipeline is considered **Unlikely**, so the overall risk to marine waters would be **Minor**. As described in Section 10.1.2, Loss of Integrity of Offshore Pipeline Resulting in Natural Gas Release, the Project will implement varying design and installation approaches depending on the pipeline depth. The pipeline will be buried in nearshore areas to reduce the potential for third-party strikes. Emergency shutdown valves will facilitate quick isolation of the pipeline in the event of an inventory loss. With implementation of these measures, the intensity ratings for potential response-related impacts on marine water quality from an offshore natural gas release from the pipeline would remain **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to marine water quality from these types of unplanned events is considered **Minor** (see Table 10.2.4-1).

Table 10.2.4-1: Risk Ratings for Unplanned Event Impacts on Marine Water Quality

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine Fuel Spill	Marine Water Quality	Unlikely	Small	Minor	Implement OSRP in the event of a spill	Minor
Loss of Integrity of Offshore Pipeline	Marine Water Quality	Unlikely	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.4.2. Riverine Water Quality

Riverine Fuel Spills

In the unlikely event of vessel collisions between support vessels and third-party vessels/ structures in the Georgetown Harbour / Demerara River area or nearshore grounding of a vessel, a riverine spill of fuels could occur. Similar to the marine environment, a release of these types of hydrocarbons in the riverine environment would undergo weathering processes resulting in their partitioning into different phases (e.g., evaporation, entrainment in water column), while at the same time experiencing dilution. Some of the spilled material would be removed from the water column completely via evaporation. Additionally, transformation processes such as biodegradation and photo-oxidation would gradually reduce hydrocarbon concentrations following a spill. The proportion of the spill that mixes through the water column due to tidal energy would be subject to rapid, high levels of dilution along with this biodegradation. Some lightweight constituents, especially aromatics, are also soluble in water. Accordingly, the proportion of the spill that mixes through the water could increase hydrocarbon concentrations in the water column and result in temporary changes to water quality. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation.

Potential impacts on water quality from a riverine spill of fuels/oils are thus related to contamination within the water column from dissolved hydrocarbon concentrations (primarily monocyclic and polycyclic aromatic hydrocarbons). Contamination in the water column from an unplanned spill of fuels or lubricating oils would most likely be short-term in nature. The constituents are mostly light aromatics, and these concentrations can rapidly decline after a spill and are usually confined to an area near the origin of the spill (ITOPF 2014). Riverine fuel spill modeling performed in support of the EIA and the OSRP (see Section 10.1, Introduction, and the OSRP in Volume III of the EIA) shows the extent of two modeled fuel spill scenarios: one at the temporary MOF and one at the Demerara Harbour Bridge. Based on these results, the intensity of impacts on water quality from a riverine fuel spill could be as much as **High**. The impact on riverine water quality would persist as long as dissolved phase constituent concentrations are present in the water column at levels of potential concern, so the frequency is considered to be **Continuous**. The hydrocarbons are expected to undergo many weathering and degradation processes once in the water column, so duration is considered to be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium.** Using the definitions for sensitivity rating presented in the assessment of potential impacts on riverine water from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a riverine spill is considered **Unlikely**, so the overall risk to riverine waters from a riverine fuel spill would be **Minor**.

As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, the Project has several embedded controls in place to facilitate safe operation of vessels in the riverine environment. Vessels will observe local navigation procedures in and around the Georgetown Harbour and Demerara River and maintain safe distances. Additionally, project contracted vessels will reduce their speed to 5 knots (9.3 kilometers per hour) when in the Demerara River. With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing spills (i.e., through the OSRP), the magnitude ratings for potential impacts on water quality from a riverine fuel spill would likely be reduced to **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to riverine water quality from these types of unplanned events is rated as **Minor** (Table 10.2.4-2).

Untreated Wastewater Release in the Demerara River

The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. Effluents from both WWTPs will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant. An untreated wastewater release from the NGL Plant to the river could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond are released to the river.

Impacts on river water quality from untreated wastewater are difficult to predict and depend on several factors such as the specific constituents in the discharge, the concentrations of the constituents in the discharge, the dilution achieved once discharged in the river, and the biological and physical processes that affect the constituents. The primary constituents in the wastewater effluents will include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), metals, oil and grease, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform. Modeling results predicted that the NGL Plant wastewater effluent, when discharged into the river, will experience a dilution factor within 100 meters of the discharge ranging from 154 to 2,475 in the dry and wet seasons, respectively (Section 7.4.3, Impact Prediction and Assessment [Water Quality]). Further, the situation that would result in discharge from the stormwater pond being unavoidable would likely coincide with the presence of a significant volume of (uncontaminated) stormwater in the stormwater pond; this would inherently dilute the wastewater effluent before it was released from the stormwater pond. On this basis, the intensity of impacts on riverine water quality from an unplanned wastewater release from the NGL Plant would be expected to range from **Negligible** to **Low**. On the basis that impacts would persist for as long as the treatment plant continues to not operate properly and the discharge continues, the frequency and duration are considered to be **Continuous**. The treatment plant operations would likely be corrected in a short period of time, but the duration is conservatively rated as **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Negligible** to **Small**. Using the definitions for sensitivity rating presented in the assessment of potential impacts on riverine water from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, an unplanned release of wastewater from the NGL Plant is considered **Possible**, so the overall risk to riverine water from an offshore or coastal fuel/oils spill would be **Minor**.

As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, the Project has several embedded controls to reduce likelihood of untreated wastewater release. EEPGL will conduct routine maintenance and monitoring to maintain WWTP performance. Additionally, wastewater will be first released to the stormwater pond, which will contain uncontaminated stormwater runoff, resulting in dilution. With implementation of these embedded controls, the intensity ratings for potential impacts on water quality from an untreated wastewater release would likely remain at **Negligible** to **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small**. In combination with the likelihood rating of **Unlikely**, the residual risk to riverine water quality from an unplanned release of untreated wastewater from the NGL Plant is considered **Minor** (see Table 10.2.4-2).

Table 10.2.4-2: Risk Ratings for Unplanned Event Impacts on Riverine Water Quality

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Riverine Fuel Spill	Riverine Water Quality	Unlikely	Small	Minor	Implement OSRP in the event of a spill	Minor
Untreated Wastewater Release	Riverine Water Quality	Possible	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.5. Sound and Vibration

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on sound and vibration include the following:

- Onshore hydrocarbon release (loss of integrity of onshore pipeline or NGL Plant facilities)

10.2.5.1. Onshore Hydrocarbon Release (Loss of Integrity of Onshore Pipeline or Natural Gas Liquids Processing Plant Facilities)

As discussed in Section 10.1.4.1, Loss of Integrity of Onshore Pipeline, an onshore hydrocarbon release as a result of loss of onshore pipeline integrity could result in a flammable gas cloud igniting, causing either a flash fire or explosion. The extent of sound and vibration impacts from such an event would be a function of the nature and location of the explosion or release. Preliminary consequence modeling indicates that the extent of a flammable gas cloud in the case of a full-bore rupture of the onshore pipeline would be up to 1 kilometer from the release point (Figure 10.1-14). If the flammable gas cloud were to ignite and result in an explosion, the resulting explosion could have a significant sound- and vibration-related impact.

The nature and extent of a sound and vibration impact resulting from an explosion stemming from a loss of integrity of the onshore pipeline has not been modeled. However, while the intensity of such an impact would be location-dependent, it could be **High** in the worst-case scenario, where the release occurred along a segment of the onshore pipeline corridor near residences.

If a hydrocarbon release were to occur as a result of a loss of integrity at the NGL Plant, this could also result in a flammable cloud igniting and causing an explosion. Additionally, a BLEVE could be caused if the contents of a pressurized storage tank at the NGL Plant were heated by an external heat source such as a fire. In this situation, the contents of the tank can start to boil, thereby increasing the pressure inside the tank until it exceeds the tank's design pressure, which can ultimately result in a vessel failure. At the point of failure, the tank can explode, creating an overpressure[6]. Based on consequence modeling of the overpressure resulting from a BLEVE, the distance to an overpressure of 0.3 pounds per square inch (psi) (corresponding to a distance with a 95 percent probability of no serious property damage, but with some potential damage to house ceiling and window glass broken) is less than 1 kilometer from the NGL Plant boundary.

The closest known structure is over 2 kilometers from the center of the NGL Plant site. This is over twice the distance to the lower threshold limit for a BLEVE described above. While the nature and extent of a sound and vibration impact resulting from a flammable cloud explosion at the NGL Plant has not been modeled, it is likely that the sound- and vibration-related impacts would be similar in nature to a BLEVE. Considering that no houses or populated areas are within close proximity, based on preliminary consequence modeling, the intensity of sound- or

[6] Overpressure is the pressure caused by the shockwaves of an explosion.

vibration-related impacts resulting from a BLEVE or flammable cloud resulting in an explosion at the NGL Plant, which is not location-dependent, is rated as **Low**.

On the basis that the sound or vibration impact resulting from a loss of onshore pipeline or NGL Plant integrity would persist until the cessation of the resulting consequence (e.g., the explosion), the frequency is considered **Continuous**. The sound or vibration impact would be instantaneous, so the duration is considered **Short-term**. This results in a magnitude rating of **Medium** for a loss of onshore pipeline integrity, depending on the location where the loss of integrity occurred, and **Small** for a loss of integrity at the NGL Plant.

With respect to receptor sensitivity to sound or vibration impacts, the rating assigned for potential impacts on community health and wellbeing for receptors within the Direct AOI (Section 9.2.3.4, Sensitivity of Receptors—Community Health and Wellbeing) is adopted for the purpose of this assessment. Based on the sensitivity rating definitions in Table 9.2-8, the resource sensitivity for physical determinants of health, including mental and physical health as a result of acute noise/vibration impacts from this type of unplanned event, is considered **High**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Large** for a loss of onshore pipeline integrity resulting in an explosion and **Medium** for a loss of integrity of the NGL Plant resulting in an explosion. As described in Section 10.1.4, Onshore Hydrocarbon Release, a loss of onshore pipeline integrity or NGL Plant integrity are both considered **Unlikely** based on a series of embedded controls that would be in place. Accordingly, the overall pre-mitigation risk related to sound and vibration in the Direct AOI as a result of a loss of onshore pipeline integrity is considered **Moderate**, and the pre-mitigation risk as a result of a loss of integrity of the NGL Plant is considered **Minor** (Table 10.2.5-1).

A number of embedded controls are in place to reduce the likelihood of an onshore hydrocarbon release. However, there are no reasonable mitigations that would reduce the residual risk rating for sound and vibration impacts if such an event were to occur. Accordingly, the residual risk rating remains at **Minor** to **Moderate**.

Table 10.2.5-1: Risk Ratings for Unplanned Event Impacts on Sound and Vibration

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Loss of Integrity of Onshore Pipeline, Resulting in Hydrocarbon Release	Individuals and communities along the onshore pipeline corridor, within closer proximity of the incident (location-dependent)	Unlikely	Large [b]	Moderate	Implement Emergency Response Plan in the event of a fire	Moderate
Loss of Integrity of NGL Plant, Resulting in Hydrocarbon Release	Individuals and communities in the vicinity of the NGL Plant	Unlikely	Medium	Minor	Implement Emergency Response Plan in the event of a fire	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur

[b] Consequence/severity rating applies to the worst-case situation where a loss of integrity of the onshore pipeline resulting in an explosion occurs along a segment of the onshore pipeline within close proximity to residential areas.

10.2.6. Air Quality, Climate, and Climate Change

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on air quality, climate, and climate change include the following:

- Marine or riverine fuel spill
- Loss of integrity of offshore pipeline, resulting in natural gas release
- Onshore hydrocarbon release (from loss of integrity of onshore pipeline or NGL Plant facilities)

Reasonable estimates for non-routine flaring emissions, while not planned to occur, have been assessed and are discussed in Section 7.6, Air Quality, Climate, and Climate Change.

10.2.6.1. Marine or Riverine Fuel Spill

Air Quality

In the case of a fuel spill, the potential for harmful concentrations of air contaminants to reach onshore areas (where potential receptors could be located) would be higher for a riverine fuel spill and a marine fuel spill that occurred closer to shore (based on the assumed closer proximity of the spill to onshore receptors). However, the spill volume (and thus affected surface area) would be relatively low. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. Elevated concentrations of air contaminants in areas with human receptors would be localized to the nearshore area alongside the spilled fuel.

Balancing the proximity of a nearshore marine fuel spill or a riverine fuel spill to receptors with the limited volume of such a spill, the intensity of potential impacts on onshore Guyana air quality from an unmitigated marine (nearshore) or riverine fuel spill could be as much as **Medium**. On the basis that air quality impacts would persist for as long as the spilled fuel is continuing to volatilize to the atmosphere, the frequency is rated as **Continuous**. Modeling indicates that the mass fraction volatilized to the atmosphere levels off within approximately two days of the spill, so the duration is considered **Short-term**. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

As noted in the discussion of potential air quality impacts from planned activities, the sensitivity of most onshore receptors to atmospheric emissions is considered **Medium**, with the potential for some receptors to have a **High** sensitivity. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Small** to **Medium**.

In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall pre-mitigation risk to onshore Guyana air quality from an unmitigated marine or riverine fuel spill would be **Minor** (Table 10.2.6-1).

Effective implementation of the OSRP (Volume III of the EIA) could reduce the duration over which the spill would be present on the water surface. As such, this would be expected to reduce the intensity of the impact of a mitigated fuel spill in the Demerara River to the range of **Negligible** to **Low** (depending on the size of the spill). This leads to a magnitude rating of **Negligible** to **Small**, reducing the consequence/severity rating to a range of **Low** to **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal fuel spill, the overall residual risk to onshore Guyana air quality from an unmitigated coastal fuel spill would be **Minor** (Table 10.2.6-1).

Climate and Climate Change

Potential risk to climate from a coastal fuel spill would stem from a potential indirect impact associated with additional fossil fuel combustion by response vessels and fuel-fired equipment, resulting in increased greenhouse gas (GHG) emissions. However, the scale of these additional GHG emissions would be limited in magnitude and time, leading to a consequence/severity rating with respect to impacts on climate and climate change of **Small**. In combination with a likelihood rating of **Unlikely** for a marine or coastal fuel spill, the overall risk to climate and climate change from a coastal fuel spill would be **Minor** (Table 10.2.6-1).

10.2.6.2. Loss of Integrity of Offshore Pipeline, Resulting in Natural Gas Release

Air Quality

Potential impacts on air quality as a result of a natural gas release resulting from a loss of integrity of the offshore pipeline would be limited to combustion emissions from vessels conducting repair activities (the material emitted to the atmosphere from the release itself would be comprised principally of methane, with insignificant quantities of criteria pollutants). This intensity of this impact would be **Negligible.** The limited air quality impacts would persist for as long as repair activities continued (**Continuous**). This would likely be completed within a year (**Medium-term**). Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

As noted in the discussion of potential air quality impacts from planned activities, the sensitivity of most onshore receptors to atmospheric emissions is considered **Medium**, with the potential for some receptors to have a **High** sensitivity. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Small**.

In combination with a likelihood rating of **Unlikely** for a loss of integrity of the offshore pipeline, the overall pre-mitigation risk to onshore Guyana air quality from this event would be **Minor** (Table 10.2.6-1).

Climate and Climate Change

Potential impacts on climate and climate change as a result of a natural gas release resulting from a loss of integrity of the offshore pipeline would stem from combustion emissions from vessels conducting repair activities, as well as the loss to the atmosphere of the inventory of natural gas in the pipeline. In the event of a loss of integrity to the offshore pipeline, the flow of gas would be automatically sealed between the NGL Plant and the FPSO. Assuming a full-bore rupture, natural gas that would be lost to the atmosphere would be on the order of 2.5 kilotonnes of methane. This equates to approximately 62 kilotonnes of carbon dioxide equivalent (CO_2e). On the basis that this represents an approximately 1.3 percent increase in the most recently reported annual emissions for Guyana (4,671 kilotonnes; see Section 7.6, Air Quality, Climate, and Climate Change), the consequence/severity of this event is rated as **Small**. In combination with a likelihood rating of **Unlikely** for a loss of integrity of the offshore pipeline, the overall risk to climate and climate change would be **Minor** (Table 10.2.6-1). A number of embedded controls are in place to reduce the likelihood of an offshore hydrocarbon release and respond in the case of such a release. However, there are no reasonable mitigations that can reduce the residual risk rating if such an event were to affect community receptors. Accordingly, the residual risk rating is maintained at **Minor**.

10.2.6.3. Onshore Hydrocarbon Release (Loss of Integrity of Onshore Pipeline or Natural Gas Liquids Processing Plant Facilities)

Air Quality

Potential impacts on air quality as a result of a hydrocarbon release resulting from a loss of integrity of the onshore pipeline or NGL Plant would, assuming the event resulted in a fire or explosion, stem from emissions related to the resulting fire combusting both natural resources and any affected anthropogenic structures. Impacts could also result from emissions related to combustion of fuel by mobile equipment used for emergency response, cleanup, and restoration. If the hydrocarbon release did not result in a fire or explosion, emissions would—with the exception of the potential for flaring at the NGL Plant as a result of the release[7]—be limited to those related to combustion of fuel by mobile equipment used for repair of the compromised infrastructure.

The extent of the impact on air quality (in terms of potential impacts on human receptors) would be a function of the nature and location of the explosion or release. If this type of unplanned event were to occur along a portion of the onshore pipeline segment where no population resides, the intensity could be **Low**, as elevated pollutant concentrations in ambient air would be less likely to affect human receptors. However, in more heavily populated areas along the onshore pipeline corridor (e.g., Lust-en-Rust / Westminister), the incident could, in a worst-case scenario, result in structure fires and/or could expose community receptors to elevated pollutant concentrations in ambient air. Therefore, while the intensity of potential air quality impacts from an onshore hydrocarbon release due to loss of onshore pipeline integrity is location-dependent, it could be **High** in a worst-case scenario.

[7] Section 7.6, Air Quality, Climate, and Climate Change, presents the results of an assessment of potential impacts on air quality as a result of non-routine flaring, including an event that involves a full blowdown to flare of the pipeline and NGL facilities.

Considering no houses or populated areas are within approximately 2 kilometers of the NGL Plant, a fire resulting from a loss of integrity at the NGL Plant has a lower possibility of resulting in air quality impacts that could affect community receptors. However, if the fire was significant enough to ignite natural sources outside of the NGL Plant, it could spread to areas in closer proximity to residential structures. Therefore, the intensity of potential air quality impacts from an onshore hydrocarbon release due to a loss of NGL Plant could also be **High** in a worst-case scenario.

On the basis that the impact on air quality resulting from a loss of onshore pipeline or NGL Plant integrity that resulted in a fire would persist until the fire was extinguished, the frequency is considered **Continuous**. The fire would likely be extinguished in a short time period (**Short-term**). This results in a magnitude rating of **Small** to **Medium** for a loss of onshore pipeline or NGL Plant integrity resulting in a fire, depending on the location where the loss of integrity occurred (in the case of the pipeline) and the area over which the fire spreads prior to being extinguished.

Consistent with the sensitivity ratings assigned for potential impacts on air quality for receptors within the Direct AOI, the sensitivity of most onshore community receptors is considered **Medium**, with the potential for some more sensitive receptors to have a **High** sensitivity.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small** to **Large**. As described in Section 10.1.4, Onshore Hydrocarbon Release, a loss of onshore pipeline integrity or NGL Plant integrity are considered **Unlikely** based on a series of embedded controls that would be in place. Accordingly, the overall pre-mitigation risk to community health and safety in the Direct AOI as a result of a loss of onshore pipeline integrity is considered **Minor** to **Moderate** (Table 10.2.6-1).

A number of embedded controls are in place to reduce the likelihood of an onshore hydrocarbon release and respond in the case of such a release. However, there are no reasonable mitigations that can reduce the residual risk rating if such an event were to affect community receptors. Accordingly, the residual risk rating remains **Minor** to **Moderate**.

Climate and Climate Change

Potential impacts on climate and climate change as a result of a hydrocarbon release resulting from a loss of integrity of the onshore pipeline or NGL Plant would—with the exception of the potential for flaring at the NGL Plant as a result of the release[8]—and assuming the event resulted in a fire or explosion, stem from GHG emissions related to the resulting fire combusting both natural resources and any affected anthropogenic structures. Impacts could also result from emissions related to combustion of fuel by mobile equipment used for emergency response, cleanup, and restoration. If the hydrocarbon release did not result in a fire or explosion, emissions would stem from combustion of fuel by mobile equipment used for repair

[8] Section 7.6, Air Quality, Climate, and Climate Change, presents the results of an assessment of potential impacts on air quality as a result of non-routine flaring, including an event that involves a full blowdown to flare of the pipeline and NGL facilities.

of the compromised infrastructure, as well as the loss to the atmosphere of the inventory of natural gas in the pipeline.

The level of GHG emissions associated with a fire, response to the fire, and restoration would be a function of the nature of the fire and the severity of any natural resource or structure damage. However, the level of GHG emissions would not likely be significant in terms of an incremental increase in existing annual GHG emissions. Accordingly, the consequence/severity of climate and climate change impacts for this scenario is rated **Small**.

With respect to a loss of natural gas to the atmosphere, in the event of a loss of integrity to the onshore pipeline, the flow of gas would be automatically sealed between the NGL Plant and the FPSO. Assuming a full-bore rupture, natural gas that would be lost to the atmosphere would be on the order of 2.5 kilotonnes of methane. This equates to approximately 62 kilotonnes of CO_2e. On the basis that this represents an approximately 1.3 percent increase in the most recently reported annual emissions for Guyana (4,671 kilotonnes; see Section 7.6, Air Quality, Climate, and Climate Change), the consequence/severity of climate and climate change impacts for this scenario is rated as **Small**. In combination with a likelihood rating of **Unlikely** for an onshore hydrocarbon release, the overall risk to climate and climate change would be **Minor** (Table 10.2.6-1).A number of embedded controls are in place to reduce the likelihood of an onshore hydrocarbon release and response in the case of such a release. However, there are no reasonable mitigations that can reduce the residual risk rating if such an event were to affect community receptors. Accordingly, the residual risk rating is maintained at **Minor**.

Table 10.2.6-1: Risk Ratings for Unplanned Event Impacts on Air Quality, Climate, and Climate Change

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine or Riverine Fuel Spill	Air Quality—individuals, communities within the Direct AOI (related to spill response)	Unlikely	Small to Medium	Minor	None	Minor
	Climate and Climate Change—related to spill response	Unlikely	Small	Minor	None	Minor
Loss of Integrity of Offshore Pipeline, Resulting in Natural Gas Release	Air Quality—individuals, communities within the Direct AOI (related to pipeline repair activities)	Unlikely	Small	Minor	Emergency Response Plan	Minor
	Climate and Climate Change—related to venting of natural gas to atmosphere	Unlikely	Small	Minor	Emergency Response Plan	Minor
Onshore Hydrocarbon Release Loss of Integrity of Onshore Pipeline or NGL Plant Facilities)	Air Quality—individuals, communities within proximity to emissions from resulting fire, if one occurs (location-dependent)	Unlikely	Small to Large	Minor to Moderate	Emergency Response Plan	Minor to Moderate
	Climate and Climate Change—related to emissions from response/restoration equipment and/or venting of natural gas to atmosphere	Unlikely	Small	Minor	Emergency Response Plan	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.7. Waste Management Infrastructure Capacity

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on waste management infrastructure capacity include the following:

- Marine or riverine fuel spill
- Onshore hydrocarbon release (including a loss of integrity of onshore pipeline or a loss of integrity of NGL Plant facilities)

These events could impact waste management infrastructure capacity primarily as a result of emergency response and/or restoration efforts related to the above unplanned events. As the nature of the potential impact on this resource would be similar for these two types of unplanned events, the risk ratings are discussed together.

10.2.7.1. Marine or Riverine Fuel Spill or Onshore Hydrocarbon Release

In the unlikely event of a marine or riverine spill, the following types of wastes could be generated:

- Recovered hydrocarbons
- Oily water mixed with recovered hydrocarbons
- Sorbent materials
- Oiled containment booms
- Oiled personal protective equipment
- Oiled soil or sediment
- Oiled vegetation
- Oiled debris
- Deceased wildlife

In the unlikely event of an onshore hydrocarbon release as a result of a loss of integrity of the onshore pipeline or NGL Plant facilities, the dominant waste generated as a result of the event would likely be non-hazardous debris (e.g., damaged piping or process equipment). However, the event could also generate hazardous waste in the form of contaminated soils (e.g., if the event resulted in a loss of integrity to a natural gas liquids (NGL) storage tank and a release of its contents to the ground surface).

All waste generated as a result of spill response activities would be managed in accordance with EEPGL's countrywide Comprehensive Waste Management Plan (CWMP) and OSRP (both provided in Volume III of the EIA) and Guyana laws and local regulations. Depending on the size of the fuel spill, an incident-specific waste management plan (to complement the CWMP) may be developed as part of the response. Further, the CWMP may be adapted as required if a spill is likely to produce more waste than can be handled by EEPGL's established waste contractors.

As described in Section 7.7, Waste Management Infrastructure Capacity, the capacity of Guyana-based facilities to treat hazardous wastes has been expanding significantly over recent years, and the suite of facilities that will be in place by the time the Project is under development will have (and to a large extent already has) the technologies and capacity to treat the bulk of the wastes that would be generated in a spill response.

Non-hazardous solid wastes from EEPGL's operations that are not recyclable and residuals from solid wastes treated by existing and planned Guyana hazardous waste treatment facilities are currently disposed at the Haags Bosch Landfill (HBL). The HBL would also be used for the disposal of the treated residues and other non-hazardous wastes that would be expected to be generated during a spill response.

As discussed in Section 7.7, Waste Management Infrastructure Capacity, a May 2019 capacity assessment indicated that, without modifications, the Guyana-based hazardous waste management capacity would likely be unable to keep up with treating the increased volume of EEPGL's hazardous solids and waste oil liquids anticipated to be generated by future EEPGL activities. Since the May 2019 capacity assessment, there has been significant expansion of third-party commercial hazardous waste handling, storage, and treatment facilities in Georgetown. This has included the addition of a pug mill (for waste stabilization), an additional thermal treatment unit, and a wash bay with pre-/post-treated water storage (for waste treatment) at the Tiger Rentals Guyana Inc.(TRG) facility. Construction is continuing at the TRG facility to add a further 318,000-liter treated water storage tank, additional thermal treatment capacity, additional pug mill facilities, and storage for post-treatment solids. Additionally, Sustainable Environmental Solutions Guyana, Inc. has developed an integrated waste management facility that became operational in 2021. The facility employs various hazardous and non-hazardous waste management technologies, including hot oil thermal desorption, incineration, decanter/centrifuge separation, wastewater treatment, waste shredding, container crusher/baling, and container washing operations.

Several additional qualified third-party waste management operators are currently seeking authorization for facility developments or expansions, as discussed above. These are expected to further expand the capacity of onshore waste management infrastructure to manage the Project's hazardous, non-hazardous, and exempt hazardous waste storage, processing, treatment, and/or recycling needs. Some or all of these facilities could also be used to manage wastes resulting from response to a spill.

The HBL facility currently receives approximately 500 tonnes of waste per day. At current disposal rates, the Government of Guyana estimates that Cell 2 has approximately 4 to 6 years of disposal capacity. This estimated life span of Cell 2 depends upon how much the waste volumes received at the landfill increase with the expanded economic development expected in the Georgetown area over the next 5 years. There remains space for additional cell(s) at the HBL location to be developed in the future. The currently available landfill capacity appears sufficient to support the Project and other users for the short-term, even considering forecasted growth in waste volumes from expanding industrial activity. Presuming additional cell(s) would be constructed on a timely basis, the future HBL capacity also appears reasonable for the longer-term (up to 10 years).

The intensity of impact of a marine or riverine spill or onshore hydrocarbon release on Georgetown-based hazardous waste management infrastructure capacity would be a function of the scale of the event and the volume of waste materials generated by the event or the response effort. Balancing the above-noted recent and ongoing expansions of hazardous waste treatment infrastructure capacity, the possibility that waste generated from the event could be a significant contributor to hazardous waste treatment demand, and the expectation that other oil and gas-related hazardous waste treatment demand would reduce during response to such a spill, the intensity of potential Project impacts on Georgetown-based hazardous waste treatment facilities is considered to be as much as **Medium**. On the basis that the impacts would persist throughout the response and restoration effort, the frequency is considered to be **Continuous**. Response and restoration efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be no more than **Medium-term**. Therefore, the magnitude of this potential impact is rated as **Medium**. Consistent with the sensitivity ratings assigned for potential impacts on non-Project users of Georgetown-based hazardous waste treatment facilities from planned activities, a sensitivity rating of **Low** is assigned, on the basis that these users have the ability to access alternate regional providers for this service, albeit likely at an increased cost and a commensurate reduction in their operational efficiency.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, and Section 10.1.4, Onshore Hydrocarbon Release, a marine or riverine fuel spill and an onshore hydrocarbon release are both considered **Unlikely**. Accordingly, the overall pre-mitigation risk to Georgetown-based hazardous waste treatment facilities component of waste management infrastructure capacity from both of these events is considered **Minor** (see Table 10.2.7-1).

As with hazardous waste treatment facilities, the intensity of impact of a marine or riverine spill or onshore hydrocarbon release on Georgetown-based non-hazardous waste management (landfill) capacity would be a function of the scale of the event and the volume of waste materials generated by the response and restoration effort. However, even with a larger event, it is not likely that response/restoration-related wastes would comprise a significant proportion of the total current demand on Georgetown-based landfill facilities (on the order of approximately 500 tonnes per day). While a larger event could produce a significant increase in the Project's non-hazardous waste volume during the response and restoration effort, the intensity of potential Project impacts on Georgetown-based landfill facilities (in the absence of future capacity expansions and/or the introduction of additional facilities of a sufficient quality) could be as much as **Low**. On the basis that the impacts would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. Response efforts would likely be completed for the most part or entirely within a year or less, so duration is considered to be **Medium-term**. Therefore, the magnitude of this potential impact is rated as **Small**. Consistent with the sensitivity ratings assigned for potential impacts on non-Project users of Georgetown-based landfill facilities from planned activities, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, and Section 10.1.4, Onshore Hydrocarbon Release, a marine or riverine fuel spill and an onshore hydrocarbon release are both considered **Unlikely**. Accordingly, the overall pre-mitigation risk to the Georgetown-based landfill component of waste management infrastructure capacity from both of these events is considered **Minor** (see Table 10.2.7-1).

As described in Section 7.7, Waste Management Infrastructure Capacity, the Project has initiated a number of mitigation measures for the Project (and all of EEPGL's operations) to continue to have access to a reliable supply of waste management infrastructure capacity for routine operations; these same mitigation measures would be directly applicable in the case of response/restoration-related waste management needs. With implementation of these mitigation measures, and considering that EEPGL has a robust plan for managing waste (i.e., through a combination of the OSRP and CWMP, as well as provisions for adapting these plans as needed based on the nature of the response effort), the intensity ratings for potential response/ restoration-related impacts on waste management infrastructure capacity from a marine or riverine fuel spill or onshore hydrocarbon release would likely be reduced to **Low** for Georgetown-based hazardous waste treatment facilities. On the basis of continued expansion of non-hazardous waste management capacity, the intensity would likely be reduced to **Negligible** for Georgetown-based landfills.

Applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a residual consequence/severity designation of **Small** for both Georgetown-based hazardous waste treatment facilities and Georgetown-based landfills. In combination with the likelihood rating of **Unlikely** for both events, the residual risk to waste management infrastructure capacity from these types of unplanned events is considered **Minor** (see Table 10.2.7-1).

Table 10.2.7-1: Risk Ratings for Unplanned Event Impacts on Waste Management Infrastructure Capacity

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine or Riverine Fuel Spill Onshore Hydrocarbon Release (including a loss of integrity of onshore pipeline or a loss of integrity of NGL Plant facilities) (response and restoration efforts)	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based hazardous waste treatment facilities)—exceedance of capacity	Unlikely	Small	Minor	As warranted based on anticipated future EEPGL waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions Implement Emergency Response Plan in the event of a fire.	Minor
Marine or Riverine Fuel Spill Onshore Hydrocarbon Release (including a loss of integrity of onshore pipeline or a loss of integrity of NGL Plant facilities) (response and restoration efforts)	Waste Management Infrastructure and Capacity (non-Project users of Georgetown-based landfill facilities)—exceedance of capacity	Unlikely	Medium	Minor	Continue monitoring of plans for further expansion of the HBL and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government) or identify suitable alternative (interim) local solutions for non-hazardous waste management Implement Emergency Response Plan in the event of a fire.	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.8. Protected Areas

Based on the analysis presented in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, none of the unplanned events considered would have a reasonable potential to result in impacts on protected areas. As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, in each of the marine fuel spill scenarios, the simulations indicated that the spill would spread predominantly in a northwest direction—roughly parallel to the shoreline, with minimal lateral spreading toward the shoreline, and with no indication of a potential impact on the Shell Beach Protected Area. For riverine spills under all scenarios modeled, the predicted extent of a spill plume is restricted to the lower Demerara River and the immediately adjacent coastal environment.

10.2.9. Marine and Coastal Biodiversity

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on freshwater biodiversity include the following:

- Marine or riverine fuel spill
- Loss of integrity of offshore pipeline resulting in natural gas release
- Marine mammal strike by a Project vessel
- Marine turtle strike by a Project vessel

The potential impacts of each of these unplanned events are discussed below.

10.2.9.1. Marine and Riverine Fuel Spills

The susceptibility of different groups of marine life to releases of liquid hydrocarbons to the environment varies depending on each group's physiologies and life histories. Hydrocarbon spills pose risks to marine birds including loss of insulating and water-repelling properties of plumage, loss or impairment of flight and buoyancy, toxic impacts from the ingestion of hydrocarbons, habitat degradation at sea and at island or shoreline breeding sites, and mortality of food resources. Marine wildlife contact, breathe, or ingest hydrocarbons can experience mortality, reduced growth rates, dermal irritation, increased susceptibility to infections, and reproductive impairment (Mearns et al. 2018; Helm et al. 2015). Marine fish and marine benthos are generally only slightly impacted by hydrocarbon spills because of their limited exposure to surface slicks and the dispersed hydrocarbons being rapidly diluted to very low concentrations in open water environments. Fish may also actively avoid spilled fuel, as they can detect hydrocarbons in the water. Juvenile life stages of marine fish tend to be more susceptible to impacts from fuel spills than adults for several reasons:

- Fuel tends to concentrate at the surface and near-surface, at least initially following a release.
- Most marine fishes spend at least their initial larval stages as plankton (referred to as ichthyoplankton).

- Although ichthyoplankton are capable of volitional movement over small scales, they tend to concentrate near the surface (Habtes et al. 2014; de Freitas and Meulbert 2004; Cowen et al. 2000).

Based on the modeling analyses presented earlier in this chapter, if a release of marine fuel were to occur, the spilled fuel would be predicted to travel towards the northwest in all scenarios and during all seasons. Based on the wide range of impact mechanisms and impacts of marine fuel spills on marine mammals and marine birds, the fact that the impacts of exposure can include mortality in both groups, and the relatively large area of ocean that could be swept by an unmitigated marine fuel spill compared to the area of ocean that could be affected by a spill in the Demerara River, the intensity of impacts of a marine fuel spill on air-breathing taxa (i.e., marine mammals and marine birds), depending on the size of the spill, could be as much as **High**. On the basis that impacts on marine birds and marine mammals from a marine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Even without mitigation, the marine environment would gradually recover to some extent—depending on the size and the extent of the spill—but impacts could still persist beyond a week, yielding a **Medium-term** duration. The intensity of impacts from a marine fuel spill on marine fish and marine benthos would likely be **Low**, and the frequency and duration would be **Continuous** and **Medium-term**, respectively. This produces a magnitude rating of **Medium** for impacts on marine mammals and marine birds, and **Small** for impacts on marine fish and benthos. The five species of marine turtles that occur in Guyana's territorial waters are special status species; therefore, the potential impacts of a marine fuel spill on marine turtles are discussed in Section 10.2.13, Special Status Species.

Modeled breakdowns of the mass balances for deterministic modeling scenario indicate that much of the fuel that would be released in both the 50-barrel (8 m^3) and 250-barrel (40 m^3) fuel spill scenarios would evaporate over a period of several days. The mass balance analysis suggests that 66 to 90 percent of the fuel released in a 50-barrel (8 m^3) release and 66 to 75 percent of the fuel released in a 250-barrel (40 m^3) release would have evaporated at the end of the 10-day simulation. This suggests that fuel vapor concentrations would be elevated at the ocean's surface for several days following the spill event, but that hydrocarbon concentrations in the water column would rapidly decrease following the spill event. The sensitivity of marine mammals and marine birds to a marine fuel spill is therefore considered **High**, and the sensitivity of marine fish and marine benthos to a marine fuel spill is rated as **Low**. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Large** for impacts on marine mammals and marine birds, and **Small** for impacts on marine fish and marine benthos. In combination with a likelihood rating of **Unlikely** for a marine fuel spill, the pre-mitigation risk to marine mammals and marine birds from a marine fuel spill is considered **Moderate,** and the pre-mitigation risk to marine fish and marine benthos from a marine fuel spill is considered **Minor**.

Effective implementation of the OSRP (Volume III of the EIA) could reduce the duration over which the spill would be present on the water surface and reduce the number of individual marine organisms potentially impacted. As such, this would be expected to reduce the intensity of the impact of a mitigated fuel spill on marine mammals and marine birds to **Medium**. This results in a reduced magnitude rating of **Medium** for impacts of a mitigated marine fuel spill on marine mammals and marine birds. Implementation of the OSRP (Volume III of the EIA) would have a similar effect on the intensity of impacts on marine fish and marine benthos, lowering the intensity of potential impacts to **Negligible**, and thus reducing the magnitude to **Negligible.** Combined with the sensitivity rating of **High** for marine mammals and marine birds and **Low** for marine fish and marine benthos, this yields a consequence/severity rating of **Large** for impacts on marine mammals and marine birds. The consequence/severity of impacts on marine fish and marine benthos would remain **Small**. In combination with a likelihood rating of **Unlikely** for a marine fuel spill, the residual risk for marine mammals and marine birds would be **Moderate** and the residual risk for marine fish and marine benthos would be **Minor.**

Based on the deterministic modelling analysis conducted for a riverine fuel spill, in most scenarios a fuel spill inside the Demerara River would have no effect on marine biota because the spilled fuel would not reach the Atlantic Ocean. Only the largest scenario modelled (a 500-barrel [80 m^3] spill) would have the potential to reach the ocean, and only if the spill occurred in the lower portion of the river under high-flow conditions. Under these circumstances, the spilled fuel could reach the nearshore zone immediately outside the mouth of the river off Vreed-en-Hoop, but the area swept by the fuel would extend less than 3 kilometers offshore. Marine birds generally forage farther offshore than 3 kilometers, and impacts on coastal birds from a riverine fuel spill are assessed in Section 10.2.10, Terrestrial Biodiversity (Unplanned Events), because they would occur at the riparian interface between the land and coastal waters. Based on the small geographical extent of the effect, the intensity of the impact from a riverine fuel spill on the remaining marine taxa would be **Low**. On the basis that impacts on marine biodiversity would persist for as long as the spill remains in or on the water (although they would reduce over time as the spilled fuel weathers), and because the impacts of an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

The sensitivity of marine taxa to a riverine fuel spill that exited the river would be equivalent to sensitivity to a marine fuel spill (i.e., **High** for marine mammals and marine birds, and **Low** for marine fish and marine benthos). Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** for impacts on marine mammals and marine birds, and **Small** for impacts on marine fish and marine benthos. In combination with a likelihood rating of **Unlikely** for a marine fuel spill, the pre-mitigation risk to all non-special status marine species from a riverine fuel spill is considered **Minor**. Effective implementation of the OSRP (Volume III of the EIA) could reduce the duration over which the spill would be present on the water surface, and reduce the number of individual marine organisms potentially impacted. As such, this would be expected to reduce the intensity of the impact of a mitigated fuel spill in the Demerara River on all marine taxa to **Negligible,** and the duration of the spill event to

Medium-term. This results in a reduced magnitude rating of **Negligible** for impacts of a mitigated riverine fuel spill on marine biota. Combined with the sensitivity rating of **High** assigned for potential impacts on marine mammals from planned activities, this yields a consequence/severity rating of **Small** for impacts on marine mammals and marine birds. The consequence/severity of impacts on marine fish and marine benthos would remain **Small**. In combination with a likelihood rating of **Unlikely** for a riverine fuel spill, the residual risk to all non-special status marine taxa from a mitigated riverine fuel spill would be **Minor.**

10.2.9.2. Loss of Integrity of Offshore Pipeline Resulting in Natural Gas Release

In the event of a loss of integrity of the offshore pipeline, natural gas would rise through the water column before diffusing into the atmosphere at the ocean's surface. This could lead to diffusion of hydrocarbons directly into the bodies of marine organisms, particularly organisms with gills (i.e., fish and marine benthos). Absorption of hydrocarbons into the bloodstream can produce a variety of physiological impacts in vertebrates; the impacts of in situ exposure of marine invertebrates to hydrocarbons in the gaseous phase has been largely unstudied.

As described in Section 10.1.2, Loss of Integrity of Offshore Pipeline Resulting in a Natural Gas Release, loss of integrity of the marine pipeline would create a funnel-shaped field of natural gas bubbles rising through the water column to the surface, where the natural gas would dissipate into the atmosphere. Gaseous-phase natural gas is not known to be harmful to air-breathing marine organisms, although the potential exists for physiological impacts if the fumes at the water surface were inhaled. Regardless of the nature or severity of the physiological impacts on marine biota, the area of the ocean within which marine biota could be affected would be very small. The intensity of the impacts of a loss of integrity of the marine pipeline on marine biodiversity is therefore rated **Low.** On the basis that impacts on marine biodiversity would persist for as long as the release persisted, the frequency of the impact is rated **Continuous**. A loss of pipeline integrity would be detectable via a loss of pressure in the pipeline virtually immediately, at which point measures would be taken to depressurize the pipeline to stop the release until the source of the leak could be located and addressed. Although pipeline repairs may take longer than a week to make, de-pressurizing the pipeline (if necessary) would be achieved more rapidly, so the duration of the impact would be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

The sensitivity of marine taxa to a natural gas release from a loss of offshore pipeline integrity would be **Low**. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Small**. In combination with a likelihood rating of **Unlikely**, the pre-mitigation risk to all non-special status marine species from a loss of marine pipeline integrity would be **Minor**. There are no mitigation measures that could be applied to a loss of pipeline integrity in the marine environment, so the residual risk to non-special status marine species from a loss of marine pipeline integrity would also be **Minor**.

10.2.9.3. Marine Mammal Strike by a Project Vessel

Marine mammals are inherently vulnerable to vessel strikes when they swim near the surface or break the surface to breathe or feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced by the water depth. Vessel collisions or strikes to whales are among the greatest threats and causes of death of whales, especially in regions with high aggregations (feeding and breeding) of whales and high volumes of vessel traffic (Peel et al. 2018). A vessel encounter can cause harm, injury, or mortality, and temporary behavior changes to marine mammals. Larger, faster vessels moving at speeds above 13 knots (24 kilometers per hour) pose a greater risk for collision with a marine mammal than smaller, slower vessels, which are also more maneuverable (Laist et al. 2001). Currently, no records of vessel collisions with marine mammals are known for Guyana, but this lack of reports does not necessarily indicate that vessel collision with marine mammals does not occur, since such incidents may not be reported or vessel operators may not be even aware of a collision event. As described in Section 8.2.2.3, Marine Mammals (Existing Conditions and Baseline Studies), the largest and least maneuverable marine mammals (i.e., the large whales) are only found in the deep portions of the Project AOI. Smaller species such as the spinner dolphin, common bottlenose dolphin, and pantropical spotted dolphin are found throughout the marine portion of the Direct Project AOI, including the continental shelf.

Project vessels will generally travel at slow speeds because they will be actively installing or inspecting the offshore pipeline (in the case of the installation vessels) or supporting the installation vessels (in the case of the support vessels). As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize and spot marine mammals, and will provide standing instructions to Project-dedicated vessel masters on what to do if they encounter marine mammals while in transit (e.g., reduce vessel speed or deviate from course, as needed, to lower the probability of a collision with a marine mammal).

Using the definitions established for assessment of potential impacts on marine and coastal biodiversity from planned Project activities and considering the above information, the intensity of potential impacts on marine mammals as a result of a vessel collision is considered **Medium**. On the basis that vessel traffic will be a consistent presence during the Construction stage but rare thereafter, the frequency is considered to be **Continuous** during the Construction phase and **Episodic** during the Operations and Decommissioning stages. Collisions between Project vessels and marine mammals are likely to result in death or permanent injury to the mammal, so the impacts associated with a collision are considered **Long-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium** during the Construction stage and **Small** during the Operations and Decommissioning stages.

The sensitivity of marine mammals to vessel strikes is considered **Medium** because a collision with a vessel is likely to have significant consequences for an individual marine mammal, but the marine mammal species that are present in Guyana’s marine waters are likely to be resilient to rare losses of individual animals. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** during the Construction stage and **Small** during the Operations and Decommissioning stages.

If a collision between a marine mammal and a Project vessel were to occur, it would be at most infrequent. Most of the Direct AOI is located where the largest, slowest, least maneuverable marine mammal species are least common. In consideration of these factors, a collision with a marine mammal is considered **Possible**, so the overall pre-mitigation risk to marine mammals, particularly whales, from a vessel collision is considered **Moderate** during the Construction stage and **Minor** during the Operations and Decommissioning stages. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating is maintained at **Moderate** for the Construction stage and **Minor** for the Operations and Decommissioning stages (see Table 10.2.9-1).

10.2.9.4. Marine Bird Strike by a Project Vessel

Rafting marine birds may suffer injury or mortality from collisions with vessels transiting the Project AOI. Observations recorded during EEPGL-commissioned marine bird surveys from 2017 through 2020 document that birds present on the water surface generally tend to move in response to oncoming vessels. In the unlikely event such an interaction would occur, impacts would vary with the abundance of marine birds present. Using the definitions established for assessment of potential impact on marine birds from planned Project activities, the intensity of potential impacts on marine birds from collision of a Project vessel with rafting marine birds is considered **Low**. Using the same rational as presented for vessel collisions with marine mammals, the frequency and duration of collision-related impacts on marine birds are considered to be **Continuous** and **Long-term,** respectively. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

Using the definitions established for assessment of potential impacts on marine and coastal biodiversity from planned Project activities, the sensitivity of marine birds to impacts from collision of a Project vessel with rafting marine birds is considered **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Small**. As an embedded control, vessel captains are trained to recognize rafting marine birds and avoid them if possible. This, combined with the expected rare occurrence of rafting marine birds, yields a likelihood rating of **Unlikely**; the pre-mitigation risk to marine birds from collision of a Project vessel with rafting marine birds is considered **Minor**. There are no additional mitigation measures that would further reduce this potential impact. As such, the residual risk to marine birds from this impact would remain **Minor** (see Table 10.2.9-1).

10.2.9.5. Marine Turtle Strike by a Project Vessel

The five species of marine turtles that occur in Guyana’s territorial waters are special status species; therefore, the impacts of a vessel strike on marine turtles are discussed in Section 10.2.13, Special Status Species.

Table 10.2.9-1 summarizes the pre-mitigation and residual risks to marine and coastal biodiversity from unplanned events.

Table 10.2.9-1: Risk Ratings for Unplanned Event Impacts on Marine and Coastal Biodiversity

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine Fuel Spill	Marine Mammals and Marine Birds	Unlikely	Large	Moderate	Implementation of the OSRP	Moderate
Marine Fuel Spill	Marine Fish and Marine Benthos	Unlikely	Small	Minor	Implementation of the OSRP	Minor
Riverine Fuel Spill	Marine Mammals and Marine Birds	Unlikely	Medium	Minor	Implementation of the OSRP	Minor
Riverine Fuel Spill	Marine Fish and Marine Benthos	Unlikely	Small	Minor	Implementation of the OSRP	Minor
Loss of Offshore Pipeline integrity	All marine taxa	Unlikely	Small	Minor	None	Minor
Strike by a Project Vessel—Construction Stage	Marine Mammals	Possible	Medium	Moderate	None	Moderate
Strike by a Project Vessel—Operations and Decommissioning Stages	Marine Mammals	Possible	Small	Minor	None	Minor
Strike by a Project Vessel	Marine Birds	Unlikely	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.10. Terrestrial Biodiversity

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on terrestrial biodiversity include the following:

- Riverine fuel spill
- Onshore hydrocarbon release
- Untreated wastewater release at the NGL Plant

10.2.10.1. Riverine Fuel Spill

In the unlikely event of a riverine fuel spill, terrestrial wildlife and vegetation within and along the lower Demerara River could be affected. The potential severity of the impact of such event on terrestrial wildlife and vegetation is dependent on the size, location, and timing of the release. The greatest potential impacts would be damage to riparian vegetation and to terrestrial wildlife, primarily birds that use the riverine and riparian habitats along the lower Demerara River.

The shoreline of the lower Demerara River contains mature riparian forest, including stands of mangrove forest. Although some residential and industrial development fragments the riparian zone along both banks of the lower Demerara River, the riparian habitats are largely intact and support a high diversity of wildlife species, particularly birds. Riverine bird surveys conducted in support of the EIA documented eight bird concentration areas in the lower Demerara River and adjacent coastal area (Figure 8.3-10). These areas reliably contain concentrations of roosting, foraging, resting, and/or nesting birds comprised of a mix of resident and migratory waterbirds, shorebirds, raptors, and landbirds, including nine Special Status bird species (Section 8.6, Special Status Species). Most notable of these eight bird concentration areas are two island habitats: (1) a sunken barge located near the mouth of the Demerara River that now supports a dense mangrove forest (#1 on Figure 8.3-10 and Table 8.3-8); and (2) Inver Island, which is a forested island located in the middle of the Demerara River near Land of Canaan, approximately 2 kilometers upstream from the proposed temporary MOF site (#8 on Figure 8.3-10 and Table 8.3-8). The sunken barge island supports thousands of roosting and nesting waterbirds, particularly Snowy Egret (*Egretta thula*), Cattle Egret (*Bubulcus ibis*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Yellow-crowned Night-Heron (*Nyctanassa violacea*), and Magnificent Frigatebird (*Fregata magnificens*), but also many other bird species, including special status species. Inver Island supports thousands of roosting Orange-winged Parrots (*Amazona amazonica*), and several other species of parrots (including three species of macaws) are known to congregate on this island for communal roosting and possibly breeding. Hoatzin (*Opisthocomus hoazin*), Guyana's National bird, has also been documented there.

As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, affected shorelines were predicted at various points along the West Bank of the lower Demerara River from approximately 4 kilometers south (upriver) of the temporary MOF site to the river mouth and adjacent nearshore coastal area, depending on the scenario modeled. This predictive modeling reflects the presence of any fuel amount that would encounter a shoreline regardless of a thickness threshold. The extent and location of the affected area would be dependent upon the location of the spill. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation.

Riparian forest along this portion of the West Bank and adjacent coastline west of the river mouth, including mature, growing mangroves that are characterized as Critical Sensitivity in prior coastal sensitivity mapping (Section 9.8.2., Existing Conditions and Baseline Studies [Ecosystem Services]), would be susceptible to exposure to a riverine fuel spill. The main threat to terrestrial (riparian) vegetation from a riverine fuel spill is the direct impact of exposure of plants to the spilled hydrocarbons, which are toxic to many plants and could impact photosynthesis and metabolic functions, damage foliage and root systems, and reduce or inhibit growth.

Riverine and riparian birds and other wildlife that use the area potentially affected by a fuel spill could be exposed to the hydrocarbons through dermal contact or ingestion of contaminated water, vegetation, or aquatic prey. Additionally, four of the eight bird concentration areas that occur in the lower Demerara River and adjacent coastal area lie within the potential spill plume trajectory based on the scenarios modeled, including the two islands (sunken barge island and Inver Island) mentioned above and two roosting sites located along the coastline just west of the river mouth. The most significant impact on birds from an unmitigated riverine fuel spill would occur if the spill reached the shoreline or nearshore waters in areas near a colonial waterbird nesting site during or immediately after the breeding period. Breeding seasons for colonial birds in Guyana vary, but generally are October through February (Zima and Francisco 2016). However, breeding may occur at any time of year in Guyana because optimum breeding conditions in the tropics are more closely related to food availability than weather conditions. During these periods, hundreds to thousands of colonial waterbirds congregate to nest and feed in and around breeding sites. Waterbirds feed primarily on fish and other aquatic prey, so they would be susceptible to contact and ingestion of fuel during preening if they were exposed to hydrocarbons from the water surface. This could injure or kill the impacted individual, and affected adults could transfer the hydrocarbons to their eggs or chicks in the nest, which are highly susceptible to the impacts of hydrocarbons (Da Silva et al. 1997). Such impacts could affect a breeding year for local populations. A similarly high impact on birds could occur if a spill plume occurred in the riverine or nearshore coastal habitats along the lower Demerara River during the spring or fall shorebird migration, when tens of thousands of migratory shorebirds stopover to forage and rest in Guyana's riverine and nearshore coastal habitats, including those in and near the lower Demerara River.

Even though the spatial extent of the impact from a riverine fuel spill would be limited, the presence of sensitive habitats (riparian forests including mangroves) and many birds and other riparian/riverine wildlife that live or forage in the water or adjacent riparian habitats along the lower Demerara River and adjacent coastline creates a high risk of direct or indirect exposure from a riverine fuel spill. As such, the intensity of potential impacts from a riverine fuel spill on terrestrial biodiversity, particularly riparian habitats and riparian/riverine bird species, is rated as **High**, particularly if the spill occurred when birds are nesting.

The geographic extent of an unmitigated riverine fuel spill would likely be limited to the Indirect AOI. On the basis that impacts on riparian/riverine wildlife species would persist for as long as the spill remains unmitigated (although they would reduce over time as the spilled fuel weathers), and because the impacts of an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

Based on the above discussion, the sensitivity of terrestrial biodiversity, and more specifically riparian and riverine habitats and wildlife, in the area that could potentially be impacted by a riverine fuel spill is considered **Medium**. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine or riverine fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to terrestrial biodiversity from a riverine fuel spill scenario is considered **Minor** (Table 10.2.10-1). EEPGL would execute the spill response plan, which for a riverine fuel spill would include shoreline protection, if warranted, but likely not removal of fuel from the water surface (the fuel would naturally evaporate or degrade relatively rapidly). As such, this mitigation would not reduce the consequence of the impact on riverine wildlife, particularly birds, so the residual risk rating is maintained at **Minor**.

10.2.10.2. Onshore Hydrocarbon Release

In the unlikely event of an onshore hydrocarbon release from a loss of integrity of the onshore pipeline or of the NGL Plant facilities, these events could result in injury or mortality to terrestrial biodiversity resources near the portion of Project infrastructure where the event occurs and the immediate surrounding impact area where a fire occurs (assuming the event results in a fire). As described in Section 10.1.4.3, Modeling of Hydrocarbon Releases, under all modeled scenarios, the zone of impact is expected to be confined to the immediate vicinity (within approximately 1 kilometer) of the NGL Plant or portion of the onshore pipeline where the release occurs.

As discussed in Section 8.3.2, Existing Conditions and Baseline Studies (Terrestrial Biodiversity), the vegetation and wildlife communities and species in the Direct AOI are modified and widespread throughout the region. Overall wildlife density in the onshore portion of the Direct AOI is low, and the number of individuals impacted by an unplanned onshore hydrocarbon release would likely be correspondingly low, depending on the size and location of the release. While there are some wildlife species of conservation interest (special status species) in the Direct AOI, impacts on special status wildlife at the population level are not anticipated. Based on the small amount of short-term vegetation loss, the common and widespread vegetation communities and species affected, lack of population-level impacts on wildlife species, and the anticipated rapid natural restoration of impacted areas, the intensity of the impact associated with an onshore hydrocarbon release on terrestrial biodiversity is considered Low.

Under a worst-case scenario, the terrestrial vegetation and wildlife within the fire zone would be permanently removed; however, the impact area would revegetate and wildlife would recolonize the area. The impact would persist until the revegetation/recolonization was complete, and this could take more than a year, so the frequency and duration are considered Continuous and Long-term. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of Small.

Based on the sensitivity rating definitions in Section 8.3.3, Impact Prediction and Assessment (Terrestrial Biodiversity), the resource sensitivity for terrestrial biodiversity is considered Low. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of Small. As described in Section 10.1.4, Onshore Hydrocarbon Release, an onshore hydrocarbon release is considered Unlikely, so the overall pre-mitigation risk of such a release to terrestrial biodiversity is considered Minor (Table 10.2.10-1).

A number of embedded controls are in place to reduce the likelihood of a loss of pipeline or NGL Plant integrity. If a fire occurs as a result of the unplanned event, EEPGL would implement its Emergency Response Plan, which would include measures to control the fire. This would reduce the potential impact on terrestrial wildlife that could occur as a result of the fire spreading. However, the residual risk rating is maintained at **Minor**.

10.2.10.3. Untreated Wastewater Release at the NGL Plant

The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. A process WWTP will be included to remove contaminants from the drained oily water and other process wastewater streams. Effluents from both WWTPs will be routed to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant. An untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond overtops the pond and is released as overland flow across the site. If the water flows across land, some of the water and contaminants will be absorbed by surficial soils, and plants and wildlife may be exposed to the water. This water could include dissolved contaminants such as nitrates, phosphates, and other nutrients; metals; hydrocarbons; biodegradable organic matter; and pathogenic microorganisms.

Impacts on terrestrial biodiversity (including inland and riparian/riverine vegetation and wildlife) from exposure to untreated wastewater are difficult to predict and depend on several factors such as the specific constituents in the discharge, whether the discharge occurs over land or in the river, the concentrations of the constituents in the discharge, the dilution achieved once discharged in the river, and the biological and physical processes that affect the constituents. The primary constituents in the wastewater effluents will include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), metals, oil and grease, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform.

Modeling for a river discharge of untreated wastewater predicted that the NGL Plant wastewater effluent will experience a dilution factor within 100 meters of the discharge ranging from 154 to 2,475 in the dry and wet seasons, respectively (Section 7.4.3, Impact Prediction and Assessment [Water Quality]). Further, the situation that would result in discharge from the stormwater pond being unavoidable would likely coincide with the presence of a significant volume of (uncontaminated) stormwater in the stormwater pond; this would inherently dilute the wastewater effluent before it was released from the stormwater pond.

The Project has several embedded controls to reduce the likelihood of an untreated wastewater release. EEPGL will conduct routine maintenance and monitoring to maintain WWTP performance. Additionally, wastewater will be first released to the stormwater pond, which will contain uncontaminated stormwater runoff, resulting in dilution.

Given the extremely limited spatial extent of the area (on land or in the river) that would likely be exposed to discharge of untreated effluent, and the correspondingly small number of plants or animals that would likely occur in the impacted area during the short period in which the potential for exposure persists, the intensity of impacts of an unplanned wastewater release on terrestrial biodiversity is rated as **Low**. On the basis that exposure to the effluent would persist for as long as the treatment plant continues to not operate properly and the discharge continues, the frequency is considered to be **Continuous**. The treatment plant operations would likely be corrected in a short period of time, but the duration is conservatively rated as **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Small**.

Using the definitions for sensitivity rating presented in the assessment of potential impacts on terrestrial biodiversity from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, an unplanned release of wastewater from the NGL Plant is considered **Possible**. Accordingly, the overall pre-mitigation risk to terrestrial biodiversity from an untreated wastewater release is considered **Minor** (Table 10.2.10-1).

While EEPGL would take measures to restore the WWTP functionality if this type of event occurred, this would not necessarily prevent the overtopping of the stormwater pond in a significant rainfall event. Accordingly, the residual risk rating is maintained at **Minor**.

Table 10.2.10-1 summarizes the pre-mitigation and residual risks to terrestrial biodiversity from unplanned events.

Table 10.2.10-1: Risk Ratings for Unplanned Event Impacts on Terrestrial Biodiversity

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Riverine Fuel Spill	Terrestrial Vegetation and Wildlife (Focused on Riparian Habitats and Riverine/Riparian Wildlife)	Unlikely	Medium	Minor	Implement OSRP	Minor
Loss of Integrity in Onshore Pipeline or NGL Plant, Resulting in Hydrocarbon Release	Terrestrial Vegetation and Wildlife	Unlikely	Small	Minor	Implement Emergency Response Plan in the event of a fire	Minor
Untreated Wastewater Release at NGL Plant	Terrestrial Vegetation and Wildlife	Possible	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.11. Freshwater Biodiversity

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on freshwater biodiversity include the following:

- Riverine fuel spill
- Riverine mammal strike by a Project vessel
- Untreated wastewater release at the NGL Plant

The impacts of each of these unplanned events are discussed below.

10.2.11.1. Riverine Fuel Spill

In the unlikely event of a riverine fuel spill, freshwater species in the lower Demerara River could be affected. As shown in Section 10.1.1.5, Marine and Riverine Fuel Spill Modeling, spills in the northern part of the river would tend to remain in the northern part of the river, and spills under high-flow conditions would tend to spread further than spills under low-flow conditions. The location and timing of a riverine fuel spill would therefore have some influence on the severity of its impacts on freshwater biota, but the severity of impacts from a spill event would be determined more by the distribution of biota in the river than by the characteristics of the spill.

A fuel spill in the Demerara River would most likely involve a release of marine diesel. Marine diesel is a relatively light hydrocarbon and spilled fuel would be expected to remain on or near the surface of the river. Most riverine benthos would therefore not come in contact with the spill except near the river's western shoreline where the river is shallow and the spilled fuel would accumulate (Figures 10.1-9a through 10.1-10c).

The most significant potential impacts of such an event on non-special status species would be on fish in the river. As summarized in Table 8.4-13 in Section 8.4.2.3, Inland Fish of Guyana, the baseline aquatic biodiversity surveys completed in support of the EIA documented 20 species of freshwater and estuarine fishes in the lower Demerara River. Over half of these species (13 species) are catfish, which are strongly bottom-oriented and would not be expected to occur near the surface as adults. Another four species do not have strong vertical tendencies and could therefore be present in the upper water column, but would not be expected to linger there during a fuel spill event. Three species (*Anchoviella lepidentostole*, *Anchoa spinifer*, and *Tomeurus* sp.) are top-water species that are morphologically and behaviorally specialized for life at the water's surface and occur most often near the surface. Adults of these species could be exposed to the spilled fuel through dermal contact or passage of contaminated water through their gills. None of these species are migratory or show strongly seasonal behaviors, so they would have the potential for exposure to spilled fuel regardless of the timing of a potential spill event.

The shoreline of the lower Demerara River supports mangroves and other aquatic vegetation, especially along the western shore. Riparian forest along this portion of the West Bank and adjacent coastline west of the river mouth includes mature, growing mangroves that were characterized as Critical Sensitivity in prior coastal sensitivity mapping (Section 9.8.2, Existing Conditions and Baseline Studies [Ecosystem Services]). These mangroves would be susceptible to exposure to a riverine fuel spill. The main threat to terrestrial (riparian) vegetation from a riverine fuel spill is the direct impact of exposure of plants to the spilled hydrocarbons, which are toxic to many plants and could impact photosynthesis and metabolic functions, damage foliage and root systems, and reduce or inhibit growth. Aquatic vegetation, particularly the prop roots of mangroves, is vital habitat for the juvenile life stages of a variety of freshwater, marine, and estuarine fishes. Although the top-water species described above would be the most susceptible fish species to the impacts of a riverine fuel spill as adults, a fuel spill in the Demerara River would have the potential to affect a wider range of fish species as juveniles in the shallow vegetated zone. Direct impacts on juvenile fishes from contact, ingestion, or absorption of hydrocarbons from the water column would be limited to a single generation, and populations would be expected to recover quickly from such an event, but degraded nursery habitat would take longer to recover and would affect successive generations of fish in the river.

Even though the spatial extent and duration of a riverine fuel spill event would be limited, the presence of sensitive aquatic species and their nursery habitats (riparian forests, including mangroves) creates a high risk of direct exposure and ongoing habitat loss from a riverine fuel spill. As such, the intensity of potential impacts from a riverine fuel spill on freshwater aquatic biodiversity, particularly on top-water fishes, juvenile fish, and riparian nursery habitat, is rated as **High**.

The geographic extent of an unmitigated riverine fuel spill would likely be limited to the Indirect AOI. On the basis that impacts on freshwater biodiversity would persist for as long as the spill remains unmitigated (although they would reduce over time as the spilled fuel weathers), and because the impacts of an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

Based on the above discussion, the sensitivity of freshwater aquatic biodiversity in the area that could potentially be impacted by a riverine fuel spill is considered **Medium**. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a riverine fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to freshwater aquatic biodiversity from a riverine fuel spill scenario is considered **Minor** (Table 10.2.11-1). EEPGL would implement its OSRP (Volume III of the EIA), which for a riverine fuel spill would include shoreline protection but likely not removal of fuel from the water surface (due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation). As such, this mitigation would not be expected to substantially reduce the consequence of the impact on riverine fishes, so the residual risk rating is maintained at **Minor** (Table 10.2.11-1).

10.2.11.2. Riverine Mammal Strike by a Project Vessel

The only riverine mammal that has a chance of being struck by a Project vessel is an American manatee (*Trichechus manatus*), which is a special status species. The potential impacts of a vessel strike on an American manatee are discussed in Section 10.2.13, Special Status Species.

10.2.11.3. Untreated Wastewater Release at the NGL Plant

The sanitary WWTP and process WWTP will collect and treat sanitary and process effluents, respectively, before routing them to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant. The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. An untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond are released in an uncontrolled manner. The risk of such a release to the freshwater environment would be strongly influenced by the volume and duration of the release. In such an event, plants and aquatic wildlife could be exposed to dissolved contaminants such as nitrates, phosphates, and other nutrients; metals; hydrocarbons; biodegradable organic matter; and pathogenic microorganisms.

Impacts on freshwater aquatic biodiversity from exposure to untreated wastewater are difficult to predict and depend on several factors such as the specific constituents in the discharge, the concentrations of the constituents in the discharge, the dilution achieved once discharged in the river, and the biological and physical processes that affect the constituents. If the discharge occurs over land, the impacts on freshwater biodiversity would also depend on whether the volume of the uncontrolled release was sufficiently large and the duration of the release sufficiently long to overcome the absorptive capacity of the land surrounding the stormwater pond. The most likely impact on freshwater biodiversity, if any, from such an event would be a small-scale fish mortality event (which can occur when spills occur in confined waterbodies with limited flushing and dilution potential). If the spill were to be discharged into a canal, a fish mortality event could occur in the canal. If the spill were to be discharged directly to the river, the likelihood of a fish mortality event would be significantly lower.

Modelling for a river discharge of untreated wastewater predicted that the NGL Plant wastewater effluent would experience a dilution factor within 100 meters of the discharge ranging from 154 to 2,475 in the dry and wet seasons, respectively (Section 7.4.3, Impact Prediction and Assessment [Water Quality]). Further, the situation that would result in discharge from the stormwater pond being unavoidable would likely coincide with the presence of a significant volume of (uncontaminated) stormwater in the stormwater pond; this would inherently dilute the wastewater effluent before it was released from the stormwater pond.

The Project has several embedded controls to reduce the likelihood of an untreated wastewater release. EEPGL will conduct routine maintenance and monitoring to maintain WWTP performance. Additionally, wastewater will be first released to the stormwater pond, which will contain uncontaminated stormwater runoff, resulting in dilution.

Given the extremely limited spatial extent of the area (on land or in the river) that would likely be exposed to discharge of untreated effluent, the intensity of impacts of an unplanned wastewater release on freshwater biodiversity is rated as **Low**. On the basis that exposure to the effluent would persist for as long as the treatment plant continues to not operate properly and the discharge continues, the frequency and duration are considered to be **Continuous**. The treatment plant operations would likely be corrected in a short period of time, but the duration is conservatively rated as **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Small**.

Using the definitions for sensitivity rating presented in the assessment of potential impacts on freshwater aquatic biodiversity from planned Project activities, a sensitivity rating of **Low** is assigned. Therefore, applying the methodology in Chapter 3, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at NGL Plant, an unplanned release of wastewater from the NGL Plant is considered **Possible**. Accordingly, the overall pre-mitigation risk to freshwater aquatic biodiversity from an untreated wastewater release is considered **Minor** (Table 10.2.11-1).

While EEPGL would take measures to restore the WWTP functionality if this type of event occurred, this would not necessarily prevent the overtopping of the stormwater pond in a significant rainfall event. Accordingly, the residual risk rating is maintained at **Minor** (Table 10.2.11-1).

Table 10.2.11-1 summarizes the pre-mitigation and residual risks to freshwater aquatic biodiversity from unplanned events.

Table 10.2.11-1: Risk Ratings for Unplanned Event Impacts on Freshwater Aquatic Biodiversity

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Riverine Fuel Spill	Riparian Vegetation and Freshwater Aquatic Wildlife (Focused on Riparian Habitats and Riverine Fishes)	Unlikely	Medium	Minor	Implement OSRP	Minor
Untreated Wastewater Release at NGL Plant	Freshwater Aquatic Wildlife	Possible	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.12. Ecological Balance and Ecosystems

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on ecological balance and ecosystems include the following:

- Marine or riverine fuel spill
- Loss of integrity of offshore pipeline resulting in natural gas release
- Loss of integrity of onshore pipeline or NGL Plant facilities resulting in hydrocarbon release
- Untreated wastewater release at the NGL Plant

The potential impacts of each of these unplanned events are discussed below.

10.2.12.1. Marine Fuel Spill

Impacts on the Marine Nutrient Cycle

As discussed in Section 10.2.9, Marine and Coastal Biodiversity (Unplanned), most marine biota would be able to largely avoid the impacts of a marine fuel spill, either because they do not naturally occur in the upper portion of the water column or by actively avoiding the portion of the ocean that would be affected. Plankton would not be able to avoid impacts from spilled fuel, and plankton are critical to nutrient cycling in the ocean. The available literature suggests that toxicological impacts of hydrocarbons on phytoplankton vary widely according to nutrient content of the water, temperature, type of oil, and exposure (Wang et al. 2008; Ozhan et al. 2014; Tang et al. 2019). Lighter refined products tend to be more hazardous to marine wildlife, but shorter-lived in the environment. Based on the modeling analyses presented earlier in this chapter, if a release of marine fuel were to occur, the spilled fuel would be predicted to travel toward the northwest in all scenarios and during all seasons. Modeled breakdowns of the mass balances for deterministic modeling scenario indicate that much of the fuel that would be released in both the 50-barrel (8 m^3) and 250-barrel (40 m^3) fuel spill scenarios would evaporate over a period of several days. The mass balance analysis suggests that 66 to 90 percent of the fuel released in a 50-barrel (8 m^3) release and 66 to 75 percent of the fuel released in a 250-barrel (40 m^3) release will have evaporated at the end of the 10-day simulation. This suggests that fuel vapor concentrations would be elevated at the ocean's surface for several days following the spill event, but that hydrocarbon concentrations in the water column would rapidly decrease following the spill event. Mortality of plankton at the sea surface would thus likely be high initially, and then taper off quickly over a number of days. Plankton in the lower portion of the water column would likely be largely unaffected.

Based on the modeling analyses, the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create, the intensity of potential impacts of an unmitigated marine fuel spill on ecological balance and ecosystems is considered **Medium**. On the basis that impacts on ecological balance and ecosystems from a marine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Even without mitigation, the marine environment would gradually recover to some extent—depending on the size and the extent of the spill—but impacts could still persist beyond a week, yielding a **Medium-term** duration. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

Impacts on Gene Flow

As described in Section 8.5.3, Impact Prediction and Assessment—Ecological Balance and Ecosystems, obstacles to efficient gene flow occur when physiochemical barriers prevent organisms from migration, breeding, or dispersal/colonization. A marine fuel spill could cause a short-term physiochemical barrier to migration through the Project AOI, although the significance of this barrier impact would vary according to species and seasons. Many marine taxa migrate for reproductive purposes, and the impacts of a marine fuel spill on gene flow would resemble impacts on general marine biodiversity. Surface oriented air-breathing taxa would be more susceptible to impacts than subsurface groups. Based on the taxonomically derived ratings in Section 10.2.9, Marine and Coastal Biodiversity (Unplanned), the intensity of a marine fuel spill on ecological balance and ecosystems would be **Medium** (reflecting a balance between **High** intensity for marine mammals and marine birds, and **Low** intensity for marine fish and marine benthos). On the basis that impacts on ecological balance and ecosystems from a marine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Even without mitigation, due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation—depending on the size and the extent of the spill—but impacts on wildlife that encounter ingest fuel or inhale fuel vapors could persist beyond a week, yielding a **Medium-term** duration. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

Impacts on Biodiversity

A marine fuel spill has the potential to cause a short-term decline in biodiversity, depending on spill volume and pre-spill ecological community conditions (Tansel 2014). Some species may exhibit avoidance behavior, and sensitive species that remain in the area may experience localized population declines or a reduction in vigor. As described above, the spill is predicted to travel toward the northwest in all scenarios during both modeled seasons. Hydrocarbons would remain in at least some portions of the ocean over the entire simulated period of 10 days. Although some groups (e.g., plankton) would experience high mortality, new recruits from the east would help repopulate quickly via the Guiana Current. Other taxa capable of avoiding the spill would probably experience a range of temporary sublethal impacts before vacating the area. Mortality would likely be generally low and no lasting effects on biodiversity would be expected, so the intensity of impacts on biodiversity would be **Low**. On the basis that impacts on ecological balance and ecosystems from a marine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Even without mitigation, marine biota would gradually recover to some extent—depending on the size and the extent of the spill—but impacts could persist beyond a week, yielding a **Medium-term** duration. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

Based on the sensitivity rating definitions in Table 8.5-4, the resource sensitivity for ecological balance and ecosystems is considered **Medium** for the marine ecosystem component. This rating is based principally on the size of the marine ecosystem relative to the impacts that are anticipated within it. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude and sensitivity ratings provided above lead to a consequence/severity designation of **Small** for impacts on the marine nutrient cycle, gene flow, and biodiversity. As described in Section 10.1.2, an marine fuel spill is considered **Unlikely**, so the overall pre-mitigation risk to the marine ecosystem and marine ecosystem balance from this event is considered **Minor** (Table 10.2.12-1).

10.2.12.2. Riverine Fuel Spill

Impacts on the Freshwater Nutrient Cycle

The impacts on the nutrient cycle from a riverine fuel spill would be similar to the impacts of a marine fuel spill in the sense that they would be largely controlled by the nature of the spill's impact on phytoplankton and primary production rates. However, the types of phytoplankton and their sensitivity to a fuel spill are expected to be different in the lower Demerara River than offshore. The effects on light transmission from a fuel spill at the water's surface are expected to be much less significant in regulating primary production in the Demerara River than offshore or the nearshore environment, because turbid conditions in the river naturally limit light transmission in the river. This would imply a greater phytoplankton resilience to fuel spills in the river than offshore. However, to the extent that phytoplankton in the river would be impacted by toxicological effects or reduced gas exchange, they may not be as easily replaced from surrounding populations as they would be in the open ocean. Therefore, fuel spill-induced reductions in primary productivity may be lower in the river than in the ocean, but the nutrient cycle in the river may also be slower to recover. Accordingly, the intensity of potential impacts of an unmitigated riverine oil spill on ecological balance and ecosystems is considered **Medium**. On the basis that impacts on ecological balance and ecosystems from a riverine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Even without mitigation, the riverine environment would gradually recover to some extent—depending on the size and the extent of the spill—but impacts could persist beyond a week, yielding a **Medium-term** duration. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

Impacts on Gene Flow

A riverine fuel spill could cause a physiochemical barrier to migration of coastal and riverine organisms that rely on passage to and from the lower Demerara River for migration, feeding, breeding, or dispersal/colonization. The significance of this impact would vary across species and seasons. Some species use the lower river as nursery habitat on a seasonal basis, such as crustaceans and fish, but as described previously these groups would be less susceptible to impacts from a fuel spill because they do not need to surface to breathe. The intensity of impacts on gene flow from a riverine fuel spill is therefore rated **Low.** On the basis that impacts on ecological balance and ecosystems from a riverine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. The riverine environment would largely recover naturally—but impacts could persist beyond a week, yielding a **Medium-term** duration. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

Impacts on Biodiversity

Impacts on biodiversity from a riverine fuel spill in the Demerara River would be similar in terms of their mechanisms to a marine fuel spill, but would affect different species. A riverine fuel spill would likely affect more species of birds, more riverine mammals, fewer marine mammals, and different species of fish than a marine fuel spill, and would have little or no impact on marine turtles. The same physiological susceptibilities of the different groups would factor into the types of impacts each group would experience for a riverine fuel spill as for a marine fuel spill. Mortality would generally be low and no lasting effects on biodiversity would be expected, so the intensity of impacts on biodiversity would be **Low**. On the basis that impacts on ecological balance and ecosystems from a riverine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Even without mitigation, riverine biota would gradually recover to some extent—depending on the size and the extent of the spill—but impacts could persist beyond a week, yielding a **Medium-term** duration. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small.**

Based on the sensitivity rating definitions in Table 8.5-4, the resource sensitivity for ecological balance and ecosystems is considered **Low** for the riverine ecosystem component. This rating is based principally on the size of the riverine ecosystem relative to the impacts that are anticipated within it. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude and sensitivity ratings provided above lead to a consequence/severity designation of **Small** for impacts on the riverine nutrient cycle, gene flow, and biodiversity. As described in Section 10.1.2, a riverine fuel spill is considered **Unlikely**, so the overall pre-mitigation risk to the riverine ecosystem and marine ecosystem balance from this event is considered **Minor** (Table 10.2.12-1).

10.2.12.3. Loss of Integrity of Offshore Pipeline Resulting in Natural Gas Release

At an ecosystem level, the factors affecting the magnitude of potential impacts associated with a loss of integrity of the offshore pipeline would be very similar to the factors affecting magnitude of impacts from a marine fuel spill. Both events would involve a release of hydrocarbons that would evaporate at the water's surface. Both events would affect marine biota through similar pathways (inhalation, ingestion, and/or dermal contact), and because both types of hydrocarbons would generally concentrate at the water's surface, the same physiological traits of affected marine biota would affect each taxonomic group's susceptibility to impacts from both events. The most significant difference between the two types of events is that natural gas would evaporate more or less immediately upon arrival at the ocean's surface, whereas spilled marine fuel would evaporate over a number of days. This difference is accounted for in the impact ratings by reducing the intensity of impacts associated with a loss of offshore pipeline integrity relative to a marine fuel release, but keeping the other factors (i.e., duration and frequency) unchanged. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small** for impacts on the marine nutrient cycle, gene flow, and biodiversity.

Based on the sensitivity rating definitions in Table 8.5-4, the resource sensitivity for ecological balance and ecosystems is considered **Medium** for the marine ecosystem component. This rating is based principally on the size of the marine ecosystem relative to the impacts that are anticipated within it. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude and sensitivity ratings provided above lead to a consequence/severity designation of **Small** for impacts on the marine nutrient cycle, gene flow, and biodiversity. As described in Section 10.1.2, an onshore hydrocarbon release is considered **Unlikely**, so the overall pre-mitigation risk to the marine ecosystem and marine ecosystem balance of such a release is considered **Minor** (Table 10.2.12-1).

In the event of a loss of integrity of the offshore pipeline, the pressure loss would be detected and the flow of natural gas to the offshore pipeline would be stopped. This would limit the potential impact on the marine ecosystem that could occur as a result from a natural gas release. However, the residual risk rating is maintained at **Minor**.

10.2.12.4. Untreated Wastewater Release at the NGL Plant

At an ecosystem level, the factors affecting the magnitude of impacts associated with a release of untreated wastewater at the NGL Plant would be very similar to the factors affecting magnitude of impacts from a riverine fuel spill. Both events would involve a release of contaminants to the riverine environment that would gradually dissipate (one through evaporation, the other through horizontal and vertical mixing). Both events would affect riverine biota through similar pathways (inhalation, ingestion, and/or dermal contact). The most significant difference between the two types of events is that whereas natural gas would evaporate more or less immediately upon arrival at the ocean's surface, an untreated release from the NGL Plant would enter and mix through the water column. As described in Section 10.2.11, the size of the mixing zone associated with a release of untreated wastewater from the

NGL Plant would vary according to flow conditions, but under all simulated conditions, a release of untreated wastewater from the NGL Plant would affect a much smaller area of the Demerara River than a fuel spill. This difference is accounted for in the impact ratings by reducing the intensity of impacts associated with a release of untreated wastewater from the NGL Plant relative to a riverine fuel spill, but keeping the other factors (i.e., duration and frequency) unchanged. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small** for impacts on the nutrient cycle, gene flow, and biodiversity.

Based on the sensitivity rating definitions in Table 8.5-4 above the resource sensitivity for ecological balance and ecosystems is considered **Low** for the freshwater and coastal/estuarine ecosystem components. These ratings are principally based on the size of the respective ecosystem relative to the impacts that are anticipated within it and the capacity of the ecosystem to withstand Project-related impacts without reaching an irreversible ecological threshold (e.g., mass extirpation event, conversion of a food web, mass habitat conversion, etc.). The freshwater aquatic ecosystem within the Direct AOI is highly modified and further modifications of the scale and type associated with the Project would not be expected to cause detectable changes in freshwater ecological receptors' functions or values.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude and sensitivity ratings provided above lead to a consequence/severity designation of **Small** for impacts on riverine nutrient cycling, gene flow, and biodiversity. As described in Section 10.1.2, a riverine fuel spill or release of untreated wastewater from the NGL Plant is considered **Unlikely**, so the overall pre-mitigation risk to the riverine ecosystem and marine ecosystem balance from such a release is considered **Minor** (Table 10.2.10-1).

A number of embedded controls are in place to reduce the likelihood of a release of untreated wastewater from the NGL Plant. These would reduce the potential impact on the riverine ecosystem that could occur as a result from this event. However, the residual risk rating is maintained at **Minor**.

10.2.12.5. Loss of Integrity of Onshore Pipeline or NGL Plant Facilities Resulting in Hydrocarbon Release

As described in Section 8.5, Ecological Balance and Ecosystems, the ecological functions of the terrestrial portion of the Project AOI are determined largely by the vegetative structure and conditions at the landscape scale. These factors influence the abiotic and biotic attributes of the terrestrial ecosystem such as water budgets and nutrient exchange, which in turn affect the condition of the plants on the landscape and the animals that depend upon them as forage and for habitat. Section 10.2.10 describes the factors that would influence impacts on both terrestrial plants and animals in the Project AOI as result of a loss of integrity of the onshore pipeline or the NGL Plant, and the ecological effects of such an event would be similar to (and driven by) the impacts discussed in that section. Therefore, the intensity of the impact associated with an onshore hydrocarbon release on ecological balance and ecosystems is considered **Low**. Depending on whether a fire occurred as a result of the release, the impact would persist until the revegetation/recolonization was complete, and this could take more than a year, so the frequency and duration are considered **Continuous** and **Long-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

Based on the sensitivity rating definitions in Table 8.5-4, the resource sensitivity for ecological balance and ecosystems is considered **Low** for terrestrial ecosystem components. The terrestrial ecosystem within the Direct AOI is highly modified, and further modifications of the scale and type associated with the Project would not be expected to cause detectable changes in terrestrial ecological receptors' functions or values. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude and sensitivity ratings provided above lead to a consequence/severity designation of **Small** for impacts on terrestrial ecological balance and ecosystems. As described in Section 10.1.2, an onshore hydrocarbon release is considered **Unlikely**, so the overall pre-mitigation risk to the terrestrial ecosystem of such a release is considered **Minor** (Table 10.2.10-1).

A number of embedded controls are in place to reduce the likelihood of an onshore hydrocarbon release. This would reduce the potential impact on the terrestrial ecosystem that could occur as a result from such an event. However, the residual risk rating is maintained at **Minor**.

Table 10.2.12-1: Risk Ratings for Unplanned Event Impacts on Ecological Balance and Ecosystems

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine Fuel Spill	Marine nutrient cycle, gene flow, and biodiversity	Unlikely	Medium to Small	Minor	Implementation of the OSRP	Minor
Riverine Fuel Spill	Riverine nutrient cycle, gene flow, and biodiversity	Unlikely	Medium to Small	Minor	Implementation of the OSRP	Minor
Loss of Offshore Pipeline integrity	Marine nutrient cycle, gene flow, and biodiversity	Unlikely	Small	Minor	None	Minor
Untreated Wastewater Release from the NGL Plant	Riverine nutrient cycle, gene flow, and biodiversity	Unlikely	Small	Minor	None	Minor
Loss of Onshore Pipeline integrity or NGL Plant Facilities Resulting in Hydrocarbon Release	Vegetative Structure and Height, Distribution of Wildlife	Unlikely	Small	Minor	Implement Emergency Response Plan in the event of a fire	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.13. Special Status Species

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on special status species include the following:

- Marine or riverine fuel spill
- Loss of integrity of the offshore pipeline resulting in a natural gas release
- Untreated wastewater release at the NGL Plant
- Marine mammal, marine turtle, or marine bird strike by a Project vessel
- Loss of integrity of the onshore pipeline or the NGL Plant resulting in a hydrocarbon release

This section assesses the potential impacts of unplanned events on special status species. The discussion follows the organization of the impact assessment of planned Project activities on biological resources, which presents the analysis according to the three categories of environments present in the Direct and Indirect AOI: marine and coastal, terrestrial, and freshwater/riverine.

As discussed in Section 8.6.2.2, Existing Conditions (Special Status Species), any of the 119 special status species with potential to occur in the region could occur within or traverse the Project AOI (including Direct and Indirect AOIs), but none is exclusively restricted to the Project AOI or immediate surroundings, and none relies on the Project AOI for critical life cycles. The majority of the species are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 9.1.3, Existing Conditions and Baseline Studies (Economic), many of these fish species are targeted by the Guyanese commercial fishing industry.

10.2.13.1. Marine and Coastal Special Status Species

There are 103 special status species that occur in the marine and coastal environment within the Direct and Indirect AOI. These include 85 fish, 5 turtle, 5 mammal, and 8 bird species. Several of the bird species also occur in the freshwater/riverine environment. These marine and coastal species could be impacted by the following four unplanned events:

- Marine fuel spill
- Riverine fuel spill
- Loss of integrity of the offshore pipeline resulting in a natural gas release
- Marine mammal, marine turtle, or marine bird strike by a Project vessel

The impacts from these unplanned events on non-special status marine and coastal species, except for marine turtles, which are discussed below, are discussed in Section 10.2.9, Marine and Coastal Biodiversity (Unplanned Events). The impact mechanisms are the same for non-special status and special status species, so the impacts are not discussed further here. However, the sensitivity of special status species to impacts differs from that of non-special status species because of the elevated conservation status (rarity) of the special status species. Section 8.6.3, Impact Prediction and Assessment (Special Status Species), contains the sensitivity definitions established for special status species. Based on these definitions, the sensitivity ratings for marine and coastal special status species range from **Medium** to **High**. The two marine mammals with an International Union for Conservation of Nature (IUCN) rating of Critically Endangered (EN) (i.e., blue whale and Sei whale) have not been sighted to date in the extensive marine mammal observation program conducted by EEPGL. Accordingly, the likelihood rating for these species relative to a potential vessel strike is considered **Unlikely**. The resulting consequence and pre-mitigation risk ratings for impacts on marine and coastal special status species from unplanned events are presented in Table 10.2.13-1.

Marine Turtles

Marine Fuel Spill and Riverine Fuel Spill

As discussed in Section 10.2.9.1, Marine and Riverine Fuel Spills, marine wildlife that contact, breathe, or ingest hydrocarbons can experience a range of lethal or sub-lethal impacts, and in situations involving light hydrocarbons such as marine diesel fuel, these impacts tend to be most severe for air-breathing species because they breathe at the air-water interface where fuel evaporates to form vapors. Marine turtles breathe at the surface, so the intensity of potential impacts on marine turtles from a marine fuel spill is rated **High**, similar to potential impacts on marine mammals and marine birds. On the basis that impacts on marine turtles from a marine fuel spill would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. Even without mitigation, the marine environment would gradually recover to some extent—depending on the size and the extent of the spill—but impacts could still persist beyond a week, yielding a **Medium-term** duration. This produces a magnitude rating of **Medium** for impacts on marine turtles from a marine fuel spill. Marine turtles do not occur in the Demerara River and are not known to congregate at the mouth of the river, so the impacts of a riverine fuel spill on marine turtles is not rated.

The sensitivity of marine turtles ranges from **Medium** to **High** depending on the IUCN listing status of each species. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium** to **Large**. Effective implementation of the OSRP (Volume III of the EIA) could reduce the duration over which a marine fuel spill would be present on the ocean's surface, and reduce the number of individual marine organisms potentially impacted. As such, this would be expected to reduce the intensity of the impact of a mitigated fuel spill on all marine turtle species to **Medium**. This results in a magnitude rating of **Medium** for impacts of a mitigated marine fuel spill on marine turtles and a range of consequence/severity ratings of **Medium** to **Large** for residual impacts on marine turtles. In combination with a likelihood rating of **Unlikely** for a marine fuel spill, the residual risk for marine turtles would be **Minor** for species with an IUCN listing status of Vulnerable (VU) or Near Threatened (NT), and **Moderate** for species with an IUCN listing status of Critically Endangered (CR) or EN.

Loss of Integrity of the Offshore Pipeline Resulting in a Natural Gas Release

As described in Section 10.2.9.2, Loss of Integrity of Offshore Pipeline Resulting in Natural Gas Release, the potential exists for physiological impacts on air-breathing marine biota if the fumes from a leaking natural gas pipeline were to be inhaled at the water surface, but the area of the ocean within which marine biota could be affected by such an event would be very small. Similar to other marine biota, the intensity of the impacts of a loss of integrity of the offshore pipeline on marine turtles is therefore rated **Low.** On the basis that these impacts would persist for as long as the release persisted, the frequency of the impact is rated **Continuous**. A loss of pipeline integrity would be detectable via a loss of pressure in the pipeline virtually immediately, at which point measures would be taken to depressurize the pipeline to stop the release until the source of the leak could be located and addressed. Although pipeline repairs may take longer than a week to make, de-pressurizing the pipeline (if necessary) would be achieved more rapidly, so the duration of the impact would be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

The sensitivity of marine turtles ranges from **Medium** to **High** depending on the IUCN listing status of each species. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Small** to **Medium**. In combination with a likelihood rating of **Unlikely**, the pre-mitigation risk to all marine turtle species from a loss of marine pipeline integrity would be **Minor**. There are no mitigation measures to apply in the event of a loss of offshore pipeline integrity, so the residual risk to marine turtles from a loss of offshore pipeline integrity would also be **Minor**.

Marine Turtle Strike by a Project Vessel

Project vessels will generally travel at slow speeds because they will be actively installing or inspecting the pipeline (in the case of the installation vessels) or supporting the installation vessels (in the case of the support vessels). As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize and spot marine turtles, and will provide standing instructions to Project-dedicated vessel masters on what to do if they encounter marine turtles while in transit (e.g., reduce vessel speed or deviate from course, as needed, to lower the probability of a collision with a marine turtle).

Using the definitions established for assessment of potential impacts on marine turtles from planned Project activities and considering the above information, the intensity of potential impacts on marine turtles as a result of a vessel collision is considered **Medium**. On the basis that vessel traffic will be a consistent presence during the Construction stage but rare thereafter, the frequency is considered to be **Continuous** during the Construction phase and **Episodic** during the Operations and Decommissioning stages. Collisions between Project vessels and marine turtles are likely to result in death or permanent injury to the turtle, so the impacts associated with a collision are considered **Long-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium** during the Construction stage and **Small** during the Operations and Decommissioning stages.

The sensitivity of marine turtles ranges from **Medium** to **High** depending on the IUCN listing status of each species. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a range of consequence/severity ratings of **Medium** to **Large** during the Construction stage, and **Small** to **Medium** during the Operations and Decommissioning stages. Coupled with a likelihood rating of **Unlikely** for a collision with a Project vessel, this yields a range of initial risk ratings of **Minor** for species with an IUCN listing status of VU or NT to **Moderate** for species with an IUCN listing status of CR or EN for impacts during the Construction stage. Initial risk ratings would be **Minor** for all marine turtle species during the Operations and Decommissioning stages. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk ratings would be equivalent to the initial risk ratings for collisions with a Project vessel for all Project stages (Table 10.2.13-1).

10.2.13.2. Terrestrial Special Status Species

There are 13 special status species that occur in the terrestrial environment within the Direct and Indirect AOI. These include 3 plant, 5 bird, 4 mammal, and 1 turtle species. These terrestrial species could be impacted by the following two unplanned events:

- Untreated wastewater release at the NGL Plant
- Loss of integrity of the onshore pipeline or the NGL Plant resulting in a hydrocarbon release

The impacts from these unplanned events on non-special status terrestrial species are discussed in Section 10.2.10, Terrestrial Biodiversity (Unplanned Events). The impact mechanisms are the same for non-special status and special status species, so the descriptions of impacts are not repeated here. As described above for marine and coastal species, the sensitivity of special status species to impacts differs from that of non-special status species because of the elevated conservation status (rarity) of the special status species. Section 8.6.3, Impact Prediction and Assessment (Special Status Species), contains the sensitivity definitions established for special status species. Based on these definitions, the sensitivity rating for terrestrial special status species is **Medium,** based primarily on IUCN Red List Status. As discussed in Section 10.2.10, Terrestrial Biodiversity (Unplanned Events), the magnitude of these impacts on terrestrial non-special status species was rated as **Small** and the same magnitude applies to terrestrial special status species. The resulting consequence of these impacts is therefore **Small** and the pre-mitigation risk rating for impacts on terrestrial special status species from unplanned events is **Minor**, as presented in Table 10.2.13-1.

10.2.13.3. Freshwater Special Status Species

There are three special status species that occur in the freshwater/riverine environment within the Direct and Indirect AOI: American manatee (*Trichechus manatus*), Neotropical otter (*Lontra longicaudis*), and giant otter (*Pteronura brasiliensis*). All of these mammal species occur in the lower Demerara River and inland canal systems of the Direct and Indirect AOI.

These freshwater mammal species could be impacted by the following four unplanned events:

- Riverine fuel spill
- Strike by a Project vessel
- Untreated wastewater release at the NGL Plant
- Loss of integrity of the onshore pipeline or the NGL Plant resulting in a hydrocarbon release

Impacts to these species from unplanned events are not discussed in Section 10.2.11, Freshwater Biodiversity (Unplanned Events), so they are evaluated below. Section 8.6.3, Impact Prediction and Assessment (Special Status Species), contains the sensitivity and intensity definitions established for special status species. Based on these definitions, the sensitivity ratings for freshwater special status species range from **Medium** to **High**.

American Manatee

American manatees occur in the lower Demerara River and its adjacent coastal area, so the species could be impacted by three of the four unplanned events that could impact freshwater special status species: a strike by a vessel in the Demerara River, a riverine fuel spill, and an untreated wastewater release that discharges to the river.

Strike by a Project Vessel

The American manatee would be susceptible to vessel collision in the lower Demerara River. It is well documented that manatees are highly vulnerable to vessel collision, and vessel collision is one of the leading causes of death and considered the greatest adverse impact on the population growth rate of the Florida manatee population (Deutsch and Reynolds 2012; Runge et al. 2007). Rangewide, approximately half of adult manatee mortalities are attributable to human-related causes, primarily watercraft collisions (Ackerman 1995; Deutsch et al. 2002). Less is known about the degree to which vessel collision affects the American manatee population in the Caribbean, but vessel collision is listed by IUCN as one of the key threats to this subpopulation of manatees (IUCN 2021). In Florida, even with vessel restrictions aimed at reducing vessel collisions with manatees (e.g., no wake zones and reduced boat speeds), around 30 percent of annual manatee mortality is attributable to vessel collisions (Aipanjiguly et al. 2003; Nowacek et al. 2004). One of the reasons that manatees are frequently struck by vessels is that manatees spend most of their time at the water surface or within several feet of the water surface, which is within the strike depth of most vessels (Edwards et al. 2016). Rycyk et al. (2018) reported that manatees responded to boats, changing their orientation, depth, and fluking behavior (i.e., using their tail fluke for movement or positioning in the water) most often when a boat approached closely (within about 10 meters). Manatees were also more likely to change their depth or swimming behavior when not on a seagrass bed. Boat speed did not affect the occurrence or intensity of manatee response, but slower passes allowed the manatee more time to respond, and behavioral change occurred earlier relative to the time of the boat's closest point of approach. Faster boats therefore likely pose a greater risk of collision with manatees than slower boats.

Collision between a Project vessel and an American manatee could cause injury or mortality to the affected individual or temporary behavioral changes, but manatees in this area are accustomed to the presence of vessels and are therefore expected to exhibit some level of avoidance behavior when vessels are passing through. No records of vessel collisions with manatees are known from Guyana, although the lack of documentation of vessel collisions with manatees does not necessarily indicate that this impact does not occur, since such incidents may not be reported or vessel operators may not be aware of a collision event. Data from EEPGL's harbor mammal surveys suggest that manatees in the lower Demerara River tend to frequent the nearshore areas outside the main channel. Very few manatees are expected to occur in the main channel of the lower Demerara River, so vessel collision with a manatee, if it were to occur, would be very infrequent.

As an embedded control, EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of riverine mammals at the river or harbor surface, and will provide standing instructions to Project-dedicated vessel masters to avoid riverine mammals while in transit and reduce speed or deviate from course, as needed, to reduce the probability of collision with a riverine mammal.

Using the definitions established for assessment of potential impacts on riverine mammals from planned Project activities, and considering the above information, the intensity of potential impacts on manatees as a result of vessel collision is considered **Low**. On the basis that vessel traffic will be a consistent presence during the Construction stage but rare thereafter, the frequency is considered to be **Continuous** during the Construction stage and **Episodic** during the Operations and Decommissioning stages. A collision between a Project vessel and a manatee is likely to result in death or permanent injury to the manatee, so the impacts associated with a collision are considered **Long-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small** during all Project stages.

American manatees' sensitivity is rated as **Medium** based on their IUCN listing status. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Small**. Coupled with a likelihood of **Unlikely**, the initial risk rating for a collision between an American manatee and a Project vessel would be **Minor**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating for this impact would remain **Minor** (Table 10.2.9-1).

Riverine Fuel Spill

The same physiological pathways for impacts from a riverine fuel spill on marine mammals and turtles from a marine fuel spill also apply to impacts on freshwater mammals. Therefore, the intensity of impacts on American manatees from a riverine fuel spill is rated **High**. On the basis that these impacts would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. On the basis that impacts on manatees from an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the duration of these impacts is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

American manatees' sensitivity is rated as **Medium** based on their IUCN listing status. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**. Effective implementation of the OSRP (Volume III of the EIA) could reduce the duration over which a riverine fuel spill would be present at the water's surface, and reduce the number of individual marine organisms potentially impacted. However, the residual intensity of the impact of a mitigated fuel spill on American manatees would likely remain **Medium**. This results in a residual magnitude rating of **Medium** and a residual consequence/severity rating of **Medium** for impacts of a mitigated riverine fuel spill on American manatees. Coupled with a likelihood rating of **Unlikely**, the initial and residual risk rating for impacts on American manatees would be **Minor**.

Untreated Wastewater Release at the NGL Plant

The sanitary WWTP and process WWTP will collect and treat sanitary and process effluents, respectively, before routing them to the stormwater pond prior to analysis and discharge to the Demerara River either directly or via a canal adjacent to the NGL Plant. The sanitary WWTP will collect all liquid domestic wastes via underground sloped piping. An untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond are released in an uncontrolled manner.

Impacts on freshwater aquatic biodiversity from exposure to untreated wastewater are difficult to predict and depend on several factors such as the specific constituents in the discharge, the concentrations of the constituents in the discharge, the dilution achieved once discharged in the river, and the biological and physical processes that affect the constituents. The most likely impact on water quality in the Demerara River from such an event would be a small-scale decrease in dissolved oxygen in the river. This would have little to no effect on American manatees; however, manatees could possibly be exposed to dermal irritation or infection from untreated sanitary or process wastewater discharges.

Modeling for a river discharge of untreated wastewater predicted that the NGL Plant wastewater effluent would experience a dilution factor within 100 meters of the discharge ranging from 154 to 2,475 in the dry and wet seasons, respectively (Section 7.4.3, Impact Prediction and Assessment [Water Quality]). Further, the situation that would result in discharge from the stormwater pond being unavoidable would likely coincide with the presence of a significant volume of (uncontaminated) stormwater in the stormwater pond; this would inherently dilute the wastewater effluent before it was released from the stormwater pond.

The Project has several embedded controls to reduce the likelihood of an untreated wastewater release. EEPGL will conduct routine maintenance and monitoring to maintain WWTP performance. Additionally, wastewater will be first released to the stormwater pond, which will contain uncontaminated stormwater runoff, resulting in dilution.

Given the extremely limited spatial extent of the area (on land or in the river) that would likely be exposed to discharging untreated effluent, the intensity of impacts of an unplanned wastewater release on American manatee is rated as **Low**. On the basis that exposure to the effluent would persist for as long as the treatment plant continues to not operate properly and the discharge continues, the frequency and duration are considered to be **Continuous**. The treatment plant operations would likely be corrected in a short time, but the duration is conservatively rated as **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Small**. Combined with a likelihood of **Possible**, the initial risk rating for impacts on American manatee from an untreated wastewater release at the NGL Plant would be **Minor**. All of the available measures to minimize the risk of an unplanned release of untreated wastewater have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating. Accordingly, the residual risk rating for this impact would remain **Minor** (Table 10.2.9-1).

Neotropical Otter

Neotropical otters occur in the lower Demerara River and its adjacent coastal area as well as inland canals within the onshore portion of the Direct and Indirect AOI, so the species could be impacted by three of the unplanned events that could impact freshwater special status species: a riverine fuel spill, untreated wastewater release, and loss of integrity of the onshore pipeline resulting in a hydrocarbon release. Otters are fast-moving species, particularly when in the water, and they avoid vessel traffic, so they would not be expected to be impacted by a vessel strike.

Riverine Fuel Spill

In the unlikely event of a riverine fuel spill, Neotropical otters within and along the lower Demerara River could be affected. The species was infrequently observed in the lower Demerara River during baseline surveys conducted in support of this EIA. The potential severity of the impact of a riverine fuel spill event on Neotropical otters is dependent on the size, location, and timing of the release and whether otters are present in the impacted area when fuel is present on the water surface. Nevertheless, otters breathe and often forage at or near the water surface, so the same physiological pathways described above for impacts on marine mammals and turtles from a riverine fuel spill also apply to impacts on Neotropical otters. Therefore, the intensity of impacts on Neotropical otters from a riverine fuel spill is rated **High**. On the basis that these impacts would persist as long as the spill remained unmitigated and present in or on the water, the frequency is considered to be **Continuous**. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. The impacts on Neotropical otters from an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, so the duration of impact is considered **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**.

The sensitivity rating for Neotropical otter is **Medium** based on the species' IUCN listing status. Applying the impact assessment methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity rating of **Medium**. Coupled with a likelihood rating of **Unlikely**, the pre-mitigation risk rating for impacts on Neotropical otter from a riverine fuel spill is **Minor** (Table 10.2.13-1). Effective implementation of the OSRP (Volume III of the EIA) could reduce the duration over which a riverine fuel spill would be present at the water's surface and limit the exposure of the shoreline and riverbank where otters spend most of their time. This could reduce the number of individual otters potentially impacted by a riverine fuel spill. Nevertheless, some exposure through surface water and inhalation would still be possible, so the residual risk rating is maintained at **Minor**.

Untreated Wastewater Release at the NGL Plant

An untreated wastewater release from the NGL Plant could occur if one of the WWTPs experiences an operational upset (i.e., to the extent that the effluent was above treatment specifications) and—at the same time—the stormwater pond capacity is exhausted such that the contents of the stormwater pond overtops the pond and is released as overland flow across the site. If the effluent is discharged to the river, Neotropical otters present where the release occurs could be exposed. The impacts on otters from exposure to untreated wastewater are difficult to predict and depend on several factors such as the specific constituents in the discharge, whether the discharge occurs over land or in the river, the concentrations of the constituents in the discharge, the dilution achieved once discharged in the river, and the biological and physical processes that affect the constituents. The primary constituents in the wastewater effluents will include solids and biodegradable organics (usually measured in terms of biochemical oxygen demand), metals, oil and grease, nutrients (primarily nitrogen and phosphorous), and pathogens such as coliform.

Modeling for a river discharge of untreated wastewater predicted that the NGL Plant wastewater effluent will experience a dilution factor within 100 meters of the discharge ranging from 154 to 2,475 in the dry and wet seasons, respectively (Section 7.4.3, Impact Prediction and Assessment [Water Quality]). Further, the situation that would result in discharge from the stormwater pond being unavoidable would likely coincide with the presence of a significant volume of (uncontaminated) stormwater in the stormwater pond; this would inherently dilute the wastewater effluent before it was released from the stormwater pond.

Given the extremely limited spatial extent of the area in the river that would likely be exposed to discharge of untreated effluent, and the correspondingly small number of otters that would be expected to occur in the impacted area during the short period in which the potential for exposure persists, the intensity of impacts of an unplanned wastewater release on Neotropical otters is rated as **Low**. On the basis that exposure to the effluent would persist for as long as the treatment plant continues to not operate properly and the discharge continues, the frequency is considered to be **Continuous**. The treatment plant operations would likely be corrected in a short time, but the duration is conservatively rated as **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude of **Small**.

The sensitivity rating for Neotropical otter is **Medium** based on the species' IUCN listing status. Therefore, applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.5, Untreated Wastewater Release at the NGL Plant, an unplanned release of wastewater from the NGL Plant is considered **Possible**. Accordingly, the overall pre-mitigation risk to Neotropical otters from an untreated wastewater release is considered **Minor** (Table 10.2.13-1).

While EEPGL would take measures to restore the WWTP functionality if this type of event occurred, this would not necessarily prevent the overtopping of the stormwater pond in a significant rainfall event. Accordingly, the residual risk rating is maintained at **Minor**.

Loss of Integrity of the Onshore Pipeline or the NGL Plant

In the unlikely event of an onshore hydrocarbon release from a loss of integrity of the onshore pipeline or of the NGL Plant facilities, these events could result in injury or mortality to Neotropical otters near the portion of Project infrastructure where the event occurs and the immediate surrounding impact area where a fire occurs (assuming the event results in a fire). As described in Section 10.1.4.3, Modeling of Hydrocarbon Releases, under all modeled scenarios, the zone of impact is expected to be confined to the immediate vicinity (within approximately 1 kilometer) of the NGL Plant or portion of the onshore pipeline where the release occurs.

Neotropical otters are highly mobile and have large home ranges. They move between the Demerara River and the inland canals in the Direct and Indirect AOI through interconnecting canals and kokers and also over land along riparian corridors. They were infrequently observed during baseline studies conducted in support of this EIA and they strongly prefer undegraded and undisturbed forested riparian habitats with low levels of modification (Alarcon and Simões-Lopes 2003). Depending on the location of a hydrocarbon release, if Neotropical otters are present in the impact area, they could be injured, killed, or displaced during the event and related emergency response. Neotropical otter density in the onshore portion of the Direct and Indirect AOI is low, and the number of individuals impacted by an unplanned onshore hydrocarbon release would likely be correspondingly low, depending on the size and location of the release. Further, the species is highly mobile, so any individuals that may be present in or near the impact area would be expected to move away from the impacted area if they are able to do so (if they are not injured or killed by the unplanned event). As such, the intensity rating for impacts on Neotropical otters from this unplanned event is **Low**.

Under a worst-case scenario, the current riparian and aquatic habitat within the fire zone would be permanently altered; however, the impact area would revegetate and wildlife, possibly including otters, would recolonize the area. The impact would persist until the revegetation/recolonization was complete, and this could take more than a year, so the frequency and duration are considered **Continuous** and **Long-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

The sensitivity rating for Neotropical otter is Medium based on the species' IUCN listing status. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.4, Onshore Hydrocarbon Release, an onshore hydrocarbon release is considered **Unlikely**, so the overall pre-mitigation risk of such a release to Neotropical otter is considered **Minor** (Table 10.2.13-1).

If a fire occurs as a result of the unplanned event, EEPGL would implement its Emergency Response Plan, which would include measures to control the fire. This would reduce the potential impact on Neotropical otter that could occur as a result of the fire spreading. However, the residual risk rating is maintained at **Minor**.

Giant Otter

Giant otters occur in the inland canal habitats of the Direct and Indirect AOI and so could be impacted by only one of the four unplanned events that could impact freshwater special status species: a loss of integrity of the onshore pipeline or the NGL Plant resulting in a hydrocarbon release. The impact mechanisms described above for Neotropical otter apply to giant otter. Giant otter density in the onshore portion of the Direct and Indirect AOI is low, and the number of individuals impacted by an unplanned onshore hydrocarbon release would likely be correspondingly low, depending on the size and location of the release. Further, the species is highly mobile, so any individuals that may be present in or near the impact area would be expected to move away from the impacted area if they are able to do so (if they are not injured or killed by the unplanned event). As such, the intensity rating for impacts on giant otter from this unplanned event is **Low**.

Under a worst-case scenario, the current riparian and aquatic habitat within the fire zone would be permanently altered; however, the impact area would revegetate and wildlife, possibly including otters, would recolonize the area. The impact would persist until the revegetation/recolonization was complete, and this could take more than a year, so the frequency and duration are considered **Continuous** and **Long-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

This species has a sensitivity rating of **High** due to the species' IUCN Red List EN status. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 10.1.4, Onshore Hydrocarbon Release, an onshore hydrocarbon release is considered **Unlikely**, so the overall pre-mitigation risk of such a release to giant otters is considered **Minor** (Table 10.2.13-1).

If a fire occurs as a result of the unplanned event, EEPGL would implement its Emergency Response Plan, which would include measures to control the fire. This would reduce the potential impact on giant otters that could occur as a result of the fire spreading. However, the residual risk rating is maintained at **Minor**.

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Table 10.2.13-1: Risk Ratings for Unplanned Event Impacts on Special Status Species

Unplanned Event	Resource/ Receptor	Sensitivity	Magnitude	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine and Coastal Special Status Species								
Marine fuel spill	Mammal species (EN)	High	Medium	Unlikely	Large	Moderate	Implement OSRP	Moderate
	Mammal species (VU and NT)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
	Fish species (CR and EN)	High	Medium	Unlikely	Large	Moderate	Implement OSRP	Moderate
	Fish species (VU and NT)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
	Turtle species (CR and EN)	High	Medium	Unlikely	Large	Moderate	Implement OSRP	Moderate
	Turtle species (VU and NT)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
	Bird species (EN)	High	Medium	Unlikely	Large	Moderate	Implement OSRP	Moderate
	Bird species (VU and NT)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
Riverine fuel spill	Mammal species (EN)	High	Small	Unlikely	Medium	Minor	Implement OSRP	Minor
	Mammal species (VU and NT)	Medium	Small	Unlikely	Small	Minor	Implement OSRP	Minor
	Fish species (VU and NT)	Medium	Small	Unlikely	Small	Minor	Implement OSRP	Minor
	Bird species (VU and NT)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
Loss of integrity of the offshore pipeline	Fish species (CR and EN)	High	Small	Unlikely	Medium	Minor	None	Minor
	Fish species (VU and NT)	Medium	Small	Unlikely	Small	Minor	None	Minor
	Turtle species (CR and EN)	High	Small	Unlikely	Medium	Minor	None	Minor
	Turtle species (VU and NT)	Medium	Small	Unlikely	Small	Minor	None	Minor
	Bird species (VU and NT)	Medium	Small	Unlikely	Small	Minor	None	Minor
Vessel strike	Mammal species (EN)	High	Medium (C) Small (O, D)	Unlikely	Large (C) Medium (O, D)	Moderate (C) Minor (O, D)	None	Moderate (C) Minor (O, D)
	Mammal species (VU and NT)	Medium	Medium (C) Small (O, D)	Possible	Medium (C) Small (O, D)	Moderate (C) Minor (O, D)	None	Moderate (C) Minor (O, D)
	Turtle species (CR and EN)	High	Medium (C) Small (O, D)	Unlikely	Large (C) Medium (O, D)	Moderate (C) Minor (O, D)	None	Moderate (C) Minor (O, D)
	Turtle species (VU and NT)	Medium	Medium (C) Small (O, D)	Unlikely	Medium (C) Small (O, D)	Minor (C, O, D)	None	Minor (C, O, D)
	Bird species (EN)	High	Small	Unlikely	Medium	Minor	None	Minor
	Bird species (VU and NT)	Medium	Small	Unlikely	Small	Minor	None	Minor
Terrestrial Special Status Species								
Untreated wastewater release at the NGL Plant	Special status birds (NT and VU)	Medium	Small	Possible	Small	Minor	None	Minor
	Special status mammals (NT and VU)	Medium	Small	Possible	Small	Minor	None	Minor
	Special status turtle (VU)	Medium	Small	Possible	Small	Minor	None	Minor

Unplanned Event	Resource/ Receptor	Sensitivity	Magnitude	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Loss of integrity of the onshore pipeline or the NGL Plant resulting in hydrocarbon release	Special status birds (NT and VU)	Medium	Small	Unlikely	Small	Minor	Implement Emergency Response Plan in the event of a fire	Minor
	Special status mammals (NT and VU)	Medium	Small	Unlikely	Small	Minor	Implement Emergency Response Plan in the event of a fire	Minor
	Special status turtle (VU)	Medium	Small	Unlikely	Small	Minor	Implement Emergency Response Plan in the event of a fire	Minor
Freshwater Special Status Species								
Riverine fuel spill	American manatee (*Trichechus manatus*)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
	Neotropical otter (*Lontra longicaudis*)	Medium	Medium	Unlikely	Medium	Minor	Implement OSRP	Minor
Vessel strike	American manatee (*Trichechus manatus*)	Medium	Small	Unlikely	Small	Minor	None	Minor
Untreated wastewater release at the NGL Plant	American manatee (*Trichechus manatus*)	Medium	Small	Possible	Small	Minor	None	Minor
	Neotropical otter (*Lontra longicaudis*)	Medium	Small	Possible	Small	Minor	None	Minor
	Neotropical otter (*Lontra longicaudis*)	Medium	Small	Unlikely	Small	Minor	None	Minor
	Giant otter (*Pteronura brasiliensis*)	High	Small	Unlikely	Medium	Minor	None	Minor

C = Construction stage; O = Operations stage; D = Decommissioning stage

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.14. Socioeconomic Conditions

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on socioeconomic conditions include the following:

- Marine or riverine fuel spill
- Vessel collision with a third-party vessel or structure (non-spill related)
- Onshore hydrocarbon release (including loss of integrity of onshore pipeline)

These events could impact socioeconomic conditions, specifically fishing livelihoods as a result of a marine or riverine fuel spill or a vessel collision, and businesses within proximity to the portion of the onshore pipeline where an onshore hydrocarbon release occurred. As the nature of the potential impact on this resource would be similar for marine or riverine fuel spill and a vessel collision, the risk ratings for these unplanned events are discussed together.

10.2.14.1. Marine or Riverine Fuel Spill, Vessel Collision

As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, in each of the marine fuel spill scenarios, the simulations indicated that the spill would spread predominantly in a direction parallel to the shoreline, with minimal lateral spreading toward the shoreline. Therefore, assuming the spill occurred outside of the immediate nearshore area, there would be no expected direct impact to the coastal agriculture sector as a result of a marine fuel spill. A marine fuel spill could result in impacts on fishery activities, either as a result of actual reduction in fish presence, interference with or closure of active fishing areas while the spill is still present on the water surface, or as a result of actual or perceived tainting of commercial fish products.

Spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, affected shorelines were predicted at various points along the west bank of the Demerara River from the shore landing to approximately 4 kilometers south of the temporary MOF (with the areas of shoreline affected dependent on the river flow conditions and tidal stage at the time of the spill). This predictive modeling results reflect the presence of any fuel amount that would encounter a shoreline, regardless of a thickness threshold. The modeling also shows the geographic extent within the river where fuel on the surface of the water would be expected at various points in time during the spill scenario, depending upon winds and tidal influences. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. As a result of a riverine fuel spill, fisheries may be impacted by any temporary reduction in fish populations or closure of active fishing areas or landing sites along the banks of the Demerara River (i.e., to allow for cleanup or to avoid potential public health impacts). There could also be a decreased demand for fish as a result of actual or perceived tainting of fish products as a result of the spill.

Depending on tidal conditions and the extent of spread of the spill, a riverine fuel spill also could prevent the opening of sluices to allow for drainage of lands along the Demerara River. Sluices not opening could prevent the spill moving inland into canals, but if this happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the potential consequence from a flooding perspective.

As discussed in Section 10.1.3.1, Vessel Collision with a Third-Party Vessel or Structure, there is a potential for collisions between Project vessels and third-party vessels/structures in the Georgetown Harbour / Demerara River area or for the nearshore grounding of a vessel. Such a vessel collision could result in damage to a vessel used for fishing or other commercial/subsistence purposes, leading to an impact related to income or livelihood for the affected individual(s).

The intensity of an unmitigated marine or riverine fuel spill or a vessel collision impacting commercial or artisanal fisherfolk and other economic users of marine and river waters is considered **High**. This is based on the importance of the fishing industry to the economy of Guyana as well as for subsistence in the Direct AOI. On the basis that restrictions on fishing livelihoods could persist over at least a multi-week period (although they would reduce significantly with time as the spilled fuel continued to weather), the frequency is considered to be **Continuous**. Response efforts (if required depending upon the magnitude of the spill and the evaporation and dispersion of fuel) would likely be less than a week in duration. Actual tainting of fish products as well as perceptions about potentially contaminated fish leading to decline in demand would likely persist until response efforts, including community outreach programs, were completed and for some period thereafter. Therefore, the duration is conservatively considered to be **Medium-term**. This results in a magnitude rating of **Medium**.

Consistent with the sensitivity ratings assigned for socioeconomic impacts from planned events, a sensitivity rating of **Medium** is assigned as both commercial and artisanal fisherfolk may adapt to the change with assistance and with some disruption in their ability to subsist and/or earn income.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, and Section 10.1.3, Vessel Collision with a Third-party Vessel, Structure, or Animal (Non-Spill-Related), a marine or riverine fuel spill and a vessel collision is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to fisherfolk loss of marine or river-based livelihood as a result of a marine or riverine fuel spill or vessel collision is considered **Minor** (see Table 10.2.14-1).

There are a number of embedded controls in place to reduce the likelihood of a marine or river fuel spill and a vessel collision. In terms of mitigation measures to respond to the impact, EEPGL will implement a claims process and, as appropriate, a livelihood remediation program (see Section 10.3, Claims and Livelihood Remediation Processes) would be established at the onset of a marine or riverine fuel spill of sufficient magnitude to affect livelihoods of fisherfolk and/or other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). This livelihood remediation program would address economic losses or impacts on livelihoods as a result of a marine or riverine fuel spill. In the case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, EEPGL would provide appropriate restitution consistent with governing contracts and applicable laws. While any compensation, claims, and restoration program would address economic losses, there would be a period of time immediately after the unplanned event and before the program benefits are realized where the livelihood impact would be maintained by the receptor(s). Accordingly, the residual risk rating remains at **Minor**.

10.2.14.2. Onshore Hydrocarbon Release (Loss of Integrity of Onshore Pipeline)

As discussed in Section 10.1.4.1, Loss of Integrity of Onshore Pipeline, an onshore hydrocarbon release as a result of loss of integrity of the onshore pipeline could result in a flammable gas cloud igniting, causing either a flash fire or explosion. In this unlikely event, there could be an impact on socioeconomic conditions as a result of damage to brick-and-mortar businesses (e.g., store fronts, food stalls, commercial properties), if any are present, within proximity to the portion of the onshore pipeline where the loss of integrity occurred. This could lead to income or livelihood loss. Although the extent of the impact would depend upon the nature and location of the explosion or release and the nature of weather conditions, the direct radius of an effect that could result in this type of damage is estimated to be no more than 1 kilometer based on preliminary consequence modeling conducted (see Figure 10.1-14 and Figure 10.1-15). If this unplanned event was to occur in more populated areas where structures are closer together and more businesses are prevalent (e.g., Crane), it could have a more significant impact on livelihoods, versus if the unplanned event occurred in less populated areas along the onshore pipeline route. An explosion or flash fire could also impact local agriculture and subsistence farming within the radius of effect, which could impact individual or community-level receptors depending upon the location.

The economies in the Direct AOI are highly dependent on fishing and agriculture for employment, income generation, and subsistence. These communities would be sensitive to impacts on fisheries and crop production that could result from any of these unplanned event scenarios. Furthermore, the loss of a residential home as a result of an explosion or flash fire would impact the occupant's ability to work or pursue income generating opportunities until such time as new housing was provided and/or compensation/remediation received.

Considering that the impact is dependent upon the exact location of the release and the resultant proximity to businesses, agriculture, and housing, this assessment conservatively assumes that any community with households, structures, and agricultural land (including grazing for animals) within a 1-kilometer radius within the onshore pipeline could be impacted in a worst-case scenario, and this could result in chronic hardship for households and/or small and medium-size businesses, or the changes could cause the receptors to cease their current livelihood activities for an extended period of time, or indefinitely. Therefore, the intensity of impact on socioeconomic conditions from a loss of onshore pipeline integrity resulting in a natural gas release is considered to be as much as **High**. On the basis that the impact of loss of onshore pipeline integrity would persist until the compromised infrastructure or livelihood was restored, the frequency is considered to be **Continuous**. Restoration in the event of a significant event (e.g., explosion or fire resulting in complete loss of livelihood) may take longer than a year, so duration is considered **Long-term**. This result in a magnitude rating of **Large**.

Consistent with the sensitivity rating assigned for potential impacts on socioeconomic conditions, households and businesses within the Direct AOI may have limited resources or capability to seek alternative livelihoods, and therefore sensitivity is considered **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Large**. As described in Section 10.1.4, Onshore Hydrocarbon Release, loss of integrity of the onshore pipeline is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to livelihoods of households, businesses, and farmers in the Direct AOI as a result of a loss of integrity of the onshore pipeline is considered **Moderate** (see Table 10.2.16-1).

There are a number of embedded controls in place to reduce the likelihood of an onshore hydrocarbon release. In terms of mitigation measures to respond to the impact, EEPGL will implement a claims process and, as applicable, a livelihood remediation program (see Section 10.3, Claims and Livelihood Remediation Processes) to address economic losses or impacts on livelihood as a result of damages to property or loss of livelihood stemming from an onshore hydrocarbon release. While any compensation, claims and restoration program will address economic losses, there will be a period of time immediately after the unplanned event and before the program benefits are realized where the livelihood impact will persist for the receptor(s). Accordingly, the residual risk rating remains at **Moderate**.

Table 10.2.14-1: Risk Ratings for Unplanned Event Impacts on Socioeconomic Conditions

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine and Riverine Fuel Spill / Vessel Collision	Deep-sea commercial fisherfolk	Unlikely	Medium	Minor	Claims and Livelihood Remediation Process	Minor
Loss of Integrity in Onshore Pipeline, Resulting in Natural Gas Release	Households, businesses, farmers along the onshore pipeline corridor, within a 1-kilometer radius of the point at which a loss of pipeline integrity occurs	Unlikely	Large	Moderate	Claims and Livelihood Remediation Process; Implement Emergency Response Plan in the event of a fire	Moderate

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.15. Community Health and Wellbeing

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on community health and wellbeing include the following:

- Marine or riverine fuel spill
- Onshore hydrocarbon release (loss of integrity of onshore pipeline or NGL Plant facilities)
- Loss of integrity of offshore pipeline resulting in natural gas release

10.2.15.1. Marine or Riverine Fuel Spill

Although Guyana as a nation is considered self-sufficient for food, disparities in food supply and family incomes create challenges in maintaining food security and proper nutrition in some communities, particularly rural populations. The result is that malnutrition and anemia are among the leading causes of death in Guyanese children.

Rural communities in the Direct AOI are dependent on fishing and agriculture for subsistence and livelihoods. In Region 3, agriculture is largely centered around farming of rice, sugar cane, and coconuts. In the Direct AOI, agriculture, fishing, and forestry comprise the largest proportion of employment among the 2021 household socioeconomic survey respondents, with over 50 percent of the 234 respondents indicating one or more of these sectors as their primary employment. Approximately 35 percent of surveyed households reported fishing in canals and other areas for primarily recreation and/or household consumption.

Fish and traditional crops such as vegetables and fruits are consumed or often sold locally at markets or roadside stands throughout the Direct AOI. Adverse impacts on these resources as a result of a marine or riverine fuel spill could have direct health impacts through entry of harmful substances into the food chain, or through malnutrition if local food supplies become unavailable. Impacts on these sectors could also have impacts via the social determinants of health. If livelihoods are impacted (as discussed in Section 10.2.14, Socioeconomic Conditions), increased household poverty could impact economic security, quality of life, access to education, and other health-promoting and health-protective resources. Increased economic hardship can also lead to or exacerbate familial problems and mental health impacts, including increased anxiety and suicide, especially for already vulnerable populations.

The intensity of an unmitigated marine or riverine fuel spill impacting food availability in the Direct AOI, and therefore the health of affected communities, is considered **High**. This is due to the following factors: (1) dependence on the marine and/or riverine environment for subsistence and income and the use of rivers and canals for transportation and daily household activities such as washing as well as bathing, (2) the high rate of poverty, (3) the current health challenges faced by rural populations in Guyana, and (4) the potential for human exposure to hydrocarbon constituents through pathways such as inhalation and consumption of food impacted by the spill.

On the basis that potential impacts from an unmitigated marine or riverine fuel spill would persist only until which time as the fuel would naturally evaporate or degrade, which is relatively quickly, the frequency is considered **Episodic**. However, the perception of impacts to fish and fish products, and resultant stress related to economic hardship that would likely coincide with the duration of these perceptions, could persist long after any response efforts were completed. Therefore, the potential duration is considered to be **Medium-term**. This results in a magnitude rating of **Small**.

Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors within the Direct AOI, in which a large portion of the population is disadvantaged and there are many areas of health vulnerability that act as barriers to protecting and promoting health, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine or riverine fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to community health and wellbeing in the Direct AOI as a result of a marine or riverine fuel spill is considered **Minor** (see Table 10.2.15-1). As mitigation measures, EEPGL would implement a spill response plan in the event of a marine or riverine spill scenario that would take into consideration community health and wellbeing factors. EEPGL would also institute a claims process, and where required, livelihood remediation (see Section 10.3, Claims and Livelihood Remediation Processes), which would provide support to affected individual(s) and further mitigate potential follow-on community health and wellbeing impacts due to loss of sustenance. On this basis, the residual risk rating is reduced to **Minor**.

10.2.15.2. Onshore Hydrocarbon Release (Loss of Integrity of Onshore Pipeline or NGL Plant Facilities)

As discussed in Section 10.1.4.1, an onshore hydrocarbon release as a result of loss of onshore pipeline integrity could result in a flammable gas cloud igniting, causing either a flash fire or explosion. In this unlikely event, there could be an impact on human health potentially resulting in injury or death. The extent of the impact and consequence on community health and wellbeing would be a function of the nature and location of the explosion or release, and the severity of any health impacts. The direct radius of the explosion or release is estimated to be no more than 1 kilometer based on preliminary consequence modeling (see Figure 10.1-14 and Figure 10.1-15). If this type of unplanned event were to occur along a portion of the onshore pipeline segment where no population resides, the intensity could be **Low**. However, in more heavily populated areas along the onshore pipeline corridor (e.g., Lust-en-Rust / Westminister), the incident could result in a profound and measurable change in the health status at the community level. Therefore, while the intensity of an onshore hydrocarbon release due to loss of onshore pipeline integrity is location-dependent, it could be **High** in a worst-case scenario.

If a hydrocarbon release were to occur at the NGL Plant, this could also result in a jet fire or a flammable cloud, both of which could potentially impact resources outside the NGL Plant boundary. However, considering that no houses or populated areas are within the radius of effect based on preliminary consequence modeling, the anticipated incidence of a health-related risk at an individual level (for a member of the community) is very rare. Therefore, the intensity of an onshore hydrocarbon release due to loss of integrity of the NGL Plant, which is not location-dependent, is rated as **Low**.

On the basis that the impact resulting from a loss of onshore pipeline or NGL Plant integrity would persist until the cessation of the resulting consequence (e.g., fire, explosion), the frequency is considered to be **Continuous**. Restoration of community health and wellbeing in the event of a significant event (e.g., explosion or fire resulting in significant destruction affecting individual or community health and wellbeing) may take longer than a year, so the duration is considered **Long-term**. This results in a magnitude rating of **Small** to **Large** for a loss of onshore pipeline integrity, depending on the location where the loss of integrity occurred, and **Small** for a loss of integrity of the NGL Plant.

Consistent with the sensitivity ratings assigned for potential impacts on community health and wellbeing for receptors within the Direct AOI, in which a large portion of the population is disadvantaged and there are many areas of health vulnerability that act as barriers to protecting and promoting health, a sensitivity rating of **High** is assigned.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Medium** to **Large** for a loss of onshore pipeline integrity and **Medium** for a loss of integrity of the NGL Plant. As described in Section 10.1.4, Onshore Hydrocarbon Release, a loss of onshore pipeline integrity or NGL Plant integrity are both considered **Unlikely** based on a series of embedded controls that will be in place. Accordingly, the overall pre-mitigation risk to community health and safety in the Direct AOI as a result of a loss of onshore pipeline integrity is considered **Minor** to **Moderate** and as a result of a loss of integrity of the NGL Plant is considered **Minor** (see Table 10.2.15-1).

A number of embedded controls are in place to reduce the likelihood of an onshore hydrocarbon release. However, there are no reasonable mitigations that can reduce the residual risk rating if such an event were to occur. Accordingly, the residual risk rating remains at **Minor** to **Moderate**.

10.2.15.3. Loss of Integrity of Offshore Pipeline Resulting in a Natural Gas Release

As noted in Section 10.1.2, a loss of offshore pipeline integrity resulting in a natural gas release could result in a fire or explosion if the released gas disperses into the atmosphere and encounters an ignition source. This could have an adverse impact on any humans in the immediate vicinity of the fire. The consequences would likely be much less severe offshore than a release from the onshore pipeline because an offshore release would be extremely unlikely to result in a fire or explosion. Further, given the low probability that a receptor (e.g., a fishing boat) would be present in the specific area where a loss of integrity occurred, the anticipated incidence of a health-related risk at an individual level would be very rare. If the loss were to occur at a location very close to land, however, the characteristics of a release could transition from those of a subsea release to those that would be closer in character to an onshore pipeline release, and an explosion could be more likely (but still unlikely) to occur. The pipeline will be buried in the shallow-water section (up to 20 meters water depth) with an adequate burying depth (1.2 meters above the top of the pipe) to prevent third-party strikes which are leading potential causes of a loss of integrity. The fishing exclusion zones established during pipeline operations will further reduce the likelihood of such an event occurring. Therefore, the intensity of an offshore pipeline resulting in a natural gas release affecting community health and wellbeing is rated as **Negligible**.

On the basis that the impact of loss of offshore pipeline integrity would persist until the comprised infrastructure was restored, the frequency is considered to be **Continuous**. Restoration of community or individual health and wellbeing in the event of a significant event (e.g., explosion or fire resulting in complete loss of livelihood) could take longer than a year, so duration is considered **Long-term**. This results in a magnitude rating of **Negligible**. Consistent with the sensitivity rating assigned for potential impacts on community health and wellbeing for fisherfolk, who typically face socioeconomic challenges that act as barriers to health protection and promotion, sensitivity is considered **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.2, Loss of Integrity of Offshore Pipeline Resulting in a Natural Gas Release, a loss of offshore pipeline integrity is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to community health and safety for fisherfolk offshore as a result of a loss of offshore pipeline integrity is considered **Minor** (see Table 10.2.15-1).

Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating remains **Minor** (see Table 10.2.15-1).

Table 10.2.15-1: Risk Ratings for Unplanned Event Impacts on Community Health and Wellbeing

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine and Riverine Fuel Spill	Individuals, communities within the Direct AOI	Unlikely	Small	Minor	Institute claims and livelihood remediation process, as necessary	Minor
Loss of Integrity in Onshore Pipeline, Resulting in Hydrocarbon Release	Individuals, communities along the onshore pipeline corridor, within a 1-kilometer radius of the incident (location dependent)	Unlikely	Medium to Large	Minor to Moderate	Implement Emergency Response Plan in the event of a fire	Minor to Moderate
Loss of Integrity in NGL Plant, Resulting in Hydrocarbon Release	Individuals, communities along the onshore pipeline corridor, within a 1-kilometer radius of the incident	Unlikely	Medium	Minor	None	Minor
Loss of Integrity in Offshore Pipeline, Resulting in Natural Gas Release	Deep-sea and nearshore commercial and artisanal fisherfolk	Unlikely	Small	Minor	None	Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.16. Social Infrastructure and Services

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on social infrastructure and services include the following:

- Marine or riverine fuel spill
- Onshore hydrocarbon release (including loss of integrity of onshore pipeline or a loss of integrity of NGL Plant facilities).

10.2.16.1. Marine or Riverine Fuel Spill

As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, in each of the marine diesel fuel spill scenarios, none of the simulations were predicted to reach shore. Therefore, there would be no direct impact to social infrastructure and services as a result of a marine fuel spill, except in an emergency response scenario. Depending on the extent of the required response, an increased demand for lodging for response teams may be the most likely impact on social infrastructure and services. These increased demands would be temporary, existing only for the duration of the required cleanup, likely in the range of a few weeks for a marine fuel spill and only a matter of days for a riverine spill, depending on the extent of the spill, shoreline impact, and complexity of remediation efforts. Since the potential spill remains offshore for a marine fuel spill, infrastructure and service demands would likely be concentrated in Georgetown, where most response vessels would be based, and where infrastructure and services capacities are greater.

The response effort for a riverine fuel spill would include shoreline protection if warranted but likely not removal of fuel from the water surface (the fuel would naturally evaporate or degrade relatively rapidly) and therefore would not require significant amount of vessels or resources, although some response personnel could require lodging in Region 3 near the spill response location for a short duration of time.

The impact of intensity of a marine or riverine fuel spill on Georgetown and Region 3 lodging infrastructure capacity would be a function of the scale of the event and the volume of personnel assigned to the response effort**.** Considering the potential size of a response workforce compared to the extensive inventory of available lodging in Georgetown (i.e., more than 1,250 rooms in the seven hotels primarily frequented by EEPGL and its contractors), an associated increase in demand for lodging in Georgetown may be perceptible, but would likely only cause minimal changes in availability. This would be the same for Region 3, where a 52-room resort is located in Vreed-en-Hoop and various guest houses / room rentals are located in communities throughout the Direct AOI. On this basis, the intensity of impact related to the response effort is conservatively predicted to be **Low**. These lodgings could serve in the short term for response team housing within close proximity to a riverine spill event. On the basis that the additional lodging demands would persist throughout the spill response effort, the frequency is considered to be **Continuous**. Response efforts for a marine spill would likely be completed within weeks (and certainly less than a year), so duration is considered to be no more than **Medium-term**. Consistent with the planned activities' sensitivity ratings assigned for potential impacts on leisure and business travelers, a conservative approach is taken and a **Medium** level of sensitivity to increased demand and/or price for lodging is assigned.

Spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, affected shorelines were predicted at various points along the west bank of the Demerara River from the shore landing to approximately 4 kilometers south of the temporary MOF. This predictive modeling reflects the presence of any fuel amount that would encounter a shoreline, regardless of a thickness threshold. Generally, the shoreline along the west bank of the Demerara River is protected by mangroves and other natural vegetation with only a few structures in direct proximity to the shoreline in communities near Canal 1, south of La Grange. The affected shorelines could also impact the riverbank area where Canal 1 meets the Demerara River. There does not appear to be any telecommunications, power infrastructure, or water and sanitation-specific infrastructure along any portion of the riverbank that would be potentially impacted by affected shorelines.

The impact of affected shorelines as a result of a riverine fuel spill could create limited and temporary loss of access to structures and/or the canal for a limited number of households nearest the river bank in the Canal 1 area. Since this is a limited geographic area and would not affect access or usage at a community level, the intensity is considered **Low**. On the basis that the impact as a result of affected shorelines would persist only for a few days (the fuel would naturally evaporate or degrade relatively rapidly) and depending upon the extent of the spill, response efforts could include shoreline protection if warranted, the frequency is considered to be **Episodic**. Response efforts, if warranted, to protect the shoreline would likely be completed within days so duration is considered to be no more than **Short-term**. Consistent with the sensitivity rating assigned for potential impacts to households within the Direct AOI that may have limited options to access areas near the canal, or for those who use that area of the canal for their personal or household use, sensitivity is considered **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small** (for impacts to lodging) and **Small** (for impacts to housing and canal use). As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine or riverine fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to Georgetown and Region 3 lodging infrastructure from a marine or riverine fuel spill response effort, as well as access impacts to structures and canals in a small geographic area near Canal 1 as a result of affected shorelines from a riverine fuel spill, is considered **Minor** (for impacts to lodging) and **Minor** (for impacts to housing and canal use). (see Table 10.2.16-1).

As described in Section 9.3, Social Infrastructure and Services, the Project has initiated a number of mitigation measures, including the Project (and all of EEPGL's operations) continuing to mitigate the potential effects of increases in future lodging demand. No specific mitigations are in place to provide redundancy for canal use in the event that use is disrupted. Therefore, the intensity ratings for a marine or riverine fuel spill would remain **Low** and the residual risk rating remains **Minor** (for impacts to lodging) and **Minor** (for impacts to housing and canal use).

10.2.16.2. Onshore Hydrocarbon Release (Loss of Integrity of Onshore Pipeline)

As discussed in Section 10.1.4, Onshore Hydrocarbon Release, an onshore hydrocarbon release as a result of loss of integrity of NGL Plant facilities would not impact social infrastructure and services resources beyond the NGL Plant boundary and is therefore not assessed in this section. However, an onshore hydrocarbon release as a result of loss of integrity of the onshore pipeline could result in a flammable gas cloud igniting, causing either a flash fire or explosion. In the unlikely event of this event, there could be an impact on social infrastructure and services, specifically any housing structures, telecommunications, power and/or water and sanitation facilities within proximity to the section of the onshore pipeline at which the event occurred. Any canals adjacent to the event location could also be impacted.

From the shore landing, the onshore pipeline follows a route approximately 25 kilometers in length to the NGL Plant, crossing through a mix of agricultural, residential, and light commercial land use. The onshore pipeline will be installed below ground, either via open trenching methods (with a minimum cover depth of 1.22 meters) or via HDD boring in which the pipeline will be installed even deeper below the ground surface. If a loss of integrity were to occur, the most likely causes would be a third-party striking the line or pipe wall corrosion that could ultimately lead to a failure. Such results have a lower probability of impacting social infrastructure and services where the HDD installation method is used (Canal 1, Canal 2, and the shore landing) as the pipeline will be much deeper and therefore much less likely to be impacted by a third-party line strike. Considering that the impact is dependent upon the exact location of the release and the resultant proximity to social infrastructure and services, this assessment conservatively assumes that any community with households, structures, and canal users near the onshore pipeline could be impacted, and this could result in loss of access to or use of social infrastructure services at a community level. Therefore, the intensity of impact on social infrastructure and services from a loss of onshore pipeline integrity resulting in a natural gas release is considered **High**. On the basis that the impact of loss of onshore pipeline integrity would persist until the comprised infrastructure was restored, the frequency is considered to be **Continuous**. Restoration in the event of a significant event (e.g., explosion or fire resulting in complete loss of housing or other social infrastructure) may take longer than a year, so duration is considered **Long-term**. This result in a magnitude rating of **Large**.

Consistent with the sensitivity rating assigned for potential impacts on households within the Direct AOI that may have limited resources or capability to seek alternative social infrastructure or services, sensitivity is considered **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Large**. As described in Section 10.1.4, Onshore Hydrocarbon Release, a loss of onshore pipeline integrity is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to social infrastructure and services in the proximity of the portion of the onshore pipeline in which a loss of integrity could occur, especially in areas where open trenching is used (and thus the pipeline is shallower and more susceptible to a third-party line strike, is considered **Moderate** (see Table 10.2.16-1). There are a number of embedded controls in place to reduce the likelihood of a loss of pipeline integrity, but no mitigation measures assigned against this specific resource that would decrease its residual risk rating. Accordingly, the residual risk rating is maintained at **Moderate**.

Table 10.2.16-1: Risk Ratings for Unplanned Event Impacts on Social Infrastructure and Services

Unplanned Event	Resource/Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine and Riverine Fuel Spill	Social Infrastructure and Services (Lodging) / Georgetown and Region 3 travelers	Unlikely	Small	Minor	None beyond assessment and monitoring of lodging demand	Minor
	Social Infrastructure and Services (Housing and Canal Use) / Households and canal users near to Canal 1 and Demerara River intersection	Unlikely	Small	Minor	None	Minor
Loss of Integrity in Onshore Pipeline, Resulting in Natural Gas Release	Social Infrastructure and Services (housing, telecommunications, power, water and sanitation, canal use) near the portion of the onshore pipeline at which a loss of integrity occurs	Unlikely	Large	Moderate	Implement Emergency Response Plan in the event of a fire	Moderate

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.17. Transportation

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on transportation include the following:

- Marine or riverine fuel spill
- Vessel collision with a structure or a third-party vessel (non-spill related)
- Vehicular accident

10.2.17.1. Marine or Riverine Fuel Spill

Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. Depending on the extent of the spill, a fuel spill could render offshore or nearshore areas inaccessible for a period of time. This limitation on accessibility could affect coastal or riverine transportation and the locations in which commercial or subsistence fishing could be conducted. For marine fuel spills that reach nearshore waters, this could also affect river and coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available.

The intensity of the impact on marine transportation from a marine fuel spill would likely be **Low** for a spill that occurred sufficiently offshore, but could be as much as **Medium** if the spill were to occur in the nearshore portion of the offshore pipeline corridor. In the case of a riverine fuel spill, the same size spill would be more likely to affect other vessels in the river. On this basis, the intensity of impacts of a riverine fuel spill on river transportation is considered **Medium**.

In the absence of mitigation, the impacts of both events would persist as long as the spill was present in the affected area, so the frequency of impact is considered to be **Continuous**. The hydrocarbons from a fuel spill would be expected to undergo rapid weathering and degradation processes once in the water column, so the duration of impacts would likely be **Short-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Medium**. Applying the methodology described in Chapter 3, these characteristics lead to a magnitude rating of **Small** for both a marine fuel spill and a riverine fuel spill. Consistent with the sensitivity ratings assigned for potential impacts on vessel transportation from planned activities, a sensitivity rating of **Low** is assigned for cargo vessels, which have a greater means of adapting to changes, and **Medium** for fishing vessels, which have a comparatively lower means of adapting to changes.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a pre-mitigation consequence/severity designation of **Small** for a marine or riverine fuel spill. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine or coastal fuel spill is considered **Unlikely**. Accordingly, the pre-mitigation risk rating to marine or riverine transportation as a result of a fuel spill is considered **Minor** (see Table 10.2.17-1).

Effective implementation of the OSRP (Volume III of the EIA) could reduce the direct risk of the fuel spill by reducing the geographic area affecting transportation. However, a mitigated marine or riverine fuel spill would still have some impact on vessel transportation due to the additional vessels and resources that would be mobilized to support spill response (as described in the OSRP [Volume III of the EIA]), potentially resulting in increased vessel congestion. The consequence/severity of increased congestion with respect to impacts on transportation would depend on the number of additional vessel movements resulting from response efforts, which would itself depend on the nature and extent of the fuel spill. In the case of a response to the marine fuel spill scenario, the level of activity associated with a response would not likely have the potential to noticeably reduce marine transportation to the extent that a change in travel behavior by other waterway users would be required. In the case of a riverine fuel spill, the extent of the spill (and thus the level of additional response vessel activity) could have a greater potential for congestion-related impacts to be experienced by other vessel operators based on the comparatively constrained area in which spill response would occur.

While there would still be impacts to marine use and transportation due to increased vessel congestion during the response, the overall intensity would likely remain at **Low** to **Medium** for both marine and riverine fuel spill scenarios. Accordingly, the residual risk rating of potential impacts on transportation from marine oil and riverine fuel spills is maintained at **Minor** (see Table 10.2.17-1).

10.2.17.2. Vessel Collision with a Structure or a Third-party Vessel (Non-spill Related)

Accidents involving Project and non-Project vessels could lead to consequences ranging from minor vessel damage to major vessel damage, damage to bridges or piers, injury, or loss of life. Vessel collisions in the Demerara River, Georgetown Harbour, or coastal areas could interfere with marine or river transportation if a collision results in one or more vessels becoming temporarily immobilized such that it presents an obstruction to other marine or riverine traffic. Such a scenario in offshore or open coastal waters would not reasonably be expected to present an obstruction to navigation, but such a scenario in the Demerara River could have the potential to present an obstruction given the reduce maneuvering space.

The Project-related increase in vessel traffic is expected to be minimal compared to existing vessel traffic in Georgetown Harbour. Vessel counts in the February 2022 river vessel survey observed an average of 23 daily vessel movements at Garden of Eden, near the proposed temporary MOF, primarily consisting of fishing vessels or private passenger vessels. About 12 percent of the February 2022 vessel observations were cargo vessels, tankers, or barges. Project river vessel movements will add an average of 1 to 2 daily barge trips to the Demerara River in this area, increasing total vessel traffic by 5 to 10 percent compared to existing conditions. Project construction would also generate vessel traffic between a shorebase on the west side of the river, south of the Demerara Harbour Bridge, and a shorebase on the east side of the river, north of the bridge. An average of 4 to 5 vessels per week will make this shorter round trip (8 to 10 total trip movements per week). At the Demerara Harbour Bridge, observations locations for the February 2022 river vessel survey, a daily average of approximately 50 vessel movements were observed. Project-related vessel traffic in this area will thus represent a 2 to 4 percent increase in existing vessel traffic.

As embedded controls, EEPGL would implement the measures listed in Section 10.1.1.1, Collision between Project Marine Vessels or between a Project Marine Vessel and Third-Party Marine Vessel, Resulting in a Fuel Spill, to reduce the possibility of vessel collisions.

The consequence of such an event would thus depend upon the nature and location of the accident and could range from **Low** to **Medium** depending on the extent of waterway obstruction, and the ability of other vessels to navigate around the immobilized vessel(s).

The duration of the impact in the case of such an obstruction would likely be **Short-Term**, as the vessel obstruction would be likely be cleared relatively quickly. The frequency of the impact would be **Continuous**, as the impact would persist for as long as the obstruction was in place. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**. Consistent with the sensitivity ratings assigned for potential impacts on marine and Demerara River vessel transportation, the sensitivity rating is considered **Low** to **Medium**.

These magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a vessel collision is considered **Unlikely**, so the overall risk to marine or riverine transportation from a vessel collision would be **Minor**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating is maintained as **Minor** (see Table 10.2.17-1).

10.2.17.3. Vehicular Accident

Additional vehicular trips generated by the Project would increase the risk of vehicular accidents. Vehicular accidents involving Project and non-Project vehicles could lead to a range of consequences depending on the nature of the event. With respect to impacts to transportation, vehicular accidents could result in traffic delays, increased congestion, and/or damage to roads or bridges.

Consistent with GIIP, as an embedded control, EEPGL has developed and implemented an EEPGL-wide Road Safety Management Procedure, which covers drivers and equipment dedicated to the Project to mitigate these risks. The Procedure includes, but is not limited to, the following components:

- Definition of required driver training, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, if applicable;
- Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems;
- Avoidance of deliveries during typical peak traffic hours or during scheduled closures of the Demerara Harbour Bridge to road traffic (i.e., when traffic conditions worsen along the East

Bank of Demerara Public Road and West Bank of Demerara Public Road), to the extent reasonably practicable;

- Monitoring and management of driver fatigue;
- Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment;
- Implementation of a community safety program for impacted schools and neighborhoods to improve traffic safety; and
- Community outreach to communicate information relating to major delivery events or periods.

While the above-reference suite of embedded controls would reduce the likely frequency and severity of vehicular accidents, the intensity of the impact of a vehicular accident on transportation would depend on the nature of the accident and could range from **Negligible** to **High**; a **Negligible** intensity would occur if a traffic accident resulted in only a brief pause or slow-down in traffic and little to no damage to transportation infrastructure. A **High** intensity impact would occur if an accident resulted in severe traffic delays or road blockages, or severe transportation infrastructure damage. Project-related traffic accidents could occur on public roads that will be used for proposed Project transportation: the West Bank of Demerara Public Road; roads used for access to the onshore pipeline installation sites; and other roads in and around Georgetown and Vreed-en-Hoop. The duration of the impact on traffic congestion and delays would most likely be **Short-term**, lasting no more than a few hours. For accidents that result damage to roads or bridges, the duration could be as high as **Medium-term**. The impact would persist as long as the traffic congestion situated persisted, so the frequency is rated as **Continuous**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Negligible** to **Medium**.

Consistent with the sensitivity ratings assigned for potential impacts on transportation from planned activities, the sensitivity rating is considered **Medium**. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small** to **Medium**.

As described in Section 9.4.3., Impact Prediction and Assessment, Project activity will add proportionally small volumes of vehicle traffic to congested intersections and will increase the traffic volumes moderately on less travelled road segments. The embedded controls listed above would reduce the likelihood of vehicular accidents. However, considering the planned life cycle for the Project (at least 20 years), the likelihood of an event is conservatively considered to be **Possible**.

In combination with a consequence/severity ranging from **Small** to **Medium**, this leads to a risk rating for vehicular accidents of **Minor** to **Moderate**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating for vehicular accidents remains **Minor** to **Moderate** (see Table 10.2.17-1).

Table 10.2.17-1: Risk Ratings for Unplanned Events Impacts on Transportation

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine or Riverine Fuel Spill	Transportation	Unlikely	Small	Minor	Implement OSRP	Minor
Vessel Collision with a Third-Party Vessel or Structure	Transportation	Unlikely	Small	Minor	None	Minor
Vehicular Accident	Transportation	Possible	Small to Medium	Minor to Moderate	None	Minor to Moderate

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.18. Cultural Heritage

As indicated in Table 10.1-10, the unplanned events with the potential to result in measureable impacts on cultural heritage include the following:

- Marine or riverine fuel spill
- Onshore hydrocarbon release (including a loss of integrity of onshore pipeline or a loss of integrity of NGL Plant facilities)

10.2.18.1. Marine Fuel Spill

In the unlikely event of a marine fuel spill, the following cultural heritage resources could be affected:

- Marine archaeology

The potential severity of the impact of such an event on marine cultural heritage is dependent on the size and location of the release. If a spill were to reach a Guyana shoreline, the spill would generally only impact the intertidal zone, unless the spill coincides with a significant storm surge. However, while archaeological sites are common along coastlines, sites in the intertidal zone tend to lack stratigraphic integrity due to the dynamic interface between the ocean and the land, especially along beaches. The greatest potential threat would likely derive from erosion of a cultural resource site due to damage to stabilizing vegetation resulting from a spill's impact on the shoreline.

Based on the results of the modeling analyses presented earlier this chapter, if a release of marine fuel were to occur, the spilled fuel is predicted to travel toward the northwest in all scenarios and during all seasons. Under no scenario modeled would a marine fuel spill reach a shoreline. Further, the modeling analyses indicated that under all fuel spill scenarios, the spilled fuel would evaporate over a period of several days and that hydrocarbon concentrations in the water column would rapidly decrease following the spill event. On this basis, the intensity of the impact of a fuel spill on marine archaeology is **Negligible**. Impacts would persist for as long as the spill remains in or on the water (although they would reduce over time as the spilled fuel weathers), and because the impacts of an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term,** yielding a magnitude of **Negligible**.

Combined with the sensitivity rating of **Low** for marine archaeology, this yields a consequence/severity rating of **Small** for impacts on marine archaeology. In combination with a likelihood rating of **Unlikely** for a marine fuel spill, the risk rating is **Minor.**

Should a marine fuel spill occur in the vicinity of a shipwreck site, the spill impact would be to water quality, and impacts would generally be confined to the upper water column. While water quality and (through limited adsorption of contaminants to suspended particulate) sediment quality impacts at a shipwreck site could occur, impacts to the site would be anticipated to be negligible. The intensity of potential impacts to marine archaeology, particularly to a previously unidentified site, is likely to be **Negligible**. The potential impact to underwater cultural heritage would persist as long as contamination in the water column was present, so the frequency is considered to be **Continuous**. The spilled material would weather and dilute rapidly in the water column, so duration is considered to be no more than **Medium-term**. This results in a magnitude rating of **Negligible**. The sensitivity of this type of resource is considered **Low**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine fuel spill is considered **Unlikely**, so the overall risk rating of a marine fuel spill to marine cultural heritage is considered **Minor**. EEPGL will maintain and implement an OSRP (Volume III—Management Plans of the EIA) in the event of a spill. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the residual risk to marine archaeology is maintained at **Minor** (Table 10.2.18-1).

10.2.18.2. Riverine Fuel Spill

In the unlikely event of a riverine fuel spill, the following cultural heritage resources could be affected:

- Coastal archaeology
- Riverine archaeology

Potential Impacts of a Riverine Fuel Spill on Coastal Archaeology

Based on the deterministic modeling analysis conducted for a riverine fuel spill, in most scenarios a fuel spill inside the Demerara River would have no effect on coastal archaeology because the spilled fuel would not reach the Guyana coastline. Only the largest scenario modeled (a 500-barrel [80 m^3] spill) would have the potential to reach the coastline, and only if the spill occurred in the lower portion of the river under high-flow conditions. Under these circumstances, the spilled fuel could reach the coastline and nearshore marine zone immediately outside the river mouth off Vreed-en-Hoop.

Many areas along the marine coastline are highly developed, reducing the likelihood that coastal archaeological resources would be present at any locations where a fuel spill could impact the shoreline. Though the geographic extent of field surveys were limited to the area around the Crane Village seawall, no coastal archaeological resources were identified in the cultural heritage field survey work described in Section 9.5, Cultural Heritage. However, sites that hold cultural heritage value have been identified along the shoreline in Region 3, most notably areas for prayer and burial/cremation rituals, where access to water and low levels of human activity are important attributes. The main threat to coastal cultural heritage lies in the indirect impact of erosion of cultural heritage sites due to a loss of stabilizing vegetation resulting from a shoreline impact. The fuel that could be potentially spilled is diesel and it would evaporate or naturally degrade within several days of release; therefore, no persistent effects on the coastline or coastal resources of any type would be anticipated. On the basis of the above, the intensity of potential impacts to coastal archaeology is considered **Low**.

Impacts would persist for as long as the spill remains in or on the water and shoreline (although they would reduce over time as the spilled fuel weathers), and because the impacts of an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term,** yielding a magnitude of **Small**. The sensitivity of coastal cultural heritage resources ranges from **Low** to **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a riverine fuel spill is considered **Unlikely**, so the overall risk rating of a riverine fuel spill to coastal archaeology is considered **Minor**. EEPGL will maintain and implement an OSRP (Volume III—Management Plans of the EIA) in the event of a spill. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the residual risk to coastal archaeology is maintained at **Minor** (Table 10.2.18-1).

Potential Impacts of a Riverine Fuel Spill on Riverine Archaeology

The effects of a fuel spill on riverine archaeology along the shoreline or banks of the lower Demerara River would be dependent on the severity and extent of the spill and the overall impact on stabilizing riparian vegetation. The shoreline of the lower Demerara River contains mature riparian forest, including stands of mangrove forest that could potentially be impacted by a fuel spill. A likely Dutch colonial era archaeological site, HS-KM-02, was identified during field surveys conducted in support of this EIA along the west bank of the lower Demerara River, and other portions of the lower Demerara River shoreline that are less developed are considered high probability for containing archaeological resources.

A riverine fuel spill could lead to contamination and erosion of shoreline cultural heritage (archaeology) sites in the area. The primary mechanism for this impact is through the loss of stabilizing vegetation, which could result in erosion and thus impact archaeological resources embedded in the river shoreline. As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, shorelines were predicted to be affected at various points along the west bank of the lower Demerara River from approximately 4 kilometers south (upriver) of the temporary MOF site to the river mouth and adjacent nearshore coastal area, depending on the scenario modeled. This predictive modeling reflects the presence of any fuel amount that would encounter a shoreline regardless of a thickness threshold. The extent and location of the affected area would be dependent upon the location of the spill. Due to the nature of the fuel, it would not be expected to persist in the environment for more than a week due to evaporation or natural degradation.

On this basis, the intensity of the impact from a riverine fuel spill on riverine archaeology would be **Low**. Impacts would persist for as long as the spill persists in the environment and because the impacts of an unmitigated riverine fuel spill and related response could—depending on the volume of release—continue over several weeks, the frequency and duration are considered to be **Continuous** and **Medium-term**. Applying the methodology described in Chapter 3, EIA Approach and Impact Assessment Methodology, these characteristics lead to a magnitude rating of **Small**.

The sensitivity of riverine archaeology to impacts from a riverine fuel spill is considered **Medium**. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Small**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a riverine fuel spill is considered **Unlikely**, so the overall risk rating of a riverine fuel spill to riverine archaeology is considered **Minor**. EEPGL will maintain and implement an OSRP (Volume III—Management Plans of the EIA) in the event of a spill. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the residual risk to riverine archaeology is maintained at **Minor** (Table 10.2.18-1).

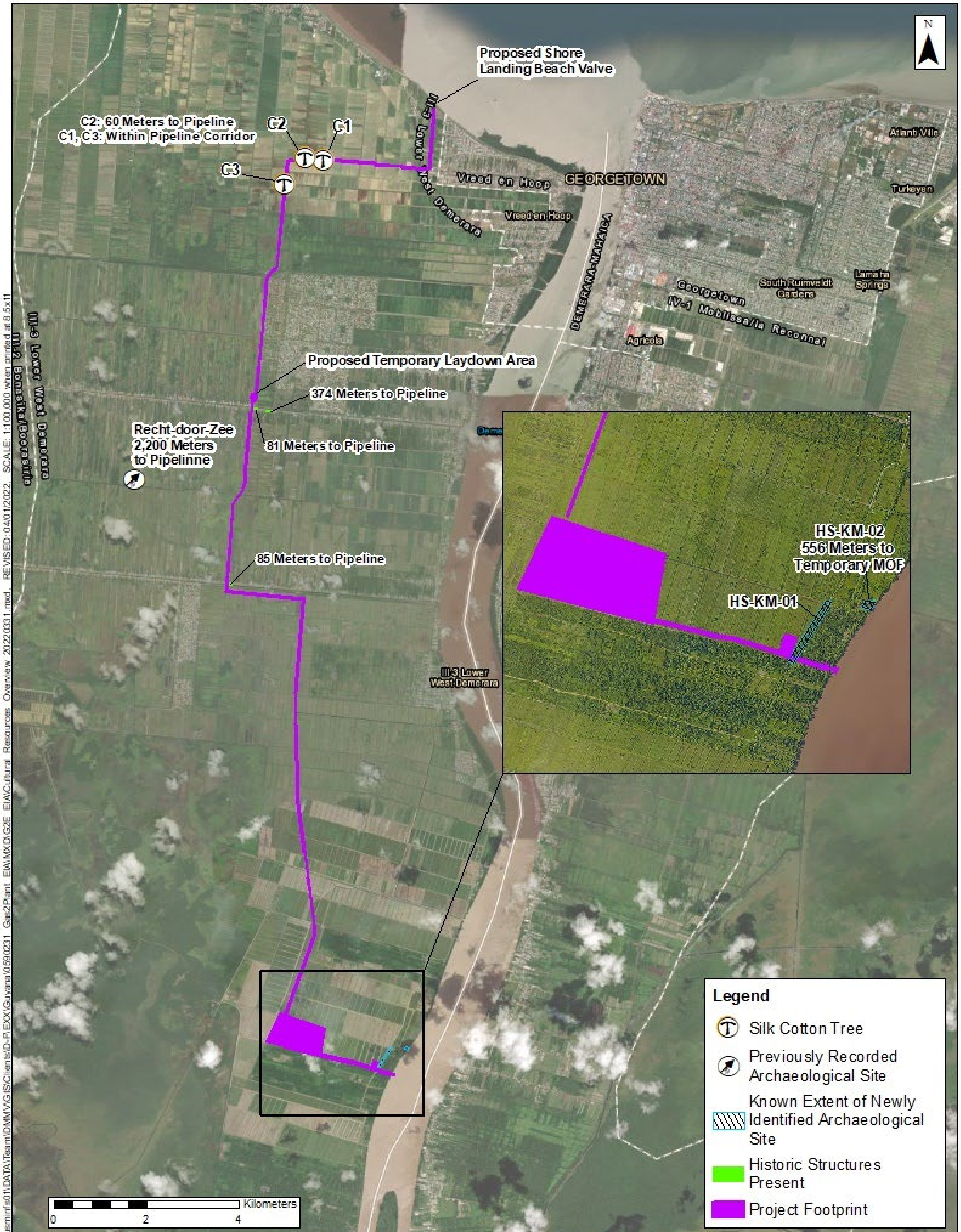
10.2.18.3. Onshore Hydrocarbon Release

In the unlikely event of an onshore hydrocarbon release from a loss of integrity of the onshore pipeline or of the NGL Plant facilities, these events could result in damage to cultural heritage resources near the portion of Project infrastructure in which the event occurred. As described in Section 9.5.2, Existing Conditions [Cultural Heritage], there were no terrestrial archaeological sites identified within the onshore pipeline corridor or within the NGL Plant site.

Some historic structures were identified within relatively close proximity to the onshore pipeline in the residential areas of Nismes, particularly the areas around Canal 1 and Canal 2 (Tables 9.5-3 and 9.5-4). However, these are located in areas where the pipeline will be installed using HDD techniques. If a loss of integrity were to occur, the most likely causes would be a third party striking the line or pipe wall corrosion that could ultimately lead to a failure. Such results have a lower probability of occurring where the HDD installation method is used, as the pipeline will be much deeper and therefore much less likely to be impacted by a third-party line strike.

Intangible cultural heritage resources are located in or near the onshore pipeline corridor, specifically in the form of three silk cotton trees. These trees could be lost in the unlikely event that the unplanned event occurred in a segment of the pipeline located near them.

Based on the above, the intensity of an onshore hydrocarbon release with respect to impacts on terrestrial cultural heritage would be **Negligible** (if the event occurred in an area with no cultural heritage resources) or **High** (if the event occurred in close enough proximity to a silk cotton tree or historic structure such that the resource is lost or damaged (Figure 10.18-1).



Source: Esri - World Oceans Map, National Geographic World Map

Figure 10.2.18-1: Overview of Cultural Heritage Resources in Relation to Project Footprint

As the tree or structure (under this worst case scenario) would be permanently removed, this would be a **Continuous** and **Long-term** impact. The magnitude of this impact under this scenario would thus be **Negligible** (if the event occurred in an area with no cultural heritage resources) to **Large** (if the event occurred in close enough proximity to a silk cotton tree or historic structure such that the resource is lost or damaged).

Based on the sensitivity rating definitions in Section 9.5.3, Impact Prediction and Assessment, the resource sensitivity for cultural heritage is considered **Low** for historic structures components and **High** for intangible cultural heritage components. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to consequence/severity designations of **Small** or **Large**. As described in Section 10.1.4, Onshore Hydrocarbon Release, an onshore hydrocarbon release is considered **Unlikely**, so the overall risk of such a release to terrestrial cultural heritage is considered **Minor** to **Moderate** (Table 10.2.18-1).

A number of embedded controls are in place to reduce the likelihood of a loss of pipeline integrity, but no mitigation measures are assigned against this specific resource that would decrease its residual risk rating. Accordingly, the residual risk rating is maintained at **Minor** to **Moderate**.

Table 10.2.18-1: Risk Ratings for Unplanned Event Impacts on Cultural Heritage

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine or Riverine Fuel Spill	Marine and Coastal Cultural Heritage	Unlikely	Small	Minor	Implement OSRP	Minor
Loss of Integrity in Onshore Pipeline, Resulting in Hydrocarbon Release	Terrestrial Cultural Heritage (Historic Structures or Intangible Cultural Heritage Resources)	Unlikely	Medium to Large	Minor to Moderate	Implement Emergency Response Plan in the event of a fire	Minor to Moderate

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.19. Land Use and Ownership

As indicated in Table 10.1-10, the unplanned events with the potential to result in measurable impacts on land use and ownership include:

- Marine or riverine fuel spill
- Onshore hydrocarbon release (from loss of integrity of onshore pipeline or NGL Plant facilities)

10.2.19.1. Marine or Riverine Fuel Spill

Marine Fuel Spill

As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, in each of the marine fuel spill scenarios, the simulations indicated that the spill would spread predominantly in a direction parallel to the shoreline, with minimal lateral spreading toward the shoreline. Therefore, assuming the spill occurred outside of the immediate nearshore area, there would be no potential impact on the coastal agriculture sector as a result of a marine fuel spill. Potential impacts of a marine fuel spill on nearshore fisheries are discussed in Section 10.2.14, Socioeconomic Conditions, and potential impacts on ecosystem services (including use of coastal shorelines) are addressed in Section 10.2.21, Ecosystem Services. No potential impact on land use or ownership is identified as a result of a marine fuel spill.

Riverine Fuel Spill

Spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, affected shorelines were predicted at various points along the West Bank of the Demerara River from near the shore landing to approximately 4 kilometers south of the temporary MOF, depending on the scenario. This predictive modeling reflects the presence of any fuel amount that would encounter a shoreline, regardless of a thickness threshold. Generally, the shoreline along the West Bank of the Demerara River is protected by mangroves and other natural vegetation, which would be affected in the event of a shoreline impact. The extent and location of the affected area would depend on the location of the spill and the river flow and tidal stage at the time of the spill. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation.

Considering the potential impacts assessed in Section 9.6, Land Use and Ownership, a potential riverine fuel spill is not anticipated to influence land ownership or tenure or result in physical displacement or relocation. Access to land used for agriculture could be affected if the fuel spill reached agricultural areas. However, agricultural areas—including actively cultivated rice, pineapple, and mixed crops, as well as fallow sugarcane fields—are located inland from the river. The river shoreline and kokers (sluice gates) would protect these inland areas from impacts of a riverine fuel spill, on the assumption that the kokers are closed at the time of a spill or shortly thereafter. On this basis, no potential impact on land use or ownership is identified as a result of a riverine fuel spill.

10.2.19.2. Onshore Hydrocarbon Release (Loss of Integrity of Onshore Pipeline or Natural Gas Liquids Processing Plant Facilities)

Based on the preliminary consequence modeling results summarized in Section 10.1.4.3, Modeling of Hydrocarbon Releases, an onshore hydrocarbon release could occur as a result of loss of integrity of the onshore pipeline, which could result in a flammable gas cloud igniting, causing either a flash fire or explosion. The onshore pipeline will pass close to residential[9] and agricultural areas along several segments. If this unlikely event were to occur, there could—depending on location of the event—be an impact on land use in the affected areas, including potential loss of homes, crops, and supporting infrastructure such as irrigation and drainage canals.

An onshore hydrocarbon release could also occur due to a loss of integrity of NGL Plant facilities, which could result in a BLEVE, flammable gas cloud, or jet fire scenario. These events would be largely contained to the NGL Plant boundary, although the outer extent (i.e., lower severity portion) of the area of potential overpressure effects could intersect with existing cultivated lands approximately 200 meters south of the NGL Plant boundary. There are no known manmade structures or habitations within this area.

Although unlikely, these events could result in damage to or loss of agricultural lands and crops, and, if populated areas near the onshore pipeline were affected, the physical displacement and relocation of affected residents.

Loss of Integrity of Onshore Pipeline

From the shore landing, the onshore pipeline follows a route approximately 25 kilometers long to the NGL Plant, crossing through a mix of agricultural, residential, and light commercial land use. The onshore pipeline will be installed below ground (with the exception of the aboveground beach valve station near the shore crossing), either via open trenching methods (with a minimum cover depth of 1.22 meters) or HDD methods, in which the pipeline will be installed even deeper below the ground surface. If a loss of integrity were to occur, the most likely causes would be a third-party striking the line or pipe wall corrosion that could ultimately lead to a failure. Such results have a lower probability of impacting land use or occupancy where the HDD installation method is used (i.e., at approximately 10 locations along the onshore pipeline route, including near the shore crossing, Canal 1, and Canal 2), as the pipeline will be much deeper and much less likely to be impacted by a third-party line strike.

The nature and extent of the potential event would be highly dependent on the exact location of the release and the resultant proximity to residential and/or cultivated areas. However, this assessment conservatively assumes that any residential or agricultural area along the onshore pipeline route could be affected, and this could result in loss of access to crops or agricultural lands and/or result in the physical displacement of residents. The potential nature and extent of potential events related to loss of integrity of the onshore pipeline are described in detail in Section 10.1.4, Onshore Hydrocarbon Release.

[9] Potential impacts on local residents, including socioeconomic conditions and social infrastructure and services, are discussed in Section 10.2 14 and Section 10.2.16, respectively.

The potential impact on access to agricultural lands, as related to a hydrocarbon release (and potential flash fire or explosion), could result in chronic hardship for residents, landowners, and/or their respective communities and could require receptors to change or cease their livelihood activities for an extended period of time. Therefore, this potential impact on land use and ownership is considered to be of **High** intensity, based on the intensity scale provided in Section 9.6, Land Use and Ownership.

A flash fire or explosion event associated with a hydrocarbon release along the onshore pipeline could also displace existing residents from their homes (potential impacts on community health and safety are discussed separately in Section 10.2.15, Community Health and Wellbeing). The degree of displacement would depend on where the event occurs but could conceivably result in chronic hardship for residents and require them to change or cease their livelihood activities for an extended period of time or indefinitely. Therefore, this potential impact on land use and ownership is also considered to be of **High** intensity.

On the basis that the impacts of loss of onshore pipeline integrity would persist until the comprised land use was restored, the frequency is considered **Continuous**. Restoration following a significant event (e.g., explosion or fire resulting in complete loss of agricultural assets) may take longer than a year, so duration is considered **Long-term**. This results in a magnitude rating of **Large**.

Consistent with the sensitivity ratings assigned, defined in Section 9.6, Land Use and Ownership, sensitivity of affected persons along the onshore pipeline route is considered **Medium**. Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Large**. As described in Section 10.1.4, Onshore Hydrocarbon Release, a loss of onshore pipeline integrity is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to agricultural land use in proximity to the portion of the onshore pipeline in which a loss of integrity could occur is considered **Moderate**. There are a number of embedded controls in place to reduce the likelihood of a loss of pipeline integrity but no mitigation measures that would decrease the residual risk rating if the event were to occur. Accordingly, the residual risk rating is maintained at **Moderate**.

Loss of Integrity of Natural Gas Liquids Processing Plant Facilities

The nearest community[10] to the proposed NGL Plant site is known as Catherina Sophia, located on the on the West Bank of the Demerara River approximately 1.5 kilometers southeast of the NGL Plant. Catherina Sophia is outside of the anticipated radius of effect for any of the unplanned scenarios considered in relation to a hydrocarbon release that could occur due to due to a loss of integrity of NGL Plant facilities (i.e., BLEVE, flammable gas cloud, or jet fire scenarios). Therefore, potential impacts from a loss of integrity of the NGL Plant facilities are not expected to result in physical displacement of residents in the area.

[10] This assessment assumes that people living in existing dwellings near the proposed heavy haul road and temporary MOF will be relocated by the Government of Guyana from the area, as described in Section 9.6, Land Use and Ownership.

However, agricultural lands have been identified approximately 200 meters south of the NGL Plant site. These lands comprise an elongated rectangle more than 2 kilometers long, running perpendicular to the Demerara River, south of the NGL Plant and heavy haul road (as shown on Figure 9.6-4 in Section 9.6, Land Use and Ownership). The lands appear to be actively cultivated with mixed small-scale crops. Depending on the specific infrastructure involved at the NGL Plant, the preliminary consequence modeling (described in Section 10.1.4.3, Modeling of Hydrocarbon Releases) indicates that a portion of these croplands could be affected by flammable cloud, jet fire, or BLEVE events. Based on prevailing wind direction, potential impacts would likely be limited to the western portion of this crop parcel.

The nature of farming activities or stakeholders related to these lands is unknown at this time. However, this assessment conservatively recognizes that the potential impact on crops and access to this section of agricultural land could result in chronic hardship for affected farmers and require them to change or cease their livelihood activities for an extended period of time. Therefore, this potential impact is conservatively considered to be of **High** intensity.

On the basis that the impacts would persist until the comprised cropland was restored, the frequency is considered **Continuous**. Restoration in the event of a significant event (e.g., explosion or fire resulting in extensive loss of agricultural assets) may take longer than a year, so duration is considered **Long-term**. This results in a magnitude rating of **Large**.

Consistent with the sensitivity ratings assigned, defined in Section 9.6, Land Use and Ownership, sensitivity of affected persons near the NGL Plant is considered **High**, given the remoteness of the area and concerns that land users may not have secure tenure (as discussed in Section 9.6, Land Use and Ownership). Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Large**. As described in Section 10.1.4, Onshore Hydrocarbon Release, a loss of onshore pipeline integrity is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to agricultural land use in proximity to the NGL Plant is considered **Moderate**. There are a number of embedded controls in place to reduce the likelihood of such an incident but no mitigation measures that would decrease the residual risk rating if the event were to occur. Accordingly, the residual risk rating is maintained at **Moderate**.

Table 10.2.19-1 summarizes the pre-mitigation and residual risks to land use and ownership from unplanned events.

Table 10.2.19-1: Risk Ratings for Potential Unplanned Event Impacts on Land Use and Ownership

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Onshore Hydrocarbon Release (from Loss of Integrity of Onshore Pipeline or NGL Plant Facilities	Agricultural land use—near the portion of the onshore pipeline at which a loss of integrity occurs	Unlikely	Large	Moderate	Implement Emergency Response Plan in the event of a fire	Moderate
	Displaced occupants of land—near the portion of the onshore pipeline at which a loss of integrity occurs	Unlikely	Large	Moderate	Implement Emergency Response Plan in the event of a fire	Moderate
	Agricultural land use—south of the NGL Plant	Unlikely	Large	Moderate	Implement Emergency Response Plan in the event of a fire	Moderate

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.20. Landscape, Visual Resources, and Light

Based on the analysis presented in Section 10.1, Introduction (Unplanned Events), and indicated in Table 10.1-10, none of the unplanned events considered could impact landscape and visual or light resources. Temporary visual impacts could occur during the event itself or during unplanned event response, but these impacts would be temporary and limited in scale to the immediate vicinity of the event, so would not alter the character of the landscape or the viewshed of the impacted area.

10.2.21. Ecosystem Services

As indicated in Table 10.1-10, the unplanned event with the potential to result in measurable impacts on ecosystem services includes the following:

- Marine or riverine fuel spill

This section considers potential impacts on provisioning, regulating, and cultural ecosystem services in relation to a marine or riverine fuel spill.

10.2.21.1. Marine or Riverine Fuel Spill

This section describes potential impacts to marine ecosystem services related to provisioning services (aquatic transportation and harvests of crabs from mangroves), regulating services (shoreline protection), and cultural services (use of coastal shoreline for recreation and cultural/spiritual practice). Potential impacts to nearshore fishing and fishing livelihoods are discussed in Section 10.2.14, Socioeconomic Conditions (Unplanned), potential impacts to use of canals are discussed in Section 10.2.16, Social Infrastructure and Services (Unplanned), and potential impacts to agriculture and related livelihoods are considered in Section 10.2.19, Land Use and Ownership (Unplanned).

As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, in each of the marine fuel spill scenarios, the simulations indicated that the spill would spread predominantly in a direction parallel to the shoreline, with minimal lateral spreading toward the shoreline. Therefore, assuming the spill occurred outside of the immediate nearshore area, there would be no expected direct impact to the coastal ecosystem services as a result of a marine fuel spill. If a marine fuel spill occurred close enough to shore, it could result in coastline impacts; this could occur as a direct result of a spill, or as a result of cleanup and remediation efforts.

Spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, affected shorelines were predicted at various points along the west bank of the Demerara River from the shore landing to approximately 4 kilometers south of the temporary MOF, depending on the scenario modeled. This predictive modeling reflects the presence of any fuel amount that would encounter a shoreline, regardless of a thickness threshold. Generally, the shoreline along the west bank of the Demerara River is protected by mangroves and other natural vegetation, which would be affected in the event of a shoreline impact. The extent and location of the affected area would be dependent upon the location of the spill. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation.

Potential Impacts to Provisioning, Regulating, and Cultural Services

Provisioning Services

Marine or riverine fuel spills could impact provisioning services, specifically availability of crabs in mangroves that line the shore. A conservative assessment is that the impact on crabbing would be localized and impact no more than 20 households, and therefore the intensity of the potential impact on the provisioning resource provided by mangroves as a source of crabs is considered **Medium** intensity**.**

The response effort to a marine or riverine fuel spill could result in an impact to the provisioning service related to aquatic transportation, as Project vessels may be deployed within the nearshore coastline area and/or Demerara River to provide shoreline protection. This could impact nearshore or riverine transportation networks that link communities and provide access to markets for rural communities. Specifically, results from the 2021 socioeconomic household survey found that residents of Brickery, Garden of Eden, and Land of Canaan on the East Bank of the Demerara River (i.e., across from the temporary MOF) use aquatic transportation to tend to agricultural fields and to transport students to attend schools on the West Bank of the Demerara River. The impact of a marine or riverine fuel spill with respect to potential impacts on the provisioning services provided by the Demerara River and nearshore marine areas for aquatic transportation is expected to be a localized impact that affects up to 20 households, so the intensity is considered **Medium**.

Regulating Services

In the unlikely event of a fuel spill, any spilled fuel amount that would encounter a shoreline, regardless of a thickness threshold, could also impact regulating services necessary for the functioning and support of ecosystems and both human and non-human life. These impacts could include reduced water and/or flood regulation and reduced coastal and/or riverside shoreline protection. Important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. The predictive modeling suggests that for some river spill scenarios, a spill could impact portions of the coastal shoreline north of Vreed-en-Hoop extending to Crane at the Project pipeline shore crossing. While the model indicates that the extent of the spill reaching the shore in this coastal location is less than farther south into the Demerara River, if the spill was severe enough to cause damage to mangrove forests, this could diminish a critical component of the country’s sea defense system and expose the riverine or coastal population to increased flooding hazard and/or increased shoreline erosion. This would be a localized impact, and the intensity of a marine or riverine fuel spill with respect to potential impacts on coastal shoreline protection is considered **Medium** intensity.

Cultural Services

Any spilled fuel amount that would encounter a shoreline, regardless of a thickness threshold, could affect access to the shoreline for cultural, spiritual, religious, and/or recreational activities. This would be an impact to the cultural services provided by the coastal or riverine shore. Along the coastal shoreline and the banks of the Demerara River, there are various places known to be used by members of the Hindu community to conduct funereal ceremonies. Throughout the year and during holy festivals, Hindu community members also perform religious and spiritual ceremonies on the shore, and erect Jhandi flags as a lasting symbol of these rites. Additionally, seawalls and beaches are important to locals for recreation, tourism, and leisure activities, although some areas are not commonly used for these purposes due to difficulty of access (particularly along the Demerara River). The potential impact of a marine or riverine fuel spill on the cultural service associated with use of the shoreline would be localized and is therefore considered to be of **Medium** intensity.

Evaluation of Severity/Consequence and Risk

On the basis that the potential impact as a result of affected riverine and coastal shorelines would persist only until which time as the fuel would naturally evaporate or degrade, which is relatively quickly, the frequency is considered to be **Episodic**. Response efforts to clean the riverine or coastal shoreline would include shoreline protection, if warranted, and would likely be completed within a week, so duration is considered to be no more than **Short-term**. This results in a magnitude of **Negligible**. Consistent with the sensitivity rating assigned for potential impacts to ecosystem services with planned activities, while these potential impacts ecosystem services (crabbing, aquatic transportation, shoreline protection, and cultural activities) are important, they may not be critical to the livelihoods and wellbeing of beneficiaries. If the ecosystem service is lost or changed, its function can be replaced or re-established over time. Therefore, the sensitivity is considered **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, these magnitude and sensitivity ratings lead to a consequence/severity designation of **Negligible**. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine or riverine fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to those in the Direct AOI from a riverine fuel spill scenario as a result of affected shorelines is considered **Negligible** (see Table 10.2.16-1). EEPGL would implement a spill response plan and a claims and/or livelihood remediation process for affected individuals, if required.

Table 10.2.21-1 summarizes the pre-mitigation and residual risks to ecosystem services from unplanned events.

Table 10.2.21-1: Risk Ratings for Potential Unplanned Event Impacts on Ecosystem Services

Unplanned Event	Resource	Likelihood of Event	Consequence/ Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Marine or Riverine Fuel Spill	Provisioning (crabbing, aquatic transport)	Unlikely	Small	Negligible	Implement spill response plan, if warranted Implement claims and/or livelihood remediation processes for affected individuals	Negligible
	Regulating (shoreline protection)	Unlikely	Small	Negligible		Negligible
	Cultural (religious and recreation)	Unlikely	Small	Negligible		Negligible

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

10.2.22. Indigenous Peoples

As indicated in Table 10.1-10, the unplanned event with the potential to result in measurable impacts on Indigenous Peoples includes the following:

- Marine or riverine fuel spill

This section considers potential impacts on Indigenous Peoples—namely, the Santa Aratak community and associated Amerindian title lands upriver of the Project—in relation to a marine oil riverine fuel spill. The Santa Aratak community uses the Demerara River for access to and from the community (via Kamuni Creek, more than 10 kilometers upstream of the proposed temporary MOF site), and activities in the river could therefore affect people living in Santa Aratak, including residents' connections to healthcare, social services, education, and markets.

10.2.22.1. Marine or Riverine Fuel Spill

Marine Fuel Spill

As discussed in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, in each of the marine fuel spill scenarios, the simulations indicated that the spill would spread predominantly in a direction parallel to the shoreline, with minimal lateral spreading toward the shoreline. Therefore, assuming the spill occurred outside of the immediate nearshore area, there would be no expected direct impact to the coastal agriculture sector as a result of a marine fuel spill. Potential impacts of a marine fuel spill on nearshore fisheries are discussed in Section 10.2.14, Socioeconomic Conditions, and potential impacts on ecosystem services (including use of coastal shorelines) are addressed tin Section 10.2.21, Ecosystem Services. No potential impact is identified in relation to the Santa Aratak community or other Indigenous Peoples as a result of a marine fuel spill.

Riverine Fuel Spill

Spill modeling was conducted for two riverine fuel spill scenarios (one volume at two different locations). In both scenarios, affected shorelines were predicted at various points along the west bank of the Demerara River from the shore landing to approximately 4 kilometers downriver (south) of the temporary MOF. This predictive modeling reflects the presence of any fuel amount that would encounter a shoreline, regardless of a thickness threshold. Due to the nature of the fuel, it will not persist in the environment for more than a week due to evaporation or natural degradation. Santa Aratak is accessed via Kamuni Creek, which feeds into the Demerara River approximately 10 kilometers upriver (north) of the temporary MOF. Therefore, a riverine fuel spill is not expected to affect the lands or waters of Santa Aratak, and the impact is considered **Negligible**.

The response effort to the riverine fuel spill could affect aquatic transportation on the Demerara River, as Project vessels may be deployed in response to a spill. EEPGL would execute the spill response plan, which for a riverine fuel spill would include shoreline protection, if warranted. This could affect river travel that connects Santa Aratak with Georgetown and other points along the lower Demerara River. As noted in Section 9.9, Indigenous Peoples, it is estimated that two boats travel between Santa Aratak and Georgetown each day, carrying 12 to 25 persons. On this basis, the intensity of a riverine fuel spill with respect to potential impacts on aquatic transportation from Santa Aratak will be localized to Santa Aratak residents and could impact up to 37 persons per day if vessels were at full capacity. Delays to river travel to navigate around spill response activities could lead to a perceptible change in wellbeing for residents travelling to markets or appointments in Georgetown, and is therefore considered **Medium**.

On the basis that the impact would persist only until which time as the fuel would naturally evaporate or degrade, which is relatively quickly, the frequency is considered to be **Episodic**. Response efforts including shoreline protection would likely be completed within a week or less, so duration is considered to be **Short-term**. This results in a magnitude rating of **Negligible**. Consistent with the sensitivity rating assigned for potential impacts to Indigenous Peoples as a result of planned activities, the community’s sensitivity to changes in travel and transportation, or potential impacts to lands and waters, is considered **Medium**.

Applying the methodology in Chapter 3, EIA Approach and Impact Assessment Methodology, the magnitude and sensitivity ratings lead to a consequence/severity designation of **Small** for potential impacts to Santa Aratak lands and waters, and **Small** for potential impacts to travel and transportation during response efforts. As described in Section 10.1.1, Marine and Riverine Fuel Spill Scenarios, a marine or riverine fuel spill is considered **Unlikely**. Accordingly, the overall pre-mitigation risk to residents of Santa Aratak from a riverine fuel spill scenario and the resultant response effort is considered **Minor** (see Table 10.2.22-1). EEPGL would implement a spill response plan. However, these mitigations would not reduce the risk of the impact and the residual risk rating is maintained at **Minor**.

Table 10.2.22-1: Risk Rating for Potential Unplanned Event Impacts on Indigenous Peoples

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence / Severity Rating	Pre-Mitigation Risk Rating [a]	Proposed Mitigation Measures	Residual Risk Rating
Riverine Fuel Spill	Indigenous Peoples—impact to Amerindian lands	Unlikely	Small	Minor	Implement spill response measures including shoreline protection, if warranted	Minor
	Indigenous Peoples—impact to transportation	Unlikely	Small	Minor		Minor

[a] Similar to the pre-mitigation significance ratings assigned for impacts from planned events, the pre-mitigation risk ratings for unplanned events assume that relevant embedded controls will be implemented to reduce the likelihood of an unplanned event occurring, and the consequences of an unplanned event if one were to occur.

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11. CUMULATIVE IMPACTS

This chapter evaluates the potential contribution of the Project toward cumulative impacts on key resources.

11.1. CIA OBJECTIVES

The specific objectives of the cumulative impact assessment (CIA) are:

- Identify Valued Environmental and Social Components (VECs) that could be impacted cumulatively in the onshore and offshore areas potentially affected by the Project, considering input from stakeholders and Potentially Affected Communities (PACs) through the consultation process;
- Identify other existing and planned projects and environmental and social external stressors that could cumulatively impact VECs;
- Identify and assess the incremental contribution of the Project to potential cumulative impacts on VECs, considering the Project and the other identified existing and planned projects and external stressors in the area; and
- Recommend a management framework for the integrated management of potential cumulative impacts.

11.2. DEFINITIONS OF KEY CUMULATIVE IMPACT ASSESSMENT TERMINOLOGY

The following are definitions of key terminology used in the CIA.

Cumulative Impact: Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to other existing, planned, and/or reasonably anticipated actions, projects, or activities. For practical reasons, the identification, assessment, and management of cumulative impacts includes those effects generally recognized as important on the basis of scientific concern and/or stakeholder concerns.

CIA: Process used to identify and evaluate cumulative impacts.

External Drivers: Sources or conditions—other than those captured in the other projects category—that could affect or cause physical, biological, or social stress on VECs, such as natural environmental and social stressors, broad-ranging human activities, and other external stressors. These can include climate change, population influx, or deforestation, among others. These are typically less defined and planned than other projects.

Other Projects: Existing, planned, or reasonably expected future developments, projects, and/or activities potentially affecting VECs.

PACs: PACs are defined as local communities potentially directly affected by the Project.

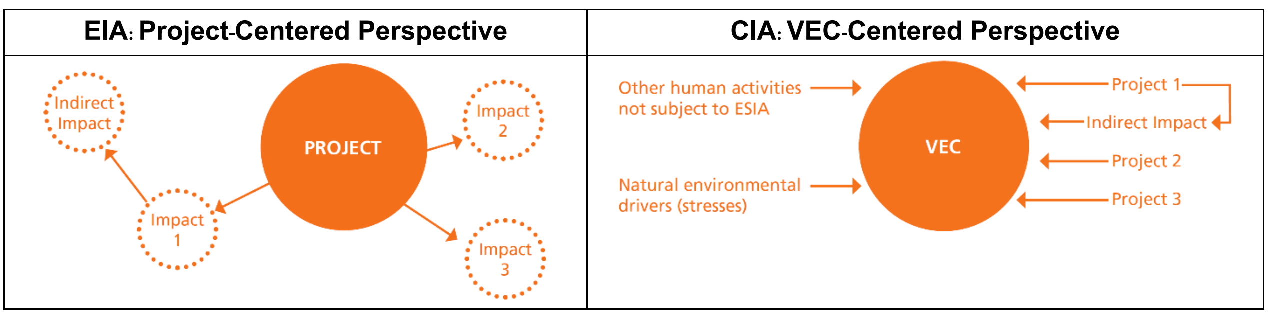
VECs: Environmental and social components considered as important by the scientific community and/or PACs. VECs may include:

- Physical features (e.g., water quality);
- Biological features (e.g., habitats, wildlife populations);
- Ecosystem services (e.g., protection from natural hazards, provision of food);
- Natural processes (e.g., water and nutrient cycles, climatic conditions);
- Socioeconomic conditions (e.g., community health, economic conditions); and
- Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites).

VECs reflect the public and scientific community's "concern" or special interest about environmental, social, cultural, economic, or aesthetic values (IFC 2013). According to the International Finance Corporation's (IFC) methodology, VECs are considered the ultimate recipients of cumulative impacts because they tend to be at the ends of impact pathways.

11.3. Cumulative Impact Assessment Approach

Unlike an EIA, which focuses on a project as a generator of impacts on various environmental and social resources, a CIA focuses on VECs as the receptors of impacts from different projects and activities (Figure 11.3-1). In a CIA, the potential overall residual condition of the VEC is assessed.

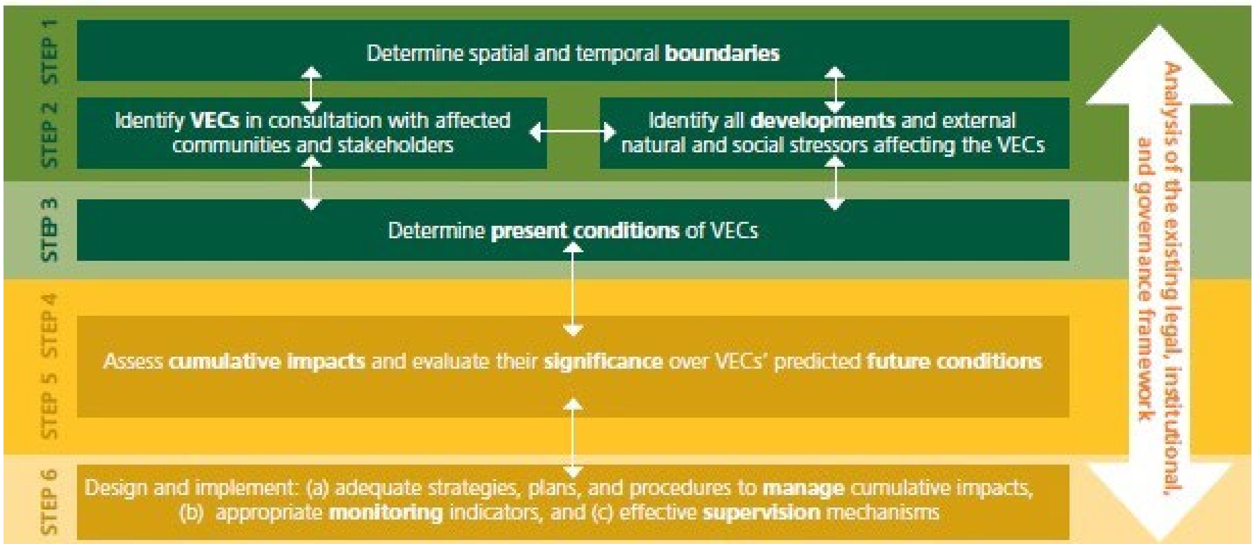


Source: IFC 2013

Figure 11.3-1: Comparing EIA and CIA

As previously described, the CIA is based on information available in the public domain; information obtained during the EIA processes for the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Project EIAs; information from other studies commissioned by EEPGL; information provided by EEPGL; and information provided by the EPA.

The approach taken for the CIA follows the IFC's *Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* ("the Handbook") (IFC 2013). The Handbook provides a methodology for identifying significant cumulative impacts; the methodology includes a desktop review of publicly available information and consultation with key stakeholders. This methodology focuses on environmental and social components referred to in the Handbook as VECs, which are: (1) rated as highly valued by potentially affected stakeholders and/or the scientific community; and (2) cumulatively impacted by the Project under evaluation, and by other projects and/or by natural environmental and social external drivers (IFC 2013). The assessment follows the six steps of the CIA process (Figure 11.3-2). The process is iterative and flexible, allowing for some steps to be revisited in response to the results of others.



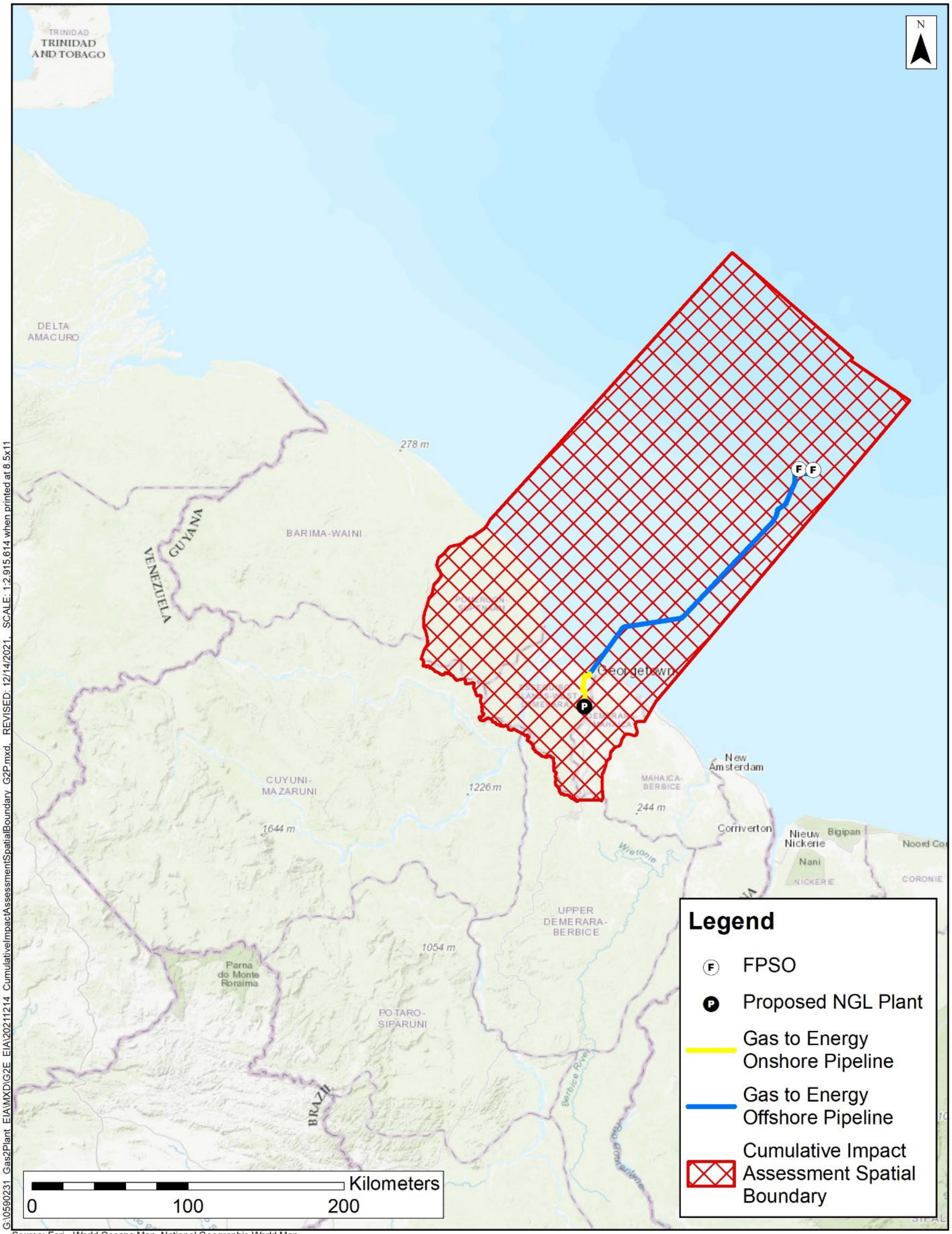
Source: IFC 2013

Figure 11.3-2: Summary of IFC's Cumulative Impact Assessment Methodology

The Handbook takes into consideration the limitations that a private developer may face when carrying out a CIA. The limitations applicable to this CIA include: (1) incomplete information about other projects and activities (e.g., the information is not available in the public domain); (2) uncertainty with respect to the future implementation of other projects and activities; and (3) difficulty in establishing thresholds or limits of acceptable change for VECs, and therefore the associated priority ratings for potential cumulative impacts.

11.3.1. Determination of Spatial and Temporal Boundaries

The geographic scope of the EIA was defined as the Project's Area of Influence (AOI) (see Section 3.2, Defining the Project Area of Influence). Based on an assessment of the VECs for the CIA, it was determined that the Indirect AOI is sufficient to serve as the spatial boundary of the CIA, in that it covers: (1) the extent of the selected VECs, and (2) the spatial and temporal extent of the potential impacts from the Project, other projects, and external stressors, which may themselves have positive or negative impacts on VECs. Figure 11.3-3 shows the spatial boundary of the CIA.



Source: Esri - World Oceans Map, National Geographic World Map

Figure 11.3-3: Spatial Boundary of the Cumulative Impact Assessment

Temporal limits for a CIA are inherently uncertain due to the limited information typically available regarding potential future projects. For this reason, good international practice suggests using a 3-year temporal boundary when conducting a CIA. While the CIA uses this time horizon for non-EEPGL projects, the temporal boundary used with respect to the Project and other potentially planned EEPGL projects assumes a 25-year time horizon, based on the life expectancy of the Project facilities (Figure 11.3-4). The Project's Construction stage is notionally expected to initiate in 2022 and last approximately 3 years. The Project pipeline is notionally expected to be ready to deliver rich gas by the end of 2024, with the natural gas liquids processing plant (NGL Plant) becoming operational in mid-2025. The Project operational life is expected to last at least 25 years.

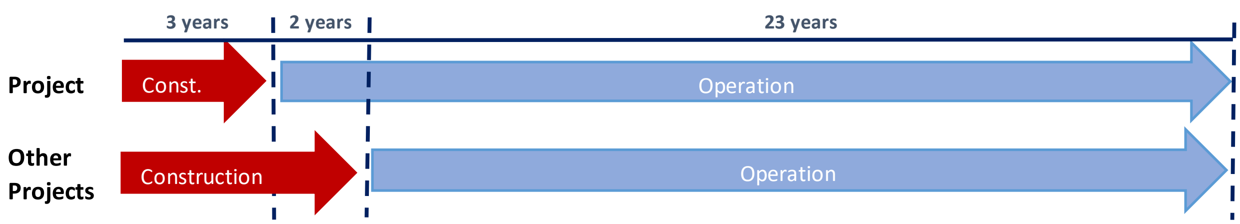


Figure 11.3-4: **Temporal Boundary of the CIA**

The Consultants identified existing and planned other (non-Project) activities deemed to be relevant with respect to the potential for their impacts to interact with Project impacts on VECs within the CIA spatial and temporal boundaries. These other projects and activities were identified through a search of public information disclosed on the EPA's website and other information in the public domain. Section 11.3.2, Identification of Other Projects, provides a brief description of each of the other projects identified.

Section 11.6, Assessment of Cumulative Impacts on VECs, provides a summary of the potential cumulative impacts resulting from the Project and other projects that could affect the same VECs. The potential impacts were assessed based on available information (e.g., published EIAs) and cover environmental and social aspects. The information available for the other projects varied in terms of the level of detail regarding their specific potential impacts; potential impacts from projects with limited information generally were assessed based on potential industry-specific impacts identified in the IFC´s Environmental, Health and Safety Guidelines for the respective sectors (IFC Undated).

11.3.2. Identification of Other Projects

After consulting with EEPGL and reviewing publicly available information, the Consultants identified the following other projects to be included in the CIA (Table 11.3-1).

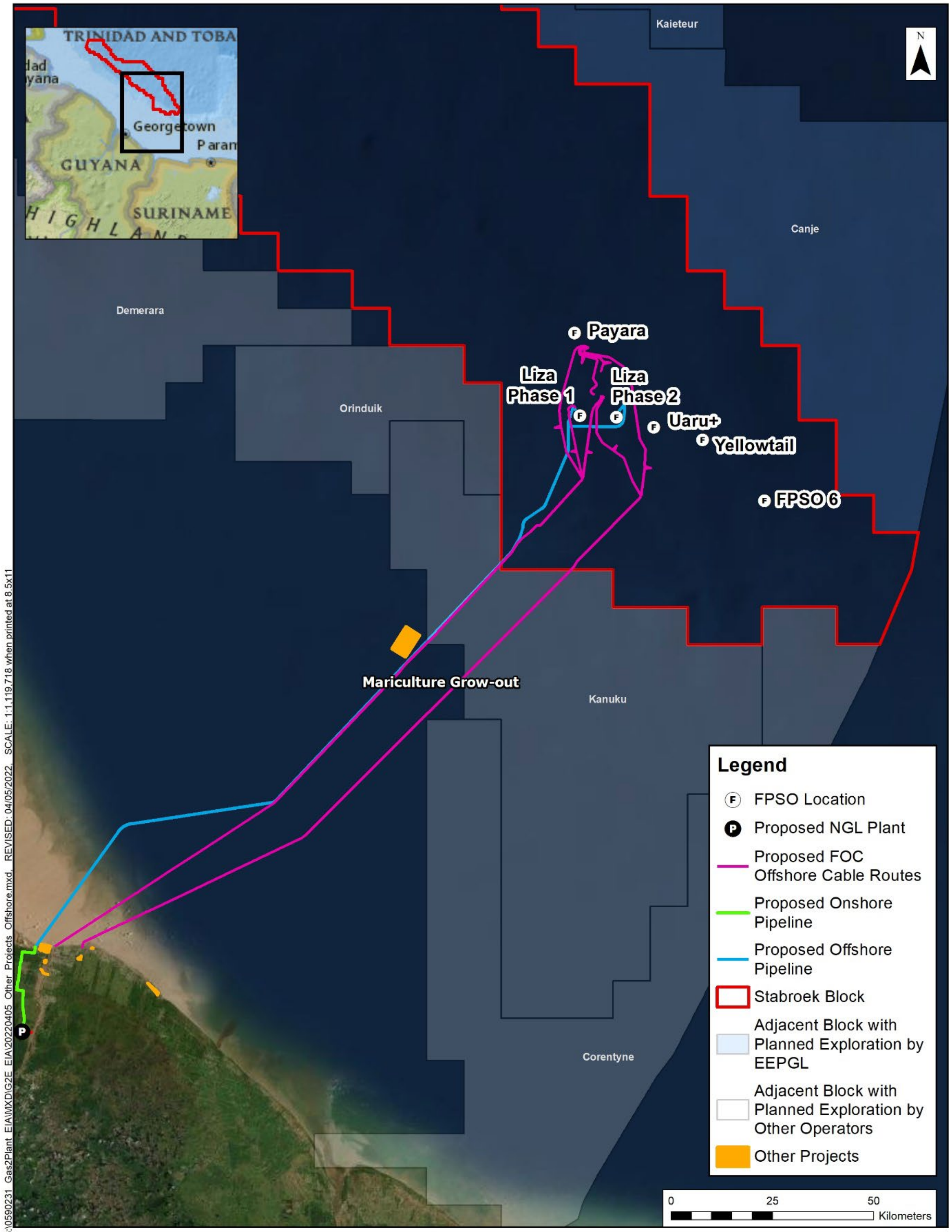
Table 11.3-1: Identification of other Projects for the CIA

Other Project Name	Developer	Project Status [a]	Located within the CIA´s Spatial Boundary	Potential Overlap with the Project´s Temporal Boundary
Liza Phase 1 Development Project	EEPGL	Ongoing	Yes	Overlap with GTE construction and operation
Liza Phase 2 Development Project	EEPGL	Ongoing	Yes	Overlap with GTE construction and operation
Payara Development Project	EEPGL	Proposed—approved	Yes	Overlap with GTE construction and operation
Yellowtail Development Project	EEPGL	Proposed-approved	Yes	Overlap with GTE construction and operation
Uaru+ Development Project	EEPGL	Proposed	Yes	Overlap with GTE construction and operation
FPSO #6 Development Project	EEPGL	Planned	Yes	Overlap with GTE operation
Continued EEPGL exploration drilling	EEPGL	Some ongoing; some proposed	Yes	Overlap with GTE construction and operation
Fiber Optic Cable Project	EEPGL	Under construction	Yes	Construction overlap with GTE construction
Guyana Office Complex Project	EEPGL	Under construction	Yes	Construction overlap with GTE construction
Non-EEPGL Offshore Oil and Gas Development	Other oil and gas companies (e.g., Repsol, Tullow, CGX)	Some ongoing; some proposed	Yes	Potential overlap with GTE construction
Caribbean Mariculture Project	Caribbean Mariculture, Inc.	Planned (?)	Yes	Potential overlap with GTE construction and/or operation
Hope Wind Farm	Hope Energy Development Inc.	Proposed	Yes	Potential overlap with GTE construction and operation
New Demerara Harbour Bridge	Guyana´s Ministry of Public Works	Proposed—approved	Yes	Overlap with GTE construction and operation
Port of Vreed-en-Hoop	NRG Holdings Inc.	Proposed—approved	Yes	Overlap with GTE construction and operation

Other Project Name	Developer	Project Status [a]	Located within the CIA´s Spatial Boundary	Potential Overlap with the Project´s Temporal Boundary
Tristar Shorebase	TriStar Inc.	Under construction	Yes	Overlap with GTE construction and operation
Government of Guyana Gas-fired Power Plant	Guyana Government	Proposed	Yes	Overlap with GTE construction and operation
Wales Estate Industrial Park	Guyana Government	Planned	Yes	Overlap with GTE construction and operation

FPSO = Floating Production, Storage, and Offloading vessel
[a] Project status categories: ongoing (activity is currently underway), under construction, proposed-approved (permitted but not yet under construction), proposed (in permitting process), and planned (reasonably foresseable, but permitting process not yet started)

Summaries of these other projects, based on publicly available information, are presented below. The approximate locations of the other projects are displayed on Figure 11.3-5 (offshore) and Figure 11.3-6 (onshore). At this time, and for the purpose of this assessment, the EEPGL Floating Production, Storage, and Offloading (FPSO) Uaru+ and FPSO #6 projects are assumed to be located in the eastern part of the Stabroek Block, near prior exploration wells with discoveries.



Source: Esri - World Ocean Base Map, National Geographic World Map

FOC = fiber optic cable

Figure 11.3-5: Proposed Locations of Other Projects (Offshore)

MOF = Material Offloading Facility; RoW = right-of-way

Figure 11.3-6: Proposed Locations of Other Projects (Onshore)

11.3.2.1. EEPGL Development Projects: Liza Phase 1, Liza Phase 2, Payara, Yellowtail, Uaru+, and FPSO #6

The Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects have been permitted to develop their respective offshore resources by drilling approximately 17 subsea development wells (Liza Phase 1), up to 33 development wells (Liza Phase 2), up to 45 development wells (Payara), and up to 45 to 67 development wells (Yellowtail) in the eastern half of the Stabroek Block. Each of these projects will use an FPSO to process, store, and offload the recovered oil. Each FPSO will be connected to the wells via associated Subsea, Umbilicals, Risers, and Flowlines, which will transmit produced fluids (i.e., oil, gas, produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to injection wells. The Liza Phase 1 Project Development Area (PDA), where the drilling and production operations activities occur, is a 76-square-kilometer (km^2) area located approximately 190 kilometers from the coastline. The Liza Phase 2 PDA is an approximately 80 km^2 area located approximately 183 kilometers from the coastline. The Payara PDA is an approximately 95 km^2 area located approximately 207 kilometers northeast from the coastline. The Yellowtail PDA covers an area of approximately 50 km^2 and is located approximately 200 kilometers northeast from the coastline.

The drilling, installation, commissioning, and start-up stages of the Payara and Yellowtail Development Projects, and the production operations stages of the Liza Phase 1, Liza Phase 2, Payara, and Yellowtail projects are projected to overlap with the Project. Shorebases, laydown areas, warehouses, fuel supply, and waste management facilities will support all four of these projects, as well as the GTE Project. These projects will share logistics, including use of marine support vessels traversing between the Stabroek Block and shorebases in Guyana or Trinidad and Tobago, and helicopters traversing between the Stabroek Block and heliport facilities in Georgetown.

The Uaru+ and FPSO #6 Development Projects are assumed for the purpose of this CIA to be designed, in concept, similar to the Yellowtail Development Project (i.e., an FPSO with a subsea tieback system). They are tentatively assumed to be located in the eastern half of the Stabroek Block near previous exploration discoveries (Figure 11.3-5). For the purposes of this CIA, it is assumed that they will be roughly similar to the Yellowtail Development Project FPSO size/capacity and development well count (including production, water injection, and gas re-injection wells).

The estimated timeline for the Uaru+ Development Project includes drilling and installation activities starting during 2025 (assuming an environmental authorization is issued) and continuing into 2028, with production operations starting in 2026. The estimated timeline for the FPSO #6 Development Project includes drilling and installation activities starting during 2026 (assuming an environmental authorization is issued) and continuing through 2028, with production operations starting in 2027. These estimated timelines for the Uaru+ and FPSO #6 developments are used only for purposes of the CIA.

11.3.2.2. Continued EEPGL Exploration Drilling

Exploration drilling by EEPGL is ongoing as of the writing of this EIA and is planned to continue in the Stabroek Block and in the adjacent Canje and Kaieteur blocks over the next several years, subject to future authorizations and continued exploration success (i.e., discoveries).

While continued exploratory drilling is contingent on the results of exploration, the current EEPGL exploration program is nominally envisioned to extend through 2028. Previously authorized exploration drilling is currently ongoing in the Stabroek and Canje blocks and applications for environmental authorization for additional exploration drilling programs in the Canje and Kaieteur blocks have been submitted to the EPA and are under review as of the writing of this EIA.

11.3.2.3. Fiber Optic Cable Project

EEPGL has recently received approval for the Fiber Optic Cable (FOC) Project, which will install fiber optic communication infrastructure from the Stabroek Block to shore, enabling high-speed, low-latency communications and data transfer between EEPGL's FPSOs and shore (Figure 11.3-5). The network includes two landing sites with terrestrial transmission to a cable landing station and then to EEPGL's new Guyana Office Complex (GOC) site. The approved FOC Project includes installation of subsea infrastructure, including optical distribution units (ODUs), located south of the Liza Phase 1 and Liza Phase 2 FPSOs, and connection of the Liza Phase 1, Liza Phase 2, and Payara FPSOs to the ODUs. As part of a future application for environmental authorization, EEPGL will propose to connect one of the ODUs to a Yellowtail drill center.

The cable will be installed using a variety of methods depending on the water depth and the on-site conditions. To protect the cable as much as possible through the fishing grounds, the cable will be plow-buried from approximately 32 kilometers from shore up to a water depth of 150 meters; from this point seaward, seabed laying is sufficient and the cable will self-bury (i.e., the cable will be laid on the ocean floor and will bury itself through natural processes). For burial portions, the cable will be trenched to a depth of 1.5 meters.

Construction of the offshore cable, distribution system, and the onshore landing sites is ongoing as of the writing of this EIA, with planned commissioning of the project connection to the Liza Phase 2 FPSO in early 2022. Construction of the connection to the GOC is planned for later in 2022. As discussed above, the Yellowtail FPSO will be connected to one of the ODUs as part of a future application for environmental authorization.

11.3.2.4. Guyana Office Complex

EEPGL is constructing a new Guyana headquarters, referred to herein as the GOC. The campus will be constructed on a greenfield 16.1-hectare site and will comprise two buildings and associated infrastructure.

The proposed location for the GOC is near the Eugene F. Correia International (Ogle) Airport (Figure 11.3-6). EEPGL leased the parcel of land from Ogle Airport Inc. to construct two office buildings, an outdoor pavilion, and parking areas. Construction is ongoing as of the writing of this EIA, with planned completion in late 2023.

11.3.2.5. Non-EEPGL Offshore Oil and Gas Development

Three other companies that have conducted exploration activities offshore Guyana are assumed for the purpose of the CIA to have the potential to conduct additional exploration in the future: (1) Repsol in the Kanuku Block; (2) Tullow in the Orinduik Block; and (3) CGX in the Correntyne and Demerara blocks. The first well drilled by Repsol in the Kanuku Block reportedly did not encounter commercial hydrocarbons. Repsol has announced plans to drill another well offshore Guyana in 2022 (OilNOW 2021b). In 2019, Tullow announced its first oil discovery in the Orinduik Block. This was followed by another discovery in the same block. Tullow's website states that it is now working with its joint venture partners on the overall prospect inventory and developing plans to unlock value from this acreage (Tullow Oil Undated). The government of Guyana granted an extension to Tullow's term in the Orinduik Block until 2023 (Tomic 2021). As of the writing of this EIA, CGX had initiated drilling of a well in the Correntyne Block (Kawa-1) and was expected to drill an additional well in the Demerara Block (Palmigiani 2021).

Beyond the information described above, the Consultants have not made assumptions about the potential success of future exploration activities, and therefore are not assuming for the purpose of the CIA that a prolonged exploration program or any associated development projects will occur that could interact with the GTE Project.

11.3.2.6. Caribbean Mariculture Project

In December 2017, an updated project summary for a mariculture project by Caribbean Mariculture, Inc. (CMI) was submitted to the EPA. On 6 February 2018, a sector scoping meeting was held for the rearing of fingerlings and marine fish in the Atlantic Ocean Project. According to a Facebook post by the EPA (EPA 2018), the comments received during this meeting were used to shape the Terms of Reference for the CMI project EIA. The Consultants were not able to identify a more recent submittal in the public domain, so it is assumed for the purpose of the CIA that the project is still proposed and has not changed in design or location.

According to the project summary document, the project is designed to farm the following marine fish species: southern red snapper (*Lutjanus purpureus*), Atlantic grouper (*Epinephelus itajara*), cobia (*Rachycentron canadum*), grey snapper (*Cynoscion acoupa*), and gillbacker (*Sciades parkeri*), which are currently caught by the marine capture fisheries in Guyana. The project asserts that by growing selected species of fish through aquaculture, the supply of fish will become more reliable and that it will reduce the pressure on wild fish stocks.

The project would have three main components: (1) hatchery, (2) shorebase area, and (3) growout area. The proposed hatchery location is at Le Ressouvenir, East Coast Demerara. The proposed shorebase operations would be land-based, at Le Ressouvenir, East Coast Demerara, located next to the hatchery, and bordered by mangroves to the east and west, the Atlantic Ocean to the north, and by residential areas and drainage structures to the south. The proposed growout operations would be located in the open ocean.

The summary document briefly describes the mariculture operation:

- **Hatchery**: Broodstock of the various species would be captured alive from the wild, and transported to the hatchery. This broodstock would be placed in eight concrete tanks, each with a capacity of 28 cubic meters. The broodstock would then be induced using environmental manipulation (i.e., photoperiod, temperature, water quality and nutrition), so as to facilitate spawning. Chlorine bleach would be used for cleaning the tanks and the hatchery in general. No additives would be used. In the hatchery, the broodstock would be spawned, producing eggs, which would then hatch into fry (very small fish). These fry would be grown to fingerlings (slightly larger fish). Lastly, the fingerlings would be transported to the growout area, where they would be stocked and grown to market-sized fish. While in the hatchery, the broodstock, fry, and fingerlings would be fed a high-quality feed.
- **Shorebase**: This operation would service the hatchery and growout areas, providing storage areas, locations for the mooring of vessels, and other supporting facilities.
- **Growout area**: In the growout area, the project would use large mesh pens with a mesh size that would accommodate the size of fingerlings to be stocked from the hatchery operations, prevent the entry of predators, and facilitate adequate water exchange. Fingerlings will be grown to market size in these pens. Each pen will be 6,400 cubic meters in size. The growout operation would be serviced by feeding, holding, and harvesting support infrastructure, as well as logistics support, so as to be able to get inputs onto, and products off of, the facility. The growout operation would also have accommodations for staff, who would be required to supervise operations and conduct required tasks on a 24-hour basis.

The December 2017 project summary report indicated that construction would take approximately 3 years; however, a start date for the construction has not been published by CMI. According to the 2017 Project Summary, the project lifespan is expected to be 50 years. The Consultants were not able to identify any recent information indicating the CMI project is still planned for implementation. As a conservative measure, however, it was assumed for the purpose of the CIA that the project is still planned. Further, as the timeline for the project was not identified in publicly available records, it is assumed for the purpose of the CIA that the project might occur at the same time as construction and/or operation of the GTE Project. Based on the coordinates provided in the project summary report, the onshore components of the mariculture project would be located approximately 10 kilometers southeast of the mouth of the Demerara River (Figure 11.3-6). The offshore component (growout area) would be located within a 24 km2 area along which the GTE Project's offshore pipeline would pass (Figure 11.3-5).

11.3.2.7. Hope Wind Farm

Hope Energy Development Inc. has submitted an EIA for the construction and operation of the first large-scale wind farm in Guyana along the East Coast of Demerara. The company has secured a 50-year land lease for the state-owned area of Hope Beach as well as private leases at Chapman's Grove, comprising a total area of 10.9 hectares. Six wind turbines will be located

28 to 30 kilometers southeast of the center of Georgetown. Each turbine will be 105 meters in height above ground level and the maximum blade tip height during rotation will be 180 meters above ground level. For this project, no mangrove trees are expected to be removed from the coast to facilitate the construction of the wind turbines.

During construction, solid waste generated by the Project will include felled vegetation, excavated material, contaminated soil (in the event of spills and leaks of hydrocarbons), crates and packaging, waste paving material, cement and cement bags, timber, plywood, nails, screws for formwork and other carpentry, polyvinyl chloride pipes and fittings, and waste electrical ducting. All materials for civil and electrical works, as well as turbine equipment, will be transported by truck from Georgetown. Over the estimated 10-month construction period, an estimated 5,100 truckloads of materials and supplies will be transported to the site, averaging 25 truckloads per workday, with an estimated peak of up to 50 truckloads per day.

Publicly available information indicated that the feasibility stage for the Hope Wind Farm was expected to be completed in the third quarter of 2021, pending receipt of a signed power purchase agreement and the Environmental Permit, but no information was identified as of the writing of this EIA to confirm current schedule or Environmental Permit issuance. The project was initially planned to be in operation by the end of 2022.

11.3.2.8. New Demerara Harbour Bridge

The Demerara Harbour Bridge in Georgetown has been in operation for approximately 40 years and is no longer able to efficiently service either present or estimated future traffic demands. The Government of Guyana has proposed to replace the heavily used bridge as a means of relieving congestion of both road- and river-based vessel traffic induced by the opening and closing of the retractor spans that allow large vessels to pass. In 2013, a pre-feasibility study identified three alternative locations for the new bridge: Houston, Peters Hall (the existing location), and New Hope. In August 2021, the Ministry of Public Works issued a project summary evaluating replacement of the bridge, calling for the replacement bridge to span the Demerara River from Nandy Park to La Grange, slightly upstream of the existing bridge (Figure 11.3-6), and for the existing bridge to be closed and demolished once the new bridge is in operation.

The replacement structure will be a fixed four-lane bridge with a vertical clearance over the channel of approximately 50 meters above the maximum tide level. The proposed design connects to the main road network at the West Bank of Demerara Public Road and the Mandela to Eccles Road (Ministry of Public Works 2021). The project will need to acquire approximately 24 lots of land and a number of homes in the area of Nandy Park, East Bank Demerara (Kaieteur News 2021). The EPA has determined the new bridge project is not required to prepare an EIA, requiring instead an Environmental and Social Assessment and Management Plan (EPA 2021). A tendering process for the bridge construction was conducted in 2021, with an award announced in November 2021. Publicly available information indicates initial estimates of a 2-year construction timeline for the bridge, but a start date has not been announced as of the writing of this EIA. It is assumed for the purpose of the CIA that construction-related activities for the bridge might occur at the same time as construction and/or operation of the GTE Project.

11.3.2.9. Port of Vreed-en-Hoop

The Guyanese-owned consortium NRG Holdings Inc. has secured EPA approval for the Vreed-en-Hoop Port Facility at Foreshore, Plantation Best on the west bank of the Demerara River. The project will construct and operate a facility that will include an offshore terminal; dry dock facility; fabrication yard; offshore components; umbilical preparation and spooling yard; administrative buildings to house offices and modernized logistics centers; warehousing; area for a helipad; and a wharf, berths, and dry dock. Located at Vreed-en-Hoop, Region 3, it will occupy some 400 hectares of coastal land. With the issuance of the Environmental Permit, NRG Holdings Inc. was required to submit an Environmental and Social Management Plan to the EPA (OilNOW 2021a).

The proposed facility location is at the western edge of the mouth of the Demerara River. The Consultants could not identify information indicating the projected schedule for construction or operation of the facility. It is assumed for the purpose of this CIA that construction and/or operation could overlap the Project's schedule.

11.3.2.10. Tristar or West Demerara Shorebase

TriStar Inc. announced that it received regulatory approvals for its planned West Demerara Shorebase facility. The shorebase will occupy a 28.3-hectare site at Versailles, located on the west bank of the Demerara River. When completed, the project will be a dedicated oil and gas shorebase with six berths (Thomas 2021).

Construction of the facility was initially anticipated to be completed by the third quarter of 2023 (Thomas 2021), although Tristar has recently announced plans to acquire an additional 300 acres in Versailles, West Bank Demerara, to support the project's operations (OilNOW 2022). The shorebase will be located roughly opposite the existing Guyana Shore Base Inc., which EEPGL uses as a primary shorebase support facility for its FPSO development projects (Stabroek News 2021).

11.3.2.11. Government of Guyana Power Plant

ExxonMobil's offshore oil developments, which also produce associated natural gas, are of interest to the Guyana government and offer the potential for using the natural gas as a more efficient, reliable, and lower greenhouse-gas-intensity fuel source for power generation, as compared to the current fuel sources used for the country's power generation. The government has announced its intention to construct a gas-fired power plant (Power Plant) located in Wales (Pipeline & Gas Journal 2021). The Power Plant would receive treated natural gas from the GTE Project's NGL Plant. The exact location and engineering details of the Power Plant are not yet defined as of the writing of this EIA, but for the purpose of the CIA, it is assumed that the Power Plant would be located within or immediately adjacent to the NGL Plant boundary (see Figure 11.3-6). As of the writing of this EIA, the Consultants understand that an Application for

Environmental Authorisation for the Power Plant project has been submitted to the EPA by the Government of Guyana.

11.3.2.12. Wales Estate Industrial Park

The Guyana government has announced that it is planning to develop a multi-purpose industrial park in Wales Estate, along the west side of the Demerara River (OilNOW 2021c).

The Wales Estate Industrial Park is expected to cover several thousand hectares of land. In addition to the GTE Project and the Government of Guyana Power Plant (see Section 11.3.2.11, Government of Guyana Power Plant), the Guyana government has also indicated plans to develop an agro-processing center at the Wales Estate Industrial Park (Guyana Chronicle 2021). The project would be a public-private partnership between the National Industrial & Commercial Investments Ltd.[1] and Caribbean Marketing Enterprises Incorporated.

11.4. IDENTIFICATION OF EXTERNAL STRESSORS

Two external stressors were identified by the Consultants as potentially relevant with respect to their potential for contributing to cumulative impacts on VECs: natural hazards and climate change; and commercial and artisanal fishing. These are discussed below.

11.4.1. Natural Hazards and Climate Change

The natural disaster risk profile for Guyana indicates that floods, droughts, and landslides pose the most significant risks for the country (UNISDR 2014; World Bank 2019). Of these, the primary natural hazards faced by the population are floods. The low-lying coastal plains in the coastal areas of Regions 1 through 6 face severe risk of flooding. In the recent past, floods have produced significant health impacts; direct economic losses for agriculture, livestock, fisheries, and forestry industries; and significant damage to roads and other infrastructure. Floods can also potentially increase the transmission of water-borne diseases—such as typhoid fever, cholera, leptospirosis, and hepatitis A—and vector-borne diseases, such as malaria, dengue, and dengue hemorrhagic fever, yellow fever, and West Nile fever (WHO Undated).

The current scientific understanding of climate change is that the consequences of global climate change have the potential to impact Guyana's climatic conditions over the long term. A discussion of these potential consequences of climate change is provided in Section 7.6.2.3, Current Scientific Understanding of Consequences of Climate Change. The information from this section has been considered in the development of the CIA.

11.4.2. Commercial and Artisanal Fishing

Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. There are four main types of marine fisheries in Guyana (see Chapter 9, Assessment and Mitigation of

[1] The Guyana government's holding company for state assets

Potential Impacts from Planned Activities—Socioeconomic Resources), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place:

- Industrial fisheries use trawls to target seabob, shrimp, and prawns, at depths of 13 to 16 meters primarily, but can also occur shallower or deeper depending on seasonal movements of the resource on the continental shelf.
- Semi-industrial fisheries use fish traps and lines to target red snapper and vermilion snapper at the edge of the continental shelf.
- Artisanal fisheries use gillnets, drift seines, Chinese seines, and other gear (e.g., Cadell line) to target shrimp and a mix of fish species, at depths of 0 to 28 meters.
- Shark fisheries use trawls, gillnets, and hook and line to target sharks throughout the continental shelf waters, although these fisheries capture a number of species as bycatch.

Guyana's marine fishing activities are directed at commercializing its shrimp resources using trawlers, and its ground-fisheries (with the exception of the deepwater, semi-industrial, trap-based fishery) are based on wooden vessels and employ a variety of gear by artisanal fisherfolk. Fishing yields vary by season, with fisherfolk reporting the highest yields from June through September. From October to early February, catches are at their lowest due to seasonally colder waters coming from the north. There has been a declining trend for artisanal finfish, prawns, and seabob catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. The prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 70 meters (Guyana Association of Trawler Owners and Seafood Processors 2016, pers. comm.). Fishing by small vessels is generally focused along the coastlines of the vessels' respective landing sites. Larger artisanal vessels that have engine sizes of greater than 40 horsepower travel greater distances and have fishing trips of longer durations. There is limited exploitation of pelagic resources over the outer continental shelf and towards the continental slope.

Interviews with fisherfolk conducted as part of the Liza Phase 1 post-permit studies and the 2019 Participatory Fishing Survey indicated that gillnets are the most productive type of gear in the smaller-scale fisheries that operate closer to the coast, although gillnets are among the most susceptible gear types to fouling by sargassum, which presents an increasing and significant challenge to fisherfolk. The spread of mangrove vegetation along the shoreline and the dynamic accretion and erosion of the Guyanese coastline as a result of natural forces also pose challenges for fisherfolk. This resultant loss of access to shore has caused some landing sites to close and fisherfolk to relocate to other landings sites.

Industrial fishing operators in Guyana are based mainly in Region 4 and have private wharves where their vessels dock. The large-scale commercial trawl fishery mainly targets seabob, a short-lived shallow water shrimp (*Xiphopenaeus kroyeri*), and various finfish species (MacDonald et al. 2015). This includes red snapper, shark, and tuna. When last studied, the deepwater tuna fleet was at 12 vessels (Department of Fisheries 2019, pers. comm.; De Freitas

2018, pers. comm.). The fishing industry is one of the most important direct and indirect economic drivers in Guyana (see Section 9.1.2, Existing Conditions and Baseline Studies (Social). However, unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles (Stiles et al. 2010). The Liza Phase 1 post-permit studies documented some remnant coral growth in some areas on the continental shelf, and indicated the trawl fishery as a probable factor preventing recovery of Guyana’s corals and other shallow benthic communities (ERM 2018).

11.5. VEC Selection and Description

11.5.1. Selected Valued Environmental Components for Inclusion in the Cumulative Impact Assessment

All the potentially eligible VECs were analyzed against the following criteria: (1) confirmed to be valued by an identified stakeholder group; (2) reasonably expected to be potentially significantly impacted by the Project (i.e., at least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of at least **Possible**); and (3) reasonably expected to be potentially impacted by some combination of other projects and external stressors. Table 11.5-1 summarizes the VECs considered in the CIA.

Table 11.5-1: Selected VECs for Inclusion in the CIA

VEC	Valued by Stakeholders	Potentially Significantly Impacted by GTE Project [a]	Potentially Affected by One or More “Other Projects”	Potentially Affected by One or More “External Drivers”
Sound and Vibration	Yes	Yes	Yes	No
Air Quality, Climate, and Climate Change	Yes	Yes	Yes	Yes
Marine and Coastal Biodiversity	Yes	Yes	Yes	Yes
Terrestrial Biodiversity	Yes	Yes	Yes	Yes
Freshwater Biodiversity	Yes	Yes	Yes	Yes
Ecological Balance and Ecosystems	Yes	Yes	Yes	Yes
Special Status Species	Yes	Yes	Yes	Yes
Socioeconomic Conditions	Yes	Yes (potential adverse and positive)	Yes (potential adverse and positive)	Yes
Community Health and Wellbeing	Yes	Yes	Yes	Yes
Social Infrastructure and Services	Yes	Yes	Yes	Yes
Transportation	Yes	Yes	Yes	Yes

VEC	Valued by Stakeholders	Potentially Significantly Impacted by GTE Project [a]	Potentially Affected by One or More “Other Projects”	Potentially Affected by One or More “External Drivers”
Cultural Heritage	Yes	Yes	No	No
Land Use and Land Ownership	Yes	Yes	Yes	Yes
Landscape and Visual, Light	Yes	Yes	No	No
Ecosystem Services	Yes	Yes	No	Yes
Indigenous Peoples	Yes	Yes	No	Yes

[a] At least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of **Possible** or higher.

11.5.2. Valued Environmental Components Not Selected for Inclusion in Cumulative Impact Assessment

Several environmental and socioeconomic resources or components were not selected as potentially eligible for the CIA; in all cases they were not reasonably expected to be significantly impacted by the GTE Project (i.e., at least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of **Possible** or higher)—and in some cases they were also not reasonably expected to be potentially impacted by some combination of other projects or external stressors. Table 11.5-2 presents the components that were not selected as VECs for the CIA.

Table 11.5-2: **VECs Not Selected for Inclusion in CIA**

Potential VEC	Valued by Stakeholders	Potentially Significantly Impacted by GTE Project [a]	Potentially Affected by One or More “Other Projects”	Potentially Affected By One or More “External Stressors”
Geology and Hydrogeology	Yes	No	No	No
Soils	Yes	No	Yes	No
Sediments	Yes	No	Yes	No
Water Quality	Yes	No	Yes	Yes
Waste Management Infrastructure Capacity	Yes	No	Yes	No
Protected Areas	Yes	No	No	Yes

[a] At least one potential residual impact significance rating of **Minor** or above for a planned Project activity or at least one residual risk rating of **Moderate** or above for an unplanned event with a likelihood of **Possible** or higher.

11.5.3. Potential Impacts from Other Projects

Table 11.5-3 provides a list of the other projects identified and a summary of their potential impacts. Some of the other projects are other EEPGL projects, which tend to have a greater level of detailed preliminary information to inform the CIA; however, detailed information is not available for all of the other projects. The identified other projects that have a similar nature, such as the other EEPGL exploration and development projects and other operator exploration drilling, and new shorebase and port facilities, are grouped, and their potential impacts discussed together. Potential impacts are annotated with a “C” and/or an “O” to indicate whether the potential impact is associated with construction (C) or operations (O) stages. For this purpose, drilling is categorized as “construction.” When there are no impacts anticipated for a particular project group that could affect the same VEC as the GTE Project, they are annotated as “N.”

Table 11.5-3: Potential Impacts from Other Projects

VEC	Description of Impacts from Other Projects that Could Potentially Impact the Same VECs as the GTE Project	Stages of Other Projects Associated with Potential Impacts that Could Potentially Impact the Same VECs as the GTE Project									
		Other EEPGL Oil and Gas Exploration & Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Government of Guyana Power Plant	Replacement of Demerara Harbor Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]	Wales Estate Industrial Park
Sound and Vibration	Sound, vibration, and/or light (as a proxy for potential disturbance of people or wildlife) from construction or operations activities.	C, O	C	C	N	C, O	C	N	N	C	C, O
Air Quality, Climate, and Climate Change	Increased concentrations of criteria pollutant emissions from various sources (i.e., construction and/or operations activities) potentially resulting in health impacts on onshore receptors.	C, O	C	C	N	C, O	C	C	C	C, O	C, O
	Increased GHG emissions from various sources (i.e., construction and/or operations activities).	C, O	C	C	C, O	C, O	C	C	C	C, O	C, O
Marine and Coastal Biodiversity	Direct mortality or injury of marine and/or coastal species from attraction to offshore Project facilities (birds and marine mammals), potential attraction and resultant mortality, disturbance or injury from collisions with wind turbines [2] or transmission line associated with power plant.	C, O	C	C	N	O	N	N	O	N	N
	Disturbance of marine and coastal fauna by exposure to permitted discharges. Distribution and habitat changes for demersal species from altered water quality from project activities and from the presence of seabed infrastructure.	C, O	C, O	C	N	O	N	N	N	N	N
	Displacement of marine or coastal species from habitat due to disturbance from in-water activity. Entrainment of early life stages from water intakes (FPSO cooling water intakes).	C, O	C, O	C	N	C	C	C, O	N	C	N
	Acoustic injury or disturbance from construction or operations sound exposure leading to deviation from the area for marine mammals, marine fish, or marine turtles.	C, O	O	C	N	N	N	N	N	C, O	N
	Predation of juveniles of various species of wild fish that will enter the pens [3] (which would be used as growing structures for the fish in the Caribbean Mariculture Project).	N	N	N	N	N	N	O	N	N	N
	Injury or mortality of marine mammals or marine turtles due to vessel strikes (an unplanned event).	C, O	C, O	C	N	N	N	C,O	N	O	N
	Use of major vessels and other offshore infrastructure as a resting place or attractant of prey for marine birds (positive impact).	O	C	N	N	N	N	N	N	N	N
Terrestrial Biodiversity	Fauna injury or mortality due to earthworks and construction activities (unplanned event).	N	N	N	C	C	N	N	N	C	C
	Removal or modification of habitat, resulting in displacement of fauna.	N	N	N	C	C	N	N	C	C	C
	Disturbance or displacement from sound, vibration, and or light from construction or operations activities.	N	N	N	N	C, O	N	N	N	C, O	C, O
Freshwater Biodiversity	Disturbance or displacement of riverine mammals or canal fauna as a result of in-river or in-canal activities.	C, O	N	N	N	C	C	N	N	C, O	N
	Disturbance of riverine or canal fauna by exposure to permitted discharges or increased suspended solids from construction activities, including dredging.	N	N	N	N	C, O	C	N	N	C, O	C

[2] The two special status seabirds are unlikely to be present in the area near the wind turbines.
[3] Four of the five species that would be grown are predaceous, and one is omnivorous.

VEC	Description of Impacts from Other Projects that Could Potentially Impact the Same VECs as the GTE Project	Stages of Other Projects Associated with Potential Impacts that Could Potentially Impact the Same VECs as the GTE Project									
		Other EEPGL Oil and Gas Exploration & Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Government of Guyana Power Plant	Replacement of Demerara Harbor Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]	Wales Estate Industrial Park
	Modification of freshwater habitat or hydrologic connectivity/patterns in freshwater networks, resulting in impacts on freshwater fauna.	N	N	N	N	C	C	N	N	C	N
	Entrainment of early life stages from water intakes (power plant cooling water intakes).	N	N	N	N	O	N	N	N	N	N
	Acoustic disturbance from construction or operations sound exposure leading to deviation from the area for riverine mammals.	C, O	C, O	C	N	N	C	N	N	C, O	N
	Injury or mortality of riverine mammals due to vessel strikes (an unplanned event).	C, O	C,O	C	N	N	C	N	N	C, O	N
Ecological Balance and Ecosystems	Changes in marine nutrient cycle resulting in localized and temporary changes in phytoplankton species distribution.	C, O	C, O	C, O	N	N	N	O	N	N	N
	Introduction of invasive species via ballast water discharges. For the mariculture project, introduction of alien species through other means, potential release of artificially propagated seed into the wild.	C, O	C, O	C, O	N	N	N	O	N	N	N
	Changes in gene flow. For the mariculture project, potential loss of genetic resources due to collection of larvae, fry, or juveniles for aquaculture production, development of antibiotic resistance in pathogenic bacteria that could then spread from farms to wild stock.	C, O	C	N	N	N	N	O	N	N	N
	Changes in carbon storage (either from changes in marine carbon cycle or uptake of carbon on land by plants).	C, O	N	N	N	C	N	C, O	C	C	C
	Changes in vegetation structure or habitat connectivity.	N	N	N	C	C	N	N	C	C	C
	Seasonal changes in hydrology.	N	N	N	N	C, O	N	N	N	N	N
Special Status Species	Habitat loss and degradation, habitat conversion, species disturbance and displacement, morality/injury of biota, disturbance and displacement or biota, and degraded water quality	C, O	C	C	N	C	C	C, O	O	C, O	C, O
Socioeconomic Conditions	Increased cost of living and potential for competition with other local businesses for qualified workers.	C, O	C	N	N	C, O	N	N	N	C, O	C, O
	Increased government revenues and increased employment, increased local business activity and household income (potential benefit).	C, O	C	N	C	C, O	N	N	O	C, O	C, O
	Reduced cost of energy and increased reliability and associated indirect economic benefits (potential benefit).	N	N	N	N	O	N	N	O	N	N
	Adverse impacts on fishing livelihoods as a result of marine safety exclusion zones for commercial fishing operations and interference with subsistence fishing.	C, O	C	C	N	N	N	N	N	O	N
Community Health and Wellbeing	Increased risk of communicable disease transmission, impacts on public safety.	C, O	C	N	N	C	C	N	C	C	C
	Reduced access to emergency and health services.	C, O	C	N	N	C	C	N	N	C	N
	Public anxiety over oil and gas sector risks.	C, O	C	N	N	N	N	N	N	N	N
Social Infrastructure and Services	Increased demand for use of lodging leading to reduced availability and/or increased cost. Decreased availability/increased cost of housing and utilities.	C	C	N	N	C	C	N	C	C	C
Transportation	Increase in road traffic congestion.	C, O	C	N	C, O	C, O	C	N	C	C, O	C, O
	Increased vessel traffic on Demerara River and between Demerara River shorebases and offshore work areas.	C, O	C	C	N	C	C	C, O	N	C, O	N

VEC	Description of Impacts from Other Projects that Could Potentially Impact the Same VECs as the GTE Project	Stages of Other Projects Associated with Potential Impacts that Could Potentially Impact the Same VECs as the GTE Project									
		Other EEPGL Oil and Gas Exploration & Development Projects [a]	Non-EEPGL Oil and Gas Exploration Projects [b]	Fiber Optic Cable Project	Guyana Office Complex Project	Government of Guyana Power Plant	Replacement of Demerara Harbor Bridge	Caribbean Mariculture Project	Hope Wind Farm	New Shorebase and Port Facilities [c]	Wales Estate Industrial Park
	Interference with commercial cargo, commercial fishing, and subsistence fishing vessels.	C, O	C	C	N	N	N	C, O	N	N	N
Cultural Heritage	Disturbance of or damage to cultural sites	C	C	C	N	N	N	N	N	N	N
Land Use and Land Ownership	Potential physical or economic displacement as a result of land use/ownership changes.	N	N	N	N	C	C	N	N	C	C
Landscape and Visual, Light	Alteration of scenic and visual character of landscape from key viewpoints and in sensitive visual landscapes	N	N	C	N	C, O	C, O	N	N	C, O	C, O
	Alteration of the nighttime visual setting	N	N	C	N	C, O	C, O	N	N	C, O	C, O
Ecosystem Services	Effects to provisioning, regulating, and/or cultural services	N	N	C	N	C, O	C	N	N	C, O	C, O
Indigenous Peoples	Interference with navigation on Demerara River	C	C	C	N	C	C	N	N	C, O	C

C = Construction (inclusive of drilling); GHG = greenhouse gas; O = Operation; VSP = Vertical Seismic Profile; N = No potential impacts to same VECs anticipated.
[a] Exploration drilling by EEPGL; Liza Phase 1; Liza Phase 2; Payara, Yellowtail; Uaru+, and FPSO #6 Development Projects
[b] Exploration drilling by Repsol, Tullow, and CGX
[c] West Demerara Shorebase (TriStar Inc) and Vreed-en-Hoop Port Facility

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11.5.4. Valued Environmental Component Description

The existing conditions sections of this EIA present the existing conditions of the selected VECs, as well as those taxon-specific VECs not selected, but discussed *in lieu* of Special Status Species (i.e., Marine Turtles and Seabirds); please refer to the following sections for details on the current status of each component:

- Sound and Vibration: Section 7.5
- Air Quality, Climate, and Climate Change: Section 7.6
- Marine and Coastal Biodiversity (seabirds, marine mammals, marine turtles, marine fish): Section 8.2
- Terrestrial Biodiversity: Section 8.3
- Freshwater Biodiversity (riverine mammals): 8.4
- Ecological Balance and Ecosystems: Section 8.5
- Special Status Species: Section 8.6
- Socioeconomic Conditions (including employment and livelihood): Section 9.1
- Community Health and Wellbeing: Section 9.2
- Social Infrastructure and Services: Section 9.3
- Transportation (vessel and vehicular): Section 9.4
- Cultural Heritage: Section 9.5
- Land Use and Land Ownership: Section 9.6
- Landscape, Visual Resources, and Light: Section 9.7
- Ecosystem Services: Section 9.8
- Indigenous Peoples: Section 9.9

11.6. ASSESSMENT OF CUMULATIVE IMPACTS ON VECS

11.6.1. Cumulative Impact Analyses

In addition to the Project-only analyses conducted for the GTE Project (see prior sections of the EIA), the following analyses were conducted:

- Air quality dispersion modeling was conducted for cumulative emissions from the Project, the Government of Guyana Power Plant, and EEPGL's ongoing, permitted, and planned offshore activities (Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects, as well as ongoing exploration drilling) (see Air Quality in Section 11.6.1.1, Air Quality, Climate, and Climate Change).

- An inventory of cumulative greenhouse gas (GHG) emissions from the Project, the Government of Guyana Power Plant, and EEPGL's ongoing, permitted, and planned offshore activities (Liza Phase 1, Liza Phase 2, Payara, and Yellowtail Development Projects, as well as ongoing exploration drilling) was developed (see Climate and Climate Change in Section 11.6.1.1, Air Quality, Climate, and Climate Change).
- Assessment of cumulative waste management infrastructure capacity demands for all of EEPGL's projected operations at the time the Project will come online was conducted (see Section 11.6.1.2, Waste Management Infrastructure Capacity).

11.6.1.1. Air Quality, Climate, and Climate Change

Air Quality

Air dispersion modeling was carried out to assess potential cumulative air quality impacts on onshore human receptors. As detailed in the Emissions Inventory and Air Quality Modeling Report (Appendix L), the following activities were reflected in the "cumulative case" air dispersion modeling:

- GTE Project normal operations;
- Government of Guyana Power Plant operations;
- Exploration drilling through end of 2028;
- Liza Phase 1 Development Project (FPSO operation);
- Liza Phase 2 Development Project (FPSO operation);
- Payara Development Project (development well drilling; installation, commissioning, and start-up; and FPSO operation);
- Yellowtail Development Project (development well drilling; installation, commission, and start-up; and FPSO operations);
- Uaru+ Development Project (development well drilling; installation, commissioning, and start-up; and FPSO operation); and
- A sixth development project FPSO #6; development well drilling; installation, commissioning, and start-up; and FPSO operation).

The modeling predicted the maximum onshore concentrations from the cumulative case to be no more than 57 percent of the ambient air quality guidelines for NO_2, no more than 15 percent of the ambient air quality guidelines for $PM_{2.5}$, and no more than 5 percent of the ambient air quality guidelines for any of the other parameters subjected to modeling.

The predicted cumulative case concentrations for NO_2 (all averaging periods and rankings) and $PM_{2.5}$ (24-hour 99th percentile and annual averaging periods) exceed 10 percent of the applicable guidelines. Accordingly, consistent with the approach described in Appendix L, Emissions Inventory and Air Quality Modeling Report, the measured ambient baseline concentrations (corresponding to the same averaging periods and rankings) for NO_2 and $PM_{2.5}$ were added to the predicted maximum concentrations for the cumulative case.

The total predicted concentrations (i.e., cumulative case sources plus ambient background concentrations) are below the guideline concentrations for NO_2 for all averaging periods and rankings. However, the predicted $PM_{2.5}$ 24-hour 99th percentile and annual averaging period total concentrations are 369 percent and 216 percent of the applicable guideline concentrations, respectively. Out of this 369 percent, 354 percent is due to the existing airshed and 15 percent is due to the cumulative case sources (98 percent of which is due to the Power Plant). Out of the 216 percent of the applicable guideline concentrations for the $PM_{2.5}$ 99th percentile averaging period, 202 percent is due to the existing airshed and 14 percent is due to the cumulative case sources (99.5 percent of which is due to the Power Plant).

The portions of the receptor grid in which the contributions from cumulative sources exceed 10 percent of the applicable guidelines (which is the trigger for considering ambient background concentrations) for the two averaging periods are located immediately south of the fenceline of the NGL Plant and cover areas of approximately 1.69 hectares for $PM_{2.5}$ 24-hour 99th percentile averaging period and 0.34 hectares for $PM_{2.5}$ annual averaging period.

Climate and Climate Change

Considering the same activities reflected in the cumulative case for air dispersion modeling, the estimated peak annual cumulative GHG emissions across these activities are presented on Figure 11.6-1. The primary sources of GHG emissions are the combustion turbines and flares on the offshore development project FPSOs, with smaller amounts from other fuel combustion sources. GHG emissions result from products of combustion of various fuel components based on the potential for each component to contribute to GHG emissions and the emissions of other emitted GHG compounds such as methane and nitrous oxides. As noted in Section 7.6, Air Quality, Climate, and Climate Change, emission factors from the AP-42 document were used to calculate combustion-related GHG emissions.

As shown on Figure 11.6-1, cumulative GHG emissions are projected to increase through 2031 to a peak of approximately 9,300 kilotonnes per year, and then decrease steadily, with a more substantial rate of decrease beginning in 2040, as predicted production levels gradually decrease for the six assessed offshore development projects. The Project itself accounts for approximately 0.4 to 0.5 percent of cumulative GHG emissions through 2040, increasing to 0.5 to 0.8 percent of cumulative GHG emissions after the Liza Phase 1 and Liza Phase 2 development projects reach their projected end of operations. Note that this CIA does not account for potential decreases in GHG emissions attributable to Guyana's planned future energy generation using lower carbon intensive natural gas.

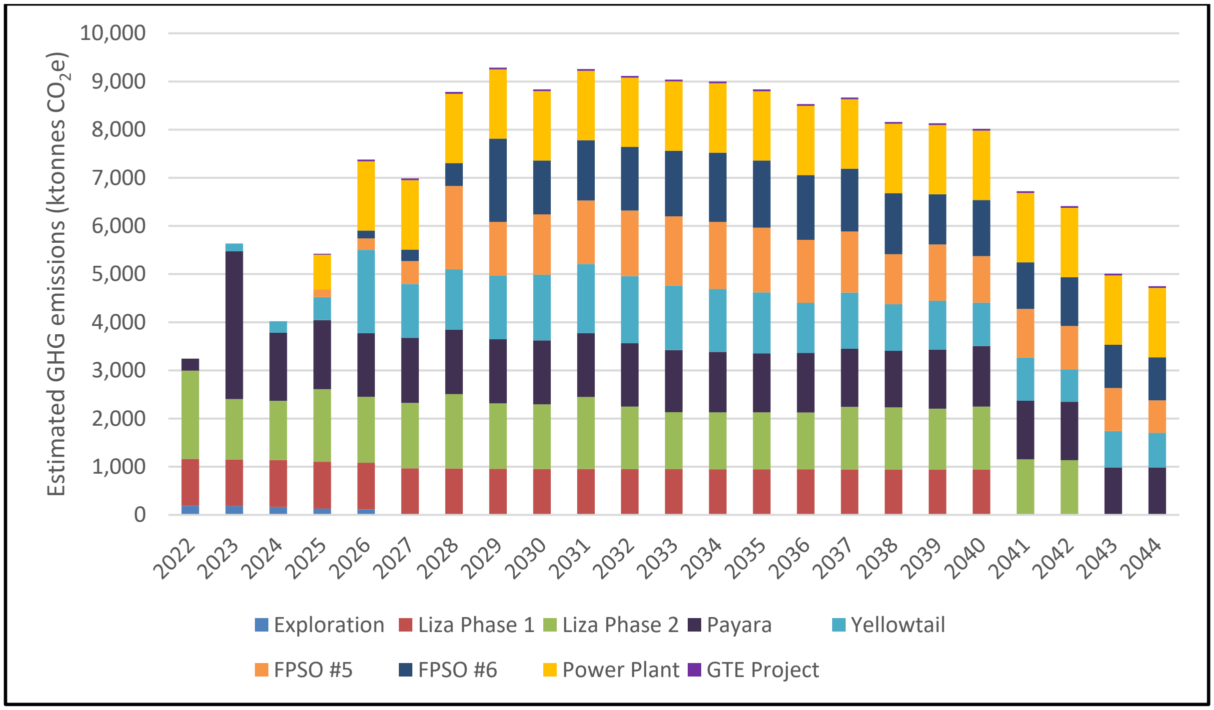

Figure 11.6-1: Summary of Estimated Annual GHG Emissions—Cumulative Case Activities

11.6.1.2. Waste Management Infrastructure Capacity

Considering the Project and the other offshore EEPGL activities included in the scope of the CIA (i.e., exploration through 2028, Liza Phase 1, Liza Phase 2, Payara, Yellowtail, Uaru+, and FPSO #6 development projects, FOC Project, GOC Project)[4], the types and estimated quantities of wastes that will be transported to shore for management are summarized below in Table 11.6-1.

[4] Waste estimates are not included for the FOC Project because the construction stage is expected to be finished by the time the GTE Project activities begin and the volume of waste generated for this project during its operations stage is expected to be *de minimis*. Waste estimates are not included for the Power Plant, as the design for this project is not sufficiently defined to facilitate an estimate of waste generation volumes. The Consultants were unable to identify publicly available waste generation estimates for the non-EEPGL projects included in the CIA.

Table 11.6-1: Summary of Estimated Annual Project Waste Generation and Management Methods—Cumulative Case Activities

Waste Generated by Category		Volume by Year/Metric Tonnes [a]									
	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031–2032	2033–2044
Non-Hazardous wastes (total) [b, c]	5,050	5,330	4,880	5,480	5,240	4,940	4,810	3,310	1,750	3,310	1,750
Hazardous wastes (total) [b, d]	3,620	4,300	3,280	5,990	5,070	3,090	1,790	1,180	580	1,180	580

[a] The annual totals reflect the current preliminary Project schedules and the production profiles for development projects and exploration drilling, which could change. The Yellowtail portion of the annual totals conservatively assumes drilling up to 2032.
[b] Totals may not sum exactly due to rounding.
[c] Includes wastes that will be directly shipped to an approved landfill and wastes that can be recycled, reclaimed, or reused. Volumes include estimated quantities of residue from treatment of hazardous waste.
[d] Includes wastes that are treated to produce residual non-hazardous effluent than can be discharged through permitted outfalls and wastes that are treated to produce residual non-hazardous solid wastes that can then be recycled, reclaimed, reused, or transported for disposal in an approved landfill.

The cumulative projected peak waste generation is on the order of approximately 955 tonnes per month (non-hazardous and hazardous combined), approximately 2.3 percent of which is attributed to the Project. Conservatively assuming all of the non-hazardous waste and all of the treated hazardous waste (assuming no reduction in mass during treatment) ultimately is disposed in a non-hazardous landfill, this represents approximately 6.4 percent of the total current demand on Georgetown-based landfill facilities (on the order of approximately 15,000 tonnes per month). Taking into consideration the opening of Cell 2, the reasonably anticipated development of additional cells at the Haags Bosch Landfill, and the limited percent contribution of the Project, this represents a relatively low level of impact on non-hazardous waste management infrastructure capacity for the longer-term (up to 10 years). New landfill development in the region may be appropriate for consideration going forward.

In the absence of other oil and gas/industrial operations exerting a significant increase in the demand on Georgetown-based hazardous waste treatment facilities, the cumulative projected peak hazardous waste generation (approximately 500 tonnes per month, approximately 0.5 to 1 percent of which is attributed to the Project) would represent a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities. However, given the recent and ongoing expansion of hazardous waste management capacity in Georgetown, this waste generation rate is not expected to overburden the treatment capacity.

11.6.2. Summary of Cumulative Impact Assessment

Table 11.6-2 summarizes the CIA for the VECs identified as eligible for the CIA. For each VEC assessed, the table provides a discussion of the nature of the potential cumulative impacts on the VEC, the cumulative impact priority rating assigned for the resource, and – as applicable – additional recommendations to address potential cumulative impacts.

Table 11.6-2 Summary of Cumulative Impact Assessment

VEC	Cumulative Impact	Priority Rating
Sound and Vibration	The Project will result in temporary increases in airborne noise levels during the Construction stage, and long-term increases in airborne noise levels during the Operations stage. For both stages, the potential increases above negligible significance levels will be limited to areas immediately adjacent to the source of noise (i.e., the construction work area and the NGL Plant site, for the Construction and Operations stages, respectively). The primary potential for noise levels from the Project to combine with noise levels from other projects or activities at the same time is related to the potential for concurrent construction, and ultimately concurrent operation of the NGL Plant and the Power Plant. The only predicted noise increases above negligible levels is associated with the potential for intermittent nighttime noise during facility startup, maintenance activities, and upset conditions. However, it is possible that continuous operational noise level from the Power Plant could combine with noise levels from NGL Plant levels to produce a greater cumulative impact on nearby residences. Accordingly, this potential cumulative impact is assigned a Medium priority and it is recommended that EEPGL work with the Government of Guyana to confirm that combined noise levels from the NGL Plant and Power Plant are adequately managed, through design and/or operation.	Medium
Air Quality, Climate, and Climate Change	The Project has the potential to result in temporary increases in dust levels during the Construction stage. Potential increases above negligible significance levels will be limited to areas immediately adjacent to the source of activity (i.e., the construction work areas). The primary potential for dust levels from the Project to combine with dust levels from other projects or activities at the same time is related to the potential for concurrent construction of the NGL Plant and Power Plant. Based on the location of the NGL Plant near residential structures, dust level concerns during Construction will be limited to the few residential structures near the proposed heavy haul approach to the temporary MOF. To the extent that Power Plant construction activities also utilized this same area, cumulative dust impacts could occur. Accordingly, this potential cumulative impact is assigned a Medium priority and it is recommended that EEPGL work with the Government of Guyana so that dust minimization efforts are implemented consistently for the combined activities in this area. With respect to potential Operations stage impacts on air quality, air quality modeling for the NGL Plant operations alone indicates that predicted maximum concentrations of criteria pollutants will be well below ambient air quality guidelines. Cumulative air quality modeling (adding the Power Plant and EEPGL's offshore development projects) indicates that that predicted maximum concentrations of NO_2 are close to the ambient air quality guideline. However, the predicted concentrations are dominated (i.e., 68 to 92 percent depending on averaging period) by predicted emission from the Power Plant, with only 0.1 to 2.6 percent contributed by the NGL Plant operations.	Medium (Air Quality) Low (Climate/Climate Change)

VEC	Cumulative Impact	Priority Rating
	With respect to potential Operations stage impacts on climate / climate change, the Project itself accounts for approximately 0.4 to 0.5 percent of the estimated GHG emissions for the cumulative case through 2040, increasing to 0.5 to 0.8 percent. The Project's embedded controls and mitigation measures are considered sufficient to address the Project's potential contribution to potential cumulative impacts on climate/climate change, yielding a Low priority rating. Additionally, while the Power Plant accounts for a larger percentage of the estimated cumulative case GHG emissions, it is noted that one of the benefits of the Power Plant is that it will produce a less carbon-intensive energy source, as compared to the current heavy fuel oil-fired power plant that comprises the bulk of the national utility's produced electricity.	
Marine and Coastal Biodiversity	Anthropogenic impacts on marine and coastal development from non-Project activities (e.g., coastal development, fishing and commercial vessel traffic, other oil and gas projects) will continue to generate additional marine and/or riverine vessel activity that could combine in time and space with the Project's predicted impacts on marine and coastal habitat and biota. The bulk of the Project's contributions to the overall level of disturbance of marine and coastal biodiversity will be short-term and will be limited to the Construction stage, and will therefore not be significant enough to create an expected significant cumulative impact over the long term. The Project's embedded controls and mitigation measures are considered sufficient to address the Project's potential contribution to potential cumulative impacts on marine and coastal biodiversity, yielding a Low priority rating.	Low
Terrestrial Biodiversity	The Project AOI lies within a highly modified landscape that is characterized primarily by common and widespread generalist plant and animal species. The species composition is characteristic of areas dominated by agriculture and other types of current and/or historical anthropogenic disturbance. The primary impacts of the Project on terrestrial biodiversity involve habitat loss and conversion, injury/mortality of biota, degradation of habitat, and disturbance/displacement of wildlife, but these impacts are minor and are not expected to have population-level impacts on any species or permanently alter the ecological condition of the Project AOI. Potential impacts to terrestrial biodiversity will be greatest during the Construction stage of the Project, which will overlap with the construction and operations stages of several other Projects in the region that could have similar impacts to terrestrial biodiversity. The Project design includes embedded controls as well as targeted mitigation measures to minimize and mitigate for impacts to terrestrial biodiversity from the Project and these measures minimize the Project's impacts to the degree that the Project is not expected to significantly contribute to cumulative impacts to terrestrial biodiversity in the region, yielding a Low priority rating.	Low
Freshwater Biodiversity	Potential impacts on freshwater biodiversity will be predominantly related to habitat conversion rather than direct injury or mortality of freshwater biota. The freshwater habitat in the Project AOI is extensively modified and the freshwater biota in the Project AOI is reflective of highly disturbed conditions. The Project represents an incremental addition to a long legacy of	Low

VEC	Cumulative Impact	Priority Rating
	watershed manipulation, channelization, and aquatic habitat conversion across Guyana's coastal plain dating to the colonial era. The Consultants have made several recommendations to manage impacts on freshwater habitat and biota. These management measures are considered sufficient to address the Project's potential contribution to potential cumulative impacts on freshwater biodiversity, yielding a Low priority rating.	
Ecological Balance and Ecosystems	The Project will be constructed in a highly modified landscape and watershed. The Project will contribute to further conversion of habitat and impacts on natural ecological function, but the overall ecological functions of the landscape and affected watershed will retain their current functions largely unchanged. The Project's contribution to ecological degradation is not expected to exceed any relevant ecological thresholds, so the management measures proposed are considered sufficient to address the Project's potential contribution to potential cumulative impacts on ecological balance and ecosystems, yielding a Low priority rating.	Low
Special Status Species	The Project will have minor to moderate potential impacts on marine, freshwater, and terrestrial special status species that are similar to, but in most cases of higher significance than, the potential impacts on non-special status marine, freshwater, and terrestrial species. Some of these potential impacts, when combined with similar impacts on the same species caused by other developments in the region that overlap in space and time with the Project, may result in cumulative impacts to special status species, particularly those with highest conservation importance (endangered and critically endangered species). However, it is considered that the Project's committed embedded controls and mitigation measures already take account for this possibility, and are designed to minimize the Project's contribution to a cumulative impact. Accordingly, this potential cumulative impact is assigned a Low priority.	Low
Socioeconomic Conditions	The cumulative effects of the growing oil and gas sector along with multiple construction projects in the area (e.g., Demerara Harbour Bridge, Port of Vreed-en-Hoop, Power Plant, Wales Estate Industrial Park) could put a combined level of pressure on the local labor force and cause increased competition for qualified workers. Accordingly, this potential cumulative impact is assigned a Medium priority rating. It is recommended that actions should be taken by EEPGL in the medium term to mitigate potential adverse cumulative impacts on local labor and workforce, including through continued partnerships (e.g., Centre for Local Business Development) to promote training and development opportunities for local workers and businesses.	Medium
Community Health & Wellbeing	The potential cumulative impacts of the onshore components of the Project combined with those of other projects, primarily during the Construction stage, has the potential to overburden emergency and health services and further reduce access to these services for members of the general public. However, it is considered that EEPGL's Project commitment to continue to utilize private medical facilities and dedicated services for Project needs will be sufficient to	Low

VEC	Cumulative Impact	Priority Rating
	mitigate potential adverse cumulative impacts on community health and wellbeing. This potential cumulative impact is therefore assigned a Low priority.	
Social Infrastructure and Services	The potential cumulative impacts of the growing oil and gas sector along combined with those of multiple planned construction projects in the area (e.g. Demerara Harbour Bridge, Port of Vreed-en-Hoop, Power Plant, Wales Estate Industrial Park) and the demand for workers in the Region 3 area, as well as any associated influx to both Region 3 and the greater Georgetown area, could lead to a combined increase in the demand for use of lodging and housing and utilities, as well as an associated increase in cost of living. Accordingly, this potential cumulative impact is assigned a Medium priority rating. To help mitigate this potential cumulative impact, it is recommended that EEPGL should monitor the accommodation needs of all contractors working on EEPGL-related projects (including the GTE Project and EEPGL's offshore projects) to assess how the companies anticipate managing those accommodation needs, in particular during the GTE Project Construction stage.	Medium
Transportation	While other activities are planned that would generate additional marine or riverine vessel activity that could combine in time and space with that of the Project, the Project's potential impacts (which comprise relatively few vessel movements and predominantly during its Construction stage) on marine and riverine traffic will not be significant enough to create an expected significant cumulative impact. The Project's embedded controls and mitigation measures for marine and riverine traffic are considered sufficient to address potential cumulative impacts to which the Project could contribute, yielding a Low priority rating. With respect to road transportation, the road transportation network in the vicinity of the GTE Project's Direct AOI is already exhibiting high levels of congestion during peak hours. Accordingly, the potential cumulative impacts of multiple construction projects (e.g., the Project, the Power Plant, shorebases) could combine to add to a network that is already near or beyond capacity in terms of roadway level of service. However, it is considered that the Project's committed embedded controls and mitigation measures (e.g., maximized use of buses for transportation of workers) already take account for this possibility, and are designed to minimize the Project's contribution to a cumulative impact. Accordingly, this potential cumulative impact is assigned a Low priority.	Low
Cultural Heritage	The potential cumulative impacts of construction activity on tangible cultural heritage are specific to each project and within each project footprint; accordingly, cumulative impacts are not expected for these resources. A change in viewsheds associated with historic structures has the potential to be cumulative for construction or operations occurring in the same time or space; however, no historic structures were identified in the areas in which concurrent/collocated activities are expected (e.g., NGL Plant/Power Plant area). The potential impacts Project impacts of a higher significance are those associated with potential impacts to intangible cultural heritage (specifically silk cotton trees). As with tangible cultural heritage, these resources are by definition location-specific, and cumulative impacts would thus be	Low

VEC	Cumulative Impact	Priority Rating
	expected only for multiple project impacts occurring in the same footprint. As this is not expected, this potential cumulative impact is assigned a Low priority rating.	
Land Use and Ownership	The potential Project impacts on land use and ownership with a higher significance are location-specific (i.e., affecting particular properties/individuals within or near the Project footprint). Cumulative impacts could occur if the same individuals whose land use or ownership will be affected by the Project have additional land use or ownership impacts from other projects. While it is assumed for purposes of this EIA that individuals in the vicinity of the temporary MOF and heavy haul road will be physically relocated, detailed information about the specific private properties or public land tenures of these individuals or others that will be affected by the Project was not available at the time of writing. Accordingly, as a precautionary measure, this potential cumulative impact is assigned a Medium priority rating. It is recommended that, consistent with the Project's commitment to support the Government of Guyana to develop and implement a Resettlement and Livelihood Restoration Strategy to implement resettlement (for physical displacement) and livelihood restoration (for economic displacement) through a process that aligns with IFC Performance Standard 5, EEPGL identify—for the individuals to be relocated from the area of the temporary MOF—whether these individuals have additional assets that could be impacted by reasonably foreseeable other projects, and consider these impacts with respect to implementation of the above strategy.	Medium
Landscape and Visual, Light	The Project will result in temporary changes to viewsheds and increases in nighttime lighting during the Construction stage, and long-term changes to viewsheds and increases in nighttime during the Operations stage (at the NGL Plant). For both stages, the potential increases above negligible significance levels will be limited to areas immediately adjacent to the location of activities (i.e., construction work areas and the NGL Plant site, for the Construction and Operations stages, respectively). Changes to viewshed as a result of the presence of the NGL Plant will not be significantly intensified with the addition of the adjacent Power Plant, as the viewshed will already have changed from a natural view to one with industrialized components (e.g., stacks). There will be a potential for cumulative impacts associated with increased nighttime lighting (i.e., between the NGL Plant and the Power Plant). However, it is considered that the Project's committed embedded controls and mitigation measures (e.g., implementation of industry-standard lighting practices to reduce lighting impacts outside the facility) already take account this possibility, and are designed to minimize the Project's contribution to a cumulative impact. Accordingly, this potential cumulative impact is assigned a Low priority.	Low
Ecosystem Services	The potential cumulative impacts on ecosystem services will be low considering that impacts are site specific. However, the change in use of canals or the Demerara River for transportation and access to livelihoods (provisioning services) as a result of construction for the Demerara Harbour Bridge, Wales Estate Development Project and/or the Power Plant	Low

VEC	Cumulative Impact	Priority Rating
	could result in cumulative impacts. However, the Project's potential impacts (which comprise relatively few vessel movements and predominantly during its Construction stage) on riverine traffic will not be significant enough to create an expected significant cumulative impact. The Project's embedded controls and mitigation measures for riverine traffic are considered sufficient to address potential cumulative impacts to which the Project could contribute, yielding a Low priority rating	
Indigenous Peoples	Construction of the Project will involve shoreline and river-based construction activities on the Demerara River to support construction of the temporary MOF and supply of equipment and materials in support of NGL Plant construction. The Santa Aratak community uses the Demerara River for access to and from the community (via Kamuni Creek, more than 10 kilometers upstream of the proposed temporary MOF site), and Project-related activities in the river could therefore affect people living in Santa Aratak. While other activities are planned that would generate additional riverine vessel activity that could combine in time and space with that of the Project, the Project's potential impacts (which comprise relatively few vessel movements and predominantly during its Construction stage) on riverine traffic will not be significant enough to create an expected significant cumulative impact. The Project's embedded controls and mitigation measures for riverine traffic are considered sufficient to address potential cumulative impacts to which the Project could contribute, yielding a Low priority rating.	Low

11.7. CUMULATIVE IMPACTS MANAGEMENT FRAMEWORK

Cumulative impacts often result from the successive, incremental, and/or combined impacts of multiple developments. Accordingly, responsibility for their prevention and management is shared among the various contributing developments. It is usually beyond the capability of any one party to implement all of the measures needed to reduce or eliminate cumulative impacts.

EEPGL has incorporated a number of embedded controls and mitigation measures to address the potential impacts from the Project (see Chapter 15, Commitment Register). These design, construction, and operations measures serve to reduce the significance of potential impacts of the Project. For those resources with an assigned cumulative impact priority rating of **Low** (Table 11.6-2), the Consultants have concluded that the Project embedded controls and mitigation measures outlined in Chapter 15, Commitment Register, are sufficient to address the Project's contribution to the associated potential cumulative impacts.

A number of resources were assigned a cumulative impact priority rating of **Medium**, suggesting that additional consideration should be given (i.e., beyond the embedded controls and mitigation measures already proposed for the Project) to address potential cumulative impacts on these resources. The Consultants' recommendations to address these potential cumulative impacts with a **Medium** priority rating include the following:

- To address potential cumulative impacts on sound and vibration during the Project Operations stage, work with the Government of Guyana to confirm that combined noise levels from operations of the NGL Plant and Power Plant are adequately managed, through design and/or operation practices.
- To address potential cumulative impacts on air quality during the Construction stage, work with the Government of Guyana so that dust minimization efforts are implemented consistently for the combined construction activities in this area of the heavy haul road and temporary MOF (the only area with residences in close enough proximity to planned Project construction activities at the NGL Plant to have potential dust impact concerns).
- To address potential cumulative impacts on socioeconomic conditions related to increased competition for local labor, take actions in the medium term to mitigate potential adverse impacts on the local labor workforce—including, through continued partnerships (e.g., Centre for Local Business Development)—to promote training and development opportunities for local workers and businesses.
- To address potential cumulative impacts on social infrastructure and services related to increased demand on lodging and housing and utilities, monitor the accommodation needs of all contractors working on EEPGL-related projects (including the GTE Project and EEPGL's offshore projects) to assess how the companies anticipate managing those accommodation needs, in particular during the GTE Project Construction stage.
- To address potential cumulative impacts on land use and ownership, consistent with the Project's commitment to support the Government of Guyana to develop and implement a Resettlement and Livelihood Restoration Strategy to implement resettlement (for any

physical displacement) and livelihood restoration (for any economic displacement) through a process that aligns with IFC Performance Standard 5, identify—for the individuals to be relocated from the area of the temporary MOF—whether these individuals have additional assets that could be impacted by reasonably foreseeable other projects, and consider these impacts with respect to implementation of the above strategy.

The CIA did not identify any **High** priority potential cumulative impacts on VECs. Therefore, the Consultants do not deem necessary the development and implementation of multi-stakeholder collaborative management framework. However, as cumulative impacts could vary in the future, with the addition of other projects or external drivers, it is recommended that EEPGL consider participation, to the extent feasible and practicable, in working groups and/or industry organizations aimed at addressing management of potential impacts on regional resources to which EEPGL's projects could incrementally contribute with respect to cumulative impacts.

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12. TRANSBOUNDARY IMPACTS

Transboundary impacts are defined as cross-border Project-related impacts (i.e., impacts that would occur outside Guyana's geopolitical boundaries[1]). As described in Chapters 7, 8, and 9, the extents of all potential impacts from planned Project activities are expected to occur entirely within either the Direct or Indirect Areas of Influence. As defined in Chapter 3, EIA Approach and Impact Assessment Methodology, both the Direct and Indirect Areas of Influence are contained within Guyana's geopolitical boundaries; therefore, no planned Project activities are expected to result in transboundary impacts.

As described in Chapter 10, Unplanned Events, the potential exists for unplanned events—those events that are not planned to occur as part of the Project (e.g., accidents), but that have the potential to occur—to cause impacts as a result of Project activities. Chapter 10 describes the categories of unplanned events that have a credible potential to occur, should unexpected conditions occur and proposed Project controls fail concurrently. These categories include:

- Fuel spill, either in the marine or riverine environments;
- Loss of integrity of offshore pipeline, resulting in a natural gas release;
- Vessel collision with a third-party vessel, structure, or animal (non-spill-related);
- Loss of integrity of onshore pipeline, resulting in a natural gas release;
- Loss of integrity of natural gas liquids processing plant (NGL Plant), resulting in a hydrocarbon release;
- Untreated wastewater release at NGL Plant; and
- Vehicular accident.

As described in Chapter 10, Unplanned Events, considering the embedded controls that have been included in the Project design (see Chapter 5, Project Description), most of the categories of unplanned events listed above are considered **Unlikely** to occur (potential vessel strikes of marine mammals, releases of untreated wastewater at the NGL Plant, and vehicular accidents are considered **Possible**). In the unlikely event that they did occur, the effects of several of the above categories of unplanned events—including a marine mammal strike, untreated wastewater release, and vehicular accident—would be localized because of the nature of the event. That is, they would either not involve releases to the environment, or the volumes of materials that could potentially be released would be sufficiently small that they would have no potential to be detectable at Guyana's nearest border under any reasonably foreseeable scenario. For these reasons, these categories of unplanned events would have no potential of resulting in transboundary impacts.

[1]For the purposes of this chapter, Guyana's geopolitical boundaries are understood to include the entire land area within Guyana's borders as established by the Arbitral Tribunal of 1899 (ICJ 2021), and Guyana's Exclusive Economic Zone as recognized by the United Nations under the Food and Agriculture Organization Order 1991 (United Nations 1991).

The other categories of unplanned events considered, such as natural gas or hydrocarbon releases (including those that could lead to fires or explosions), could have effects outside of the localized area where the event occurred, depending on the volumes of materials released, the duration of the event, and the specific environmental/atmospheric conditions at the time of the event. As described in Chapter 10, Unplanned Events, consequence modeling was performed for representative scenarios in each of these unplanned event categories, and in each case the modeling demonstrated no potential for these events to result in impacts on environmental or socioeconomic receptors outside of Guyana's geopolitical boundaries. Accordingly, these categories of unplanned events also would have no potential of resulting in transboundary impacts.

13. ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT AND MONITORING PLAN FRAMEWORK

13.1. INTRODUCTION

This chapter provides a framework for the Project Environmental and Socioeconomic Management and Monitoring Plan (ESMMP). The ESMMP Framework describes the measures EEPGL will implement to manage the Project's potential environmental and socioeconomic risks and reduce impacts on the environment and communities. The scope of this chapter includes the following:

- Overview of the regulatory and policy framework underpinning the ESMMP Framework;
- Description of the ESMMP Framework structure;
- Description of the general ESMMP Framework guiding principles;
- Description of the general content of the management plans comprising the ESMMP Framework; and
- Description of how updates to the ESMMP Framework will be managed.

The ESMMP Framework is comprised of a combination of Project-specific management plans (e.g., ESMMP, Preliminary Decommissioning Plan) and affiliate-level management plans (e.g., Stakeholder Engagement Plan, Comprehensive Waste Management Plan, Oil Spill Response Plan). These are all included as part of the EIA. EEPGL will update the ESMMP Framework and its constituent management plans, as needed, to address the final conditions from the environmental authorization upon approval of the Project by the EPA.

13.2. REGULATORY AND POLICY FRAMEWORK

The Project will be subject to various regulatory requirements—as described in Chapter 2, Policy, Regulatory, and Administrative Framework, and the conditions established by the EPA upon issuance of an environmental authorization, once issued. Through its role as the operator of the Project, EEPGL is committed to complying with the laws and regulations of Guyana, and conducting business in a manner that is compatible with the environmental and economic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (see Section 2.5).

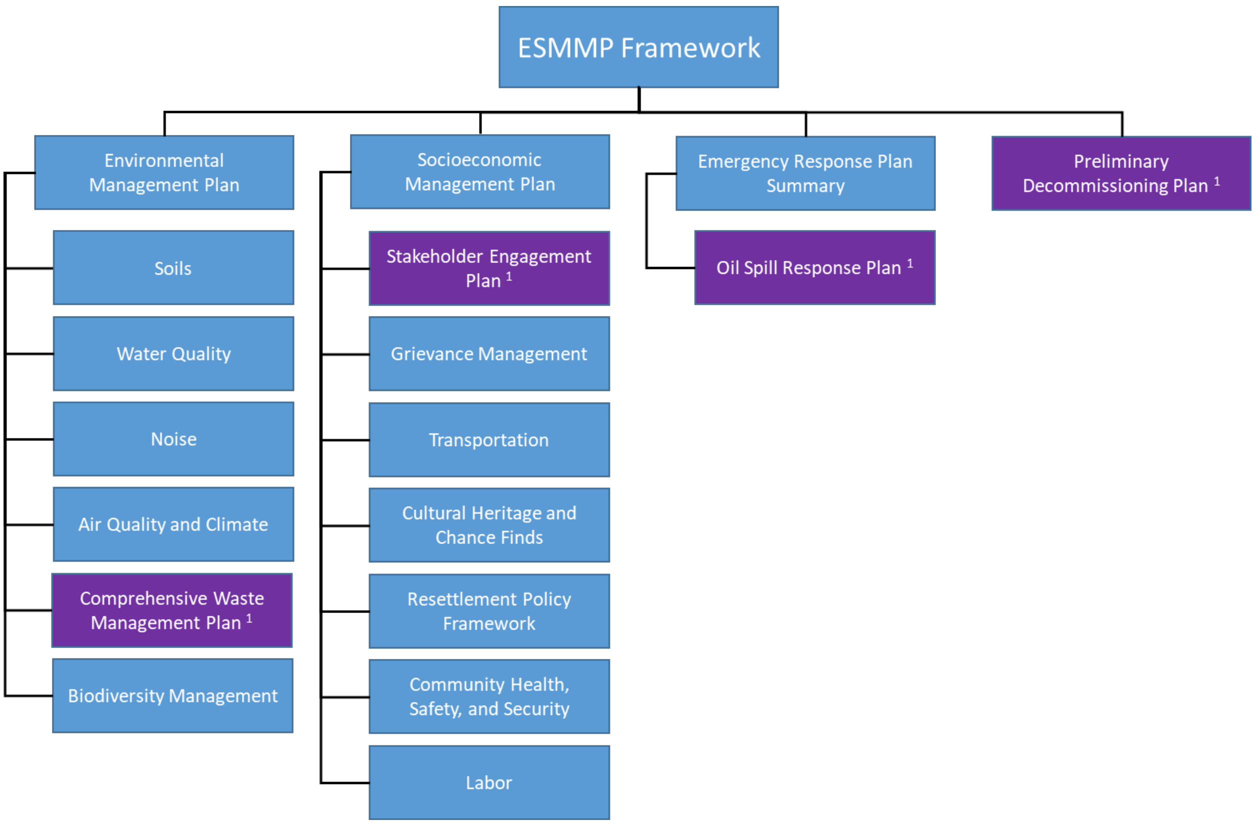
13.3. ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN FRAMEWORK STRUCTURE

Figure 13.3-1 depicts the overall structure of the Project ESMMP. The specific management plans included in the ESMMP Framework are organized into four categories:

- Environmental Management
- Socioeconomic Management

- Emergency Response Plan Summary, which includes oil spill response
- Preliminary Decommissioning Plan

Each of these categories includes one or more specific management plans that are included within the ESMMP Framework, as shown on Figure 13.3-1.



[1] Due to the size and/or complexity of these documents, these are stand-alone plans, and are provided as a separate attachment to the EIA in Volume III—Management Plans.

Figure 13.3-1: Environmental and Socioeconomic Management and Monitoring Plan Framework

13.4. General ESMMP Framework Guiding Principles

Each of the specific management plans comprising the ESMMP Framework have been prepared consistent with the following guiding principles:

- Covers all Project stages (i.e., there are not separate management plans for each Project stage, except for the Preliminary Decommissioning Plan);
- Contains a level of detail that is fit for purpose and varies among the individual management plans;
- Represents a "living document" that will be revised or amended as the Project progresses in response to changing circumstances, lessons learned, or other appropriate reasons; and
- Reflects the Project's regulatory commitments and obligations, including those from the EIA, other management plans, and the environmental authorization.

13.5. Management Plan Contents

The ESMMP Framework contains an introduction and scope as well as a summary of the applicable regulations, standards, and guidelines. The environmental and socioeconomic management plan elements within the ESMMP Framework are fit for purpose, and therefore vary to some extent in content, but contain resource-specific management measures that include proposed mitigation measures developed from the impact assessment as well as embedded controls. The component management plans also include the following information:

- The source of potential impact;
- The affected receptor;
- The specific Project component(s) for which the control/measure will be implemented (e.g., offshore pipeline, onshore pipeline, natural gas liquids processing plant) and/or the specific stage or stages of the Project during which each measure will be implemented (e.g., early works, construction and installation, operations);
- A description of the management measure; and
- Monitoring, recordkeeping, and reporting requirements, where applicable.

13.6. Management of Change

During Project implementation, changes may be required to address unanticipated conditions or situations. Managing change is an integral part of the Operations Integrity Management System. Monitoring, risk assessments, audits, inspections, and/or observations may identify the need for amendments to the ESMMP Framework. In these cases, the ESMMP Framework will be updated to reflect the change. In addition, the ESMMP Framework will be updated when applicable environmental or socioeconomic laws, regulations, standards, and/or company processes, systems, and/or technologies that are being applied to the Project change. The ESMMP Framework is envisioned to be a living document that will be updated to reflect continuous learning and improvements, and any significant updates or changes will be shared with the Government of Guyana for their records and use.

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14. RESIDUAL IMPACTS AND CONCLUSIONS

This section summarizes the potential environmental and socioeconomic impacts resulting from planned Project activities and the risks from potential unplanned events on resources, as well the Project's potential contributions to cumulative impacts on valued environmental and social components.

14.1. SUMMARY OF RESIDUAL IMPACTS

14.1.1. Planned Project Activities

The planned Project activities are predicted to have **Negligible** to **Moderate** impacts on physical resources, **Negligible** to **Moderate** impacts on biological resources, and **Negligible** to **Moderate** impacts on socioeconomic resources—with a number of positive impacts on socioeconomic conditions.

In the case of physical resources, the higher significance ratings stem from potential Construction-stage impacts related to potential noise and dust impacts on residential properties in the portions of the onshore pipeline construction corridor that will be in close proximity to existing communities or isolated residences (approximately 3.5 kilometers of the approximately 25-kilometer onshore pipeline corridor).

In the case of biological resources, the higher significance ratings stem from potential Construction-stage impacts related to mortality and injury of marine benthic organisms from offshore pipeline installation, and impacts on freshwater and terrestrial biodiversity (including special status species) related to construction of the onshore pipeline corridor.

In the case of socioeconomic resources, the higher significance ratings stem from potential impacts from infrequent and short-term periods of noise during the Construction and Operations stages, potentially leading to increased stress-related mental health impacts for nearby residents. For cultural heritage resources, the higher significance rating will only apply if the Project is unable to avoid removal of the silk cotton tree identified in the temporary pipeline right-of-way at Kilometer Point 4.1. Higher significance ratings are also associated with physical displacement and change in access to land used for agricultural livelihoods (i.e., potential economic displacement), which could affect a limited number of residents and land users in proximity to the onshore pipeline or the natural gas liquids processing plant (NGL Plant), heavy haul road, and temporary MOF.

The significance ratings of these potential impacts are reduced through the suite of embedded controls that will be incorporated into the Project design and execution. These same embedded controls contribute to the lower significance ratings for the other potential impacts assessed for planned Project activities. Additionally, the Consultants have recommended a suite of mitigation measures to reduce potential impact significance to as low as reasonably practicable.

14.1.2. Unplanned Events

Unplanned events, such as a vessel fuel spill or a loss of integrity of Project infrastructure resulting in a fire or explosion, are considered unlikely to occur due to the extensive preventive measures employed by EEPGL; nevertheless, events such as these are considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the nature and location of an unplanned event, as well as the ambient conditions (e.g., wind speed/direction, river flow conditions). The EIA describes (1) modeling of fuel spill scenarios to evaluate a range of possible spill trajectories and rates of travel, and (2) modeling of loss of process infrastructure integrity scenarios to evaluate a range of potential consequences from such an event.

Based on the limited volume of fuel that would likely be released to the environment in the unlikely event of a marine fuel spill from one of the offshore pipeline installation vessels or a support vessel, and the fact that marine diesel would weather (i.e., evaporate, degrade, and partition to the water column) very rapidly once in the ambient environment, the impacts from this type of event would be expected to be short-term and limited in extent. Socioeconomic resources (e.g., to fisheries or shorelines) would only be expected if the spill occurred in the nearshore/shore crossing segments of the offshore pipeline.

In the case of a riverine spill, the same limited spill volume and rapid weathering would reduce the level and extent of potential impact. However, the constrained geography within the Demerara River would lead to a high likelihood of shoreline impact, with the length of shoreline affected being a function of spill location and ambient river conditions (i.e., flow volume and tidal stage) at the time of the spill. This event, assuming a spill of the nature reflected in the modeled scenario, would therefore have a high likelihood of affecting biological and socioeconomic resources in the Demerara River and potentially along the shoreline adjacent to the river.

The magnitude of impact for either a marine or riverine fuel spill would depend on the volume and duration of the release as well as the time of year at which the release were to occur (e.g., whether a spill would coincide with the time of year when biological resources are more abundant in the area affected by the spill). Effective implementation of EEPGL's Oil Spill Response Plan (Volume III of the EIA) would reduce the risk to resources primarily by efforts to protect shorelines from the spill.

With respect to a potential loss of integrity of Project infrastructure leading to a release of hydrocarbons—and potentially a fire or explosion—the EIA included a preliminary analysis of the potential consequences of such an event, including evaluation of multiple scenarios that could lead to an accidental release of hydrocarbons. The highest risk associated with this type of event would be associated with the portions of the onshore pipeline segment located in close proximity to communities (i.e., where human receptors would have the highest likelihood of being affected by the event). As with a potential fuel spill, EEPGL's primary focus is on prevention of such an event through the rigorous design, construction, and operations procedures that will be put in place. However, in the unlikely situation that such an event occurs, EEPGL has an Emergency Response Plan (see the Environmental and Socioeconomic Management and Monitoring Plan in Volume III of the EIA) that will be updated prior to introduction of natural gas into Project infrastructure, and EEPGL will conduct regular training and drills to facilitate Project readiness to address an emergency event of this nature.

Additional unplanned events, which are also considered unlikely to occur due to the preventive measures employed by EEPGL, could include a loss of integrity of the offshore pipeline; collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting marine birds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the NGL Plant. The impact extent from these types of events would depend on the exact nature of the event. However, in addition to reducing the likelihood of occurrence, the embedded controls that EEPGL will put in place if such an event were to occur (e.g., training of vessel operators to recognize and avoid marine mammals, riverine mammals, and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) would also serve to reduce the likely extent of impact.

14.1.3. Cumulative Impacts

The Project's expected contribution to potential cumulative impacts will be limited by the fact that the Project's impacts with higher significance ratings will generally not, with the exception of the Power Plant, overlap spatially with impacts from the other projects considered in the cumulative impact assessment. Other EEPGL offshore Guyana oil and gas exploration and development activities considered in the cumulative impact assessment include the Liza Phase 1 Development Project and Liza Phase 2 Development Project, which are currently operational; the approved Payara and Yellowtail Development Projects; continued exploration drilling; and future proposed or planned offshore development projects (assumed for the purpose of this assessment to also be in the Stabroek Block). Potential future offshore Guyana oil and gas exploration by other developers and planned shorebase development and replacement of the Demerara Harbour Bridge could, in combination with Project activities in the Demerara River, also potentially contribute to cumulative impacts.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together have the potential to cumulatively impact the following resources:

- Sound and vibration (via increased noise levels during construction or operation in the vicinity of the NGL Plant);
- Air quality (via increased criteria pollutant emissions);
- Climate / climate change (via increased emissions of greenhouse gases);
- Marine and coastal biodiversity (via potential vessel strikes, marine sound, and marine habitat disturbance);
- Terrestrial biodiversity (via habitat loss and degradation, habitat conversion, mortality/injury of biota, introduction and spread of invasive and/or exotic vegetation species, wildlife disturbance and displacement, and degraded water quality);

- Freshwater biodiversity (via habitat conversion, degraded water quality, and mortality/injury of biota);
- Ecological balance and ecosystems (via potential degradation of existing ecological functions);
- Special status species (via habitat loss and degradation, habitat conversion, mortality/injury of biota, disturbance and displacement of biota, and degraded water quality);
- Socioeconomic conditions (via increased competition for labor and business);
- Community health and wellbeing (via increased demand on limited medical treatment capacity);
- Social infrastructure and services (via increased demand for limited housing, utilities, and services);
- Transportation (via additional marine or river vessel traffic congestion, especially near Georgetown Harbour, and increased road traffic along already-congested road segments in Region 3);
- Cultural heritage (via potential damage to intangible cultural heritage in the vicinity of the Direct Area of Influence);
- Land use and land ownership (via physical displacement or reduced access to land and natural resources);
- Landscape, visual resources, and light (via changes to landscape character during construction activities or as a result of long-term modifications to the character of the Demerara River, and nighttime lighting);
- Ecosystem services (via change in use of canals or Demerara River); and
- Indigenous peoples (via potential interference with navigation on the Demerara River).

The Project will adopt a number of embedded controls, mitigation measures, and management plans. These are considered sufficient and appropriate to address the contributions of the Project to potential cumulative impacts. With respect to the contributions of multiple EEPGL projects to cumulative impacts, it is recommended that EEPGL, when designing and undertaking these additional projects and activities, implement the same level of potential impact management for new projects as for the Gas to Energy Project. In addition, with the intention of minimizing the potential interactions between impacts of multiple projects, it is recommended that EEPGL actively manage, where feasible and practicable, the spatial and temporal overlap of the multiple project activities. These measures are expected to be sufficient to address contributions of the Project and other EEPGL projects to cumulative impacts.

14.2. DEGREE OF IRREVERSIBLE CHANGE

The planned Project activities will result in irreversible change to the onshore areas on which permanent aboveground Project infrastructure will be constructed. While portions of the approximately 75-hectare NGL Plant site may be revegetated and allowed to remain in a generally natural state during the Operations stage, it is conservatively assumed for the purpose of this EIA that this entire area will be permanently altered (noting that some or all of the area may be returned to a natural condition depending on the final decommissioning alternative selected). The temporary portions of the pipeline construction corridor will be restored after construction, but a permanent right-of-way (covering an area on the order of approximately 23 hectares) will be maintained (i.e., in a height-managed, vegetated state) for the life of the Project. Given the length of the planned operational life cycle, this is considered to be permanently altered. There will be a permanent loss of benthic habitat offshore as a result of the laying of the offshore pipeline on the seabed for up to 205 kilometers of the offshore pipeline length (amounting to approximately 6.6 hectares), which is proposed to be left in place upon decommissioning. However, this equipment can ultimately provide the substrate for recolonization of the impacted areas.

In the unlikely event of a fuel spill or fire/explosion resulting from a loss of Project infrastructure integrity, little irreversible change would be expected, although it could take several years for all resources to fully recover, depending on the nature and extent of the event as well as the time of year.

14.3. SUMMARY OF PROJECT BENEFITS

The Project will generate benefits for the citizens of Guyana in several ways:

- Project purchasing of in-country goods and services from Guyanese businesses in alignment with the EEPGL Local Content Plan approved by the Ministry of Natural Resources in June 2021.
- Hiring Guyanese nationals, either directly by EEPGL or indirectly by Project contractors, in alignment with the EEPGL Local Content Plan.
- Efforts to enhance the Guyana labor force (i.e., to increase experience, capacity, and skills of local workers) through efforts such as the Greater Guyana Initiative, (a decade-long program funded by the Stabroek Block co-venturers), which provides $20 billion GYD ($100 million USD) in support of sustainable economic diversification and capacity development programs across Guyana. Guyana is known for having a large percentage of the tertiary-educated population emigrate from the country primarily to Organisation for Economic Co-operation and Development nations (World Bank 2016, 2000; Guyana Chronicle 2015). Provided that a more robust employment environment can be demonstrated, an increase in high-skilled, higher-paying jobs associated with the oil and gas sector should contribute to the attenuation of this phenomenon, creating a larger pool of advanced workers for all areas of the economy.

- Through provision of natural gas to the Government of Guyana's proposed Power Plant, by enabling improved reliability of power and energy independence for Guyana as well as more reliable and less carbon-intensive power generation (as compared to the current fuel oil-fired power sources). Improved electrification at a national scale is typically linked to improvement of economic growth and overall growth in gross domestic product.

In addition to expenditures, employment, and strategic investments, the Project will also likely generate induced economic benefits. These induced benefits could result from the re-investment, hiring, and spending by Project-related businesses and/or workers, which in turn benefits other non-Project-related businesses and generates more local tax for the government. These beneficial "multiplier" impacts are expected to occur throughout the Project life.

14.4. SUMMARY

Table 14.4-1 provides a summary of the predicted residual impact significance ratings (taking into consideration proposed mitigation measures) for impacts that may potentially result from the planned Project activities in each Project stage (i.e., Construction, Operations, and Decommissioning). For each resource, Table 14.4-1 shows the highest residual impact significance rating among the potential impacts assessed for each Project stage. For each resource, the table also summarizes the highest residual risk rating for potential risks to resources from unplanned events (e.g., fuel spill, vessel strike) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

Table 14.4-1: Summary of Residual Impact Significance Ratings, Residual Risk Ratings, and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Construction	Operations	Decommissioning		
Geology and Groundwater	Negligible	Negligible	---	Minor	NA
Soils	Negligible	Negligible	Negligible	Minor	NA
Sediments:					
• Marine Sediments	Negligible	---	---	Minor	NA
• Riverine Sediments	Negligible	Negligible	Negligible	Minor	NA
Water Quality:					
• Marine Water Quality	Negligible	---	---	Minor	NA
• Riverine Water Quality	Negligible	Negligible	---	Minor	NA
Sound and Vibration [c]	Negligible to Moderate	Negligible to Moderate	Negligible	Moderate	Medium
Air Quality, Climate, and Climate Change:					
• Air Quality	Negligible to Moderate	Negligible	Negligible to Moderate	Minor to Moderate	Medium
• Climate / Climate Change	Negligible	Minor	Negligible	Minor	
Waste Management Infrastructure Capacity	Negligible	Negligible	NR	Minor	NA
Protected Areas	---	---	---	---	NA
Marine and Coastal Biodiversity	Moderate	---	Negligible		Low
Terrestrial Biodiversity	Moderate	Negligible	Negligible	Minor	Low
Freshwater Biodiversity	Minor	Negligible	Negligible		Low
Ecological Balance and Ecosystems	Minor	Negligible	Negligible		Low
Special Status Species	Moderate	Negligible	Negligible	Moderate	Low
Socioeconomic Conditions:					
• Economic Development	Positive	Positive	---	---	Low
• Employment and Business Growth	Minor [a]	Positive [b]	Positive [b]	---	Medium

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Construction	Operations	Decommissioning		
• Existing Livelihoods	Minor	Minor	---	Moderate	Low
Community Health and Wellbeing:					
• Individual and Social Determinants of Health	Negligible to Minor	Minor	---	---	Low
• Physical Determinants of Health	Moderate	Moderate	Negligible	Minor to Moderate	Low
• Institutional Determinants of Health	Minor	---	---	---	Low
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Medium
• Housing and Utilities	Minor	Negligible	Negligible	Moderate	Medium
• Water and Sanitation	Minor	Negligible	Negligible	Moderate	
Transportation:					
• Marine Transportation	Moderate	Negligible	---	Minor	Low
• River Transportation	Minor	Negligible	Minor	Minor	Low
• Road Transportation	Minor	Minor	Minor	Minor to Moderate	Low
Cultural Heritage	Minor to Moderate	Negligible	---	Minor to Moderate	Low
Land Use and Ownership	Moderate	Minor	---	Moderate	Medium
Landscape, Visual Resources, and Light:					
• Landscape and Visual	Minor	Minor	---	---	Low
• Light	Minor	Minor	---	---	Low
Ecosystem Services	Minor	Negligible	---	Negligible	Low
Indigenous Peoples	Minor	Minor	---	Minor	NA

”---“ = no potential impacts identified for this stage; NA = not applicable (not assessed in cumulative impact assessment; scoped out as potentially eligible [see Chapter 11, Cumulative Impacts]); NR = not rated

[a] This stage also has a potential Positive impact(s).

[b] This stage also has potential impact(s) rated as Negligible.

[c] Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.

15. COMMITMENT REGISTER

This section presents a summary of the Project commitments presented in the EIA. These comprise embedded controls (Table 15-1), mitigation measures (Table 15-2), and monitoring measures (Table 15-3) referenced in the resource-specific impact assessment chapters of the EIA (Chapters 7, 8, and 9). For each commitment, the tables list the sections of the EIA in which the commitment is listed.

15.1. TABLE 15-1: EMBEDDED CONTROLS

EIA Section	Commitment: Embedded Controls
Section 7.1	Design horizontal directional drilling (HDD) fluid composition based on consideration of the characteristics of the soils through which HDD bores will be completed and adjust drilling fluids as needed during HDD operations based on the results of HDD fluids/cuttings returns.
Section 7.1	Conduct dewatering along work segments and only for durations required to implement the construction activity for the work segment; cease dewatering as soon as reasonably practicable after completing pipeline installation in a work segment.
Section 7.1	To the extent reasonably practicable, return extracted waters from dewatering to an adjacent segment of the same canal to minimize/avoid long term decreases in water level in the canal.
Section 7.1	Use industry standard filtration techniques to reduce solids content in dewatering discharges to surface water features.
Section 7.1	Install groundwater extraction well(s) at the natural gas liquids processing plant (NGL Plant) using standard well construction techniques, including features to prevent downward migration of contaminants to the groundwater bearing unit.
Section 7.1	Use only non-petrochemical-based, non-hazardous additives that comply with permit requirements, and environmental regulations, such as NSF International/ANSI 60 Drinking Water Treatment Chemicals—Health Effects compliant in the drilling fluids.
Sections 7.2, 8.4, 8.6, and 9.3	Implement soil erosion, stormwater runoff, and sedimentation control measures during soil disturbance (e.g., use of silt fences, installation of temporary and permanent drainage systems to manage water runoff from construction areas, use of sediment basins and check dams to control water runoff).
Sections 7.2, 8.3, 8.4, 8.6, and 9.3	Limit clearing and disturbance to the designated work areas. Minimize the area of bare soil at any one time to the extent practicable, and progressively revegetate or otherwise stabilize disturbed areas as work moves along the construction footprint.
Sections 7.2 and 9.3	Outside of the permanent RoW and within temporarily disturbance areas, restore active agricultural areas to their preconstruction conditions to support continued agricultural use.
Sections 7.3, 8.2, and 8.6	Monitor and manage suction dredging or jet plowing and burial rates to improve efficiency and reduce turbidity.
Sections 7.3, 8.2, and 8.6	To the extent practicable, avoid suction/jetting any deeper than what is required for protection of the pipeline.
Sections 7.3, 7.4, 8.3, 8.4, and 8.6	Monitor and manage excess overflow from hopper on dredging facility to improve efficiency and reduce turbidity in dredging supernatant.
Sections 7.3, 7.4, 8.3, and 8.4	Monitor and manage suction rate to improve efficiency and reduce turbidity in the water column during dredging.

EIA Section	Commitment: Embedded Controls
Sections 7.4, 8.2, and 8.6	Implement chemical selection processes and principles that exhibit recognized industry safety, health, and environmental standards. Use low-hazard substances and use the Offshore Chemical Notification Scheme (CEFAS 2019) as a resource for chemical selection in its production operations. The chemical selection process is aligned with applicable Guyanese laws and regulations and includes: • Review of material safety data sheets; • Evaluation of alternate chemicals; • Consideration of hazard properties while balancing operational effectiveness and meeting performance criteria, including: – Using the minimum effective dose of required chemicals; and – Using the minimum safety risk relative to flammability and volatility; • Risk evaluation of residual chemical releases into the environment.
Sections 7.5, 8.3, 8.5, 8.6 and 9.2	Limit, when practicable, construction activities (including onshore construction activities) to daytime hours aside from infrequent instances in which a particular activity could not be stopped mid-completion (e.g., an HDD drilling activity).
Sections 7.5, 8.2, and 8.3	Maintain marine and onshore construction equipment, power generators, and vehicles in accordance with manufacturer's specifications to reduce noise generation to the extent practicable.
Sections 7.5, 8.3, and 8.6	Design equipment at NGL Plant so that in-plant sound levels in accessible areas do not exceed 85 A-weighted decibels (dBA) under normal operations or 115 dBA for emergency events and so that community and/or fenceline noise levels do not exceed applicable regulations.
Section 7.5	Subject NGL Plant operational equipment to routine maintenance in accordance with manufacturer's specifications.
Sections 7.6, 8.3, and 8.6	Minimize dust-emitting activities such as cutting, grinding, and sawing by employing alternative methods or technologies, such as the use of pre-fabricated material wherever possible.
Sections 7.6 and 8.6	Review construction plan and confirm availability of water for dust suppression on site for dust suppression.
Sections 7.6 and 8.6	Keep uncovered stockpiles moist.
Sections 7.6 and 8.6	Apply water to unpaved haul roads to minimize dust generation.
Sections 7.6 and 8.6	Train workers to employ material handling methods that will minimize dust emissions. These include minimizing drop heights to control the fall of materials and minimizing exposure of stockpiles to wind by removal of earth from small areas of secure covers when needed.
Sections 7.6, 8.3, 8.6, and 9.6	Use appropriate control measures to minimize dust arising from construction works.
Sections 7.6, 8.3, and 8.6	Require construction equipment and other workforce vehicle drivers to adhere to Project-established speed limits within the construction worksites.
Section 7.6	With respect to non-routine flaring of gas at the NGL Plant, the following measures will be implemented: • Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations; • Design and build combustion equipment to appropriate engineering codes and standards; • Use flare tip of a non-pollutant type, with low NO_x emissions, and a burning efficiency high enough to support low hydrocarbon emissions to the atmosphere;

EIA Section	Commitment: Embedded Controls
	• Minimize risk of pilot blowout by ensuring sufficient exit velocity and provision of wind guards; • Use a reliable pilot ignition system; • Minimize liquid carryover and entrainment in the gas flare stream with a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, and which is designed in accordance with good engineering practice; • Equip liquid separation system (e.g., knockout drum) with high-level facility shutdown or high-level alarms and empty as needed to increase flare combustion efficiency; and • Minimize flame lift off and/or flame lick.
Sections 7.6, 8.3, and 8.6	Employ reasonable efforts and execute a maintenance program to minimize equipment breakdowns and NGL Plant upsets that could result in flaring, and make provisions for equipment sparing and plant turn-down protocols where practical.
Sections 7.6, 8.3, and 8.6	Implement inspection, maintenance, and surveillance programs (including Leak Detection and Repair systems) to identify and prevent unplanned emissions to atmosphere from the NGL Plant.
Section 7.6	Avoid routine venting (excludes tank flashing emissions, truck loading, standing / working / breathing losses) except during safety and emergency conditions.
Sections 7.6, 8.2, 8.3, 8.4, 8.5, and 8.6	Regularly maintain equipment, marine vessels, vehicles, and helicopters and operate them in accordance with manufacturers' guidance and/or Company and Operator best practices, as applicable, and at their optimal levels to minimize atmospheric emissions and sound levels to the extent reasonably practicable.
Sections 7.6, 8.3, and 8.6	Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.
Section 7.7	For transport of hazardous wastes off site for treatment or disposal, confirm that the waste is accompanied by a manifest signed by the hazardous waste generator and transporter.
Section 7.7	Provide for adequate onshore waste management equipment and facilities for the proper management of waste in accordance with local regulation and good international industry practice.
Section 7.7	For wastes generated offshore that cannot be reused, treated, or discharged/disposed on marine vessels, properly manifest and transfer such wastes to appropriate onshore facilities for management.
Section 7.7	Periodically audit waste contractors to verify that appropriate waste management practices are being used.
Section 7.7	Avoid, reduce, and reuse/recycle wastes preferentially prior to disposal in accordance with the waste management hierarchy.
Sections 8.2, 8.4, 8.5, and 8.6	For all vessel effluent discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization and International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.
Sections 8.2, 8.4, 8.5, and 8.6	Inspect and maintain onboard equipment (engines, compressors, generators, sewage treatment plants, and oil-water separators) in accordance with manufacturers' guidelines to maximize efficiency and minimize malfunctions and unnecessary discharges into the environment.
Sections 8.3 and 8.6	Conduct paced, sequential clearing to allow for mobile wildlife to move away from work zones.
Sections 8.3, 8.6, and 9.7	Restore and revegetate the temporary onshore pipeline corridor following construction.

EIA Section	Commitment: Embedded Controls
Sections 8.4, 8.6, and 9.3	Dewater any trenches by first installing temporary drainage and use methods to prevent excessive transport of sediments into existing canals.
Sections 8.4, 8.6, and 9.3	Manage stormwater to minimize potential erosion and excessive sediment transport into canals adjacent to the onshore pipeline corridor.
Sections 8.4 and 8.5	Use procedures for loading, storage, processing, and offloading operations, either for consumables (i.e., fuel, drilling fluids, and additives) or for liquid products, to minimize spill risks. Inspect pumps, hoses, and valves on a monthly basis, and perform maintenance as needed.
Sections 8.3, 8.4, 8.5, and 8.6	Provide domestic and process WWTPs that comply with World Bank Indicative Values for Treated Sanitary Sewage Discharges (World Bank 2007a) and Effluents Levels for Natural Gas Processing Facilities (World Bank 2007b).
Section 8.5	For effluent released from the STPs on board Project marine vessels, comply with aquatic discharge standards in accordance with MARPOL 73/78 regulations.
Section 8.5	Implement engineering controls, administrative controls, and training to protect offshore workforce from high noise levels in the offshore work environment.
Section 8.5	Adhere to operational controls regarding material storage, wash-downs, and drainage systems.
Section 8.5	Provide a stormwater management facility at the NGL Plant site.
Section 8.5	For Project marine vessels necessitating ballast water exchanges, abide with IMO (2004) guidelines including the International Convention for the Control and Management of Ship's Ballast Water and Sediments, with the exception of Regulation D-2 (Ballast Water Performance Standard), and abide with MARPOL 73/78.
Section 8.6	Confirm there is no visible oil sheen from commissioning-related discharges (i.e., flow lines/risers commissioning fluids, including hydrotesting waters).
Section 9.1	Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable.
Section 9.1	Work with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities in alignment with Guyana's Local Content policy.
Section 9.1	Procure Project goods and services from Guyanese suppliers when available on a timely basis and when they meet minimum standards and are commercially competitive.
Section 9.2	Provide health-screening procedures for Project workers to reduce risks of transmitting communicable diseases.
Section 9.2	Provide Project-dedicated medical resources on the west side of the Demerara River to support project related activities and treat workers for minor medical issues.
Sections 9.2, 9.6, 9.8, and 9.9	Develop and implement a Stakeholder Engagement Plan (SEP) that includes measures for continued engagement with communities, including informal settlements, potentially affected residents, landowners and Indigenous Peoples, aimed at increasing awareness of the nature of the Project and the measures in place to prevent accidents.
Sections 9.2, 9.6, 9.8, and 9.9	Implement a transparent, accessible, and consistent CGM prior to onset of Project activities. Take measures to promote the CGM being well publicized and understood by the public, including residents of informal settlements and Indigenous Peoples—in particular in the Santa Aratak community.
Section 9.3	Require construction contractors to locate, identify, and flag existing underground utilities to prevent accidental damage during onshore pipeline construction.
Section 9.3	Collect stormwater and route, if feasible, to existing canals.

EIA Section	Commitment: Embedded Controls
Section 9.4	Restore all roads to their pre-construction condition or better following completion of each contractor's component of the construction process (potentially including retention and handover of temporary bridge spans to the Government of Guyana, where appropriate).
Section 9.4	Complete pipeline road crossings using trenchless methods where practicable. Where open-trench crossings are used, minimize the time of road closure to the extent practicable, and provide adequate detours.
Section 9.5	Prior to initiation of seabed disturbance, conduct a seabed survey to assess the presence of potential underwater cultural heritage resources. If any potential cultural heritage resources are found, adjust the layout of Project features to avoid such resources or subject the resources to assessment by a cultural resources specialist and, as warranted, consult with the National Trust of Guyana prior to disturbing such resources.
Section 9.5	Use HDD techniques or adjust onshore pipeline corridor construction area to avoid physical disturbance of silk cotton trees where reasonably practicable.
Section 9.5	Where HDD techniques are used for a segment where a silk cotton tree falls within the permanent RoW, avoid removal of the tree from the permanent RoW.
Section 9.5	Use HDD to install onshore pipeline crossings at Canal 1 and Canal 2.
Section 9.7	Use HDD techniques at major road and waterway crossings to help minimize visual impacts on key viewpoints during construction activities.
Section 9.7	Subject to direction from the Government of Guyana regarding its desire to continue to use the temporary material offloading facility (MOF) after the Project Construction stage is complete, remove temporary MOF infrastructure as soon as feasible following completion of Project construction and attainment of stable operations, (the temporary MOF will be removed prior to the 10-year design life of the structure being met) and revegetate disturbed areas in consultation with appropriate Guyanese authorities (e.g., National Agricultural Research and Extension Institute).
Section 9.7	Design and locate aboveground structures associated with the onshore pipeline (e.g., beach valve station) so as to minimize their visual profile and the degree to which they impact views of sensitive visual resources.
Section 9.7	Implement industry-standard lighting practices, including (but not limited to): • Use the minimum lighting intensity necessary for health and safety. • Use directional lighting with full-cutoff features that direct light only to locations where it is necessary, while minimizing leakage into surrounding areas. • Use timers, motion sensors, or other features that activate lights only when necessary. • Use lights with lower color temperatures (i.e., closer to the yellow end of the spectrum).
Sections 9.8 and 9.9	During dredging activities associated with the temporary MOF, conduct the dredging operation so as to maintain the ability for passenger vessels to pass up- and down-river of the temporary MOF, between the Santa Aratak community and downriver locations.
Section 10.1	Bury offshore pipeline in shallow water depths.
Section 10.1	Maintain marine safety exclusion zones to be issued through the Maritime Administration Department (MARAD) with a 500-meter radius around major installation vessels, to prevent unauthorized vessels from entering areas with an elevated risk of collision.
Section 10.1	Use leak detection systems for equipment, treatment, and storage facilities (fuel, chemical, etc.) on Project vessels in accordance with good international oilfield practice.

EIA Section	Commitment: Embedded Controls
Section 10.1	Maintain marine safety exclusion zones to be issued through MARAD with a 2-nautical-mile (approximately 12,150-foot) radius around the Floating Production, Storage, and Offloading vessel (FPSO), to prevent unauthorized vessels from entering areas with an elevated risk of collision.
Section 10.1	Equip Project vessels with radar systems and communication mechanisms to communicate with third-party mariners.
Section 10.1	Use secondary containment for storage of bulk fuel, where practicable.
Section 10.1	Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and riverine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals, riverine mammals, and marine turtles while underway and reduce speed or deviate from course, when possible, to reduce probability of collisions.
Section 10.1	Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting marine birds when transiting to and from the offshore pipeline corridor.
Section 10.1	Provide standing instructions to Project-dedicated vessel masters to reduce their speed within 300 meters of observed marine mammals and marine turtles, and to not approach the animals closer than 100 meters.
Section 10.1	Require vessels to reduce their speed to 5 knots (9.3 kilometers per hour) when entering the Demerara River awaiting berth space to dock and vessels also slow to less than 5 knots (9.3 kilometers per hour) and prohibit them from entering the 2-nautical-mile (3.7-kilometer) exclusion zone around the FPSO and the 500-meter exclusion zone around major installation vessels.
Section 10.1	Design the onshore pipeline to a Class 3 location classification under ASME B31.8.
Section 10.1	Install aboveground pipeline markers along the onshore pipeline corridor, indicating the location of the buried pipeline and including standard signage to not excavate in the area prior to contacting EEPGL.
Section 10.1	Install a fiber optic cable (FOC)-based system along the pipeline at the time the pipeline is buried, to detect leaks and/or third-party intrusion the pipeline.
Section 10.1	For the aboveground valve near the shore landing, install anti-cut / anti-climb perimeter fencing around the valve, with fiber optic intrusion detection, 24-hour per day closed-circuit television monitoring of the compound, and security lighting.
Section 10.1	Apply external corrosion coating on the onshore pipeline.
Section 10.1	Install and monitor an impressed current cathodic protection system along the onshore pipeline
Section 10.1	Conduct routine internal inspections for corrosion through the use of pipeline intelligent pigging tools.
Section 10.1	Use industry design standards for construction of Project infrastructure (e.g., appropriate material selection, corrosion protection)
Section 10.1	Implement mechanical integrity programs as part of routine operations and maintenance.
Section 10.1	As part of detailed design, complete an Escape, Evacuation, and Rescue Assessment, Dispersion Analysis, Fire and Explosion Hazards Assessment Study.
Section 10.1	Install emergency shutdown systems to enable isolation and blowdown/ depressurization of equipment.
Section 10.1	Provide active fire protection, including a pressurized ring main, with sufficient capacity to provide at least 4 hours of continued operation of fire pumps at maximum capacity.
Section 10.1	Install foam deluge systems in areas with potential for hydrocarbon fires.

EIA Section	Commitment: Embedded Controls
Section 10.1	Provide overpressure protection for process equipment and piping to relieve excess pressure and safely dispose of hydrocarbons in the flare system.
Section 10.1	Provide structural fire proofing, where necessary, to reduce the risk of equipment and structures collapsing
Section 10.1	Configure spacing and layout of the NGL Plant to minimize the risk of fire and explosion, including consideration of detailed fire and explosion analysis studies and measures to minimize the accumulation and spread of flammable gases and liquids, minimize probability of ignition, and facilitate effective emergency response.
Section 10.1	Adhere to electrical classification of equipment to reduce the likelihood that equipment will ignite flammable gases or liquids
Section 10.1	Strategically place gas, smoke, and fire detection equipment to automatically initiate protection actions to isolate the source of a leak, minimize the possibility of ignition, and activate fire suppression systems and pumps.
Section 10.1	Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.
Section 10.1	Design the open drain system to accommodate a 100-year rainfall event.
Section 10.1	Grade the NGL Plant site so as to direct stormwater flow across the site into the stormwater pond
Section 10.1	Conduct routine maintenance and monitoring to maintain the performance of the WWTPs
Section 10.1	Discharge WWTP effluents into the stormwater pond, diluting the concentrations of constituents present in the wastewater effluents prior to discharge from the stormwater pond into the Demerara River.
Section 10.1	Implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in the Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities; • Definition of required driver training for Project-dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak-traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and Community outreach to communicate information relating to major delivery events or periods.
Section 10.1	Maintain an Oil Spill Response Plan (OSRP) to facilitate an effective response to a marine or riverine fuel spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.

15.2. Table 15-2: Mitigation Measures

EIS Section	Commitment: Mitigation Measures
Section 7.5	Based on the result of noise monitoring during onshore pipeline construction, develop additional mitigations, as needed, for areas where residential structures are expected to fall within **Moderate** to **Major** noise level—ideally prior to the pipeline construction operation arriving at these areas.
Section 7.5	To the extent practicable, position the HDD rig on the side of the HDD segment associated with the smaller number of potential residential structures that could experience a **Moderate** to **Major** noise level.
Section 7.5	Plan onshore pipeline HDD operations to avoid operation during nighttime hours, such that nighttime operations are conducted only if an unexpected situation results in a delay that extends an uninterruptable activity into nighttime hours or if the length of the boring is such that there is not reasonable means for avoiding nighttime hours.
Section 7.5	To the extent practicable, conduct planned start-up and maintenance activities during daytime hours.
Section 7.5	If noise levels at a potential residential structure for planned activities are expected to exceed **Moderate** significance levels, make reasonable efforts to communicate with the residents in the respective structures ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts.
Section 7.5	Prominently display contact information for EEPGL's CGM during construction activities in residential areas.
Sections 7.6 and 9.6	Undertake early liaison with the relevant property owners or operators and potentially affected users of agricultural lands prior to construction and demolition, as part of the SEP, to inform them of the work activities and feedback/complaints procedure.
Section 7.6	Use the CGM to obtain feedback or complaints, and investigate and take action to address any issues that may arise during Construction or Decommissioning stage activities.
Section 7.6	Annually quantify direct Project greenhouse gas (GHG) emissions from the dedicated Project facilities and equipment used within the Project Area of Influence (AOI). Annually review these quantified GHG emissions and establish plans to achieve continuous improvement.
Section 7.7	(Affiliate level) To address future waste capacity constraints in Georgetown relative to Project's predicted waste management needs: • As warranted based on anticipated future EEPGL hazardous waste generation trends and trends in non-EEPGL hazardous waste generation, continue enabling the expansion of existing local waste management capacity for hazardous wastes, and explore use of new local hazardous waste treatment facilities, or identify suitable alternative solutions. • Continue monitoring plans for further expansion of the Haags Bosch Landfill and/or (if approved by the EPA) construction of additional landfill sites in other locations (as decided by the government), or identify suitable alternative (interim) local solutions for non-hazardous waste management.
Sections 8.3 and 8.6	Plant new or restore old native riparian species along the riparian zone of the new canals to improve habitat value of the new canals
Sections 8.3, 8.4, and 8.6	Discharge hydrostatic test water to the Demerara River only under higher flow conditions to the extent practicable.
Sections 8.4 and 8.6	Use smallest practicable diameter pipes for the piles for the temporary MOF.
Sections 8.4 and 8.6	Use noise attenuating methods when driving piles in the Demerara River as appropriate, especially if large-diameter steel pipes are used as piles.

EIS Section	Commitment: Mitigation Measures
Section 8.6	Replace impacted mangrove trees in cooperation with NAREI in accordance with Guyanese law.
Section 8.6	Conduct pre-construction surveys and consult with local and international experts (e.g., IUCN Otter Specialist Group) and implement appropriate measures to minimize impacts on neotropical otter and giant otter.
Section 9.1	Notices to Mariners are issued through the Maritime Administration Department for their communication with the public, and information is provided to the Department of Fisheries for their distribution to stakeholders (including associations, co-ops, and fisherfolk) within the fishing industry in country, regarding movements of major marine vessels to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Section 9.1	Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
Sections 9.1 and 9.3	Proactively communicate the Project’s limited direct staffing requirements as a measure to reduce the magnitude of potential population influx to Region 3 and Georgetown from job seekers; also advertise the number and types of jobs expected to be contracted during the Construction stage.
Section 9.1	Augment stakeholder engagement and recruitment efforts to specifically target households and businesses within the Direct AOI with communications material related to Project employment and business opportunities in an effort to proactively manage expectations.
Section 9.1	Develop contract language for pipeline and NGL Plant contractors encouraging recruitment and training of women for various Project-related construction roles.
Section 9.1	Develop contract language for pipeline and NGL Plant contractors to advertise the types of goods and services they will procure locally (within the Direct AOI) and the bidding process for ensuring transparency.
Section 9.1	Proactively engage with nearshore artisanal fisherfolk in advance of construction and advertise a cut-off date for all fisherfolk to remove fishing equipment from the Nearshore Project Exclusion Zone.
Section 9.2	Require Project workers to adhere to a worker code of conduct, which will address off-duty social interactions and considerations.
Section 9.2	Use a dedicated medical provider to complement the services of the local, private medical clinic used by the Project and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure.
Section 9.2	Prior to initiation of onshore construction activities, prepare a traffic and access management plan to provide secondary means of access for vehicles and pedestrians to eliminate restrictions of public movement.
Section 9.2	Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to Project vehicle movements.
Section 9.2	Communicate with the residents in the respective structures ahead of the onset of elevated noise levels to alert them to the expected nature and duration of impacts. Share details related to the community feedback mechanism.
Section 9.3	Communicate EEPGL’s health, safety, and security standards and requirements to interested hotel owners.

EIS Section	Commitment: Mitigation Measures
Section 9.3	Should housing prices increase dramatically within the first year of data collection (see monitoring measure below), make efforts to meet workforce accommodations needs by the Project through lodging options and/or expansion of the worker camp.
Section 9.3	Require Project primary contractors to complete a worker housing survey to understand Project housing demands and requirements.
Section 9.4	To address potential impacts on commercial and subsistence fishing vessel operators in the marine environment and Demerara River, proactively communicate plans for offshore pipeline construction, temporary safety zones, marine and river cargo transportation to fishing vessel operators, using community groups and other contacts established through EEPGL's ongoing work in the region.
Section 9.4	Maximize use of bus transportation to reduce the volume of employee vehicles.
Section 9.4	Schedule deliveries and, to the extent feasible, personnel transport, during non-peak traffic periods
Section 9.4	Engage with community stakeholders to obtain local understanding of traffic flow and congestion within towns and settlements and to provide information on anticipated Project traffic.
Section 9.4	Survey the West Bank of Demerara Public Road to confirm that route geometrics are adequate for safe passage of buses and trucks.
Section 9.5	Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.
Section 9.5	Maintain a high-visibility exclusion fence around silk cotton trees during construction activities and preserve a buffer around the trees during construction activities in the vicinity of the trees.
Section 9.5	Ensure an archaeological monitor is present when work, including open-cut techniques, occurs in a segment of the onshore pipeline corridor where a silk cotton tree is present in the temporary or permanent right-of-way.
Section 9.5	Ensure an archaeological monitor is present when initial ground disturbance work occurs at the temporary MOF site.
Section 9.5	If a silk cotton tree is planned to be disturbed, notify the National Trust, consult with the community leaders, and ensure an archaeological monitor is present when work occurs near the tree.
Section 9.5	For segments of the onshore pipeline corridor that have not been subjected to pedestrian survey, ensure that a vegetation specialist examines the segments for potential silk cotton trees, before initiating ground disturbance. If any silk cotton trees are identified, address the avoidance or removal of these trees in accordance with the embedded controls and other mitigation measures listed above.
Section 9.6	Support the Government of Guyana to develop and implement a Resettlement and Livelihood Restoration Strategy for resettlement (for physical displacement) and livelihood restoration (for economic displacement) through a process that aligns with International Finance Corporation Performance Standard 5.
Section 9.6	Based on the result of dust monitoring during onshore pipeline construction, develop additional mitigations, as needed.
Section 9.8	Work with the Government of Guyana to conduct proactive engagement and communication with agricultural land owners and land users near the onshore pipeline corridor to provide information about planned changes to the canal network, solicit input from stakeholders in advance, and address grievances.
Section 9.8	Engage with residents and landowners near the shore crossing to proactively address potential concerns related to shoreline protection.

EIS Section	Commitment: Mitigation Measures
Section 9.8	Prior to initiating construction activities at the shore crossing, identify jhandi flags or other religious or spiritual symbols within the affected area. Consult with local stakeholders (e.g., religious leaders) to determine an appropriate course of action if disturbance cannot be avoided.
Section 10.1	Issue Notices to Mariners to the Trawler's Association and fishing co-ops via MARAD for movements of major marine installation vessels to facilitate their avoidance of areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.
Section 10.1	Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
Section 10.1	Promptly remove damaged Project vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.
Section 10.1	Implement the OSRP in the unlikely event of a marine or riverine fuel spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate PPE by response workers; and Implementing a Wildlife Oil Response Program, as needed.
Section 10.1	Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of a marine or riverine fuel spill.
Section 10.1	In case of a collision involving a Project vessel and a non-Project vessel that may result in a claim arising from such type of incident, provide appropriate restitution, consistent with governing contracts and applicable laws.

15.3. Table 15-3: Monitoring Measures

EIS Section	Commitment: Monitoring Measures
Section 7.1	Visually monitor the ground surface and nearby surface waterbodies (e.g., canals) during advancement of HDD borings for any evidence of fluid release.
Section 7.1	Monitor HDD fluid/cuttings returns to assess for potential excessive fluid loss to formation.
Section 7.1	Monitor solids content of dewatering discharges.
Sections 7.2 and 9.3	Conduct routine inspections of erosion, stormwater runoff, and sedimentation control measures while bare soils are exposed.
Sections 7.4, 8.3, 8.5, and 8.6	Conduct routine inspections to confirm the sanitary and process water WWTPs are working according to design specifications and monitor effluent quality regularly.
Sections 7.5, 8.3, and 8.6	During open trenching and HDD operations along the onshore pipeline corridor, conduct noise monitoring during the initial stages of construction and again during later stages of construction (as warranted based on changes in the nature of construction activities, weather conditions, or other factors) in order to quantify the actual extent of Project noise impacts.
Sections 7.6, 8.3, and 9.6	During construction, monitor dust levels along portions of the onshore pipeline corridor with residential structures in close enough proximity to potentially be affected by dust emissions.
Section 7.6	Monitor on an ongoing basis the volume of fuel used by all combustion sources and equipment at the NGL Plant.
Section 7.6	Monitor volume of fuel used for helicopter operation.

EIS Section	Commitment: Monitoring Measures
Section 7.6	Keep records of non-routine flaring of gas.
Section 7.6	Properly inspect, maintain, monitor, certify, and function-test flare equipment prior to and throughout operations.
Section 7.7	Record type and quantity of each individual waste stream any time a new waste is generated.
Section 7.7	Inspect on a regular basis temporary waste storage areas and containers; log inspections.
Section 7.7	Sample and perform analytical testing as needed to properly classify wastes for disposal/treatment.
Sections 8.2 and 8.6	Perform daily inspections to verify no visible sheen from discharges from pipeline installation and support vessels.
Sections 8.2 and 8.6	Monitor chlorine concentration of treated sewage discharges from pipeline installation and support vessels.
Sections 8.2 and 8.6	Perform daily visual inspection of discharge points to verify absence of floating solids or discoloration of the surrounding waters from pipeline installation and support vessels.
Sections 8.2, 8.5, and 8.6	Record estimated quantities of grey water, black water, and comminuted food waste discharged (based on number of persons on board and water consumption) in Garbage Record Book for Project construction/installation vessels.
Sections 8.2, 8.5, and 8.6	Perform oil in water content (automatic) monitoring of bilge water to comply with 15 parts per million MARPOL 73/78 limit and record in Oil Record Book.
Sections 8.2, 8.5, and 8.6	Record estimated volume of ballast water discharged and location (per ballasting operation) for Project construction/installation vessels.
Sections 8.2 and 8.6	Monitor visual detections of marine mammals onboard pipeline installation and support vessels.
Sections 8.3 and 8.6	Monitor otter use of the canals in the Project AOI where otters are known to occur based on baseline surveys to document presence and activity during and post-construction (through one year post-construction).
Section 8.3	Monitor birds and mammals at baseline survey sites for 1 year after the onshore pipeline is installed and every 3 years once the Project becomes fully operational throughout the Operations stage of the Project.
Sections 8.3, 8.4, and 8.6	Conduct a single round of post-decommissioning monitoring of terrestrial vegetation, birds, mammals, insects, aquatic macroinvertebrates, fish, and water quality.
Section 8.4	Monitor aquatic macroinvertebrates, fish, and water quality at baseline survey sites for 1 year after the pipeline is installed and every 3 years once the Project becomes fully operational throughout the Operations stage of the Project.
Section 9.1	Monitor percentage of Project Workforce made up of Guyanese nationals on a quarterly basis; disaggregate by gender.
Section 9.1	Monitor percentage of Project goods and services expenditures procured locally on a quarterly basis, including within the Direct AOI.
Sections 9.1, 9.2, 9.6, 9.8, and 9.9	Monitor frequency of engagement with stakeholders, including fisherfolk, canal users, communities within the Direct AOI, vulnerable groups, and Indigenous populations, especially those in closest proximity to the onshore pipeline (during Construction) and the NGL Plant (in all stages)
Sections 9.2, 9.6, 9.8, and 9.9	Track number and types of complaints received and resolved via the Project CGM; adjust the CGM and other management measures on an ongoing basis, as appropriate, based on feedback received. Disaggregate the data by location of complainant (e.g., community, Georgetown, other location).

EIS Section	Commitment: Monitoring Measures
Sections 9.2, 9.6, 9.8 and 9.9	Monitor average time for processing and resolution of grievances, and track percentage of grievances resolved.
Section 9.2	Monitor noise levels during onshore construction activities near sensitive receptors.
Section 9.2	Test for communicable diseases through standard medical screening / surveillance protocols.
Section 9.3	Monitor housing prices (purchase and rental) for company-related transactions on a semiannual basis as an indicator of the company's potential impact on the availability and prices in the housing market.
Sections 8.3, 8.6, and 9.7	Conduct post-restoration vegetative cover monitoring along the onshore pipeline corridor.
Section 9.8	Monitor shoreline changes and/or erosion during and after construction of the shore crossing, and implement additional measures to stabilize shoreline if required.

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CHAPTER 8 ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—BIOLOGICAL RESOURCES

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Chapter 9 Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

Section 9.1 Socioeconomic Conditions

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