

## **ENVIRONMENTAL IMPACT STATEMENT**

### **EXECUTIVE SUMMARY**

In 2015, oil was discovered in the Liza field within the Stabroek Block, approximately 190 kilometers (120 miles) offshore from Georgetown in waters approximately 1,500 to 1,900 meters (932 to 1,180 feet) deep. Based on exploration and assessment activities to date, Esso Exploration and Production Guyana Limited (EEPGL) has estimated that the Stabroek Block contains more than 6 billion barrels of oil-equivalent recoverable resource.

EEPGL (45 percent) and its co-venturers Hess Guyana Exploration Limited (30 percent) and CNOOC Petroleum Guyana Limited (25 percent) are parties to a Petroleum Agreement with the Government of Guyana.

EEPGL, on behalf of itself and its co-venturers, and in accordance with the Guyana Environmental Protection Act, is seeking an environmental authorization from the Guyana Environmental Protection Agency (EPA) for a third project development in the eastern half of the Stabroek Block (hereafter referred to as the Payara Development Project, or “the Project”); the area that will be developed as part of the Project is located approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown, Guyana. As part of its regulatory role, the EPA, considering recommendations from the Environmental Advisory Board and other government entities, is responsible for deciding whether and under what conditions to grant EEPGL’s Application for Environmental Authorisation (Application), which was filed with the EPA on 3 December 2018. Based on an initial assessment of the Application, the EPA determined that an Environmental Impact Assessment (EIA) was required in support of the Application.

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 to permit 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 Project will consist of the drilling of up to 45 development wells (including production, water injection, and gas re-injection wells); installation and operation of Subsea, Umbilicals, Risers, and Flowlines equipment; installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block; and—ultimately—Project decommissioning. Onshore logistical support facilities and marine/aviation services will be used to support each stage of the Project. EEPGL will use proven and industry-accepted standards and has incorporated many embedded controls into the overall Project design to reduce environmental and socioeconomic impacts. It could take up to 5 years to drill the wells, with drilling beginning in 2020. The initial production is expected to begin by early 2023, with

operations continuing for at least 20 years. The Project is expected to employ up to 600 persons during development well drilling, approximately 600 persons at the peak of the installation stage, and up to about 140 persons during production operations.

The planned activities of the Project are predicted to have negligible residual impacts on most physical resources (air quality, marine geology and sediments, and marine water quality)—with potential moderate residual impacts on climate, no impacts on coastal biological resources, negligible to minor residual impacts on most marine biological resources (with potential moderate residual impacts on marine mammals), and negligible to minor residual impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions. These predictions are based on the fact that the bulk of the Project activity will occur approximately 207 kilometers (approximately 128 miles) offshore; and the Project will capture and re-inject produced natural gas (that which is not used as fuel on the FPSO) back into the targeted Project reservoirs, treat all required wastewater streams prior to discharge to the sea, have a very small physical footprint (e.g., infrastructure construction disturbs only about 0.8 square kilometers [0.3 square miles] of benthic habitat), and use Marine Mammal Observers and “soft starts” during selected activities to reduce the potential for auditory injury to marine mammals.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL. Nevertheless, EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel in the unlikely event of a spill. The location of the Project 207 kilometers (approximately 128 miles) offshore, prevailing northwest currents, the medium nature of the Payara field crude oil, and the region’s warm waters would all help reduce the severity of a spill. A type of modeling known as stochastic modeling was performed for a number of spill scenarios. Stochastic modeling accounts for the variability in conditions such as winds and ocean currents by simulating hundreds of individual spills (theoretically occurring at different times and under different wind/current conditions) and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path that a spill would follow. Stochastic modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates only a 5 to 20 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and the low likelihood that such a spill would occur.

Although the probability of an oil spill reaching the Guyana coast is very low, a subsea release of crude oil from a loss-of-well-control event would impact marine water quality and marine biological resources found near the well. Marine turtles and marine mammals would be particularly susceptible to impacts from an oil spill due to the need to surface to breathe and the resulting inhalation risks. Baleen whales feed near the surface where oil would be entrained, so an oil spill could foul their baleen plates and expose them to ingestion of oil as well as inhalation of volatilized hydrocarbons. Should spilled oil reach the coast in Region 1, the risks of oiling nesting beaches could pose inter-generational risks to marine turtles. Other physical and biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although current speeds in the Project Development Area regularly exceed 1 meter (3.3 feet) per second and, as the deterministic modeling discussed in EIA Section 9.1.5, Oil Spill

Modeling Results, demonstrates, spilled oil would travel rapidly to the north and/or west, depending on the season. Most of the biological resources listed are mobile and would be capable of at least some measure of avoidance of the higher hydrocarbon concentrations. This means that with the exception of immobile organisms in the immediate vicinity of the affected well, most physical and biological resources would likely experience impacts on the order of a few days at most.

Systemic ecological and food-web-related impacts could last longer depending on the extent of the acute impacts experienced from a spill event. Most species in the open ocean are at least somewhat mobile. This means that following initial detection of the oil, they would tend to avoid the affected area for the duration of the spill and return once the event is over, response activities are complete, and food resources recover. Given the likelihood that direct exposure to the effects of a spill would be short-term for most of these species, it is unlikely that an oil spill would cause widespread mortality and/or inter-generational impacts. The marine food web is based on planktonic organisms, many of which (with the exception of some fishes and a few macrobenthic species) would be expected to recover within a few weeks or months of the event. Even long-lived species with planktonic early life-stages would be expected to lose at most one year-class of recruits, and recover through emigration from unaffected areas within a few years of the event.

A spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact 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 these species are more abundant in the Project Development Area). Based on the results of the studies, fish diversity and abundance generally increase in the nearshore zone in the rainy season, marine turtle presence shows little variation over the seasons in terms of their abundance offshore, and marine mammals are more abundant in autumn and winter. Marine turtles are relatively abundant offshore Region 1 during the nesting season, but less common at other times of year. Regardless of seasonal trends in abundance or spatial distribution among the major taxonomic groups, effective implementation of the Oil Spill Response Plan (OSRP) would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing potential exposure of these species to oil.

Oil spill modeling indicates that transboundary impacts could potentially occur for the largest spill scenarios considered (2,500-barrel release from an FPSO offloading spill and 20,000 barrels of oil per day to 202,192 barrels of oil per day release from a loss-of-well-control event) assuming no mitigation measures were implemented. The unmitigated modeling results for these scenarios indicate there is the potential for oil to reach portions of a number of countries in the Caribbean. Potential impacts on resources and receptors in these other countries would be similar to those for Guyana. Further, there are some additional resources that could potentially be affected (e.g., corals), which recent marine surveys have documented are sparsely distributed across the middle and outer continental shelf and continental slope.

Additional unplanned events, also considered unlikely to occur because of the preventative measures employed by EEPGL, could include collisions between Project vessels and third-party

vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and third-party vehicles; Project helicopter strikes with seabirds; and discharge of untreated wastewater from the Project FPSO. The extent of the impacts 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 will be put in place by EEPGL (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 a Road Safety Management Procedure) would also serve to reduce the likely extent of impact, were such an event to occur.

Although a large marine oil spill is considered unlikely and the probability of reaching the Guyana coast is very low, given the sensitivity of many of the resources that could be potentially impacted by a spill (e.g., Shell Beach Protected Area, marine mammals, critically endangered and endangered marine turtles, coastal Guyanese and Amerindian communities reliant on ecosystem services for sustenance and their livelihood), preparation for spill response is warranted. Therefore, EEPGL will implement from time to time regular oil spill response drills, simulations, and exercises. EEPGL will involve appropriate Guyanese authorities and stakeholders in these activities and document the availability of appropriate response equipment on board the FPSO as well as offsite equipment required to be mobilized for a timely response.

With respect to potential transboundary impacts from an oil spill, implementation of EEPGL's OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana Exclusive Economic Zone, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on well location within 9 days in certain circumstances (e.g., where there is no debris that prevents or delays installation of the capping stack). Mitigated scenario modeling demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. Additionally, EEPGL has committed to work with the Government of Guyana for the coordination of applicable activities with representatives of the respective countries that could be potentially impacted by a large oil spill.

It is recommended that all of EEPGL's planned embedded controls, as well as the mitigation measures described herein, and appropriate Environmental and Socioeconomic Management Plan components, including an OSRP, 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 minor 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 (EIS) was prepared for the Payara Development Project (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), international good practice, Esso Exploration and Production Guyana Limited’s (EEPGL’s) standards, and the Project’s Final Terms and Scope (24 June 2019) for the Project Environmental Impact Assessment (EIA).

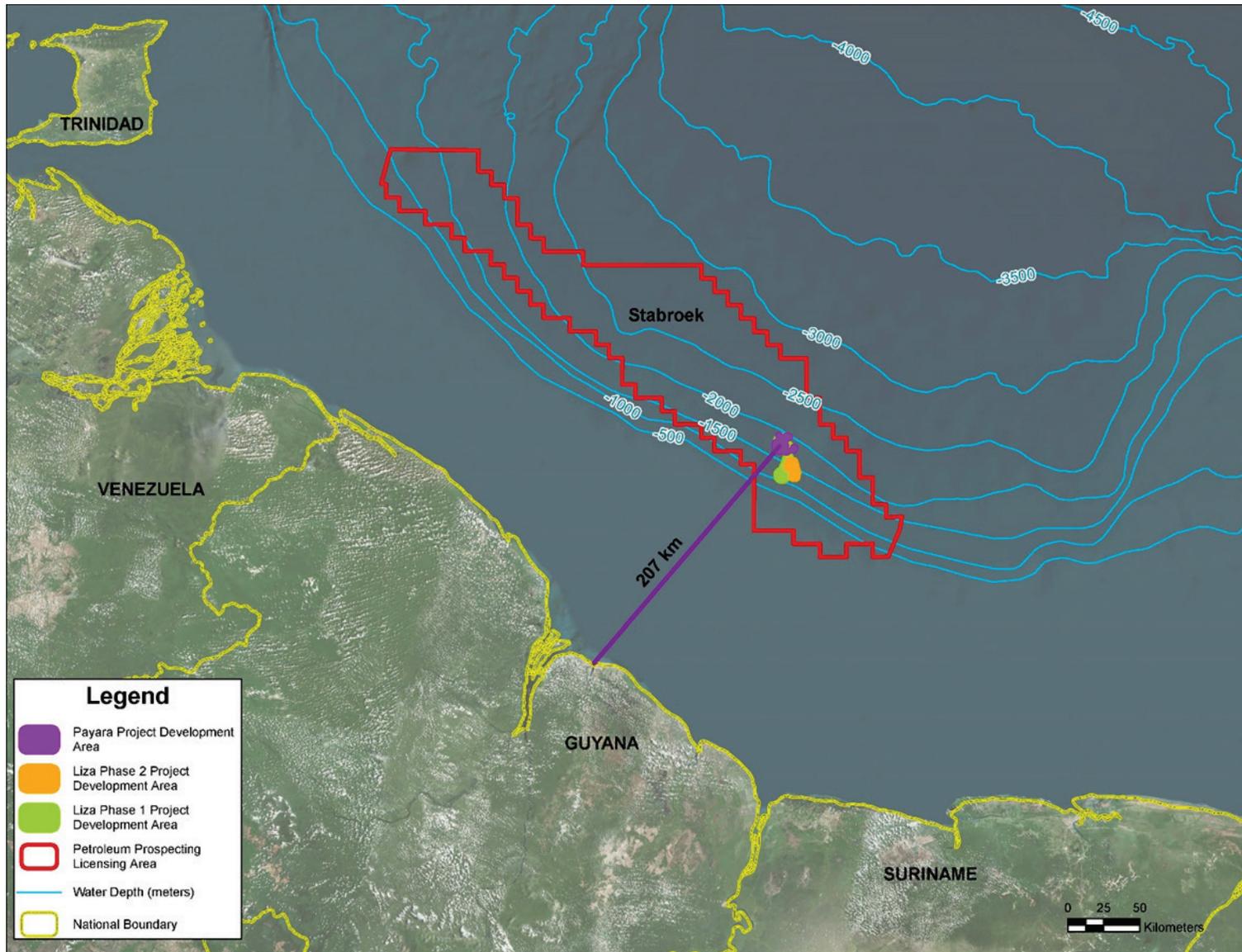
The EIA was prepared by a team of consultants including Environmental Resources Management (ERM), an international environmental and social consulting firm with a local registration in Guyana and extensive experience in the preparation of EIAs for offshore oil and gas development projects, and the Guyanese consultancies Environmental Management Consultants (EMC) and Ground Structures Engineering Consultants Ltd. (GSEC). ERM, EMC, and GSEC are collectively referred to herein as “the Consultants.” Appendix B provides the curriculum vitae of the key members of the EIA team.

### **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**

EEPGL (with the co-venturers) holds an offshore Petroleum Prospecting Licence for the Stabroek Block from the Government of Guyana. In 2015, oil was discovered in the Liza field within the eastern half of the Stabroek Block approximately 207 kilometers (approximately 128 miles) northeast of the coastline of Georgetown in waters approximately 1,500 to 1,900 meters (approximately 4,900 to 6,233 feet) deep (Figure EIS-1). Based on exploration and assessment activities to date, EEPGL has identified the presence of multiple reservoirs of crude oil with an estimated recoverable resource in excess of 6 billion barrels of oil-equivalent resource in the eastern half of the Stabroek Block. The Project described herein represents EEPGL’s third project development in the eastern half of the Stabroek Block, in the Payara, Pacora, Liza Deep, and northern area of the Liza fields. EEPGL and its co-venturers are parties to a Petroleum Agreement with the Government of Guyana.



**Figure EIS-1: Location of the Payara Project Development Area within Stabroek Block**

### **1.3. PURPOSE OF THE PROJECT**

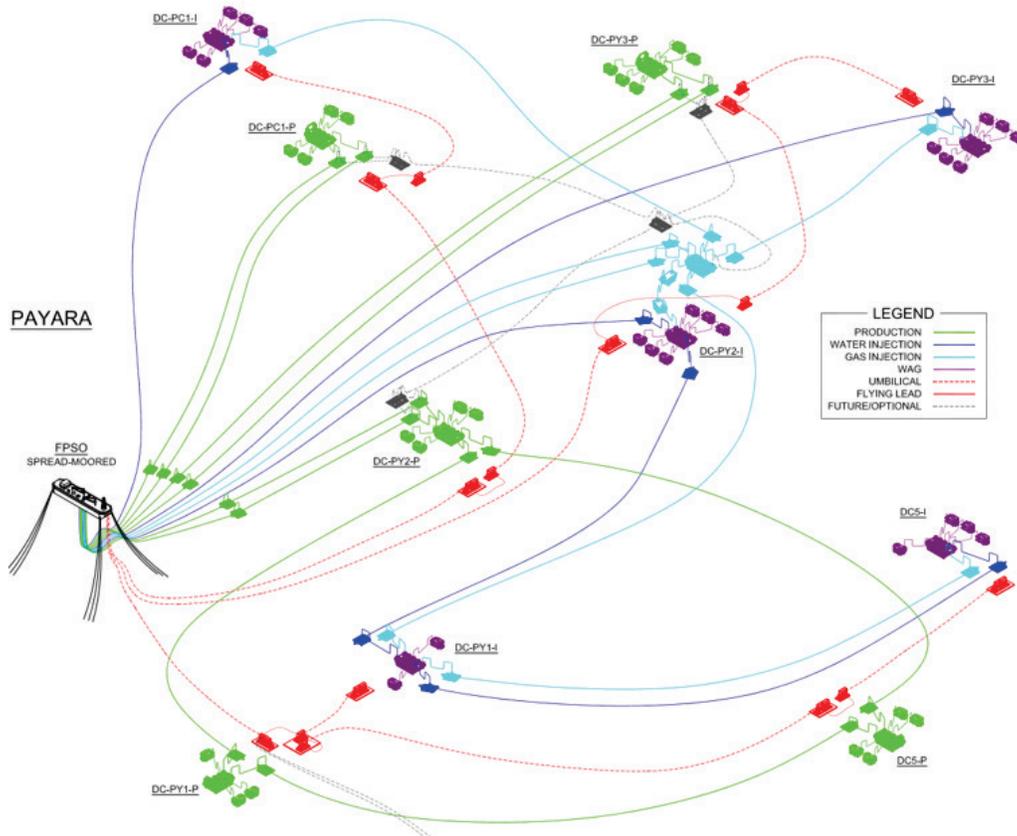
The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the Payara, Pacora, Liza Deep, and northern area of the Liza fields.

### **1.4. REGULATORY FRAMEWORK AND PURPOSE OF THIS EIA**

To develop the Project, EEPGL has applied for a Project Environmental Authorisation from the Guyana Environmental Protection Agency (EPA) in accordance with the Guyana Environmental Protection Act (as amended in 2005). To that end, EEPGL filed its application with the EPA on 3 December 2018 (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 will develop the offshore resource by drilling up to 45 development wells (including production, water injection, and gas re-injection wells) and using a Floating Production, Storage, and Offloading (FPSO) vessel to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated equipment, collectively referred to as Subsea, Umbilicals, Risers, and Flowlines (SURF), to transmit produced fluids (i.e., oil, gas, and produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to the injection wells. The combined extent of the area affected by both surface and subsea components and activities is referred to as the Project Development Area (PDA). The exact locations of the Payara development wells have not yet been finalized; however, the wells will be drilled from ten drill centers. During drilling and installation of the FPSO/SURF facilities, work may be performed in a subsea area within the PDA that could potentially cover an estimated 7,800 hectares. This area is referred to as the Subsea PDA. During the production operations stage, work performed on the surface of the ocean could potentially cover an estimated 5,000 to 5,500 hectares. This area is referred to as the Surface PDA. The PDA is located approximately 207 kilometers (approximately 128 miles) offshore (Figure EIS-2). The Project will also involve use of onshore shorebases and other support facilities and marine/aviation services to support development drilling, SURF and FPSO installation, production operations, and, ultimately, decommissioning.



**Figure EIS-2: Preliminary Payara Field Layout**

Natural gas will be produced in association with the produced oil. EEPGL will use some of the recovered gas as fuel on the FPSO, and proposes to re-inject the remaining gas back into the reservoir, which will assist in optimizing management of the reservoir. Alternative uses of gas for future phases are being studied and any such uses would be addressed in a separate environmental authorization.

The Project will consist of three stages: (1) Drilling and Installation, (2) Production Operations, and (3) Decommissioning. Each of these stages is described briefly below.

## 2.1. DRILLING AND SURF/FPSO INSTALLATION

The Project will use several drill ships similar to that shown on Figure EIS-3 to drill the development wells. The number of drill ships required will be determined during the design development process based primarily on the number of wells required for initial oil production. For the purposes of environmental assessment, two full-time drill ships working concurrently on Project development wells will be the basis of analysis. Additional drill ships may be used to accelerate the drilling schedule, as allowed by simultaneous operations. The wellheads will be clustered around ten drill centers rather than being distributed over the seabed above the producing reservoirs. For safety reasons, a 500-meter (approximately 1,640-foot) marine safety exclusion zone around the drill ships and major installation vessels will be established to avoid interactions with unauthorized vessels.

For each well, the initial section (i.e., structural casing section) will feature a pipe inserted into the borehole and cemented in place. This section will be drilled using water based drilling fluids, and drill cuttings from this section will be discharged to the seafloor near the well. Subsequent (lower) sections of the wells will be drilled using low-toxicity non-aqueous drilling fluids (NADF) with low to negligible aromatic content. The used cuttings from the lower sections will be directed to the drill ship, where the drilling fluids will be recovered for reuse to the extent practicable and the cuttings will be treated to limit the percentage of fluid retained on the cuttings. After treatment, the cuttings will be discharged to the sea. As each well is drilled, a wellhead and tree will be installed and the well will be connected to a manifold, which will be connected to a production or injection flowline. The flowlines will be laid on the seafloor, and risers will connect the seafloor infrastructure to the FPSO. The flowlines and risers will be hydrostatically tested with treated seawater to ensure no leakage. After the testing, the hydrostatic water used to test the water and gas injection flowlines will be discharged near the seafloor, and the fluid used to test the production flowlines will be recovered and treated prior to discharging overboard.

The FPSO (Figure EIS-4) will be new-built with double-hull protection, with the capacity to store 2 million barrels of stabilized crude oil. The FPSO will be secured to the seafloor by a 20-point spread mooring anchor system. The FPSO and the mooring system will be designed to remain in place for at least 20 years and accommodate extreme (100-year return period) environmental conditions (associated wind, waves, and current). The FPSO will also provide living quarters and associated utilities for approximately 160 personnel. For safety reasons, the FPSO will have a 2-nautical mile exclusion zone during offloading to avoid interactions with unauthorized vessels.



**Figure EIS-3: Typical Drill Ship**



**Figure EIS-4: Typical FPSO**

## 2.2. PRODUCTION OPERATIONS

The FPSO will be designed to separate the recovered reservoir fluids into its oil, water, and gas phases (Table EIS-1). The oil will be treated to remove impurities (e.g., sulfate and other salts) and then sent to storage tanks in the hull. The water from the reservoir (referred to as produced water) will be treated to remove hydrocarbons and will then be discharged to the sea. The FPSO will dehydrate, compress, and re-inject the produced natural gas into the targeted Project reservoirs, although some of the gas will be used as fuel on the FPSO, and some gas may be occasionally flared on a temporary basis. The FPSO will also have the capacity to treat (by filtration, deaeration, and sulfate removal) seawater for injection into the reservoir to maintain reservoir pressure (and offset the withdrawal of reservoir fluids) to enhance oil production.

**Table EIS-1: FPSO Key Design Rates**

Service	Design Rate <sup>a,b</sup>
Oil production	220,000 BOPD
Produced water	215,000 BPD
Total liquids	270,000 BPD
Produced gas	395 MMscfd
Gas injection	365 MMscfd (assumes 30 MMscfd of produced gas will be used as fuel gas for the FPSO)
Water injection	250,000 BPD

BPD = barrels per day; BOPD = barrels of oil per day; MMscfd = million standard cubic feet per day

<sup>a</sup> All design rates are presented as the peak annual average.

<sup>b</sup> For the purposes of the EIA, 264,000 BOPD will be used as the conservative basis to assess potential impacts from the Project.

The FPSO will offload produced crude oil to conventional oil tankers on a regular basis. The tanker, under the guidance of a Mooring Master, will maneuver to within approximately 120 meters (390 feet) of the FPSO and hold position with the aid of up to three tugboats (Figure EIS-5). Crude oil will be pumped from the FPSO storage tanks to the offloading tanker using a floating hose at a rate of approximately one million barrels of oil in approximately 28 hours.



**Figure EIS-5: General Offloading Configuration**

### **2.3. DECOMMISSIONING**

In advance of the completion of the Payara production operations stage, EEPGL will prepare a decommissioning plan for the facility. EEPGL will perform comparative assessments of facilities components where there may be multiple decommissioning options. Wells will be permanently plugged and abandoned by restoring suitable cap rock to prevent escape of hydrocarbons to the environment. Plugging and abandonment barriers will be installed in the wellbore, of adequate length to contain reservoir fluids, and deep enough to resist being bypassed by fracturing. It is expected that the risers, flowlines, umbilicals, subsea equipment, FPSO mooring lines, and anchor piles will be disconnected and abandoned in place on the seafloor, unless an alternative strategy is selected based on the results of the comparative assessments. The FPSO will be disconnected from its mooring system, removed from the production location, and towed to a new location for re-use or decommissioning.

## 2.4. ONSHORE, MARINE, AND AVIATION SUPPORT

Shorebases, laydown areas, pipe yards, fabrication/maintenance facilities, warehouses, fuel supply, heliport, and waste management facilities are planned to support development drilling, FPSO/SURF installation, production operations, and ultimately, decommissioning. EEPGL plans to use an existing Guyana shorebase located on the east side of the Demerara River as the primary shorebase supporting the Project. All onshore support facilities will be owned/operated by others and will not be dedicated to the Project.

Marine support will include various supply vessels with an average of approximately 12 to 15 round-trips per week to the Stabroek Block (combined for Liza Phase 1, Liza Phase 2, and Payara) during development drilling and FPSO/SURF installation and approximately 5 to 10 round-trips per week (combined for Liza Phase 1, Liza Phase 2, and Payara) during production operations. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Aviation support is expected to average at peak about 45 to 55 round-trip flights per week during drilling and installation (combined for Liza Phase 1, Liza Phase 2, and Payara) and an estimated maximum of 20 to 30 round-trip flights per week during production operations and continued development-drilling activities (combined for Liza Phase 1, Liza Phase 2, and Payara).

## 2.5. PROJECT WORKFORCE

EEPGL estimates it will require a workforce of approximately 600 persons at the peak of the development well drilling, approximately 600 persons at the peak of the installation stage, approximately 150 shorebase and marine logistical support onshore staff (some of whom will be Project-dedicated while others will be shared resources) at the peak of installation and drilling activities, approximately 100 to 140 persons at peak of production operations, and approximately 60 persons at the peak of decommissioning.

## 2.6. PROJECT SCHEDULE

It could take up to 5 years to drill the approximately 45 wells, with drilling planned to begin in late 2020. Installation of the SURF and FPSO is planned to be initiated in 2021 to be ready for initial production by early 2023, with operations continuing for at least 20 years (Figure EIS-6).

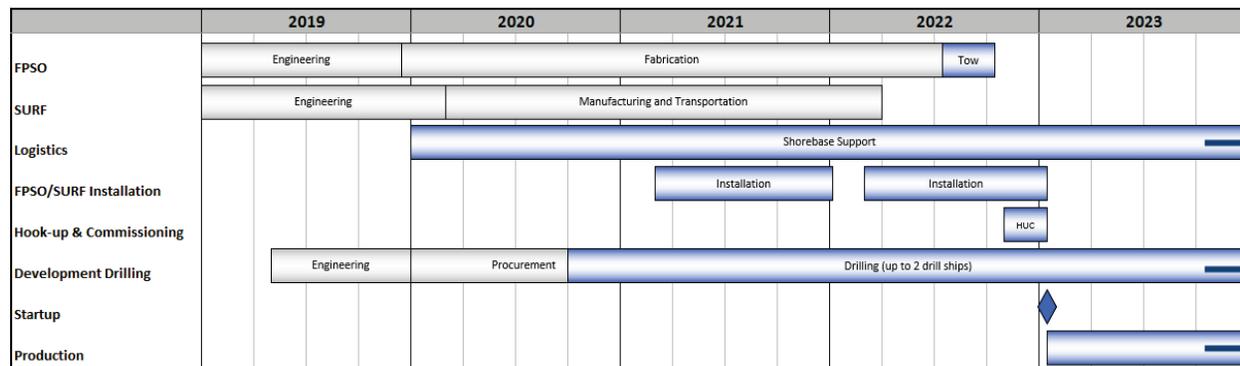


Figure EIS-6: Preliminary Project Schedule

## 2.7. PUBLIC CONSULTATION

EEPGL and the Consultants have conducted a robust public consultation program to both inform the public about the Project 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 or planned specific to the EIA stage are summarized below.

- EEPGL has held a number of engagements and workshops on specific topics with the government and agencies related to the offshore oil and gas exploration and development in general and the Payara Development Project specifically, including but not limited to the Department of Energy (DE) (which falls under the Ministry of Presidency and recently took over responsibility for petroleum operations from the Ministry of Natural Resources), Guyana Geology and Mines Commission, and EPA.
- During scoping and the EIA development, EEPGL and/or the Consultants:
  - Held meetings and key informant interviews with and/or gathered relevant data from more than 15 Guyana government agencies, commissions, professional or business associations, non-governmental organizations, and elected officials and regional administrators; and
  - Held focus group meetings with more than 440 members of coastal communities and over 80 artisanal and commercial fisherfolk in Regions 1 to 6.

A Notice to the Public concerning the submission of the Application for the Project was published in the Stabroek News on 15 December 2018, and was posted on the EPA's website, initiating the 28-day public comment period. During this period, five public consultation meetings with the public were held.

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.

## 2.8. ALTERNATIVES

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

- Location Alternatives. The location of the offshore Project infrastructure, particularly the development wells and SURF hardware, is primarily driven by the location of the resource to be recovered. However, within the proximity of the resource, there is some flexibility in selecting the location of the FPSO and associated mooring system within the PDA. The locations/orientations of FPSO, SURF equipment, and drill centers were selected to reduce to the extent practicable the potential impacts on the environment and to optimize the recovery of resources. A key consideration in FPSO location is to minimize interference and facilitate efficient four-dimensional seismic operations in the Stabroek Block. Another consideration for the FPSO location is to avoid positioning FPSO anchor piles in areas that could create

geotechnical challenges. Routing of flowlines/pipelines/risers between the manifolds and FPSO primarily seeks to minimize overall length while also avoiding clashing (e.g., between risers, umbilicals, and mooring lines). Minimizing length not only reduces Project cost, but also Project footprint (and impact). The FPSO and subsea equipment locations were chosen so that initial projects can be operated, including the marine operations associated with oil offloading, while subsequent projects are in the drilling or offshore installation phases. With respect to onshore components of the Project, the preferred alternative from an environmental perspective is to use existing shorebases in Georgetown with sufficient capacity to meet Project needs. If additional shorebases are developed in the future by third parties through separate permitting processes, EEPGL will consider the potential benefits (environmental, technical, and economic) of using these shorebases in addition to or in lieu of the shorebases that currently exist.

- Development Concept Alternatives
  - Drilling Facility Type: The primary alternatives considered for development well drilling facilities included a drill ship and a semi-submersible drilling rig. Drill ships allow for more efficient development operations as compared to semi-submersibles, given their increased variable deck load—which is critical due to multi-well drilling and completion equipment requirements. Drill ships also allow for faster transit speeds between drill centers, resulting in significant time-savings due to frequency of well movements during batch operations.
  - Production Facility Type: Several different types of production facility alternatives were evaluated during the early stages of the design process. Given the water depth and distance to shore of the Liza field, the development alternatives for the Project are primarily limited to floating production systems (e.g., FPSO, semi-submersible, tension leg platforms). Regardless of the structure, the chosen facility for the Project would need to process the same volumes of oil, gas, and water. As such, topsides facilities are similar between an FPSO and a semi-submersible. The real distinction is the need for oil storage. An FPSO has storage integrated into its facilities. A semi-submersible would require an additional floating, storage, and offloading (FSO) facility to allow for the oil storage. The FSO adds cost above the FPSO design and a semi-submersible with an FSO would also require additional moorings as compared to an FPSO. The use of an FSO would thus significantly increase the Project offshore infrastructure, which would increase potential Project impacts on air quality (e.g., increased air emissions), marine water quality (e.g., additional wastewater effluent discharges), marine benthos (e.g., increased disturbance of the seafloor for the FSO mooring system), and marine use and transportation (e.g., additional marine safety exclusion zones for additional marine vessels). For these reasons, an FPSO was selected as the preferred production facility alternative for the Project.

- Crude Oil Commercialization: The principal alternatives for an offshore development are: (1) transmission to shore via subsea pipeline infrastructure to an onshore refining facility; and (2) offloading to export tankers for transport to onshore refining facilities located further from the resource than can be feasibly connected via pipeline infrastructure. As there are no existing petroleum refineries in Guyana or existing regional offshore pipeline infrastructure in close proximity, the only feasible alternative is offloading to export tankers for sale to existing refining facilities around the world.
- Associated Gas Management: Three primary alternatives were considered for addressing associated gas produced during Project operations: gas re-injection, continuous flaring, and gas export. Gas re-injection was determined to be feasible for the Project, and it also provides benefits in terms of reservoir management by helping to maintain pressure in the reservoir (thereby increasing the amount of crude oil that can be recovered over time) and reduced air emissions (as compared to continuous flaring). Under this alternative, produced gas not used as fuel gas on the FPSO will be re-injected under normal operations. Continuous flaring of gas on a routine basis is not preferred, primarily due to the associated air emissions. Gas export alternatives for future development continue to be evaluated, with due consideration of the challenges related to commercialization of associated gas. Any proposal for implementation of gas export would be addressed under a separate environmental authorization process, and is therefore outside the scope of this EIA.
- Technology Alternatives. EEPGL is using the most appropriate industry-proven technologies in developing the Project, in terms of well drilling, drilling fluids, equipment selection, development concepts, and environmental management. EEPGL's parent company Exxon Mobil Corporation, its affiliates, and their contractors have extensive experience in delivering offshore deepwater development projects around the world, particularly with FPSO and SURF components, and are applying that knowledge, experience, and technology in the development of this Project. EEPGL evaluated the best available technology decisions for the following technology aspects: drill cuttings, gas processing, injection compressors, power generation, produced water, and sulfate removal.
- No Action Alternative. If this alternative is selected, the existing conditions described in EIA Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and Chapter 8 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. Therefore, evaluating the no action alternative means evaluating the tradeoff between positive and negative impacts.

Overall, the proposed Project reflects optimized locational siting, appropriate development concept, use of industry-proven technology, and selection of the environmentally preferred action alternative.

### 3. PROJECT IMPACTS

This section summarizes the predicted environmental and socioeconomic impacts of the Project resulting from planned activities and potential risks resulting from unplanned events, as well the Project’s contributions to cumulative impacts on resources and receptors. The resources/receptors considered in this analysis are listed in Table EIS-2. The impacts of the Project were evaluated against the conditions of the existing environment, as described in Chapters 6, 7, and 8 of the EIA.

**Table EIS-2: Resources and Receptors Considered in this EIA**

<b>Physical Resources</b>	<b>Biological Resources</b>	<b>Socioeconomic Resources</b>
Air Quality and Climate	Protected Areas and Special Status Species	Socioeconomic Conditions
Sound	Coastal Habitats	Employment and Livelihoods
Marine Geology and Sediments	Coastal Wildlife	Community Health and Wellbeing
Marine Water Quality	Seabirds	Marine Use and Transportation
	Marine Mammals	Social Infrastructure and Services
	Riverine Mammals	Cultural Heritage
	Marine Turtles	Waste Management Infrastructure Capacity
	Marine Fish	Land Use
	Marine Benthos	Ecosystem Services
	Ecological Balance and Ecosystems	Indigenous Peoples

#### 3.1. PLANNED ACTIVITIES

The Project is an offshore oil development and all drilling, installation, production operations, and decommissioning activities will occur over 207 kilometers (approximately 128 miles) off the coast of Guyana. The planned Project activities will not disturb any natural onshore habitats. There will be a negligible increase in traffic congestion due to Project-related vehicle movements. The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment, and select Project purchasing from Guyanese businesses. The resources with the potential to incur meaningful impacts from planned Project activities are the physical resources water quality and climate, some marine-oriented biological resources, and some socioeconomic resources. These resources and their residual significance ratings (after mitigation measures are considered) are discussed briefly below. Additionally, while the EIA concludes that air quality will not incur any meaningful adverse impacts from planned Project activities, this resource is also discussed briefly below, due to the level of interest in this resource identified during consultation for the EIA.

### 3.1.1. Air Quality and Climate

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, non-routine flaring used to combust produced gas when not consumed as fuel gas on the FPSO or injected back into the reservoir, and vents; and (2) general area sources such as marine support vessels, installation vessels, and helicopters. Such emissions contribute to increases in the ambient air concentrations of certain pollutants.

The CALPUFF model was used to assess the dispersion of air pollutants and the potential impact for onshore human receptors. For all modeled constituents, the maximum onshore concentrations predicted to result from Project activities are negligible relative to World Health Organization guidelines (the highest predicted onshore concentration being less than 1.7 percent of the World Health Organization guideline), indicating a **Negligible** residual impact on onshore air quality from the Project.

The Project will also emit greenhouse gases (GHGs) throughout its predicted life cycle (at least 20 years), with peak emissions during steady-state production operations estimated to be approximately 1,355 kilotonnes of carbon dioxide-equivalents (CO<sub>2</sub>e) per year. There are no applicable regulatory criteria against which these GHG emissions can be compared, but these emissions will be disclosed in accordance with good international practice to aid in managing GHG emissions at a national and international level. EEPGL proposes to re-inject recovered natural gas (that which is not used as fuel on the FPSO) back into the targeted Project reservoirs for reservoir pressure management, which contributes to a significant reduction in potential GHG emissions versus that which would result from continuous gas flaring. Guyana's 2012-reported annual GHG emissions were approximately 2 million tonnes of CO<sub>2</sub>e, with total annual removals of approximately 60 million tonnes of CO<sub>2</sub>e (resulting in net annual removals of approximately 58 million tonnes of CO<sub>2</sub>e). Accordingly, although the overall emissions at a country level would be increased measurably by Project GHG emissions, net removals would decrease only slightly (i.e., approximately 2.5 percent). Further, the Project has applied technologies aligned with Good International Oil Field Practice to reduce GHG emissions, and the 1,355 kilotonnes of CO<sub>2</sub>e per year rate represents an 82 percent reduction from projected GHG emissions without the application of these technologies. With these technologies, the Project's GHG performance factor is significantly better than the global industry average. Balancing these factors with the fact that climate change is an issue of global importance, a residual significance rating of **Moderate** is applied for the production operations stage of the Project.

### 3.1.2. Marine Water Quality

The Project will impact marine water quality in a localized manner via planned discharges during well drilling, hydrostatic testing of the flowlines and risers following installation, and production operations stages. Planned discharges of drill cuttings and fluids may have a localized impact on marine water quality as a result of increased total suspended solids (TSS) concentrations in the water column. Cuttings and fluids released at the seafloor during jetting and drilling of the initial sections of the well will increase TSS concentrations around the well near the seafloor. Cuttings

discharged overboard from the drill ships will increase TSS concentrations in the photic zone (the upper level of the water column through which sunlight can penetrate). Modeling predicts that TSS concentrations above a threshold of 35 milligrams per liter will occur during drilling of the initial well sections only, and these instances are confined to within a relatively small area around the well locations, near the seafloor. The area impacted will be localized and impacts will occur over a short time period; however, a small fraction of the overall benthic community (sponges living on the hard seafloor features in the PDA) would have an elevated sensitivity to elevated TSS, so the residual impacts on marine water quality from TSS increases resulting from drill cuttings discharge are considered **Minor**.

During installation, the subsea flowlines and risers must be hydrostatically tested to confirm there are no leaks. Treated seawater is used for this purpose to prevent biofouling. A hydrate-inhibiting substance, such as methanol or ethylene glycol, will also be used to prevent formation of hydrates during commissioning of the production and gas injection lines. After testing is completed, the hydrostatic test water from the water injection and gas injection lines, and the hydrate inhibitor from the gas injection lines will be released at the seafloor. The hydrostatic test water and hydrate inhibitor from the production lines will be returned to the FPSO, treated, and discharged from the overboard water line. These discharges would be a one-time, short-term impact, and the treated seawater and hydrate inhibitor would be quickly diluted within the water column, resulting in a **Negligible** residual impact.

During production operations, the FPSO will discharge five primary effluent streams to the ocean (Table EIS-3) as permitted discharges. The FPSO systems associated with these discharges will be designed to ensure applicable discharge criteria are met, which may require treatment in some cases. Modeling indicates that concentrations of chemical constituents would be reduced to insignificant levels and temperature increases from cooling water and produced water discharges will be less than 3°C within approximately 100 meters (approximately 328 feet) of the discharge point, resulting in a **Negligible** residual impact.

**Table EIS-3: Summary of Production Operations Discharges**

Discharges	Source	Potential Contaminants	Discharge Rate	Comments
Cooling Water	Process water to dissipate heat from FPSO systems, no hydrocarbon contact	Temperature, residual chlorine	≤ 1,600,000 BPD	Discharge will meet internationally recognized standards limiting increases in ambient water temperature. Discharge meets applicable international residual chlorine standards without treatment.
Produced Water	Water separated from reservoir fluids	Oil and grease, temperature, residual production and water treatment chemicals	≤ 300,000 BPD	Will be treated to meet internationally recognized limits on oil and grease content. Discharge will meet internationally recognized standards limiting increases in ambient water temperature.

Discharges	Source	Potential Contaminants	Discharge Rate	Comments
Sulfate Removal and Potable Water Processing Brines	Removal of sulfates from seawater prior to injection; potable water processing	Biocide, chlorine, oxygen scavenger, Scale inhibitor	≤ 265,000 BPD	Discharge meets applicable standards without treatment.
Domestic and Sanitary Wastewater	Personnel black water and food wastes (treated); gray water (untreated)	Nutrients, chlorine, bacteria	360 BPD	Will be treated in accordance with internationally recognized standards prior to discharge, as required.
Offloading Tanker Ballast Water	Offloading tanker will discharge ballast water as it loads oil from the FPSO	None anticipated	≤ 1,200,000 barrels total (at each tanker loading)	Discharge will be conducted in accordance with internationally recognized standards.

BPD = barrels per day

### 3.1.3. Marine Geology/Sediments and Marine Benthos

The drilling of wells and the placement of flowlines and other subsea equipment will physically disturb approximately 0.8 km<sup>2</sup> (0.3 mi<sup>2</sup>) of the sea bottom. After the initial structural casing section is installed, the remaining NADF drill cuttings will be returned to the drill ships for treatment to remove associated drilling fluids prior to discharge to the sea in order to meet acceptable discharge thresholds. The planned discharge of NADF drill cuttings will result in a localized accumulation of cuttings on the seafloor, primarily around the drill center locations, with the distribution of deposition determined by oceanographic conditions. Modeling has indicated that the discharge of these cuttings will not significantly impact sediment quality because of the relatively low toxicity and expected dispersion. Overall, the Project impact on marine sediments will be negligible.

Marine benthos (organisms living on the seafloor) could also be impacted by Project-related seafloor disturbance by potential smothering from the drill cuttings. The most sensitive component of the benthic community to elevated TSS concentrations is sponges living on the hard seafloor features in the PDA. Due to their immobile adult life form, sponges located on a relatively small portion the hard seafloor features that will be impacted by the elevated TSS concentrations will be unable to relocate to avoid impacts. While, this community accounts for a small proportion of the seafloor within the Subsea PDA, a small fraction of the overall benthic community would have an elevated sensitivity to elevated TSS, so the overall residual significance to benthic communities will be **Minor**.

### 3.1.4. Seabirds (including Special Status Species)

Seabirds have the potential to be impacted by planned Project activities through attraction- and disturbance-related effects or collision with a Project vessel or helicopter. It was determined that the significance of these residual impacts range from **Negligible** to **Minor** (for seabirds as a whole and special status seabirds, respectively) for the reasons explained below.

The EEPGL-commissioned marine bird survey completed from 2017 through 2019 indicated that the seabird community offshore Guyana is moderately diverse, but the abundance of birds is low compared with other areas in the greater Caribbean and tropical Western Atlantic region. The Project could impact seabirds by acting as an attractant to seabirds because of its lighting; or exposing them to disorientation, collision risks, additional energy expenditure, and compromised navigation for night-migrating birds. The Project lighting will be downcast when feasible to minimize its attraction potential. Potential benefits from the Project to seabirds are use of the FPSO, drill ship, and installation vessels for rest or shelter during adverse weather conditions or during long migrations and, if such vessels act as consistent attractants for seabird prey, providing a reliable food resource for seabirds.

Two special status species, Leach's Storm-Petrel (*Oceanodroma leucorhoa*) and Black-capped Petrel (*Pterodroma hasitata*) are known to occur in the Project Area of Influence (AOI), although only Leach's Storm-Petrel was observed during marine bird surveys conducted from 2017 through 2019. These species will have the same exposure to potential impacts as non-special status seabirds because their habitat use, behavior patterns, and biology are similar; accordingly, the impact ratings for special status species seabirds were not changed from those used for non-special status seabirds.

### **3.1.5. Marine Fish (including Special Status Species)**

Marine fish survey conducted between 2017 and 2019 indicates that deepwater fish diversity is poor in the vicinity of the PDA and the pelagic fish community is typical of the region. The data suggest that offshore pelagic fish may be slightly more abundant in the latter half of the year, while nearshore fish are more abundant and diverse during the rainy season when freshwater inputs to the estuaries are greatest. The Project could impact marine fish by deterioration of water quality from the discharges described above and the potential to entrain (suck in) fish at the cooling water intake. Modeling indicates that water quality will return to near background conditions within 100 meters (approximately 328 feet) of the FPSO, so the area impacted will be very small, and fish are mobile and are known to avoid areas with degraded water quality. Water intakes will be designed to minimize the entrainment of fish. Several special status marine fish species are known or thought to occur in the Project AOI. While the magnitude of potential impacts on marine fish would be **Negligible to Small**, the significance of potential residual impacts on some species was considered to be **Minor**.

### **3.1.6. Marine Mammals (including Special Status Species)**

Marine mammals have the potential to be impacted by the planned Project activities, primarily as a result of exposure to underwater sound, and it was determined that the significance of these potential residual impacts ranges from **Negligible to Moderate**. Marine mammal observations recorded during surveys in and around the Stabroek Block since 2015 indicate that the marine mammal community in the Stabroek Block consists primarily of small cetaceans, and that large cetaceans (i.e., whales) rarely occur south of the Stabroek Block on the relatively shallow continental shelf. Marine mammals have the potential to be impacted by two types of sound from planned Project activities: continuous sound from vessels and machinery operating in the PDA;

and comparatively louder, shorter-duration impulse sound from Vertical Seismic Profiling (VSP) and pile driving. Both the continuous sound and impulse sound sources would be loud enough to cause injury in the immediate vicinity of the source, but would attenuate to non-injurious levels within approximately 10 meters (approximately 33 feet) from the vessels, approximately 75 meters (approximately 246 feet) from the VSP, and approximately 1,400 meters (approximately 4,600 feet) from the driven piles (at depths of more than 1,500 meters [approximately 4,920 feet]).

Modeling results indicate sound levels from vessels and the VSP are insignificant compared to the predicted sound levels from impact pile driving. The distances from Project underwater sound sources to injury thresholds are largest for pile driving. Based on the premise that marine mammals will actively avoid physical discomfort associated with Project-related sound, if impact-driven piles are used, mid-frequency cetaceans (MFCs) would be expected to generally avoid the portion of the water column within at least approximately 700 meters (2,297 feet) from the location where pile driving is taking place, and low-frequency cetaceans (LFCs) would be expected to generally avoid the portion of the water column within at least approximately 1,400 meters (approximately 4,600 feet) of the activity. Both categories of cetaceans would be expected to avoid these areas for the duration of the pile-driving activity. LFC species, including many of the larger baleen whales and dolphins, and some MFC species, including toothed whales, will naturally remain outside of the area of potential effect because it will be deeper than their deepest recorded dive depths. Some MFC species, such as sperm whales, dive much deeper than LFC species (approximately 1,200 meters [approximately 4,000 feet] in tropical and subtropical latitudes), but most species do not dive deep enough or remain at depths long enough that they could potentially be exposed to injurious sound levels within the PDA.

### **3.1.7. Riverine Mammals (including Special Status Species)**

Two species of riverine mammals—the West Indian manatee (*Trichechus manatus*) and the neotropical otter (*Lontra longicaudis*)—have the potential to be impacted by planned Project activities as a result of increased Project vessel traffic within the Demerara Harbour. Manatees and neotropical otters occur in low numbers in the brackish/intertidal waters of the Demerara Harbour and lower Demerara River, but resident riverine mammals of the harbor are expected to be habituated to the constantly changing and human-influenced environments of the harbor. The slight increase in overall marine vessel traffic in Georgetown Harbour that will occur as a result of the Project (1 to 4 percent increase) may result in a slight incremental increase in temporary avoidance behavior and displacement from the vessel transport route, which itself represents a small portion of the available riverine habitat within the harbor, but it was determined that the significance of this potential residual impact was **Minor**.

### **3.1.8. Marine Turtles**

Marine turtles have the potential to be impacted by planned Project activities, but it was determined that the significance of these potential residual impacts is **Negligible**. Marine turtles are generally considered to be less sensitive to marine sound than marine mammals, so underwater sound from Project activities would not have the same potential to impact marine

turtles as marine mammals. Marine turtles have been detected at a much lower rate than marine mammals offshore Guyana during surveys conducted from 2015–2019, which suggests that the density of marine turtles offshore is comparatively low. Preliminary tracking data from a marine turtle telemetry study initiated as part of the Liza Phase 1 Development Project indicate that individual turtles may nest multiple times a season at Shell Beach and that during the period between nesting events, they generally remain close to the nesting beaches, which would reduce the probability of their being disturbed by Project vessel traffic moving within the PDA or between the PDA and shorebases in Guyana.

### 3.1.9. 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, gene flow, and maintenance of biodiversity. The significance of potential residual impacts on ecological balance and ecosystems was concluded to range from **Negligible** to **Minor**. Changes in water quality could affect the planktonic base of the marine food web, but based on the negligible significance of water quality impacts and the very small portion of the North Brazil Shelf Large Marine Ecosystem that will be exposed to these impacts, the Project is predicted to have little if any measureable ecosystem-level impacts on nutrient cycling. The Project is not expected to create any significant obstacles to migration, breeding, or dispersal/colonization, so Project-related residual impacts on gene flow are expected to be **Negligible**. Ballast water exchange during the production operations stage is predicted to have potential impacts on biodiversity due to the potential for introduction of exotic or invasive species, but embedded controls will limit the potential for this impact (and the extent of the impact if it were to occur) and it is not expected to lead to the loss of any species or other long-lasting biological effects within the North Brazil Shelf Large Marine Ecosystem. Therefore, the Project's residual impacts on maintenance of biodiversity are expected to be **Minor**.

### 3.1.10. Employment and Livelihoods

As discussed above, the Project will generate a variety of marine vessel trips throughout the Project life (at least 20 years) and these will potentially impact open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA, and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. In addition to the potential impacts on commercial and subsistence fishing vessels navigation, there may be potential impacts on livelihoods of artisanal fisherfolk nearshore and industrial fishing vessel operators in remote offshore areas as a result of navigation impacts. While commercial fishing vessels offshore will lose access to some fishing areas that are currently available to them as far out as the PDA, the significance of this potential residual impact on commercial fishing livelihoods was assessed as **Negligible** considering the small number of operators that currently participate in deep-sea fishing (no more than 12 vessels), the small footprint that will be impacted in the PDA, and the ability to provide information in advance about EEPGL's operations and marine safety exclusion zones. The highest potential for Project interactions with fisherfolk may be encounters with support vessels

transiting between the PDA and shorebases in Georgetown. This could result in some limited and temporary disruption to mostly artisanal fishing activity in these areas. Artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential disruption to subsistence fishing activities, and since many do not carry radios, use remote ports, and/or may not receive notices of increased vessel activity, the significance of this potential residual adverse impact on artisanal fishing livelihoods was assessed as **Minor**. Overall, the potential impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending are considered to be **Positive**.

### 3.1.11. 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 public safety as a result of the presence of Project workers, increased public anxiety concerning the oil and gas industry as a whole, and decreased availability of emergency medical and health services. Given the small size of the Project workforce in comparison with the receiving community (less than 1 percent of the population of Georgetown), the Project workers' limited and occasional onshore presence, and the embedded health controls in place to further reduce risk, the significance of potential residual impacts related to both communicable disease transmission and public safety are considered **Negligible**. The residual significance of public anxiety over oil and gas sector risks, especially among the more vulnerable populations along the coastal areas in Region 1, is assessed to be **Minor**. In Georgetown, where there are higher 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, anxiety and misconceptions about Project risks are considered to be **Negligible**. The potential for reduced access to emergency and health services as a result of Project activities, even considering a Project-dedicated onshore medical provider and ambulance, is assessed to have a **Minor** residual significance, principally in relation to the population in Georgetown and the vicinity, considering existing health system gaps.

### 3.1.12. Marine Use and Transportation

The Project will generate a variety of marine vessel trips throughout the Project life (at least 20 years), including maritime transport of Project materials, supplies, and personnel as well as the presence of the FPSO, drill ships, and major installation vessels. These marine activities will potentially impact vessel traffic into and out of Georgetown Harbour, open-ocean shipping in the vicinity of the PDA, the limited commercial fishing activity that occurs as far out as the PDA and commercial and subsistence fishing activity within the portion of the Direct AOI that connects the PDA to Georgetown Harbour. Project-related traffic is expected in both the active commercial port and in international waters and commercial vessels are expected to be able to safely navigate around other vessels. Therefore, the significance of potential residual impacts on commercial cargo vessels in Georgetown Harbour and in the vicinity of the PDA is considered to be **Negligible**. Commercial fishing vessels offshore will lose access to some fishing areas that are currently available to them, and will have to avoid Project-related vessel traffic where none currently exists. Subsistence fishing vessels will not lose access to existing fishing areas, as

subsistence fishing does not occur as far out to sea as the PDA. Subsistence fishing vessels could experience interference due to movements of Project-related vessel traffic. While Notices to Mariners will be provided to mitigate potential interference with commercial and subsistence fishing vessel navigation, there are limitations—in particular for subsistence vessels—to the effectiveness of these notices. Accordingly, the significance of potential residual impacts on commercial and subsistence fishing vessels navigation as a result of increased marine traffic is assessed as **Minor**.

### **3.1.13. Social Infrastructure and Services**

The planned Project activities with the potential to impact social infrastructure and services include Project worker presence (with the potential to impact availability of lodging and the availability and/or cost of housing and utilities) and ground and air transportation (with the potential to increase traffic congestion). Although the Project will have limited onshore planned activities, the presence of Project workers and of those seeking Project-related work has the potential to increase demand for housing and utilities in the Georgetown area, where current shortfalls of housing and appropriate utilities infrastructure already exist. While the anticipated number of Project workers is insignificant (less than 1 percent) compared to the Georgetown population, the significance of the potential residual impact (decreased availability/increased cost of housing and utilities) is assessed as **Minor** during the drilling and installation stages—when the workforce is at its peak. Due to smaller numbers of Project workers anticipated during the production operations stage, the residual impact significance is assessed as **Negligible** for this stage.

The presence of Project workers also has the potential to increase demand for lodging in the Georgetown area, which may lead to reduced availability and/or increased cost. While an assessment of available lodging in Georgetown indicates minimal chance for capacity constraints, due to the anticipated number of Project workers requiring lodging, the potential residual impact is assessed as **Minor** during the drilling and installation stages—when the workforce requiring lodging is at its peak. Due to smaller numbers of Project workers anticipated during the production operations stage, the residual impact significance is assessed as **Negligible**.

Planned Project activities will generate additional vehicular traffic around Georgetown as a result of EEPGL-related personnel movements and non-personnel (e.g., equipment, supplies, etc.) movements. Traffic impact modeling confirmed that the additional EEPGL-related vehicle trip counts in 2021, 2023, and 2025 will not meaningfully change traffic congestion levels on the road segments across Georgetown anticipated to potentially be among the more heavily used by EEPGL-related vehicle movements. On this basis, the significance of potential residual impacts on ground transportation as a result of planned Project activities is considered to be **Negligible**.

### **3.1.14. Waste Management Infrastructure Capacity**

The planned Project activities have the potential to impact waste management infrastructure capacity for current users of Georgetown-based hazardous waste treatment facilities (primarily other oil and gas operators) and non-hazardous waste landfills (primarily the general community)

due to increased burden of Project wastes on the capacity of these facilities. Based on an assessment of Georgetown-based hazardous waste treatment facilities, it was concluded that, without modifications, the infrastructure capacity of the hazardous waste treatment facilities would likely be unable to treat all of EEPGL's hazardous solids and waste oil liquids by late 2020. A separate assessment by the operator of the Georgetown-based non-hazardous waste landfill concluded that the capacity of the landfill, without opening a new cell, will be exhausted by the end of 2019.

The projected Project waste generation represents a significant portion of the total demand for Georgetown-based hazardous waste treatment facilities, but less than 2 percent of the total current demand at Georgetown non-hazardous waste landfill facilities.

Although the Project itself is not considered a receptor 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 to ensure Project viability, and in recognition of the potential future capacity constraints and potential impacts on non-Project users of Georgetown-based waste management infrastructure, the Project has initiated the following mitigation measures:

- Enable increases to existing Georgetown-based waste management capacity for hazardous wastes, explore use of new Georgetown-based hazardous waste treatment facility or facilities, or identify suitable alternative regional solutions; and
- Monitor the Ministry of Communities' planned construction of Cell 2 at the Haags Bosch landfill, or (if approved by the EPA) construction of an alternative landfill site in Georgetown, or identify suitable alternative regional solutions for non-hazardous waste disposal.

In addition to these mitigation measures, EEPGL will implement a number of waste management-related embedded controls, which are summarized in the Waste Management Plan provided as an appendix to the Environmental and Socioeconomic Management Plan (ESMP). Implementation of these mitigation measures and embedded controls will reduce the effects of Project-related demands on waste management infrastructure capacity, particularly related to hazardous waste management, resulting in a residual impact significance rating of **Negligible** for this aspect. However, in view of the fact that capacity expansions for the Georgetown-based landfill facilities are not under EEPGL's control, the significance rating for potential residual impacts on Georgetown-based landfill capacity is maintained at a level of **Minor**.

### 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 these events are not planned, they are evaluated using methods different from those used for planned events, specifically taking into consideration the likelihood that an unplanned event will occur. For purposes of the Project, five types of unplanned events were identified and considered: hydrocarbon spill, discharge of untreated wastewater from the FPSO, vessel strike of a marine mammal, marine

turtle, riverine mammals, or seabird; seabird collision with the FPSO flare tower, flare, or radiant heat plume; vessel collision; and onshore vehicular accident.

### **3.2.1. Vessel Collisions or Vehicular Accidents**

While a vessel collision or vehicular accident could result in injuries, the potential for a vessel collision that led to significant injury or fatality would be expected to be low considering the robust controls incorporated into the Project, and the likely vessel and vehicle speeds in areas where risk of collisions would be highest. Based on consideration of the likelihood of occurrence and the likely range of severity given these factors, vessel collisions and vehicular accidents (i.e., related to the community health and wellbeing resource) are considered to have a residual risk level of **Minor** to **Moderate**.

### **3.2.2. Vessel Strikes of Marine Mammals, Marine Turtles, or Riverine Mammals**

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.

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 higher concentrations of turtles in the shallow nearshore areas.

Riverine mammals likely to be present within the nearshore and riverine zone of the PDA 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 West Indian 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.

Most Project activities will take place in deep waters, and vessel speeds within the PDA will be low, reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/exiting shorebases, but even at the peak of drilling and installation, the incremental increase in traffic near shorebases will represent a small increase in overall risk to marine mammals and marine turtles. There is very little potential for collisions to occur within the PDA, but the potential remains for individual marine mammals or marine turtles to collide with vessels transiting between the PDA and shorebases. With respect to risk to marine turtles, the planned shorebases are all located more than 100 kilometers (62.1 miles) away from the nearest portion of the Shell Beach Protected Area, where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data).

With respect to riverine mammals, collision between a Project vessel and a West Indian 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. Very few manatees are expected to occur in the lower Demerara River, so vessel collision with a manatee, if it were to occur, would be very infrequent.

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, a vessel collision is considered to be **Moderate** for marine mammals and marine turtles and **Minor** for riverine mammals.

### **3.2.3. Discharge of Untreated Wastewater from FPSO**

The FPSO will be equipped with an onboard sewage treating system, which will treat black water prior to discharge overboard. While there will be a number of controls to prevent a discharge of untreated black water to the ocean, an upset to this treatment system lasting for an extended period could result in untreated black water being discharged overboard for a short period of time. While there are a number of controls that would prevent this scenario from occurring, modeling of the scenario was conducted to assess the risk associated with such an event. Modeling results show that the short-term release of untreated wastewater will result in a plume of limited extent, with dilution of almost 99.9 percent within 100 meters (approximately 328 feet) of the discharge point, yielding a residual risk rating of **Minor** for all potentially affected resources.

### **3.2.4. Seabird Collision with FPSO Flare Tower, Flame, or Radiant Heat Plume**

The FPSO will have a flare system for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine maintenance or repairs, or emergency shutdown events. Should flaring occur, the flame and radiant heat plume will emanate from a flare tower located on top of the FPSO. While individual seabirds could be significantly impacted through contact with the FPSO flare tower, its flame, or its radiant heat plume, the likelihood of a seabird colliding with the tower or being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. To date, marine bird surveys conducted on behalf of EEPGL since 2017 have not documented flocking birds in the Stabroek Block. While this does not preclude the possibility of a flock to occur, it is considered relatively rare and any such flocks would likely be small. Even during migration, most individuals are solitary or flying in loose groups (spread out spatially). Accordingly, in the circumstance that such an event occurred, it would likely only impact a single individual, yielding a risk rating of **Minor**.

### 3.2.5. Oil Spill

The Project will be producing, processing, storing, and offloading oil as its core activity, so the risk of an oil spill would be present. EEPGL has identified 15 spill scenarios, including spills of different types of hydrocarbons (e.g., crude oil, marine diesel, fuel oil, lubricating oil, NADF), with several being applicable for spills at the shorebases and on vessels in the Demerara River estuary (e.g., from a supply vessel) or in the Atlantic Ocean (e.g., from a well, drillship, supply vessel, tanker, FPSO). The largest of these scenarios considered a loss-of-well-control incident at the seafloor. For these scenarios, EEPGL worked with third-party specialists to model two worst-case discharge (WCD) scenarios for a loss-of-well-control event.

The WCD scenarios were developed based on a request from the DE regarding the Liza Phase 2 Project Development Plan. In accordance with the DE's request, EEPGL commissioned a third party to develop WCD calculations for the reservoirs to be developed as part of the Project in accordance with the U.S. Bureau of Safety and Environmental Enforcement's (BSEE's) guidelines published in the U.S. Department of Interior BSEE Worst Case Discharge Analysis (Volume I, February 2016). As stated in the BSEE guidelines document, although WCD modeling results "present an extremely dire representation of the potential for contact between the discharged oil and the environment, they do provide a working baseline of datum that will be useful for further analysis" (BSEE 2016).

The U.S. Bureau of Ocean Energy Management defines the WCD as the single highest daily flow rate of liquid hydrocarbon during an uncontrolled wellbore flow event (i.e., the average daily flow rate on the day that the highest rate occurs, under worst-case conditions). The WCD values represent an open well condition in which *no flow restrictions or well control technologies* such as blow out preventers are in operation. The WCD is neither the total volume spilled over the duration of the event, nor the maximum possible flow rate that would result from high-side reservoir parameters. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using expected reservoir properties. The main purpose of a WCD calculation is to support oil spill response planning. The duration of the WCD release is typically 30 days unless shutting in the well with a capping stack or other technology is expected to occur earlier.

The third-party specialist incorporated information for the six reservoirs to be developed as part of the Project into its WCD simulation program and calculated six reservoir-specific WCDs ranging from 25,151 to 202,192 barrels of oil per day (BOPD). In consultation with EEPGL's oil spill modeling contractor, EEPGL identified two WCD scenarios to model a potential Project well-control scenario with loss of containment. EEPGL's standard scenario for a loss-of-well-control event (20,000 BOPD, developed by EEPGL based on its worldwide experience conducting similar analysis) is very close to the lowest of the calculated WCD rates (and therefore would be expected to produce similar modeling results), so this scenario was modeled as the "Most Credible WCD." Additionally, the highest of the calculated WCD rates was modeled as the "Maximum WCD." Although modeling of the Maximum WCD scenario supports oil spill response planning, the scenario represents an operational condition that is highly unlikely to be encountered during drilling operations. In a more representative scenario, apart

from blowout preventers on the wellhead, there would be drill string, tubing, and/or other equipment that would be in the wellbore during a well-control event, which would partially constrain and restrict flow from the reservoir.

EEPGL's well-control philosophy is focused on blowout prevention using safety and risk management systems, management of change procedures, global standards, and trained experienced personnel. EEPGL has a mature program that emphasizes attention to safety, well control, and environmental protection. This includes proper preparation for wells (e.g., well design, well-control-equipment inspection and testing), detecting changes in pressure quickly, and efficiency in the process for temporary closing of a well (personnel training and proficiency drills).

In addition to these prevention measures, EEPGL also has developed a detailed Oil Spill Response Plan (OSRP) to ensure an effective response to an oil spill, if one were to occur. The OSRP identifies the organizations that would respond to a release event depending on the magnitude and complexity of the spill. The OSRP clearly delineates the responsibilities of each entity that would take part in a response and describes how EEPGL would mobilize both its own resources and those of its oil spill response contractors, as well as notifying the government of Guyana with respect to mobilizing its resources.

Due to the precautionary measures proposed by EEPGL to prevent and control an oil spill, as described above, the chance of an oil spill occurring is unlikely. Nevertheless, EEPGL has conducted oil spill modeling and coastal sensitivity mapping to identify and characterize the resources/receptors with the potential to be exposed to oil in the unlikely event of a spill. An overview of this modeling and mapping is provided below.

The spill modeling evaluated the range of possible trajectories and rate of travel of an oil slick from each of the two above-referenced loss-of-well-control scenarios. Several factors would inherently reduce the severity of an oil spill occurring in the PDA and would increase subsequent ecosystem recovery rates, including the following:

- **Location of Spill**—A Payara loss-of-well-control incident would occur approximately 207 kilometers (approximately 128 miles) offshore. It would take some time for oil to reach the Guyana shoreline, which allows time to implement the Project's OSRP, and also allows more time for evaporative and dispersive forces to act on the spilled material.
- **Prevailing Currents**—The Guiana Current is a strong, nearly year round westerly flowing current along the coast of Guyana. The SAT-OCEAN current model used in the oil spill modeling analysis is based on the Hybrid Coordinate Ocean Model that includes three-dimensional current speeds in a 4°×4° grid over the Stabroek Block region (56°-60°W, 7°-11°N). The horizontal resolution of the model is 1/64°, and the model defines current speed and direction on 64 vertical layers through the water column. The time series data set defines three-dimensional currents at a 3-hour interval for the 10 years between 2005 and 2014. The data from the SAT-OCEAN current model were calibrated by current data measured at a location offshore Guyana (8.08°N, 56.95°W) during 2015. Considering the extent of the historical record and calibration with measured data, these data are

appropriately representative of the region and are expected to capture expected variability in the current forcing. Modeling indicates that this current significantly reduces the probability of spilled oil reaching the coast of Guyana; however, this effect also increases the probability of an oil spill impacting the coastal zones of nearby countries to the north and west.

- **Properties of Spilled Oil**—The Project will be producing a medium crude oil. Medium crude oils exhibit greater evaporation and lower emulsification, and are less persistent in the environment than heavy crude oils. These qualities make the oil readily amenable to oil spill response strategies such as chemical dispersion and in-situ burning, which are appropriate and highly effective in this offshore environment. This medium crude is also amenable to more traditional oil spill response strategies such as mechanical booming and recovery.
- **Climate**—The relatively warm year-round waters of the AOI would keep any spilled oil less viscous, which helps clean-up operations such as skimming and pumping.

The modeling predicted that surface oil would generally travel towards the northwest in all scenarios during both the Jun–Nov and Dec–May seasons. A type of modeling known as stochastic modeling was performed for a number of spill scenarios. Stochastic modeling accounts for the variability in conditions such as winds and ocean currents by simulating hundreds of individual spills (theoretically occurring at different times and under different wind/current conditions) and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path that a spill would follow. Stochastic modeling of an unmitigated subsea release of crude oil from a loss-of-well-control event indicates that even in the unlikely event of an oil spill, there is only a 5 to 20 percent chance of shoreline oiling in Guyana. It is important to note that this stochastic modeling does not account for any oil spill response (e.g., aerial, vessel, or subsea dispersant application; offshore containment and recovery; source control operations), so any preventative measures taken to keep oil from reaching the coast during a response would further reduce the potential of shoreline oiling in Guyana below the estimated 5 to 20 percent.

In addition to the low probability of oil reaching the Guyana shoreline (even in the absence of any spill response), stochastic modeling indicates it would take 5 to 30 days (depending on WCD scenario and actual wind and current conditions) for oil to reach the Guyana shoreline. This would allow ample time for mobilization of spill response resources to further reduce the risk of oil actually reaching the shoreline. Despite this, if oil were to reach the Guyana shoreline, those resources most at risk would include protected areas (i.e., Shell Beach), coastal habitats (especially mangroves and marshes), and coastal wildlife (especially birds), as well as coastal communities and indigenous peoples dependent on fishing in the ocean and other ecosystem services (Table EIS-4).

To assess the potential magnitude of impacts in the unlikely event of an oil spill, the 95<sup>th</sup> percentile spill event for shoreline stranding by oil with a thickness greater than 1 micrometer was selected from each stochastic scenario in the Jun–Nov and Dec–May seasons, and deterministic modeling was conducted for each of these scenarios. This deterministic modeling resulted in a prediction of the sea surface area swept by oil and the length of shoreline oiled with a thickness greater than 1 micrometer, assuming no implementation of response

measures. For the four (unmitigated) loss-of-well-control event spill scenarios (Jun–Nov and Dec–May for each of the two WCDs), deterministic modeling of an unmitigated spill predicts no shoreline oiling in Guyana for any of the modeled scenarios.

To aid in preparing to respond to the unlikely event of an oil spill, coastal sensitivity maps were prepared for the entire Guyana coastline, and the coastlines of 11 other countries for which modeling indicates a potential risk of shoreline oiling due to an unmitigated release. To provide additional detail to these maps, ecosystem services mapping was conducted for Regions 1–6. In Region 1, the only Guyana region that could be directly affected by a spill resulting from an unmitigated loss-of-well-control event, provisioning services (focused on fishing, agriculture, hunting, and traditional resource use) and regulating services (associated with mangroves’ role in stabilizing and protecting the coast) were key ecosystem services identified and field-verified.

The combination of the low probability of an oil spill actually reaching the Guyana shoreline and the time available to allow for spill response results in the residual risk to coastal resources being considered **Minor** (Table EIS-4). If an oil spill were to reach the coast during the migratory or breeding season for coastal birds or the mudflats that these species use to feed, the impacts could be significant. The ecosystem services component of the coastal sensitivity mapping also highlighted the role that the coastal habitats within the Shell Beach Protected Area play in sustaining marine fisheries on the western Guyana continental shelf, and the importance of ecosystem services to sustaining the coastal communities along the entire coast, and particularly in the Amerindian communities of Region 1.

**Table EIS-4: Coastal Resources Potentially Impacted by an Oil Spill**

Resource	Potential Impact	Residual Risk Rating
Protected Areas	Shell Beach Protected Area and its vicinity could be impacted if oil were to reach the Guyana shoreline.	Minor
Coastal Habitats and Coastal Wildlife (including Special Status Species)	Mangroves, wetlands, and mudflats are common habitats along the Guyana coastline that support many wildlife species, particularly coastal birds. These habitats and species are sensitive to oil contamination.	Minor
Ecosystem Services, Coastal Communities and Indigenous Peoples	Many rural coastal communities, and especially Indigenous communities, rely on many ecosystem services (e.g., for food, housing materials, medicinal plants, income producing products, flood protection) for sustenance and livelihoods.	Minor

Even though the probability of a spill impacting the coastal resources of Guyana is very low, such an oil spill would likely have adverse impacts on marine resources in the area impacted by the spill. Those resources most at risk would be marine water quality, seabirds, marine mammals, and marine turtles, as described in Table EIS-5. Although effective implementation of the OSRP would help mitigate this risk by further reducing the ocean surface area impacted by a spill and oil exposure to these species, the residual risk to all of these resources aside from marine mammals and seabirds as a whole is considered **Moderate**. In the case of Leach’s Storm-Petrel, the offshore PDA is a migratory corridor for a relatively large number of this species. Accordingly, the residual risk to Leach’s Storm-Petrel from an oil spill is considered **Moderate**.

**Table EIS-5: Marine Resources Potentially Impacted by an Oil Spill**

Resource	Potential Impact	Residual Risk Rating
Marine Water Quality	Dissolution of some spilled oil into the water column, but light oil expected to degrade quickly and the impacts are reversible.	Moderate
Seabirds (Non-special Status Species)	Seabirds are typically among the species most impacted by an oil spill because they spend significant time on the water surface and so may come in contact with the spilled oil, but seabirds are primarily transient in the PDA.	Minor <sup>a</sup>
Leach’s Storm-Petrel (Special Status Species)	The nature of the impact on Leach’s Storm Petrel ( <i>Oceanodroma leucorhoa</i> ) is the same as for (nonspecial status) seabirds as a whole. However, the residual risk rating for this species is considered <b>Moderate</b> based on the results of the marine bird post-permit study, which documented the importance of the offshore zone as a migratory corridor for this particular species.	Moderate
Marine Mammals	Ingestion and respiratory irritation from inhalation of vapors at the water surface, and the potential for fouling of baleen whale plates, which are used to feed.	Minor
Marine Turtles	Dermal irritation from contact with oil, ingestion, and respiratory irritation from inhalation of vapors at the water surface.	Moderate

<sup>a</sup> Excludes Leach’s Storm-Petrel, which is discussed separately

### 3.3. TRANSBOUNDARY IMPACTS

Oil spill modeling indicates that transboundary impacts could potentially occur for the three largest spill scenarios considered (2,500-barrel FPSO offloading spill and the two loss-of-well-control scenarios), assuming no mitigation measures were implemented. The modeling results for these scenarios indicate there is the potential for an unmitigated oil spill to reach three main geographic regions:

- Trinidad and Tobago, the northern South American coast, and the so called “ABC Islands” (Aruba, Bonaire, and Curaçao);
- The southern Lesser Antilles; and
- The Greater Antilles.

An unmitigated oil spill from a loss-of-well-control event during the Dec-May season would take a west-northwesterly route through the Gulf of Paria and across the southern edge of the Caribbean Sea. Comparatively strong easterly winds in the Dec–May season would expose the northern coast of South America and the southern Lesser Antilles to the bulk of shoreline oiling risk. An equivalent spill during the Jun–Nov season would be exposed to lower wind speeds, allowing the surface plume to be transported to the north of Trinidad and Tobago and swept into the Caribbean Sea. The plume would track slightly more to the north, across the central Caribbean Sea and the central and southern portions of the Lesser Antilles, to the Greater Antilles.

Mitigated oil spills from each of the two loss-of-well-control scenarios would have the potential to reach all three of the above regions as well, but the extent of shoreline oiling associated with mitigated spills would typically be reduced relative to the corresponding unmitigated spill.

### **3.3.1. Trinidad and Tobago and the Northern South American Coast, including Aruba, Bonaire, and Curaçao**

Due to its location at the southern end of the Lesser Antilles, Trinidad and Tobago is the only island country that would have the potential to be affected by the transboundary effects of any unmitigated loss-of-well-control event, regardless of season. The probability of oiling at least a portion of the coast of Trinidad and Tobago and/or its coastal waters is approximately 90 to 100 percent for any of the unmitigated loss-of-well-control event scenarios. With the exception of the Gulf of Venezuela, stochastic modeling indicates a 5 to 60 percent probability of surface oil reaching the Venezuelan coastal zone, depending on location and season. Deterministic modeling suggests the Maximum WCD loss-of-well-control scenario would pose oiling risks to the Venezuelan mainland in the Dec–May season, but only to Isla La Blanquilla in the Jun–Nov season.

Similar to Venezuela, deterministic modeling suggests that both unmitigated loss-of-well-control scenarios would result in oiling of the west coast of Bonaire in the Dec–May season. The only unmitigated loss-of-well-control scenario that would pose a risk of shoreline oiling in Bonaire in the Jun–Nov season would be the Most Credible WCD Case scenario. Much of Aruba’s and Curaçao’s east coasts would be at risk of oiling under both loss-of-well-control scenarios in the Dec–May season. There would be no risk of coastal oiling in either country during the Jun–Nov season under either of the scenarios. The only portion of Colombia that could be affected by an unmitigated loss-of-well-control event would be the northeastern portion of the La Guajira Peninsula, which is a very remote area at the extreme northern tip of the country. Deterministic model results suggest oiling risks under both loss-of-well-control scenarios in the Dec–May season.

Venezuela has numerous marine turtle nesting beaches, mangroves, important bird areas, coral reefs, and shallow coastal lagoons that would be at risk of oiling. The highest concentrations of most of these resources occurs in the Orinoco Delta in the eastern portion of country, although the corals and seagrasses tend to be more abundant surrounding offshore islands in the western portion of the country. The same types of resources tend to be found on Aruba, Bonaire, and Curaçao or their adjacent marine territories. Numerous fishing areas are located east of Trinidad and could be impacted by a large unmitigated spill from a loss-of-well-control event. The economies of Aruba, Bonaire, and Curaçao are dependent on tourism to varying degrees but especially so in Bonaire, which is known internationally as a destination for recreational diving. The economic effects of an oil spill on these countries would depend to a large degree on the extent to which these industries would be affected, and how rapidly they would recover.

### **3.3.2. Southern Lesser Antilles**

The only Lesser Antillean countries north of Tobago that would be at risk of oil coming ashore from a loss-of-well-control event are Grenada and St. Vincent and the Grenadines. These countries would only be at risk of shoreline oiling under the Maximum WCD scenario for both the Jun–Nov and Dec–May seasons. The probability of nearshore waters in the southern Lesser Antillean region north of Tobago being affected by a spill under the Maximum WCD scenario varies widely according to location, season, and volume, from an 80 to 90 percent probability along the southern coast of Grenada in the Jun–Nov season to a 5 to 10 percent probability near Dominica in both seasons.

### **3.3.3. Greater Antilles**

The Greater Antilles would be exposed to the greatest risk of shoreline oiling during the Jun–Nov season, when comparatively weak trade winds would allow an oil plume to track further north than at other times of the year. A Most Credible WCD spill would not be expected to reach the Greater Antilles at any time of year, but an unmitigated Maximum WCD spill would be predicted to reach the coasts of the Dominican Republic, Haiti, and Jamaica in the Jun–Nov season.

The portion of the Greater Antilles that could be affected by an unmitigated oil spill is notable for the number of protected areas it contains. These include:

- The Arrecifes de Suroeste (Southwest Reefs) Marine Sanctuary and Scientific Reserve in the Dominican Republic, which is an array of coral reefs and seagrass meadows located along the coast and is purported to support the West Indian manatee, dolphins, and other marine mammals;
- Jaragua National Park in the Dominican Republic, which has terrestrial and marine components and has cultural significance due its numerous caverns that contain pictograms and petroglyphs from the Taino culture, as well as other pre-Columbian archaeological sites. The park is reported to support 130 bird species (10 of them are endemic), solenodons and hutias, as well as West Indian manatees and bottlenose dolphins;
- The Portland Bight Protected Area (PBPA), which is the largest protected area in Jamaica. Its terrestrial area is 520 square kilometers (201 square miles) in the southern sections of St. Catherine and Clarendon parishes, including the coastline from east of Hellshire to almost Milk River in the west. It includes contiguous coastal land and the marine area out to the 200-meter (656-foot) depth contour (1 nautical mile, or approximately 20 kilometers [12.4 miles] south of Portland Point). It is a Ramsar wetland site, contains sandy beaches and cays which support nesting marine turtles, nesting seabirds), nearshore islands which support endemic lizards, and mangroves. Benthic marine resources in the PBPA include seagrass and coral reefs;

- The Black River Lower Morass, another wetland Ramsar site located approximately 15 kilometers (9 miles) west of the PBPA and Jamaica's largest wetland. It supports the IUCN-listed American crocodile (Vulnerable) and is listed as an IBA by Birdlife International; and

### **3.3.4. Impacts of International Importance**

In addition to the country-specific impacts listed above, seabirds would have the potential to be affected at a regional scale. Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. There are 49 Marine IBAs of global or regional importance to seabirds that lie within the swept zone of a Maximum WCD unmitigated loss-of-well-control scenario (considering both seasons together). These sites contain regionally or globally important breeding and foraging sites for numerous species of seabirds, including species with elevated conservation status (i.e., IUCN listing status of Vulnerable or higher). Two of these 49 Marine IBAs that are located along the southern coastline of Hispaniola (Haiti and the Dominican Republic) are particularly significant as they support the world's only known breeding sites for Black-capped Petrel (*Pterodroma hasitata*) (IUCN Endangered).

### **3.3.5. Mitigation of Transboundary Impacts**

The unmitigated oil spill modeling used to characterize potential transboundary impacts did not take into consideration any emergency response actions. Implementation of the OSRP would help to significantly reduce potential transboundary impacts just as it would reduce impacts within the Guyana Exclusive Economic Zone, as demonstrated by oil spill modeling that considers OSRP implementation (i.e., mitigated scenarios). In particular, EEPGL has put in place an interim solution that will facilitate installation of a capping stack on well location within 9 days in certain circumstances (e.g., where there is no debris that prevents or delays installation of the capping stack). Mitigated scenario modeling demonstrates that this, in combination with other response measures (e.g., dispersant application), would significantly reduce the extent of transboundary impacts. In any case, EEPGL will work with representatives of the respective countries that could be potentially impacted by a large oil spill to be prepared for the unlikely event of a spill by:

- Coordinating operations and communications between different command posts;
- Creating a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues;
- Identifying places of refuge in the impacted region where response vessels could go for repairs and assistance;
- Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions;

- Determining financial liability and establishing claims and/or livelihood remediation processes during a response to a transboundary event; and
- Working with local communities within the impacted areas to raise awareness of oil spill planning and preparations.

### **3.4. CUMULATIVE IMPACTS**

The Project's expected contribution to cumulative impacts will be limited by its distance offshore, by the distance between EEPGL projects/activities, and by the small number of non-EEPGL projects or activities either operating or currently planned to be operating offshore Guyana. There are other offshore Guyana oil and gas exploration and development activities planned by EEPGL, including the approved Liza Phase 1 Development and Liza Phase 2 Development projects, continued exploration drilling, two other future planned development projects in the Stabroek Block (assumed to be south or southeast of the Payara Project FPSO), a fiber optic cable installation project, and the Gas-to-Shore Project - a project which is expected to transport associated gas from the Liza Phase 1 PDA to shore for creation of natural gas liquids and natural gas power production (gas from the Payara Project is currently not planned to be transported to shore as part of the Gas-to-Shore Project). Additionally, there is a limited number of non-oil and gas related projects proposed by others that could potentially impact the same types of resources that could be impacted by the Project. Three other oil and gas operators are planning exploration programs in blocks adjacent to the Stabroek Block, but the current schedules for these efforts and their locations are such that they would not be expected to overlap in time or geographically with Project activities.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as climate (via increased emissions of GHGs), marine water quality (via discharge of drill cuttings and associated increases in TSS concentrations), special status fish (via changes in distribution due to altered water quality), special status seabirds (via attraction to offshore facilities or disturbance from Project activities), marine mammals (via vessel strikes or potential disturbance from underwater sound), marine turtles (via vessel strikes), marine fish (via degraded water quality), community health and wellbeing (via increased demand on limited medical treatment capacity), marine use and transportation (via additional marine congestion, especially near Georgetown Harbour), employment and livelihoods (via interference with artisanal fishing activities), social infrastructure and services (via increased demand for limited housing and lodging), and waste management infrastructure capacity (via increased burden on waste treatment or disposal facilities in Georgetown). Many of the above potential impacts that require offshore interaction between the Project and others to result in a cumulative impact have a limited chance of occurring, given the size of the Stabroek Block.

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 Payara Project) be implemented. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, it is recommended that EEPGL take measures, where feasible and practicable, to share logistical resources between development projects—to reduce the number of additional vessel movements associated with additional projects. This approach would be expected to be sufficient to address contributions of the Project and other EEPGL projects/activities to cumulative impacts on marine mammals. Regarding climate, EEPGL has developed a flare minimization plan for its operations in Guyana, as well as committing to continue measuring and reporting its GHG contributions to national emissions. It is recommended that EEPGL continue to assess measures that can be taken to minimize GHG emissions during each Project's production operations stage, and ensure that a Best Available Technology assessment process (i.e., as conducted for the Payara Project) be undertaken to assess the feasible and appropriate embedded controls and mitigation measures that can be implemented to reduce GHG emissions. In the case of waste management infrastructure capacity, the mitigation measures already initiated by EEPGL represent appropriate collaborative efforts with industry and government to manage the cumulative impacts on this resource.

### **3.5. DEGREE OF IRREVERSIBLE DAMAGE**

The planned Project would not cause irreversible damage to any onshore areas of Guyana. There would be a very minor (approximately 0.8 km<sup>2</sup> [0.3 mi<sup>2</sup>]) permanent loss of benthic habitat offshore as a result of the installation of wells, flowlines, and other subsea equipment, 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. Even in the unlikely event of a large marine oil spill, little irreversible damage would be expected, although it could take a decade or more for all resources to fully recover, depending on the volume and duration of the release, as well as the time of year at which the release were to occur.

### **3.6. ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN**

An ESMP has been developed to manage and mitigate the impacts identified in the EIA. The ESMP includes the following:

- ESMP Framework
- Environmental Management Plan, including:
  - Air Quality Management
  - Water Quality Management
  - Marine Ecosystems Management
- Socioeconomic Management Plan, including:
  - Stakeholder Engagement Plan
  - Grievance Management
  - Marine Transportation Management
  - Road Transportation Management
  - Cultural Heritage Management and Chance Finds

- Environmental and Socioeconomic Monitoring Plan
- Emergency Response Plan Summary
- Oil Spill Response Plan, including:
  - Oil Spill Modeling
  - Net Environmental Benefit Analysis
  - Emergency Preparedness and Response Procedures
  - Wildlife Response Plan
  - Geographic Strategic Response Maps
- Waste Management Plan
- Preliminary End of Operations Decommissioning Plan

## 4. CONCLUSIONS AND RECOMMENDATIONS

### 4.1. CONCLUSIONS

The planned Project activities are predicted to have **Negligible** to **Moderate** residual impacts on physical resources (i.e., air quality and climate, marine geology and sediments, marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** residual impacts on marine biological resources, and **Negligible** to **Minor** residual impacts on socioeconomic resources—with largely positive impacts on socioeconomic conditions. These predictions are due to the fact that the bulk of the Project will occur approximately 207 kilometers (approximately 128 miles) offshore; and the Project will capture and re-inject recovered natural gas (the portion that is not used as fuel on the FPSO) into the reservoir, treat all wastewater streams as required prior to discharge to the sea, have a very small physical footprint (e.g., installation of infrastructure will only physically disturb about 0.8 km<sup>2</sup> (0.3 mi<sup>2</sup>) of benthic habitat), and use Marine Mammal Observers and “soft starts” during VSP and pile driving operations to reduce the potential for auditory damage to marine animals. The Project will generate benefits for the citizens of Guyana through revenue sharing with the Government of Guyana, a minor increase in employment and select Project purchasing from Guyanese businesses.

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL; nevertheless, an oil spill is considered possible. The types of resources that would potentially be impacted and the extent of the impacts on those resources would depend on the volume and duration of the release, as well as the time of year at which the release were to occur, but impacts would tend to be most significant for a well-control event with loss of containment during the drilling stage. EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel. The location of the Project 207 kilometers (approximately 128 miles) offshore, prevailing northwest currents, the medium nature of the Payara field crude oil, and the region’s warm waters would all help reduce the severity of a spill. Accounting for these factors, modeling of an unmitigated subsea release of crude oil from an unmitigated loss-of-well-control event indicates only a 5 to 20 percent

probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response, and in the unlikely event that a spill were even to occur.

Although the probability of an oil spill reaching the Guyana coast is very small, an unmitigated subsea release of crude oil from a loss-of-well-control event at a Payara well would likely impact any marine resources found near the well—which could include marine turtles and certain marine mammals (especially baleen whales) that may transit or inhabit the area impacted by a spill, as well as marine water quality. Other physical and biological resources such as air quality, seabirds, marine fish, and marine benthos could also be impacted, although likely to a lesser extent because the duration of acute impacts would not be long and the impacts are reversible. A spill could potentially impact Guyanese fisherfolk if commercial fish and shrimp resources were impacted. The magnitude of this impact 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 these resources are more abundant in the PDA). Effective implementation of the OSRP would reduce this risk by reducing the ocean surface area impacted by a spill and thereby reducing the exposure of these resources to oil.

Additional unplanned events, also considered unlikely to occur because of the preventative measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, riverine mammals, or rafting seabirds; collisions between Project vehicles and non-Project vehicles; and a release of untreated wastewater from the FPSO. The extent of the impacts 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 has or will put in place (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 a Road Safety Management Procedure) would also serve to reduce the likely extent of impact, were such an event to occur.

Table EIS-6 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., development well drilling and SURF/FPSO installation, production operations, and decommissioning). For each resource, the table shows the highest residual impact significance rating among the potential impacts relevant to each Project stage. The table also summarizes, for each resource, the highest residual risk rating for potential risks to resources from unplanned events (e.g., oil spill, vessel strike, etc.) and the priority rating for potential cumulative impacts on each resource, as determined by the cumulative impact assessment.

**Table EIS-6: 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
	Drilling and Installation	Production Operations	Decommissioning		
Air Quality	Negligible	Negligible	Negligible	Minor	NA
Climate	Negligible	Moderate	Negligible	Minor	Medium
Sound <sup>a</sup>	None	None	None	None	None
Marine Geology and Sediments	Negligible	None	None	Minor	NA
Marine Water Quality	Minor	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Minor	NA
Special Status Species: <sup>b</sup>					
• Critically Endangered and terrestrial species	Negligible	Negligible	Negligible	Minor	Low
• Vulnerable/Near Threatened fish species	Minor	Minor	Negligible	Minor	Low
• Endangered fish and Endangered black-capped petrel ( <i>Pterodroma hasitata</i> )	Negligible	Minor <sup>d</sup>	Negligible	Minor	Low
• Vulnerable Leach's storm-petrel ( <i>Oceanodroma leucorhoa</i> )	Negligible	Minor <sup>d</sup>	Negligible	Moderate <sup>c</sup>	Low
Coastal Habitats	None	None	None	Minor	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds <sup>c</sup>	Negligible	Minor	Negligible	Minor	NA
Marine Mammals	Moderate	Minor	Negligible	Moderate	Medium
Riverine Mammals	Minor	Minor	Minor	Minor	Low
Marine Turtles	Negligible	Negligible	Negligible	Moderate	Low
Marine Fish <sup>f</sup>	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Minor	Positive	Positive	Minor	Low
Ecological Balance and Ecosystems	Negligible	Minor	Negligible	Minor	Low
Socioeconomic Conditions	Positive	Positive	Positive	Minor	NA
Employment and Livelihoods	Positive	Positive	Positive	Minor	Low
Community Health and Wellbeing	Minor	Minor	Minor	Minor to Moderate	Low
Marine Use and Transportation:					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Low
• Commercial fishing	Minor	Minor	Minor	Minor	Low
• Subsistence fishing	Minor	Minor	Minor	Minor	Low
Social Infrastructure and Services:					
• Lodging	Minor	Negligible	Negligible	Minor	Low
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
• Ground and air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management Infrastructure Capacity	Minor	Minor	Minor	Minor	Medium
Cultural Heritage	Negligible	None	None	Minor	NA
Land Use	Negligible	Negligible	Negligible	Minor	NA
Ecosystem Services	None	None	None	Minor	NA
Indigenous Peoples	None	None	None	Minor	NA

NA = Not assessed in cumulative impact assessment; scoped out as potentially eligible (see EIA Chapter 10, Cumulative Impact Assessment)

<sup>a</sup> Potential underwater sound-related impacts on marine mammals, marine turtles, and marine fish are assessed in the resource-specific sections for those resources.

<sup>b</sup> Excludes listed marine turtles, which are covered in the Marine Turtles resource category.

<sup>c</sup> Excludes listed seabirds, which are covered in the Special Status Species resource category.

<sup>d</sup> Based on the 20-year presence of the FPSO (as a lighted attractant), the potential impact significance to special status marine birds during the production operations stage is considered Minor.

<sup>e</sup> The residual risk rating for Leach’s Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017, 2018, and 2019, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.

<sup>f</sup> Excludes listed marine fish, which are covered in the Special Status Species resource category

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

- Through revenue sharing with the Government of Guyana, as detailed in the Petroleum Agreement between the Government of Guyana and EEPGL et al., which was made available to the public in December 2017. The type and extent of benefits associated with revenue sharing will depend on how decision makers in government decide to prioritize and allocate funding for future programs, which is unknown to EEPGL and outside the scope of the EIA.
- By procuring select Project goods and services from Guyanese businesses in alignment with the Petroleum Agreement and the EEPGL Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals in alignment with the Petroleum Agreement and the EEPGL Local Content Plan.

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 (at least 20 years).

## 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 Authorisation for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see EIA Chapter 13).
- Mitigation Measures—adopt the recommended mitigation measures (see EIA Chapter 13).
- Management Plans—implement the proposed Environmental and Socioeconomic Management Plan 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 large spill that affects the Guyana coastline and/or other regional coastlines is unlikely. But given the sensitivity of many of the resources that could potentially be impacted by a spill (e.g., Shell Beach Protected Area; marine mammals; critically endangered, endangered, and vulnerable marine turtles; and Amerindian, fishing, and other communities reliant on ecosystem services for sustenance and their livelihood), 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 on board the FPSO, 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 Payara Development Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

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