Environmental Impact Assessment

Liza Phase 2 Development Project

Esso Exploration and Production Guyana Limited

Volume I

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Acronym	Definition
°	degree
%	percent
%BFROC	percentage of base fluid retained on cuttings
°C	degrees Celsius
°F	degrees Fahrenheit
µg/g	micrograms per gram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
µmol/kg	micromoles per kilogram
µPa	micro pascal
AASM	Airgun Array Source Model
ADCP	Acoustic Doppler Current Profiler
AIDS	acquired immunodeficiency syndrome
AOI	Area of Influence
AUV	automated underwater vehicle
bbl	barrel(s)
BDL	below detection limit
BOEM	U.S. Bureau of Ocean Energy Management
BOP	blowout preventer
BOPD	barrels of oil per day
BPD	barrels per day
CARICOM	Caribbean Community
CARITRANS	Caribbean Transportation Consultancy Services Company Limited
CCR	central control room
CDC	Community Development Council
CGM	Community Grievance Mechanism
CIA	cumulative impact assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CJIA	Cheddi Jagan International Airport
cm	centimeter
cm/s	centimeter per second
CO	carbon monoxide
COD	chemical oxygen demand
Consultants	Environmental Resources Management (ERM), Environmental Management Consultants (EMC), and Ground Structures Engineering Consultants Ltd. (GSEC)
CPI	Carbon preference index

Acronym	Definition
CR	Critically Endangered (IUCN)
CTD	conductivity, temperature, and depth
dB	decibel
DD	Data Deficient
DP	Dynamic Positioning
DWBC	Deep Western Boundary Current
EAB	Environmental Assessment Board
EBS	environmental baseline survey
ECIA	Eugene F. Correira International Airport
eDNA	environmental DNA
EEPGL	Esso Exploration and Production Guyana Limited
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EITI	Extractive Industries Transparency Initiative
EMC	Environmental Management Consultants
EN	Endangered (IUCN)
EPA	Guyana Environmental Protection Agency
ERL	Effect Range Low
ERM	Environmental Resources Management
ESMP	Environmental and Socioeconomic Management Plan
ESS	ecosystem services
EUNIS	European Nature Information System
FLET	flowline end termination
FPSO	Floating Production, Storage, and Offloading (vessel)
FSO	Floating Storage and Offloading (vessel)
Fugro	Fugro Marine Geoservices, Inc.
FWRAM	Full Waveform Range-dependent Acoustic Model
g/m^2	grams per square meter
gal	gallon
GDP	gross domestic product
GEA	Guyana Energy Agency
GEMSS	Generalized Environmental Modeling System for Surfacewaters
GGMC	Guyana Geology and Mines Commission

Acronym	Definition
GHG	greenhouse gas
GHP	Global Health Practice
GI	gas [re]injection
GMPHOM	Guide to Manufacturing and Purchasing Hoses for Offshore Moorings
GSEC	Ground Structures Engineering Consultants Ltd.
GWI	Guyana Water Inc.
GYD	Guyanese dollar
H_2S	hydrogen sulfide
Handbook	Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets
HIV	human immunodeficiency virus
HP	high pressure
Hz	hertz
IBA	Important Bird Area
IBH	Important Bird Habitat
ICSS	Integrated Control and Safety System
ICZM	Integrated Coastal Zone Management
IDB	Inter-American Development Bank
IFC	International Finance Corporation
ILO	International Labour Organization
IMO	International Maritime Organization
IOGP	International Oil and Gas Producers
IP	intermediate pressure
ITCZ	Inter-Tropical Convergence Zone
IUCN	International Union for Conservation of Nature
JNCC	Joint Nature Conservation Committee
kg	kilogram
kHz	kilohertz
km	kilometer
km^2	square kilometer
LADCP	Lowered Acoustic Doppler Current Profiler
lb	pound
LC	Least Concern (IUCN)
LCDS	Low Carbon Development Strategy
LFC	Low-frequency cetacean
LME	Large Marine Ecosystem
LOS	Level of Service
LP	low pressure
m	meter
m^2	square meter

Acronym	Definition
m^3	cubic meter
MARAD	Maritime Administration Department
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
MFC	Mid-frequency cetaceans
mg/L	milligrams per liter
mi^2	square miles
MICS	Multiple Indicator Cluster Survey
mm	millimeter
MMO	Marine Mammal Observer
MMscfd	million standard cubic feet per day
MOC	North Atlantic Meridional Overturning Circulation
MONM	Marine Operations Noise Model
MoNRE	Ministry of Natural Resources and Environment
NA	not applicable
NABF	non-aqueous base fluid
NADF	non-aqueous drilling fluid
NBC	North Brazil Current
ND	no data
NDC	Neighbourhood Democratic Councils
NDS	National Development Strategy
NEAP	National Environmental Action Plan
NEBA	Net Environmental Benefit Analysis
NECC	North Equatorial Counter Current
ng/L	nanograms per liter
NGO	non-governmental organization
NO_2	nitrogen dioxide
NOAA	U.S. National Oceanic and Atmospheric Administration
NORM	naturally occurring radioactive material
NOx	nitrogen oxides
NPD	naphthalene, phenanthrene, anthracene, and dibenzothiophene
NR	not rated
NS	not sampled
NT	Near Threatened (IUCN)
NV	no value
NW-NNW	northwest-north-northwest
OCIMF	Oil Companies International Marine Forum
OIMS	Operations Integrity Management System
OSRP	Oil Spill Response Plan
OUT	operational taxonomic unit
PA	Petroleum Agreement

Acronym	Definition
PAC	Project-Affected Communities
PAH	polycyclic aromatic hydrocarbons
PC	Project Contribution
PCS	Process Control System
PDA	Project Development Area
PEC	Predicted Environmental Concentration
$PM_{2.5}$	particulate matter with aerodynamic diameter of less than 2.5 micrometers
PM_{10}	particulate matter with an aerodynamic diameter of less than 10 micrometers
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
Pr/Ph Ratio	Ratio of pristane to phytane
Project	Liza Phase 2 Development Project
PS	Performance Standard
PSC	Private Sector Commission
PTS	Permanent Threshold Shift
R95%	Maximum distance from the source at which the given sound threshold is predicted in the modeled maximum-over-depth sound field over all azimuths, after the 5 percent of the threshold-exceeding area farthest from the source is excluded
R_{max}	maximum distance from the source at which the given sound threshold is predicted in the modeled maximum-over-depth sound field over all azimuths
RDC	Regional Democratic Council
RMS	root mean square
ROV	remotely operated vehicle
s	second
SBPA	Shell Beach Protected Area
SDU	Subsea Distribution Unit
SEL	sound exposure level
SEL_{24h}	24-hour sound exposure level
SEP	Stakeholder Engagement Plan
SGSCS	Suriname-Guyana Submarine Cable System
SHC	saturated and aliphatic hydrocarbons
SIS	Safety Instrumented System
SO_2	sulfur dioxide
SOLAS	International Convention for the Safety of Life at Sea
SPL	sound pressure level
SRU	Sulfate Removal Unit
SSHE	Safety, Security, Health, and Environment
SSS	side-scan sonar
SURF	Subsea, Umbilicals, Risers, and Flowlines
SWF	Sovereign Wealth Fund
TB	tuberculosis
TC	Town Council
TDS	total dissolved solids
THC	total hydrocarbons
TOC	total organic carbon
ToR	Terms of Reference
TSS	total suspended solids
UCM	Unresolved complex mixture
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	U.S. dollars
USEPA	U.S. Environmental Protection Agency
USOS	Upper Slope and Outer Shelf
VEC	Valued Environmental and Social Component
VIR	Vertical Infrared Thermal Unit
VOC	volatile organic compounds
VSP	Vertical Seismic Profile
VU	Vulnerable (IUCN)
WBDF	water-based drilling fluids
WHO	World Health Organization
WI	water injection
WMP	Waste Management Plan

GLOSSARY

Term	Definition
anthropogenic	Made by humans or attributable to human activity.
barrel	The basic unit for measuring volume of oil or other liquids in the oil and gas industry. A barrel is equal to 42 U.S. gallons.
biogenic	Made by living organisms or attributable to the activity of living organisms.
biomagnification	Increasing concentration of a persistent substance, usually a pollutant or toxin, in the tissues of organisms at successively higher levels in a food chain.
borehole (or wellbore)	A deep hole drilled in the earth for the purpose of extracting a core, releasing gas, oil, water, etc.
casing	Steel pipe inserted into an oil or gas well to prevent the wall of the borehole from caving in, to prevent movement of fluids from one formation to another, and to improve the efficiency of extracting petroleum (for producing wells).
circumtropical	Distributed throughout the world's tropical latitudes.
congregatory	Tending to gather in large groups on a cyclical or otherwise regular and/or predictable basis.
crude oil	Liquid petroleum as it comes out of the ground. The properties of crude oil, such as color, gravity, and viscosity, can vary.
cumulative impact	Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to effects from other existing, planned, and/or reasonably certain actions, projects, or activities.
cuttings (or drill cuttings)	Broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil. Cuttings are usually carried to the surface by the drilling fluid circulating up from the drill bit, and can be separated from the drilling fluid using a variety of treatment methods (e.g., centrifuge).
development well	A well drilled in a proven area in a field for the purposes of producing hydrocarbons.
drill center	Defined as a group of wells (including production, water injection, and/or gas re-injection wells) clustered around one or more manifolds. Each drill center incorporates separate manifolds that are designed for production or injection.
drill ship	A self-propelled floating offshore drilling unit that is a ship constructed to allow a well to be drilled from it. Drill ships are generally the preferred option for drilling wells in deep, remote waters.
drilling fluids	Specially formulated fluids that are typically a mixture of barite, clay, water, and other chemical additives. Drilling fluids are circulated into the borehole to lubricate and cool the rotary drill bit, to lift the cuttings out of the borehole and to the surface, and to help maintain well control.
ecosystem services	The benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment.
embedded control	Physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.
eutrophication	Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae.

Term	Definition
exploration	A term in the oil and gas industry referring to activities related to the search for oil and gas resources. Exploration operations can include aerial surveys, geophysical surveys, geological studies, core testing, and the drilling of test wells.
flare (or flaring)	In the oil and gas industry, a system of piping and burners used to dispose (by burning) of surplus gas or vapors produced with the oil and gas.
Floating Production Storage and Offloading (FPSO) vessel	A floating vessel that is used for offshore oil and gas operations and is designed to process hydrocarbons and store oil until the oil can be offloaded onto a tanker ship. The processing equipment (or topsides) is located on the FPSO’s deck, while the oil storage is below the deck within the hull of the vessel.
flowline	The pipe through which oil travels from a production well to processing equipment or to storage.
freehold property	Property owned by the land user, not leased.
hawser	A taut line connecting the FPSO to tankers during offloading. The hawser helps the offloading tanker maintain a safe distance from the FPSO.
hydrostatic test	A way in which facilities such as pipelines, plumbing, gas cylinders, boilers, pressure vessels, and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurizing the vessel or pipe system to the specified test point. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.
hypoxia	Deficiency in dissolved oxygen concentrations.
ichthyoplankton	Fish eggs and larvae that drift with the ocean currents, usually near the surface, prior to developing directional swimming ability.
injection well	A well in which fluids, such as gas or water, are injected to increase pressure in the reservoir and drive the oil remaining in the reservoir to the vicinity of production wells.
Lagrangian	A type of model in which particles or parcels are moved under the influence of external forcing (winds, currents, buoyancy, turbulence, etc.) based on its individual location. The term is often used to differentiate such models from Eulerian models, where a field is established representing properties of interest (mass, concentration, etc.) in a discrete gridded space, and external forcing is applied to the entire property of that grid.
laydown area	An area that has been cleared for the storage of equipment and supplies. Laydown areas are usually covered with rock and/or gravel to ensure accessibility and safe maneuverability for transport and offloading vehicles.
manifolds	Gathering points or central connections made up of valves, hubs, piping, sensors, and control modules.
marine safety exclusion zone	A specific area of water where persons, vessels, and other activities are prohibited as the area has been designated for exclusive use by an activity; a form of safety control measure used to keep unauthorized persons and vessels away from a higher risk activity/event.
natural gas	A highly compressible, highly expansible mixture of hydrocarbons, which at atmospheric conditions of temperatures and pressure are in a gaseous phase.
oil-equivalent barrels	A unit of energy based on the approximate energy released by burning one barrel of crude oil. Quantities of natural gas and natural gas liquids are often translated into oil-equivalent barrels. The energy content of 6,000 cubic feet of natural gas is roughly equivalent to the energy in one barrel of oil (i.e., one oil-equivalent barrel).
photo-oxidation	The process of chemical breakdown caused by exposure to sunlight.

Term	**Definition**
pig	A specially designed device that is placed in the flowline at a launcher at one end and pushed by pressure until it reaches a receiving trap or catcher at the other end. Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines and pipelines.
plugging and abandonment	When used in reference to a well after its productive life, the sealing of the well casing with materials (e.g., cement and/or mud) and removal of the wellhead.
produced water	Water that comes up a well with the oil and gas. Produced water is usually high in salinity. After leaving the well, the produced water is separated from the oil and gas. Can also be referred to as formation water, saltwater, or oilfield brine.
production well	A well that is used to retrieve petroleum or gas from an underground deposit.
reservoir	In the oil and gas industry, a porous and permeable sedimentary rock containing commercial quantities of oil and gas.
risers	The pipe and special fittings used on floating offshore drilling rigs to establish a seal between the top of the wellbore, which is on the ocean floor, and the drilling equipment, located above the surface of the water. A riser pipe serves as a guide for the drill stem from the drilling vessel to the wellhead and as a conductor of drilling fluid from the well to the vessel. The riser consists of several sections of pipe and includes special devices to compensate for any movement of the drilling rig caused by waves. Risers are also used to carry production fluids to the FPSO from the seabed and carry injection fluids (water and gas) from the FPSO to the seabed.
shorebase	A land-based facility that provides logistical and material support for offshore activities and facilities.
spread mooring system	A group of mooring lines distributed from the bow and stern of a vessel (FPSO) to anchors on the seafloor. The vessel is positioned in a fixed heading, which is determined by the sea and weather conditions. The symmetrical arrangement of anchors helps to keep the vessel on its fixed heading location. The spread mooring system does not allow the vessel to weathervane, which means to rotate in the horizontal plane due to wind, waves, or current.
structural casing	The outer layer of large-diameter, heavy-wall pipe installed in wells drilled from floating installations to isolate very shallow sediments from subsequent drilling, resist the bending moments imposed by the marine riser, and help support the wellhead installed on the conductor casing.
umbilical	A cable and/or hose that provides the electrical, hydraulic, chemical, and communications connections needed to provide power and control between the FPSO and subsea equipment
wellhead	A structure that is installed at the top of a natural oil or gas well. Its main function is to ensure a safe operation and manage the flow of oil or gas from the well into the gathering-system. It is a system composed of valves, spools, and assorted adapters that control the pressure of the production well. It acts as an interface between the surface facilities and the casing-strings in the wellbore.
wellhead tree	An assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production.

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 deep. Subsequent surveys and exploratory drilling identified a reservoir of oil in a sandstone formation approximately 3,600 meters (approximately 11,800 feet) below the seabed (approximately 5,400 meters (approximately 17,700 feet) below sea level). In February 2018, Esso Exploration and Production Guyana Limited (EEPGL) announced estimated gross recoverable resources for the Stabroek Block at more than 3.2 billion recoverable oil-equivalent barrels.

EEPGL (45 percent) and its co-venturers Hess Guyana Exploration Limited (30 percent) and CNOOC Nexen Petroleum Guyana Limited (25 percent) are parties to a Petroleum Agreement with the Government of Guyana. Under this agreement, and in light of the Liza field discovery, EEPGL obtained a Petroleum Production Licence and submitted a Project Development Plan to the Minister Responsible for Petroleum, who approved the plan.

EEPGL, on behalf of itself and its co-venturers, is seeking an environmental authorization for the second phase of development of the Liza field in the eastern half of the Stabroek Block (hereafter referred to as the Liza Phase 2 Development Project, or the Project); the area that will be developed as part of the Project is located approximately 183 kilometers (114 miles) northeast of the coastline of Georgetown, Guyana. A key approval required for EEPGL for the Project is an Environmental Authorisation from the Guyana Environmental Protection Agency (EPA), in accordance with the Guyana Environmental Protection Act (as amended in 2005). As part of its regulatory role, the EPA, considering recommendations from the Environmental Advisory Board and Guyana Geology and Mines Commission, 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 December 4, 2017. 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. F

The Project will consist of the drilling of up to 33 development wells (including production, water injection, and gas re-injection wells), installation and operation of Subsea Umbilicals, Risers, and Flowlines (SURF) 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 utilized to support each stage of the Project. EEPGL will utilize 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 three years to drill the wells, with drilling beginning in 2020. The initial production is expected to begin by early- to mid-2022, 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 impacts on physical resources (i.e., air quality, marine sediments, and water quality), no impacts on coastal biological resources, negligible to minor impacts on most marine biological resources (with potential moderate impacts on marine mammals and special status species), and negligible to minor 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 183 kilometers (approximately 114 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 Liza reservoir, treat all significant 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 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 183 kilometers (approximately 114 miles) offshore, prevailing northwest currents, the light nature of the Liza 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 a 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 well control event at a Liza well would likely impact marine resources found near the well, including 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 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.

Additional unplanned events, also considered unlikely to occur because of the extensive preventative measures employed by EEPGL, could include collisions between Project vessels and third-party vessels; Project vessel strikes of marine mammals, marine turtles, or rafting seabirds; and collisions between Project vehicles and third-party vehicles. 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 and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) will 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, nevertheless, 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, 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.

It is recommended that all EEPGL's planned embedded controls, as well as the mitigation measures described herein, and appropriate Environmental and Socioeconomic Management Plan (ESMP) 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 Liza Phase 2 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) corporate standards, and the Project's Final Terms of Reference (30 May 2018) for the Project Environmental Impact Assessment (EIA).

This 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." EIA Appendix B provides the Curriculum Vitae of the key members of the EIA team.

1.1. PROJECT SPONSOR

The Project Sponsor is a joint venture among EEPGL, Hess Guyana Exploration Limited (Hess), and CNOOC Nexen Petroleum Guyana Limited (Nexen). Hess and Nexen are referred to as EEPGL's "co-venturers". EEPGL will be the operator of the Project, and is used in this EIA to represent the joint venture. EEPGL, which is an affiliate of Exxon Mobil Corporation, was formed on 16 October 1998 and subsequently registered in Guyana on 29 June 1999. Exxon Mobil Corporation, either directly or through subsidiaries, conducts oil and gas exploration activities worldwide.

1.2. PROJECT CONTEXT

EEPGL holds an offshore Petroleum Prospecting License 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 183 kilometers (approximately 114 miles) offshore from Georgetown in waters approximately 1,500 to 1,900 meters(approximately 4,900 to 6,233 feet) deep (Figure EIS-1). Subsequent surveys and exploratory drilling identified a reservoir of oil in a sandstone formation approximately 3,600 meters (approximately 11,800 feet) below the seabed (approximately 5,400 meters [17,700 feet] below sea level). In February 2018, EEPGL announced estimated gross recoverable resources for the Stabroek Block at more than 3.2 billion recoverable oil-equivalent barrels.

EEPGL and its co-venturers are parties to a Petroleum Agreement with the Government of Guyana. Under this agreement, and in light of the Liza field discovery, EEPGL has obtained a Petroleum Production Licence and submitted a Project Development Plan to the Minister Responsible for Petroleum, which has been approved.

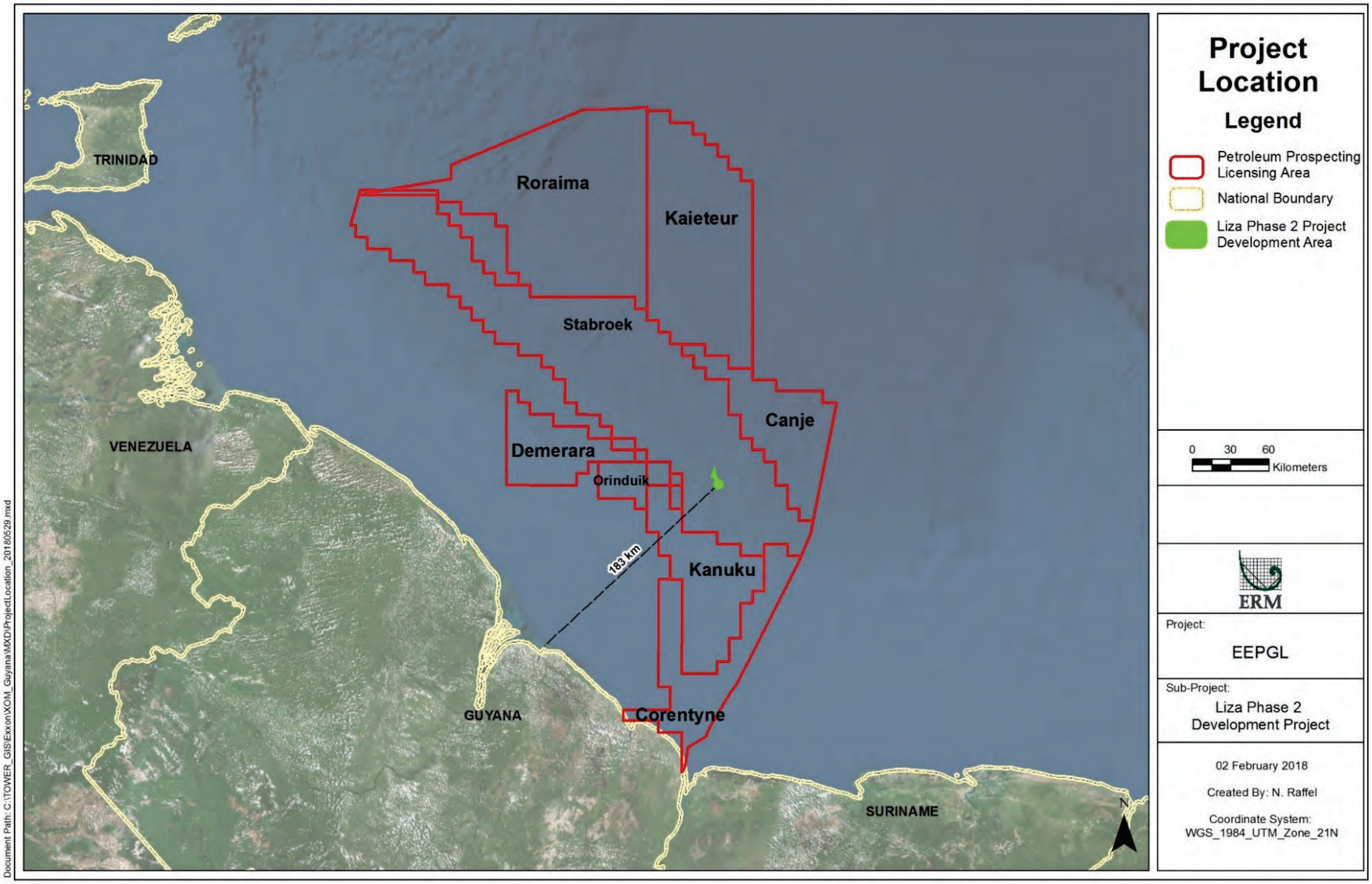

Figure EIS-1: Location of the Liza Phase 2 Project Development Area within Stabroek Block

1.3. PURPOSE OF THE PROJECT

The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the Liza field. The Petroleum Agreement between EEPGL, Hess, Nexen, and the Government of Guyana defines how revenues from the Project are to be shared between the parties. The Government of Guyana will begin receiving oil revenues when oil is produced.

1.4. REGULATORY FRAMEWORK AND PURPOSE OF THIS EIA

In order to develop the Liza field, EEPGL needs to obtain approval of an Application for Environmental Authorisation (Application) 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 4 December 2017. As part of its regulatory role, the EPA, taking into consideration recommendations from the Environmental Advisory Board and the Guyana Geology and Mines Commission (GGMC), 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 33 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, 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). 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 77 square kilometers (km^2). 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 45 to 50 km^2. This area is referred to as the Surface PDA. The PDA is located approximately 183 kilometers (approximately 114 miles) offshore (Figure EIS-2). The Project will also involve use of onshore shorebase(s) and other support facilities and marine/aviation services to support development drilling, SURF and FPSO installation, production operations, and, ultimately, decommissioning.

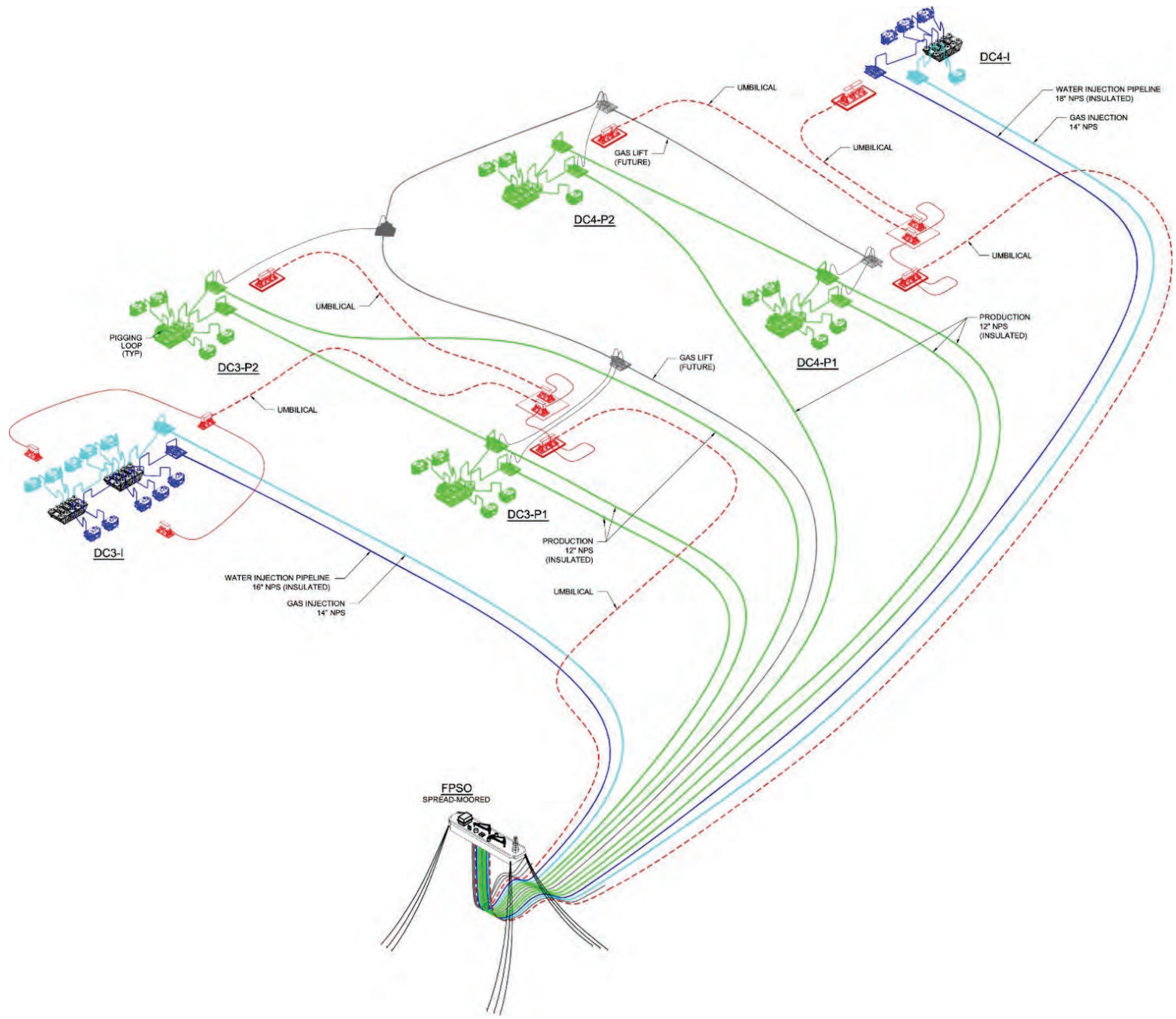

Figure EIS-2: Preliminary Liza Phase 2 Field Layout

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 Liza 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 essentially 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 up to two drill ships (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. The wellheads will be clustered around two major 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. Once each well is drilled, a wellhead and tree will be installed and the well will be connected to a manifold, which will be connected, as appropriate to an umbilical and production, gas, or water 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 a minimum of 2 million barrels of stabilized crude oil. The FPSO will be secured to the seafloor by an up to 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: Computer Simulated Picture of a 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 Liza 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 [a,b]**
Oil production	220,000 BOPD
Produced water	225,000 BPD
Total liquids	300,000 BPD
Produced gas	400 MMscfd
Gas injection	370 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

[a] All design rates are presented as the peak annual average.

[b] The facilities will have the potential to safely operate at sustained peaks of oil production up to approximately 250,000 BOPD. For the purposes of the EIA, 300,000 BOPD will be used as the 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: Typical FPSO Offloading to a Conventional Tanker

2.3. DECOMMISSIONING

In advance of the completion of the Liza Phase 2 production operations stage, EEPGL will prepare a decommissioning plan for the facility in compliance with the laws and regulations in effect at that time, while also considering the technology available at that time. The decommissioning plan and strategy will be based on a notice of intent for decommissioning the production facilities and plugging and abandonment of the development wells, which will be provided to the GGMC and EPA to obtain approval in accordance with the requirements of the Guyana Petroleum (Exploration and Production) Act (1998) and Environmental Protection Act (as amended in 2005). It is expected that the risers, pipelines, 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

Shorebase(s), laydown areas, pipe yards, 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. Marine support will include various supply vessels with an average of approximately 12 round-trips per week to the Stabroek Block (combined for Liza Phase 1 and Liza Phase 2) during drilling and installation and about seven round-trips per week (combined for Phase 1 and Phase 2) during production operations. The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Aviation support is expected to average about 30 to 35 round-trip flights per week during drilling and installation (combined for Phase 1 and Phase 2) and about 20 to 25 round-trip flights per week during production operations (combined for Phase 1 and Phase 2).

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 three years to drill the approximately 33 wells, with drilling planned to begin in 2020. Installation of the SURF and FPSO are likely to be initiated in 2020 to be ready for initial production by early- to mid-2022, with operations continuing for at least 20 years (Figure EIS-6).

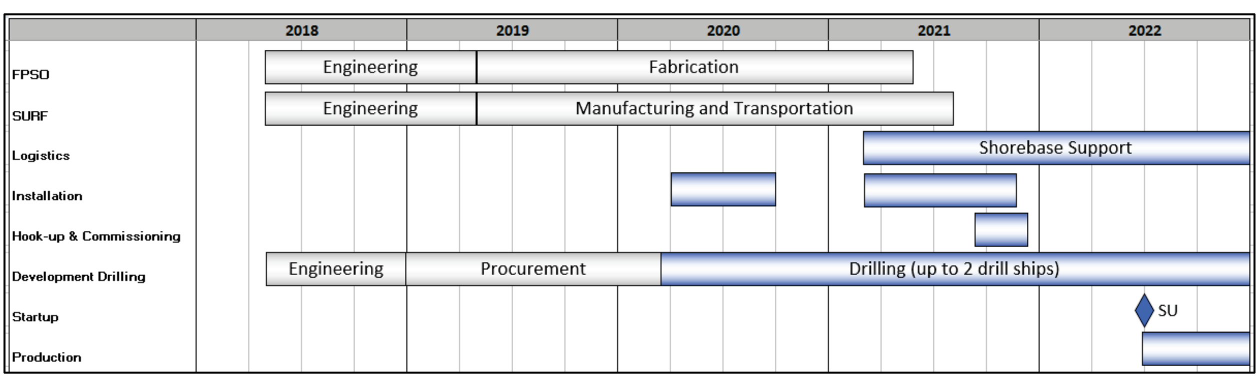

Figure EIS-6: Preliminary Project Schedule

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 meetings and workshops with the Government and others on offshore oil and gas exploration and development.
- During the EIA development, EEPGL and/or the Consultants:
  - Held meetings and key informant interviews with or gathered relevant data from more than 20 Guyana government agencies, commissions, professional or business associations, non-governmental organizations, and elected officials and regional administrators.
  - Held ecosystem services-related interviews with 63 coastal regional, democratic, and village councils in Regions 1-6.
- A Notice to the Public concerning the submission of the Application for the Project was published in the Stabroek News on 11 January 2018, and was posted on the EPA's website, initiating the 28-day public comment period. During this period, meetings with the public were held in each of the six coastal regions, along with a separate meeting in Georgetown for the sector agencies.

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. Accordingly, there are no feasible alternative PDA locations that could effectively recover the resource. 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. While there could be alternative locations for these components within the PDA, these alternative locations could potentially increase environmental impacts. With respect to onshore components of the Project, the preferred alternative from an environmental perspective is to use existing shorebase(s) in Georgetown with sufficient capacity to meet Project needs. If additional shorebase(s) 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 shorebase(s) in addition to or in lieu of the shorebase(s) that currently exist.

- Development Concept Alternatives
  - Facility Type: 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). With the exception of the FPSO concept, the other deepwater production systems would necessitate the use of a separate Floating Storage and Offloading (FSO) vessel for oil storage and offloading to enable export of the oil to buyers. The use of an FSO would 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). Therefore, the FPSO was chosen as the preferred concept for the Project because it is a more efficient, stand-alone solution for deepwater oil processing and storage, and it also provides for fewer potential impacts.
  - 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.
  - Gas Disposition: 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. While gas re-injection is the preferred alternative selected for the Project, the FPSO has been designed to enable gas export, should an export alternative be identified in the future. 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 ExxonMobil and its 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.
- No-go Alternative. If this alternative is applied, the existing conditions described in 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-go 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 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

Physical Resources	**Biological Resources**	**Socioeconomic Resources**
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
	Marine Turtles	Cultural Heritage
	Marine Fish	Waste Management
	Marine Benthos	Land Use
	Ecological Balance and Ecosystems	Ecosystem Services
		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 183 kilometers (approximately 114 miles) off the coast of Guyana. The Project should not disturb any natural onshore habitats. There will be a negligible increase in traffic congestion near the onshore shorebase(s). 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 only resources with the potential to incur any meaningful adverse impacts from planned Project activities are marine-oriented resources (i.e., biological resources). These are discussed briefly below. Additionally, while the EIA concludes that neither air quality nor water quality will incur any meaningful adverse impacts from planned Project activities, these resources are also discussed briefly below, due to the level of interest in these resources identified during consultation for the EIA.

3.1.1. Air Quality

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 (WHO) guidelines (the highest predicted onshore concentration being less than 1.5 percent of the WHO guidelines), indicating a **Negligible** impact on onshore air quality from the Project.

The Project will also emit greenhouse gases (GHGs) throughout its predicted life cycle (approximately 20 years), with peak emissions during steady-state production operations stage estimated to be approximately 2,325 kilotonnes of carbon dioxide-equivalents 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 Liza reservoir for reservoir pressure management, which also represents a significant reduction in potential GHG emissions versus that which would result from routine gas flaring.

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. Based on the limited area impacted and the short time period during which concentrations above the threshold are expected to persist, the impacts on marine water quality from TSS increases resulting from drill cuttings discharge are considered **Negligible.**

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 the completion of the testing, the hydrostatic test water and hydrate inhibitor from the gas injection line 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** impact.

During production operations, the FPSO will discharge five primary effluent streams to the ocean (Table EIS-3). 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** 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.
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 & 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	500 BPD	Will be treated in accordance with internationally recognized standards prior to discharge.
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 Sediments and Marine Benthos

The drilling of wells and the placement of flowlines and other subsea equipment will physically disturb approximately 0.8 km^2 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. Based on surveys of the seafloor, however, benthic organisms, primarily consisting of annelids (mostly polychaetes), crustaceans, and mollusks (occurring at low densities). Neither the grab sampling nor remotely operated vehicle components of the three environmental baseline studies conducted in the Stabroek Block have identified any unique or rare benthic communities within the area that could be directly affected by the Project. Two species that were previously unknown from Guyana's waters, the giant isopod and deepsea red crab, were captured in the Stabroek Block during the deepwater component of the fish surveys conducted for the Liza Phase 1 Development post permit studies, but these species are neither rare nor particularly susceptible to mortality from cuttings deposition. Modeling indicates that potential benthos smothering effects from deposition of drill cuttings would be limited to a very small area around the well (with the largest such area predicted by modeling to be approximately 49 meters (approximately 161 feet) in radius from the well), resulting in a **Negligible** impact.

3.1.4. Seabirds

Seabirds have the potential to be impacted by the Project, but it was determined that the significance of these impacts range from **Negligible** (for seabirds as a whole) to **Minor** (for special status seabirds) for the reasons explained below.

The marine bird survey completed as part of the Liza Phase 1 post permit studies 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 to minimize its attraction potential and flaring will be non-routine and temporary (e.g., during select maintenance activities), so the overall Project impact on seabirds was determined to be negligible. 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 in 2017 and 2018. While the magnitude of potential impacts on seabirds would be small, the significance of some potential impacts on these species was considered to be **Minor**, based on their special status designations.

3.1.5. Marine Fish

Marine fish have the potential to be impacted by the Project, but it was determined that the significance of these impacts range from **Negligible** (for marine fish as a whole) to **Minor** (for special status marine fish), for the reasons explained below.

The marine fish survey component of the Liza Phase 1 post permit studies indicated that deepwater fish diversity is poor in the vicinity of the Liza Phase 2 PDA. The pelagic community is typical of the region. The results of the survey 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 impacts on some of these special species was considered to be **Minor**, based on their special status designations.

3.1.6. Marine Mammals

Marine mammals have the potential to be impacted by the Project, and it was determined that the significance of some of these potential impacts was **Moderate**. Marine mammal observations conducted prior to issuance of the Environmental Permit, and subsequently as part of the Liza Phase 1 post permit studies, 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 comparatively 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 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 not deep enough that they could potentially be exposed to injurious sound levels within the PDA. Even if an individual of an MFC species were to dive to a sufficient depth to encounter the acoustic injury threshold, it would be physiologically unable to dive to these depths for a sufficient duration to cause injury.

3.1.7. Marine Turtles

Marine turtles have the potential to be impacted by planned Project activities, but it was determined that the significance of these potential impacts ranges from **Negligible** to **Minor**. 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 prior to and since the Project was permitted, 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 post permit studies 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 encountering Project vessel traffic moving within the PDA or between the PDA and shorebase(s) in Guyana.

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., 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, or seabird; 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 are considered to have a risk level of **Minor** to **Moderate**.

3.2.2. Vessel Strikes of Marine Mammals or Marine Turtles

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 ship 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 ship 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.

Most Project activities will take place in deepwaters, 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 shorebase(s), but even at the peak of drilling and installation, the incremental increase in traffic near shorebase(s) 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 shorebase(s). With respect to risk to marine turtles, the planned shorebase(s) are all located more than 100 kilometers 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).

EEPGL will provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals and marine turtles at the sea surface, and will issue standing instructions to Project-dedicated vessel masters to avoid marine mammals and marine turtles while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions. While these measures will serve to reduce the risk of a vessel collision with a marine mammal or marine turtle, the risk is considered to be **Moderate**.

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.

3.2.4. 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 14 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 shorebase(s) 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 considers a loss of well control incident at the seafloor, releasing 20,000 barrels of oil per day for 30 days.

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 likelihood 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 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 an extended loss of well control (20,000 barrels of oil per day for 30 days). Several factors would inherently reduce the severity of an oil spill occurring in the Liza offshore development area and would increase subsequent ecosystem recovery rates, including the following:

- Location of Spill—a Liza well control incident would occur approximately 183 kilometers (approximately 114 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. Modeling indicates that this current significantly reduces the probability of spilled oil reaching the coast of Guyana.
- Properties of Spilled Oil—the Project will be producing a light crude oil, which has low smothering potential and tends to spread readily on the ocean surface, both of which can reduce severity of impacts on shoreline resources.
- Climate—the relatively warm year-round waters of the Project area 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 summer and winter seasons. Modeling of an unmitigated release 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 modeling does not account for any oil spill response (e.g., aerial, vessel or sub-sea 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), it would take 5 to 15 days for oil to reach shore. 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 aid in preparing to respond to the unlikely event of an oil spill, coastal sensitivity maps were prepared for areas predicted by the spill modeling to have the potential to be impacted by an unmitigated release. To provide additional detail to these maps, ecosystem services mapping was conducted for Regions 1-6. In Region 1, the only region that could be directly affected by a spill resulting from a 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 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 results of the Liza Phase 1 post permit fish surveys and 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	Per oil spill model, Shell Beach Protected Area and its vicinity could be impacted if oil were to reach the Guyana shoreline.	Minor
Coastal Habitats and Coastal Wildlife	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 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 risk to all of these resources aside from seabirds as a whole is considered **Moderate**. In the case of Leach's Storm-Petrel (*Oceanodroma leucorhoa*), surveys conducted as part of the Liza Phase 1 Project post permit studies indicated the offshore PDA is a migratory corridor for a relatively large number of this species. Accordingly, the 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	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 [a]
Leach's Storm-Petrel (Special Status Species)	The nature of the impact to Leach's Storm Petrel (*Oceanodroma leucorhoa*) is the same as for (non-special status) seabirds as a whole. However, the residual risk rating for this species is considered **Moderate** 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.	Moderate
Marine Turtles	Dermal irritation from contact with oil, ingestion, and respiratory irritation from inhalation of vapors at the water surface.	Moderate

[a] Excludes Leach's Storm-Petrel, which is discussed separately

3.3. 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 Project (approximately 8.5 kilometers [approximately 5.3 miles] to the west of Liza Phase 2 PDA), continued exploration drilling, a future planned development project approximately 20 kilometers (approximately 12.4 miles) north of the Liza Phase 2 PDA, and the Gas to Shore Project, which is expected to transport associated gas from the Liza Phase 1 Project Development Area to shore for creation of natural gas liquids and natural gas power production. Additionally, there are 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.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as marine mammals (via vessel strikes or potential acoustic injury from underwater sound), marine turtles (via vessel strikes), marine fish (via degraded water quality and entrainment of fish from cooling and ballast water intakes), community health and wellbeing (via increased demand on limited medical treatment capacity), marine use and transportation (via additional marine congestion, especially near Georgetown

Harbour), and social infrastructure and services (via increased demand for limited housing, utilities, and services; or via increased traffic congestion). Many of the above potential impacts that require offshore interaction between the Project and others 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 to 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 in Phase 2) be implemented. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, EEPGL can actively manage, where feasible and practicable, the spatial and temporal overlap of their additional projects activities. This approach would be expected to be sufficient to address contributions of the Project and other EEPGL projects to cumulative impacts.

3.4. 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^2) 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.

3.5. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

An Environmental and Socioeconomic Management Plan (ESMP) has been developed to manage and mitigate the impacts identified in the EIA. The ESMP includes the following:

- Environmental and Socioeconomic Management Plan 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

- Oil Spill Response Plan, including
  - Oil Spill Modeling
  - Geographic Strategic Response Maps
  - Net Environmental Benefit Analysis
  - Emergency Preparedness and Response Procedures
- 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** impacts on physical resources (i.e., air quality, marine geology and sediments, marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** impacts on marine biological resources, and **Negligible** to **Minor** 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 183 kilometers (approximately 114 miles) offshore; and the Project will capture and re-inject recovered natural gas (the portion that is not used as fuel on the FPSO) back into the Liza reservoir, treat all the required wastewater streams 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^2 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 mammals. 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 183 kilometers (approximately 114 miles) offshore, prevailing northwest currents, the light nature of the Liza 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 a 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, a subsea release of crude oil from a well control event at a Liza field 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 extensive preventative measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, or rafting seabirds; and collisions between Project vehicles and non-Project vehicles. 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 and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) will 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/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 and Climate	Negligible	Negligible	Negligible	Minor	NA
Sound [a]	None	None	None	None	None
Marine Geology and Sediments	Negligible	None	None	Minor	NA
Marine Water Quality	Negligible	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Minor	NA
Special Status Species: [b]					
• Critically Endangered and Terrestrial Species	Negligible	Negligible	Negligible	Minor	Low
• Vulnerable/Near Threatened Fish Species	Minor	Minor	Minor	Minor	Low
• Endangered Fish and Endangered Black-Capped Petrel (*Pterodroma hasitata*)	Negligible	Minor [d]	Negligible	Minor	Low
• Vulnerable Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Negligible	Minor [d]	Negligible	Moderate [e]	Low
Coastal Habitats	None	None	None	Minor	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds [c]	Negligible	Negligible	Negligible	Minor	NA
Marine Mammals	Moderate	Negligible	Negligible	Moderate	Medium
Marine Turtles	Negligible	Negligible	Negligible	Moderate	Low
Marine Fish	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Negligible	Positive	Positive	Minor	NA
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:					
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low
• Ground and air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management	Negligible	Negligible	Negligible	Minor	NA
Cultural Heritage	Negligible	None	None	Minor	NA

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		
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 Chapter 10, Cumulative Impact Assessment)
[a] Potential underwater sound-related impacts on marine mammals, marine turtles and marine fish are assessed in the resource-specific sections for those resources
[b] Excludes listed marine turtles, which are covered in the Marine Turtles resource category.
[c] Excludes listed seabirds, which are covered in the Special Status species resource category.
[d] 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.
[e] The residual risk rating for Leach's Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017 and 2018, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.

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, 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 to the extent reasonably practicable, in alignment with The Liza Development Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals to the extent reasonably practicable, in alignment with the Liza Development Local Content Plan.

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

4.2. Recommendations

The Consultants recommend the following measures be considered by the EPA, GGMC, and the Environmental Advisory Board 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 many controls into the Project design to prevent a spill from occurring, and we agree that a large spill that affects the Guyana coastline 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 Liza Phase 2 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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ENVIRONMENTAL IMPACT ASSESSMENT

1. INTRODUCTION

Esso Exploration and Production Guyana Limited (EEPGL)[1], together with its co-venturers Hess Guyana Exploration Limited and CNOOC Nexen Petroleum Guyana Limited, is seeking an environmental authorization for the second phase of development of the Liza field in the eastern half of the Stabroek Block (hereafter referred to as the Liza Phase 2 Development Project, or the Project); the area that will be developed as part of the Project is located approximately 183 kilometers (114 miles) northeast of the coastline of Georgetown, Guyana (Figure 1-1). The Stabroek Block is estimated to have a recoverable resource in excess of 3.2 billion oil-equivalent barrels.

1.1. PURPOSE OF THIS EIA

Guyanese law requires EEPGL to obtain an environmental authorization from the Guyana Environmental Protection Agency (EPA) to undertake the Project. The EPA oversees the effective management, conservation, protection, and improvement of the environment in Guyana. In this role, the EPA is responsible for managing the environmental authorization process. EEPGL filed an Application for Environmental Authorisation (Application) with the EPA on 4 December 2017. 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 this EIA is to provide the factual and technical basis required by EPA to make an informed decision on EEPGL's Application to permit the Project. After submission and review of this EIA, the EPA will take into account the review of the Guyana Geology and Mines Commission (GGMC), comments from other Agencies and Ministries, the public's comments, EPA's own review, including support from technical experts, and recommendations from the Environmental Assessment Board (EAB) in deciding whether and under what conditions to grant EEPGL an Environmental Authorisation[2] for the Project.

[1] EEPGL will be the operator of the Project, and is used in this Environmental Impact Assessment to represent the joint venture.

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

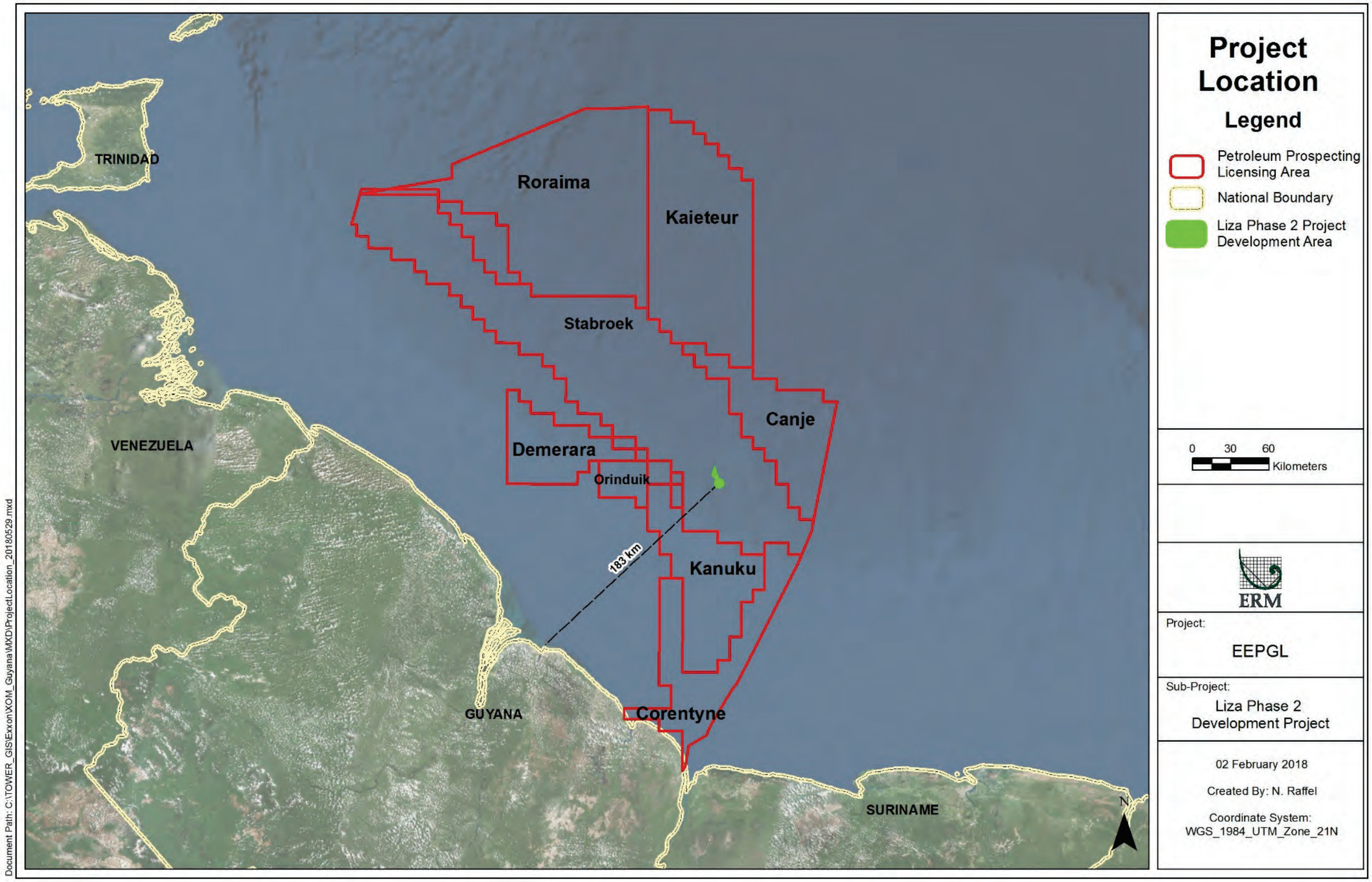

Figure 1-1: Location of the Liza Phase 2 Project Development Area within Stabroek Block

The GGMC has several functions, including promoting and regulating the exploration and development of the country's mineral and petroleum resources. The Petroleum Division of the GGMC is responsible for promoting Guyana's petroleum potential and monitoring exploration and production activities. The GGMC oversees EEPGL's Prospecting Licence, under which EEPGL's offshore exploration and drilling activities were conducted. The GGMC will provide technical input into the review of the EIA, as discussed above, and will consider the granting of an Environmental Authorisation by the EPA as part of its evaluation of EEPGL's application for a Petroleum Production Licence for the Project.

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

This 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". In the Project's Final Terms of Reference (ToR), EPA approved this team as the independent consultant to undertake the EIA. This EIA has been prepared in compliance 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, and EEPGL's corporate standards, and in accordance with the Consultant's standard practices.

1.2. EEPGL Exploration Well Drilling History

EEPGL has drilled 11 exploration wells within the Stabroek Block offshore Guyana, as indicated in Table 1.2-1. After completion of the exploration testing, each of these wells was closed consistent with good industry practice. EEPGL has plans to explore in other blocks, but no drilling has yet occurred outside of Stabroek Block.

Table 1.2-1: EEPGL Stabroek Block Exploration Well Drilling History

Well Name	Year Drilled	Result
Liza-1	2015	Successful (oil found)
Liza-2	2016	Successful
Liza-3	2016	Successful
Skipjack-1	2016	Dry well (no oil found)
Payara-1	2016	Successful
Liza-4	2017	Successful
Snoek-1	2017	Successful

Well Name	Year Drilled	Result
Payara-2	2017	Successful
Turbot-1	2017	Successful
Ranger-1	2017	Successful
Pacora-1	2018	Successful
Sorubim-1	2018	Dry well

1.3. Goal and Objectives of the EIA

In accordance with the ToR for this EIA, for which the EPA granted interim approval on 9 April 2018 - enabling the EIA to commence - and final approval on 30 May 2018, the goal of the EIA is to provide the factual and technical basis required by the EPA to make an informed decision on EEPGL's Application for Environmental Authorisation to permit the Project.

To that end, the following are the objectives of the EIA:

- Describe the components and activities of the Project, including:
  - Development drilling, including well design and drill ships;
  - Subsea Umbilicals, Risers, and Flowlines (SURF);
  - Floating Production, Storage, and Offloading (FPSO) vessel, including topsides facilities and the vessel mooring system;
  - Installation, hookup, and commissioning of FPSO and SURF components;
  - Production operations, including third-party operated offloading tankers;
  - Onshore support, including shorebases;
  - Marine and aviation support vessels and equipment; and
  - End of Project operations (decommissioning).
- Describe the existing conditions within the Project Area of Influence (AOI). The evaluation of existing conditions in the Project AOI will leverage the scientific body of knowledge that has previously been acquired during prior environmental authorizations, as well as additional studies that are specific to the Project.
- Identify and assess the potential direct, indirect, and cumulative environmental and socioeconomic impacts that could credibly result from the Project during the drilling, installation, production, and decommissioning stages.
- Describe, to the extent possible, potential induced impacts associated with ancillary activities or facilities that may not be a component of the Project itself, but are associated with the Project.
- Describe a strategy to manage the potentially significant direct, indirect, and cumulative adverse impacts of the Project.
- Characterize potential positive benefits of the Project.
- Recommend monitoring to assess the effectiveness of the management strategy.

1.4. COMPONENTS OF THE EIA

As required by the Guyana Environmental Protection Act (as amended in 2005) and further described in the Guyana Environmental Impact Assessment Guidelines, this EIA includes the required components of an EIA:

- Project Description: Chapter 2, Description of the Project;
- Environmental Baseline Studies and Environmental Assessment:
  - 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
  - Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
  - Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events
  - Chapter 10, Cumulative Impact Assessment
- Environmental Impact Statement: provided at the beginning of the EIA; and
- Environmental and Socioeconomic Management Plan: Chapter 11, Environmental and Socioeconomic Management Plan Framework.

EEPGL has elected to submit these components as one document.

The *Environmental Impact Assessment Guidelines Volume 1—Rules and Procedures for Conducting and Reviewing EIAs, Volume 5* (EPA 2004) includes an EIA Review Checklist. Provided below in Table 1.4-1 is an EIA "roadmap" that shows where all of the checklist items evaluated can be found.

Table 1.4-1: EIA Review Checklist Roadmap

EIA Review Checklist Items	Corresponding EIA Reference
1. Adherence to the ToR *Adherence to the ToR must be verified simply by checking that all items and information requested in the ToR have been presented, regardless of the content or quality of such information.*	• Adherence to the approved ToR confirmed (9 April 2018 Interim Approval and 30 May 2018 Final Approval)
2. Multidisciplinary Team *The accuracy of the EIA depends on the qualifications of the multidisciplinary team not only regarding the EIA process and methods but also regarding their knowledge of the several stages of the specific type of project. Therefore, individual CVs should be submitted as part of the EIA Annexes. Signatures of each member of the team must be affixed.*	• Chapter 14, Project Team, lists all team members and references, Appendix A provides signatures, and Appendix B includes all Curricula Vitae.

EIA Review Checklist Items	Corresponding EIA Reference
3. Inter-disciplinary Achievement *An EIA must present information regarding the interactions and integration between the physical, biological and socio-economic aspects of the environment in that particular area of the study.*	• Chapter 6 assesses physical resources/receptors • Chapter 7 assesses biological resources/receptors • Chapter 8 assesses socioeconomic resources/receptors
4. Executive Summary *The Executive Summary, also referred to as the non-technical summary, should provide a brief description of the project and information regarding the potential impacts of the project, arranged in order of significance, along with the proposed mitigation/compensatory measures for each impact. The summary should end with the consultants' recommendations.*	• Executive Summary included in Environmental Impact Statement
5. Project Description *The process of environmental impact assessment depends on the full understanding of the project proposal and accurate identification of the project actions. If actions are unclear, sufficiently detailed impacts are not likely to be identified with the accuracy and specificity needed to enable the development of appropriate mitigation measures.*	
5.01 Is the project proposal fully understood?	• Chapter 2, Description of the Project
5.02 Are all phases identified (e.g. planning, construction, operation and decommissioning)?	• Section 2.5, Drilling and Well Design • Section 2.8, Installation, Hookup, and Commissioning • Section 2.9, Production Operations, • Section 2.11, End of Phase 2 Operations (Decommissioning)
5.03 Is the geographical area for each phase identified?	• Section 2.1, Project Area (all stages occur within this same area)
5.04 Are the land use requirements for each phase identified?	• Section 2.4, Onshore, Marine, and Aviation Support (only onshore supply and support activities have any land use requirements)
5.05 Is there an inventory of the nature and quantity of materials used in the production process?	• Section 2.12, Materials, Emissions, Discharges, and Wastes
5.06 Are there inventories of the type and quantity of products, by-products and effluents expected to be produced by the project?	• Section 2.12, Materials, Emissions, Discharges, and Wastes
5.07 Is there an inventory of the type and quantity of residues?	• Section 2.12, Materials, Emissions, Discharges, and Wastes
5.08 Are the levels of emissions expected detailed with respect to *- Noise?* *- Vibration?* *- Light?* *- Heat?* *- Radiation?* *- Gases?* *- Liquids? Are the types and levels of any other emissions included?*	• Noise impacts: Section 6.2.3, Impact Assessment—Sound; Section 7.5.3, Impact Assessment—Marine Mammals • Thermal and liquid discharges: Section 6.4.3, Impact Assessment—Marine Water Quality • Radiation: Section 2.12.5, Radioactive Sources • Air (gaseous) emissions: Section 6.1.3, Impact Assessment—Air Quality and Climate
5.09 Is information on employment provided?	• Section 2.5, Project Workforce

EIA Review Checklist Items	Corresponding EIA Reference
6. Identification and Description of Alternatives *The assessment of sound alternatives is necessary to validate the EIA process. Therefore reasonable alternatives have to be fully and comprehensively considered. As a minimum, one of the following alternatives must be considered: location, project layout, technology, scheduling, project scale.*	• Section 2.8, Alternatives
6.01 Did the developer consider alternatives?	• Section 2.8, Alternatives
6.02 Was the "no-project" scenario considered?	• Section 2.8, Alternatives
6.03 Were the environmental factors adequately presented for each alternative?	• Section 2.8, Alternatives
6.04 Is the final choice adequate?	• Section 2.8, Alternatives • Chapter 12, Conclusions and Summary of Impacts
7. Definition and Justification of Physical Boundaries (Direct and Indirect Area of Influence) *Inconsistency in identifying the correct areas of influence will inevitably lead to inconsistency in the baseline data and the impact analysis. The indirect area of influence is the area likely to be affected by indirect, secondary and/or long term impacts.*	• Section 5.1, The Area of Influence
8. Analysis of the Legal Aspects Involved *The analysis of the legal framework involves more than a list of legal Acts. It involves assessing the consequences for the project of enforcing all the environmental legislation and regulations regarding the proposed site and sectoral requirements related to the proposed activity.*	• Chapter 3, Administrative Framework • Additionally, resource-specific administrative framework discussions are provided in each resource-specific section in Chapters 6, 7, and 8
9. Identification of Other Existing Planned Activities or Projects in the Area of Influence *This information is of utmost importance to ensure that land-use and other types of conflicts do not arise later during the project implementation.*	• Chapter 10, Cumulative Impact Assessment
9.01 Has the compatibility between the proposal and the identified existing activities been analysed?	• Section 10.3, Other Projects and External Drivers
9.02 Are the activities compatible?	• Section 10.3, Other Projects and External Drivers
9.03 Does the inventory of existing activities match what is observed?	• Section 10.3, Other Projects and External Drivers
10. Adequacy and Completeness of Relevant Baseline Data *Baseline data must be specific and relevant to the area of influence. General and superficial information does not allow for the use of adequate impact prediction techniques.*	• Chapter 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
10.01 Is the information presented specific and relevant?	• 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.02 Were difficulties in attaining information (if any) documented?	• 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
10.03 Have the impact indicators identified been adequately covered (see Section 13)	• 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
11. Appropriateness of EA Methods *The use of appropriate EA methods is necessary to ensure reliability of the results of the EIA study. Each type of EA method has different strengths and vulnerabilities regarding its appropriateness to perform each step of the EIA study. Some EA methods are unable to provide the means of identification of cause-effect relationships; others do not enable the identification of indirect, secondary and/or long-term impacts. Scientific and technical accuracy of the EIA methods used must therefore be evaluated to ensure the reliability of the conclusions drawn from the impact assessment.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.1. Physical Impacts *- Have all the identified impacts on air, water, soil, noise, landscape and natural resources been checked against the relevant impacts defined in the ToR?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?*	• Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources

EIA Review Checklist Items	Corresponding EIA Reference
12.2. Biological Impacts *- Have all the identified impacts on flora, fauna, rare / endangered species, sensitive ecosystems, species habitats and ecological balance been checked against the relevant impacts in the ToR.* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources
12.3. Social and Health Impacts *- Have all the identified impacts on the social and health context been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to human health, demographic and household characteristics, employment opportunities, size and distinguishing characteristics of resident population, the provision of social services and infrastructure?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- To what extent does the project protect/improve human health?* *- To what extent does the project protect/improve human living conditions?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.4. Cultural, Historical and/or Archeological Impacts *- Have all the identified impacts related to cultural, historical and/or archeological sites and heritage been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to cultural heritage?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Section 8.7, Cultural Heritage

EIA Review Checklist Items	Corresponding EIA Reference
12.5. Economic Impacts *- Have all the identified impacts on the economy (local, regional, national) been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to economic assets and activities?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?* *- Are impacts identified with respect to income generation for the community and at the National Level?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Have the social implications of the impacts been assessed?* *- Have cause/effect relations been properly identified?*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
12.6. Other impacts *- Have all other impacts been checked against the relevant impacts defined in the ToR?* *- Are impacts identified with respect to _____________?* *- Are impacts characterized (positive/negative, direct/indirect, primary/secondary, short/medium/long term, reversible/irreversible, temporary/permanent, local/regional/national/strategic, avoidable/unavoidable)?* *- Have the magnitudes been estimated?* *- Have the impacts been assigned a significance?* *- Has the social distribution of the impacts been identified?* *- Have cause/effect relations been properly identified?*	• Other potentially impacted resources not specifically listed above have been included, such as marine geology and sediments (Section 6.3), marine use and transportation (Section 8.4), and indigenous peoples (Section 8.10).
13. Cumulative Impacts *There may be cases where an activity/project will contribute to a cumulative impact on the environment although individually it may not have a significant environmental impact. This may be as a result of the presence of similar activities within the vicinity of the project.*	• Chapter 10, Cumulative Impact Assessment
13.01 Have cumulative impacts been adequately identified and characterized?	• Chapter 10, Cumulative Impact Assessment
13.02 Have the magnitudes been estimated?	• Section 10.5, Assessment of Cumulative Impacts on VECs (Valued Environmental and Social Component)
13.03 Have the impacts been assigned a significance?	• Section 10.5, Assessment of Cumulative Impacts on VECs
13.04 Has the social distribution of the impacts been identified?	• Section 10.5, Assessment of Cumulative Impacts on VECs

EIA Review Checklist Items	Corresponding EIA Reference
13.05 Have cause/effect relations been properly identified?	• Section 10.5, Assessment of Cumulative Impacts on VECs
14. Impact Indicators *Impact indicators are the parameters used to estimate the magnitude of the impacts.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
14.01 Were the impact indicators used adequate for all the impacts identified?	• 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15. Prediction Techniques *Impact prediction techniques are necessary to enable the estimation of the magnitude of the impacts. Without the use of adequate impact prediction techniques, accurate impact analysis is not possible.*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
15.01 Have the impact prediction techniques used been described? Are they adequate?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
15.02 Are they adequate?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

EIA Review Checklist Items	Corresponding EIA Reference
16. Magnitude of Impacts *Magnitude is the estimate of the absolute measure/value/dimension of the difference between the environmental situation of a given parameter before and after the project is implemented. In the majority of cases – physical, biological and economic impacts – it must be expressed in* ***quantitative*** *values. The estimation of the magnitude of each relevant impact is one of the most important steps in impact analysis. It ensures the accuracy of the EIA and allows for the identification of appropriate and cost-effective mitigation measures. Have the magnitude of all the relevant impacts been adequately estimated (refer to impact indicators – Section 14)?*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment • 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
17.0 Importance/Significance of Impacts *Usual methods involve objective criteria regarding the ecological and social relevance of the project*	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
17.01 Is the relative importance/significance of each impact with regard to the environmental factor affected, and with regard to the other impacts given?	• Chapter 4, Methodology for Preparing the Environmental Impact Assessment
17.02 Is the significance based on objective criteria in order to minimize subjectivity of judgments?	• 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 • Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
18 Social Distribution of Impacts *Identifies which social groups will be affected by the positive and the negative impacts. These groups are often not the same. The balance between positive and negative impacts cannot be done without the correct identification of the social distribution of the impacts, because it would not have scientific and technical relevance.*	• Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources
19 Stakeholder Participation	
19.01 Are the results of stakeholder participation, such as the results of interviews, hearings etc. clearly documented?	• Section 4.5, Stakeholder Engagement
19.02 Have questionnaires used been included?	• No specific questionnaires were used, but numerous Key Informant Interviews, informal meetings, and capacity building workshops, as well as one sector agency scoping consultation meeting and seven public scoping consultation meetings in Regions 1-6 were held.
19.03 Are the extent and method of stakeholder participation adequate?	• Section 4.5, Stakeholder Engagement
19.04 Are the conclusions drawn valid, based on available data?	• Section 4.5, Stakeholder Engagement
20 Analysis and Selection of Best Alternative *Selection must be based on criteria derived from the impact assessment, and appropriate analysis and decision-making methods must be used.*	• Section 2.16, Alternatives • Chapter 12, Conclusions and Summary of Impacts

EIA Review Checklist Items	Corresponding EIA Reference
21 Environmental Management Plan (EMP) *An EMP is sometimes called an Impact Management Plan. It is a necessary step to ensure that the developer is effectively committed to the implementation of the mitigation measures. It is also a useful corporate management tool. Does the EMP, as a minimum, present* *- The set of mitigation, remedial or compensatory measures?* *- A detailed description of each one, with indication and criteria for their effectiveness?* *- Detailed budgets for each one?* *- Timetables for implementation?* *- Assignment of responsibilities, including an Environmental Manager?* *- The Environmental Policy*	• Environmental and Socioeconomic Management Plan (ESMP) • Chapter 11, Environmental and Socioeconomic Management Plan Framework
22 Monitoring *Monitoring is a necessary step to ensure cost-effectiveness of the EMP. It is usually addressed under the EMP (see Section 20) Does the monitoring plan, as a minimum, address* *- What is going to be monitored (impact indicators)?* *- Where will samples be taken?* *- How the samples will be analysed (method/technique)?* *- Criteria used to evaluate the results?* *- Financial and human resources required?*	• ESMP
23 Implementation Plan for the Mitigation Measures and the Environmental Management Plan *Implementation mechanisms must be in place to ensure effective implementation of the mitigation measures and all other recommendations that might arise from the EIA study. It usually involves the assignment of a person responsible for environmental management and an approved timetable for implementation of measures.*	• ESMP • Chapter 11, Environmental and Socioeconomic Management Plan Framework

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2. DESCRIPTION OF THE PROJECT

Previous seismic testing and exploratory drilling have determined the presence of multiple reservoirs of crude oil with an estimated recoverable resource in excess of 3.2 billion oil-equivalent barrels in the eastern half of the Stabroek Block. The Project represents the second phase of development of the Liza field.

The Project will consist of the drilling of up to 33 development wells (including production, water injection, and gas re-injection wells), installation and operation of Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment, installation and operation of a Floating Production, Storage, and Offloading (FPSO) vessel in the eastern half of the Stabroek Block (Figure 2-1), and ultimately, Project decommissioning. Onshore logistical support facilities and marine/aviation services will be utilized to support each stage of the Project.

This chapter discusses the following information related to the Project:

- Project area;
- Project schedule;
- Project workforce;
- Overview of development concept;
- Drilling and well design;
- SURF;
- FPSO vessel, including topsides facilities and the vessel mooring system;
- Installation, hookup, and commissioning activities;
- Production operations, including offloading by third-party owned/operated conventional tankers;
- Onshore, marine, and aviation support;
- End of operations (decommissioning);
- Materials, emissions, discharges, and wastes;
- Embedded controls[1];
- Worker health and safety;
- Project benefits; and
- Project alternatives.

[1] Embedded controls are physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.

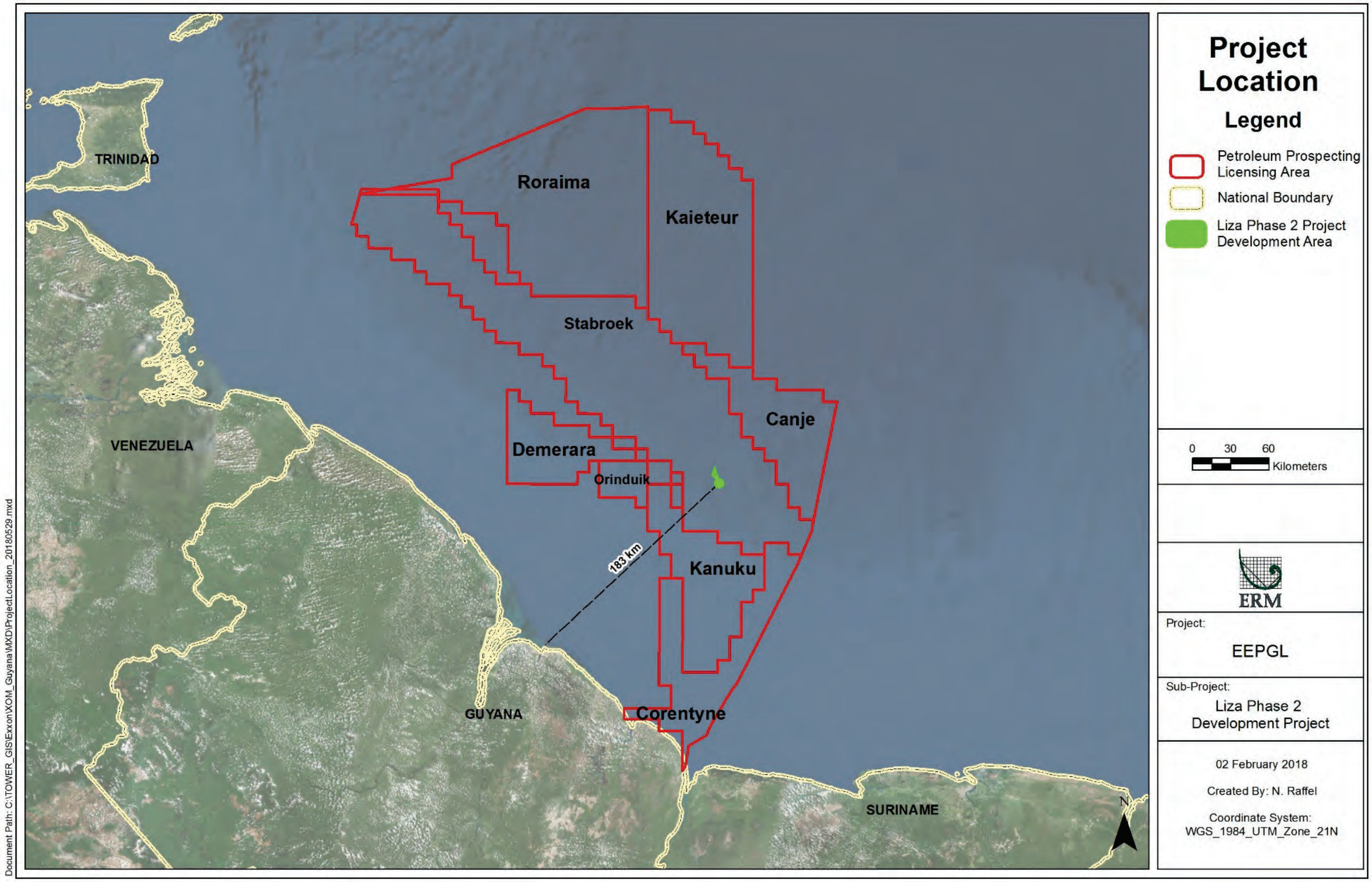


Figure 2-1: Location of the Liza Phase 2 Project Development Area within Stabroek Block

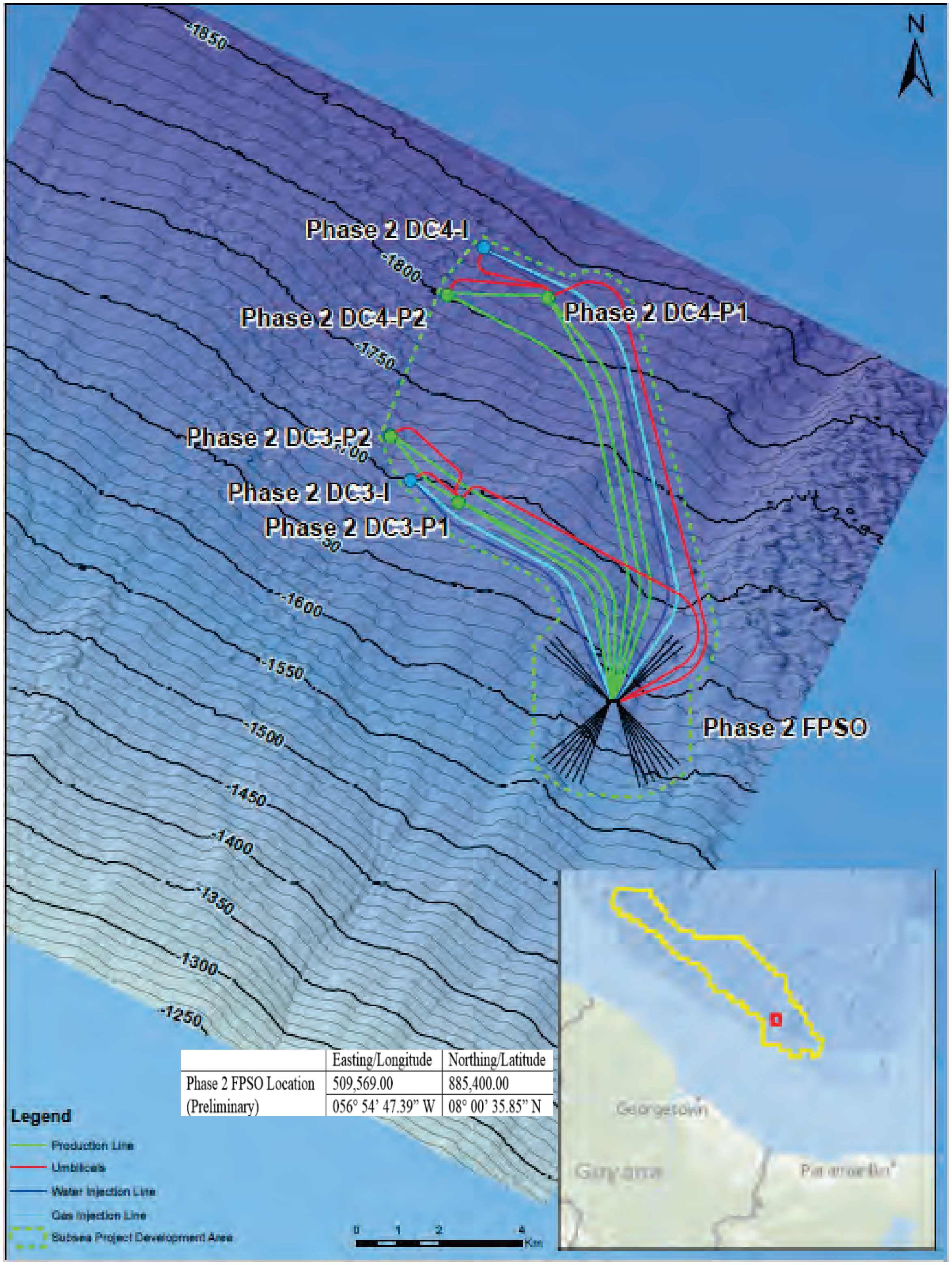
2.1. PROJECT AREA

The Stabroek Block, which covers an area of approximately 26,800 square kilometers (km^2), is oriented roughly parallel to the Guyana coastline, extending across the entire width (northwest to southeast) of Guyana territorial waters. There will be components of the Project located on the seafloor, suspended in the water column, and at the ocean surface. The combined extent of the area affected by both surface and subsea components and activities is referred to as the Project Development Area (PDA). Figure 2-1 illustrates the location of the PDA within the Stabroek Block; the PDA is located approximately 183 kilometers (114 miles) northeast of the coastline of Georgetown, Guyana. Figures 2.1-1 and 2.1-2 illustrate the preliminary conceptual layout of the FPSO, the SURF equipment, and the drill centers within the PDA.

The exact locations of the Liza Phase 2 development wells have not yet been finalized; however, the wells will be drilled from two main drill centers[2]. 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 7,660 hectares. This area is referred to as the Subsea PDA. Much of this subsea area will not be physically disturbed, except where the SURF equipment and the FPSO mooring system are sited, as shown on Figure 2.1-1.

During the production operations stage, work performed on the surface of the ocean could potentially cover an estimated 4,500 to 5,000 hectares. This area is referred to as the Surface PDA. As further described in subsequent sections and shown on Figure 2.1-2, this area of the ocean surface may have operational constraints that would restrict unauthorized vessels from entering defined marine safety exclusion zones during drilling and production operations. While Figure 2.1-2 shows seven marine safety exclusion zones around the drilling manifold locations, drilling will not occur at all locations simultaneously. The marine safety exclusion zones for the large installation vessels that will conduct FPSO and SURF facility installation are not denoted on Figure 2.1-2; however, the size of these marine safety exclusion zones will be similar to those utilized for the drill ships.

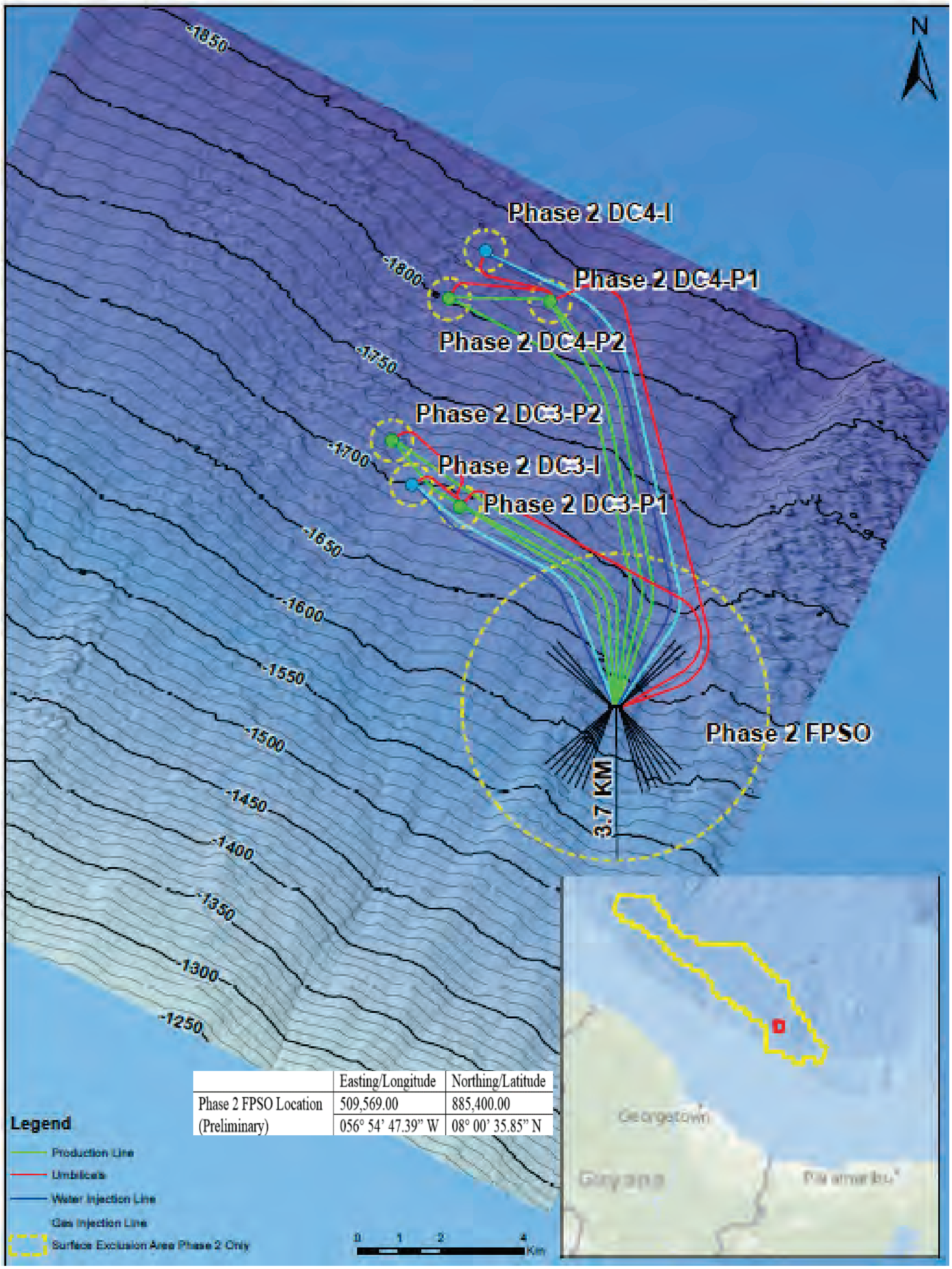
[2] For the Project, a drill center is defined as a group of wells (including production, water injection, and/or gas re-injection wells) clustered around one or more manifolds. Each drill center incorporates separate manifolds that are separated by several kilometers and are designed for production or injection. For example, Drill Center 3 will be separated into production (DC3-P1 and DC3-P2) and injection (DC3-I) components.



	Easting/Longitude	Northing/Latitude
Phase 2 FPSO Location	509,569.00	885,400.00
(Preliminary)	056° 54' 47.39" W	08° 00' 35.85" N

Note: Locations on figure subject to change

Figure 2.1-1: Liza Phase 2 Subsea Project Development Area



Note: Locations on figure subject to change

Figure 2.1-2: Liza Phase 2 Surface Project Development Area

2.2. PROJECT SCHEDULE

The Project life cycle will include engineering, development drilling, installation, hook-up, commissioning, startup, operations and maintenance, and decommissioning. Operations and maintenance will follow startup, and will be the longest stage of the Project.

Figure 2.2-1 provides a preliminary schedule for the major Project components and activities up to the start of production operations. As depicted on Figure 2.2-1, initial oil production is planned for mid-2022. To support this timing, development-well drilling is planned to start in early 2020. Installation of subsea components is planned to begin in 2020; the FPSO installation is planned to commence in late 2021. Production will continue for at least 20 years. These milestones are still being refined and are subject to change. This schedule provides for simultaneous development drilling and FPSO/SURF production operations after startup.

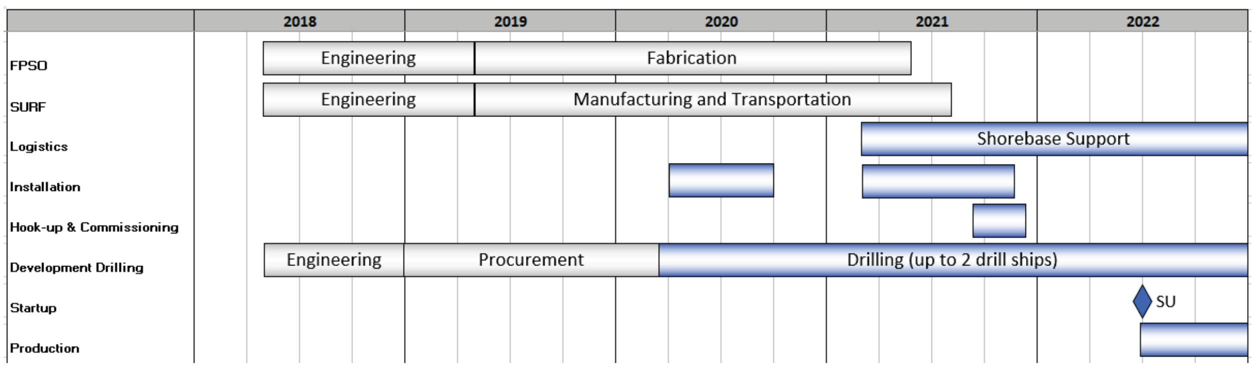


Figure 2.2-1: Preliminary Project Schedule

2.3. PROJECT WORKFORCE

Preliminary workforce estimates are provided in Table 2.3-1. These estimates may be further refined following selection and contracting for the drill ship(s), FPSO, SURF installation, support vessels, and shorebase support facilities. The current plan is to conduct primary support activities from shorebases in Guyana and Trinidad and Tobago.

Table 2.3-1: Preliminary Workforce Estimates

Project Stage	Estimated Workforce
Development well drilling	Approximately 600 persons at peak (Assuming two drill ships; dependent upon final drill ship and support vessel selection)
FPSO and SURF mobilization, installation, and hook-up	Approximately 600 persons at peak (Dependent upon final construction/installation and support vessel selection)
Production operations, including FPSO and conventional export tankers	Approximately 100 to 140 persons at peak (an additional 25–30 persons would be on board each export tanker)
Decommissioning	Approximately 60 persons at peak

In addition to the offshore components, there will also be personnel providing shorebase and marine logistical support on shore (approximately 100 to 150 persons), some of whom will be Project-dedicated while others will be shared resources. The onshore logistical support staff will ramp up gradually through the mobilization and installation stage until reaching a peak during the development drilling campaign and FPSO/SURF installation activities.

2.4. OVERVIEW OF THE DEVELOPMENT CONCEPT

2.4.1. Development Concept

The Liza field will be developed during Phase 2 with up to 33 development wells drilled from two drill centers, each with separate production, gas, and water injection manifolds. Figure 2.4-1 illustrates the preliminary field layout for the Project facilities, including the development wells, SURF, and a spread-moored FPSO vessel. The facility layout will continue to evolve during the design development process. The various components included in Figure 2.4-1 are further described below in the relevant drilling, SURF, and FPSO sections.

The development wells include production wells, water injection wells, and gas re-injection wells. A portion of the associated gas produced from the reservoir will be used on board the FPSO as fuel gas, and the remaining balance will be re-injected back into the reservoir via the gas re-injection wells. Water and gas injection will be used as needed to maintain reservoir pressure for optimal production over the life cycle of the Project.

The Project will utilize a spread-moored FPSO (see Section 2.7, Floating Production, Storage, and Offloading Vessel). The FPSO will support the topsides facilities, process the produced fluids from the production wells, and store the processed crude oil until offloading. Offloading of the processed crude oil for export will occur directly to conventional tankers. Subsea production, gas, and water injection wells and manifolds will be tied back directly to the FPSO via flowlines and risers (see Section 2.6, Subsea Umbilicals, Risers, and Flowlines).

2.4.2. Applicable Codes, Standards, and Management Systems

The various aspects of engineering design and operations will be carried out according to applicable Guyana statutory requirements, applicable international design codes and standards, applicable EEPGL and contractor design specifications, the EEPGL Operations Integrity Management System (OIMS)[3], and the EEPGL Safety, Security, Health, and Environment (SSHE) policies[4]. EEPGL and its contractors will have a structured management system to verify the ongoing application of all necessary codes, standards, procedures, and management systems. An overview of the EEPGL OIMS framework is included in Chapter 3, Administrative Framework.

[3] http://corporate.exxonmobil.com/company/about-us/safety-and-health/operations-integrity-management-system

[4] The policies are part of the overall Standards of Business Conduct policy: http://corporate.exxonmobil.com/en/company/about-us/guiding-principles/standards-of-business-conduct

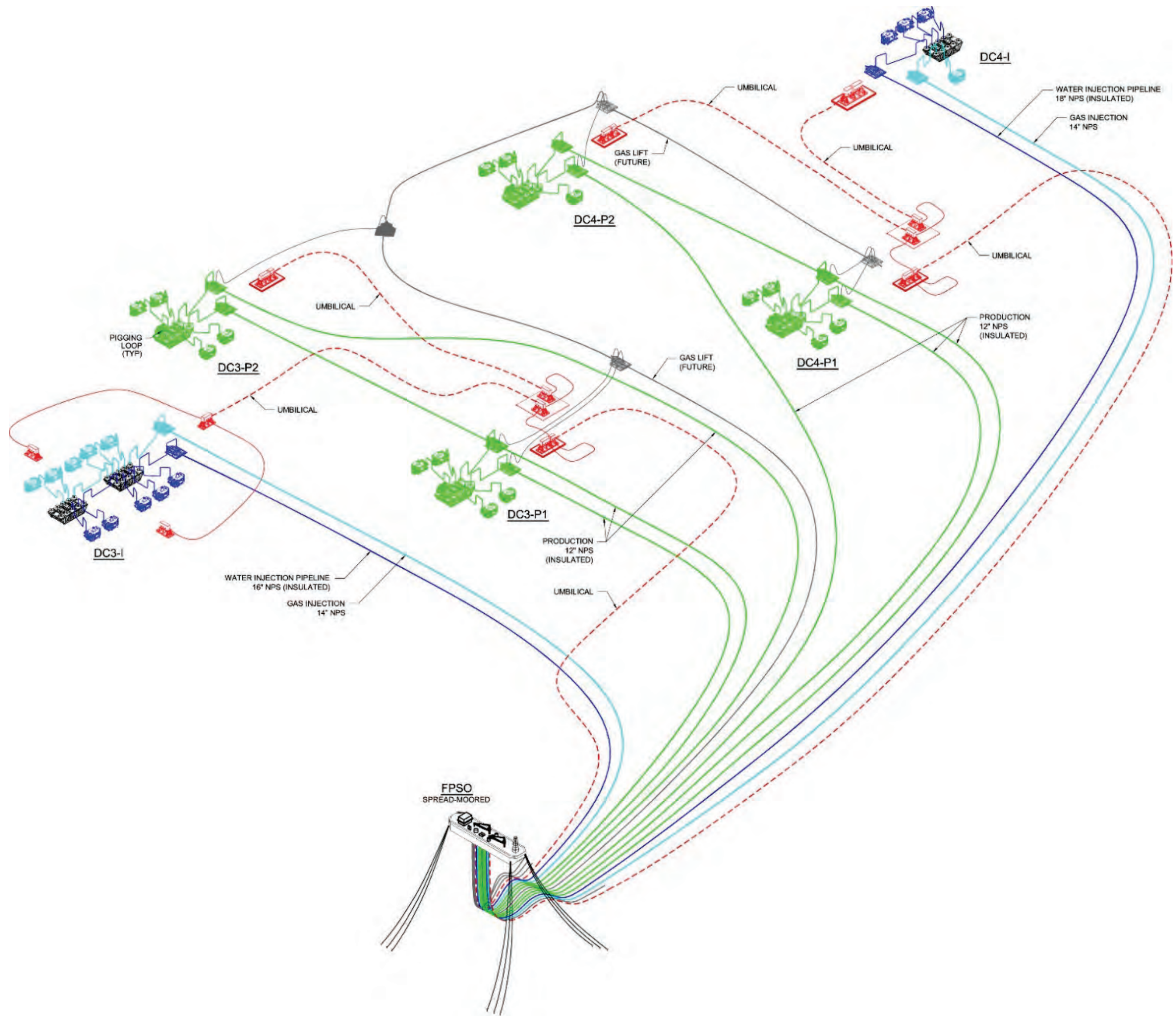


Figure 2.4-1: Preliminary Liza Phase 2 Field Layout

2.5. DRILLING AND WELL DESIGN

2.5.1. Drilling Program

The Project will use up to two drill ships similar to that shown on Figure 2.5-1 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. Drilling operations may occur prior to, during, and after the installation of the FPSO and SURF components.

Figure 2.5-1: Typical Drill Ship

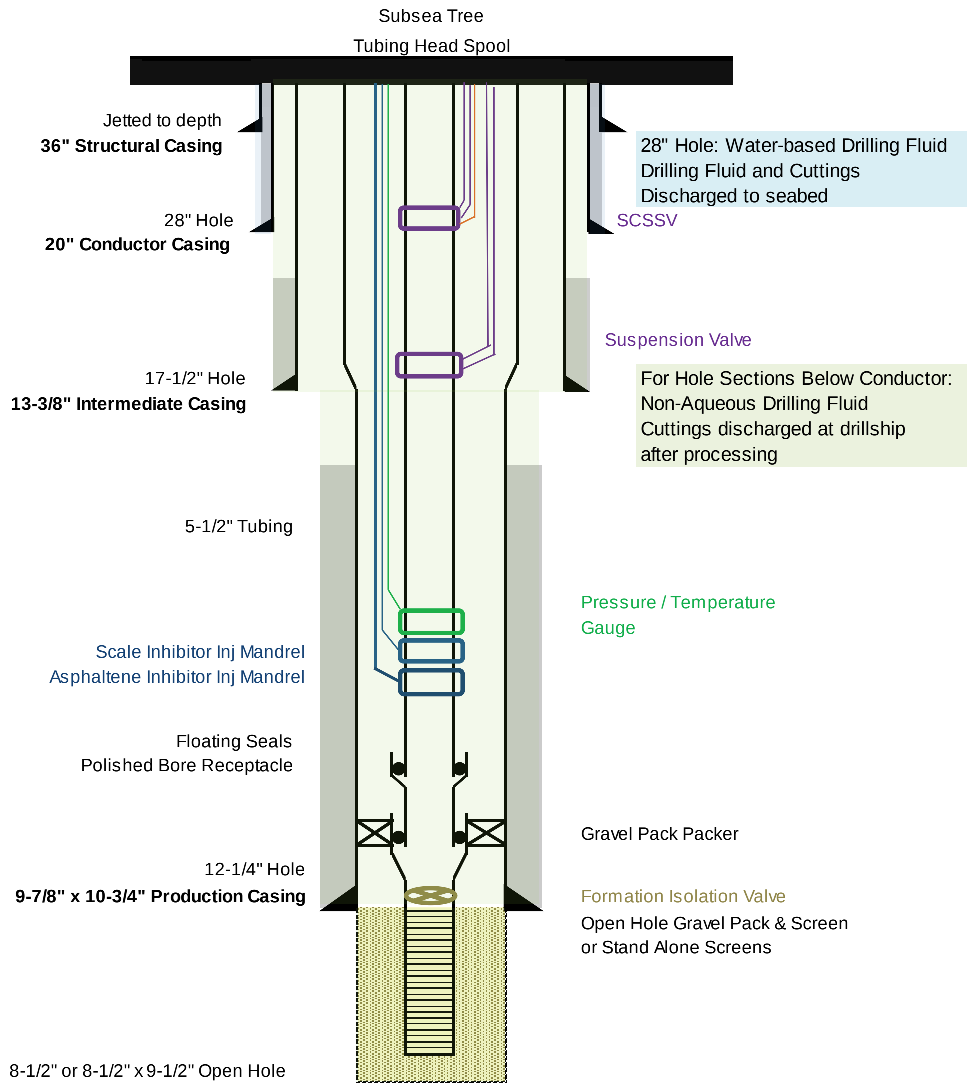
During the drilling process, drill ships will require various tubulars[5], instruments, and devices (collectively referred to as the drill string) to conduct the well construction process, which consists of drilling the borehole, running and cementing casings using a sequential batch drilling program followed by installing the completion and production tubing. The wellheads will be clustered around two major drill centers rather than being distributed over the seabed above the producing reservoirs. This approach reduces the number of drilling locations, thereby reducing the seabed area potentially affected by drilling operations, including discharge of drill cuttings[6]. The planned development-drilling program and its cuttings management approach are consistent with industry practices and have previously been the basis for exploration wells in the Stabroek Block; they are also the basis for the development wells for the Liza Phase 1 Development Project.

2.5.2. Typical Well Design

Once the borehole is started for a well, pipe (also known as casing) is inserted into the borehole and cemented in place to keep the well from collapsing and to seal the casing to the formation. Various sized casings are progressively set as the well is drilled deeper. After each casing (for the conductor casing and deeper casings) is installed, pressure and integrity testing will be performed according to standard industry practices. A provisional well program and design for the Liza Phase 2 development-drilling program, including casing types and sizes, setting depths, drilling fluid types, and discharge locations, is shown on Figure 2.5-2.

Figure 2.5-3 shows the various components of a typical subsea drilling system.

[5] Tubulars include various types of piping, such as drill pipe, drill collars, casing, and production tubing.
[6] Drill cuttings are the broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil.



SCSSV = surface-controlled subsurface safety valve

Figure 2.5-2: Provisional Casing Program for Development Drilling Program

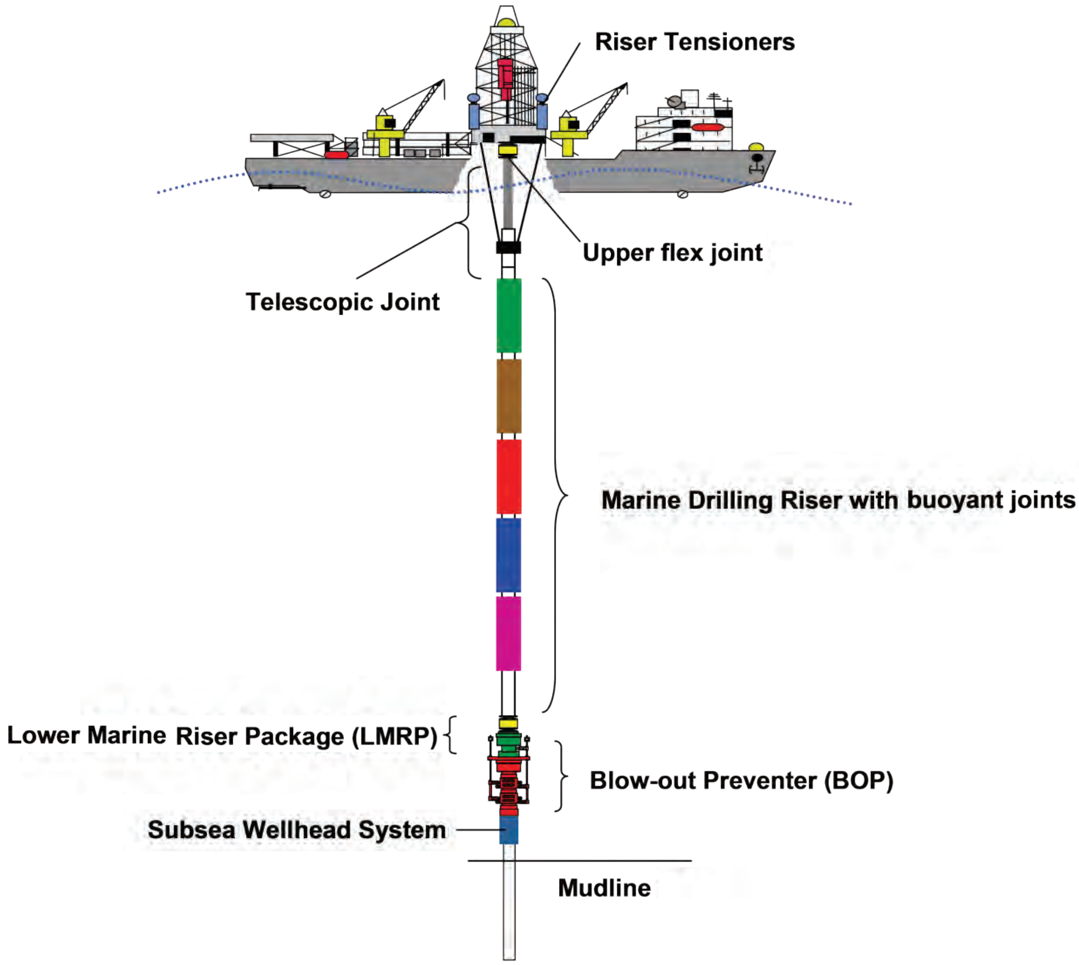


Figure 2.5-3: Typical Subsea Drilling System

2.5.3. Drilling Fluids

The drilling process will require drilling fluid to remove cuttings and to control formation pressures. The choice of drilling fluids will be based on the challenges associated with drilling in deep-water environments, which differ from shallow-water drilling in the following aspects:

- Colder temperature/higher seawater hydrostatic pressure at the mudline;
- More narrow window between pore pressure[7] and fracture gradient[8]; and
- Longer drilling risers requiring larger volumes of drilling fluid.

Three categories of drilling fluids will be used: seawater, water-based drilling fluids, and non-aqueous drilling fluids (NADF) in which the continuous phase is an International Oil and Gas Producers Group (IOGP) III low-toxicity non-aqueous base fluid (NABF) with low to negligible aromatic content. Water-based drilling fluids will be used when drilling the upper sections of the well. Based on wellbore stability analysis and experience gained from exploration drilling, NADF will be required to maintain borehole stability while drilling all well sections below the conductor casing.

Solids control and cuttings drying equipment will be installed on the drill ships to process and reduce the percentage of NABF retained on cuttings (%BFROC). The cuttings will be discharged to the sea after treatment, in accordance with standard industry practice. The use of this equipment on other similar projects has significantly reduced the %BFROC.

2.5.4. Well Cleanup and Ancillary Processes

2.5.4.1. Well Cleanup

Development wells will be drilled, completed, and tied-back to the FPSO. Injection wells will not be flowed back (i.e., unloaded) to the FPSO or to the rig before commencing injection. For oil-producing wells, fluids left in the well bore will be flowed back to the FPSO and cleaned up through the subsea tree/flowlines/production equipment.

2.5.4.2. Vertical Seismic Profiling

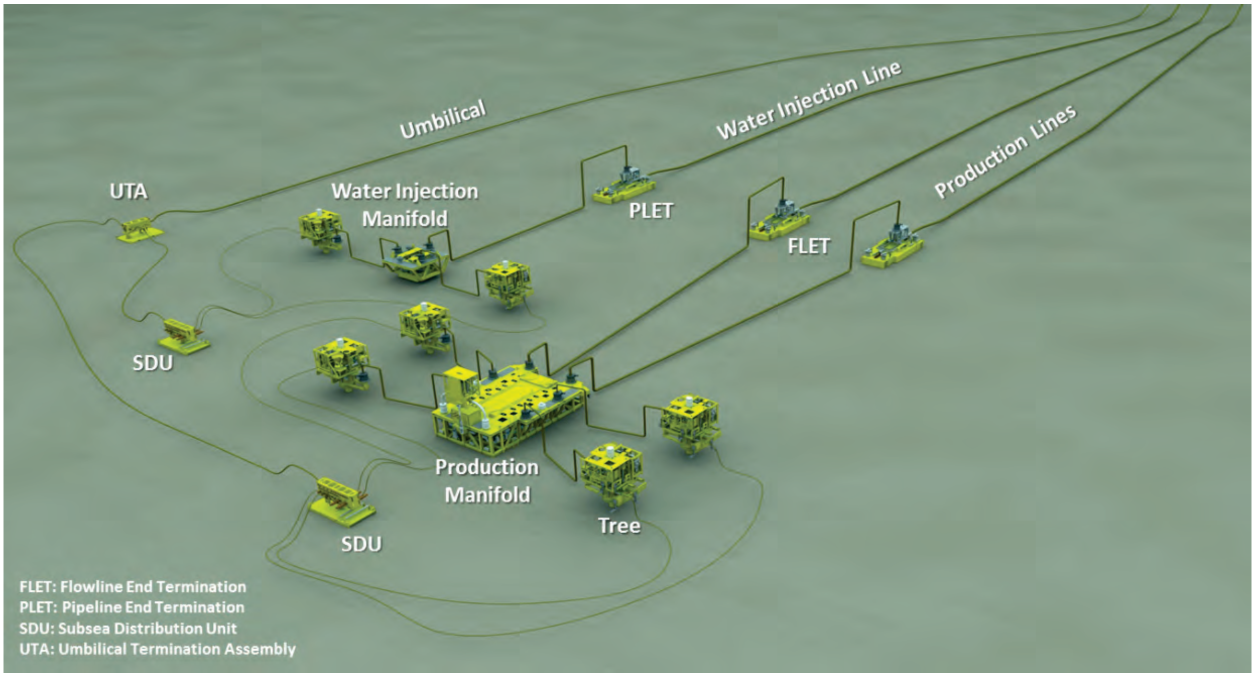
Vertical Seismic Profile (VSP) data may be collected to improve velocity modeling and reduce uncertainty in reservoir mapping. VSP surveys can be used to correlate the surface-seismic data to the information on the physical properties and characteristics of the hydrocarbons gained from drilling the well. VSP data, along with check shots and well logs, provide further time/depth information from which to improve knowledge and understanding of the structure and stratigraphy of a reservoir.

A VSP survey requires a sound source (commonly compressed air) and a receiver. Data are acquired by the receiver, which is installed within the wellbore. The source may be located above the wellhead or may be located farther away or "walked away" using a boat. The final scope of such a survey and specific geophysical tools to be used is still under review.

[7] Pressure of fluids within the pores of a reservoir
[8] Pressure required to induce fractures in rock at a given depth

2.6. SUBSEA UMBILICALS, RISERS, AND FLOWLINES

The SURF facilities for the Project will include subsea production, gas re-injection, and water injection wells clustered around subsea manifolds. The development wells will be drilled from two subsea drill centers. This approach of clustering the wells around drill centers reduces the required number of manifolds, flowlines, and umbilicals[9], as well as the size of equipment and marine vessels needed for installation. The risers and umbilicals will connect the infrastructure on the seafloor to the FPSO. The manifolds will connect the individual development wells to the rest of the subsea system. The subsea system will be monitored and controlled from the FPSO using a control system connected to the FPSO through an umbilical that also supplies power, hydraulic fluid, and chemicals to the subsea manifolds and wellhead trees[10]. The hydraulic fluid for operating the subsea control system will be a low-toxicity, water-soluble hydraulic fluid. The SURF system will be designed to withstand the full shut-in pressure from the production wells, and the gas/water injection components will be designed to withstand the highest required injection pressures. Overpressure protection will be provided on the FPSO, in accordance with industry standards, to protect the subsea systems. Figure 2.6-1 shows an illustration of a representative SURF system similar to what is currently being designed for the Project.



Note: Schematic is not necessarily representative of number of drill centers or wells.

Figure 2.6-1: Representative SURF System

[9] A cable and/or hose that provides the electrical, hydraulic, chemical, and communications connections needed to provide power and control between the FPSO and subsea equipment

[10] Assembly of valves, spools, pressure gauges, and chokes fitted to the wellhead of a completed well to control production

The production drill centers also will be connected to the FPSO with round-trip piggable production flowlines. A "pig" is a specially designed device that is placed in the flowline at a launcher at one end and pushed by pressure until it reaches a receiving trap or catcher at the other end. Pigging is performed to aid in the maintenance, operations, cleaning, and/or inspection of flowlines. Figure 2.6-2 shows an example of a pig.

Figure 2.6-2: Example of Wire Brush Cleaning Pig

2.6.1. Well Flow Connections

Well flow connections between the subsea wells and the FPSO include several components. Each subsea development well is capped by a wellhead tree, which includes a choke valve to control production or water/gas injection. For a given set of wells tied to the same manifold, each wellhead tree is connected by jumpers to the well manifold, which is connected by a flowline jumper to a flowline end termination (FLET) located at the drill center end of the flowline.

A typical configuration of subsea wells, flowlines, and manifolds at a drill center is shown on Figure 2.6-3.

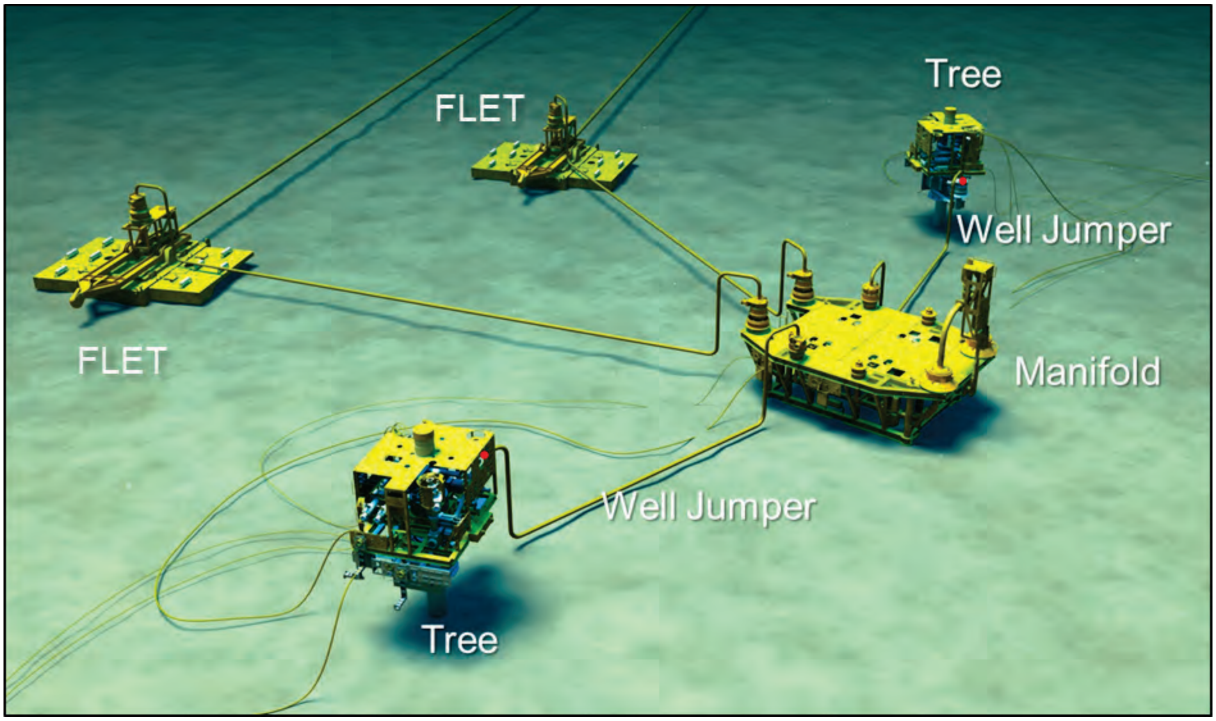


Figure 2.6-3: Typical Subsea Wellhead Tree, Jumper, and Manifold

From the drill center, the rigid flowline travels on the seabed to the vicinity of the FPSO. At the FPSO end of the flowline, the flowline transitions to a riser, which carries the fluids between the seafloor and the FPSO at the surface.

The risers transition from the seabed to the FPSO in a “lazy wave” configuration as shown on Figure 2.6-4.

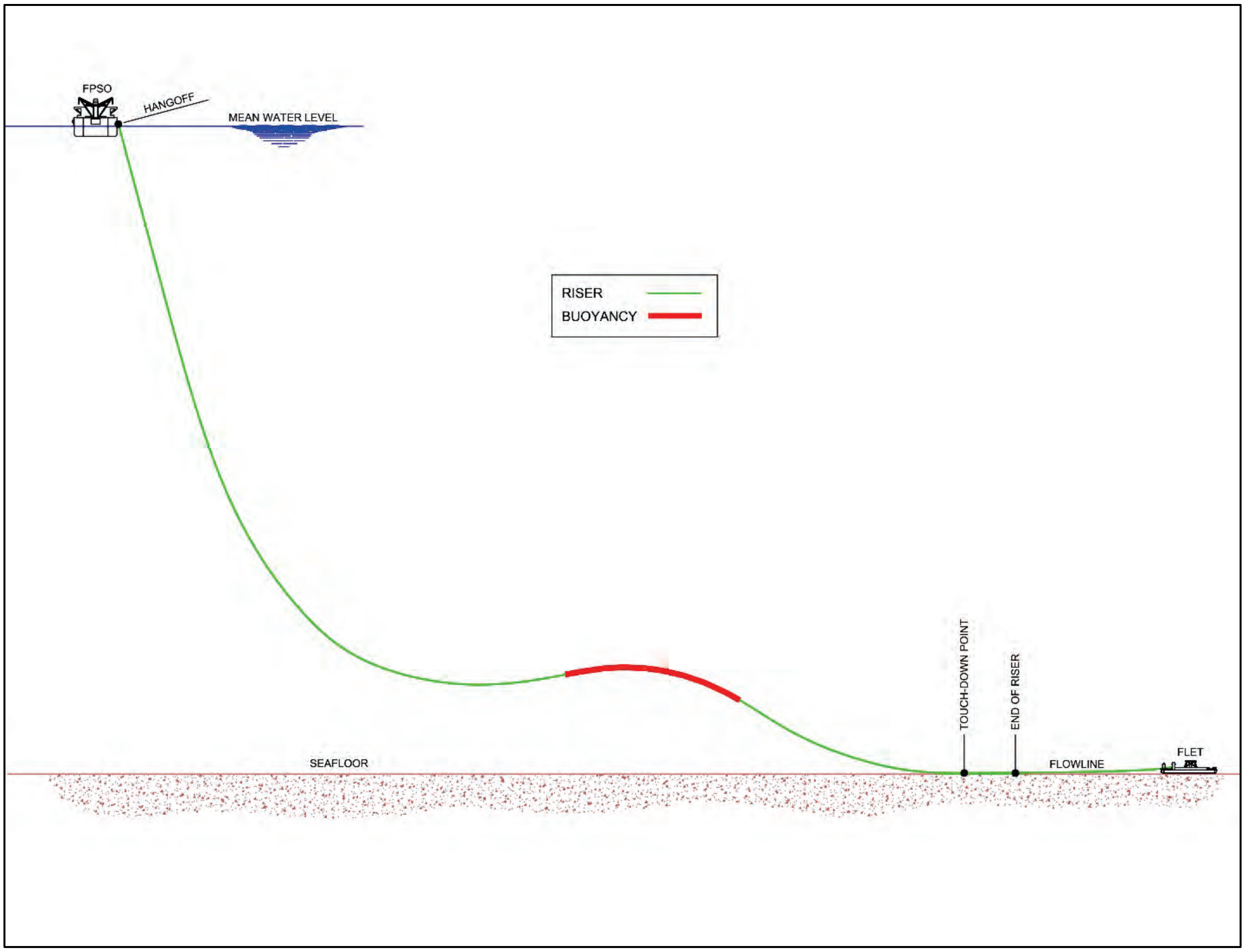


Figure 2.6-4: Representative Steel Catenary Riser

2.6.2. FPSO Subsea System Control

The FPSO will provide power, utilities, cabling, and tubing/piping tie-ins to equipment installed on its topsides to control the subsea equipment (see Figure 2.6-5). The FPSO will be configured with backup power so operations can continue in the event primary power is lost.

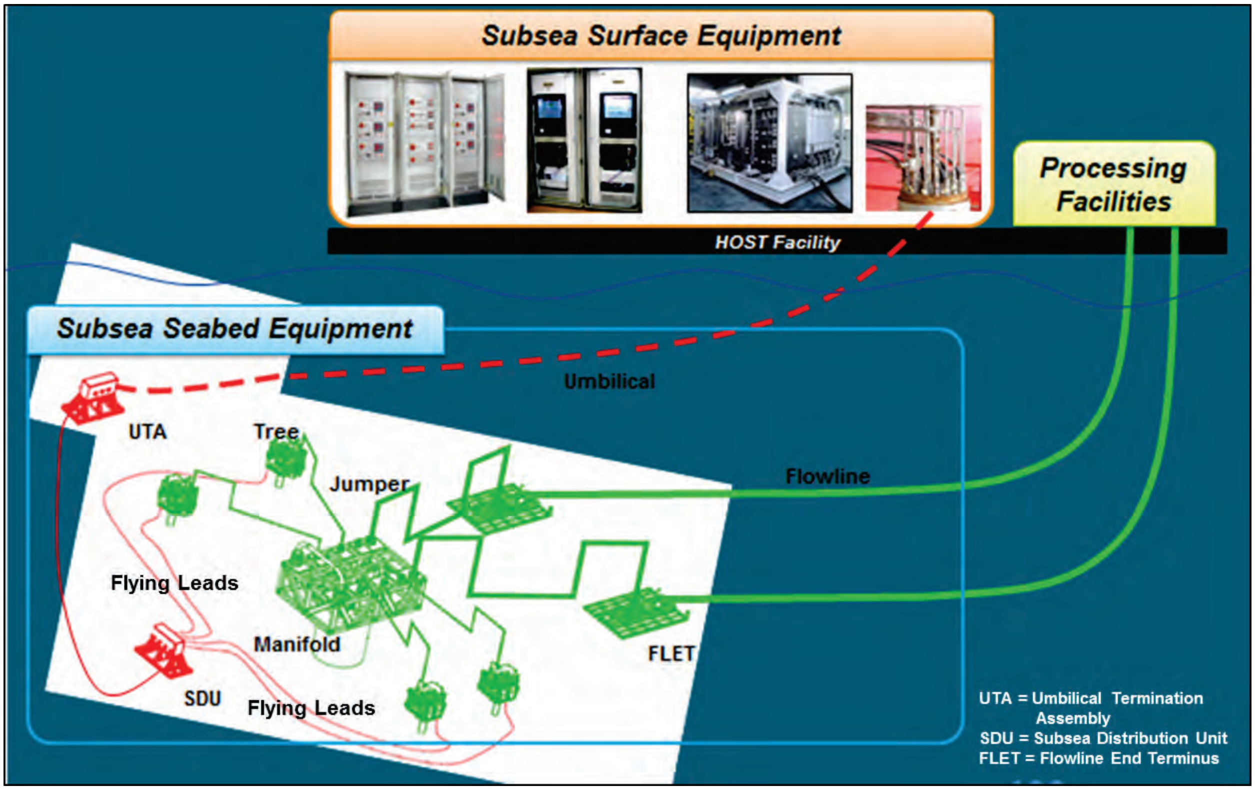


Figure 2.6-5: Representative Subsea Control System

The subsea wells and manifolds will be monitored and controlled from the FPSO. Each tree will have a subsea control module mounted on it that controls and monitors the tree functions (e.g., choke-valve position) and associated manifold functions. Subsea controls will accommodate typical monitoring requirements such as pressure and temperature measurement.

The control systems at each drill center will be supplied from the Process Control System (PCS) on the FPSO by an umbilical. The umbilical will supply control fluid to operate all hydraulically operated valves, provide chemicals as required to ensure flow to the FPSO, and provide low-voltage power and communication to operate and monitor the SURF facilities. The umbilical will terminate in a Subsea Distribution Unit (SDU). Hydraulic and electrical leads ("flying leads") will be used to connect the SDU to the well-mounted subsea control modules and may be installed together to reduce congestion on the seabed.

2.6.3. Risers, Flowlines, Umbilicals, and Manifolds

2.6.3.1. Risers and Flowlines

The Project will incorporate production, water injection, and gas injection flowlines and risers, as shown on Figure 2.4-1. Flowline and umbilical lengths will range from 4 to 13.5 kilometers (approximately 2.5 to 8.4 miles), excluding risers, in water depths of approximately 1,600 to 1,900 meters. The current design lengths are based on preliminary shallow hazard surveys and current field layout, and may be adjusted slightly during detailed design.

2.6.3.2. Umbilicals

Umbilicals will be designed as an integrated bundle of tubes and cables to serve multiple functions (see Figure 2.6-6). Two dynamic umbilicals, each of which will be connected to the FPSO and terminate subsea at a single manifold for one of the drill centers (DC3 and DC4), will service the entire Liza Phase 2 production operation. The remaining drill center components, composed of the subsea trees, manifolds, flying leads, and jumpers, will be connected via in-field umbilicals.

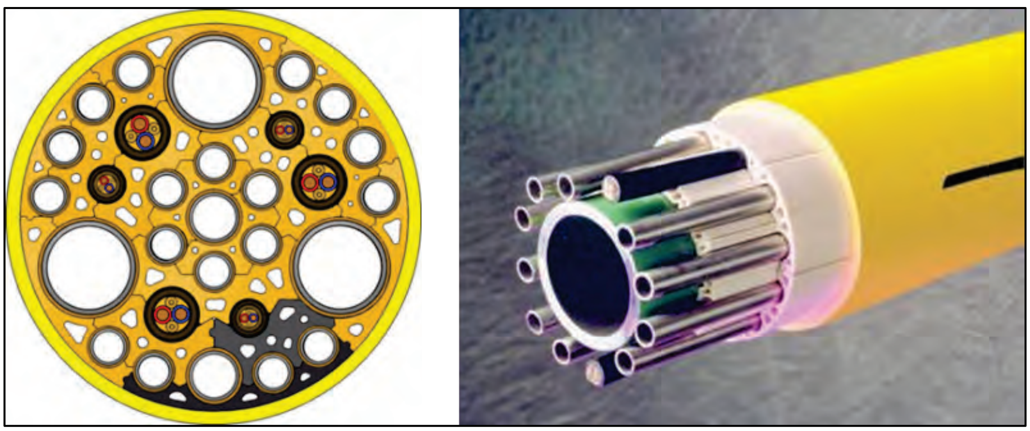


Figure 2.6-6: Representative Integrated Dynamic Umbilical with Cross Section

2.6.3.3. Manifolds

Manifolds are gathering points or central connections made up of valves, hubs, piping, sensors, and control modules. Manifolds (see Figure 2.6-7) include a protective structural framework that rests on a foundation on the seabed where multiple trees, jumpers, and flowlines gather to consolidate flows before they are transported either to the surface as part of production or back downhole as part of injection into the reservoir.

Figure 2.6-7: Representative Subsea Manifold

2.6.3.4. Gas Lift System

The FPSO riser support system will be designed for gas-lift capability. The gas-lift system is not required for initial startup and may be installed at some future time during the Liza Phase 2 service life based on the production characteristics of the Liza field. This system will include a riser and flowline to DC3 and DC4, with connections to the production flowline's FLETs.

2.7. FLOATING PRODUCTION, STORAGE, AND OFFLOADING VESSEL

2.7.1. General Description

The FPSO to be utilized for the Project will utilize a spread-moored configuration to maintain station continuously for at least 20 years. The FPSO will be designed to receive the full production wellstream from the development wells and will process crude oil at a design rate of 220,000 barrels of oil per day (BOPD), with potential to safely operate at sustained peaks of up to 250,000 BOPD. For the purposes of the EIA, potential impacts generated by the Project will be assessed based on a conservative production rate of 300,000 BOPD. The FPSO will be capable of storing a minimum of 2 million barrels of stabilized crude oil. The FPSO will be able to offload approximately 1 million barrels to a tanker in a period of approximately 28 hours.

The FPSO will also have the capability to process, dehydrate, compress, and re-inject the gas produced from the reservoir. The FPSO will be configured to treat seawater used for facility cooling purposes for discharge and injection into the reservoir and to process produced water for discharge overboard. Living quarters and associated utilities will be provided to support the operations on the FPSO. The FPSO topsides equipment and design will have a design life of at least 20 years.

Table 2.7-1 provides an estimate of the design rates for the FPSO facility.

Table 2.7-1: FPSO Key Design Rates

Service	**Design rate** [a,b]
Oil production	220,000 BOPD
Produced water	225,000 BPD
Total liquids	300,000 BPD
Produced gas	400 MMscfd
Gas injection	370 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; MMscfd = million standard cubic feet per day

[a] All design rates are presented as the peak annual average.

[b] The facilities will have the potential to safely operate at sustained peaks of oil production up to approximately 250,000 BOPD. For the purposes of the EIA, 300,000 BOPD will be used as the basis to assess potential impacts from the Project.

Key FPSO design features include the following:

- The FPSO will be designed to remain moored for at least 20 years without dry-docking, and will include facilities to support in-water hull/structural surveys and repair and maintenance.
- The FPSO will be designed to operate in extreme (100-year return period) environmental conditions (associated wind, waves, and current).
- The FPSO will be designed to re-inject produced gas back into the reservoir except during times of injection system unavailability, which will require temporary, non-routine flaring during maintenance/repair.

A computer-simulated picture of a typical FPSO is provided on Figure 2.7-1.

Figure 2.7-1: Computer Simulated Picture of a Typical FPSO

2.7.2. FPSO Topsides

The FPSO's topsides design utilizes an interconnected module concept where process equipment is packaged in modules. The design concept maximizes pre-commissioning and functional testing of the modules prior to arrival offshore Guyana. The FPSO will arrive for installation, hook-up, and commissioning in the Stabroek Block fully fabricated and preassembled. The following are the principal functions of the topsides process facilities:

- Receive, separate, and process the produced reservoir fluids to provide:
  - Crude oil for offloading onto conventional tankers;
  - Produced water of sufficient quality for environmentally acceptable discharge to the sea; and
  - Produced gas that meets fuel gas requirements for FPSO power and for re-injection into the reservoir;
- Treat seawater to provide a suitable supply of water for injection into the reservoir; and
- Provide support systems for the safe accommodation of approximately 80 to 120 persons involved in the operation of the production facilities and, on occasion, persons involved with the drilling program.

Temporary accommodations may also be utilized during key activities including hook-up, commissioning, and maintenance operations to increase accommodations capacity to 160 persons.

The FPSO accommodations block will be located at the stern of the vessel, isolated from processing equipment, and positioned in proximity to the fully enclosed life boats. It will be outfitted, decorated, and furnished according to current shipbuilding standards and of a modern European style. The cabins will be a mix of one and two person cabins. Some cabins will have an associated dayroom/office, some will be superintendent-type cabins, and some will be regular sleeping cabins. Noise levels within the cabins are designed for less than 45 decibels (A-weighted). The cabins in the accommodation block are designed to accommodate a total complement of 160 persons on board.

The accommodations block will also be outfitted with recreational spaces available to all personnel onboard, including a quiet lounge and library, recreation lounge, gymnasium, and smoking room. Catering services and provision stores will be located in the block. Additional ancillary spaces in the accommodation block will include the following:

- Clinic
- Control Room and Emergency Response Base
- Offices
- Male/female change rooms and laundry
- Technical equipment rooms and duty lockers

The air conditioning and ventilation system in the accommodation block will be designed for 25 years in accordance with industry standards and guidelines. The accommodation spaces will be pressurized to +50 pascals relative to the external atmospheric pressure. Differential pressure transmitters will be provided at each deck level within the accommodation block, and alarms will be raised in the Central Control Room (CCR) in the event of a loss of pressurization inside the accommodations. Entrance into the accommodation block will be completed via an airlock. The airlock will be provided with two doors; the design of this two-door airlock system will ensure that the accommodations remain pressurized and prevent outdoor air from entering in the accommodation block when outer doors are open. The outer door will be at a minimum weather tight while the inner door will be the self-closing type. The linings and ceiling used in the airlock will be constructed with air-sealed joiner panels.

The accommodation spaces will also be equipped with fire and gas detection systems. In the CCR, there will be a direct line of sight to the fire and gas monitors from the operators' positions. With regards to passive fire protection, class and other flag state requirements will be used to determine the necessary structural fire protection. At a minimum the following spaces will be at least A-60 insulated:

- CCR
- Galley
- Accommodation Equipment Room
- Telecom Equipment Room
- Computer Equipment Room

The forward facing bulkhead of the accommodation block will be marine-grade H-60[11] insulated up to the C-deck and A-60 insulated for everything beyond the C-deck. All doors and windows located in this bulkhead will have the same insulation rating as the bulkhead in which they are installed. In general, all windows within the accommodation block are expected to have the same fire integrity as the wall in which they are installed. The entire window unit will be gas tight and weatherproof and have a minimum blast resistance of 0.5 barg[12]. The blast wall (an extension of the forward accommodation bulkhead) will be A0 rated and will run transversally up the sides of the vessel and vertically from the main deck to the D-deck. Structural deckhouse extensions forward of the accommodation front bulkhead and unprotected deckhouse areas 3 meters aft of the accommodation front bulkhead will also be H-60/A-60 protected.

The following signage within the accommodation block will be photo-luminescent at a minimum to indicate the following:

- Emergency exit signs on emergency exit doors;
- Push/pull signs or handle position signs on emergency exit doors;

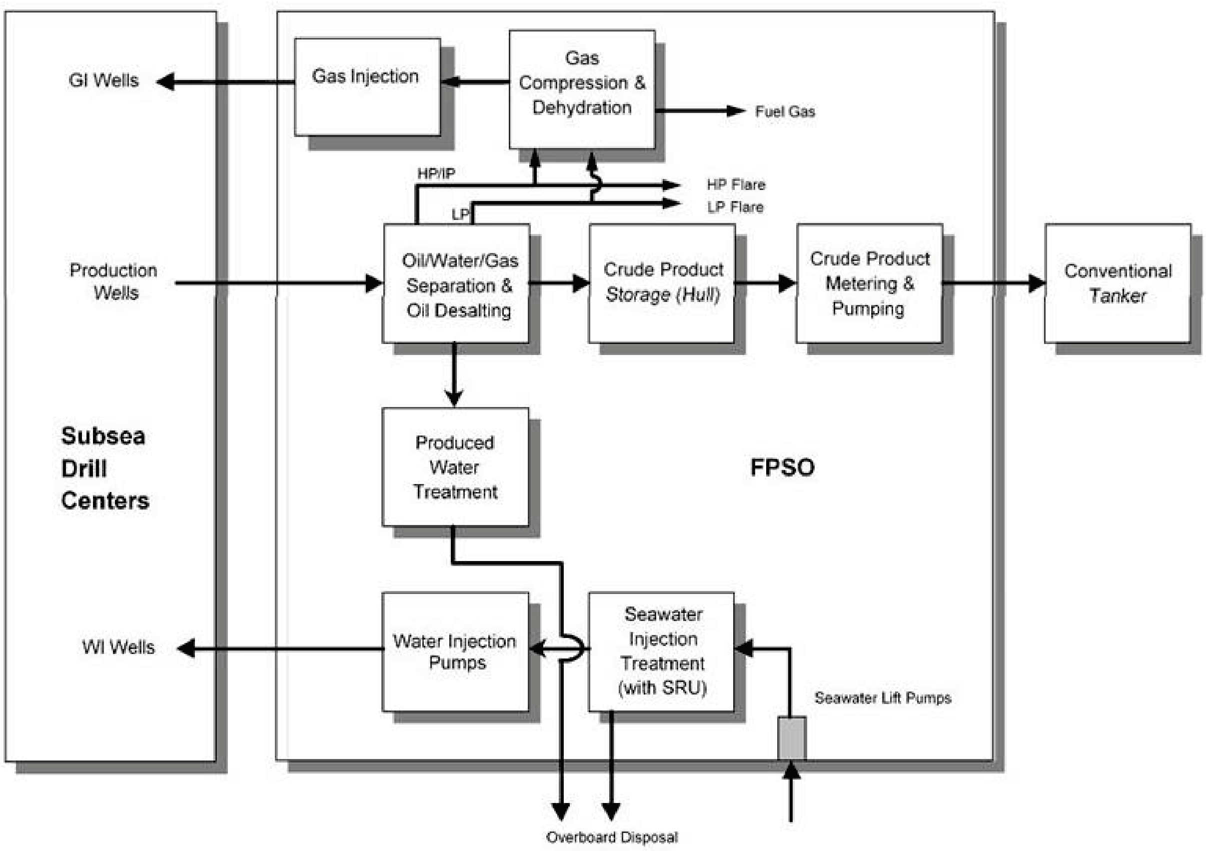
[11] If subjected to the standard fire test for 60 minutes, has an average temperature rise on the unexposed side of the insulated bulkhead or deck of less than 139°C (250°F) above the temperature before the standard fire test and has a temperature rise at any point on the unexposed surface, including any joint, of less than 180°C (325°F) above the temperature before the standard fire test. *Source: Mobile Offshore Drilling Units, 46 [U.S.] Code of Federal Regulations 107-109 (2013)*

[12] Barg pressure is the pressure, in units of bars, above or below atmospheric pressure

- Exit signs on high traffic area doors such as mess room, recreation room, and conference room;
- Direction markers indicating escape routes positioned at low levels in corridors and escape ways;
- Signs indicating route to and direction of internal stairways;
- Signs indicating route to and direction of external stairways; and
- Signs indicating directions to the lifeboat loading areas

2.7.3. FPSO Process Systems

The process facilities on the FPSO topsides are shown schematically on Figure 2.7-2 and are described in the following sections.



GI = gas [re]injection; HP = high pressure; IP = intermediate pressure; LP = low pressure; SRU = Sulfate Removal Unit; WI = water injection

Figure 2.7-2: FPSO Topsides Process Flow Diagram

2.7.3.1. Oil/Water/Gas Separation and Oil Desalting

An inlet manifold is required to receive full wellstream-produced fluids from the reservoir (consisting of oil, gas, and water) via the production flowlines, and to route the fluids to the FPSO processing facilities. The full wellstream-produced fluids will be separated into oil, water, and gas phases. Fresh water will then be added to the stabilized crude oil to remove dissolved salts as part of what is known as "oil desalting." The final crude oil from the separation/ stabilization process will be treated to meet the specifications for sale prior to being sent to the crude oil storage tanks in the FPSO hull. Further processing of the water and gas streams from the separation process and the process for treating seawater for injection are described below.

2.7.3.2. Gas Processing

The purpose of the FPSO gas-processing system is to condition the associated produced gas (that which is not consumed as FPSO fuel gas) to the appropriate specification prior to re-injection into the reservoir. The gas-processing system consists of the following subsystems:

- Flash Gas Compression—recovers and compresses flash gas from the intermediate-pressure (IP) and low-pressure (LP) separators to mix with the gas from the high-pressure (HP) separator;
- Main Gas Compressor—compresses gas from the HP separator and the flash gas compressor to an inter-stage pressure where it can be used as fuel gas, with the remaining gas compressed up to an appropriate pressure for gas lift (when required);
- Gas Dehydration—removes water vapor from gas to prevent hydrate formation in the gas lift and gas injection systems where HP gas will cool to seabed temperatures;
- Fuel Gas—provides fuel gas to all electrical power generation gas turbines, direct-drive gas turbines, and all other LP gas users (marine boilers, pressure control of vessels, etc.); and
- Injection Gas Compression—compresses discharge gas from the main gas compressor(s) to an appropriate pressure level where it can be re-injected into the reservoir. The HP re-injection gas is routed to the gas injection riser and then directed to the remote, subsea injection wells.

The Project is planning to re-inject any produced gas (that which is not consumed as fuel gas on the FPSO) back into the reservoir.

During equipment maintenance and process upsets, including startup and shutdown scenarios, part or all of the off-gas from the separation/stabilization process will be sent to the HP or LP Flare Systems. Flaring will be temporary and non-routine.

2.7.3.3. Produced Water Treatment

The produced water treatment system will be designed to collect produced water from process facilities and treat the water for discharge overboard. Produced water that does not meet the overboard discharge specification after treatment will be routed to an appropriate tank in the hull and managed as described in Section 2.7.8.1, FPSO Cargo Systems.

2.7.3.4. Seawater Treatment and Water Injection System

Seawater will be used for water injection and will be treated prior to injection into the producing reservoirs. Water injection will be used for reservoir pressure maintenance to enhance oil production. Seawater lift pumps on the FPSO will be used to pump seawater from depths up to 100 meters below the surface to access colder seawater than is available from the shallower depths. The filtration system will remove particulate from the incoming seawater. Following filtration, the seawater will be treated to remove dissolved oxygen and sulfate ions. The treated seawater will then be pumped at the pressure necessary for injection into the reservoir.

A portion of the treated seawater will be further treated through a reverse osmosis system to make fresh water. Fresh water is required both for potable water requirements as well as for removal of salt from the crude oil as part of oil desalting, as described in Section 2.7.3.1, Oil/Water/Gas Separation and Oil Desalting.

2.7.4. FPSO Utility Systems

This section discusses the utility system requirements for the FPSO.

2.7.4.1. Process Cooling

Cooling of process streams via a closed-loop, water-based cooling medium system is required to dissipate heat generated by the oil and water treating systems, compression systems, and miscellaneous utility systems. The seawater lifting system will supply the required seawater for cooling (see Section 2.7.3.4, Seawater Treatment and Water Injection System). Process hydrocarbon fluids will not come into contact with this seawater. After use in the cooling system, seawater will be discharged overboard at a rate and configuration suitable to maintain ocean temperatures at or below permitted levels established to avoid adverse effects to marine life.

2.7.4.2. Process Heating

A process heating system is required as part of the crude oil treatment process to achieve the required crude oil specifications. A closed-loop, water-based heating medium system will be used to add heat to the incoming production stream. Waste heat from the power generation system will be used as the source of heat.

2.7.4.3. Flaring System

EEPGL intends to re-inject produced gas under routine conditions, except that which will be utilized as fuel gas for FPSO operations. A flare system will be provided for the collection and safe disposition of produced hydrocarbon gases resulting from unplanned, non-routine relief and blowdown events. Relief events occur to prevent overpressure scenarios in the process equipment. Blowdown events occur to depressurize the facilities in a controlled manner as a result of emergency shutdown events. In addition, temporary, non-routine flaring will occur during equipment maintenance and process upsets, including startup. The flare system will include both an HP and LP flare sharing a common flare tower. The flare tower has elevated flare tips for both HP and LP flares, which provides for the safe ignition of hydrocarbon gases.

Both flares will support high-efficiency combustion and will utilize pilots that have minimal emissions.

2.7.4.4. Topsides and Subsea Chemical Injection

The FPSO will have storage and injection facilities to inject the required amounts of chemicals and methanol into the production fluids to support production operations, both for subsea chemical injection requirements and for topsides chemical injection requirements. Topsides chemicals may include corrosion inhibitors, scale inhibitors, asphaltene inhibitors, emulsion breakers, anti-foam agents, demulsifiers, oxygen scavengers, biocides, water-treatment chemicals, and hydrogen sulfide (H_2S) scavengers. Subsea chemicals may include methanol, scale inhibitor, corrosion inhibitor, asphaltene inhibitor, and xylene. Methanol and xylene will be stored in tanks that are integrated into one of the FPSO hull cargo tanks.

2.7.4.5. Air

An air compression system will be provided to supply hull and topsides equipment. Compressed air is required primarily for the operation of control valves and other process instrumentation requirements.

2.7.4.6. Nitrogen

Instrument air will feed the nitrogen generation system. Nitrogen will be provided as required for purging, inerting, and blanketing, and as required for miscellaneous utilities.

2.7.4.7. Drains

The topsides will be equipped with the following drain systems:

- Non-hydrocarbon open drain—used to collect drain fluids from non-hydrocarbon areas (e.g., rainwater) and to route them to the slop tank in the FPSO hull or directly overboard;
- Hydrocarbon open drain—used to collect drain fluids from hydrocarbon areas (e.g., oil-contaminated water) and to route them to the slop tank in the FPSO hull; and
- Closed drain system—used to collect drain fluids from produced water systems and to route them back into the process.

2.7.4.8. Other

A minimum of two deck cranes will be provided for supply boat offloading and materials handling and to support general maintenance activities. Workshops, a laboratory capable of checking the properties of the produced and injection fluids as well as select discharges for compliance, a medical facility, and a storage facility for supplies and spare parts will also be provided. Heating, ventilation, and air conditioning systems will be provided for buildings and enclosures.

2.7.5. Power Generation System

The required power for the FPSO will be generated by three systems:

- The main power generation system will be gas turbine-driven generator sets with spares available in the case of unplanned downtime. All generator sets will be dual-fuel (diesel, produced gas).
- The essential services power generation system will be a diesel-driven generator set. Essential services include systems required for facility restart and for flow assurance hydrate mitigation activities after an unplanned shutdown.
- The vessel emergency power generator set will be diesel-driven and will provide power to both the hull and topsides emergency systems (e.g., safety systems including emergency lighting, telecommunication, etc.).

Additionally, for backup power during emergency situations, an uninterruptible power-supply system will be provided to power equipment such as the Integrated Control and Safety System (ICSS), subsea controls, etc.

2.7.6. Integrated Control and Safety System

Monitoring and control of the FPSO production operations will be performed by an ICSS. Located in the main control room of the FPSO, the ICSS will include process shutdown, emergency shutdown, and fire and gas systems to protect the facilities and personnel. These systems will interface with a public address and general alarm system to provide distinct audible and visual alarm notification. The ICSS includes the following subsystems:

- PCS: the PCS will perform primary process control, monitoring, and data acquisition functions.
- Safety Instrumented System (SIS): the SIS will implement functions for abandoning the host facility, emergency shutdown, fire and gas detection, and process shutdown. Also included in the SIS will be a shutdown function for the subsea control/safety system. The SIS will provide detection, logic sequencing, and actuation of devices to place the facility in a safe state.
- Fire and Gas System.
- Alarm Management System.
- Operator graphics/consoles.
- Third-party interfaces to packaged systems (such as compressors, subsea, marine, etc.).

2.7.7. Communication Systems

Telecommunications equipment will be installed on the FPSO to enable safe operation of the facilities in normal and emergency conditions. This equipment will allow communication with the shorebase(s), support vessels, helicopters, and tankers, as well as communication within the FPSO.

2.7.8. Additional Vessel Systems

2.7.8.1. FPSO Cargo Systems

The main purpose of the FPSO cargo system will be as follows:

- To receive, distribute, and store on-specification crude oil from the process facilities into designated FPSO cargo tanks;
- To receive and store off-specification crude oil from the process facilities into a designated FPSO cargo tank; and
- To offload the crude oil stored in the FPSO cargo tanks into a conventional tanker at regular intervals.

In addition to the FPSO cargo tanks, there will be a slop tank to receive stripping water from the cargo tanks and discharge from the topsides nonhazardous and hazardous drain system. The oil and water in the slop tank will be gravity-separated by a minimum residence and retention time. Once separated, the oil will be skimmed off the top and sent to the cargo tanks and the water will be discharged overboard to discharge specifications.

The FPSO cargo tanks will be blanketed with gas. A tank vapor recovery system will be provided to recover vapor from the cargo tanks and route the vapor to the gas processing system.

The marine cargo system supports the following routine activities:

- Flushing of the crude oil offloading export hose;
- Emergency and temporary ballasting of FPSO cargo tanks with seawater; and
- Inspection and maintenance of FPSO cargo tanks and piping systems between offloading operations.

2.7.8.2. Crude Oil Offloading

Export of the crude oil from the FPSO will be via a floating hose connected to the manifold of a conventional tanker. The FPSO will be configured for tandem offloading to a conventional tanker. The separation distance between the stern of the FPSO and the conventional tanker will be approximately 120 meters (390 feet). The maximum conventional tanker classification envisioned is a Very Large Crude Carrier class. During offloading operations, the conventional tanker will maneuver and hold station relative to the FPSO with the help of up to three assistance tugs, as shown on Figure 2.7-3. Crude oil will be transported to the buyers' final location(s) by the conventional tankers after each offloading operation.

Figure 2.7-3: Example of General Offloading Configuration

2.7.8.3. Ballast System

Ballast water will be required during the FPSO transit from the shipyard to offshore Guyana. Once on site, the un-needed ballast water from the FPSO may be discharged overboard.

2.7.8.4. Spread Mooring System

The FPSO will be permanently moored by fixed, spread mooring with an up to 20-point mooring line system, with each line connected to a separate anchor pile embedded into the seafloor. The anchor piles will be either suction piles or driven piles. The mooring system will be designed to maintain the FPSO on-station for extreme (100-year return period) environmental conditions (associated wind, waves, and current).

2.7.9. Safety and Personnel Protection Systems

Safety systems will include the following:

- Firewater System—The firewater system will have pumps located at the fore and aft ends of the FPSO.
- Fire and Gas Detection Systems—Fire and smoke detectors will be located throughout the topsides and living quarters and will be wired centrally with alarms sounding in the central control room, which will activate the general alarm system on the FPSO. Gas detectors will be placed in areas where gas might be released or could accumulate.
- Blanket Gas—The cargo tanks will be operated with a gas blanket at all times except during tank entry. The gas for cargo tanks will normally be supplied by the fuel gas system as part of the cargo vapor recovery system. If the vapor recovery system/fuel gas supply is offline, the inert gas generator will be used to supply blanket gas. To provide gas blanketing for other

spaces, including the methanol and xylene tanks, nitrogen gas will be provided by routing compressed air through the nitrogen membrane package.

- Lifeboats and Life Rafts—The FPSO will be provided with lifeboats on either side of the accommodation, having a capacity on each side for 100 percent of the personnel on board. A fast rescue boat will also be provided, complete with a davit launching and retrieving system.

2.8. Installation, Hookup, and Commissioning

Final design of the installation, hookup, and commissioning activities for the SURF, FPSO, and associated moorings has not been completed; however, key installation, hook-up, and commissioning activities will include the following:

- FPSO Mooring Installation—installation of the FPSO's anchor piles and mooring lines. Following installation, the mooring lines will be staged on the seafloor until arrival of the FPSO.
- Flowline/Riser Installation—installation of the production, water injection, and gas re-injection flowlines and risers. These components will be cleaned and tested to verify integrity after installation. Some components may be staged on the seafloor until arrival of the FPSO; others may be brought in and installed with the FPSO.
- FPSO Positioning and Mooring Connection—positioning of the FPSO using support tugs, followed by retrieval of the FPSO mooring lines from the seafloor and hook-up of the FPSO to its mooring system.
- Manifold/Drill Center Components—installation of the manifold foundation piles/mud mats and subsea components at the drill centers and testing to verify integrity after installation.
- Umbilical Installation—installation of the umbilicals and SDU.
- Riser Connection—retrieval from the seafloor, pull-in, and connection of the risers to the FPSO.
- Testing and Commissioning—testing and commissioning of the connected, integrated FPSO and SURF production systems, including testing and dewatering/displacing flowlines and umbilicals with commissioning fluids and testing SURF control and shutdown systems.

The above activities will be executed in an optimal sequence with activities completed in parallel where possible.

During the installation stage, a remotely operated vehicle (ROV) may be periodically utilized underwater to support the above-mentioned activities (e.g., observations, connections, sampling, etc.).

2.9. PRODUCTION OPERATIONS

This section discusses the production operations for the FPSO.

2.9.1. Common Flow Assurance Additives

Some industry-standard chemicals will be required to process the crude oil on the FPSO. Both the FPSO and SURF facilities will also require the use of industry-standard additives to provide flow assurance and prevent corrosion, scale formation, hydrate formation, and asphaltene formation, as previously noted in Section 2.7.4.4, Topsides and Subsea Chemical Injection. The chemical requirements and estimated quantities will be determined as part of the ongoing FPSO and SURF facilities design work, and will be addressed in the EIA process. Particular attention will be paid to scenarios that could result in flow instabilities, restrictions, or blockages, or which could jeopardize the integrity of the fluid-transfer systems or reduce overall system operability. The objective of the following sections is to provide a general overview of the flow assurance challenges and strategies.

2.9.2. Hydrogen Sulfide Management

The concentration of H_2S will be extremely low for the initial stage (i.e., 5 to 10 years) of FPSO/SURF production operations. There may be potential for the reservoir to sour[13] over time, which influences material selection and corrosion inhibition for certain FPSO, SURF, and drilling systems. In the unlikely event that concentrations of H_2S increase to a level that could represent potential health or safety concerns for the Project's offshore workforce, additional management measures will be implemented as appropriate (e.g., training programs, personal protective equipment (PPE), response planning, and equipment for leak detection and alarms).

2.9.3. Marine Safety

The Maritime Administration Department (MARAD) of the Ministry of Public Infrastructure is responsible for issuing notices to mariners concerning safety at sea. MARAD will be advised of the locations of drill ships during the drilling of the development wells and the performance of well workovers in the PDA so that mariners can be made aware of these activities. As shown on Figure 2.9-1, marine safety exclusion zones with a 500-meter radius will be established around drill ships during drilling operations and around drill centers during well workovers, as well as around major installation vessels, in accordance with industry standards and practices.

[13] A reservoir "souring" means the levels of sulfur in the recovered crude oil increases over time, relative to levels at the initial stages of recovery.

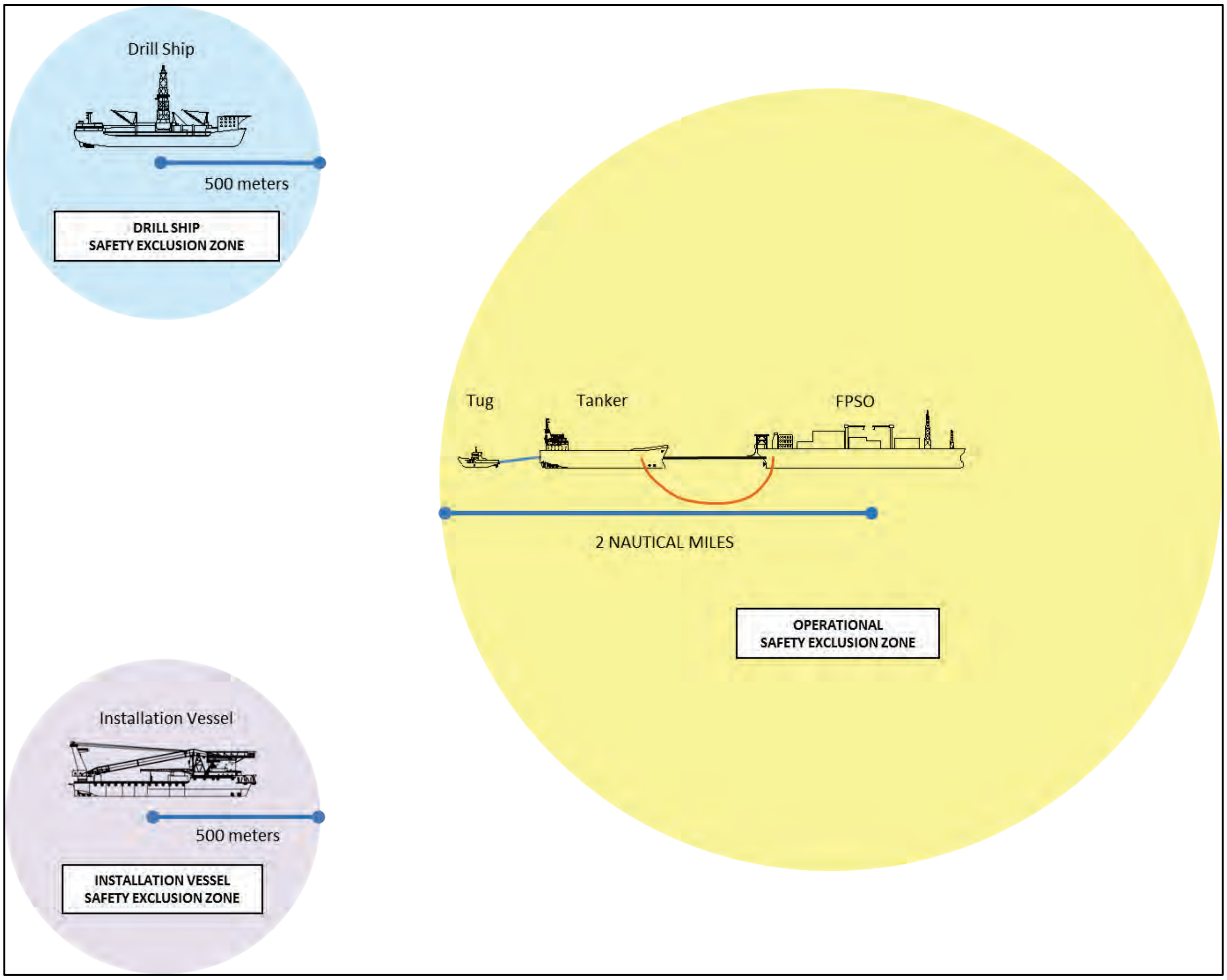


Figure 2.9-1: Preliminary Marine Safety Exclusion Zones

Authorizations for in-water activities will be obtained from MARAD and notices to mariners will be issued for all marine vessels, including the FPSO, supply and support vessels, tugs, and those vessels to be utilized during the installation, hook-up, and commissioning stage.

As shown on Figure 2.9-1, the FPSO will have a 2-nautical mile-radius marine safety exclusion zone centered on the FPSO during offloading activities, where marine support and tanker offloading will occur. No unauthorized vessels will be allowed to enter this approximately 4,000-hectare operational marine safety exclusion zone during offloading activities.

2.9.4. Offloading Tankers

Conventional tankers supporting offloading operations will typically arrive anywhere from 1 day to several hours ahead of the scheduled loading time, as a function of weather and ocean conditions. To accommodate these vessels, an anchorage area will be established several kilometers away from the FPSO. When the tanker is ready to approach, a Mooring Master will board the conventional tanker approximately 2 kilometers from the FPSO to guide the conventional tanker to the FPSO and to support the offloading operation. The conventional tankers will export the crude oil for sale after offloading operations have been completed. Conventional tankers will be owned/operated by others and will not be dedicated to the Project.

The following is a summary of the tanker activities anticipated as a result of the Project, as well as the operational procedures and controls (maritime navigation protocols, safety procedures, communication protocols, etc.) that will be implemented in relation to these activities, including tanker transit within Guyana waters and during offloading of oil from the FPSO to the tankers on the Stabroek Block. Although outside the scope of the EIA, the information below also includes a conceptual description of the key marine and terminal operational procedures and safety controls that will be utilized during international transit outside of Guyana waters. The discussion is presented for two phases: pre-cargo (activities up to the point where crude oil is offloaded from the FPSO to the offloading tanker); and post-cargo (activities from the completion of offloading at the FPSO up to the offloading of the crude oil at the delivery port).

2.9.4.1. Pre-Cargo Phase

The Pre-Cargo Phase covers the offloading tanker from the time of Nomination by Lifter[14] through the start of cargo operations at the FPSO. This includes ocean transit to the tanker waiting area, final approach to the offloading station, mooring operations, and activities to prepare for the commencement of offloading operations. The operations and controls for this phase include the following:

- Ocean transit to waiting area: The offloading tanker will be under the control of the Vessel Master, governed by international and flag-state regulation and owner/operator policies.
- Final approach to station[15] and mooring operation: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master acts as the FPSO representative and advisor and will be located onboard the offloading tanker. The Mooring Master is tasked with coordinating and directing the offloading tanker's approach, communications with assist tugs and the FPSO, and mooring operations between the offloading tanker and the FPSO. The Vessel Master is ultimately responsible for safety, security, regulation, and owner/operator policy enforcement as relates to the operations of the offloading tanker.
- Activities to prepare for the commencement of cargo operations: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master may assist with communications and enforcement of FPSO procedures onboard the offloading tanker. The Vessel Master is ultimately responsible for safety, security, regulation, and owner/operator policy enforcement as relates to the operations of the offloading tanker.

[14] The "Lifter" is the co-venturer (EEPGL, Hess, or Nexen) that is obligated to offload from the FPSO on certain dates based on the designated schedule. "Nomination" is when the Lifter provides the name and details of the planned offloading vessel to EEPGL. This is anticipated to be no later than 10 days prior to the lifting window.

[15] "Station" is the point where the offloading tanker is located when the offloading of crude oil takes place.

2.9.4.2. Post-Cargo Phase

The Post-Cargo Phase covers the offloading tanker from the completion of offloading of crude oil from the FPSO through the eventual discharge of the loaded cargo at the delivery port. This includes completion of cargo documentation, pre-departure safety checks, unmooring, departure from station, ocean transit to the discharge port, and discharge of loaded cargo. The operations and controls for this phase include the following:

- Completion of cargo documentation and pre-departure safety checks: The offloading tanker will be under the control of the Vessel Master, who is responsible for the safety, security, and regulation/company policy enforcement as relates to operations of the offloading tanker.
- Unmooring and departure from station: The offloading tanker will be under the control of the Vessel Master, assisted by the Mooring Master from the FPSO. The Mooring Master is tasked with coordinating and directing the unmooring operations, and communications with assist tugs and FPSO. The Vessel Master is ultimately responsible for safety, security and regulation/company policy enforcement as relates to operations of the offloading tanker.
- Ocean transit to discharge port and discharge of loaded cargo (outside the scope of the EIA): The offloading tanker will be under the control of the Vessel Master, governed by international and flag state regulation and company policies.

2.9.4.3. Governance and Industry Standards

A number of protocols and procedures will be followed in relation to tanker activities in Guyana waters, and outside of Guyana waters (i.e., in transit to the international delivery port). These include the following:

- Safety of Life at Sea (SOLAS) Convention: Specifies minimum standards for the construction, equipment, and operation of ships, focused on safety standards. Key topics in SOLAS include Safety of Navigation (Chapter V) and Management for the Safe Operation of Ships–ISM Code (Chapter XI-2), among others.
- International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1978 (MARPOL 73/78): Developed by the International Maritime Organization (IMO); includes international standards for seafarer training, regulations on mandatory traffic separation schemes, and requirements for segregated ballast tanks and double hulls for tankers, among other standards.
- International Safety Guide for Oil Tankers and Terminals: An industry-wide accepted guide for the safe carriage and handling of crude oil on tankers and at terminals; recommended to be kept and used onboard every tanker and in every terminal so there is a consistent approach to operational procedures and shared responsibilities for operations at the ship/shore interface; covers General Information (properties, hazards of petroleum, hazards for ship and terminal, etc.), Tanker Information (shipboard systems, equipment and operations, carriage and storage of hazardous materials, etc.), Terminal Information (terminal systems and equipment, cargo transfer equipment, emergency preparedness, etc.), and Management of the

Tanker and Terminal Interface (communications, mooring, precautions on ship and terminal during cargo operations, etc.).

- Oil Companies International Marine Forum (OCIMF): Developed under a voluntary association of oil companies having an interest in the shipment of terminaling crude oil, oil products, petrochemicals and gas; objective is to develop and publish guidance, recommendations and best practice by harnessing the skills and experience of OCIMF members and the wider industry; the OCIMF consults with IMO to influence and create internationally-accepted regulations aimed at improving the safety of tankers and protecting the environment.

2.10. Onshore, Marine, and Aviation Support

2.10.1. Onshore Supply and Support Activities

Shorebases, laydown areas, pipe yards, 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 the existing Guyana shorebase(s) located on the east side of the Demerara River as the primary shorebase(s) supporting the Project. Additional onshore facilities may be utilized by other companies. All onshore support facilities will be owned/operated by others and will not be dedicated to the Project. Should any new or expanded shorebase(s) or onshore support facilities be utilized, the construction/expansion and any required dredging of such facilities, as well as the associated environmental authorization, would be the responsibility of the owner/operator and such work scope is therefore not included in the scope of the Project EIA.

A typical shorebase quay is shown on Figure 2.10-1, and a typical laydown yard is shown on Figure 2.10-2. Additional logistical support may be provided by other regional suppliers outside of Guyana to address Project needs (e.g., deepwater port access in Trinidad), as informed by inputs from EEPGL contractors after contract award.

Figure 2.10-1: Typical Shorebase Quay

Figure 2.10-2: Typical Laydown Yard

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

Daily activities and operations to be performed at the shorebase(s) will generally include the following:

- Storage of pipe, equipment, and spares;
- Loading and unloading cargo from trucks and marine vessels;
- Use of cranes and other lifting equipment;
- Bulk storage of chemicals, fuels, and industrial consumables;
- Operation of a cement and drilling fluids and mud plant to support offshore drilling operations; and
- Secure handling, storage, and treatment of wastes pending final recycling, treatment, or disposal.

Most of the major SURF equipment will be preassembled, pretested, and shipped directly to the Liza Phase 2 PDA from their points of origin. Other minor equipment, supplies, and materials may be temporarily staged at shorebase(s), laydown yards, and warehouses until transferred offshore for installation or use. The owners/operators of these contracted facilities may be required to seek environmental authorization for any changes to current operations (e.g., bulk storage of chemicals and fuels).

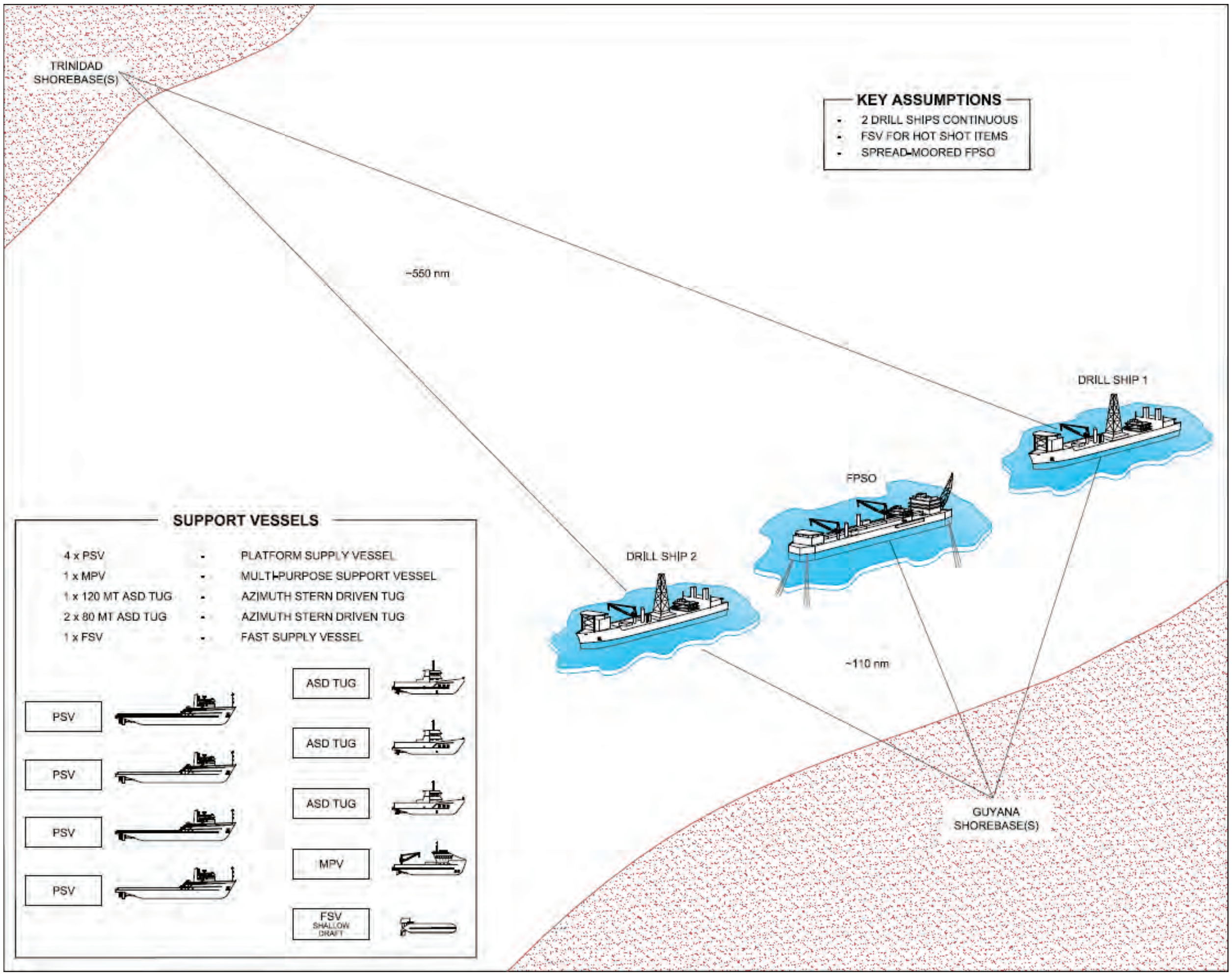
Support and supply vessels will require sufficient water depths to transit between the Liza field and the shorebase(s). There is potential for some initial and periodic maintenance dredging to be performed by the shorebase owners/operators. Any such dredging will be subject to receipt of environmental authorization by the shorebase owners/operators.

2.10.2. Logistical Support

Logistical support will be optimized and shared between the Liza Phase 1 and Phase 2 Development Projects. Typically, up to 10 round-trip helicopter flights are currently being made per week to support ongoing exploration drilling activities. It is estimated that during development drilling and FPSO/SURF installation for the Project, flights may increase at peak to a total of approximately 30 to 35 round-trip flights per week (combined for Phase 1 and Phase 2). During FPSO/SURF production operations for the Project, an estimated maximum of 20 to 25 round-trip flights per week (combined for Phase 1 and Phase 2) will be necessary to support FPSO/SURF production operations and continued development-drilling activities.

There will be a variety of marine and aviation support equipment supporting the FPSO, installation vessels, and drill ship(s), as shown on Figure 2.10-3. The support vessels will consist of multiple platform-supply vessels and a fast-supply vessel conducting resupply trips to the FPSO and drill ships, tug vessels supporting tanker offloading activities, and multipurpose vessels supporting subsea installation and maintenance activities. Based on current drilling activities and past experience with similar developments, it is estimated that during Liza Phase 2 development drilling and FPSO/SURF installation, an average of approximately 12 round-trips per week may be made to the Stabroek Block (combined for Phase 1 and Phase 2) by marine vessels. During Phase 2 FPSO/SURF production operations, it is estimated that this number will be reduced to approximately seven round-trips per week (combined for Phase 1 and Phase 2). The vessels will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Figure 2.10-4 depicts a conceptual diagram of the number and types of logistical support equipment that will be utilized to support the Project.

Figure 2.10-3: Typical Logistics Support Vessels



Note: Total number of drill ships and support vessels to be confirmed based on detailed planning

Figure 2.10-4: Marine Support Vessels

2.10.3. Waste Management

Waste generated offshore will be reduced, recycled, and treated offshore where practicable, with the remainder directed for onshore treatment, recycling, reuse, or disposal. For the exploration-drilling program, EEPGL is currently utilizing a regional supplier that is operating an existing waste management facility in Georgetown (see Figures 2.10-5 and 2.10-6). EEPGL is planning to utilize this facility or similar facilities in Guyana or the region during the Project development drilling and FPSO/SURF production operations stages. EEPGL would potentially consider the use of alternative Guyanese or regional waste management services according to Project needs, should they become available in the future. All waste streams will be managed in accordance with the Waste Management Plan that will be part of the Project Environmental and Socioeconomic Management Plan (ESMP).

Figure 2.10-5: Typical Waste Management Facilities at Shorebase

Figure 2.10-6: Vertical Infrared Unit with Wet Scrubber and Oxidizer at Typical Waste Management Facilities

2.11. End of Phase 2 Operations (Decommissioning)

In advance of the completion of the Liza Phase 2 production operations stage, EEPGL will prepare a decommissioning plan for the facility in compliance with the laws and regulations in effect at that time, while also considering the technology available at that time. The decommissioning plan and strategy will be based on a notice of intent for decommissioning the production facilities and plugging and abandonment of the development wells, which will be provided to the GGMC and EPA to obtain approval in accordance with the requirements of the Guyana Petroleum (Exploration and Production) Act (1998) and Environmental Protection Act (as amended in 2005).

EEPGL will perform inspections, surveys, and testing to assess current conditions, which will provide the basis and required information to prepare a plan for decommissioning. All risers, pipelines, umbilicals, subsea equipment, and topsides equipment will be safely and properly isolated, de-energized, and cleaned to remove hydrocarbons and other hazardous materials to a suitable level prior to being taken out of service.

Near the time of decommissioning, EEPGL will select, in consultation with the EPA, the final decommissioning strategy based on a comparative assessment designed to evaluate the potential safety, environmental, technical, and economic impacts, and associated mitigation measures to finalize the decommissioning plan.

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, and these will be of adequate length to contain reservoir fluids and deep enough to resist being bypassed by fracturing. The number of barriers required will depend on the distribution of hydrocarbon-bearing permeable zones within the wellbore.

It is expected that the risers, pipelines, 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.

Selected waste streams associated with decommissioning activities, including hazardous and nonhazardous wastes, will be managed and disposed in accordance with standard industry practice and applicable regulations. Methods may include injection downhole into the reservoir, separation and incineration offshore, or transport to onshore waste management facilities for treatment and/or disposal in accordance with standard industry practice and applicable regulations.

2.12. Materials, Emissions, Discharges, and Wastes

This section describes the materials (i.e., primarily chemicals) used across the various stages of the Project, as well as the Project's planned emissions, discharges, and wastes.

The Project may potentially produce small amounts of naturally occurring radioactive material (NORM) from the reservoir over the life of the production operations stage. The Project may also utilize radiography periodically to support installation and maintenance activities (e.g., non-destructive examination of materials for quality control purposes). The Project will follow standard industry practices to manage any workforce or third-party exposure to NORM or radiography sources. Any equipment containing such sources will be registered, strictly tracked, controlled, and returned to the vendor at the end of their use or if they must be replaced at any time.

The Project will not generate any meaningful vibration which could impact resources/receptors. EEPGL will manage airborne sound through engineering controls, through administrative controls, and by providing appropriate PPE to its Project workforce as described in Section 6.2.3, Impact Assessment—Sound. Underwater sound is discussed in the marine mammals and marine turtles impact evaluations (see Sections 7.5.3 and 7.5.4 and Sections 7.6.3 and 7.6.4, respectively). The Project will generate heat, primarily in the form of a cooling water discharge to the sea, which is discussed as part of the marine water quality impact evaluation (see Sections 6.4.3 and 6.4.4). The Project will generate light, which is discussed as part of the seabirds and marine turtles impact evaluations (see Sections 7.4.3 and 7.4.4 and Sections 7.6.3 and 7.6.4, respectively).

2.12.1. Materials Inventory

Offshore oil development is primarily an extractive process (e.g., producing oil from the Liza field). This extractive process will, however, require the use of various equipment described in this chapter (e.g., drill ships, pipes, flowlines, FPSO), as well as some chemicals used to facilitate well drilling, crude oil recovery, water/waste treatment, pipeline maintenance, and other purposes, which have been described in prior sections of this chapter. The required volumes of these chemicals are yet to be determined.

Table 2.12-1 below provides preliminary list of the primary chemicals that will be used as part of the Project's drilling, installation/commissioning, and production operation stages. Table 2.12-2 provides estimates, where known at this time, of the quantities of materials that will be used during development well drilling (on a per-well basis). These estimates are based on estimated quantities for the Liza Phase 1 development well drilling program in 2018. Well completion activities for the Liza Phase 1 development well drilling program are planned to start in January 2019, so completion additive estimates are not yet available for use in estimating Liza Phase 2 quantities. Tables 2.12-3 and 2.12-4 provide estimates, where known at this time, of the quantities of materials that will be used during the installation and production operations stages.

Residual quantities of drilling and production chemicals may be discharged to the sea as components of drilling fluid or produced water, injected into the reservoir, or emitted to the atmosphere, as described in prior sections of this chapter. Unused or used and recovered chemicals will be re-used, recycled, or disposed of in accordance with applicable regulations and best practices.

All chemicals will be stored, either at the shorebase(s) or on the drill ships or FPSO, in appropriate storage containers with either secondary containment or appropriate drainage control.

Table 2.12-1: Project Materials and Chemicals

Project Phase	Primary Chemical Materials / Products	
Drilling	• Water-based drilling fluid • Inorganic salts • Barite • Water-soluble biopolymers and modified biopolymers • Thinners • Calcium carbonate • Lost circulation material • Brines • Acids • Caustic soda • Surfactants • Hydrate inhibitor • Oxygen scavenger • Biocide • Soda ash • NADF	• Wetting agent • Viscosity modifiers • Fluid loss modifiers • Lime • Corrosion inhibitor • Sand suspension additive • Cement class "G" • Extender • Defoamer • Retarder • Dye • Breaker • Silica flour • Lubricant • Alkalinity control agent • Fluids loss control agent • Filtration medium

Project Phase	Primary Chemical Materials / Products	
	• Base Oil (IOGP Group III) • Emulsifier • Non-emulsifier	• Gas control agent
SURF Equipment Commissioning	• Low-toxicity, water soluble hydraulic fluid • Nitrogen • Hydrate inhibitor (e.g., methanol, ethylene glycol) • Marine gas oil	• Corrosion inhibitor • Scale inhibitor • Asphaltene inhibitor • Xylene
Production Operations	• Corrosion inhibitor • Scale inhibitor • Asphaltene inhibitor • Xylene • Methanol • Demulsifier • Defoamer • Floatation aid	• Polyelectrolyte • Triethylene glycol • Oxygen scavenger • Biocide • Clarifier/coagulant • Hydraulic fluid • Methylene glycol

Table 2.12-2: Estimated (Per Well) Project Materials and Chemicals Quantities—Drilling Stage

Chemical Material/Product	Quantity	Units
Water-based drilling fluid	10,000	bbl
Inorganic salts	47,570	lb
Barite	860	tonne
Water-soluble biopolymers and modified biopolymers	1,250	gal
Thinners	1,450	gal
Thinners	8,750	lb
Calcium carbonate	120,000	lb
Lost circulation material	7,500	lb
Brines	10,130	bbl
Acids	100	lb
Acids	1,500	gal
Caustic soda	9,645	lb
Surfactants	8,100	gal
Surfactants	1,150	lb
Hydrate inhibitor	500	bbl
Oxygen scavenger	50	gal
Biocide	25	gal
Soda ash	1,650	lb
NADF	32,500	gal
Base Oil (IOGP Group III)	12,000	bbl
Emulsifier	9,240	gal
Non-emulsifier	2,000	gal
Wetting Agent	3,025	gal

Chemical Material/Product	Quantity	Units
Viscosity modifiers	10,290	gal
Viscosity modifiers	45,600	lb
Fluid loss modifiers	2,780	lb
Lime	44,950	lb
Corrosion inhibitor	1,075	gal
Sand Suspension Additive	400	gal
Cement class “G”	480	ton
Extender	559	gal
Defoamer	669	gal
Retarder	200	gal
Dye	74	gal
Breaker	550	lb
Silica Flour	74,500	lb
Lubricant	125	gal
Alkalinity control agent	200	lb
Fluids loss control agent	900	gal
Filtration medium	25,000	lb
Gas control agent	2,300	gal

bbl = barrel; gal = gallon; lb = pound

Table 2.12-3: Estimated Project Materials and Chemicals Quantities—Installation Stage

Chemical Material/Product	Quantity	Units
Low-toxicity, water soluble hydraulic fluid	10	bbl
Nitrogen	150,000	scf
Hydrate inhibitor (e.g., methanol, ethylene glycol)	2,660	bbl
Marine gas oil	36,500	bbl
Corrosion inhibitor	80	bbl
Scale Inhibitor	90	bbl
Asphaltene inhibitor	410	bbl
Xylene	50	bbl

bbl = barrel; scf = standard cubic feet

Table 2.12-4: Estimated Project Materials and Chemicals Quantities—Production Operations Stage

Chemical Material/Product	Quantity	Units
Corrosion inhibitor	18,526	bbl
Scale inhibitor	638	bbl
Asphaltene inhibitor	46,424	bbl
Xylene	44,560	bbl
Methanol	79,700	bbl
Demulsifier	547	bbl
Defoamer	145	bbl

Chemical Material/Product	Quantity	Units
Floatation Aid	106	bbl
Polyelectrolyte	106	bbl
Triethylene glycol	77	bbl
Oxygen scavenger	338	bbl
Biocide	195	bbl
Clarifier/coagulant	45	bbl
Hydraulic fluid	49	bbl
Methylene glycol	28	bbl

bbl = barrel

2.12.2. Emissions

The Project will include several sources of atmospheric emissions. The principal sources of atmospheric emissions from the Project operations can be divided into four main categories:

- **Combustion Emissions**: generated from combustion of liquid fuel or natural gas during aviation and marine support and installation activities, operation of the FPSO and drill ships, waste incineration, and flaring of gas that is not re-injected into the reservoir;
- **Venting Emissions**: consisting of emissions related to tank storage operations (flashing emissions, standing/working/breathing losses [e.g., FPSO crude oil storage tanks], secondary seals);
- **Vessel-Loading Emissions**: dominated by emissions released during the transfer of crude oil from FPSO to tankers, but also including fuel transfer operations; and
- **Fugitive Emissions**: leakage through process equipment components (e.g., valves, flanges).

Table 2.12-5 provides estimated maximum annual Project atmospheric emissions in three distinct periods, selected to account for differing activity levels over the Project life. Primary activities in each of these periods to which the corresponding emissions can be attributed are as follows:

- 2020–2021: Development well drilling, SURF installation and commissioning, FPSO installation, and operation of related support vessels;
- 2022–2024: Continued development well drilling, operation of related support vessels, FPSO startup and associated temporary, non-routine flaring, beginning of production operations, and tanker loading; and
- 2025–2042: Production operations following cessation of drilling, including temporary non-routine flaring, operation of related support vessels, and tanker loading.

Table 2.12-5: Estimated Annual Atmospheric Emissions Summary

Pollutant	Source Category	Annual Emissions (tonnes unless otherwise specified)		
		2020-2021	2022-2024	2025-2042
Nitrogen Oxides	FPSO	0	2,875	2,780
	FPSO Flaring (temporary, non-routine)	0	575	255
	Tanker Loading	0	305	300
	Area Sources [a]	2,055	590	450
	Drill Ship	1,675	840	0
	Total	3,730	5,185	3,785
Sulfur Dioxide	FPSO	0	145	145
	FPSO Flaring (temporary, non-routine)	0	95	45
	Tanker Loading	0	55	50
	Area Sources	75	25	20
	Drill Ship	60	30	0
	Total	135	350	260
Particulate Matter	FPSO	0	65	60
	FPSO Flaring (temporary, non-routine)	0	20	10
	Tanker Loading	0	25	25
	Area Sources [a]	145	45	35
	Drill Ship	120	60	0
	Total	265	215	130
Carbon Monoxide	FPSO	0	735	715
	FPSO Flaring (temporary, non-routine)	0	3,130	1,370
	Tanker Loading	0	65	65
	Area Sources	430	125	95
	Drill Ship	350	175	0
	Total	780	4,230	2,245
Other Pollutants				
Hydrogen Sulfide	FPSO Flaring (temporary, non-routine)	NA	<5	<1
Volatile Organic Compounds	All Sources	95	4,855	4,410
Greenhouse Gases ([kilotonnes CO_2-equivalents])	All Sources	195	2,325	1,510

NA = not applicable
Notes: The annual estimated totals currently reflect the preliminary Project schedule, which could change. Annual emissions are rounded to the nearest 5 tonnes (or kilotonnes in the case of greenhouse gases); totals may not add up to activity-specific values due to rounding. Volatile organic compounds (VOCs) are, by U.S. Environmental Protection Agency (USEPA) definition, a broad class of carbon-containing compounds that, due in part to their ability to volatilize and become airborne, participate in atmospheric photochemical reactions that contribute to the formation of ozone. Methane and ethane are specifically excluded from the USEPA definition of VOCs.
[a] Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling, installation, production operations, and decommissioning.

2.12.3. Discharges

The Project will have several planned discharges to water. These planned discharges, based on the preliminary design information, are listed in Table 2.12-6. Potential discharges include drill cuttings and fluids, cement, well completion and treatment fluids, produced water, cooling water, sulfate removal and potable water processing brines, topsides drainage, hydrostatic test water, commissioning fluids, ballast water, blowout preventer (BOP) testing fluids, and sanitary and domestic wastewater and food preparation wastes, as described below. All Project vessels will be equipped to comply with the water pollution control standards required by the IMO MARPOL 73/78.

- **Drill Cuttings and Fluids**: Water-based drilling fluids (WBDF), as listed in Table 2.12-1, and associated cuttings will be discharged to the sea without treatment per standard industry practice. The process for treating and discharging cuttings with residual NADF, as listed in Table 2.12-1, is described in Section 2.5.3, Drilling Fluids.
- **Cement**: Cement slurry returns are only expected during the cementing of the first casing string for each development well. The excess spacer and lead slurry will be discharged directly to the seafloor immediately around the well. Excess/unused cement will be discharged to the sea.
- **Well Completion and Treatment Fluids**: Well completion and treatment fluids will be treated and discharged to the sea or shipped to shore for appropriate treatment/disposal per standard industry practice.
- **Produced Water**: The produced water treating system will collect produced water from process facilities and treat the water prior to discharge overboard, as described in Section 2.7.3.3, Produced Water Treatment.
- **Cooling Water**: Seawater is used to dissipate heat generated by the crude oil and water treating systems, the compression systems, and miscellaneous utility systems. Process hydrocarbon fluids will not come into contact with this seawater. Cooling water will be disposed of overboard at a suitable temperature so as not to significantly impact marine life.
- **Sulfate Removal and Potable Water Processing Brines**: These brine disposal streams are byproducts of the membrane processes used offshore to generate sulfate-free water for injection and to generate fresh water for crude oil desalting and for living quarters' requirements. No treatment of these streams (essentially seawater) is required prior to discharge.
- **Topsides Drainage**: The topsides will have a non-hydrocarbon and hydrocarbon drain system. The hydrocarbon drain system will direct drainage to a slop tank, where oil and water will be gravity separated. Once separated, the oil will be skimmed off the top and sent to the cargo tanks, and the water will be discharged overboard in accordance with treatment specifications. The non-hydrocarbon drain system (e.g., rainwater) will route the drain fluids to the slop tank in the FPSO hull or directly overboard.

- **Hydrostatic Test Water**: Seawater treated with chemicals (e.g., biocides) will be injected in the flowlines and risers to ensure the lines are sealed properly during installation, prior to the flow of hydrocarbons. The treated seawater used for hydrostatic testing of the water and gas injection lines will be discharged near the seafloor per standard industry practice. The treated seawater used for hydrostatic testing of the production lines will be round-trip pigged to the FPSO and will be treated and discharged overboard with produced water.
- **Commissioning Fluids**: A hydrate-inhibiting substance (e.g., methanol or ethylene glycol) will be used to prevent formation of hydrates during commissioning of the production and gas injection lines. The fluid used for the gas injection line will be discharged at the seafloor, and the fluid used for the production lines will be returned to the FPSO, treated, and discharged from the overboard water line.
- **Ballast Water**: Discharges of ballast water will be required for initial FPSO installation and recurring tanker offloading. Un-needed ballast water may be discharged as per the Ballast Water Management Plan.
- **BOP Testing Fluids**: During periodic testing (approximately every two weeks) of the BOP system, approximately 30 barrels of low-toxicity power fluid (i.e., fluid used to hydraulically move the preventers) will be discharged near the seafloor. The typical composition of this fluid is approximately 97 percent water with approximately 3 percent biocide/ lubrication/corrosion protection chemicals.
- **Gray Water/Black Water/Food Preparation Wastes**: The Project will provide wastewater treatment for sanitary wastes (black water/sewage) and food preparation wastes in accordance with MARPOL requirements. Gray water will be discharged overboard.

Table 2.12-4 summarizes drilling-related discharges and Table 2.12-7 summarizes commissioning and production-related discharges.

Table 2.12-6: Summary of Drilling and Completion-Related Discharges

Fluid Type	Estimated Discharge Per Well (bbl) [a]
Drill Cuttings Discharges	6,600
WBDF Discharges	24,500
NABF Retained on Cuttings	600
Cement Returns	3,000
Completion and Treatment Fluids	3,000

bbl = barrel
[a] Values based on deepest well

Table 2.12-7: Summary of Commissioning and Production-Related Discharges

Type of Discharge and Effluent Characteristics	**Expected Discharge Volume/Rate**	**Discharge Criteria**	**Treatment Required to Meet Criteria?**
SURF & FPSO Installation / Commissioning Discharges			
Ballast Water (FPSO initial deballasting)	≤ 550,000 bbl total	1) Perform discharge in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
Hydrostatic Test Water • Biocide: ≤ 500 ppm • Oxygen scavenger ≤ 100 ppm • Corrosion inhibitor ≤ 100 ppm	65,000 bbl (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)	No visible oil sheen on receiving water	No
Gas Injection Line Commissioning Fluids • Hydrate inhibitor (e.g., methanol or ethylene glycol)	1,400 bbl total	None	NA
Production Discharges			
Produced Water • Oil and grease • Residual production and water treatment chemicals	≤ 300,000 BPD	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 meters from discharge	Yes
Cooling Water • Hypochlorite: ≤ 5 ppm	≤ 1,600,000 BPD	No visible oil sheen on receiving water Temperature rise <3°C at 100 meters from discharge	No
Sulfate Removal & Potable Water Processing Brines • Hypochlorite: ≤ 1 ppm • Electrolyte: ≤ 1 ppm • Biocide: ≤ 5 ppm • Oxygen scavenger: ≤ 10 ppm • Scale inhibitor: ≤ 5 ppm	≤ 265,000 BPD	None	NA
Subsea Hydraulic Fluid Discharge • Water soluble, low-toxicity	≤ 5 BPD	None	NA
FPSO Bilge Water	1,800 BPD	Oil in water content: <15 mg/L	Yes
Inert Gas Generator Cooling Water	Negligible	None	NA
FPSO Slop Tank Water (includes off-specification oil from process and deck drainage)	Rainfall dependent	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum)	Yes
Miscellaneous Discharges including Boiler Blowdown, Desalinization Blowdown, Lab Sink Drainage	<10 BPD	None	NA

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
Tanker Ballast Water	Maximum 1,200,000 bbl total (at each tanker crude loading)	1) Perform in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
BOP System Testing Water-Soluble Low-Toxicity Hydraulic Fluid	30 bbl every two weeks	None	NA
Gray Water	250 BPD	None	NA
Black Water (sewage)	200 BPD	Total residual chlorine as low as practical but not less than 1 ppm	Yes
Food Preparation Wastes	<40 BPD	Macerated to <25 mm diameter	Yes

°C = degrees Celsius; bbl = barrels; BPD = barrels per day; mg/L = milligrams per liter; mm = millimeter; NA = not applicable; ppm = parts per million

2.12.4. Wastes

The Project will generate a variety of solid wastes including both hazardous and non-hazardous wastes, which vary over time by Project stage. As Table 2.12-8 indicates, waste will begin to be generated when drilling commences, as early as 2020 per the current Project schedule. Waste volumes generated will increase as drilling activity increases in 2021 and 2022. Additional waste will be generated from SURF installation and FPSO commissioning and hookup activities in the 2020-2022 timeframe. Waste volumes will then begin to decrease as drilling activity declines in 2023 and significantly decrease during the production operations stage once drilling activity is complete (2024 to 2042). When production operations cease, some waste will be generated from decommissioning activities.

Table 2.12-8: Summary of Estimated Annual Project Waste Generation and Management Methods

	Representative Waste Streams	Estimated Annual Waste Generation (metric tonnes) [a]					
		2020	2021	2022	2023	2024-2039	2040
Totals by Classification							
Non-hazardous wastes [b]	Plastic, glass, paper, scrap metal	5,870	7,920	7,730	4,260	780	790
Hazardous wastes	Used oil, paint waste, oil-contaminated cement	6,020	7,870	7,480	7,370	580	720
Totals by Management Method							
Onshore Treatment / Incineration	Used NADF, oil sludge, unused chemicals	5,850	7,540	7,130	7,130	500	560
Onshore Landfill (all non-hazardous) [b]	General trash, incinerator ash,	5,420	7,100	6,870	3,760	650	660
Recycle into Process	Used oil, oily water	0	20	50	50	50	50

	Representative Waste Streams	Estimated Annual Waste Generation (metric tonnes) [a]					
		2020	2021	2022	2023	2024-2039	2040
Recycle (all non-hazardous)	Plastic, glass, scrap metal	170	320	330	200	70	70
Recycle (preferred if feasible) / Landfill	Wood, paper, cardboard	470	840	850	500	100	180

[a] The annual totals reflect the current preliminary Project schedule, which could change.
[b] Non-hazardous volumes include estimated quantities of residue from treatment of hazardous waste

Solid waste generated offshore will be reduced, recycled, treated, and disposed offshore (i.e., incinerated and accounted for in Table 2.12-4 under FPSO source) where practicable, with the remainder directed for onshore treatment, recycling, reuse, or disposal. EEPGL is currently utilizing a regional supplier who is operating an existing onshore waste treatment/incineration facility at a local shorebase in Georgetown, Guyana (see Figure 2.10-5). The Project is planning to utilize similar facilities in Guyana or the region during the development drilling, FPSO/SURF installation and commissioning, production operations, and decommissioning stages. To the extent that solid wastes are being disposed of by a Guyanese licensed onshore disposal facility (e.g., landfill, incinerator) in accordance with their permit, then impacts from the proper disposal of these wastes are not further discussed in this EIA. All Project waste streams will be managed in accordance with the Waste Management Plan that will be part of the Project ESMP.

2.12.5. Radiation Emission Sources

Radiation sources and radiation-producing devices used by the Project and its contractors may potentially include radiographic equipment (e.g., welding inspection application), certain types of process instrumentation (such as level gauges), and certain types of lab equipment (e.g., crude oil testing application). As of the submission date of the EIA, the status of the design and procurement process for the Project indicates that FPSO process instrumentation and FPSO lab equipment will not likely include any radiation sources or radiation producing devices; if such equipment is utilized on the FPSO, the controls described below would be applied.

Additionally, Naturally Occurring Radioactive Material (NORM) can sometimes be found in trace concentrations in underground formations and in oil and gas production streams. NORM from production reservoirs can accumulate within production equipment (vessels, piping, valves, etc.) as a scale or sludge. It is not yet known whether the crude that will be extracted for the Project will contain NORM at some point during production operations; this will be determined via monitoring conducted during production operations.

To manage occupational health risks associated with radiation, EEPGL and its contractors will apply standard industry health controls. Typical radiation related health controls, which can be variable depending on the application, may include:

- Compliance with local regulations, including administrative controls related to importation permits and licensing.
- Use of a qualified Radiation Safety Officer.
- Use of site inventory for radiation sources.

- Clearly labeled radiation sources managed under a chain of custody protocol.
- Personal protective equipment.
- Barricading and signs.
- Personnel exposure monitoring procedures.
- Medical surveillance for identified personnel.
- Radiography performed outside of common work areas or at lower workforce exposure times (i.e., night shift) where feasible.
- Documented baseline surveys for facilities with NORM.
- Exposure control practices for personnel where NORM is present (i.e., for line breaks).
- Clear hazard warning labeling of equipment or materials sent offsite that may have residual NORM contamination.
- Management of any wastes with residual NORM contamination by a qualified waste contractor.
- Training requirements.

Emergency procedures for source damage/loss.

2.13. EMBEDDED CONTROLS

EEPGL has incorporated the embedded controls[16] provided in Table 2.13-1 into the Project:

Table 2.13-1: Embedded Controls Incorporated into the Project

Embedded Controls	**Resources/Receptors Benefited**
Development Well Drilling and SURF/FPSO Installation and Commissioning	
Utilize WBDF to the extent reasonably practicable (upper sections of the wells) and in other cases use low-toxicity IOGP Group III NABF.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
When NADF is used, utilize a solids control and cuttings dryer system to treat drill cuttings prior to discharge, such that the content of NADF on discharged cuttings, averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Avoid visible oil sheens on receiving water as a result of any commissioning-related discharges or FPSO cooling water discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos

[16] Embedded controls are physical or procedural controls that are planned as part of the Project design (i.e., not added solely based on a mitigation need identified by the impact significance assignment process). These are considered from the very start of the impact assessment process as part of the Project, and are factored in to the pre-mitigation impact significance rating.

Embedded Controls	Resources/Receptors Benefited
Initiate VSP activities during daylight hours after a suitable pre-watch by Marine Mammal Observers is performed and begin with soft-start procedures, which incrementally increase source sound levels to allow sensitive marine organisms time to move away from the activity before full sound source energy is utilized, in accordance with Joint Nature Conservation Committee guidelines.	Marine mammals, marine fish, marine turtles
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Utilize dry-break connections on liquid hydrocarbon bulk transfer hoses; • Utilize a liquid hydrocarbon checklist before every bulk transfer • Perform required inspections and testing of all equipment prior to deployment/installation; • Utilize certified BOP equipment; • Regularly test certified BOP equipment and other spill prevention equipment; • Utilize overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well control training) for drill ship supervisors and engineers; • Regularly audit field operations on the drill ships to ensure application of designed safeguards; and • Utilize controls for mitigating a failure of the dynamic positioning system on the drill ships and maintaining station keeping, which include: – Use of a Class 3 Dynamic Positioning (DP) system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria; – Continuous DP proving trials; – System Failure Mode and Effects Analysis; – Continuous DP failure consequence analysis; and – Establishment of well-specific operations guidelines.	Air quality, marine geology and sediments, marine water quality, protected areas and special status species, coastal habitats, coastal wildlife, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).	Marine mammals, marine turtles, marine fish
Maintain marine safety exclusion zones to be issued through MARAD with a 500 meter (approximately 1,640 foot) radius around drill ships and major installation vessels, and a 2 nautical mile (approximately 12,150 foot) radius around FPSO during offloading operations - to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with IMO/MARPOL 73/78 requirements.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Utilize leak detection controls during installation and operation of SURF equipment (e.g., pigging and pressure testing of lines, periodic remotely operated vehicle surveys of subsea trees, manifolds, flowlines and risers).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds

Embedded Controls	**Resources/Receptors Benefited**
Production Operations	
Re-inject produced gas that is not used as fuel gas on the FPSO to avoid routine flaring. With respect to non-routine flaring, the following measures will be implemented: • Monitor flare performance to maximize efficiency of flaring operation; • Ensure flare equipment is appropriately inspected and function-tested prior to production operations; and • Ensure flare equipment is appropriately maintained and monitored during production operations.	Air quality
Notify regulator when process upset events or unplanned maintenance occur, resulting in a flaring event sustaining at least 10 million standard cubic feet per day and lasting 5 days or longer.	Air quality
Avoid routine venting (excludes tank flashing emissions, standing/working/breathing losses) except during safety and emergency conditions.	Air quality
Avoid use of chlorofluorocarbons and polychlorinated biphenyls.	Air quality
Treat produced water on the FPSO to limit oil and grease content to 29 mg/L monthly average and 42 mg/L daily maximum.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Design produced water and cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Utilize a Mooring Master from the FPSO located onboard the offloading tanker to support safe tanker approach/departure and offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Ensure FPSO offloading to tankers occurs within an environmental operating limit that is established to ensure safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a certified marine-bonded, double-carcass floating hose system that complies with the recommendations of OCIMF Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM) 2009 Edition or later.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds

Embedded Controls	Resources/Receptors Benefited
Utilize breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a load monitoring system in the FPSO control room to support FPSO offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize leak detection controls during FPSO offloading that include: • Leak detection for breach of the floating hose that complies with the recommendations of OCIMF GMPHOM 2009 Edition or later; and • Utilization of instrumentation/procedures to perform volumetric checks during offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize low-sulfur fuels for major vessels, where available and commercially viable.	Air quality
Utilize dust suppression measures at the shorebase(s) to reduce impacts on air quality.	Air quality
Provide trained medical personnel on board the FPSO and major installation vessels and provide an EEPGL dedicated ambulance service to minimize reliance on medical infrastructure and facilities in Guyana.	Community health and wellbeing
Ensure Project vessels conduct ballasting operations in accordance with IMO/MARPOL requirements.	Ecological balance and ecosystems
General Measures	
Maintain equipment, marine vessels, and helicopters in good working order and operate in accordance with manufacturers' specifications to reduce atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality, sound, marine water quality, marine mammals, marine turtles
Equip project vessels with radar systems and communication mechanisms to communicate with third party mariners.	Marine use and transportation
Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent practicable.	Air quality, marine water quality
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Air quality
Utilize secondary containment for bulk fuel storage, drilling fluids, and hazardous materials, where practicable.	Marine water quality
Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Marine water quality
Perform regular audits of field operations on the drill ships, FPSO, and shorebase(s) to ensure application of designed safeguards.	Air quality, marine water quality
Treat sewage to applicable standards under MARPOL 73/78.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds

Embedded Controls	**Resources/Receptors Benefited**
For those wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, ensure they are manifested and safely transferred to appropriate onshore facilities for management. Waste management contractors will be vetted prior to utilization. If deficiencies in contractors' operations are noted, an action plan to address the identified deficiencies will be established.	Waste management
Utilize oil/water separators to limit oil in water content in bilge water to less than 15 parts per million per MARPOL 73/78.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals and marine turtles while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions.	Marine mammals, marine turtles
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA.	Seabirds
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Marine use and transportation
Ensure Project workers are subjected to health screening procedures to minimize risks of transmitting communicable diseases.	Community health and wellbeing
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practical. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.	Socioeconomic conditions, employment and livelihoods
Procure Project goods and services locally when available on a timely basis, and when they meet minimum standards and are commercially competitive.	Socioeconomic conditions, employment and livelihoods
Utilize a Worker Code of Conduct that includes requirements for interaction with local communities while on shore-leave.	Community health and wellbeing
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM is well publicized and understood by the public.	Community health and wellbeing
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate.	Community health and wellbeing
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Social infrastructure and services, community health and wellbeing
Develop and implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities	Social Infrastructure and Services, Community Health and Wellbeing

Embedded Controls	Resources/Receptors Benefited
• Definition of required driver training for Project dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits, through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Social infrastructure and services
Utilize an established SSHE program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Ensure all workers and contractors receive training on implementation of these principles and are required to adhere to them in the daily execution of their duties.	Occupational health and safety
Maintain an Oil Spill Response Plan (OSRP) to ensure an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.	All resources and receptors potentially impacted by an oil spill
Where practicable, direct lighting on FPSO and major vessels to required operational areas rather than at the sea surface or skyward.	Seabirds, marine turtles
Provide screening on FPSO and drill ships for seawater intakes to minimize the entrainment of aquatic life, where practical.	Marine fish

˚C = degrees Celsius; mg/L = milligrams per liter

2.14. WORKER HEALTH AND SAFETY

EEPGL is committed to protecting the safety, security, and health of its employees, contractors, and the public, with a goal of *Nobody Gets Hurt*. Consistent with this commitment, the Project will employ a robust and effective management system to protect its Project workforce. EEPGL will implement its OIMS (see Section 2.4, Overview of the Development Concept) during each Project stage. This program is designed to manage occupational risks to Project workers and. Additional information regarding EEPGL's occupational safety and health program is provided in the Project ESMP.

2.15. PURPOSE AND NEED OF THE PROJECT

The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the Liza field. The Petroleum Agreement between EEPGL, Hess, Nexen, and the Government of Guyana defines how revenues from the Project are to be shared between the parties. The Government of Guyana will begin receiving oil revenues when oil is produced.

2.16. Project Benefits

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 (PA) 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 PA and the Liza Development Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals in alignment with the PA and the Liza Development Local Content Plan.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits 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.

2.17. Alternatives

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

- Location alternatives
- Development concept alternatives
- Technology and process alternatives
- No-go alternative

2.17.1. 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. Accordingly, there are no feasible alternative PDA locations that could effectively recover the resource. The locations/orientations of the 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. While there could be alternative locations for these components within the PDA, these alternative locations could potentially increase environmental impacts.

With respect to onshore components of the Project, the preferred alternative from an environmental perspective is to use existing shorebase(s) in Georgetown with sufficient capacity to meet Project needs. If additional shorebase(s) 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 shorebase(s) in addition to or in lieu of the shorebase(s) that currently exist.

2.17.2. Development Concept Alternatives

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). With the exception of the FPSO concept, the other deepwater production systems would necessitate the use of a separate Floating Storage and Offloading (FSO) vessel for oil storage and offloading to enable export of the oil to buyers. The use of an FSO would 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). Therefore, the FPSO was chosen as the preferred concept for the Project because it is a more efficient, stand-alone solution for deepwater oil processing and storage, and it also provides for fewer potential impacts.

With respect to commercialization of recovered crude oil, 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.

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. While gas re-injection is the preferred alternative selected for the Project, the FPSO has been designed to enable gas export, should an export alternative be identified in the future. 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.

2.17.3. 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 ExxonMobil and its 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.

2.17.4. No-Go Alternative

The "no-go" alternative means that the Project would not be executed. If this alternative is applied, the existing conditions described in 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-go alternative means evaluating the tradeoff between positive and negative impacts.

2.17.5. Summary of Alternatives

EEPGL considered a range of alternatives for the various aspects of the Project, along with the potential environmental and socioeconomic impacts associated with these alternatives. The preferred alternatives—which comprise the Description of the Project—reflect EEPGL's identification of the preferred alternatives from the standpoint of environmental performance, and technical and economic feasibility. This selection is supported by the fact that the FPSO and SURF production system is a proven development concept for deepwater oil recovery, and would leverage both operator- and industry-proven technologies and experience.

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3. ADMINISTRATIVE FRAMEWORK

The Project will be regulated under several Guyanese statutes. These statutes contain requirements to be implemented to ensure compliance with the applicable laws and regulations of Guyana.

This chapter reviews the relevant laws and regulations in Guyana that are applicable to the Project; the chapter is separated into four sections:

- Section 3.1, National Legal Framework, describes the laws and regulations that apply to environmental issues in a general context, such as the Constitution of Guyana, as well as specific national laws that focus specifically on environmental issues such as the Environmental Protection Act, as amended in 2005. This section also identifies several resource-specific environmental laws that are more narrowly focused and have either direct or indirect relevance to the Project.
- Section 3.2, National Policy Framework, describes the Government of Guyana's strategies and policies that apply to the Project. These strategies and policies articulate the Government's management goals with respect to various environmental issues.
- Section 3.3, International Conventions and Protocols, describes the international and regional conventions and protocols to which Guyana is a signatory and which are relevant to the Project.
- Section 3.4, EEPGL's Operations Integrity Management System, describes EEPGL's framework for addressing risks inherent in its business that can potentially have an impact on personnel and process safety, security, health, environmental, and socioeconomic performance.

3.1. NATIONAL LEGAL FRAMEWORK

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

3.1.1. National Constitution of Guyana

Guyana is governed according to the Constitution of the Co-operative Republic of Guyana, as amended. The Constitution took effect in 1980 and expressly provides for protection of the environment. Article 25 establishes "improvement of the environment" as a general duty of the citizenry. In addition, Article 36 reads as follows:

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

3.1.2. The Environmental Protection Act

In 1996, the Environmental Protection Act (hereinafter referred to as the Act) was enacted to implement the environmental provisions of the Constitution. The Act is Guyana's single most significant piece of environmental legislation because it articulates national policy on important environmental topics such as pollution control, the requirements for environmental review of projects that could potentially impact the environment, and the penalties for environmental infractions. It also provides for the establishment of an environmental trust fund. Most importantly, the Act authorizes the formation of the EPA, and establishes the EPA as the lead agency on environmental matters in Guyana. The Act further mandates the EPA to oversee the effective management, conservation, protection, and improvement of the environment (EPA 2018). It also requires the EPA to take the necessary measures to ensure the prevention and control of pollution, assessment of the impact of economic development on the environment, and sustainable use of natural resources.

3.1.3. The Guyana Geology and Mines Commission Act

The Guyana Geology and Mines Commission Act was enacted in 1979 and authorized the government to establish the Guyana Geology and Mines Commission (GGMC), which is within the Ministry of Natural Resources. The GGMC promotes and regulates the exploration and development of the country's mineral resources. The GGMC has a dedicated Petroleum Unit charged specifically with regulatory supervision of the oil and gas sector; however, petroleum-related activities also occur in other divisions, such as the Geological Services Division and the Environment Division.

3.1.4. The Petroleum Act

The Petroleum (Exploration and Production) Act was enacted in 1986 to regulate the prospecting for and production of petroleum in Guyana, including the territorial sea, continental shelf, and exclusive economic zone. This act identifies persons allowed to hold prospecting licenses, establishes the process for obtaining prospecting licenses, and specifies requirements for further resource development in the event petroleum resources are discovered.

In 2012, the Commonwealth Secretariat was commissioned by the Government's then Ministry of Natural Resources and Environment, now the Ministry of Natural Resources, to prepare recommendations to reform Guyana's regulatory regime that governs the upstream petroleum sector. In September 2015, the Minister of State (via the GGMC's Petroleum Unit) announced plans to upgrade the country's upstream oil and gas policy, which was originally crafted in 2012 and finalized in 2014. In June 2016, the Ministry of Natural Resources completed a new national oil and gas policy that is still in draft form.

3.1.5. Protected Areas Act

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

3.1.6. Other Resource-Specific National Environmental and Social Laws

Several additional Guyanese environmental laws with more narrowly defined scopes pertain to specific biological or physical natural resources. Other laws which primarily have a public health-related focus may also be relevant to the Project. Several of Guyana’s environmental statutes were enacted prior to the Constitution and were subsequently incorporated into the newly formed national legal framework, but most were enacted after 1980. These laws are discussed in the relevant resource/receptor-specific discussions in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Protected Areas and Special Status Species; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

3.2. ENVIRONMENTAL PERMITS AND LICENSES

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

- Environmental Permit—To undertake the Project, EEPGL is required to obtain an Environmental Authorisation (also commonly referred to as an Environmental Permit) from the EPA. The Application for Environmental Authorisation filed with the EPA on 4 December 2017 initiated this regulatory process. After submission and review of this EIA, the EPA will take into account the review of the GGMC, comments from other agencies and ministries, the public’s comments, EPA’s own review, including support from technical experts, and recommendations from the Environmental Assessment Board (EAB) in deciding whether and under what conditions to grant EEPGL an Environmental Authorisation for the Project.
- Hazardous Waste Permit—With regard to onshore waste management, to operate a facility that generates, transports, treats, stores or disposes of hazardous waste, an application for environmental authorization must be submitted to the EPA by the operator of the facility. The application for environmental authorization must be prepared in accordance with the provisions of regulation 17 of the Environmental Protection (Authorisations) Regulations

2000. As such, the vessel owner/operators supporting transport of waste for the Project will be required to comply with the Environmental Protection (Authorisations) Regulations. Also, the vehicle owner/operators supporting transport of waste for the Project will be required to comply with the Environmental Protection (Authorisations) Regulations. Similarly, any environmental authorizations for third-party operated facilities used to manage hazardous waste will be obtained by the owner/operators of such facilities.

3.3. National Policy Framework

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

3.3.1. National Development Strategy

The National Development Strategy (NDS) sets priorities for Guyana's economic and social development policies for the next decade. The NDS contains technical analysis of problems and future prospects in all sectors of the economy and in areas of social concern.

The NDS contains six volumes. Volumes 3 and 5 are the most relevant to the Project. Volume 3 of the NDS sets government policy with regard to the environment as well as social equality issues. It identifies 12 distinct features of Guyana's natural resources and environment, and sets policies governing the management of each feature. Features covered under Volume 3 with relevance to the Project include the coastal zone, fisheries, waste management, pollution control, and environmental impacts of private-sector activities (NDS 1997).

Volume 5 relates in part to the energy sector. It describes the condition of the energy sector in Guyana, reviews past government policies related to the energy sector, identifies challenges facing the energy sector in Guyana, and describes the government's vision for future development and regulation of the sector into the future (NDS 1997).

3.3.2. National Environmental Action Plan

Guyana's National Environmental Action Plan (NEAP) articulates the government's approach to managing the environment from the perspective of economic development. The NEAP considers the issues of environmental management, economic development, social justice, and public health to be inextricably linked. It identifies deforestation, pollution, and unregulated gold mining as historically minor but with growing environmental problems, and identifies private sector investment as one of the primary opportunities to generate the necessary capacity within Guyana to: (1) provide an appropriate level of public services to its citizens; (2) reduce and/or eliminate the avoidable environmental degradation that occurs when resource development occurs in a regulatory vacuum; and (3) reduce unsustainable uses of natural resources due to the socioeconomic pressures of widespread poverty.

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

3.3.3. Integrated Coastal Zone Management Action Plan

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

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

Under the *Caribbean Planning for Adaptation to Climate Change project*, Guyana has also conducted a socioeconomic assessment of sea-level rise as part of a wider vulnerability assessment and developed a Climate Change Adaptation Policy and Implementation Strategy for coastal and low-lying areas.

3.3.4. Guyana's National Biodiversity Strategy and Action Plan

Guyana's current National Biodiversity Strategy and Action Plan (NBSAP) was formally adopted in 2015, and is the third iteration of the NBSAP. It establishes the national vision for biodiversity, which is to sustainably utilize, manage, and mainstream biodiversity by 2030, thereby contributing to the advancement of Guyana's bio-security, and socioeconomic and low carbon development. It is intended to guide national policy with respect to biodiversity through 2020. It recognizes the importance of biodiversity to the growing ecotourism industry and other economic sectors. The NBSAP sets forth nine strategic objectives intended to promote conservation and sustainability on a national scale, improve biodiversity monitoring, harmonize legal and policy-based mechanisms across all levels of government to support biodiversity conservation, and prioritize funding to meet these objectives.

3.3.5. Low Carbon Development Strategy and the Green Economy

In June 2009, the Government of Guyana announced the Low Carbon Development Strategy (LCDS). The LCDS aims to protect and maintain the forests in an effort to reduce global carbon emissions and at the same time attract payments from developed countries for the climate services that the forests provide. In 2013, the LCDS was updated to focus on two main goals:

(1) transforming the national economy to deliver greater economic and social development by following a low carbon development path while simultaneously combating climate change; and (2) providing a model for the world of how climate change can be addressed through low-carbon development in developing countries. The LCDS identifies *Reducing Deforestation and Forest Degradation Plus* as a primary mechanism for achieving the goals of the strategy.

Although there is no formal government plan for achieving a green economy, the Government of Guyana has expressed interest in the concept. President David Granger has defined the green economy as consisting of the four pillars of energy, environmental security, ecological services, and enterprise and employment (Kaieteur News 2016). The LCDS provides the conceptual framework for implementing the green economy.

3.3.6. Guyana Energy Agency's Strategic Plan

The Guyana Energy Agency (GEA) was established by the Guyana Energy Agency Act of 1997 (as amended) with a mandate to advise the Prime Minister on energy-related issues, develop a national energy policy, improve energy efficiency, monitor the energy sector, and educate the public on energy efficiency and renewable energy. The GEA's Strategic Plan for 2014-2018 specifically charges the GEA with monitoring the production, importation, distribution, and utilization of petroleum and petroleum products (GEA 2014).

3.4. International Conventions and Protocols

Guyana is signatory to a number of international agreements and conventions relating to environmental management and community rights, although not all of these agreements have been translated into national legislation. The key agreements potentially relevant to the Project, to which Guyana has acceded or is a signatory, are summarized in the relevant resource/receptor-specific discussions in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Protected Areas and Special Status Species; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

Guyana is a member state of two organizations that administer multiple international treaties and conventions: the International Labour Organization (ILO) and the International Maritime Organization (IMO). The ILO has established eight fundamental conventions that provide certain general protections to workers in signatory states such as the right to organize, standards for remuneration, restrictions on child labor (including minimum ages to work), and protection from forced labor. In addition to these fundamental agreements, Guyana is signatory to several specific agreements that will govern certain specific aspects of the Project as they relate to labor. These conventions are further discussed in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Protected Areas and Special Status Species; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

The IMO is a similar organization whose member states have agreed to one or more conventions related to maritime activities. These include three key conventions (the International Convention for the Safety of Life at Sea, the International Convention for the Prevention of Pollution from Ships, and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers), as well as several other agreements concerning more specific aspects of maritime activity such as safety and security at sea, maritime pollution, and liability for maritime casualties. The Guyana Maritime Administration Department (MARAD) manages compliance with the requirements of the IMO agreements to which Guyana is a signatory, with technical assistance from the IMO's Regional Maritime Advisory Office in Port of Spain, Trinidad. These conventions are further discussed in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Protected Areas and Special Status Species; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources.

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

To highlight Guyana's adherence to international standards and guidelines relevant to the oil and gas sector, in May 2010, the country announced its commitment to the implementation of the Extractive Industries Transparency Initiative (EITI) and most recently, in September 2015, the country recommitted its support to the ILO. EITI is a global standard to promote the open and accountable management of the extractives resources; it seeks to strengthen government and company systems, inform the public, and promote industry understanding. It was founded in 2003 with an aim of protecting the interests of developing or frontier countries such as Guyana (EITI 2018).

In October 2017, Guyana became the 53rd candidate country in the EITI. To gain membership status, Guyana was required to assemble a multi-stakeholder group, which included equal representation from the government, civil society, and industry. The goal was to develop a consensus reporting system that applied to all extractive companies operating in the country and to make that report public every year. Guyana is now tasked with producing its first report in the next 18 months; these reports will be audited by a third party and distributed publicly for review.[1]

EEPGL's parent organization, Exxon Mobil Corporation (ExxonMobil), has been a part of EITI since its inception and is a founding member. ExxonMobil has constructively worked to help develop and support EITI initiatives where its affiliates and subsidiaries operate.

3.5. EEPGL's Operations Integrity Management System

ExxonMobil (EEPGL's parent organization) and its affiliates (including EEPGL) are committed to conducting business in a manner that is compatible with the environmental and economic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety

[1] For more information about Guyana EITI visit: https://gyeiti.org/

policies. These policies are put into practice through a disciplined management framework called OIMS.

The ExxonMobil OIMS Framework establishes common expectations used by ExxonMobil affiliates worldwide for addressing risks inherent in its business. The term “Operations Integrity” is used to address all aspects of its business that can impact personnel and process safety, security, health, and environmental performance.

Application of the OIMS Framework is required across all ExxonMobil affiliates, with particular emphasis on design, construction, and operations. Management is responsible for ensuring that management systems that satisfy the OIMS Framework are in place. Implementation is consistent with the risks associated with the business activities being planned and performed. Figure 3.4-1 provides a high-level description of the OIMS Framework and its 11 essential Elements.

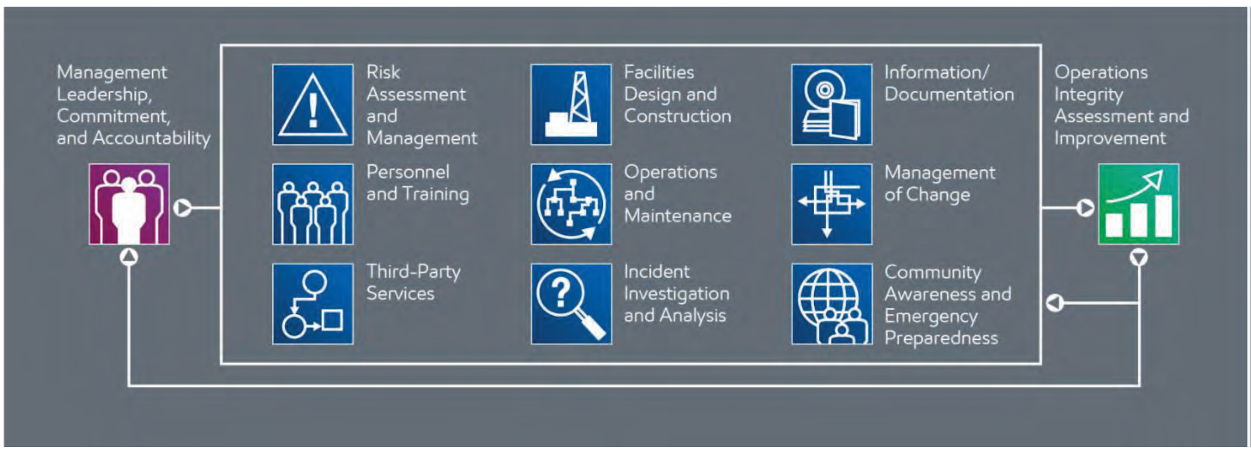


Figure 3.4-1: Operations Integrity Management System

4. METHODOLOGY FOR PREPARING THE ENVIRONMENTAL IMPACT ASSESSMENT

The purpose of this EIA is to assess the potential physical, biological, and socioeconomic (including social, economic, community health, and cultural) impacts of the Project. This chapter provides a summary of the approach and methodology used to assess the potential impacts associated with the Project. The EIA has been prepared in compliance with the Guyana Environmental Protection Act (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), other applicable Guyana regulations, international good practice, and EEPGL's corporate standards, and in accordance with the Consultants' standard practices.

This chapter also describes the process used to conduct the EIA. The EIA was prepared to provide an independent, science-based evaluation of the potential impacts associated with the development drilling, installation, production operations, and decommissioning stages of the Project. The EIA is also the primary mechanism for sharing those findings with stakeholders and decision-makers so they can make informed decisions regarding the potential benefits and impacts of the Project, as well as the measures proposed to enhance these benefits and mitigate these impacts.

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

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

Although the Environmental Protection Act does not define positive impacts, examples of potential positive impacts include increased employment opportunities and revenue sharing with the Government of Guyana.

The EIA considered the possibility of both direct and indirect impacts of the Project. Information on potential impacts, including potential cumulative impacts related to the Project, was obtained by Consultants from various primary and secondary sources, including: consultation and key informant interviews with the EPA, Government of Guyana, Guyana Geology and Mines Commission (GGMC), and other stakeholders; field studies in the Project Area of Influence (AOI); environmental impact assessments for other similar projects worldwide; and scientific literature.

The key stages for the EIA approach are:

- Screening
- Scoping and Terms of Reference
- Assessing Existing Conditions
- Project Description and Interaction with Design and Decision-Making Process
- Stakeholder Engagement
- Assessment of Impacts and Identification of Mitigation Measures
- Mitigation, Management, and Monitoring
- Disclosure and Reporting

The methodologies for the key stages are described in the following sections.

4.1. SCREENING

The first stage of the EIA process involved the EPA screening the Project to determine the appropriate level of analysis to support the Application submitted by EEPGL. The EPA screens projects based on the information provided in the Application and determines the depth of environmental assessment/type of document required to support the Application.

Based on the results of its screening assessment, the EPA can determine that the information included in the Application is sufficient to support a permitting decision, or it can require a Strategic Environmental Assessment, Environmental Management Plan, and/or an EIA. In this case, the EPA determined that the Project could result in potentially significant impacts and, in accordance with the Environmental Protection Act (as amended in 2005), indicated in January 2018 that an EIA is required to inform a decision to approve or reject the Application.

4.2. SCOPING AND TERMS OF REFERENCE

The key objectives of scoping are to:

- Identify key sensitivities and those Project actions having the potential to cause or contribute to significant impacts on physical, biological, and socioeconomic resources/receptors;
- Identify potential siting, layout, and technology alternatives for the Project;

- Obtain stakeholder views through consultation; and
- Help inform the Terms of Reference (ToR) for the EIA through consultation, to aid in focusing the EIA process and output on the key issues. The ToR describes the scope and technical approach for the EIA, and the key issues to be considered in the EIA.

Following EEPGL's submittal of the Application, a notice of the Application was published. This initiated a 28-day Public Notification Period, during which the public had the opportunity to provide comments on the Application and forthcoming ToR. During this period, the EPA conducted a series of scoping consultation meetings to aid in the development of the ToR (see Table 4.2-1). The objectives of the meetings were to provide stakeholders with information about the Project and the initially identified potential environmental and socioeconomic impacts of the Project, and to allow the public and government agencies to provide feedback on the scope of the ToR. This included feedback on the key issues to be addressed as part of the ToR development and eventual EIA process. Meetings with the public were held in each of the six coastal regions, along with a separate meeting in Georgetown for the sector agencies.

Table 4.2-1: Scoping Consultation Meetings

Meeting	Town	Location	Date
Sector Agencies	Georgetown	Pegasus Hotel	16 January 2018
Region 1	Mabaruma	Learning Resource Centre	2 February 2018
Region 2	Anna Regina	Cotton Field Secondary Public School	24 January 2018
Region 2	Charity	Charity Office Site	25 January 2018
Region 3	Leonora	Leonora Technical &Vocational Training Centre	26 January 2018
Region 4	Georgetown	Marian Academy	5 February 2018
Region 5	Hopetown	Multipurpose Cooperative Society	17 January 2018
Region 6	No. 66 Village	Fishing Cooperative	18 January 2018

The EPA and the Consultants jointly considered the concerns, issues, and suggestions received during the public and sector agency scoping consultation meetings and worked together to develop the final ToR. The EPA provided initial comments on the draft ToR and granted an interim approval of the ToR on 9 April 2018, which enabled the EIA to commence. On 21 May 2018, the EPA provided additional comments on the EPA. The Consultants provided a response to these comments on 23 May 2018, and the EPA stated its concurrence with the responses. The ToR was finalized in accordance with the above comments and EPA approved the Final ToR on 30 May 2018. The Final ToR outlined the EIA requirements, and was used to guide the preparation of the EIA.

4.3. ASSESSING EXISTING CONDITIONS

The description of existing physical, environmental, and socioeconomic conditions provides information on resources/receptors identified during scoping as having the potential to be significantly impacted by the Project. The description of existing conditions is aimed at providing sufficient detail to meet the following objectives:

- Identify the key conditions and sensitivities in the Project AOI;
- Provide a basis for extrapolation of the current situation, taking into consideration natural variability, and development of future scenarios without the Project;
- Provide data to aid in the prediction and evaluation of potential impacts of the Project;
- Understand stakeholder concerns, perceptions, and expectations regarding the Project;
- Inform development of appropriate mitigation measures; and
- Provide a benchmark to inform assessments of future changes and of the effectiveness of mitigation measures.

Field studies conducted to document existing conditions for the EIA are described in 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.

4.4. PROJECT DESCRIPTION AND INTERACTION WITH DESIGN AND DECISION-MAKING PROCESS

The interaction between the EIA team and the design and decision-making process was one of the key areas in which the EIA influenced how the Project will be developed. It included involvement in defining the Project and identifying those activities with the potential to cause physical, biological, or socioeconomic impacts. Project planning, decision-making, and refinement of the Project description continued throughout the assessment process in view of identified potential impacts and proposed mitigation measures. During the EIA process, there was extensive communication between the impact assessment team and the Project design team with regard to identifying alternatives, potential impacts, and mitigation measures.

4.5. STAKEHOLDER ENGAGEMENT

Stakeholder engagement was conducted to support the development of the EIA and associated Environmental and Socioeconomic Management Plan (ESMP). The objectives of the Project's stakeholder engagement activities are to:

- Identify Project stakeholders and understand their interests and concerns in relation to Project activities, and incorporate such interests and concerns into the EIA and ESMP development processes, and, if appropriate, the Project design;
- Promote the development of respectful and open relationships between stakeholders and EEPGL during the Project life cycle;
- Provide stakeholders with timely information about the Project in ways that are appropriate to their interests and needs, and also appropriate to the level of expected risks and potential adverse impacts;

- Satisfy regulatory requirements and EEPGL expectations for stakeholder engagement; and
- Record feedback and address any grievances that may arise from Project-related activities through a formal feedback mechanism.

4.5.1. Stakeholder Engagement Plan

Project stakeholder engagement activities are guided by a Stakeholder Engagement Plan (SEP), which describes:

- Stakeholders identified for engagement;
- A program of engagement and communications activities throughout the Project life cycle;
- A dedicated phone line and email address through which stakeholders can contact EEPGL to voice concerns, provide information, or ask questions about the Project and its activities; and
- Mechanisms through which EEPGL will monitor and report on external engagement and communications.

The SEP is a document that is updated periodically as the Project progresses to reflect new information, changing conditions, and additional stakeholders.

4.5.2. Stakeholder Identification and Engagement Strategy

Project stakeholders have been identified through a combination of desktop research and in-country assessment and engagement. Stakeholder categories include, but are not limited to government officials, communities (including indigenous peoples), interest groups, non-governmental organizations (NGOs), the private sector, media, academic and research institutions, and professional, business, and worker associations.

Building on this stakeholder identification and mapping, EEPGL's stakeholder engagement strategy identifies mechanisms and tools to facilitate stakeholder communications and public information sharing. These tools are divided into two tiers that interact to facilitate informed engagement. The first tier is information sharing, in which EEPGL provides information about the Project to stakeholders to support their understanding of what is proposed to occur. The second tier is consultation, in which EEPGL seeks to support open dialogue and to receive stakeholder feedback, opinions, concerns, and knowledge regarding the way the Project may interact with the natural and social environment. The objective of consultation is to enable EEPGL to identify key stakeholder issues and concerns.

EEPGL may disseminate information through print and online publications and media releases, as well as presentations and open houses. The intent of these types of activities is to provide information to a broad audience or group of stakeholders as efficiently as possible. Consultation or dialogue activities involving a two-way flow or exchange of information between stakeholders and EEPGL or the Consultants may include one-on-one and small group meetings, public meetings including a question and answer session, and feedback mechanisms such as a dedicated email address (guyanastaff@exxonmobil.com) and phone line (+592 231 2866, extension 12400). EEPGL also communicates regularly with its stakeholders through its Facebook page.[1] The intention of these activities is to allow for not only a two-way exchange of information, but also a means for EEPGL to gather information concerning topics that are important to its stakeholders. These activities also help ensure stakeholders' comments and opinions are heard and legitimate concerns are addressed.

4.5.3. Stakeholder Engagement Process

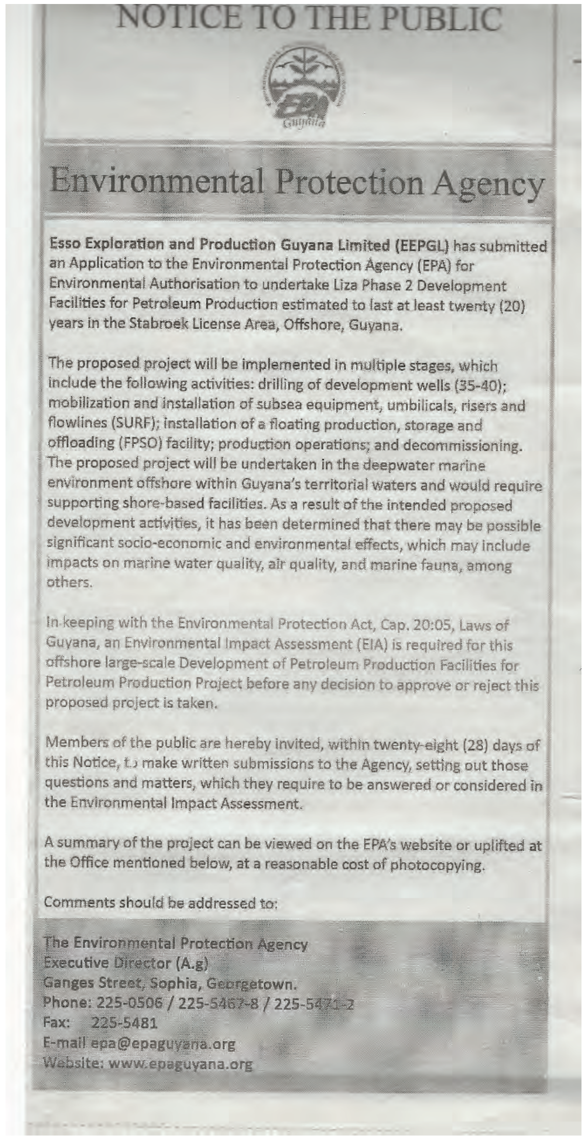
Stakeholder engagement activities are an integral part of the Project life cycle: from the initial notification when the Project is proposed, to the scoping of potential impacts, to the EIA, and throughout the life of the Project (at least 20 years).

EEPGL has conducted a robust public consultation program to both inform the public about the Project and understand community and stakeholder concerns so they could be incorporated into the EIA. 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 meetings and workshops with the Government and others on offshore oil and gas exploration and development.
- A Notice to the Public concerning the submission of the Application for the Project was published in the Stabroek News on 11 January 2018 (Figure 4.5-1), and was posted on the EPA's website (Figure 4.5-2), initiating the 28-day public comment period. As noted above, during this period, meetings with the public were held in each of the six coastal regions, along with a separate meeting in Georgetown for the sector agencies.
- As discussed in Section 4.2, Scoping and Terms of Reference, the EPA granted an interim approval of the ToR on 9 April 2018, which enabled the EIA to commence.
- The final ToR was approved on 30 May 2018.
- During the EIA development, EEPGL and/or the Consultants held meetings and key informant interviews with or gathered relevant data from more than 20 Guyana government agencies, commissions, professional or business associations, NGOs, and elected officials and regional administrators. This was in addition to the ecosystem services-related interviews with 63 coastal regional, democratic, and village councils in Regions 1-6, in which 536 local leaders and community members participated. The information received from these engagements was incorporated into the existing conditions and impact assessment components of the EIA (Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; Chapter 7, Assessment and Mitigation of Potential

[1] https://www.facebook.com/exxonmobilguyana/

Impacts from Planned Activities—Biological Resources; and Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources).



NOTICE TO THE PUBLIC

Environmental Protection Agency

Esso Exploration and Production Guyana Limited (EEPGL) has submitted an Application to the Environmental Protection Agency (EPA) for Environmental Authorisation to undertake Liza Phase 2 Development Facilities for Petroleum Production estimated to last at least twenty (20) years in the Stabroek License Area, Offshore, Guyana.

The proposed project will be implemented in multiple stages, which include the following activities: drilling of development wells (35-40); mobilization and installation of subsea equipment, umbilicals, risers and flowlines (SURF); installation of a floating production, storage and offloading (FPSO) facility; production operations; and decommissioning. The proposed project will be undertaken in the deepwater marine environment offshore within Guyana's territorial waters and would require supporting shore-based facilities. As a result of the intended proposed development activities, it has been determined that there may be possible significant socio-economic and environmental effects, which may include impacts on marine water quality, air quality, and marine fauna, among others.

In keeping with the Environmental Protection Act, Cap. 20:05, Laws of Guyana, an Environmental Impact Assessment (EIA) is required for this offshore large-scale Development of Petroleum Production Facilities for Petroleum Production Project before any decision to approve or reject this proposed project is taken.

Members of the public are hereby invited, within twenty-eight (28) days of this Notice, to make written submissions to the Agency, setting out those questions and matters, which they require to be answered or considered in the Environmental Impact Assessment.

A summary of the project can be viewed on the EPA's website or uplifted at the Office mentioned below, at a reasonable cost of photocopying.

Comments should be addressed to:

The Environmental Protection Agency
Executive Director (A.g)
Ganges Street, Sophia, Georgetown.
Phone: 225-0506 / 225-5467-8 / 225-5471-2
Fax: 225-5481
E-mail epa@epaguyana.org
Website: www.epaguyana.org

Figure 4.5-1: Notice to the Public Initiating 28-Day Public Comment Period—Newspaper Notice

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Website: www.epaguyana.org

Figure 4.5-2: Notice to the Public Initiating 28-Day Public Comment Period—EPA Website

Once the EIA process is complete, and assuming EEPGL obtains environmental authorization and other approvals from the EPA and GGMC, the Project will transition into execution, subject to a final investment decision by EEPGL. Plans for stakeholder engagement during Project execution are described in the SEP, and engagement activities will be adjusted to reflect evolving Project status and activity level, as well as stakeholder concerns over the life of the Project. During Project execution, the emphasis of engagement shifts from input gathering to disclosure about planned activities as well as consultation (including receipt of feedback) on ongoing and planned activities. EEPGL will keep the public informed about the general progress of the Project (e.g., completion of Project stages such as development well drilling) and will respond to any grievances (i.e., specific concerns) filed under the Project's Grievance Procedure, which is described in the SEP. The Grievance Procedure will be in place throughout the life of the Project (at least 20 years).

4.5.4. Stakeholder Comments and Considerations

This section summarizes the key comments and suggestions received from stakeholders during the EIA consultation processes to date and how these comments have been considered and addressed in the EIA.

During the Project's EIA scoping phase, the EPA led a series of eight scoping consultation meetings (one meeting attended by agency and NGO representatives; one public meeting each in Regions 1, 3, 4, 5, and 6; and two public meetings in Region 2). These meetings served to inform stakeholders about, and receive feedback from stakeholders on the Project. Stakeholders were also informed that comments could be submitted directly to the EPA during the 28-day public comment period.

Comments referencing a total of 113 distinct[2] issues or concerns were received from public, government agency, and NGO stakeholders over the course of the scoping phase. The key themes of these issues/concerns included the following:

- Socioeconomic implications of the Project, most of which were focused on the expected benefits to society from the Project, including economic and community development, and employment and livelihoods;
- Environmental impacts of the Project, including impacts on marine life and other biological resources, fishing livelihoods, and air quality;
- Regulatory process (e.g., EIA approach, process and/or methodology, scope and timeline of the EIA, data collected to support the EIA, and stakeholder engagement efforts over the course of the EIA process);
- Worker health and safety;
- Potential for unplanned events such as oil spills to occur;

[2] This number does not account for every individual comment received; rather, comments addressing a similar issue/concern were aggregated and represented as a single distinct issue/concern.

- Project design, location, and schedule;
- Cumulative impacts;
- Waste management; and
- Potential transboundary issues.

Table 4.5-1 lists these key themes and addresses how the key themes were considered in the EIA.

Table 4.5-1: Key Themes for Scoping Consultation Comments Received and How They Were Considered in the EIA

Key Theme	Consideration in EIA
Socioeconomic impacts	Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, describes the assessment of potential socioeconomic impacts of the Project for planned activities. Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, describes the assessment of potential socioeconomic impacts of the Project for unplanned events (e.g., oil spills).
Environmental impacts	Each resource/receptor-specific discussion in Chapter 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources, and Chapter 7 Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources, describes the assessment of potential impacts on environmental resources/receptors from planned Project activities, and the management measures recommended to address those potential impacts. Chapter 9 describes the assessment of potential environmental impacts of the Project for unplanned events (e.g., oil spills).
Regulatory process	Chapter 3, Administrative Framework, describes the administrative framework applicable to the Project, including the regulatory process for the EIA. Chapter 4, Methodology for Preparing the Environmental Impact Assessment, provides additional detail on the EIA process.
Worker health and safety	Chapter 3, Administrative Framework, describes the ExxonMobil Operations Integrity Management System (OIMS) Framework, which underpins EEPGL's processes and procedures to facilitate safe operation of the Project. Chapter 2, Description of the Project, and Chapter 13, Recommendations, describe the specific embedded controls that will aid in managing health and safety related risks.
Unplanned events	Chapter 9 assesses the potential impacts from unplanned events, including oil spills. The Oil Spill Response Plan, which is included as an attachment to the EIA, describes EEPGL's specific approach for managing the impacts of an oil spill, should one occur.
Project design, location, and schedule	Chapter 2 includes a description of the proposed Project, and includes a schedule describing anticipated timing for the major phases of the Project, assuming receipt of regulatory approval to proceed.
Cumulative impacts	Chapter 10, Cumulative Impact Assessment, assesses the potential cumulative impacts of the Project combined with the likely effects of other reasonably foreseeable activities with the potential to impact the same resources/receptors as the Project.

Key Theme	Consideration in EIA
Waste management	A Waste Management Plan, which is included as an attachment to the EIA, describes EEPGL's strategy for addressing Project-generated wastes.
Transboundary impacts	The planned activities of the Project are not expected to result in transboundary (i.e., outside of Guyana) impacts. Chapter 9 discusses potential transboundary impacts in the unlikely event of an oil spill.

4.6. Assessment of Impacts and Identification of Mitigation Measures

The primary purpose of an EIA is to predict the potential impacts resulting from a proposed project and to identify measures to avoid, reduce, or remedy these potential impacts. The Consultants used a standard impact assessment methodology for identifying potential impacts and assessing their significance.

Impacts can be "direct," "indirect," or "induced," as defined below:

- Direct—impacts that result from a direct interaction between a project and a resource/receptor (e.g., disturbance of a benthic community habitat on the seafloor);
- Indirect—impacts that follow from direct interactions between a project and other resources/receptors (e.g., impacts on marine fish who feed off a directly impacted benthic community); and
- Induced—impacts that result from other non-Project activities that occur as a consequence of a project (e.g., impacts from an influx of job seekers).

The assessment of impacts proceeded through an iterative four-step process, as illustrated in Figure 4.6-1.

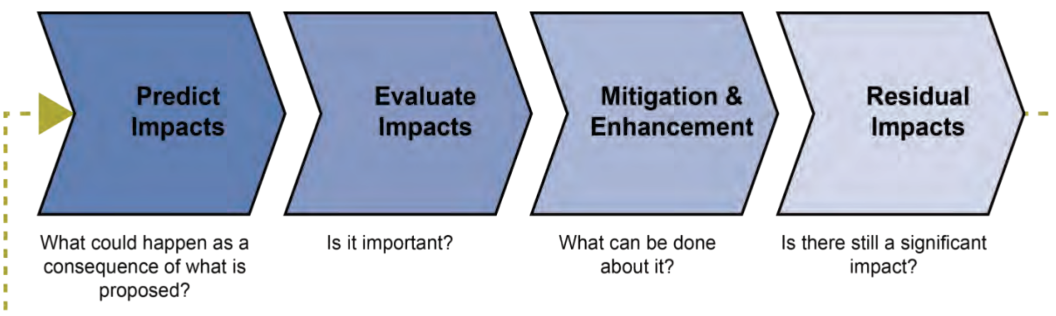


Figure 4.6-1: Impact Prediction and Evaluation Process

4.6.1. Step 1: Predict Impacts

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

4.6.1.1. Predicting Magnitude of Impacts

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

- Extent
- Duration
- Scale
- Frequency
- Likelihood (for unplanned events only)

The magnitude of an impact takes into account the various dimensions of a particular impact to determine where the impact falls on the spectrum (in the case of adverse impacts) from **Negligible** to **Large**. Some impacts will result in changes to the environment that may be immeasurable, undetectable, or within the range of normal natural variation. Such changes are characterized as having a **Negligible** magnitude.

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

- Positive
- Negligible
- Small
- Medium
- Large

Not all impacts can be assessed according to the same criteria, so the magnitude ratings for specific impacts may be determined differently according to the resource/receptor (or the type of impact) being assessed.

4.6.1.2. Predicting Sensitivity, Vulnerability, or Importance of Impacts

Multiple factors are taken into account when defining the sensitivity/vulnerability/importance of a resource/receptor. For physical resources (e.g., marine water quality), the resource's sensitivity to change and/or importance are typically considered. For biological or cultural resources/receptors (e.g., a mangrove forest), the importance (e.g., local, regional, national, or international importance) and sensitivity to the specific type of impact are typically considered. For human receptors, the vulnerability of the individual, community, or wider societal group is generally considered. Other factors may also be considered when characterizing sensitivity/vulnerability/importance, such as legal protection, government policy, stakeholder views, and economic value.

As in the case of magnitude, the approach for determining ratings of sensitivity/vulnerability/ importance designations will vary on a resource/receptor basis. The following sensitivity/vulnerability/importance designations are used in the EIA:

- Low
- Medium
- High

4.6.2. Step 2: Evaluate Impacts

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

4.6.2.1. Evaluating Potential Impacts from Planned Activities

For potential impacts associated with planned activities of the Project, the significance of each potential impact is assigned based on evaluation of the magnitude of the impact and the sensitivity/vulnerability/importance of the resource/receptor. The matrix depicted in Figure 4.6-2 is used for assigning impact significance ratings. The assignment of a significance rating enables decision-makers and stakeholders to understand and prioritize key potential Project impacts and consider what mitigation measures may be warranted.

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

Figure 4.6-2: Impact Significance Rating Matrix for Planned Activities

An impact of **Negligible** significance is one where a resource/receptor will not be noticeably impacted by a particular activity; the predicted impact is deemed to be imperceptible or is indistinguishable from natural background variations, or the impact is of a small magnitude impacts and is expected to affect resources/receptors with a low sensitivity or vulnerability to the particular impact.

In the case of positive impacts, the EIA does not attempt to characterize magnitude; therefore, significance ratings for positive impacts are not determined.

The specific criteria used to evaluate significance of impacts for each resource/receptor are presented in 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.

4.6.2.2. Evaluating Potential Impacts from Unplanned Events

Non-routine/unplanned events related to the Project (e.g., oil spills, traffic accidents, or other events with a low probability of occurrence) do not lend themselves readily to the analysis described above for planned activities. For these types of unplanned events, assessing the significance of the risk requires understanding:

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

For unplanned events, a risk matrix (Figure 4.6-3) is used to rate the risk of potential impacts associated with these events.

Risk Matrix		**Consequence/Severity**		
		Low	**Medium**	**High**
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

Figure 4.6-3: Impact Risk Rating Matrix for Unplanned Events

"Consequence/severity" takes into consideration the magnitude, as defined for Step 1, of the potential impact if the unplanned event were to occur. "Likelihood" reflects the probability of occurrence and is defined as follows:

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

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

4.6.3. Step 3: Mitigation and Enhancement

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

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

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

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

Measures were developed to address the potential impacts identified in the EIA process. These measures are described in each resource/receptor-specific discussion in 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. Chapter 13, Recommendations, summarizes all of these measures. Mitigation measures are generally not developed for potential adverse impacts that are assessed as having a significance rating of **Negligible**.

In addition, an ESMP was prepared that describes all the mitigation measures incorporated into the EIA, summarizes how each measure will be implemented, and identifies a monitoring strategy to evaluate the effectiveness of each measure. The ESMP is included as an attachment to the EIA.

EEPGL recognizes that demonstrating capacity to manage non-routine, unplanned events, such as oil spills, is an important and integral component of the impact management process. As such, the ESMP includes an Oil Spill Response Plan (OSRP) to address the management of potential impacts resulting from an unplanned oil spill.

4.6.4. Step 4: Determine and Manage Residual Impacts

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

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

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

5. SCOPE OF THE ENVIRONMENTAL IMPACT ASSESSMENT

The scope of the EIA includes all Project stages described in Chapter 2, Description of Project (i.e., development drilling, installation, hook-up/commissioning, production operations, and decommissioning) and all planned activities listed in Section 5.1, The Area of Influence. The EIA also addresses non-routine, unplanned events (e.g., spills and releases). The EIA builds on the previous Strategic Environmental Assessment prepared for EEPGL's original exploration drilling in the Stabroek Block (ERM 2014), the Environmental Management Plan prepared for EEPGL's Liza Field Multiwell Exploration Program (ERM 2016), and the EIA prepared for the Liza Phase 1 Development Project (ERM 2017). Additional data collection and further analyses were conducted to evaluate the potential environmental and socioeconomic impacts of the Project, and these are discussed herein.

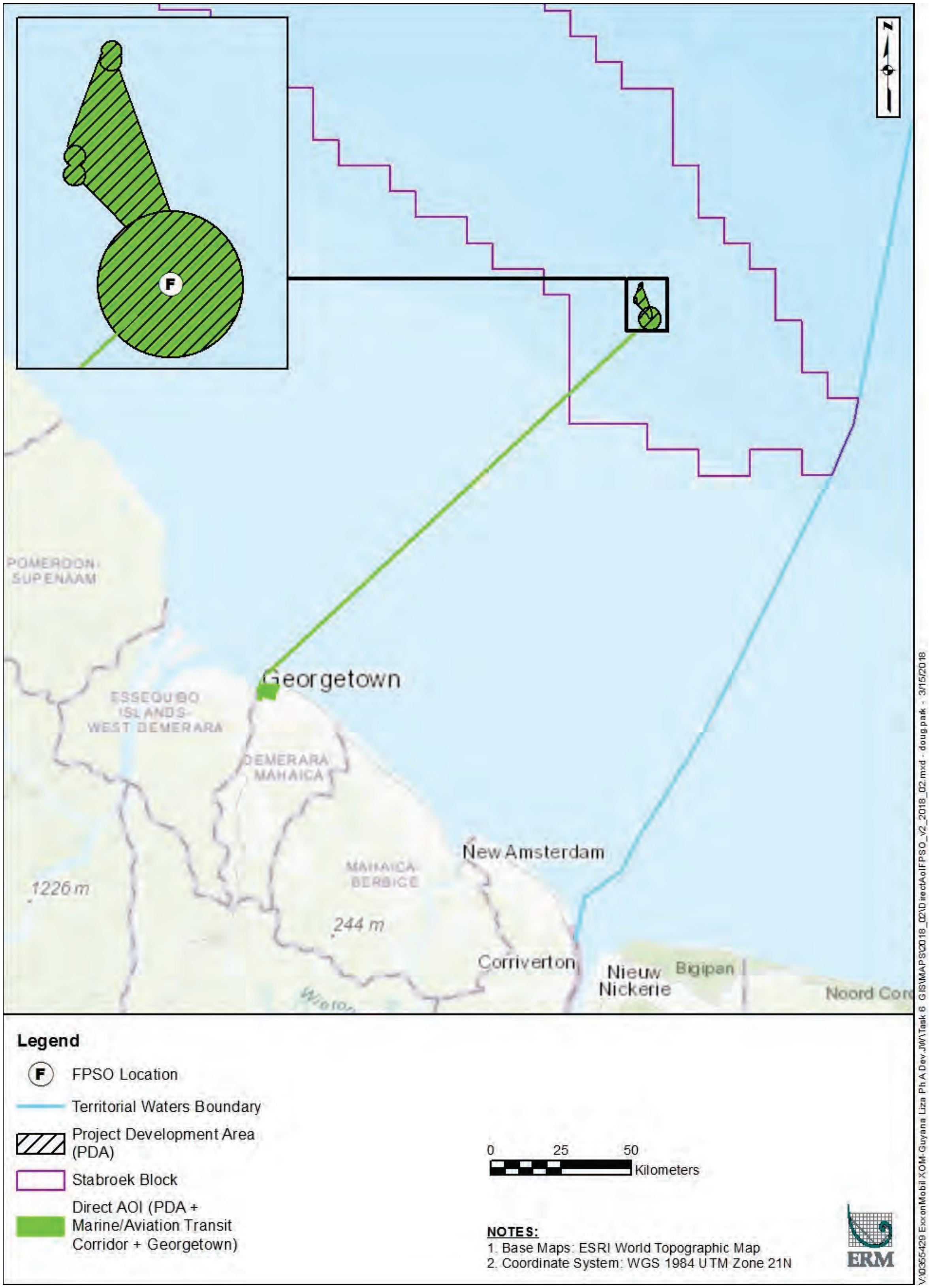
5.1. THE AREA OF INFLUENCE

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

- Direct AOI, within which the Project is expected to have potential direct impacts (Figure 5.1-1). This area includes: (1) the Project Development Area (PDA) (i.e., the subsea development area including the wells, Subsea, Umbilicals, Risers, and Flowlines (SURF) equipment, and other subsea infrastructure; and the surface development area including the Floating Production, Storage, and Offloading (FPSO) vessel, drill ships, other Project marine vessels and associated marine safety exclusion zones); (2) the marine and aviation transit corridors between the PDA and onshore activity centers in Guyana and Trinidad (within territorial boundary of Guyana); and (3) the City of Georgetown. These areas collectively were defined as the Direct AOI because they comprise, based on the potential impacts identified during the scoping phase, the geographic extent in which direct Project impacts (i.e., potential impacts resulting from a direct interaction with planned Project activities and environmental or socioeconomic resources) are anticipated to potentially occur. The planned Project activities will generate emissions to air and discharges to water. Modeling for these parameters was conducted to assess whether these emissions and discharges could result in potential impacts to air quality and water quality, respectively, outside of the geographic extent encompassed by the Direct AOI. The results of modeling (see Sections 6.1.3, Impact Assessment—Air Quality and Climate Change, and 6.4.3, Impact Assessment—Water Quality) confirmed that the Direct AOI is inclusive of the extent of potentially significant impacts to these resources.
- Indirect AOI, within which the Project is expected to have potential indirect impacts (Figure 5.1-2). This area includes coastal areas and marine waters within the territorial boundary of Guyana that could potentially be impacted by an unplanned event (i.e., an oil spill [see Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events, for more details on oil spill modeling]). Oil spill modeling conducted for the Liza Phase 2 Project confirmed that only (portions of) the Region 1 coastline could potentially be

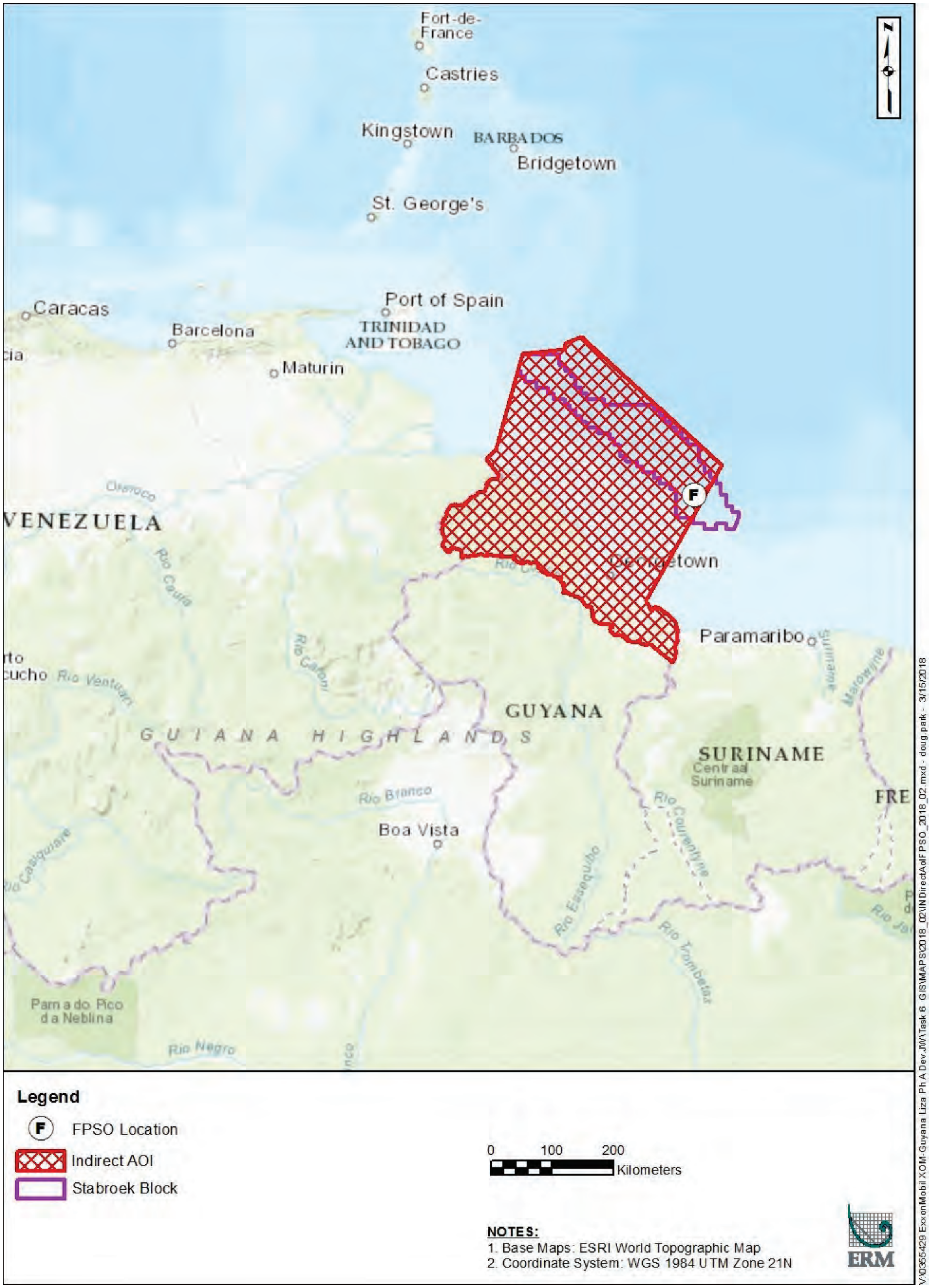
impacted by a spill, and that an oil spill would not have a reasonable likelihood of affecting marine waters southeastward or seaward of the FPSO. However, considering the potential for community members from all coastal regions (in particular fishermen and other marine users) to be indirectly affected in the event of an oil spill, as well as the potential for socioeconomic impacts from some planned Project activities (e.g., Project vessel movements), all six coastal regions and the entire extent of Guyana's marine waters downgradient of the FPSO were defined collectively as the Indirect AOI. Although all 10 regions of Guyana would potentially benefit from the shared government revenue stream from the Project, the Indirect AOI does not include the entire country because the extent to which any specific region could benefit from the revenues is dependent on the government's policies rather than on the Project activities assessed in this EIA.

As described in Chapter 10, Cumulative Impact Assessment, cumulative impacts on environmental and socioeconomic resources could potentially result from incremental impacts of the Project, when combined with other past, present, and reasonably foreseeable future projects/ developments within the Project AOI. The geographic area of concern for the cumulative impacts analysis is generally consistent with the Project AOI.



Note: map does not represent a depiction of the maritime boundary lines of Guyana

Figure 5.1-1: Direct Area of Influence



Note: map does not represent a depiction of the maritime boundary lines of Guyana

Figure 5.1-2: Indirect Area of Influence

To define the scope of the environmental and socioeconomic impact analysis, it is necessary to identify the potential interactions between the Project and the resources/receptors within the Project AOI. These interactions are the mechanisms that could trigger Project-related impacts on resources/receptors.

The planned Project activities and potential unplanned events listed below may potentially interact with existing resources/receptors, and these interactions could potentially create direct, indirect, or cumulative environmental or socioeconomic impacts:

- Development drilling stage
  - Drill ship and drilling operations
    - Power generation
    - Drill cuttings discharges
    - Drilling fluids discharges
    - Wastewater effluent discharges
    - Offshore waste treatment and disposal, including incineration
  - Vertical Seismic Profile (VSP) operations
  - Remotely operated vehicle (ROV) operations
  - Onshore waste management, recycling, treatment, and disposal
- Installation of FPSO/SURF components stage:
  - Marine installation vessels and FPSO
    - Power generation
    - Installation of FPSO mooring system
    - Discharge of hydrostatic test water, hydrate inhibitor, and ballast water
    - Wastewater effluent discharges
    - Offshore waste treatment including waste incineration
  - ROV operations
  - Installation of SURF equipment
  - Hookup and commissioning of FPSO and SURF equipment
  - Onshore waste management, recycling, treatment, and disposal
- Productions operations stage:
  - FPSO Vessel Operations
    - Power and heat generation
    - Non-routine, temporary flaring
    - Treated produced water discharge
    - Brine discharges from sulfate removal and potable water processing
    - Treated sanitary wastewater effluent discharge
    - Ballast water discharge (one time at mobilization)
    - Non-hydrocarbon (non-contact) cooling water discharges
    - Gas re-injection into reservoir
    - Seawater intake

        - Treated seawater injection into reservoir
        - Chemical use (topsides, subsea, downhole)
    - Oil offloading to conventional tankers
        - Tanker power generation
        - Venting of cargo tanks during oil loading
        - Seawater intake for ballast operations
        - Tanker ballast water discharge on arrival
        - Tanker treated domestic wastewater effluent discharge
    - Offshore waste treatment and disposal, including waste incineration
    - Potential for onshore waste management, recycling, treatment, and disposal
- Decommissioning stage
    - Marine decommissioning vessels and FPSO
        - Power generation
        - Disconnection of mooring system and SURF equipment
        - Wastewater effluent discharges
        - Offshore waste treatment, including waste incineration
    - Onshore waste management, recycling, treatment, and disposal
- Logistical support (across all Project stages)
    - Supply and support vessel/aircraft operations
    - Onshore fuel transfers from suppliers
    - Utilization of shorebase(s), including pipe yards and warehouses
    - Onshore waste management, recycling, treatment, and disposal
- Non-routine, unplanned events
    - Oil spill or release—FPSO/SURF production operations
    - Oil spill or release—well control event
    - Other oil spills or releases
- Other unplanned events (e.g., vehicular accident, helicopter accident, vessel collision, nearshore vessel grounding)

Ancillary activities or facilities (e.g., shorebase[s]) that are not components of the Project but are associated with the Project also may potentially interact with existing receptors, and these interactions could potentially create induced environmental or socioeconomic impacts.

5.2. Resources/Receptors Assessed in the EIA

One of the purposes of the scoping process is to identify which resources/receptors could potentially be significantly impacted by the Project and which resources/receptors would not have the potential to be significantly impacted by the Project. Based on the Project description and understanding of existing conditions at the time of scoping, Table 5.2-1 lists those resources/receptors that were identified as having the potential to be impacted by the Project, subject to further assessment. These resources/receptors were retained for further consideration in the EIA.

Table 5.2-2 lists those resources/receptors that were identified as being unlikely to have the potential to be significantly impacted by the Project and the rationale for this determination. These resources/receptors were excluded from further consideration in the EIA.

5.2.1. Assessment of Potential for Geological/Seismic Impacts

During the scoping process for the Phase 2 EIA, the public indicated concern that the Project's offshore activities could potentially result in a seismic event, which could in turn cause a tsunami that affected onshore safety. Based on consideration of the potential for Project activities to result in this type of event, the Consultants determined it was appropriate to exclude this potential impact from further consideration in the EIA. However, in light of the public's stated concerns, the following discussion is presented to elaborate on the justification for this exclusion.

5.2.1.1. Natural Disaster Risk Ratings for Guyana

In 2014, the United Nations International Strategy for Disaster Reduction (UNISDR) assessed natural hazard risk in Guyana as part of a global initiative to assess vulnerability to natural disasters. UNISDR's disaster risk profile for Guyana indicates that based on historical records, floods, droughts, and landslides pose the most significant risks to Guyana (UNISDR 2014). This assessment was based on a "look back" at the incidence of natural hazards that have occurred in the past, but did not indicate probability of hazards occurring in the future. However, UNISDR also conducted a probabilistic assessment that used mathematical models to combine possible future hazard scenarios, information about the exposed assets, and potential vulnerability, to provide estimates of probable economic losses due to different categories of disasters. Unlike the "look back" assessment, the probabilistic risk assessment overcame the limitations associated with deriving risk from historical disaster loss data by accounting for all types of disasters that can occur in the future, including higher-intensity losses with long recurrence intervals (UNISDR 2014). This assessment indicated that floods pose by far the most significant risk to Guyana, followed by relatively minor risks from earthquakes. The risks posed by tsunamis were determined to be not significant enough to be reported in the economic analysis. The same assessment indicated that the predicted recurrence interval of a tsunami in Guyana exceeded 1,500 years (UNISDR 2014).

5.2.1.2. Assessment of Tsunami Risks to Guyana

Guyana could experience tsunamis generated from other areas of seismic activity outside Guyana if such activity propagated waves of sufficient magnitude and in the required direction. Most of the available research on seismic risk in the region has focused on three potential sources (see Figure 5.2-1):

- The Septentrional Fault Zone and the Hispaniola Trench, both of which are north of the Dominican Republic; and
- The Puerto Rico Trench, which begins off the northeast coast of Hispaniola and extends along a generally east-west axis for more than 750 kilometers (approximately 466 miles) into the western Atlantic Ocean.

Source: WHOI 2005

Figure 5.2-1: Areas of Potential Seismic Risk

In 2005, the Woods Hole Oceanographic Institute reported that although all three of these features are capable of producing earthquakes large enough to induce tsunamis, the overall risk of such an event is small, and the greatest risk associated with earthquake-generated tsunamis in these locations would be to Hispaniola and Puerto Rico (WHOI 2005; Brink and Lin 2004).

In the unlikely event of a tsunami generated at the Septentrional Fault Zone or the Hispaniola Trench, the risk to Guyana would be essentially zero because the land masses of Hispaniola, Puerto Rico, and the Lesser Antilles would shield Guyana from any tsunami that propagated in a southerly direction. The same would be true of seismic activity along the western portion of the Puerto Rico Trench, but Guyana could be exposed to a tsunami that arose at the extreme eastern end of the Puerto Rico Trench and propagated southward.

The Puerto Rico Trench is located on the boundary between the Caribbean and North American crustal plates, approximately 1,000 kilometers (approximately 621 miles) away from the Project PDA. Given the distance involved, drilling in the Liza Field would have no reasonable potential to affect seismic stability of the Puerto Rico Trench.

5.2.1.3. Assessment of Fault Presence in the Liza Phase 2 Project Development Area

Natural processes that modulate the spatial and temporal occurrence of earthquakes include tectonic stress changes, migration of fluids in the crust, Earth tides, surface loading and unloading, heavy precipitation, atmospheric pressure changes, and groundwater loss (Kundu et al. 2015). In rare cases, human-related activities may supplement natural tectonic processes and trigger earthquakes (Foulger et al. 2018). For oil and gas operations, these activities include injection, production, and stimulation. In all cases, the presence of critically stressed planes of weakness (e.g., faults) are required to host and accommodate seismic slip (Alt and Zoback 2016). There are no mapped faults at the Liza reservoir interval in the Liza field area, and, consequently, the likelihood of seismic slip is anticipated to be extremely low.

5.2.1.4. Conclusion

The Project is considered to have a negligible potential to result in seismic risk, including risk of tsunamis reaching Guyana, for the following reasons:

- Guyana has a low risk of exposure to seismic risks in general.
- Guyana would be naturally buffered from the effects of a tsunami originating at most of the known seismically active zones in the region, in the extremely unlikely event that such an event occurred.
- The Project's drilling activities would not have a reasonable potential to affect seismic stability at the areas identified in the region as seismic risk areas (the nearest being approximately 1,000 kilometers [approximately 621 miles] away from the PDA).
- There are no mapped faults at the Liza reservoir interval in the Liza field area, and, consequently, the likelihood of seismic slip in the PDA is anticipated to be extremely low.

Accordingly, potential seismic impacts have therefore been scoped out of further assessment in the EIA.

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Table 5.2-1: Summary of Resources/Receptors, Potential Impacts, Sources of Potential Impacts, and Assessment Approach

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Physical Resources			
Air Quality and Climate	Air emissions resulting from the Project have the potential to change ambient air quality in the Project AOI on a localized basis. Air quality is important for health of humans and wildlife.	• Power generation • Other marine vessel and support aircraft combustion sources • Non-routine, temporary flaring • Fugitive emissions from crude oil storage and offloading • Waste incineration	Ambient offshore air quality data were collected in and around the PDA for the Liza Phase 1 Development Project, approximately 190 kilometers (approximately 120 miles) offshore of Guyana, and included measurements of respirable particulate matter (PM_{10}), carbon monoxide, sulfur dioxide, hydrogen sulfide, nitrogen dioxide, and volatile organic compounds. An additional set of offshore air quality monitoring data for these constituents, as well as for fine particulate matter ($PM_{2.5}$), will be collected in the vicinity of the Phase 2 PDA. The collective data set will inform the assessment of potential impacts on air quality by validating the initial assumptions in the modeling regarding ambient air quality conditions. Project emission inventories will be prepared for these pollutants and air quality dispersion modeling will be conducted to identify potential air quality impacts associated with planned Project activities. Estimated greenhouse gas emissions for the Project will be calculated.
Sound	Operations on the FPSO and other Project marine vessels will have the potential to result in auditory impacts on Project workers. Potential underwater sound impacts on biological receptors are addressed below for those groups of receptors.	• Equipment/machinery operating on board the FPSO, drill ships and other marine vessels (relative to potential impacts on Project workers)	The EIA will discuss that occupational-related risks will be managed through appropriate design and industrial hygiene and exposure management practices.
Marine Geology and Sediments	The Project will disturb marine geology and sediments on a localized basis in the PDA and could impact sediment quality from deposition of NABF adhered to discharged drill cuttings. Indirect impacts on seismicity and other natural hazards are not expected; the rationale for this will be provided in the EIA.	• Drilling of development wells, including cuttings discharge • Installation of FPSO mooring lines and SURF components	EEPGL conducted prior sampling of marine sediments in the Stabroek Block as part of iterative EBS events. Additional data will be collected from the Phase 2 PDA to expand this data set. The collective EBS data will inform the assessment of potential impacts on sediment quality by describing the biophysical attributes of the seafloor (e.g., composition, stability) that influence stability and recovery after disturbance. A fate and transport model will be used to simulate cuttings and drilling fluid deposition surrounding the Project development wells. The predicted changes to the native seafloor morphology from the accumulated drill cuttings and other Project-related activities that will impact the seafloor, as well as the distribution of residual NABF on drill cuttings, will be described based on the results of the modeling analysis. The EIA will describe the reasonably foreseeable effects of oil extraction and injection of water and gas on geological stability, as well as an assessment of the Project's foreseeable impact on geological/seismic hazards (to the extent they may exist).
Marine Water Quality	The Project could have localized impacts on marine water quality in the PDA from discharge of drill cuttings and from routine operational and hydrotesting discharges. The Project also could potentially impact marine water quality in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drilling of development wells (cuttings and drilling fluid discharge) • Cooling water discharges • Installation of FPSO and SURF components • Wastewater effluent discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned event (i.e., oil spill or release)	EEPGL conducted prior sampling of marine water quality in the Stabroek Block as part of iterative EBS surveys. The collective data will inform the assessment of potential impacts on marine water quality by validating the assumptions of the model regarding ambient water quality conditions. Fate and transport modeling will be used to evaluate total suspended solids concentrations resulting from discharge of cuttings. The GEMSS model will be used to simulate the mixing zone around the drill ships and FPSO, and to support an analysis of impacts on marine water quality from routine production operations discharges and one-time hydrotesting discharges. Oil spill modeling will be used to estimate concentrations of dissolved hydrocarbons that might result from different unplanned event scenarios (i.e., oil spills or releases).

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Biological Resources/Receptors			
Protected Areas and Special Status Species	The Project is not expected to impact protected areas as a result of routine, planned activities in the Project AOI. The Project could potentially impact protected areas in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release). The Project could potentially impact some special status species individuals (e.g., listed endangered or threatened species) in the PDA as a result of underwater sound, light, seawater withdrawal, and/or changes in marine water quality. The Project could potentially impact special status species in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Underwater sound generated by marine operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater effluent discharges • Drilling of development wells (cuttings and drilling fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Vessel movements • Non-routine, unplanned event (e.g., oil spill or release, vessel strikes with marine mammals or turtles)	As part of an ongoing study initiated prior to scoping for the Project EIA, data on marine fish abundance and distributions are being collected from the Stabroek Block. An additional marine fish sampling survey will be conducted in the Phase 2 PDA. The combined data set from these surveys will be incorporated into the EIA to inform the assessment of impacts on special status marine fish species. The study will be used to determine whether the fish community in the Project AOI includes any particularly sensitive species, as well as to characterize the distribution of fishery resources relative to the Project AOI. A study initiated prior to scoping for the Project EIA includes tagging and tracking of movements of nesting marine turtles in the Shell Beach Protected Area. Data from this study will be used to supplement existing information on marine turtle movements (and their consequent susceptibility to Project-related impacts). Marine mammal and other protected species observations from EEPGL's offshore vessels have been ongoing since 2015. Findings from these observations will be incorporated into the assessment of impacts on protected marine mammal and other protected fish and turtle species. Based on a review of the Phase 1 Development Project subsea noise modeling analysis, the physical attributes of the Phase 2 Project subsea infrastructure, and marine features that could affect subsea noise propagation (primarily depth, proximity to unique bathymetric features, and angle and direction of the continental slope), the modeling conducted for the Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Phase 2 project. Accordingly, these results will be incorporated into the Phase 2 Project EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on sensitive species. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and assess the potential risk of oiling impacting any designated protected areas. Consistent with the approach taken for marine mammals, turtles, and fish without special-status designation, the scientific literature will be reviewed for information on the impacts of planned offshore activities on special status species, including marine turtles, marine fish, and marine mammals. Oil spill modeling will be used to assess potential spill-related impacts. The GEMSS model will be used to simulate the mixing zone around the drill ships and FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess any associated impacts on special status marine species). A fate and transport model will be used to evaluate total suspended solids concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on special status marine species.
Coastal Habitats	The Project is not expected to impact beaches, mangroves, or wetlands in the Project AOI as a result of routine, planned activities. The Project could potentially impact beaches, mangroves, and wetland habitats in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated prior to scoping for the Project EIA, coastal sensitivity mapping, and field verification is being conducted to characterize coastal habitats within the Project AOI. The results of this study will be used primarily to prioritize oil-spill response activities. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and the results of the oil spill modeling will be considered together with coastal sensitivity mapping data to assess the risk from oiling beaches, mangroves, or wetlands.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Coastal Wildlife	The Project is not expected to impact coastal wildlife during routine, planned activities in the Project AOI. The Project could potentially impact coastal wildlife in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated prior to scoping for the Project EIA, coastal sensitivity mapping and field verification are being conducted to characterize coastal biodiversity with the Project AOI. The results of this study will be used primarily to prioritize oil-spill response activities. As part of a study initiated prior to scoping for the Project EIA, surveys are being conducted to characterize coastal bird abundance and distributions from different seasons. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and the results of the oil spill modeling will be considered together with coastal biodiversity data and coastal bird data to assess the risk to these resources/receptors from an oil spill or release.
Seabirds	The Project could potentially impact seabirds in a localized manner as a result of light (i.e., disorientation) and other offshore marine operations. The Project could potentially impact seabirds in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drill ships, FPSO, and support vessel operations • Lighting on offshore facilities (related to potential for disorientation of seabirds) • Non-routine, temporary flaring • Waste incineration • Non-routine, unplanned event (e.g., oil spill or release)	As part of a study initiated prior to scoping for the Project EIA, surveys of marine bird abundance and distributions from different seasons are being conducted within the Stabroek Block. The combined data set from these surveys will be incorporated into the EIA to inform the assessment of impacts on marine birds by identifying any particularly sensitive species in the Project AOI. Oil spill modeling will be used to simulate the trajectory of an oil spill and the results of oil spill modeling will be considered together with the marine bird data to assess potential spill-related impacts on seabirds.
Marine Mammals	The Project could potentially impact marine mammal individuals in a localized manner in the Project AOI as a result of Project-related underwater sound, light, seawater withdrawal, and/or changes in marine water quality. The Project could potentially impact marine mammal individuals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release, vessel strikes)	Marine mammal and other protected species observations from EEPGL's offshore study vessels have been ongoing since 2015. Findings from these observations will be reviewed together with information from scientific literature to inform the assessment of impacts on marine mammal species by identifying any particularly sensitive species and describing the distribution of fishery resources relative to the Project AOI. Based on a review of the Phase 1 Development Project subsea noise modeling analysis, the physical attributes of the Phase 2 Project subsea infrastructure, and marine features that could affect subsea noise propagation (primarily depth, proximity to unique bathymetric features, and angle and direction of the continental slope), the modeling conducted for the Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Phase 2 project. Accordingly, these results will be incorporated into the Phase 2 Project EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on marine mammals. The GEMSS model will be used to simulate the mixing zone around the drill ships and FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess associated impacts on marine mammals). A fate and transport model will be used to evaluate total suspended solids concentrations resulting from discharge of drilling fluid and cuttings, and to assess associated impacts on marine mammals. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling will be considered together with the marine mammal data to assess potential spill-related impacts on marine mammals.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Marine Turtles	The Project could potentially impact marine turtle individuals in a localized manner in the Project AOI as a result of Project-related underwater sound, light, seawater withdrawal, and/or changes in marine water quality. The Project could potentially impact marine turtle individuals in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release, vessel strikes)	A study initiated prior to scoping for the Project EIA includes tagging and tracking of movements of nesting marine turtles in the Shell Beach Protected Area. Data from this study will be used to supplement existing information on marine turtle movements (and their consequent susceptibility to Project-related impacts). The GEMSS model will be used to simulate the mixing zone around the drill ships and FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess associated impacts on marine turtles). A fate and transport model will be used to evaluate total suspended solids concentrations resulting from discharge of drilling fluid and cuttings, and to assess any associated impacts on marine turtles. Based on a review of the Phase 1 Development Project subsea noise modeling analysis, the physical attributes of the Phase 2 Project subsea infrastructure, and marine features that could affect subsea noise propagation (primarily depth, proximity to unique bathymetric features, and angle and direction of the continental slope), the modeling conducted for the Phase 1 Development Project EIA is relevant to the assessment of potential impacts from the Phase 2 project. Accordingly, these results will be incorporated into the Phase 2 Project EIA by reference, and used as the basis for the assessment of potential underwater noise impacts on marine turtles. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling will be considered together with the marine turtle data to assess potential spill-related impacts on marine turtles.
Marine Fish	The Project could potentially impact marine fish as a result of underwater sound, light, seawater withdrawal, and changes in marine water quality in the PDA. The Project could potentially impact marine fish in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Underwater sound generated by marine operations • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater effluent discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned events (i.e., oil spill or release)	As part of an ongoing study initiated prior to scoping for the Project EIA, data on marine fish abundance and distributions are being collected from the Stabroek Block. An additional marine fish sampling survey will be conducted in the Phase 2 PDA. The combined data set from these surveys will be incorporated into the EIA to inform the assessment of impacts on marine fish species by identifying any particularly sensitive species and describing the distribution of fishery resources relative to the Project AOI. The findings of the study will also support prioritization of response activities in the OSRP. The GEMSS model will be used to simulate the mixing zone around the drill ships and FPSO and to support an analysis of changes to marine water quality from routine operational discharges and one-time hydrotesting discharges (and to assess associated impacts on marine fish). A fate and transport model will be used to evaluate total suspended solids concentrations resulting from discharge of drilling fluid and cuttings, and to assess any associated impacts on marine fish. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and the results of oil spill modeling will be considered together with the marine fish data to assess potential spill-related impacts on marine fish.

Resource or Receptor	**Potential Impact**	**Primary Sources of Potential Impacts**	**Proposed Assessment Approach**
Marine Benthos	The Project could potentially disturb some benthic habitat and organisms in a localized manner in the PDA.	• Drilling of development wells (cuttings discharge and deposition) • Installation of FPSO (mooring structures) and SURF components	EEPGL conducted prior sampling of marine benthos in the Stabroek Block as part of iterative EBS surveys. The collective EBS data will inform the assessment of potential impacts on marine benthos. Additionally, as part of an ongoing study initiated prior to scoping for the Project EIA, ancillary observations of marine benthos are being collected from the Stabroek Block as part marine fish studies. An additional marine fish sampling survey will be conducted in the Phase 2 PDA. The combined data set from these surveys will be incorporated into the EIA to inform the assessment of impacts on marine benthos by characterizing the overall rarity or sensitivity of the benthic community and identifying any particularly sensitive species. A fate and transport model will be used to predict the extent and thickness of cuttings discharged on the seafloor surrounding the development wells. This data will be considered in combination with the above information to assess any impacts on marine benthos as a result of drill cuttings deposition.
Ecological Balance and Ecosystems	The Project could have indirect impacts on ecological functions in the Project AOI, particularly if special status species or trophic relationships are disturbed.	• Underwater sound generated by marine operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Installation of FPSO and SURF components • Installation-related disturbances to seafloor • Wastewater effluent discharges • Ballast water discharges • Waste incineration • Non-routine, unplanned event (e.g., oil spill or release)	The scientific literature will be reviewed to assess the ecological relationships between major marine taxonomic groups. Oil spill modeling will be used to assess potential spill-related impacts on marine organisms.
Socioeconomic Resources / Receptors			
Economic Conditions	The Project is generally anticipated to have a positive impact on the economy of Guyana as a result of government revenue sharing from the Project, as well as employment and local procurement opportunities. Potential adverse impacts may include potential shorter-term increases in the cost of living as a result of increased demand for specific goods and services. Potential adverse impacts on income from agriculture and fisheries could also occur as a result of non-routine, unplanned events (i.e., oil spill or release).	• Government revenue sharing from Project • Local Project purchases of select materials, goods and services • Limited local Project employment (direct and indirect) • Increased spending on select materials, goods and services (indirect multiplier impacts for local/regional population)	Government reports will be reviewed and key informant interviews will be conducted to identify key economic drivers in the national, regional, and local economies and determine the likely Project-related effects on these economic factors. A particular emphasis will be placed on livelihoods that are important to coastal communities.
Employment and Livelihoods	The Project is expected to build capacity in the local labor force, increase demand for skilled labor, and increase demand for service industries. There is the potential for limited adverse impacts on fishing activities as a result of marine safety exclusion zones or marine traffic, and non-routine, unplanned events (i.e., oil spill or release).	• Local employment for • Drill ships • Installation vessels • FPSO topside equipment and operations • Marine support and supply vessels • Tankers • Tugs and support vessels • Aviation operations • Marine safety exclusion zones • Project-related marine traffic • Drilling; FPSO/SURF installation, hookup and commissioning; and FPSO and support vessel operations (aspects relating to occupational health and safety for Project workforce) • Non-routine, unplanned event (e.g., spill or release)	Project workforce projections and types of labor requirements will be assessed against data obtained through key informant interviews on the existing service industry within Guyana. The potential for adverse impacts on fishing activities will be assessed by taking into consideration the distance from shore at which different fishery types typically operate, in comparison to the locations and durations of Project-related marine activity and marine safety exclusion zones. As part of studies initiated prior to scoping for the Project EIA, consultations were conducted with fisherfolk and others that may be directly or indirectly dependent on fishing to characterize catch quantities at key fish landing sites. Concerns regarding potential impacts on fishing were also discussed during the Phase 2-focused scoping consultation meetings. The collective body of information from these consultations will be used to assess potential socioeconomic impacts on fisherfolk in the AOI. The EIA will discuss that occupational-related risks will be managed through appropriate design and industrial hygiene and exposure management practices.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Community Health and Wellbeing	Most Project activities will be located offshore and will have no direct impacts on communities in Guyana. Project-related increases in vehicular traffic could increase the potential for vehicle accidents. Introduction of limited levels of foreign labor for the Project workforce could potentially have community health and socioeconomic impacts due to social interaction or pressure on wages and increased competition for skilled labor. Non-routine unplanned events (i.e., oil spill or release) could impact health and wellbeing of communities via impacts on resources on which these communities depend.	• Increased traffic as a result of Project activities at the shorebase locations used by the Project (related to increased potential for vehicle accidents) • Social interaction between foreign Project workers and residents • Pressure on wages from introduction of foreign Project workers and increased competition for skilled labor • Non-routine, unplanned event (e.g., oil spill or release)	Potential risks to safety and health of local communities posed by shorebase operations will be assessed. Key informant interviews will be conducted to characterize existing road, marine and air traffic safety conditions, as well as coastal agriculture, aquaculture, and offshore/coastal fishing resources. As part of a study initiated prior to scoping for the Project EIA, the uses of natural resources by local coastal communities are being mapped to identify specific dependencies on resources that could be impacted by the Project. These data will be assessed to assess potential Project impacts on the quality or accessibility of these services. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and to assess potential spill-related impacts on community health and wellbeing.
Marine Use and Transportation	The Project activities will result in increased marine shipping and general marine-related traffic, which could potentially contribute to marine vessel congestion in port areas.	• Marine vessel operations	Key informant interviews will be conducted to characterize communities dependent on marine transportation and use for livelihoods (e.g., speedboat operators and fisherfolk), and to characterize existing marine vessel operations in the Project AOI. Publically available records of existing marine vessel traffic within the Port of Georgetown will be reviewed and these will be supplemented with additional primary data collected via observations of marine vessel traffic operating between the Guyana shorebase(s) and the mouth of the Demerara River. These data will be considered in conjunction with estimates of anticipated Project-related traffic and marine use to assess the incremental change in demand on the port's and harbor's capacities to accommodate foreseeable marine use and transportation demands. The EIA will also include a discussion of the tanker activities anticipated as a result of the Project, as well as the key operational procedures and controls (both within and outside of Guyanese waters) that will be implemented in relation to these activities.
Social Infrastructure and Services	The Project will use public infrastructure and services and thus could potentially compete with other existing businesses and consumers across a range of services (e.g., roads, medical and emergency response, accommodation, and utilities). The Project will result in increased vehicular traffic in Georgetown, which could potentially contribute to vehicular congestion in certain areas.	• Project demand requirements for selected infrastructure and services, which could increase the burden on existing capacity and supply • Shorebase operations and other Project-related onshore transportation of materials and personnel, which could contribute to traffic congestion	Key informant interviews and review of publically available government reports will be conducted to assess existing demand on public infrastructure and services and to assess the impact that additional Project-related demand on these resources could have on impacted communities. Existing vehicular traffic conditions will be characterized through a traffic study conducted in the vicinity of the Guyana shorebase(s). Information from this study will be considered together with estimates of Project-related onshore traffic to assess the impact of Project-related vehicle movements on local traffic conditions and identify any problem areas in the vicinity of the Guyana shorebase(s) that currently present congestion-related concerns. These results will be used to assess the need for optimizing Project-associated vehicular traffic in the vicinity of the Guyana shorebase(s). The impact assessment section will include transportation and road safety management procedures that will be informed by the traffic study and focused on impacts predicted in the impact analysis.
Cultural Heritage	The Project has the potential to adversely affect cultural heritage through localized disturbance of any archeological or historic resources present in the subsea Project footprint. Such resources could have conservation, cultural, and other values to stakeholders. The Project also could potentially impact cultural heritage resources outside of the subsea Project footprint as a result of non-routine, unplanned events (i.e., oil spill or release).	• Drilling of development wells • Installation of FPSO and SURF components • Non-routine, unplanned event (i.e., oil spill or release)	EEPGL has completed a geophysical and shallow geotechnical analysis that assessed the layout and field architecture for the Project AOI to site facilities away from faults, seabed obstructions, archaeological resources, sensitive biological resources, or other resources or hazards that could either damage the wells or SURF or be damaged by installation of these components. Autonomous underwater vehicles and other geophysical surveys will be utilized to assess for the presence of man-made objects on the seabed within the PDA. As part of an ongoing study initiated prior to scoping for the Project EIA, coastal communities in the Project AOI, including indigenous communities, are being engaged with respect to characterizing areas along the coast with cultural heritage significance. As part of this effort, key informant interviews are being conducted and Traditional Cultural Knowledge is being leveraged. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill and to assess the potential for a release from an unplanned event to contact terrestrial cultural heritage sites.

Resource or Receptor	Potential Impact	Primary Sources of Potential Impacts	Proposed Assessment Approach
Land Use	No new Project-dedicated land disturbance is planned. There is the potential that third-party onshore facilities may elect to expand or impact adjacent land as a result of supporting Project-related needs; however, these impacts are outside the scope of this EIA.	• Shorebase operations • Pipe yards • Warehouses • Bulk fuel storage and transfers • Onshore waste recycling, treatment and disposal facilities	Land use in the area surrounding onshore facilities planned for Project use will be reviewed and assessed with respect to the potential for impacts on land use as a result of the Project.
Ecosystem Services	Project-related impacts on natural resources could lead to shorter-term direct or indirect impacts on the services and/or values derived from natural resources and ecosystems in the Project AOI.	• Direct or indirect impacts derived from one or more of the impacts on physical, biological, or socioeconomic resources described above	As part of an ongoing study initiated prior to scoping for the Project EIA, the uses of natural resources by local coastal communities, including indigenous communities, are being engaged to identify specific dependencies on resources that could be impacted by the Project. Data from this effort, including Traditional Cultural Knowledge, will be used to aid in assessing dependencies on natural resources that could be impacted by the Project in terms of local communities' access to and use of impacted resources. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill from the Project and to assess the potential for oil to contact areas providing ecosystem services.
Indigenous Peoples	The Project is not expected to directly cause any changes to population or demographics in indigenous communities. The Project could potentially impact indigenous peoples in the Project AOI as a result of non-routine, unplanned events (i.e., oil spill or release).	• Non-routine, unplanned event (i.e., oil spill or release)	As part of an ongoing study initiated prior to scoping for the Project EIA, coastal communities, including indigenous communities, in the Project AOI are being engaged with respect to characterizing coastal biodiversity and ecosystem services. As part of this effort, key informant interviews are being conducted and Traditional Cultural Knowledge is being leveraged to characterize socioeconomic conditions in communities, and their reliance on natural resources. Data from this effort will be used to aid in the assessment of impacts for the Project. Oil spill modeling will be used to simulate the trajectory of a hypothetical oil spill from the Project and to assess the potential for oil to contact lands and natural resources of coastal communities.

EBS = environmental baseline survey; GEMSS = Generalized Environmental Modeling System for Surfacewaters; NABF = non-aqueous base fluid; OSRP = Oil Spill Response Plan; $PM_{2.5}$= particulate matter with aerodynamic diameter of less than 2.5 micrometers; PM_{10} = particulate matter with aerodynamic diameter of less than 10 micrometers

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Table 5.2-2: Resources and Receptors Excluded from Further Consideration in the EIA

Resource/Receptor	Rationale for Excluding
Coastal (Onshore) Resources	
Onshore geology/soils	The Project will not result in any onshore disturbance to geology and soils.
Topography/landscape	The Project will not require any excavation, fill, or other land-based activities that could change onshore topography or landscapes.
Groundwater	The Project will not require any changes in land use that could impact ground water quantity or quality.
Terrestrial vegetation	The Project will not require any clearing or disturbance of terrestrial vegetation. Even in the case of an unplanned event such as a spill, only estuarine vegetation (e.g., mangroves) would be expected to be potentially impacted. Terrestrial vegetation should be unaffected by a spill event.
Freshwater habitats	The Project is offshore, with no new onshore disturbance, so will not have any impact on freshwater habitats.
Marine Resources	
Aquatic plants	The marine aspects of the Project will occur in an area that is too deep to support vascular marine plants.
Physical Resources	
Vibration and radiation	The Project will not generate any vibration or radiation that are expected to impact resources/receptors. See Section 2.12, Materials, Emissions, Discharges, and Wastes, for a description of radiation sources that will be used by the Project, and the related procedures that will be employed to ensure protection of Project workers.

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6. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—PHYSICAL RESOURCES

For the purposes of this EIA, physical resources include non-biological natural resources.

6.1. AIR QUALITY AND CLIMATE CHANGE

6.1.1. Administrative Framework—Air Quality and Climate Change

Table 6.1-1 summarizes the legislation, policies, treaty commitments, and industry practices that focus specifically on air quality and climate.

Table 6.1-1: Legislation, Policies, Treaty Commitments and Industry Practices—Air Quality and Climate

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Air Quality Regulations, 2000	Establishes that the EPA shall, at any time after the commencement of the Regulation, establish limits for any of the contaminants specified in the Regulation. Sets reporting requirements, penalties for violations of standards, and permitting requirements for stationary and mobile sources of air emissions.	Applicable to Project sources of air emissions (although no limits have yet been established by EPA).
International Agreements Signed/Acceded by Guyana		
United Nations Framework Convention on Climate Change	Promotes international cooperation to limit average temperature increases and resulting changes in climate and international cooperation to adapt to these impacts.	Provides for controls on greenhouse gas (GHG) emissions within Guyana's territory (maritime and land), and establishes national policy regarding adaptation to climate change. Guyana's Intended Nationally Determined Contributions under the convention are focused on preserving the country's forests as a carbon sink and include avoiding deforestation, minimizing emissions from forestry and mining operations, expansion of renewable energy sources, and integrated water resource management. Guyana acceded and ratified in 1994.
Kyoto Protocol	Extends the United Nations Framework Convention on Climate Change and commits countries to reduce GHG emissions.	Establishes national GHG emission reduction targets. Guyana acceded in 2003.
Vienna Convention on the Protection of the Ozone Layer	Provides a framework for the protection of the ozone layer.	Establishes measures for protecting the ozone layer. Guyana acceded in 1993.

Title	Objective	Relevance to the Project
Montreal Protocol on Substances that Deplete the Ozone Layer	A protocol to the Vienna Convention designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.	Prohibits the use of several groups of halogenated hydrocarbons that may deplete the ozone layer. Guyana acceded in 1993.

6.1.2. Existing Conditions—Air Quality and Climate Change

This section describes the existing air quality conditions and climate in the Project Area of Influence (AOI). Air quality in a geographic area is determined by the presence of background concentrations due to natural and distant sources, the type and amount of pollutants emitted locally into the atmosphere, the topography of the area, and the weather and climate conditions. The levels of pollutants and pollutant concentrations in the atmosphere are typically expressed in units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$), averaged over various periods of time.

6.1.2.1. Air Quality

Since the Project Development Area (PDA) is located approximately 183 kilometers (approximately 114 miles) offshore in the Atlantic Ocean and far removed from any anthropogenic sources of emissions other than intermittent marine traffic and exploration and development well drilling activity, ambient air quality is determined primarily by regional influences rather than by local emission sources or topographic influences. Additionally, the prevalent wind direction is from the northeast (an open ocean area); therefore, ambient air quality within the PDA is expected to be good. To assess existing offshore air quality conditions in the PDA and its general vicinity, the Consultants have conducted three offshore air monitoring campaigns:

- From 3 October through 23 October 2016, air quality monitoring equipment was deployed on a research vessel and samples were collected within the Stabroek Block and the Liza Phase 1 PDA (approximately 8.5 kilometers [approximately 5.3 miles] west of the Liza Phase 2 PDA). Pollutants sampled included inhalable particulate matter (i.e., that fraction with aerodynamic diameter of less than 10 micrometers [PM_{10}]), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), and volatile organic compounds (VOCs).
- From 9 April through 16 April 2018, air quality monitoring equipment was deployed on a research vessel and samples were collected within the Stabroek Block and the Liza Phase 2 PDA. Pollutants sampled included PM_{10}, CO, SO_2, H_2S, NO_2, and VOCs.
- From 2 May through 13 May 2018, air quality monitoring equipment was deployed on a fishing trawler and samples were collected within the Stabroek Block and the Liza Phase 2 PDA. Pollutants sampled included particulate matter with an aerodynamic diameter of less than 2.5 micrometers ($PM_{2.5}$), SO_2, H_2S, NO_2, and VOCs.

The data from the 2016 monitoring in the Liza Phase 1 PDA were presented in an air quality monitoring report provided with the Liza Phase 1 Development Project EIA. An air quality monitoring report summarizing the methodology and results of the 2018 efforts is included in Appendix D to this EIA. As in the case of the 2016 effort, the measurements from the 2018 survey efforts found that ambient concentrations of constituents were below laboratory reporting limits, with the exception of PM_{10} (measured 24-hour average concentrations ranging from 33 to 43 µg/m^3) and $PM_{2.5}$ (measured 24-hour average concentrations ranging from 7 to 18 µg/m^3). Chemical analysis of the particulate matter samples found that largest single component of the collected particulate mass was sodium chloride—the most likely source of which is sea salt. The maximum reported laboratory concentrations for total VOCs were less than 30 ppb—very low, by comparison to typical urban environment ambient air concentrations, and consistent with measurements documented in the literature for remote, offshore marine environments (National Research Council 1991). The lack of detectable CO demonstrates that the monitoring was not significantly biased by the vessels' engine emissions.

To assess existing onshore air quality conditions for purposes of the EIA, relevant literature was used to identify appropriate ranges of concentrations to represent existing conditions. Based on the estimated Project emissions profile. A report by the Yale Center for Environmental Law & Policy (YCELP 2016) ranked Guyana 6th (from the best) out of 180 countries in air quality.

6.1.2.2. Climate

Information on meteorological conditions in coastal Guyana was obtained from publicly available sources and technical literature. Parameters discussed include rainfall, offshore wind direction, air temperature, and relative humidity.

Guyana has a wet tropical climate characterized by two pronounced wet seasons and year-round warm temperatures. The bimodal wet/dry regime is caused by the annual migration of the Inter-Tropical Convergence Zone (ITCZ), which changes latitude based on the Earth's position and angle in relation to the sun. Northward movement of the ITCZ occurs as energy from the sun is strongest in the Northern Hemisphere during the Northern Hemisphere's summer, thereby increasing solar heating in that hemisphere. The relative changes in solar heating slightly shifts the atmosphere's primary circulation cells, which causes the area of trade wind convergence closest to the Equator to migrate seasonally. In the areas closest to the ITCZ, one can expect increased thunderstorm activity and heavy rainfall between mid-April and the end of July, with peak rainfall in June. This period is known in Guyana as the primary wet season. The secondary wet season occurs during the southward migration of the ITCZ from mid-November to the end of January, with peak rainfall in December. The intervening periods (January to April and mid-August to mid-November) are relatively dry, but rain can occur at any time of the year. Average monthly rainfall totals range between approximately 100 millimeters and 300 millimeters (4 inches to 12 inches) (World Weather & Climate Information 2016). During El Niño years, Guyana's long dry season is often drier and warmer than normal, and La Niña years bring wetter and cooler conditions than normal during the long wet season (McSweeney et al. 2010).

Although the ITCZ moves seasonally, it is generally located between 5 degrees (°) North latitude and 5° South latitude. North and south of the ITCZ, atmospheric circulation and the Coriolis effect create global wind patterns including the Northern Hemisphere's trade winds and westerlies (NOAA 2008). Guyana's coastal zone is located approximately between 6° and 8° latitude, and the Stabroek Block is located between 7° and 8° latitude, both within the southern portion of the area impacted by the trade winds. The influence of the trade winds produces a strongly dominant northeast wind offshore of Guyana, which gives rise to the afternoon "sea breeze" that usually blows inland across coastal Guyana from the ocean.

Annual average temperatures in coastal Guyana are relatively constant, with an annual average daytime maximum temperature of 29.6 degrees Celsius (°C) (85.3 degrees Fahrenheit [°F]) and an annual average night time minimum temperature of 24.0 °C (75.2°F). The average daily temperature is approximately 27 °C (81°F). Relative humidity is high at 80 percent or more year round in the coastal zone.

To develop more specific climate information regarding the conditions in the PDA, EEPGL and ERM have deployed oceanographic moorings in the PDA to collect information on existing oceanographic and meteorological conditions. The meteorological moorings are equipped with a Datawell Direction Wavescan Buoy, which measures wave and atmospheric conditions. With respect to atmospheric conditions, the instrument measures and logs:

- Wind direction/speed (two anemometers record 10-minute average wind speeds and gusts);
- Air temperature;
- Atmospheric pressure;
- Solar radiation;
- Precipitation; and
- Relative humidity.

6.1.3. Impact Assessment—Air Quality and Climate Change

This section addresses potential impacts on air quality due to emissions resulting from planned Project activities. Additionally, while potential climate impacts are more of a global concern from cumulative worldwide greenhouse gas (GHG) emissions, the section addresses potential impacts on climate from Project GHG emissions. The key potential impacts assessed include increases in ambient concentrations of pollutants as a result of stationary and mobile combustion sources associated with planned Project activities, and GHG emissions from these same sources.

6.1.3.1. Relevant Project Activities and Potential Impacts

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, flares used to combust produced gas when not consumed as fuel gas on the Floating Production, Storage, and Offloading (FPSO) vessel or injected back into the Liza 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. Depending on the magnitude and extent of the increases relative to the location of potential human receptors onshore in Guyana, the increases may have the potential to contribute to health impacts. Because potential air quality-related health effects for Project workers will be addressed through standard occupational exposure guidelines, the air quality impact assessment was limited to consideration of potential onshore community receptors. With respect to climate, the combustion of hydrocarbons in support of Project activities will generate GHG emissions. While the GHG emissions from the Project have been estimated with an acceptable level of confidence, the potential influence of those GHG emissions on global climate change is not measurable with an acceptable level of confidence; therefore, potential global climate change impacts are not addressed in this EIA.

Table 6.1-2 summarizes the Project stages and activities that could result in potential Project impacts on air quality and climate.

Table 6.1-2: Summary of Relevant Project Activities and Key Potential Impacts— Air Quality and Climate

Stage	Project Activity	Resource	Key Potential Impacts
Development Well Drilling FPSO and SURF Installation	Operation of drill ships (power generation and engines), marine support and installation vessels, and support aircraft	Ambient air quality (onshore population as receptors)	Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors
		Climate	Increased emissions of GHGs, potentially contributing to climate impacts [a] (more of a global concern)
Production Operations	Operation of FPSO (power generation and engines), marine support vessels, and support aircraft; temporary, non-routine flaring of gas when not re-injected	Ambient air quality (onshore population as receptors)	Increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore receptors
		Climate	Increased emissions of GHGs, potentially contributing to climate impacts [a] (more of a global concern)

SURF = Subsea, Umbilicals, Risers, and Flowlines
[a] See discussion in Section 6.1.3.1, Relevant Project Activities and Potential Impacts.

6.1.3.2. Magnitude of Impact—Air Quality

Project Emissions

Emissions to air from the Project have been estimated based on a number of factors, including activity levels, fuel type, equipment capacities, and standard emission factors that are published by the U.S. Environmental Protection Agency (USEPA) in the publication AP-42: Compilation of Air Pollutant Emission Factors (USEPA 2018). As described in AP-42, an emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., milligrams of nitrogen oxides [NO_x] emitted per cubic meter of natural gas combusted). The use of these factors allows estimation of emissions from various sources of air pollution. In most cases, these factors are averages of available data of an acceptable quality, and are generally assumed to be representative of long-term averages for a particular type of source.

Table 6.1-3 provides a summary of expected annual emissions from various Project activities for three time periods: 2020–2021 (development well drilling; Subsea, Umbilicals, Risers, and Flowlines (SURF) installation and commissioning; FPSO installation; and operation of related support vessels); 2022–2024 (continued development well drilling, FPSO startup and associated temporary, non-routine flaring, beginning of production operations, tanker loading); and 2025–2042 (production operations following cessation of drilling, including temporary, non-routine flaring, operation of support vessels, and tanker loading). For each of the time periods following 2021, the annual emissions presented for each pollutant in Table 6.1-3 represent the maximum anticipated annual emissions for that pollutant for any of the years during the indicated time period. While there are some differences in emissions for different years within the time periods, they are relatively minor and the use of maximum emissions for the impact assessment provides a degree of conservatism in the results.

Table 6.1-3: Annual Air Emissions Summary

Pollutant	Source Category	Annual Emissions [a] (tonnes unless otherwise specified)		
		2020–2021	2022–2024	2025–2042
NO_x	FPSO	0	2,875	2,780
	FPSO Flaring (temporary, non-routine)	0	575	255
	Tanker Loading	0	305	300
	Area Sources [b]	2,055	590	450
	Drill Ship	1,675	840	0
	Total	3,730	5,185	3,785
SO_2	FPSO	0	145	145
	FPSO Flaring (temporary, non-routine)	0	95	45
	Tanker Loading	0	55	50
	Area Sources	75	25	20
	Drill Ship	60	30	0
	Total	135	350	260
Particulate Matter (PM) [c]	FPSO	0	0	65
	FPSO Flaring (temporary, non-routine)	0	0	20
	Tanker Loading	0	0	25
	Area Sources	145	145	45
	Drill Ship	120	120	60
	Total	265	265	215
CO	FPSO	0	0	735
	FPSO Flaring (temporary, non-routine)	0	0	3,130
	Tanker Loading	0	0	65
	Area Sources	430	430	125
	Drill Ship	350	350	175
	Total	780	780	4,230

Pollutant	Source Category	Annual Emissions [a] (tonnes unless otherwise specified)		
		2020–2021	2022–2024	2025–2042
Other Pollutants				
H_2S	FPSO Flaring (temporary, non-routine)	NA	<5	<1
VOCs [d]	All Sources	95	4,855	4,410
GHGs (kilotonnes CO_2-equivalents)	All Sources	195	2,325	1,510

Note: The emission rates in this table reflect annual totals. In some cases, the activities generating the emission are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions estimates reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period, to reflect maximum short-term emission rates.

[a] The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.6, Project Schedule), which could change.

[b] Area Sources are mobile equipment such as aviation and marine support vessels (besides the FPSO and drill ships) used during drilling, installation, production operations, and decommissioning.

[c] PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} and $PM_{2.5}$ standards (a conservative assumption).

[d] VOC emissions are shown in this table but were not included in the impact assessment modeling, as no ambient air quality criteria have been established for these substances as a group of compounds.

Ambient Air Quality Guidelines and Concentrations

Ambient air quality guidelines are concentration levels in air that are established by governing authorities to protect human health in locations where exposure can occur. These generally include a margin of safety to ensure that vulnerable individuals are also protected. Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment were those established by the World Health Organization (WHO) (see Table 6.1-4). These guidelines were published in *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide* (WHO 2005) except for CO and H_2S, which were published in WHO's *Air Quality Guidelines for Europe* (WHO 2000).

Existing offshore air quality in the vicinity of the Liza Phase 2 PDA and existing onshore air quality in the Georgetown area is discussed in Section 6.1.2, Existing Conditions—Air Quality and Climate Change. Based on a comparison of measured ambient offshore concentrations of pollutants to WHO standards and on literature regarding onshore air quality in Guyana, it was concluded that the offshore airshed in the vicinity of the Phase 2 PDA and the onshore airshed in the Georgetown area can be considered *undegraded airsheds* for the purpose of the impact assessment process (see below).

Table 6.1-4: WHO Ambient Air Quality Guidelines

Pollutant	Averaging Period	Guideline Concentration (µg/m^3)
NO_2	1-hour	200
	Annual	40
SO_2	10-minute	500
	24-hour	20
PM_{10}	24-hour	50
	Annual	20
$PM_{2.5}$	24-hour	25
	Annual	10
CO	1-hour	30,000
	8-hour	10,000
H_2S	30-minute	7

Source WHO 2000; WHO 2005

Air Quality Dispersion Modeling

Air dispersion modeling was carried out to assess air quality impacts for onshore human receptors. The key elements of the modeling are discussed below, including receptors, source inputs, model selection, and meteorological data.

Receptors: A grid of potential receptor points was established for onshore areas in the Project AOI. The purpose of this grid was to identify maximum-predicted pollutant concentrations generated by the Project across the onshore portion of the Project AOI. Maximum concentrations were predicted at all of the onshore grid points using the dispersion model, and then compared to concentrations that may potentially result in significant impacts. If the maximum predicted concentrations are determined to be not significant, it follows that air quality impacts on any specific human receptors throughout the onshore Project AOI also would be not significant. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling.

Sources: With regard to source characteristics, point sources were modeled with fixed stack parameters, including physical dimensions and exhaust characteristics. Flares were also modeled as stacks, with additional calculations applied to adjust the release height and stack parameter to account for increased thermal buoyancy associated with the high temperature of the flare. All of the emissions sources on the FPSO were conservatively modeled at a single location (representing the highest predicted ambient air concentration scenario). Area sources (i.e., mobile sources without fixed locations) were modeled in a fashion to represent their transit across planned travel areas. For example, support vessels and helicopters were assumed to operate and generate emissions within the PDA and also to transit between Georgetown and the PDA. There is a potential that additional support vessels for some stages of the Project may transit between Trinidad and Tobago and the PDA; however, based on the low level of emissions contributed by support vessel/helicopter traffic, relative to emissions from sources in the PDA, and the expectation that most support vessel/helicopter traffic will originate from Guyana shorebase facilities, modeling of support vessel area sources was limited to vessels transiting between Guyana and the PDA.

Figure 6.1-1 displays the modeling domain used in this analysis, showing the locations of the main Project point sources (the FPSO and the drill ships [the drill center locations are noted]), and the area sources (including support vessels, helicopters, installation vessels, and other sources without a fixed location), as configured for the modeling. Terrain elevations used in the modeling are also depicted on this figure. The green symbols on Figure 6.1-1 represent the locations of Liza Phase 1 air pollutant emissions sources (i.e., the Phase 1 FPSO, and Phase 1 drill centers); these were used for modeling of cumulative impacts, as described in Chapter 10, Cumulative Impact Assessment.

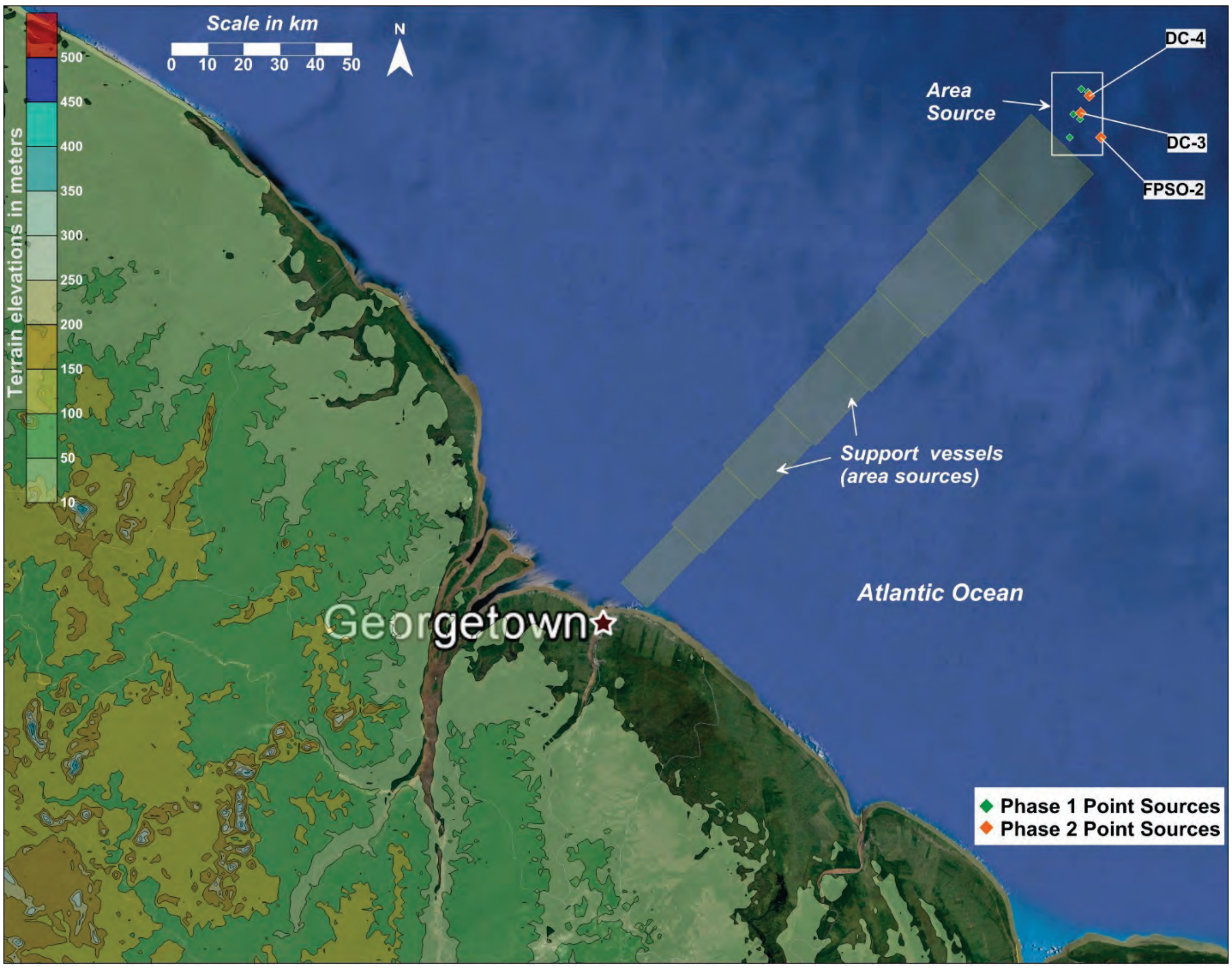


Figure 6.1-1: Air Quality Modeling Domain

Model Selection: The CALPUFF model (a non-steady-state model used in the United States and around the globe for long-range transport and complex wind modeling) was selected for use in the assessment. CALPUFF is a Lagrangian "puff" model that treats a plume as a series of puffs that it tracks as the wind carries the plume towards potential receptor locations. CALPUFF is also capable of modeling near-field impacts.

The selection of CALPUFF was based on the relatively large distance between the principal Project-related sources and potential onshore receptors. As shown on Figure 6.1-1, the distance from the PDA to the closest shoreline is greater than 183 kilometers. At this distance, emission plumes released from Project point sources will travel for 10 hours, assuming an average wind speed of 5 meters per second (typical for the area). During this transport time, winds can change direction and speed. Accordingly, prediction of plume dispersion is most appropriately accomplished with a non-steady state model.

Meteorological Data: The Weather Research and Forecasting model was used to develop hourly meteorology inputs for CALPUFF for 3 years—calendar years 2014, 2015 and 2016. This model is a prognostic meteorological model that creates profiles of winds and temperature at grid points across a domain. The grid spacing chosen for this analysis was 12 kilometers (7.5 miles), meaning that a two-dimensional profile of hourly winds and temperature was developed every 12 kilometers (7.5 miles) within the domain shown on Figure 6.1-1. The profiles were used by CALPUFF to simulate the transport and dispersion of emission plumes from Project sources, allowing the model to calculate predicted constituent concentrations at potential receptor locations.

Predicted Ambient Air Concentrations

Using the methodology described above, modeling was conducted with CALPUFF to estimate maximum ambient concentrations of Project-generated constituents of interest at potential onshore receptor locations. Model results were developed for each modeled constituent, for each averaging period with an associated WHO guideline concentration (Table 6.1-4). Results are summarized in Table 6.1-5.

Table 6.1-5: Summary of Modeling Results—Maximum Predicted Concentrations at Onshore Locations

Pollutant	Averaging Period	WHO Guideline Concentration (μg/m³)	Maximum Predicted Onshore Concentration (μg/m³)			Percent of WHO Guideline		
			2020-2021	2022-2024	2025-2042	2020-2021	2022-2024	2025-2042
NO_2	1-hour	200	1.4	2.8	2.4	0.7%	1.4%	1.2%
	Annual	40	0.1	0.2	0.1	0.3%	0.4%	0.3%
SO_2	10-minute	500	0.1	0.5	0.4	0.0%	0.1%	0.1%
	24-hour	20	0.0	0.1	0.1	0.1%	0.7%	0.6%
PM_{10}	24-hour	50	0.0	0.1	0.0	0.1%	0.1%	0.1%
	Annual	20	0.0	0.0	0.0	0.1%	0.0%	0.0%
$PM_{2.5}$	24-hour	25	0.0	0.1	0.0	0.2%	0.2%	0.2%

Pollutant	Averaging Period	WHO Guideline Concentration ($\mu g/m^3$)	Maximum Predicted Onshore Concentration ($\mu g/m^3$)			Percent of WHO Guideline		
			2020-2021	2022-2024	2025-2042	2020-2021	2022-2024	2025-2042
	Annual	10	0.0	0.0	0.0	0.1%	0.1%	0.1%
CO	1-hour	30,000	0.4	1.6	1.2	0.0%	0.0%	0.0%
	8-hour	10,000	0.3	1.1	0.8	0.0%	0.0%	0.0%
H_2S	30-minute	7	n/a	n/a	0.0004	n/a	n/a	0.0061%

n/a – no emissions of this pollutant during the indicated timeframe

Magnitude Rating

The magnitude rating for potential air quality impacts is determined on the basis of two factors:

- The increase in pollutant concentrations in air as a result of the Project (Project Contribution—"PC"); and
- The total air pollutant concentrations arising as a result of the PC added to the existing conditions (the Predicted Environmental Concentration—"PEC").

The PC and PEC are considered in the context of the relevant WHO air quality guidelines. Once the PC and PEC have been estimated, there are a number of approaches that may be used to determine the magnitude of impact. In jurisdictions such as Guyana that do not have specified approaches, the approach taken for the EIA is based on guidance from the International Finance Corporation (IFC 2007), and is shown on Figure 6.1-2.

Magnitude of Impacts

	Undegraded Airshed (Baseline < AQS)	Degraded Airshed (Baseline >AQS)
Negligible	PC < 25% of AQS	PC <10% of AQS
Small	PC >25% of AQS, <50% of AQS, and PEC <100% of AQS	PC >10% of AQS, <15% of AQS
Medium	PC >25% of AQS, <50% of AQS, and PEC >100% of AQS; or PC >50% of AQS, <100% of AQS, and PEC <100% of AQS	PC >15% of AQS, <25% of AQS
Large	PC >50% of AQS, <100% of AQS, and PEC >100%; or PC >100% of AQS	PC >25% of AQS

Source: IFC 2007

Undegraded airshed = environmental conditions where no existing concentrations exceed a specific air quality guideline. Coastal Guyana is considered an undegraded airshed based on the literature regarding onshore air quality in Guyana.

Figure 6.1-2: Definitions for Magnitude Ratings for Potential Impacts on Air Quality

As shown in Table 6.1-5, for all the modeled pollutants, the maximum onshore concentrations predicted to result from planned Project activities are all less than 1.5 percent of the respective WHO ambient air quality guidelines. Accordingly, the magnitude of potential impacts on air quality is considered **Negligible**.

6.1.3.3. Sensitivity of Receptors—Air Quality

The standard approach taken in air quality impact assessment assumes that the sensitivity to air pollutant-related health impacts for receptors within the general population is **Medium**. This is on the basis that, as air quality standards are set to protect the most vulnerable individuals in society, there is inherently a margin of safety within air quality standards. There are a small number of specific cases where receptor sensitivity may be defined as **High**; these cases include where there are particularly vulnerable individuals (e.g., a hospital where there are intensive care wards and high-dependency wards where patients will be particularly sensitive to air pollution).

As such, the sensitivity of most potential onshore receptors is considered **Medium**, with the potential for some receptors to have a **High** sensitivity.

6.1.3.4. Impact Significance—Air Quality

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on air quality for all receptors is **Negligible**.

6.1.3.5. Characterization of Impacts—Climate

Table 6.1-6 summarizes the estimated annual GHG emissions for the Project throughout the projected Project life cycle.

Table 6.1-6: Estimated Annual Project GHG Emissions

	Estimated Annual GHG Emissions (kilotonnes CO_2-equivalents)		
	2020-2021	**2022-2024**	**2025-2042**
All Project Activities (combined)	195	2,325	1,205

Note: The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.6, Project Schedule), which could change.

As potential climate impacts are more of a global concern from cumulative worldwide GHG emissions, as opposed to a concern for a local airshed, modeling of GHG emissions is typically not performed as part of an EIA for a single project. Additionally, as there are no applicable regulatory criteria to which GHG emissions can be compared, this impact was not assigned magnitude and sensitivity ratings. However, EEPGL environmental performance monitoring and reporting management systems are in line with international good practice methods with respect to GHG management. EEPGL will quantify direct Project GHG emissions from the Project facilities and equipment used within the Project AOI. Quantification of GHG emissions will be conducted annually in accordance with internationally recognized methodologies and good practice.

6.1.4. Mitigation Measures—Air Quality and Climate

Based on the **Negligible** significance of potential air quality impacts, no mitigation measures are proposed. However, a number of embedded controls incorporated into the Project will aid in reducing emissions of pollutants to the atmosphere:

- Maintaining equipment, marine vessels, and helicopters in good working order and operating them in accordance with manufacturer's specifications to reduce atmospheric emissions to the extent reasonably practicable;
- Utilizing low-sulfur fuels for major Project vessels, where available and commercially viable;
- Avoiding use of chlorofluorocarbons and polychlorinated biphenyls on the FPSO;
- If well testing is performed, implementing the following measures:
  - Flow only the minimum volume of hydrocarbons required for the test and reduce the test duration to the extent reasonably practicable;
  - Use an efficient test flare burner head equipped with an appropriate combustion enhancement system to minimize incomplete combustion, black smoke, and hydrocarbon fallout[1] to the sea;
  - Ensure all pipes and joints are regulatory monitored for leakages and fugitive emissions, a leak detection and repair program is maintained, and all collected gaseous streams are burned in high-efficiency flares; and
  - Ensure sufficient compressed air is provided to the oil burner;
- Regularly inspecting and servicing shorebase cranes and construction equipment to reduce atmospheric emissions to the extent reasonably practicable;
- Shutting down (or throttling down) sources of combustion equipment in intermittent use where reasonably practicable to reduce air emissions;
- Performing regular audits of field operations on the drill ship, FPSO, and shorebase(s) to ensure application of designed safeguards; and
- Re-injecting produced gas that is not utilized as fuel gas on the FPSO to avoid routine production flaring. With respect to flaring, the following measures will be implemented:
  - Ensure flare equipment is designed and built to appropriate engineering codes, including:
    - Use of efficient flare tips and optimized size and number of burning nozzles;
    - Reduced risk of pilot blowout through ensuring sufficient exit velocity and provision of wind guards;
    - Use of a reliable pilot ignition system;

[1] Hydrocarbons that are deposited on the ocean surface due to both wet and dry deposition processes

        - Use of a high-integrity instrument pressure protection systems, where appropriate, to reduce overpressure events and avoid or reduce flaring situations;
        - Use a suitable liquid separation system, with sufficient holding capacity for liquids that may accumulate, in order to minimize liquid carryover and entrainment in the gas flare stream;
        - Ensure the liquid separation system is equipped with a high-level facility shutdown or high-level alarms;
    - Ensure flare equipment is appropriately inspected, certified, and function-tested prior to production operations;
    - Ensure flare equipment is appropriately maintained and monitored during production operations;
- Maximize efficiency of flaring by controlling and optimizing flare fuel, air, and stream flowrates to ensure the correct ratio of assist stream to flare stream; and
- In the event of an emergency or equipment breakdown on the FPSO, or when facility upset conditions arise, excess gas should not be vented but rather should be sent to an efficient flare gas system, where practical and operationally safe.

In addition to aiding in reducing emissions of air pollutants to the extent practicable, the above embedded controls will also serve to reduce emissions of GHGs.

Table 6.1-7 summarizes the assessment of potential pre-mitigation and residual Project impacts on air quality and climate. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the air quality-specific methodology described in Sections 6.1.3.2 and 6.1.3.3.

Table 6.1-7: Summary of Potential Pre-Mitigation and Residual Impacts—Air Quality and Climate

Stage	Resource/Receptor—Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Ambient air quality—increased concentrations of pollutants in ambient air, potentially contributing to health impacts for onshore human receptors	Negligible	Medium (most of population) or High (more sensitive receptors)	Negligible	None	Negligible
All Project Stages	Climate—increased GHG concentrations, potentially contributing to climate impacts [a] (more of a global concern)	NR	NR	NR	[b]	NR

NR = not rated
[a] See discussion in Section 6.1.3.1, Relevant Project Activities and Potential Impacts.
[b] EEPGL will quantify and report GHG emissions to the EPA consistent with international guidelines.

6.2. SOUND

6.2.1. Administrative Framework—Sound

Table 6.2-1 summarizes the legislation, policies, treaty commitments, and industry practices that focus specifically on sound.

Table 6.2-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Sound

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Noise Management Regulations, 2000	Establishes general provisions for noise avoidance and restrictions from multiple commercial and industrial sources, including sound making devices, equipment, tools, and construction activities. Authorizes EPA to set specific permissible noise levels in the future. Includes reporting requirements, penalties for violations of standards, and permitting requirements for operations that emit noise.	Regulated facilities include any offshore installation and any other installation, whether floating or resting on the seabed.
Guyana Standard, Requirements for Noise Emission into the Environment, 2010	Establishes standard used for monitoring of noise emission into the environment; sets permissible noise levels for residential, commercial, and industrial areas (day and night).	Relevant to Project-related noise levels that could be perceived in commercial, residential or industrial districts (i.e., onshore or nearshore activities)
Joint Nature Conservation Committee (JNCC) Guidelines for Minimising the Risk of Injury and Disturbance to Marine Mammals from Seismic Surveys	Reduces the risk of injury to marine mammals from geophysical survey activities.	Although the JNCC guidelines are voluntary, they are widely recognized as a global best practice in the oil and gas industry for managing the potential adverse effects of seismic surveys on marine mammals, and will be applicable to VSPs conducted on any of the development wells.

6.2.2. Existing Conditions—Sound

This section includes a summary of the desktop review of existing underwater sound conditions in the Project AOI. It also describes the different metrics commonly used to represent underwater acoustic fields. A discussion of the modeling study used to predict underwater sound levels associated with Project activities in the PDA is provided in Section 7.5, Marine Mammals.

The characterization of existing sound conditions and the analysis of predicted sound levels associated with Project activities are limited to underwater sound because the Project is located approximately 183 kilometers (approximately 114 miles) offshore from Georgetown. Accordingly, airborne sound and ground-borne vibration from Project activities in the PDA will not impact onshore community or public receptors in Guyana. Offshore, the principal airborne sound receptors of potential concern will be the workforce on the Project vessels, who will be provided with appropriate personal protective equipment (PPE), including ear protection (when engineered controls must be augmented to manage sound exposure). The Project is not expected to result in significant changes to existing sound or vibration levels at the shorebase(s), pipe yards, and warehouse locations, as such facilities have existing industrial operations. Therefore, airborne sound and ground-borne vibration are not discussed further in this section.

6.2.2.1. Underwater Acoustic Metrics

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure (p_0 = 1 micro Pascal [µPa])[2] or reference energy level (1 μPa^2•s). The following are three common acoustic metrics used to characterize underwater sound levels:

- Peak Sound Pressure Level (peak SPL, measured in dB re 1 µPa);
- Root Mean Square SPL (RMS SPL, measured in dB re 1 µPa); and
- Sound Exposure Level (SEL, measured in dB re 1 μPa^2•s).

The peak SPL metric is the maximum instantaneous SPL in a stated frequency band attained by an acoustic event. This peak metric is commonly used to characterize impulsive sounds, but does not describe the duration or bandwidth of the sound. At higher intensities, the peak SPL can be a valid criterion for assessing whether a sound may have the potential to result in auditory injury impacts on a marine receptor.

The RMS SPL is a measure of the average pressure or the "effective pressure" over the duration of an acoustic event, such as the emission of one acoustic pulse from a seismic source (e.g., vertical seismic profiler). RMS is often used to assess whether an acoustic event may have the potential to result in behavioral disturbance on a marine receptor.

The SEL is a measure of the total acoustic energy contained in one or more acoustic events and is often used as an indication of the sound energy dose over a specific event or time period. The SEL metric measures the total sound energy to which a receptor would be exposed over the associated period of time, and can be used to assess the potential for auditory injury impacts. When assessing the potential for auditory damage using the SEL metric, the predicted noise levels are frequency-weighted to mirror the expected hearing ability of a receptor across the frequency range.

More information on the underwater acoustic metrics described above, including the analytical formulation of these metrics, is provided in the document Underwater Sound Associated with Liza Phase 1 Project Activities, prepared by JASCO Applied Sciences in December 2016, included as Appendix F to this EIA.

[2] Sound levels expressed in dB in water are not the same as sound levels expressed in dB in air due to differences in the reference level and impedance of the two media. For sounds in water, the reference level is expressed as "dB re 1 µPa," referring to the relative amplitude of a sound wave to a reference pressure of 1 µPa (IAGC 2014).

6.2.2.2. Methodology for Characterizing Existing Conditions in the PDA

Ambient underwater sound levels were characterized based on literature values. Research has indicated that with the exception of localized or short-term events that may result in rises in sound levels (e.g., passage of a ship, intense rain events, whale vocalizations, etc.) underwater sound levels do not vary much in the open ocean. Non-Project related human activities are minimal in the PDA (principally related to commercial fishing and transit of other ocean-going vessels). Therefore, literature values for the open ocean are expected to be a reasonable representation of underwater sound conditions in the PDA.

Ambient underwater sound levels can serve as the context in which to measure potential disturbance impacts associated with Project activities. Sound in the ocean is the result of both natural and anthropogenic sources. Natural contributions include sources such as wind-driven waves and rainfall. A generalized model for deep-water ocean ambient sound was presented by Hildebrand (2009) and characterizes ambient sound levels at a depth of 1,000 meters, taking into account natural sources of sound (e.g., wind, sea state) as well as what the author characterized as “modern shipping noise.” The model predicts ambient sound ranging across a frequency spectrum from 20 hertz (Hz) to more than 70 kilohertz (kHz). Across this spectrum, predicted sound levels decrease from a high of approximately 60 to 80 dB re 1 $\mu Pa^2 Hz^{-1}$ (at 20 Hz), to approximately 30 to 46 dB re 1 $\mu Pa^2 Hz^{-1}$ (at 20 kHz). Predicted sound levels decrease sharply between 20 kHz and 70 kHz (Hildebrand 2009). It is noted that where a noise spectrum is presented in this way, the noise has been filtered into 1 Hz bandwidths and the noise levels are presented as dB re 1 $\mu Pa^2 Hz^{-1}$ to reflect this.

Other than the ongoing EEPGL exploration activities and the development well drilling for the Liza Phase 1 Development Project and sporadic transits of commercial fishing vessels and other ocean-going vessels in the vicinity of the PDA, there are currently no notable sources of mechanical or human-generated background underwater sound in the PDA. Considering the spectral noise levels described above, and based on frequencies from approximately 20 Hz up to approximately 20 kHz, this suggests a total broadband sound level (excluding periodic sound levels associated with exploration and Phase 1 development well drilling) of approximately 100 to 120 dB re 1 µPa [RMS].

6.2.3. Impact Assessment—Sound

As indicated above, the only receptors of airborne sound from Project activities in the PDA will be workers on board the FPSO, drill ships, and other Project-associated vessels. EEPGL will use industry-standard engineering and administrative controls for sound mitigation, will periodically monitor sound levels, and will provide appropriate hearing-protection PPE for workers, as needed. With respect to airborne sound from Project activities at the shorebase(s), the shorebase(s) owner/operator will manage sound levels from Project-related activities so as to not cause exceedances of the applicable levels contained in the Guyana Standard, Requirements for Noise Emission into the Environment, 2010. Therefore, the Project’s potential impacts from airborne sound and ground-borne vibration are not assessed further in this EIA.

Potential impacts from Project-related underwater sound are discussed in the sections relating to potential marine life receptors (Sections 7.5.3, Impact Assessment—Marine Mammals; 7.6.3, Impact Assessment—Marine Turtles; and 7.7.3, Impact Assessment—Marine Fish).

6.2.4. Mitigation Measures—Sound

As potential impacts from airborne sound and ground-borne vibration are not assessed further in this EIA, no mitigation measures are proposed.

Mitigation measures to address potential impacts from Project-related underwater sound are discussed in the sections relating to potential marine life receptors (Sections 7.5.4, Mitigation Measures—Marine Mammals; 7.6.4, Mitigation Measures—Marine Turtles; and 7.7.4, Mitigation Measures—Marine Fish).

6.3. MARINE GEOLOGY AND SEDIMENTS

6.3.1. Administrative Framework—Marine Geology and Sediments

The Consultants have not identified any legislation, policies, treaty commitments, or industry standards that focus specifically on marine geology and sediments.

6.3.2. Existing Conditions—Marine Geology and Sediments

6.3.2.1. Coastal Geology

Guyana's continental shelf occupies an area of 18,790 square miles (mi^2). The average width of the continental shelf is approximately 113 kilometers (approximately 70 miles) (NDS 1997). The shelf is widest near the borders of Suriname and Venezuela, and slightly narrower near the center. Guyana's coastline is approximately 431 kilometers (approximately 268 miles) long (NDS 1997). The Guyana coast is a sedimentary plain that has formed from successive deposits of sediment with a series of coastal ridges crossing the coast from east to west. These ridges are connected with submarine features that move across the shallow continental shelf in a northward direction driven by the nearshore current.

6.3.2.2. Marine Stratigraphy

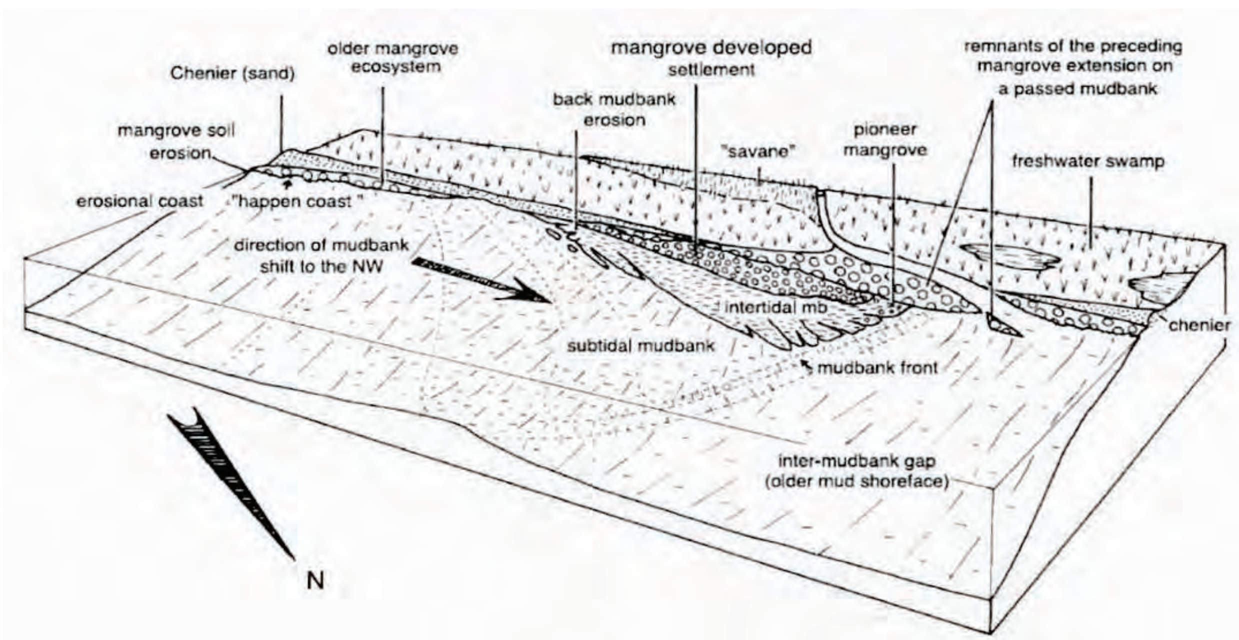
The Guyana Basin has been described as a passive margin basin associated with the rifting and opening of the equatorial Atlantic Ocean. Part of the Guyana Basin is onshore, but most of it occurs offshore. Table 6.3-1 summarizes the age and composition of the major geologic formations (listed in descending order from ground surface) that comprise the Guyana Basin (Workman 2000; CGX 2009).

Table 6.3-1: Major Geologic Formations of the Guyana Basin

Formation	Age	Composition
Corentyne	Pleistocene-Pliocene	Sandstone and shale
Pomeroon	Miocene-Eocene	Carbonate sandstone and shale
Georgetown	Maastrichtian	Sandstone, shale and carbonate
New Amsterdam	Lower Tertiary to Maastrichtian	Sandstone and shale
Canje	Santonian to Turonian	Organic shale, non-organic shale, and sandstone
Potoco Formation	Aptian	Carbonates
Stabroek Formation	Cretaceous–Barremian	Basal shales and sandstones of continental origin
Precambrian Basement	Proterozoic-Hadean	Metamorphic rock

6.3.2.3. Marine Sedimentology

Fine clay and mud sediment are transported from the mouth of the Amazon River and are deposited approximately 21 to 60 kilometers (approximately 13 to 37 miles) offshore, to an average thickness of approximately 20 meters (approximately 65 feet) along Guyana's continental shelf (CGX 2009). Moving further out to sea (i.e., toward the edge of the continental shelf), sand gradually becomes the dominant sediment layer. The bathymetric profile of the continental shelf forms a generally smooth, gradual slope from nearshore to shelf edge, but a series of low mud ridges or mudbanks are located approximately 21 to 60 kilometers (13 to 37 miles) offshore (Figure 6.3-1).



Source: Royal Haskoning 2004

Figure 6.3-1: Typical Distribution of Mudbanks and Mangroves on Guyana's Coast

Although the Essequibo and several other smaller rivers (e.g., the Demerara, Corentyne, and Berbice rivers) discharge large quantities of fine sediment, which are subsequently transported seaward and westward across the continental shelf, analysis of the humic content, nutrient composition, and ratio of surface area to mass of Guyanese marine sediments indicates that they are nearly identical to Amazonian sediments and unlike continental Guyanese sediments (Eisma and van der Marel 1971). This evidence strongly indicates that from a sedimentary perspective, the Guyanese continental shelf functions as a marine extension of the Amazonian delta system. At greater depths, calcarenite (coral fragment) substrates become more prevalent (Strømme and Sætersdal 1989). The Stabroek Block occupies the transition area between the Amazonian-influenced zone and the older, deeper calcarenite zones.

In the PDA, the foundation zone of the seabed sediments comprises a hemipelagic drape of very soft to soft clay irregularly interbedded with interpreted coarse-grain-prone turbidites. The mud content of the sediments samples analyzed from a 2016 environmental baseline survey in the vicinity of the PDA averaged 60.8 percent and the sand content averaged 39.1 percent across the 2016 survey area. The surficial layer is underlain by a regional Mass Transport Complex consisting of a heterogeneous clay-prone matrix material with intact blocks. The thickness of the surficial soft clay varies across the PDA from approximately 4.5 meters (approximately 15 feet) to 41 meters (135 feet). These features could influence the design or siting of certain subsea components that will rest on the seafloor, although they do not present structural or operational hazards to the Project (FUGRO 2016).

Particle size analysis of sediment samples collected during a 2017 environmental baseline survey in the PDA vicinity showed high variability in particle size distribution consistent with U.S. Department of Agriculture soil classifications ranging from clay to clay loam and sandy loam. In general, the 2017 survey results indicated the clay fraction tended to decrease with distance from the shore, while the sand fraction tended to increase with distance from the shore.

6.3.2.4. Sediment Quality

Sediment samples were collected from the Stabroek Block offshore Guyana as part of a 2014 environmental baseline survey as well as the 2016 and 2017 surveys discussed above. The surveys were conducted prior to EEPGL exploration drilling activities in April and May of 2014 (Maxon and TDI Brooks 2014); as well as during and after subsequent EEPGL exploration drilling activities in March of 2016 (FUGRO 2016) and October and December of 2017 (ESL 2018). The full environmental baseline survey reports are presented in Appendices G, H, and I. Sediment samples were collected from 10 sampling stations as part of the 2014 survey, 25 sampling stations as part of the 2016 survey, and 10 sampling stations as part of the 2017 survey (these locations are collectively referred to as the Study Area in this section); the stations included locations within the PDA as well as locations outside the PDA, within the southeastern portion of the Stabroek Block and along the continental shelf. A discussion of the results from all three surveys is provided below. Summaries of the results for reported metals and hydrocarbon concentrations in the sampled sediments are presented in Table 6.3-2 and Table 6.3-3, respectively.

Table 6.3-2: Summary Results for Sediment Total Metals, Reported in µg/g Dry Weight

Parameter	Mean	Minimum	Maximum	Mean Background [a]	Effects Range Low [b]	Effects Range Median [c]
2014 Liza EBS (n=10)						
Aluminum	11,495	8,100	15,000	77,440	--	--
Arsenic	6.1	4.5	11.4	2	8.2	70
Barium	98.9	57.4	159	668	--	--
Cadmium	0.125	0.102	0.165	0.102	1.2	9.6
Chromium	14.9	8.6	21.1	35	81	370
Copper	13.1	9.9	16.5	14.3	34	270
Iron	19,130	13,500	25,300	30,890	--	--
Lead	11.6	8.3	15.6	17	46.7	218
Mercury	0.042	0.026	0.062	0.056	0.15	0.71
Nickel	21.4	14.1	32.3	18.6	20.9	51.6
Vanadium	23.5	18.1	28.3	53	--	--
Zinc	45.5	26.9	63.7	52	150	410
2016 Liza EBS (n=25)						
Aluminum	43,432	13,900	66,600	77,440	--	--
Arsenic	11.6	6.1	97.1	2	8.2	70
Barium	175	44	272	668	--	--
Cadmium	0.120	0.073	0.255	0.102	1.2	9.6
Chromium	36.1	14.5	53.4	35	81	370
Copper	20.2	6.9	30.5	14.3	34	270
Iron	30,364	12,100	98,100	30,890	--	--
Mercury	0.029	0.016	0.042	0.056	0.15	0.71
Selenium	0.22	0.05	0.75	0.083	--	--
Lead	15.5	9.9	27.5	17	46.7	218
Nickel	27.0	10.8	51.5	18.6	20.9	51.6
Zinc	69.7	32.5	101.0	52	150	410
2017 Liza EBS (n=10)						
Aluminum (total)	6,510	2,900	13,000	77,440	--	--
Arsenic (total)	15	3.6	50	2	8.2	70
Barium (total)	7.5	3.5	16	668	--	--
Cadmium (total)	BDL	BDL	BDL	0.102	1.2	9.6
Chromium (total)	15	7.7	24	35	81	370
Copper (total)	3.1	BDL	6.7	14.3	34	270
Iron (total)	20,720	8,900	35,000	30,890	--	--
Mercury (total)	BDL	BDL	BDL	0.056	0.15	0.71
Selenium (total)	BDL	BDL	BDL	0.083	--	--
Lead (total)	7.8	3.8	15	17	46.7	218
Nickel (total)	8.6	3.8	15	18.6	20.9	51.6
Zinc (total)	29	11	55	52	150	410

µg/g = microgram per gram; BDL = below detection limit; EBS = environmental baseline surveys
Note: One half of the detection limit was used for non-detect results in all statistical calculations.
[a] Mean concentration in upper continental crust (Wedepohl 1995)
[b] U.S. National Oceanic and Atmospheric Administration (NOAA) Effects Range Low (Macdonald et al. 1996)
[c] NOAA Effects Range Median (Macdonald et al. 1996)

Table 6.3-3: Summary Results for Sediment Hydrocarbons

Parameter		Mean	Minimum	Maximum	Background [a]
2014 Liza EBS (n=10)					
Total Saturated Hydrocarbon (SHC) ($\mu g\ g^{-1}$)		10.64	8	14	NA
Total Unresolved SHC ($\mu g\ g^{-1}$)		6.97	3	12	NA
Total Resolved SHC ($\mu g\ g^{-1}$)		3.68	2	8.9	NA
CPI (Carbon Preference Index)		1.97	1.47	3.27	NA
Pristane ($\mu g\ g^{-1}$)		0.007	0.004	0.012	NA
Phytane ($\mu g\ g^{-1}$)		0.005	0.003	0.010	NA
Pristane/Phytane Ratio		1.34	0.67	1.8	NA
$nC_{16}/(nC_{15}+nC_{17})$		0.40	0.24	0.51	NA
Total PAH ($\mu g\ g^{-1}$)		0.03861	0.02458	0.05336	NA
Petrogenic/Pyrogenic		3.36	2.14	4.65	NA
2016 Liza EBS (n=25)					
THC ($\mu g\ g^{-1}$)		2.8	1.5	4.8	0.2-5
Unresolved Complex Mixture (UCM) ($\mu g\ g^{-1}$)		1.8	0.9	2.8	NA
n-alkanes	nC_{12-20} ($\mu g\ g^{-1}$)	0.06	0.02	0.13	NA
	nC_{21-36} ($\mu g\ g^{-1}$)	0.21	0.1	0.38	NA
	nC_{12-36} ($\mu g\ g^{-1}$)	0.27	0.12	0.5	NA
CPI	nC_{12-20}	1.29	1.1	2.41	NA
	nC_{21-36}	2.62	2.09	2.99	NA
	nC_{12-36}	2.22	1.83	2.7	NA
Pristane ($\mu g\ g^{-1}$)		0.002	0.001	0.013	NA
Phytane ($\mu g\ g^{-1}$)		0.003	0.001	0.012	NA
Pristane/Phytane Ratio		1.28	0.13	2.27	NA
Total PAH (Sum of 2-6 Rings) ($\mu g\ g^{-1}$)		0.048	0.016	0.239	NA
Sum of 2-3 Rings (NPD) ($\mu g\ g^{-1}$)		0.016	0.006	0.082	NA
Sum of 4-6 Rings ($\mu g\ g^{-1}$)		0.032	0.010	0.157	NA
NPD/4-6 Ring		0.54	0.35	0.82	NA
2017 Liza EBS (n=10) (detected constituents only)					
n-Dotriacontane (µg/g)		0.213	0.17	0.26	NA
n-Hexatriacontane (µg/g)		0.194	0.14	0.28	NA
n-Octadecane (µg/g)		0.14	BDL	1.4	NA
n-Triacontane (µg/g)		0.22	0.17	0.31	NA
Total Extractable Hydrocarbons		7.1	4.9	10	NA

µg/g = microgram per gram; BDL = below detection limit; CPI = carbon preference index (the ratio of odd number carbon chain n-alkanes to even numbered carbon chain n-alkanes); EBS = environmental baseline surveys; NA = not applicable; NPD = naphthalene, phenanthrene, anthracene, and dibenzothiophene (2 ring and 3-ring PAHs); PAH = polycyclic aromatic hydrocarbon; Pr/Ph = ratio of pristane to phytane; SHC = saturated and aliphatic hydrocarbons; THC = total hydrocarbons; UCM = unresolved complex mixture

Notes:

Petrogenic/Pyrogenic = Ratio of the sum of combustion-related PAHs (fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene divided by the sum of petrogenic PAHs (naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrene, dibenzothiophenes, chrysenes, and fluoranthenes/pyrenes).

2-6 Ring PAH = Total 2- to 6-ring polycyclic aromatic hydrocarbons

nC_{12-20} = alkanes ranging from carbon numbers 12 to 20

nC_{21-36} = alkanes ranging from carbon numbers 21 to 36

nC_{12-36} = alkanes ranging from carbon numbers 12 to 36

[a] Typical THC levels (i.e. 'background') in sediments remote from anthropogenic activities (North Sea Task Force 1993)

2014 Survey

During the 2014 survey (TDI Brooks 2014), sediment samples were analyzed for the following parameters:

- Total organic carbon (TOC)
- Metals
- Hydrocarbons

Total Organic Carbon

Concentrations of TOC were less than 1 percent at all survey stations. Higher concentrations of TOC were found in the southwest portion of the survey area, which is closer to shore.

Metals

Twelve metals were analyzed to assess general patterns of distribution across the Study Area, which was defined as the Liza AOI for the purpose of the study. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were used as indicators of anthropogenic sources; the remaining 2 metals (aluminum and iron) were used to provide geological source information. All of the ten anthropogenic-indicator metals had concentrations similar to those reported for the upper continental crust (Wedepohl 1995), with the exception of arsenic, which was slightly elevated (average of 4.51 $\mu g\ g^{-1}$ compared to an upper continental crust mean background concentration of 2 $\mu g\ g^{-1}$). However, all average concentrations were at or below the U.S. National Oceanic and Atmospheric Administration (NOAA) Effect Range Low (ERL) values.

Hydrocarbons

Hydrocarbons are divided into two classes of compounds: aliphatic compounds and aromatic compounds. The hydrocarbon analysis consisted of the analysis of saturated and other aliphatic hydrocarbons (SHC), including selected isoprenoids, and the analysis of polycyclic aromatic hydrocarbons (PAHs).

Aliphatic compounds can be “saturated” (alkanes with carbon atoms joined by single bonds), or “unsaturated” (alkenes with carbons joined by double bonds). The study measured concentrations of total SHC that encompass light and heavy fractions of petroleum (i.e., alkanes nC_{9-40}) and selected isoprenoids (branched chain unsaturated hydrocarbons), including pristane and phytane. Concentrations of total SHC ranged from 8 $\mu g\ g^{-1}$ to 14 $\mu g\ g^{-1}$. The unresolved portion of the SHC analysis (i.e., SHCs that cannot be identified through the use of standard analytical methods) ranged from 3 $\mu g\ g^{-1}$ to 12 $\mu g\ g^{-1}$, with an average of 7 $\mu g\ g^{-1}$, which makes up approximately 66 percent of the reported average total SHC concentration.

Several SHC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. These parameters and ratios are listed below, along with a general discussion of their relevance in determining the source of the hydrocarbons:

- Carbon Preference Index (CPI): The total odd-chain hydrocarbons divided by the total even-chain hydrocarbons. A value of 2 to 4 indicates input from plants. As petroleum is added, the value decreases, approaching 1.
- Pristane/Phytane Ratio: The source of phytane is mainly petroleum, whereas pristane is derived from both biological matter and petroleum. In environmental samples with no petroleum contribution, this ratio is greater than 1 and it decreases as petroleum is added.
- Hexadecane (nC_{16})/(Pentadecane [nC_{15}] + Heptadecane [nC_{17}]) ratio: At "background" levels, hydrocarbons nC_{15} and nC_{17} can be used as indicators of plankton hydrocarbon inputs. As plankton productivity increases, this ratio decreases. If the ratio were to increase over time or within the data set, the rationale would be that it is related to anthropogenic sources. Hexadecane (nC_{16}) is rarely found in biolipids (Thompson and Eglinton 1978); paraffins of nC_{15}, nC_{17}, or nC_{19} have been found to be predominant in benthic algae (Clark and Blumer 1967; Youngblood et al. 1971).

The results of the sediment samples exhibited a predominance of odd-chain hydrocarbons as compared to even-chain hydrocarbons, with an average CPI value of approximately 2; this indicates a primarily biogenic sources of hydrocarbons. This could be expected given the volume of land runoff from the Essequibo and Demerara rivers.

The average pristane/phytane ratio of 1.34 reflects a predominance of pristane over phytane in the sediments, also indicating a predominantly biogenic source of hydrocarbons.

The low ratio (less than 1) of nC_{16} over the sum of nC_{15} + nC_{17} for all samples also indicates relatively higher concentrations of plankton-related hydrocarbons, as compared to hydrocarbons from anthropogenic sources.

PAHs are composed of aromatic rings. PAHs analyzed included 20 parent (i.e., unalkylated) compounds and 23 alkylated homologues, consisting of two- to six-ring PAH compounds. Concentrations of total PAHs (all 43 analytes combined) ranged from 0.02458 $\mu g\ g^{-1}$ to 0.05336 $\mu g\ g^{-1}$.

The sample distribution of individual PAHs provided information for a range of hydrocarbon sources. The petrogenic/pyrogenic distribution ratio listed below is useful to distinguish between petroleum-derived hydrocarbons and those derived from combustion of fossil fuels. The ratio increases as inputs from petroleum increase.

- Petrogenic/Pyrogenic Ratio—The ratio of the sum of petrogenic PAHs divided by the sum of pyrogenic (i.e., combustion-related) PAHs, where:
  - Petrogenic PAHs include naphthalene, acenaphthene, acenaphthalene, fluorene, phenanthrenes, and dibenzothiophenes, as well as the daughter compounds of the chrysenes and fluoranthenes/pyrenes; and
  - Pyrogenic PAHs include the parent compounds of fluoranthene, pyrene, and chrysene, as well as benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

In general, sample distributions of PAHs were dominated by the low molecular weight PAHs—naphthalenes and anthracene-phenanthrenes. The petrogenic/pyrogenic ratios of greater than 1 indicate hydrocarbons are from biogenic or natural material (potentially including petroleum-derived) rather than combustion-related compounds. High concentrations of perylene relative to other PAHs were also observed. Perylene is a biogenic compound linked to plant pigments from terrestrial runoff and is not indicative of either petrogenic or pyrogenic sources (FUGRO 2016). Both total PAHs and total SHC exhibited strong positive correlations with TOC, further supporting biogenic origins of the trace hydrocarbons.

Overall, the 2014 survey results indicate that biogenic or natural materials are the primary source of the low-level hydrocarbon concentrations measured during the survey. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs.

2016 Survey

During the 2016 survey (FUGRO 2016), sediment samples were analyzed for the following parameters:

- TOC
- Metals
- Hydrocarbons

TOC

Similar to the 2014 results, concentrations of TOC ranged from below the reporting limit to 1.1 percent. TOC concentrations were found to be higher at sampling locations with a greater proportion of fine sediments, indicating a negative correlation between grain size and organic content (logical given that smaller grain sizes have a greater surface area and thus more ability to adsorb organic matter).

Metals

Twelve metals were measured to determine general patterns of distribution across the survey area. Of the 12 metals analyzed, 10 metals (i.e., arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, vanadium, and zinc) were used as indicators of anthropogenic sources and 2 metals (i.e., aluminum and iron) were used to provide geological source information. The maximum concentrations of the individual metals measured during the 2016 survey were consistently higher than those from the 2014 survey; this is possibly a result of the different acids used by the 2014 and 2016 laboratories for extraction, or of greater variability in the data set due to the significantly larger sample area covered by the 2016 survey, as compared to that of the 2014 survey. Average concentrations of anthropogenic-indicator metals arsenic and nickel exceeded their respective NOAA ERL values. While this may reflect the composition of source material, there may be some contribution from terrestrial runoff contaminated from mining or other industries, as carried to the Guyana Basin via riverine inputs from Brazil and the Guiana Shield.

Hydrocarbons

The hydrocarbon analyses include measurements of total hydrocarbons (THC) and PAHs.

THC concentrations ranged from 1.5 µg g^{-1} to 4.8 µg g^{-1}. THC showed positive correlations with metals concentrations, with the exception of copper and arsenic, as well as with TOC concentrations. The unresolved complex mixture (UCM, i.e., fraction of THC that cannot be resolved/identified) concentrations ranged from 0.9 µg g^{-1} to 2.8 µg g^{-1}, and the average was 1.8 µg g^{-1}, which makes up 64 percent of the average THC concentration. Concentrations of alkanes (nC_{12-36}) ranged from 0.12 µg g^{-1} to 0.50 µg g^{-1}. Reported concentrations of short chain alkanes (nC_{12-20}) were consistently lower than those of the long chain alkanes (nC_{21-36}).

Several THC-based parameters and ratios were used to distinguish between biogenic and petroleum-derived sources. CPI values for the total range of alkanes (nC_{12-36}) ranged from 1.83 µg g^{-1} to 2.27 µg g^{-1}. These results display a predominance of odd-chain hydrocarbons over even-chain hydrocarbons, with an average CPI value greater than 2, indicating primarily biogenic sources of hydrocarbons. The average pristane/phytane ratio was 1.28, meaning a predominance of pristane over phytane exists in the samples, indicating the primary source of the hydrocarbons is likely biological.

Concentrations of total PAHs ranged from 0.016 µg g^{-1} to 0.239 µg g^{-1}. The ratio of the sum of naphthalene, phenanthrene, anthracene, and dibenzothiophene (NPD; petrogenic indicators) divided by the sum of 4 to 6-ring PAHs (pyrogenic indicators) is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons. The ratio increases as inputs from petroleum increase. In general, samples showed a predominance of 4 to 6 ring PAHs (i.e., NPD/4 to 6 ring ratios of less than 1), indicating predominantly pyrogenic sources of hydrocarbons, as opposed to petrogenic sources. However, high concentrations of perylene (a biogenic compound linked to plant pigments from terrestrial runoff and not indicative of either petrogenic or pyrogenic sources) relative to other PAHs were also observed.

Overall, the 2016 survey results indicate that the low levels of hydrocarbons measured in the Study Area could have derived from biogenic or natural materials as well as combustion-related compounds. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs, while combustion-related emissions could arise from multiple natural or anthropogenic sources.

2017 Survey

During the 2017 survey (ESL 2018), sediment samples were analyzed for the following parameters:

- TOC
- Moisture content
- Oxidation-reduction (redox) potential
- Metals (total and bioavailable)
- Hydrocarbons

TOC

Consistent in general with the 2014 and 2016 surveys, concentrations of TOC were less than 1 percent in all ten samples. TOC concentrations tended to be higher in samples with higher clay content.

Moisture Content

Sediment moisture content is an important fundamental physical property that may be highly variable. Its value is dependent upon particle size and type, organic matter content, as well as physico-chemistry of the sediment. Temporal and special changes may occur in sediment porosity that also affect water content (Bennett et al. 1990). Sediment moisture content ranged from 22.1 percent to 38.6 percent with an average value of 27.4 percent. There was limited variability among the samples; the highest value was measured at a station located 20 meters from the shoreline and the lowest was measured at a station 67 meters from the shoreline, suggesting no correlation between depth and sediment moisture content.

Redox Potential

The redox state of sediment is the result of the combined effect of biological and chemical processes of reversible and/or irreversible nature (Bågander 1978). Redox reactions control organic-matter oxidation and element cycling in aquatic ecosystems (Schlesinger and Bernhardt 2013). Redox conditions in surface sediments depend on the degree of organic enrichment (Zobell 1946). Organic enrichment of sediments usually leads to reduced conditions which equate to “poor” sediment quality (i.e., low dissolved oxygen and elevated ammonia or sulphide concentrations), wherein natural benthic communities undergo substantial changes (ECASA 2004). Negative redox potential values are therefore associated with anoxic conditions, in which the degradation of the organic matter is performed by anaerobic bacteria (ECASA 2004). The values detected in all 10 samples were positive, indicating oxic conditions within the sediment at the time of sampling.

Metals

Twelve metals were measured to determine general patterns of distribution across the survey area. Of the 12 metals analyzed, 10 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc) were used as indicators of anthropogenic sources and 2 metals (aluminum and iron) were used to provide geological source information. Samples were analyzed both for total concentrations of metals as well as bioavailable concentrations of metals. The average concentrations and ranges of concentrations for all metals were comparable to those observed during the 2014 and 2016 surveys.

The average concentration of one anthropogenic indicator metal (arsenic) exceeded the NOAA ERL value. When the 2016 survey results for total arsenic and iron were taken into consideration, it was observed that almost all the values showed a strong positive correlation. A comparison of the 2017 arsenic/iron correlation to that of the 2016 data further revealed that seven of the ten detected values of 2017 were consistent with the background levels recorded in 2016. Thus, the observed variation in total arsenic concentrations at most of the 2017 sampling stations likely reflect natural background concentrations associated with variation in sediment geochemistry. For the remaining three stations, the higher arsenic to iron ratios are indicative of anthropogenic inputs.

The bioavailable concentrations of metals were below the detection levels for most of the metals in most samples. The exceptions were two detections of bioavailable aluminum (14 µg g^{-1} and 20 µg g^{-1}), and one detection of bioavailable arsenic (1.3 µg g^{-1}).

Hydrocarbons

All 10 samples were analyzed for the full suite of saturated hydrocarbons, which constituted a total of 39 individual analytes. Five of the 39 analytes were detected at one or more stations, while the remaining 34 analytes (87 percent) were not detected above their respective detection levels at all 10 stations. Only 2 of the 5 detected hydrocarbon analytes were detected at all 10 stations. Where detected, saturated hydrocarbons ranged from 0.14 to 10.0 milligrams per kilogram, with n-dotriacontane concentrations consistent across the ten stations, while n-hexatriacontane varied with distance from the shoreline.

6.3.3. Impact Assessment—Marine Geology and Sediments

This section addresses potential impacts on marine geology and sediments resulting from planned Project activities. The potential impacts assessed include changes to seafloor morphology from accumulation of discharged drill cuttings on the seafloor and changes to sediment quality from the residual hydrocarbon contained on the discharged drill cuttings.

During installation of the FPSO and SURF components, there will be some localized disturbance of sediments in a limited area; however, this potential impact on seafloor morphology will not be significant. Essentially, the installation of suction or driven piles and flowlines on the seafloor may result in localized disturbance of the top-most seabed sediment without introducing any foreign material. Given the largely cohesive nature of the seafloor material (i.e., large percentage of clays), the seafloor is expected to be resilient to scour. Accordingly, potential impacts to marine geology and sediments as a result of SURF/FPSO infrastructure installation on the seabed is not discussed further.

Additional discussion regarding potential impacts on marine benthos from accumulation of discharged drill cuttings on the seafloor and changes to sediment quality from the residual hydrocarbon contained on the discharged drill cuttings is provided in Section 7.8.3, Impact Assessment—Marine Benthos.

No impacts on marine geology and sediments are expected as a result of activities associated with production operations or decommissioning.

6.3.3.1. Relevant Project Activities and Potential Impacts

The process of drilling development wells will produce drill cuttings that will be discharged either directly to the seafloor (in open-hole sections drilled riserless and with seawater) or from the drill ship (after treatment including solids control and processing through a centrifugal cuttings dryer system) into the ocean (in hole sections drilled with a riser). The planned development drilling program and its cuttings management approach is consistent with industry practices. For each well, approximately 3,200 barrels (bbl) of cuttings for the riserless sections will be discharged directly to the seafloor per standard industry practice, as these sections will be drilled using water-based drilling fluids (WBDF) instead of non-aqueous drilling fluid (NADF). For sections drilled with a riser, approximately 3,400 bbl of cuttings (per well) will be treated to remove associated drilling fluids to acceptable discharge thresholds before discharge from the drill ship into the ocean (refer to Chapter 2, Description of the Project, for a description of the drilling process). Planned discharges of drill cuttings and fluids will potentially impact the marine sediment layer locally as a result of accumulation of cuttings on the seafloor. Cuttings will accumulate on the seafloor around the well locations, with the distribution of cuttings determined by oceanographic conditions.

Table 6.3-4 summarizes the Project stages and activities that could result in potential Project impacts on marine geology and sediments.

Table 6.3-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Geology and Sediments

Stage	Project Activity	Key Potential Impacts
Development Well Drilling SURF/FPSO Installation	Discharge of drill cuttings during drilling of wells, and resulting deposition of cuttings on the seafloor	• Changes to seafloor morphology from accumulated drill cuttings • Impacts on sediment quality from residual hydrocarbon on discharged cuttings

6.3.3.2. Characterization of Impacts—Changes to Seafloor Morphology

Magnitude of Impact—Changes to Seafloor Morphology

To assess the magnitude of predicted changes to seafloor morphology from discharge of drill cuttings, modeling of cuttings deposition was performed using the Generalized Environmental Modeling System for Surfacewaters (GEMSS) model. This three-dimensional, particle-based model uses Lagrangian[3] algorithms in conjunction with currents, specified mass load rates, release times and locations, particle size distributions, settling velocities, and shear stress values to calculate the fate and transport of discharged drill cuttings. Model outputs provide estimates of the thickness of deposits on the seafloor, and the mass distribution of base hydrocarbon (adhered to the cuttings) across the seafloor.

Eight scenarios were modeled, for a production well (DC3-P1 and DC4-P1) and an injection well (DC3-I and DC4-I) at each of the two drill centers, each under two current conditions: the minimum and the maximum of the monthly averaged and depth-averaged current speeds. These current speeds were derived from the SAT-OCEAN ocean circulation model. To provide a conservatively high estimate of the potential accumulation rate, modeling was conducted assuming cuttings from the open-hole sections (containing WBDF) will be discharged at the

[3] A gridless model in which pollutant particles move according to the wind field, buoyancy, and turbulence effects. Term is often used to differentiate such models from Eulerian models, which use a gridded model domain.

seafloor (as noted above, these cuttings may alternatively be discharged from the drill ship prior to treatment, per standard industry practice).

Table 6.3-5 summarizes the results of the modeling for the eight drill cuttings discharge scenarios. Releases from near the seafloor at DC4 were predicted to travel a shorter distance and therefore result in a smaller depositional footprint near DC4 than at DC3. This is because the bulk of the deposition greater than 5 centimeters in thickness results from near-seafloor releases and modeled currents near the seafloor at DC4 were slower than the modeled currents near the seafloor at DC3.

Table 6.3-5: Summary of Modeling Results for Drill Cuttings Discharge Scenarios

Scenario	Maximum Predicted Thickness (cm)	Total Area (m^2) with Predicted Thickness > 5 cm
1a DC3-I; Minimum Currents	58.5	5,961
1b DC3-I; Maximum Currents	20.5	3,210
2a DC3-P1; Minimum Currents	98.3	7,386
2b DC3-P1; Maximum Currents	25.2	6,347
3a DC4-I; Minimum Currents	16.2	1,468
3b DC4-I; Maximum Currents	17.3	1,759
4a DC4-P1; Minimum Currents	20.8	1,483
4b DC4-P1; Maximum Currents	19.1	1,773

cm = centimeter; m^2 = square meters

Modeling of cuttings discharge and deposition indicates the maximum depositional thickness of cuttings on the seafloor is predicted to be between 19.1 and 98.3 centimeters, depending on currents and drill center location. The cuttings for the initial open-hole sections settle relatively close to the well, as they are discharged at the seafloor. In contrast, the cuttings for the lower well sections are subjected to greater dispersion, as they are distributed by the currents during their settling from near the sea surface. A literature-based deposition threshold rate of 5 centimeters per month (Ellis and Heim 1985; MarLIN 2011) was used to assess the extent of the area with the potential to impact benthic organisms via smothering (an indirect impact resulting from impacts on marine sediment morphology, further discussed in Section 7.8.3, Impact Assessment—Marine Benthos). This threshold represents the accumulation rate above which benthic organisms would be expected to be unable to overcome the rate of deposition and become smothered, thereby limiting their mobility and access to oxygen. Modeling predicts the extent of cuttings deposition above this threshold is confined to within a relatively short distance from the well location, with the largest such area measuring approximately 49 meters in radius from the well. Deposition thicknesses decrease rapidly with increasing distance from the well. This is apparent from Table 6.3-5, which shows maximum deposited cuttings thickness of 98.3 centimeters at DC3-P1, dropping to a thickness of less than 5 centimeters within a distance of 49 meters from the drill center.

While the above results are expressed in terms of total depositional thickness at completion of drilling of the well, it is appropriate to compare these total thicknesses to the deposition threshold (rate) of 5 centimeters per month. This is based on the fact that the modeling was conducted assuming a constant well-completion rate that simulates even the deepest of the modeled wells being completed in approximately 21 days. In reality, the drilling process includes some active drilling time (where drill cuttings are generated) and other well construction activities, meaning the actual drilling duration likely will be greater than 21 days. Under the assumption that a subsequent well at a given drill center will not start any sooner than 30 days after the start of the previous well at that drill center, the predicted (total) depositional thicknesses per well listed above represent a conservatively high estimate of the average depositional rate across a full month.

In terms of magnitude, the potential impact on sediment morphology was viewed in the context of the resources' overall functionality with respect to providing a habitat for benthic organisms. In this sense, the magnitude rating is expressed based on the fraction of the overall resource being impacted at any one time by the Project. If it is assumed that two drill ships are active simultaneously, the conservative approach is therefore to double the highest total area results from Table 6.3-5 to reflect the largest area predicted to be subjected to a cuttings deposition rate greater than 5 centimeters per month at any one time. This results in a predicted area of approximately 14,800 square meters (approximately 159,310 square feet), which represents approximately 0.02 percent of the area of the Subsea PDA (which itself covers approximately 0.3 percent of the Stabroek Block). Further, the currents are expected to redistribute the cuttings away from their initial deposition sites over time, gradually reducing their thickness on the seafloor at these locations. Considering the extremely limited scale of potential impact relative to the overall sediment resource of the Stabroek Block, the magnitude of impact on sediment morphology from drill cutting deposition is considered **Negligible**.

As discussed in Section 6.3.2, Existing Conditions—Marine Geology and Sediments, mud banks of critical ecological importance exist within Guyana waters. The mud banks are critically important as feeding zones for birds, nursery areas for fish, and habitat for a variety of invertebrates, but they are located on the nearshore portion of the continental shelf, well outside the area that modeling indicates will be affected by drill cuttings deposition. Therefore they are not discussed further in this section.

Sensitivity of Resource—Changes to Seafloor Morphology

The sensitivity of the overall marine sediment resource to potential changes in morphology from drill cuttings deposition is considered **Low**, as unlike the offshore mud banks that are of critical ecological importance as feeding zones for birds, nursery areas for fish, and habitat for a variety of invertebrates, the deepwater sediments on which drill cuttings will settle do not support high densities of unique marine species; this was corroborated by the environmental baseline surveys, deepwater fish surveys, and ROV surveys that have been carried out in the vicinity. These ecological communities are discussed further in Sections 7.7, Marine Fish, and 7.8, Marine Benthos.

Impact Significance—Changes to Seafloor Morphology

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on sediment morphology from discharge of drill cuttings is considered **Negligible**.

6.3.3.3. Characterization of Impacts—Sediment Quality Changes

Magnitude of Impact—Sediment Quality Changes

The embedded controls in the Project design that will reduce the potential impact of drilling discharges on sediment quality include: (1) use of WBDF to the extent reasonably practicable (for drilling of initial open-hole well sections), and (2) use of International Oil and Gas Producers (IOGP) Group III non-aqueous base fluid (NABF) in all other cases. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. When NADF is used, the discharge of treated cuttings will be controlled such that residual base fluid content on discharged cuttings will average no more than 6.9 percent (wet weight).

The NABF to be used in the NADF will be IOGP Group III, with low to negligible aromatic content, reducing the potential that changes in sediment quality as a result of discharge of the treated cuttings will lead to potential toxicological impacts on benthic fauna. While the magnitude rating assigned for sediment quality was not based on a quantitative calculation, as was the case for sediment morphology, the calculation presented for sediment morphology illustrates the extremely low proportion of the Subsea PDA that could be potentially impacted by drill cuttings deposition. For this reason, and considering the low-toxicity nature of the NADF, the magnitude of potential impacts on marine sediment quality as a result of drill cuttings deposition is considered **Negligible**.

Sensitivity of Resource—Sediment Quality Changes

As in the case of potential sediment morphology impacts from drill cuttings deposition, the sensitivity of the marine sediment resource to sediment quality impacts from drill cuttings deposition is considered **Low**, as unlike the offshore mud banks that are of critical ecological importance, the deepwater sediments potentially impacted by the drill cuttings discharge do not support high densities of marine species and are not unique.

Impact Significance—Sediment Quality Changes

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine sediment quality as a result of drill cuttings deposition is considered **Negligible**.

6.3.4. Mitigation Measures—Marine Geology and Sediments

Based on the **Negligible** significance of potential marine geology and sediment impacts, no mitigation measures are proposed. It is noted, however, that the limited significance of potential marine geology and sediment impacts is supported by a suite of embedded controls related to discharge management (see summary in Chapter 13, Recommendations).

Table 6.3-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine geology and sediments. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental

Impact Assessment, and the marine geology and sediment-specific methodology described in Sections 6.3.3.2 and 6.3.3.3.

Table 6.3-6: Summary of Potential Pre-Mitigation and Residual Impacts - Marine Geology and Sediments

Stage	Resource - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Sediment morphology—changes from accumulated drill cuttings	Negligible	Low	Negligible	None	Negligible
	Sediment quality—impacts from residual NABF on deposited drill cuttings	Negligible	Low	Negligible	None	Negligible

6.4. MARINE WATER QUALITY

6.4.1. Administrative Framework—Marine Water Quality

Table 6.4-1 summarizes the legislation, policies, treaty commitments, and industry practices that focus specifically on water quality.

Table 6.4-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Water Quality

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Water Quality Regulations, 2000	Establishes that the EPA shall, at any time after the commencement of the Regulation, establish parameter limits of effluent that may be discharged into any inland or coastal waters or land of Guyana. Includes reporting requirements, penalties for violations of standards, and permitting requirements for discharges.	Regulates discharges of listed substances, which could include substances used as part of the Project.
International Agreements Signed/Acceded by Guyana		
International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Applies to the handling and disposition of controlled substances from the drill ships, FPSO, and support vessels. Guyana acceded in 1997.

6.4.2. Existing Conditions—Marine Water Quality

6.4.2.1. Oceanographic Conditions

Guyana's marine environment is bounded, and heavily influenced, by the Orinoco and Amazon rivers in Venezuela and Brazil, respectively. During the rainy season, Guyana's coastal marine waters receive large volumes of freshwater discharges from these major rivers, as well as from Guyana's own Essequibo, Demerara, and Berbice rivers (FAO 2005).

Guyana's surficial marine waters are crossed by the Guiana Current, which is part of the northern limb of the North Atlantic Meridional Overturning Circulation (MOC). The North Atlantic MOC circulates water between the subtropics and polar region. The Guiana Current derives from the North Brazil Current (NBC) flowing north along the northeastern coast of South America from northern Brazil toward the southeastern Caribbean Sea. As it reaches French Guiana, part of the NBC separates from the coast to join the North Equatorial Counter Current (NECC), while the rest continues flowing northwest to form the Guiana Current. Figure 6.4-1 illustrates the proximity of the Guiana Current, NBC, and NECC to the Stabroek Block.

Several times a year, the NBC turns back on itself to create closed circulation and form regions of strong eddies (circular currents). These eddies can separate the NBC and NECC and travel northwest along the South American coast. The eddies may range from approximately 145 kilometers to 400 kilometers (approximately 90 to 250 miles) in diameter and current magnitude within the eddies can vary significantly depending on the depth.

During the spring, the Guiana Current can extend as far as 300 nautical miles offshore to cover Guyana's entire continental shelf. Its highest velocities tend to occur along the edge of the continental shelf (i.e., in Guyana just shoreward of the Stabroek Block). Fluctuations in the ITCZ and the trade winds lead to significant variation in the strength of the Guiana Current and the extent of its influence offshore, but maximum speeds generally occur from April to May, while minimum speeds commonly occur in September (Gyory et al. 2013).

The Guiana Current primarily influences the upper portion[4] of the water column, while the deeper portion of the water column in the Stabroek Block is strongly influenced by the North Atlantic Deep Western Boundary Current (DWBC), which is the southward limb of the North Atlantic MOC. The North Atlantic DWBC returns colder, denser water from polar regions to the subtropics at intermediate and deep levels.

[4] There is limited information documenting the depths at which the Guiana Current and North Atlantic DWBC exert an influence, but metocean data collected by EEPGL (Figure 6.4-3) suggests the Guiana Current exerts an influence in at least the top 200 meters (approximately 656 feet) and the North Atlantic DWBC exerts an influence at depths of more than 800 meters (approximately 2,625 feet). The strength of the Guiana Current will also likely dictate how deep its influence extends at a given time, as it weakens/strengthens depending on the winds and Amazon River flows.

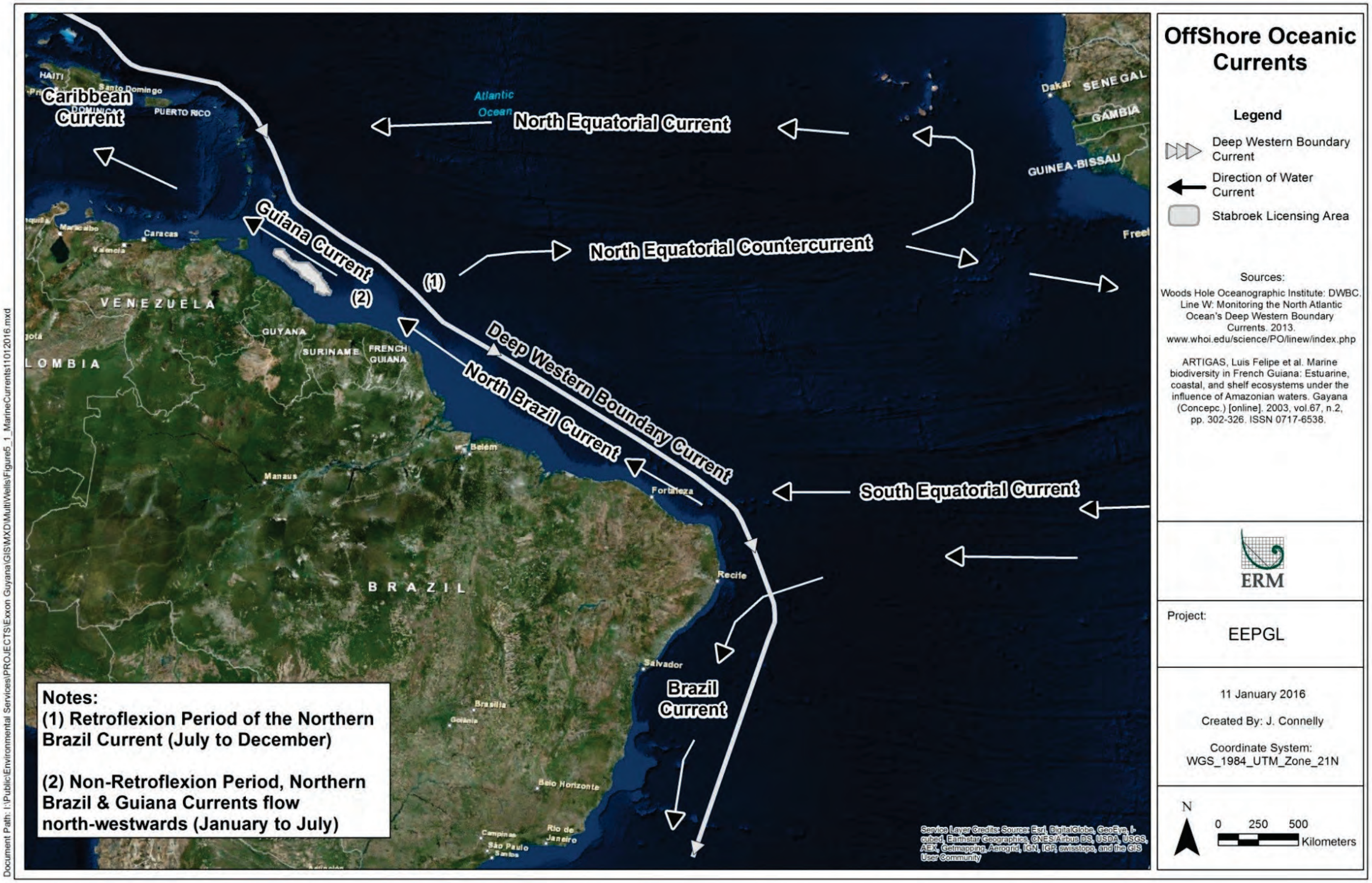


Figure 6.4-1: Marine Currents in the Vicinity of the Project Development Area

In May 2014, EEPGL commissioned a Lowered Acoustic Doppler Current Profiler (LADCP) survey of four stations along a transect located in the central portion of the Stabroek Block to support Project design development. The LADCPs were placed at depths ranging from approximately 970 meters to 1,100 meters. To supplement the above data, in March 2016, an EEPGL contractor deployed and maintained a series of four deepwater current profile mooring buoys and one surface buoy (RPS 2016; 2017a, b, c). Two of the mooring buoys were deployed in the Liza field along with the surface buoy, and the remaining two mooring buoys were deployed northwest of the Liza field. Figure 6.4-2 shows the locations of the LADCPs (shown as "Station 1" through "Station 4"), the two Liza field mooring buoys (shown as "LF" and "LG") and the met station buoy (shown as "LC").

The LADCP data indicate the presence of both the Guiana Current and the North Atlantic DWBC. Figure 6.4-3 shows vector stick plots from the four stations along the LADCP transect. The three deepest stations (Stations 1, 2, and 3) showed similar vertical current structure (i.e., a north-westward surface flow influenced by the Guiana Current and a south-eastward deep flow influenced by the North Atlantic DWBC). The shallowest station (Station 4) showed a similar layered structure, but the speed of the north-westward surface current was significantly greater at this station than at the others (TDI-Brooks 2014).

Processed final datasets from the mooring buoys were available for buoy deployments spanning March 2016 through March 2018. In addition to confirming the overall circulation pattern off the coast of Guyana as measured in 2014, these moorings also helped identify regional current phenomena. For example, the data showed the existence of a northwest/north-northwest (NW-NNW) current that is characteristic of the NBC current at this location (see data from "LF" mooring buoy on Figure 6.4-4). The currents shown on the plot are directed towards NW-NNW with a strong magnitude starting around 19 February 2017. The NBC is an aperiodic current, and Figure 6.4-4 shows the onset of the leading edge of this current reaching the LF mooring buoy location. The vector stick plot (Figure 6.4-3) shows a point in time when the NBC ring was present at the LADCPs.

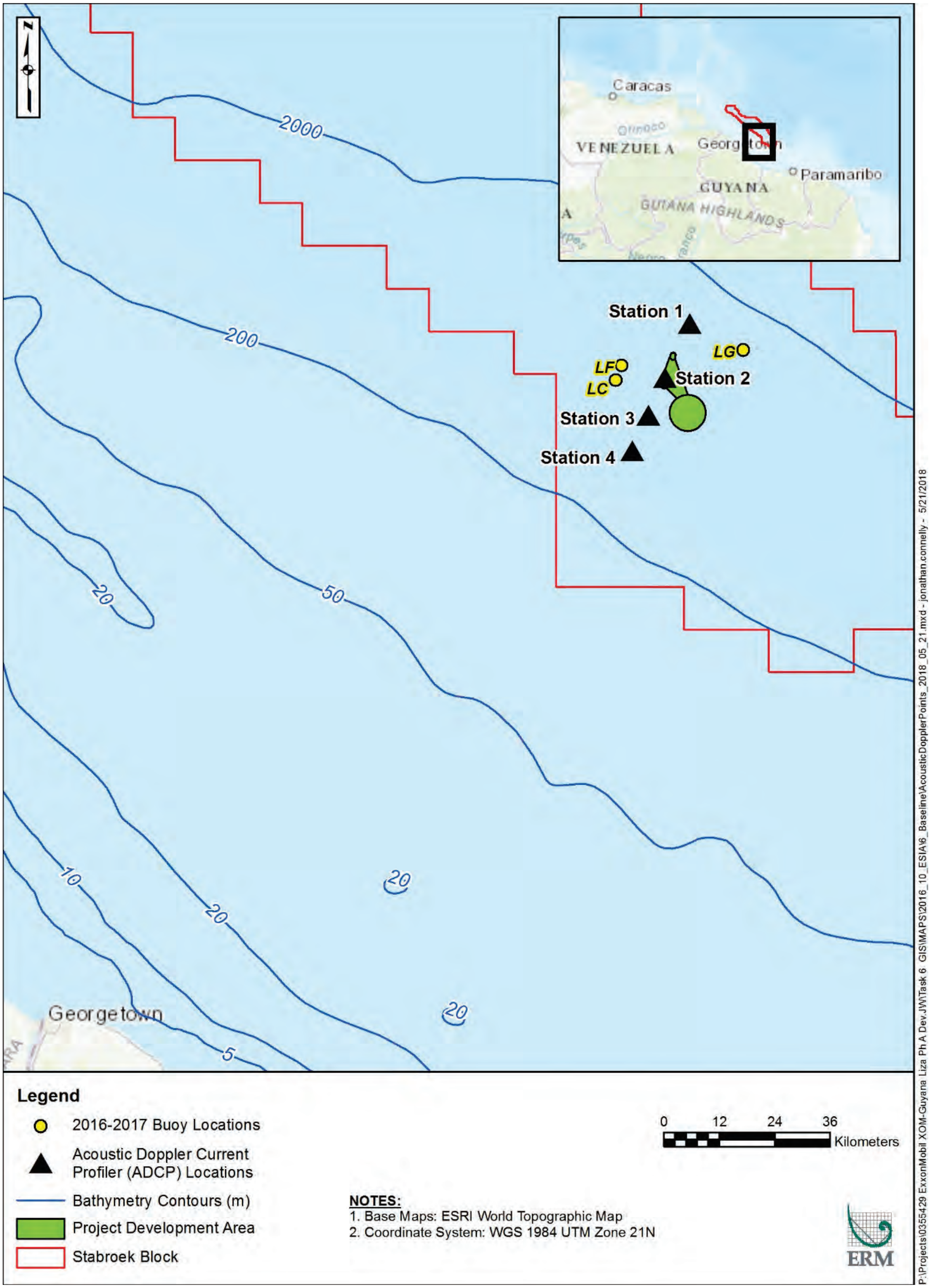
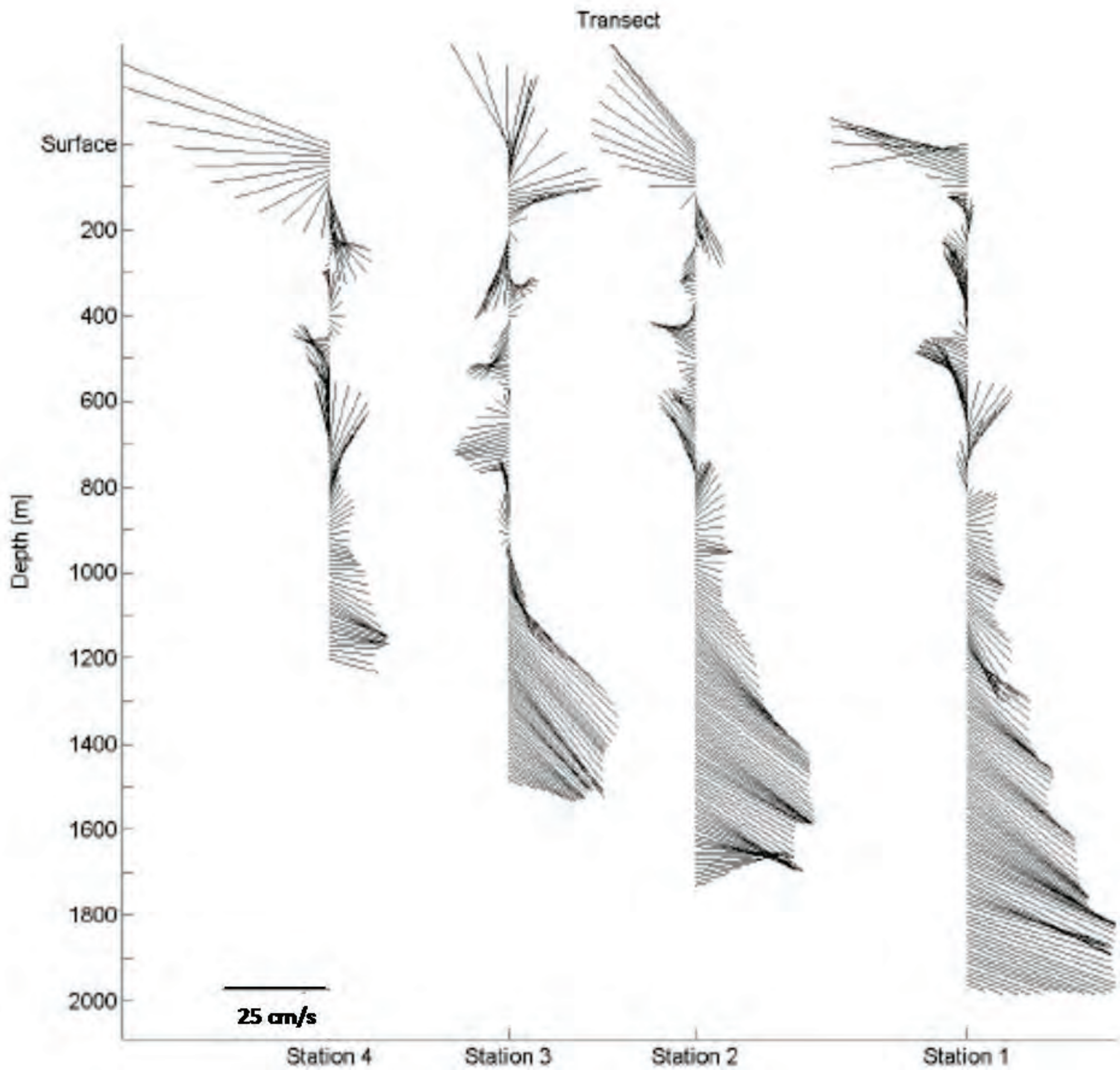


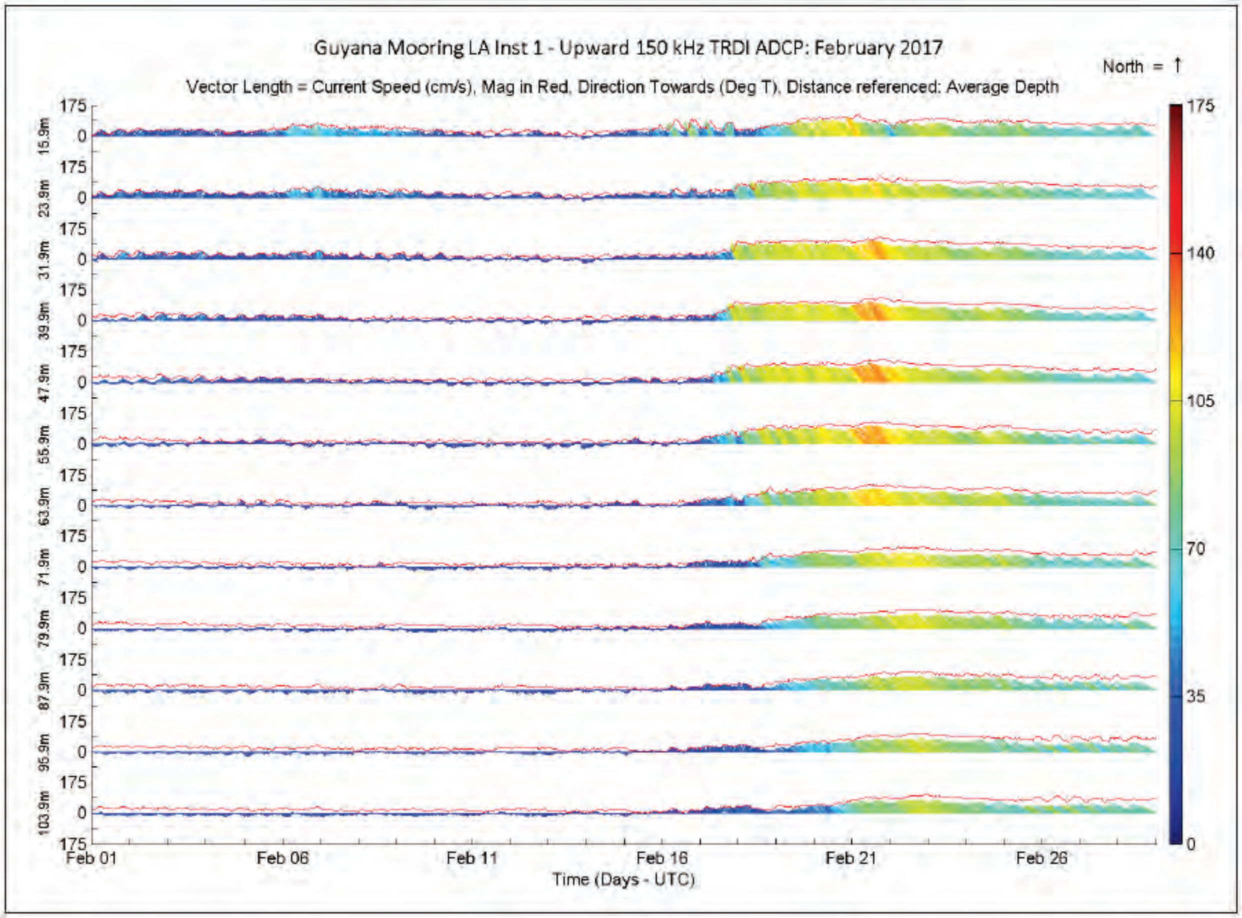
Figure 6.4-2: LADCP and Mooring Buoy Locations



Source: TDI-Brooks 2014

Note: Each "stick" (also called a vector) describes the direction, speed, and depth of a discrete measurement. The length of the vector is directly proportional to its speed (a scale is provided at the bottom of the plot). The depth of each measurement is provided on the y-axis. The direction of the vector points in the compass direction of the current flow (north corresponding to "up" on the plot). The horizontal distance between stations on the x-axis is to scale.

Figure 6.4-3: Vector Stick Plot for Stations on the Stabroek Block LADCP Transect



Source: RPS 2018

ADCP = Acoustic Doppler Current Profiler; cm/s = centimeter per second

Figure 6.4-4: Near Surface Currents at "LF" Mooring Buoy, Showing the Onset of the Strong NW-NNW Currents related to the NBC

6.4.2.2. Marine Water Quality

Regional Water Quality Influences

The hydrographic[5] and isohaline[6] conditions in Guyana's coastal marine waters are greatly impacted by the outflow of the coastal rivers in the region, as described in Section 6.4.2.1, Oceanographic Conditions. The large amount of freshwater discharge impacts ocean salinity and temperature. Oceanic water is relatively heavy, cold, and saline compared to the lighter, warmer, and fresher water of the Amazon and Orinoco plumes that converge offshore of Guyana. These convergences form oceanic fronts offshore of Guyana. Freshwater lenses[7] generated by the Amazon and Orinoco rivers are transported across Guyana's continental shelf to points north and west. These lenses persist for months and have been detected as far away as Barbados and Trinidad (Sherman and Hempel 2009).

Of the several coastal rivers that influence the Guyana offshore marine environment, the Amazon River, with an average discharge of 180,000 cubic meters per second (Nittrouer and De Master 1987), is the most prominent factor in terms of marine water quality. Analysis of the Amazonian plume has shown there is little seasonal variation in the plume's nutrient content (e.g., silicates of 144 micromoles per kilogram [µmol/kg], phosphates of 0.7 µmol/kg, and nitrates of 16 µmol/kg) (De Master and Pope 1996). It has been estimated that 40 to 50 percent of the annual Amazon run-off transits along the coast of Guyana (Nittrouer and De Master 1987).

The entire region offshore of Guyana is considered part of the North Brazil Shelf Large Marine Ecosystem (LME). The ocean temperature in the North Brazil Shelf LME has alternately warmed and cooled over the last few decades. A period of cooling lasted from the mid-1970s through the mid-1990s; since the mid-1990s, the LME has consistently warmed (Sherman and Hempel 2009). The net change in LME water temperature since 1957 equates to an average increase of +0.22˚C over 50 years (Sherman and Hempel 2009).

Characterization of Water Quality in the Stabroek Block

EEPGL has collected water quality samples from the Stabroek Block as part of three surveys in 2014, 2016, and 2017. The full reports are provided in Appendices G, H, and I, respectively. Figure 6.4-5 displays the combined water quality sampling locations for the three events. Descriptions of the sampling program for each survey and summaries of the results are provided below.

[5] Relating to the characteristic features (such as flow or depth) of bodies of water

[6] Isohalines are areas in the aquatic systems that have the same salinity.

[7] Freshwater lenses are formed near the surface of a marine environment when fresh (non-saline) water from rivers or rainfall enters a marine/saline waterbody. Freshwater is lighter and floats to the top of the saline water column, creating a layer (lens) of fresh, lower-salinity water.

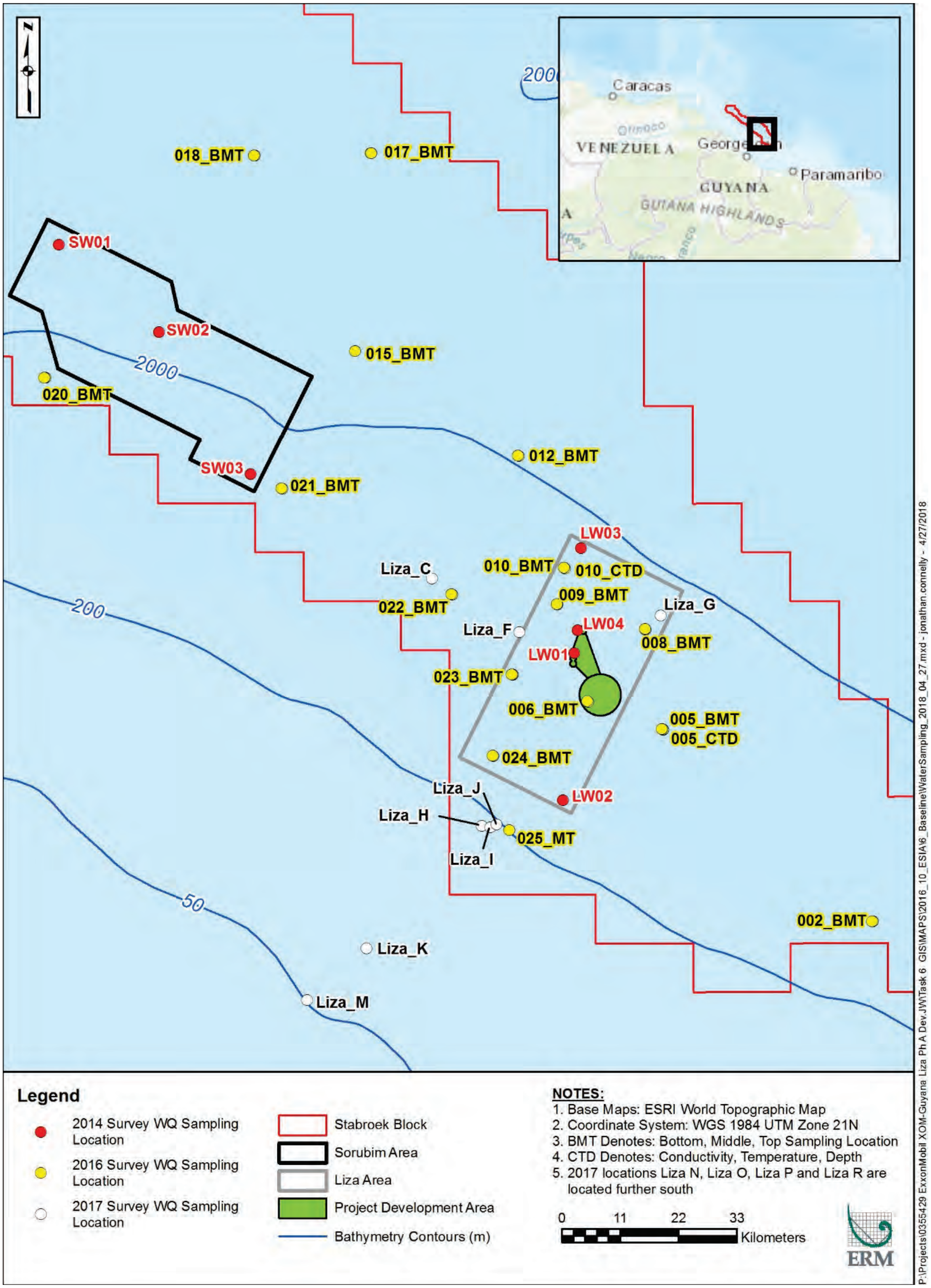


Figure 6.4-5: Combined Water Quality Sampling Locations—2014, 2016, and 2017 Surveys

2014 Survey

In the 2014 survey, water quality sampling was conducted at four stations in the Liza field and three samples at a location approximately 100 kilometers northwest of the Liza field (referred to in the survey as the Sorubim area). Three discrete water samples were collected at each station from the near-surface (5- to 10-meter depth), from the mixed layer (around 25-meter depth), and from approximately 5 to 10 meters above the seafloor, resulting in a total of 21 water samples. All samples were analyzed for total suspended solids (TSS), TOC, SHC, PAHs, and metals. Additionally, at each station, a vertical profile of water quality was determined with a conductivity-temperature-depth meter (CTD), augmented with additional sensors for dissolved oxygen and turbidity.

Water-column profiling depicted a steep halocline, reaching a maximum salinity of 37 percent at 100-meter depth. Water temperature dropped from 28°C at the surface to 3°C around 2,000 meters. The water column was highly stratified, likely limiting nutrient flux into surface waters from below the mixed layer. The permanent (non-seasonal) pycnocline[8] extends down to approximately 200 meters, below which density increases slowly with depth. The water column was relatively clear, with light transmittance through the 25-centimeter path length typically greater than 95 percent. Dissolved oxygen was consistently high, ranging from roughly 6 milligrams per liter (mg/L) near the surface to greater than 8 mg/L in near-bottom waters.

Average TOC concentrations were 0.81 mg/L for both the Liza and Sorubim areas. Average TSS concentrations were 4.3 mg/L and 4.8 mg/L for the Liza and Sorubim areas, respectively.

Barium was the only metal detected in all samples. Copper, mercury, and zinc were the only other metals detected, with mercury concentrations (detected in 2 out of 21 samples) at less than 1 part per trillion. Arsenic, cadmium, chromium, and lead were not detected in any of the samples. Concentrations of all metals were well below those considered harmful to aquatic organisms in marine waters.

Total PAH concentrations (for 43 compounds) were extremely low in all samples (≤50 nanograms per liter [ng/L]). The majority of detected PAH compounds were naphthalene, and C1- and C2-naphthalenes, suggesting the potential for trace-level introduction from the analytical laboratory (these compounds are ubiquitous laboratory contaminants). Total SHCs were detected in only 4 out of 21 samples, with the highest reported concentration at 230 micrograms per liter (µg/L) (Maxon Consulting 2014).

2016 Survey

The 2016 survey provided additional data from an area covering 247 mi² (approximately 64,000 hectares). Water quality samples were collected at 15 locations in the Stabroek Block; at each location, samples were collected at top, middle, and bottom depths and samples were analyzed for TOC, TSS, hydrocarbons, PAHs and metals. Additionally, the water column was

[8] A layer in a body of water in which water density increases rapidly with depth

profiled at each station with a CTD, augmented with additional sensors for dissolved oxygen, pH, and turbidity.

Water profiling at all sampling stations identified a generally stratified water column, with depth of thermocline[9], halocline[10], and oxygen boundary[11] increasing with water depth. At all 15 stations, temperature, salinity, and dissolved oxygen displayed a strong thermocline, halocline, and oxygen boundary. Salinity exhibited a narrow range, with a maximum value of 37.05 ppt. Surface temperatures were relatively consistent across stations, but the lower water column temperatures decreased proportionally with water depth. The mean surface temperature was 27.8°C and the mean bottom temperatures ranged from 2.7°C (deepest site) to 11.2°C (shallowest site). Turbidity within the water column remained reasonably constant throughout the entire length of all water profiles, with mean values equal to or less than 2.9 formazine turbidity units. At all stations, the pH (which ranged between 8.18 and 8.47) increased gradually with increasing depth, and pH profiles were very similar between stations.

TOC and TSS were generally low at all stations, with TOC increasing slightly overall with depth from a mean surface concentration of 2.3 mg/L to a mean bottom concentration of 1.8 mg/L. TSS exhibited a similar profile, with a mean surface concentration of 6.7 mg/L and a mean bottom concentration of 3.4 mg/L.

Total hydrocarbon concentrations and PAH concentrations were generally at low levels across the survey area, with little variation between samples (highest reported total hydrocarbon concentration of 35.9 µg/L and highest reported total PAH concentration of 20.6 ng/L). All levels were below the USEPA water quality guidelines published in Burgess et al. 2013. Gas chromatography traces exhibited only small spikes in individual long-chain n-alkanes at all stations.

Reported metal concentrations were low in all water samples and did not vary substantially between stations or with depth. Metals reported above detection limits included cadmium, chromium, copper, lead, zinc, and arsenic. Concentrations of all metals were below their respective USEPA Saltwater Quality Standards thresholds (USEPA 2016), where these are available (Fugro EMU Limited 2016).

2017 Survey

The 2017 survey included sampling at 12 additional locations along the continental shelf, along the continental slope, and within the Stabroek Block. Samples were collected at surface, mid-depth, and bottom, for a total of 72 samples (duplicates of each were collected). Samples

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[9] A thermocline is the location within a stratified water column where a steep gradient of temperature exists. Typically, a thermocline marks a transition layer between a warmer (and mixed) surface layer and a cooler deep layer.

[10] Similar to a thermocline, a halocline is the location within a stratified water column where a steep gradient of salinity exists. Typically, a halocline marks the transition layer between a fresher surface layer and more saline deep layer.

[11] An oxygen boundary develops due to the presence of a thermocline and/or halocline, which reduce oxygen transport across these transition layers. Across the oxygen boundary, a sharp gradient in dissolved oxygen exists where the layer near the surface is typically well mixed and near saturation due to re-aeration, whereas the layer below reaches anoxic (very low dissolved oxygen) conditions.

were analyzed for TOC, TSS, total dissolved solids (TDS), chemical oxygen demand (COD), SHCs, metals, cyanide, and ammonia. Additionally, the water column was profiled at each station with a CTD, augmented with additional sensors for dissolved oxygen and turbidity.

Depths profiled for temperature and salinity revealed the presence of a thermocline and halocline at the deepwater stations (1,705 to 2,006 meters) and well-mixed conditions at the continental shelf stations (14 to 26 meters) and continental slope stations (134 to 215 meters). The strengths (gradient) of these profiles were consistent with the data collected in 2014 and 2016. The range of temperatures observed near the surface were also consistent with previous observations. Dissolved oxygen ranged from 6.21 mg/L to 6.86 mg/L at shelf stations, 6.23 mg/L to 8.05 mg/L at slope stations, and 6.28 mg/L to 10.56 mg/L at deepwater stations.

TDS, TSS, TOC, and COD showed decreases in concentrations at deeper locations. In general, TDS concentrations were highest at the top of the water column and lowest at the middle. The average level of TDS decreased with increasing distance from the shore. TOC concentrations were similar but tended to decrease with increasing depth, ranging between 1.3 mg/L and 2.1 mg/L at the surface and between 1.1 mg/L and 1.9 mg/L in the bottom depths. TSS concentrations also generally decreased with increasing depth, ranging between 2.8 mg/L and 28 mg/L near the surface and between 3.3 mg/L and 10.6 mg/L in the bottom depths. COD concentrations also generally decreased with increasing depth, with the average values at the top being approximately 1.5 times higher than the average values at the bottom.

Total cyanide and all analyzed metals were reported to be not detected in all samples. SHCs were detected at all of the slope and shelf locations, but not at the deepwater stations. Reported detections ranged from 210 to 580 µg/L. Ammonia was detected only at shelf locations, with reported detections ranging from 0.01 mg/L to 0.02 mg/L (ESL 2018).

6.4.3. Impact Assessment—Marine Water Quality

This section addresses potential impacts on marine water quality resulting from planned Project activities. The potential impacts assessed include changes to marine water quality physico-chemical conditions as a result of the various effluent discharges associated with the Project. The following sections describe the various discharges for which potential marine water quality impacts were assessed, the application of computational models for impact magnitude quantification, and a discussion of the significance of potential impacts.

6.4.3.1. Relevant Project Activities and Potential Impacts

Planned discharges of drill cuttings and fluids may have a localized impact on marine water quality as a result of increased 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 more shallow level of the water column). These increases in TSS may clog fish gills or, in the photic zone, cause light inhibition for photosynthetic organisms.

During installation and commissioning of SURF equipment, hydrotesting fluids containing biocides, oxygen scavengers, and corrosion inhibitors, as well as hydrate inhibiting fluid (such as methanol or ethylene glycol), will be discharged to the sea, resulting in localized changes to water quality.

The FPSO will have several discharges related to its operation and maintenance during production operations. The potential impacts from these discharges include localized changes to water quality from effluent discharges during production operations, and localized changes to water temperature from discharge of cooling water effluent.

Table 6.4-2 summarizes the Project stages and activities that could result in potential Project impacts on marine water quality.

Table 6.4-2: Summary of Relevant Project Activities and Key Potential Impacts—Marine Water Quality

Resource/Receptor	Stage	Project Activity	Key Potential Impacts
Marine water quality (marine fauna as receptors)	Development Well Drilling FPSO/SURF Installation	Discharge of drill cuttings, resulting in increased TSS concentrations in water column Discharge of liquid effluents from drill ships and marine installation and support vessels (chemical substances) Discharge of hydrotesting fluids	• Increased TSS concentrations in water column, potentially contributing to health impacts on marine fauna • Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna
	Production Operations	Discharge of liquid effluents from FPSO and marine support vessels (chemical substances, and elevated temperature streams)	• Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna • Increased temperature in water column, potentially leading to avoidance of the area by marine fauna
	Decommissioning	Discharge of liquid effluents from marine support vessels (chemical substances)	• Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna

6.4.3.2. Characterization of Impacts—Increased TSS from Drill Cuttings Discharge

Magnitude of Impact—Increased TSS Concentrations from Drill Cuttings Discharge

As described in Appendix J, Water Quality Modeling Report, modeling of discharge and deposition of cuttings was performed using the GEMSS model. This three-dimensional particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values to calculate the fate and transport of discharged drill cuttings. Model outputs provide estimates of the water column TSS concentrations resulting from the planned drilling operations.

Eight scenarios were modeled, for two different current conditions at a production well (DC3-P1 and DC4-P1) and an injection well (DC3-I and DC4-I) at each of the two drill centers. Current conditions modeled were the minimum and the maximum of the monthly averaged and depth-averaged current speeds. These current speeds were provided by the SAT-OCEAN ocean circulation model. As was assumed with drill cutting deposition modeling (Section 6.3.3, Impact Assessment—Marine Geology and Sediments), modeling of increases in water column TSS concentrations was conducted assuming cuttings from the open-hole sections (containing WBDF) will be discharged at the seafloor (as noted above, these cuttings may alternatively be discharged from the drill ship prior to treatment, per standard industry practice). This was confirmed to be a conservative assumption, as modeling indicated the highest predicted TSS concentration increases are associated with discharge of cuttings at the seafloor (see results discussion below).

Modeling of cuttings discharge and deposition predicts the maximum TSS concentrations at the seafloor during drilling of the initial sections of the well will be between approximately 5,783 milligrams per liter (mg/L) and 41,055 mg/L, depending on currents and well location. These concentrations correspond to only the initial sections of the well, where WBDF and cuttings are discharged directly from the casing. In contrast, modeling indicates the maximum TSS concentrations in the water column for subsequent sections of the well will be between approximately 3.1 mg/L and 14.1 mg/L, depending on currents and well location. These predicted concentrations are much lower because drill cuttings and fluids from the subsequent well sections will be processed on the drill ship to remove a substantial amount of the drilling fluid prior to discharge near the surface. Additionally, discharges near the surface are also subjected to greater mixing from the higher current speeds at the shallower depths.

A TSS threshold of 35 mg/L is recommended by MARPOL 73/78 (IMO 2006) for discharges of effluent from marine vessels. This threshold was used to assess the extent of the area with the potential to contribute to health impacts on marine fauna, either through gill fouling or through inhibited photosynthesis via a reduction in light penetration (a potential indirect impact resulting from increased TSS concentrations in the water column). Table 6.4-3 summarizes the results of the modeling for the four drill cuttings discharge scenarios.

Modeling predicts that TSS concentrations above the 35 mg/L threshold 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. These water depths are too great to allow for photosynthesis. In the case of subsequent well sections, none of the maximum predicted TSS concentrations exceed the 35 mg/L threshold.

Table 6.4-3: Summary of TSS Concentration Modeling Results for Drill Cuttings Discharge Scenarios

Scenario	Maximum Predicted TSS Concentration (mg/L) Surface Discharge/Seafloor Discharge	Area (km^2) with Predicted TSS Concentration > 35 mg/L Threshold Surface Discharge/Seafloor Discharge
1a DC3-I; Minimum Currents	7.2 / 12,591	0 / 0.080
1b DC3-I; Maximum Currents	14.1 / 9,801	0 / 0.282
2a DC3-P1; Minimum Currents	6.3 / 5,783	0 / 0.069
2b DC3-P1; Maximum Currents	6.9 / 7,269	0 / 0.208
3a DC4-I; Minimum Currents	6.0 / 39,613	0 / 0.405
3b DC4-I; Maximum Currents	3.1 / 19,857	0 / 0.521
4a DC4-P1; Minimum Currents	8.1 / 41,055	0 / 0.325
4b DC4-P1; Maximum Currents	10.4 / 15,690	0 / 0.475

While TSS concentrations for discharges at the seafloor will result in conditions exceeding the threshold, modeling indicates TSS concentrations will be reduced to below the threshold through settling and dispersion within approximately 1 hour of cessation of the approximately half-day of jetting and drilling for each initial well section. Furthermore, with respect to inhibition of photosynthetic impacts, these are less relevant to the area near the seafloor, which is well below the photic zone. Based on the limited area impacted and the short time period during which concentrations above the threshold are expected to persist, the magnitude of impacts on marine water quality from TSS increases resulting from drill cuttings discharge is considered **Negligible**.

Sensitivity of Resource—Increased TSS Concentrations from Drill Cuttings Discharge

The sensitivity of the marine environment to increased TSS concentrations is considered **Low**, as the numbers of individual receptors (e.g., fish and photosynthetic organisms) are expected to be low in the zones affected by short-term increases of TSS concentrations above the threshold, and because these individual receptors would generally be expected to avoid the area during the relatively short periods of elevated TSS concentrations.

Impact Significance—Increased TSS Concentrations from Drill Cuttings Discharge

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine water quality from increased TSS concentrations resulting from drill cuttings discharge is considered **Negligible**.

6.4.3.3. Characterization of Impacts—Changes to Water Quality and Temperature

Magnitude of Impact—Changes to Water Quality and Temperature

Project Discharges

The Project will include several discharges with the potential to change water quality and temperature. These discharges, based on the preliminary Project design information, are listed in Table 6.4-4.

Table 6.4-4: Summary of Project-Related Discharges

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
SURF and FPSO Installation/Commissioning Discharges			
Ballast water (FPSO initial deballasting)	≤ 550,000 bbl total	1) Perform in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
Hydrostatic test water • Biocide: ≤ 500 ppm • Oxygen scavenger ≤ 100 ppm • Corrosion inhibitor ≤ 100 ppm	65,000 bbl (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)	No visible oil sheen on receiving water	No
Gas injection line commissioning Fluids • Hydrate inhibitor (e.g. methanol or ethylene glycol)	1,400 bbl total	None	NA
Production Discharges			
Produced water • Oil and grease • Residual production and water treatment chemicals	≤ 300,000 BPD	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 meters from discharge	Yes
Cooling water • Hypochlorite: ≤ 5 ppm	≤ 1,600,000 BPD	No visible oil sheen on receiving water Temperature rise <3°C at 100 meters from discharge	No
Sulfate removal and potable water processing brines • Hypochlorite: ≤ 1 ppm • Electrolyte: ≤ 1 ppm • Biocide: ≤ 5 ppm • Oxygen scavenger: ≤ 10 ppm • Scale inhibitor: ≤ 5 ppm	≤ 265,000 BPD	None	NA
Subsea hydraulic fluid discharge • Water soluble, low-toxicity	≤ 5 BPD	None	NA
FPSO bilge water	1,800 BPD	Oil in water content: <15 mg/L	Yes
Inert gas generator cooling water	Negligible	None	NA

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
FPSO slop tank water	Negligible [a]	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum)	Yes
Miscellaneous discharges including boiler blowdown, desalinization blowdown, lab sink drainage	<10 BPD	None	NA
Tanker ballast water	Maximum 1,200,000 bbl total (at each tanker crude loading)	1) Perform in accordance with IMO requirements 2) No visible oil sheen on receiving water	No
BOP system testing water-soluble low toxicity hydraulic fluid	30 bbl every 2 weeks	None	NA
Gray water	250 BPD	None	NA
Black water (sewage)	200 BPD	Total residual chlorine as low as practical but not less than 1 ppm	Yes
Food preparation wastes	<40 BPD	Macerated to <25 millimeters diameter	Yes

BPD = barrels per day; NA = not applicable; ppm = parts per million
[a] FPSO slop tank water includes deck drainage in addition to off specification oil from the process. While the expected volume of off-specification oil will be negligible, if it rains significantly, the expected discharge volume for this stream will be increased (though the increase would be entirely rainwater).

Based on the estimated discharge rates in Table 6.4-4, cooling water, produced water, and brines from the Sulfate Removal Unit and freshwater reverse osmosis system (all associated with the production operations stage) are the operational discharges that were the focus of modeling to assess the nature and extent of potential marine water quality impacts. Additionally, although the discharge of hydrotest water and commissioning fluids will occur over only a short time period during the SURF installation and commissioning stage, they were also included in the offshore discharge modeling as a conservative measure. Potential impacts from the other effluent discharges listed above were considered to be of **Negligible** significance. There may be localized toxic effects on fish, crustacean, plankton, and benthos from some of the chemicals in the low volume of subsea hydraulic fluid discharge, but the chemicals used will be of low toxicity and will dilute and disperse rapidly.

The constituents considered for each of these modeled discharges are listed in Table 6.4-5. The constituents are associated with potential indirect impacts on marine aquatic life, as indicated in the table.

Table 6.4-5: Summary of Modeled Discharges and Considered Constituents for Production Operations and SURF Hydrotesting

Modeled Discharge	Considered Constituents	Potential Indirect Impacts on Marine Aquatic Life
Cooling Water	• Temperature • Residual chlorine	Temperature increase and associated avoidance impacts on marine species Increased residual chlorine concentrations and associated toxicity impacts on marine species
Produced Water	• Oil and grease • Temperature • Residual production-related and water treatment chemicals (e.g., scale and corrosion inhibitors)	Increased concentrations of oil and grease and production-related and water treatment chemicals, and associated toxicity impacts on marine species
Sulfate Removal and Potable Water Processing Brines	• Hypochlorite • Electrolyte • Biocide • Oxygen scavenger • Scale Inhibitor	Increased chemical concentrations and associated toxicity impacts on marine species
Hydrotest Water	• Biocides • Oxygen scavenger • Corrosion inhibitor	Increased chemical concentrations and associated toxicity impacts on marine species
Gas Injection Line Commissioning Fluid	• Hydrate inhibitor (e.g., methanol or monoethylene glycol)	Increased chemical concentrations and associated toxicity impacts on marine species

The cooling water discharge is the return flow associated with a routine operational process used to cool selected machinery onboard the FPSO. The cooling water discharge will have an elevated temperature (relative to the ambient water temperature for the marine environment) and will contain a limited amount of hypochlorite (generated from seawater and added as an anti-biofouling agent). Aquatic species may be indirectly impacted by the elevated temperature and residual chlorine in the discharge. Elevated temperatures may result in aquatic species avoiding regions close to the discharge. Residual chlorine may interact with naturally occurring organic matter, resulting in chlorinated byproducts with the potential to result in indirect toxicity impacts on aquatic species. There are no regulatory limits for residual chlorine in marine discharges in Guyana. Although not technically applicable to a cooling water discharge, the IMO's 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants recommends that when chlorine is used as a disinfectant, the best technical practice is used to keep the disinfectant residual in the effluent below 0.5 mg/L. Residual chlorine toxicity depends not only on exposure (concentration and duration), but also on individual species' sensitivity. This makes defining a single impact threshold for residual chlorine exposure difficult. If the discharge is designed such that the exposure is reduced to the extent reasonably practicable, the potential for resulting impacts should be limited and can be managed.

Discharge of produced water containing oil and grease and residual quantities of certain production-related and water treatment chemicals can result in localized increases in concentrations of chemical constituents in the marine environment. Discharge of sulfate removal and potable water processing brines can also result in localized increases in concentrations of chemical constituents in the marine environment. Depending on the specific constituent concentrations in these discharges, some aquatic species may experience indirect toxicity impacts from these constituents. Additionally, the produced water discharge will have an elevated temperature (relative to the ambient water temperature for the marine environment).

Hydrotest water discharges may contain biocides, oxygen scavengers, and corrosion inhibitors, which can result in locally increased concentrations of chemical constituents and associated potential for indirect toxicity impacts on aquatic species. The hydrotest discharge and hydrate inhibitor discharge will occur only during a limited time period during SURF installation and commissioning activities, unlike the discharge of cooling water, produced water, and sulfate removal and potable water processing brines discharge, all of which will occur continuously during production operations.

Water Quality Modeling

The USEPA-approved CORMIX[12] dilution model was used to predict the nature and extent of discharge plumes from the various modeled discharges. CORMIX is a design tool routinely used by regulatory agencies to estimate mixing zones resulting from water discharges. Understanding the mixing characteristics of the various discharges and assessing impacts requires understanding the properties of the discharged effluent (e.g., temperature), the properties of the receiving (ambient) water, and the method by which the discharge stream enters the ambient water (e.g., pipe, diffusers). Collectively, these factors control the near-field mixing and dilution of the discharge.

Discharge velocity, an important determinant of the mixing characteristics of a discharge, is directly related to the discharge pipe diameter. At a given discharge flow rate, smaller pipe diameters result in higher exit velocities, which facilitate increased mixing. However, engineering constraints may limit the degree to which the pipe diameter can be reduced. Similarly, the location of the discharge pipe (submerged or above water) can significantly influence the near-field mixing. An above-surface discharge accelerates under gravity to reach increased velocities before entering the sea, a desirable outcome that can be achieved if further reductions in pipe diameter are not practicable. As the detailed design for the Project has not been finalized, conservative assumptions were used for the modeled discharge pipe diameters. Pipe diameters that are smaller than those considered in the modeling will result in increased mixing (and lower concentrations at the edge of mixing zone, relative to those predicted by modeling).

[12] CORnell MIXing Zone; http://www.cormix.info/

For the receiving environment, the ambient currents selected for modeling consisted of bounding cases (5th and 95th percentile for the range of current velocities identified) as well as a typical case (50th percentile for the range of current velocities identified). Ambient temperatures selected for modeling also consisted of bounding cases (1st and 99th percentiles) and a typical case (50th percentile).

The modeling of potential impacts from these discharges found that even under the most conservative bounding case for each discharge modeling scenario, the discharges were subject to rapid mixing and consequently experienced substantial reductions in constituent concentrations within a relatively small distance from the point of discharge.

Guyana has not established a specific thermal discharge limit; therefore, a 3°C maximum temperature rise at a distance of 100 meters from the discharge point was used as a reference point for cooling water and produced water discharges, consistent with recognized international benchmarks (IFC 2015). Table 6.4-6 summarizes the results of the modeling of discharges for the most conservative bounding cases, including percent reduction in constituent concentrations at the 100-meter reference distance from the source. International standards and guidelines and established regulatory requirements provide appropriate discharge benchmarks for oil and grease content in produced water, and MARPOL 73/78 specifies limits on oil and grease in bilge water. There are no prescribed limits for the constituents contained in the other discharge streams.

Table 6.4-6: Summary of Modeling Results for Most Conservative Bounding Case Conditions (Predicted Results at 100-Meter Reference Distance)

Discharge	Most Conservative Bounding Case Conditions	Modeled Parameters/ Constituents	Modeled Results at 100 Meters
Cooling Water (Thermal)	Minimum ambient temperature, maximum ambient current	Temperature rise [a]	Ambient temperature rise <3°C
Cooling Water (Residual Chlorine)	Minimum ambient temperature, maximum ambient current	Residual chlorine	97% reduction (0.16 mg/L)
Produced Water	Maximum ambient current	• Oil and grease [b] • Temperature Rise • Residual production chemicals	Ambient temperature rise <3°C 98.6% reduction in oil and grease and other residual production chemicals
Sulfate Removal and Potable Water Processing Brines	Maximum ambient current	• Hypochlorite • Electrolytes • Biocide • Oxygen scavenger • Scale inhibitor	99.7% reduction
Hydrotest Water	Minimum ambient current	• Biocide • Oxygen scavenger • Corrosion inhibitor	98.9% reduction

Discharge	Most Conservative Bounding Case Conditions	Modeled Parameters/ Constituents	Modeled Results at 100 Meters
Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Minimum ambient current (ethylene glycol); high ambient current (methanol)	Hydrate inhibitor (either methanol or ethylene glycol)	89.5% reduction in ethylene glycol or 99.9% reduction in methanol

[a] Design specifications for the cooling water discharge port were not finalized at the time of the EIA; modeling was conducted to ensure the most probable design will result in a temperature rise less than 3°C at the edge of the 100-meter mixing zone.
[b] Discharges will adhere to a limit of 42 mg/L oil and grease (daily maximum) and 29 mg/L (monthly average) at the point of discharge (consistent with recognized international benchmarks).

Magnitude Ratings

In terms of potential impacts on marine water quality from production operations and hydrotesting discharges, Table 6.4-7 summarizes the assigned magnitude ratings based on consideration of the modeling results.

Table 6.4-7: Magnitude Ratings for Modeled Production Operations and Hydrotesting Discharges

Discharge	Impact Magnitude Rating	Rationale for Magnitude Rating
Cooling Water	Small	Modeling indicates the temperature rise in the water column will reduce to no greater than the reference benchmark of 3°C at the edge of the recommended 100-meter mixing zone. At this same distance, chlorine concentrations are predicted to decrease by 97 percent to a concentration of 0.16 mg/L.
Produced Water	Negligible	At the 100-meter reference distance, concentrations of oil and grease and residual production-related and water treatment chemicals are predicted to decrease by 98.6 percent, and temperature rise is predicted to be less than 3°C.
Sulfate Removal and Potable Water Processing Brines	Negligible	At the 100-meter reference distance, concentrations of hypochlorite, electrolyte, biocide, oxygen scavenger, and scale inhibitor are predicted to decrease by 99.7 percent.
Hydrotest Water	Negligible	At the 100-meter reference distance, concentrations of biocide, oxygen scavenger, and corrosion inhibitor are predicted to decrease by 98.9 to 99.6 percent, depending on pipe diameter. Additionally, each release event will be short-term in nature (approximately 60 minutes or less).
Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Negligible	At the 100-meter reference distance, the concentration of hydrate control fluid (methanol or monoethylene glycol) is predicted to decrease by 89.5 to 99.9 percent, depending on the fluid selected. Additionally, the release event will be short-term in nature (a matter of hours).

Considering the information presented above, the overall magnitude of potential impacts on marine water quality from changes in water quality and temperature is considered **Negligible**.

Sensitivity of Resource—Changes to Water Quality and Temperature

As described in Section 7.7.3, Impact Assessment—Marine Fish, elevated temperature is known to have several physiological lethal and sub-lethal impacts on fish including reduced reproductive success, reduced early life stage survivorship, and increased metabolic stress. Thermal thresholds for such impacts vary widely by species, but thresholds from the scientific literature range from about +1.5 ˚C to +6 ˚C (Donelson et al. 2014; Pankhurst and Munday 2011). Most of the research on thermal thresholds for these types of impacts has focused on reef or structure-oriented species that spend their entire adult lives in a small area rather than the open-ocean pelagic species that will occur near the surface in the PDA. Pelagic species are much more likely to move away from a thermal mixing zone that exceeds their optimum range than structure-oriented species, so the species that occur within the PDA will also be resilient to these thermal impacts based on their propensity to actively avoid suboptimal water temperatures.

Similar to temperature increases, chlorine can also induce a range of negative impacts in fish, including disruption of cardiac function, respiration, and growth. Chlorine toxicity depends not only on dosage (concentration and exposure time) but also on individual species' sensitivity to chlorine. The combined impact of increased temperature and chlorine concentrations will make the localized mixing zone inhospitable to some species. However, unless they are physically confined or otherwise prevented from escaping lethal water quality conditions, or water quality conditions decline so quickly that escape is impossible, fish are usually capable of detecting and avoiding harmful water quality conditions. This is especially true of water quality conditions that cause discomfort or are otherwise physically apparent at sub-lethal levels like chlorine, and is also especially true of the pelagic species that move throughout their lives and will be in the most direct contact with elevated temperatures and chlorine concentrations. On the basis of consideration of potential marine life receptors, the sensitivity of the marine environment to elevated constituent concentrations and increased temperature is considered **Low**.

Impact Significance—Changes to Water Quality and Temperature

Based on the magnitude of impact and resource sensitivity ratings, the significance of potential impacts on marine water quality from changes in water quality and temperature resulting from production operations and hydrotesting discharges is considered **Negligible**.

6.4.4. Mitigation Measures—Marine Water Quality

Based on the **Negligible** significance of potential marine water quality impacts, no mitigation measures are proposed. It is noted, however, that the limited significance of potential marine water quality impacts is supported by a suite of embedded controls related to water quality management (see summary in Chapter 13, Recommendations).

Table 6.4-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine water quality. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine water quality-specific methodology described in Sections 6.4.3.2 and 6.4.3.3.

Table 6.4-8: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Water Quality

Stage	Resource - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling SURF/FPSO Installation	Increased TSS concentrations—potential health impacts on marine life	Negligible	Low	Negligible	None	Negligible
Development Well Drilling SURF/FPSO Installation Production Operations	Water quality and temperature changes—potential health impacts on or avoidance of marine life	Negligible	Low	Negligible	None	Negligible
Decommissioning	Water quality changes—potential health impacts on marine life	Negligible	Low	Negligible	None	Negligible

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7. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—BIOLOGICAL RESOURCES

7.1. PROTECTED AREAS AND SPECIAL STATUS SPECIES

7.1.1. Administrative Framework—Protected Areas and Special Status Species

Table 7.1-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on protected areas and special status species.

Table 7.1-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Protected Areas and Special Status Species

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
Protected Areas Act, 2011 (also discussed in Chapter 3)	Provides for protection of Guyana's natural heritage and natural capital, including creation and management of a system of protected areas, maintenance of ecosystem services, establishment of a Protected Areas Commission, and other related functions.	Shell Beach, which is a coastal area subject to potential impact from a Project unplanned event (i.e., oil spill), was identified as one of the five priority areas for establishment of protected areas in Guyana and was designated a protected area with the passage of the Protected Areas Act in 2011.

Title	Objective	Relevance to the Project
International Agreements Signed/Acceded by Guyana		
Protocol on Specially Protected Areas and Wildlife	Protocol supplementing and supporting the Cartagena Convention. Requires signatories to adopt an ecosystem approach to conservation. Provides mechanism for compliance with the Convention on Biological Diversity.	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity. Guyana acceded and ratified in 2010.
Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)	Protects endangered plants and animals from international trade.	Restricts collection and trade of endangered species. Guyana acceded in 1977.

7.1.2. Existing Conditions—Protected Areas and Special Status Species

7.1.2.1. Protected Areas

Formerly, the EPA was Guyana’s focal point for the Convention on Biological Diversity, and the agency coordinated the National Protected Areas System (EPA undated), which included five protected areas. In 2011, Guyana enacted the Protected Areas Act, which established a Protected Areas Commission to oversee and manage protected areas. This legislation established a list of prohibited activities, including unlawfully entering or remaining within a protected area; disturbing or destroying the vegetation (common or endangered); removing or exterminating wildlife species (common or endangered); damaging archaeological finds or sites; and mining. If any prohibited activities occur, fines range from $50,000 to $500,000 (Guyanese dollars [GYD]; $240 to $2,400 U.S. dollars [USD]) (Protected Areas Act 2011). Guyana’s National Biodiversity Strategy and Action Plan (EPA and MoNRE 2015) describes the overall importance of biodiversity’s role within the country:

> “Guyana’s biodiversity provides an important basis for climate regulation, poverty reduction, provisioning of fresh water and hydropower, economic growth and development in areas such as agriculture, forestry and fisheries, payment for forest climate services, community based economies, particularly in hinterland communities and biodiversity-related education, scientific research and recreation. Loss of biodiversity and any disruption in the provision of ecosystem services would impact negatively on the economy and more particularly on the quality of life in the hinterland and indigenous communities.”

The 2011 legislation also established Shell Beach and the Kanuku Mountains as Guyana’s newest nationally protected areas. This increased the total number of protected areas in Guyana to seven and increased the total land area protected to approximately 1.8 million hectares, or about 9 percent of Guyana’s land area, as summarized in Table 7.1-2. Figure 7.1-1 illustrates the locations of Guyana’s protected areas. There are currently no designated marine protected areas in Guyana.

Table 7.1-2: Protected Areas in Guyana

Protected Area	Area (ha)
Kaieteur National Park	63,000
Iwokrama Forest	371,000
Kanashen (Community Owned Conservation Area)	625,000
Kanuku Mountains	611,000
Shell Beach Nature Reserve	200,000
Moraballi Forest Reserve	11,000
Mabura Hill Forest Reserve	2,000

Source: IUCN and UNEP-WCMC 2016

Of the seven protected areas, Shell Beach Protected Area (SBPA) is the only one located on Guyana's coast, and is most pertinent to the assessment of potential impacts from the Project. SBPA includes Guyana's coastline but does not extend into the Atlantic Ocean; however, the ecology of the coastal zone and Shell Beach are inextricably connected to the coastal marine ecosystem.

Figure 7.1-2 provides a detailed map of SBPA, the beaches it incorporates, and the surrounding area. It is located in northwestern Guyana and extends for almost 140 kilometers (approximately 87 miles) between the Waini, Baramani, and Moruka rivers and the Atlantic Ocean. The Project Development Area (PDA) is located approximately 300 kilometers (approximately 187 miles) northeast of the southernmost (closest) point of Shell Beach.

Shell Beach, which derived its name from the fact that its entire stretch of coastline is comprised mainly of pulverized crustacean shells (EPA et al. 2004), is a dynamic area. Its landscape constantly changes due to the competing impacts of erosion and accretion along the shoreline. The area is 70 percent forested; the rest is made up of mostly swamp (less than 30 percent) and sandy beaches (less than 1 percent) (Kandaswamy 2014). Shell Beach supports numerous plant species, including coconut, papaya, and palm trees (GMTCS 2011; Bovell 2011).

The vegetative community has changed little in recent history apart from limited clearing to accommodate a few dispersed encampments and farmsteads. The rivers bordering the SBPA discharge nutrients through the protected area's mudflats and mangroves. These high nutrient levels contribute to the productivity of the marine ecosystem. Fish, prawns, and crabs from the nearshore marine area use the mangrove covered coastlines as nursery habitat.

Shell Beach is best known as a marine turtle nesting site. The composition of the substrate at Shell Beach, its geographical location, and the low anthropogenic activity makes it an ideal nesting site for marine turtles. Most nesting beaches in Guyana are used by only one or two species of marine turtles, but four species (leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], olive ridley turtle [*Lepidochelys olivacea*], and green turtle [*Chelonia mydas*]) nest at Shell Beach (Pritchard 2001). In addition to marine turtles, there are also at least four other species of turtles present within the SBPA, including yellow-foot tortoise (*Geochelone denticulata*), scorpion mud turtle (*Kinosternon scorpioides*), giant river turtle (*Podocnemis expansa*), and mata mata (*Chelus fimbriata*).

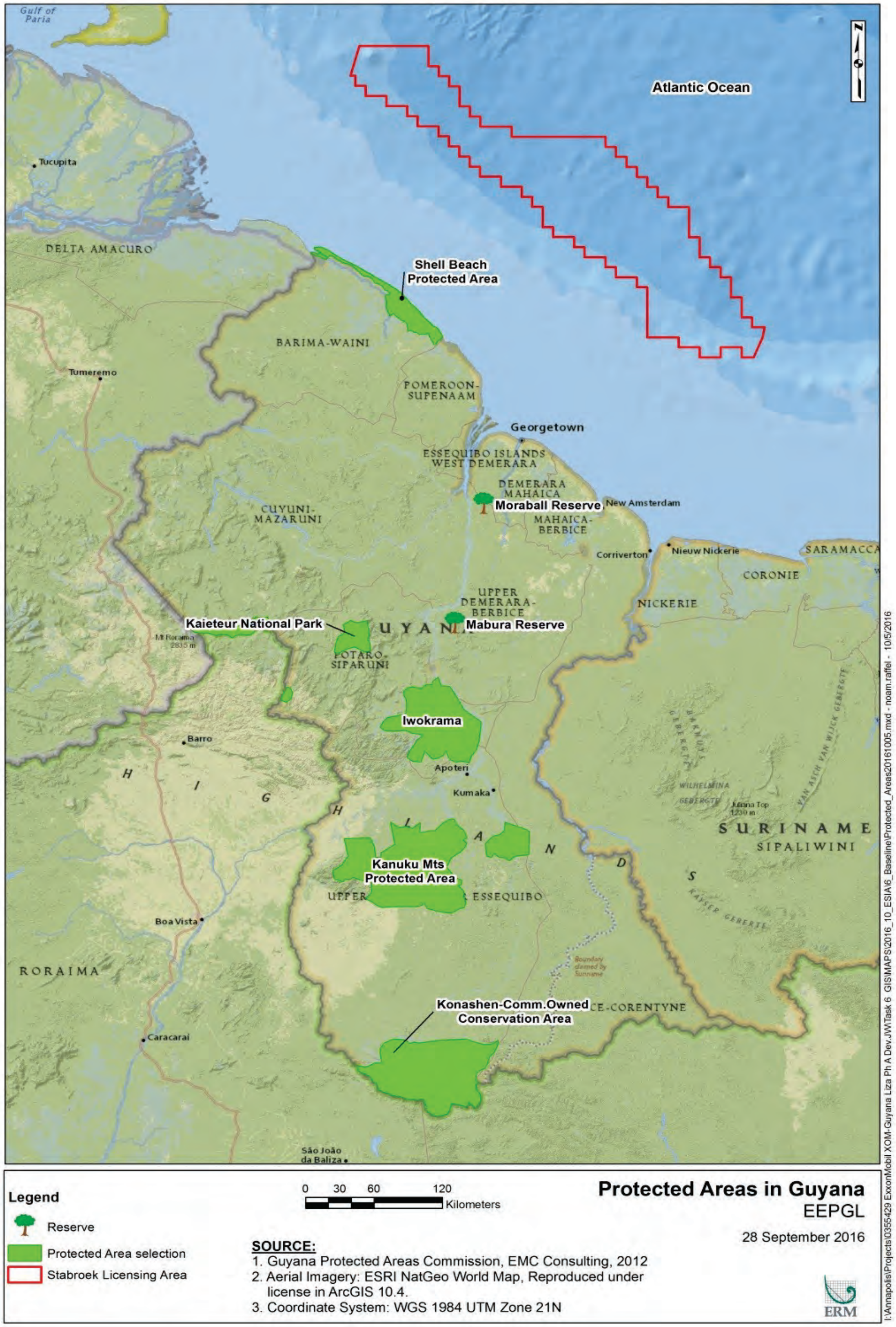


Figure 7.1-1: Protected Areas of Guyana

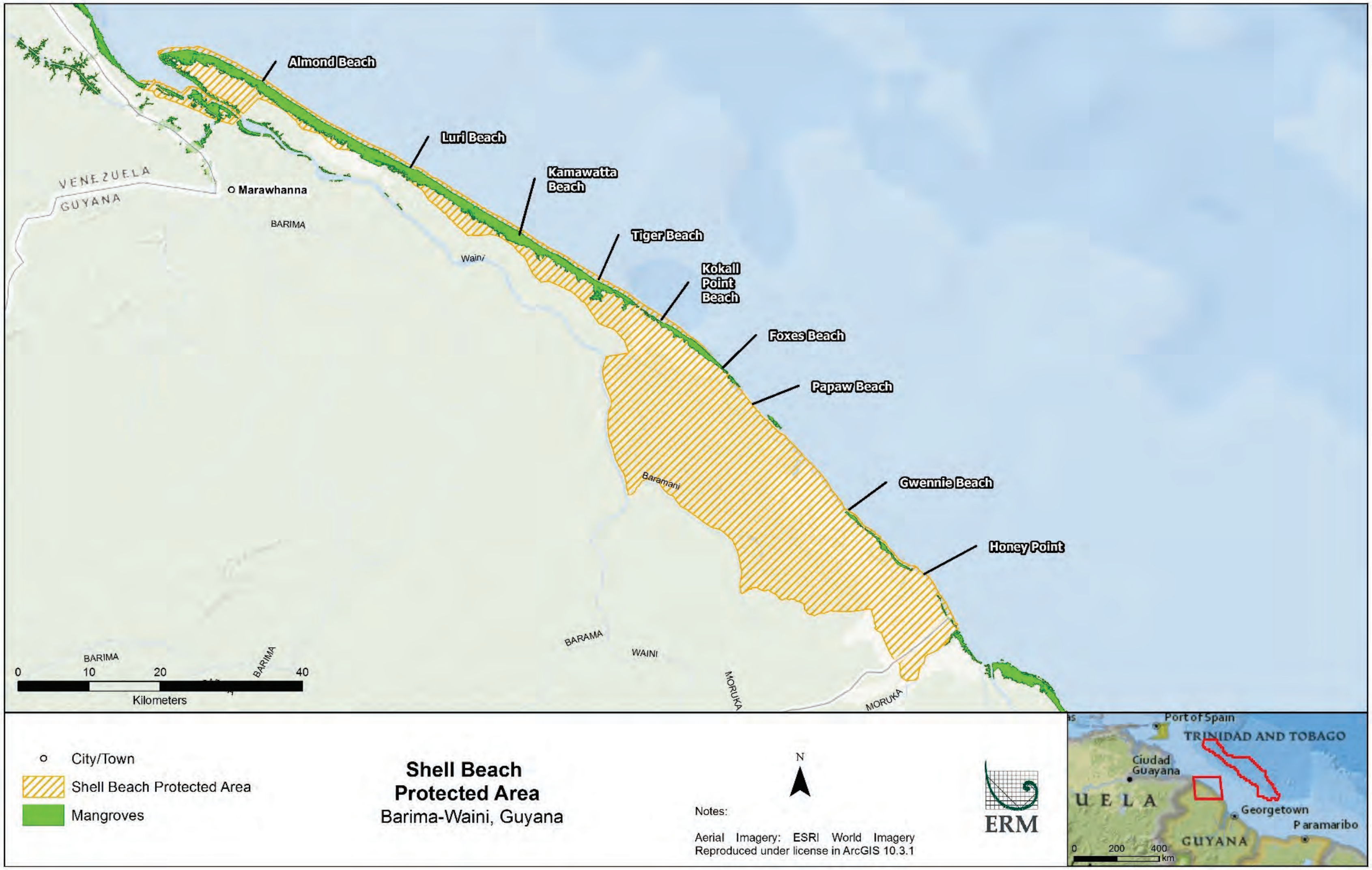


Figure 7.1-2: Shell Beach Protected Area

The SPBA also supports rich bird, herpetofauna (reptiles and amphibians), and mammal communities. The 2004 Rapid Biodiversity Assessment (EPA et al. 2004) documented 170 species of birds, 20 species of mammals, and 31 species of herpetofauna. The 170 species of birds represent one of the richest populations in Guyana and include well known species such as Scarlet Ibis (*Eudocimus ruber*), Roseate Spoonbill (*Platalea ajaja*), and Caribbean Flamingo (*Phoenicopterus ruber*), Orange-winged Amazon Parrots (*Amazona amazonica)*, and several species of macaws.

Sixteen herpetofauna species (other than turtles) are known to inhabit the Shell Beach area. These include the Ameiva lizard (*Ameiva ameiva*), whiptail lizard (*Cnemidorphous lemniscatus*), water labaria (*Helicops angulatus)*, cane toad (*Rhinella marina*), paradoxical frog (*Pseudis paradoxa*), and numerous tree frogs (*Hyla* spp.) (EPA et al. 2004).

Resources within Protected Areas are a key factor in supporting local communities (see Section 8.9, Ecosystem Services, for additional information). Areas within and near Shell Beach have been inhabited for 10,000 years by Amerindian groups from the Warao, Carib, and Arawak tribes (Charles et al. 2004). Most of the current indigenous residents of the Shell Beach area are concentrated in a community known as Almond Beach, near the northern end of the SBPA. Other communities included within the boundary of the SBPA, as delineated in 2011, include Father's Beach and Assakata. The remainder of the SBPA is sparsely populated, if at all.

Indigenous communities have historically used the Shell Beach area for subsistence fishing, crabbing, trapping, farming, logging, and palm harvesting. The important crab species that are used by the locals include blue sheriga (*Callinectes bocourti*), sheriga (*Portunas spinimamus*), bunderi (*Cardiosoma guanhumi*), and buck-crab (*Ucides cordatus*) (EPA et al. 2004). They have also historically engaged in marine turtle trapping and egg harvesting. While these activities have declined in recent years as emphasis on conservation and sustainability has increased, illegal catching of turtles may still occur (Charles et al. 2004).

Increasing human activity in proximity to Shell Beach has led to increasing exploitation of natural resources and has the potential to lead to additional ecological harm. In 1997, a fire caused by human activity extensively damaged an area of mangroves (Pritchard 2001). Throughout the past few decades, there have also been various industrial proposals for Shell Beach. These include proposals to extract shell material from the beaches as feedstock for fertilizer production and to develop a luxury tourist outpost (Charles et al. 2004). Amerindian communities in the area have also expressed interest in developing ecotourism in the area (Charles et al. 2004).

7.1.2.2. Special Status Species

The International Union for the Conservation of Nature (IUCN) Red List is the definitive authority on global species conservation status. In addition to the global IUCN Red List, many countries have a National Red List that assess species status at a national or smaller scale. Guyana does not have a National Red List (NRL 2018) so the IUCN Red List is used herein. For the purposes of this assessment, special status species are defined as those that are listed as: (1) Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the IUCN Red List Version 2017.3 (IUCN 2018). Table 7.1-3 summarizes the IUCN Red List categories. Species categorized as CR, EN, and VU are collectively considered to be internationally “threatened,” while NT species are close to qualifying as “threatened.” Conversely, Least Concern (LC) species are considered internationally widespread and abundant. Species listed as Data Deficient (DD) are poorly understood, so their conservation status and extinction risk is unknown.

Table 7.1-3: Definitions of IUCN Red List Categories of Extinction Risk

IUCN Red List Status	Definition
Extinct (EX)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), and throughout its historical range have failed to record an individual.
Critically Endangered (CR)	A taxon is Critically Endangered when the best available evidence (severe population decline, very small population, very small geographic area occupied, or a probability of extinction in the next 10 years of >50%) indicates that it is facing an extremely high risk of extinction in the wild.
Endangered (EN)	A taxon is Endangered when the best available evidence (large population decline, small population, small geographic area occupied, or a probability of extinction in the next 20 years of >20%) indicates that it is facing a very high risk of extinction in the wild.
Vulnerable (VU)	A taxon is Vulnerable when the best available evidence (substantial population decline, small population, fairly small geographic area occupied, or a probability of extinction in the next 100 years is >10%) indicates that it is considered to be facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered, or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Least Concern (LC)	A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Taxa that are widespread and abundant are included in this category.
Data Deficient (DD)	A taxon is Data Deficient when there is inadequate information to make a direct or indirect assessment of its risk of extinction based on its distribution and/or population status.

Source: IUCN 2001

There are 296 species known to occur in the coastal and marine habitats in Guyana that are on the IUCN Red List. Sixty-three of these marine and coastal species have been ranked NT or higher. Appendix L, IUCN-Listed Species in Guyana, lists the 63 species with elevated conservation status (ranked NT or higher) and their current Red List status. An additional 31 species are listed by IUCN as DD (Appendix L). These 63 species with an elevated conservation status include 51 fish, 3 birds, 4 marine turtles, 1 terrestrial turtle, and 4 mammals (1 marine mammal and 3 coastal/riverine mammal species). The vast majority of the species ranked NT or higher are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, many of these fish species are also targeted by the Guyanese commercial fishing industry.

According to the IUCN's classification scheme, these species currently face a credible threat of extinction. Of these 63 species, 15 have been observed in the Stabroek Block, along the Guyana coast, or between the coast the Stabroek Block during the following EEPGL-commissioned survey and monitoring activities (Table 7.1-4):

- Marine and coastal bird surveys of the area between Georgetown and the Stabroek Block and within the Stabroek Block in October 2017 and April 2018 (three sampling events) (ERM 2018a; ERM 2018b);
- Marine and coastal fish surveys in 2017 and 2018 (two sampling events) (ERM 2018c);
- Protected species observer monitoring (paired observer and passive acoustic monitoring) conducted during EEPGL seismic programs from 2015 through 2018 (RPS 2018); and
- Marine benthos surveys in 2014, 2016, and 2017 (three sampling events) (Maxon and TDI Brooks 2014; Fugro 2016; ESL 2018)

The 15 sightings included two marine mammal, four marine turtle, four fish, four bird, and one coastal/freshwater mammal species (Table 7.1-4).

Table 7.1-4: Species Observed during EEPGL-Commissioned Surveys and Protected Species Monitoring with IUCN Red List Status of NT or Higher

Common Name	Scientific Name	IUCN Red List Status	Survey	Primary Habitat
West Indian Manatee	*Trichechus manatus*	VU	Coastal bird survey 2018; Region 1 coastal mapping	Coastal and riverine
Sperm Whale	*Physeter macrocephalus*	VU	RPS Protected Species Observer Data	Marine
Green Sea Turtle	*Chelonia mydas*	EN	RPS Protected Species Observer Data	Marine and coastal (nest in SBPA)
Olive Ridley Turtle	*Lepidochelys olivacea*	VU	RPS Protected Species Observer Data	Marine and coastal (nest in SBPA)
Leatherback Turtle	*Dermochelys coriacea*	VU	RPS Protected Species Observer Data	Marine and coastal (nest in SBPA)
Hawksbill Turtle	*Eretmochelys imbricata*	CR	RPS Protected Species Observer Data	Marine and coastal (nest in SBPA)
Tiger Shark	*Galeocerdo cuvier*	NT	RPS Protected Species Observer Data	Marine
Giant Manta Ray	*Manta birostris*	VU	RPS Protected Species Observer Data	Marine
Ocean Sunfish	*Mola mola*	VU	RPS Protected Species Observer Data	Marine
Yellowfin Tuna	*Thunnus albacares*	VU	RPS Protected Species Observer Data	Marine
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	VU	Marine bird survey 2018	Marine
Semipalmated Sandpiper	*Calidris pusilla*	NT	Coastal bird surveys 2017 and 2018	Coastal

Common Name	Scientific Name	IUCN Red List Status	Survey	Primary Habitat
Bicolored Conebill	*Conirostrum bicolor*	NT	Coastal bird surveys 2017 and 2018	Coastal mangrove
Rufous Crab-Hawk	*Buteogallus aequinoctialis*	NT	Coastal bird surveys 2017 and 2018	Coastal mangrove
Neotropical Otter	*Lontra longicaudis*	NT	Coastal bird survey 2018; Region 1 coastal mapping	Coastal and riverine

Photo credit: Romeo DeFreitas

Figure 7.1-3: Green Turtle (*Chelonia mydas*) at Shell Beach Protected Area, IUCN Red List Endangered, March 2018

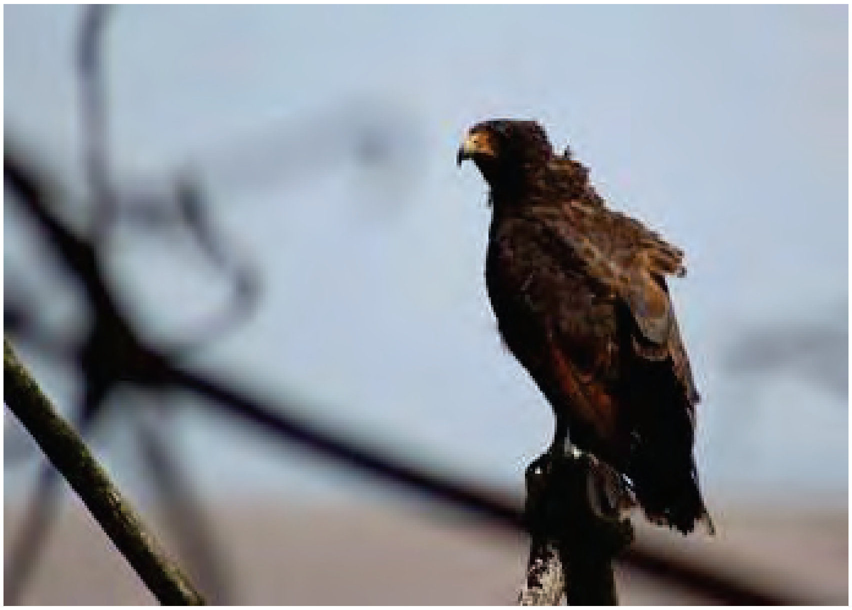


Photo credit: Waldyke Prince

Figure 7.1-4: Rufous Crab-Hawk (*Buteogallus aequinoctialis*), IUCN Red List Near Threatened, at Ruimzeight Seaside, October 2017

7.1.3. Impact Assessment—Protected Areas and Special Status Species

This section describes the assessment of potential impacts on protected areas and special status species.

7.1.3.1. Protected Areas

Planned activities of the Project and associated air emissions, effluent discharges, and sound generation, which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not impact SBPA, which is Guyana's only designated protected area within the Project Area of Influence (AOI). The Project's only potential impacts on SBPA would be as a result of an unplanned event, which is discussed in Section 9.5, Protected Areas and Special Status Species.

7.1.3.2. Special Status Species

For the purposes of this assessment, special status species are defined as those listed on the IUCN Red List as NT, VU, EN, or CR on the IUCN Red List Version 2017.3 (IUCN 2018) that are known or expected to occur in the Project AOI (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species, and Appendix L, IUCN-Listed Species in Guyana). A list of designated protected species occurring in Guyana and their IUCN conservation status is provided in Appendix L.

Relevant Project Activities and Potential Impacts—Special Status Species

Of the 63 special status species known or expected to occur in the Project AOI, five are strictly coastal species, so they will not be impacted by planned Project activities (Section 7.3.3, Impact Assessment—Coastal Wildlife). They would only be affected by an unplanned event, the impacts of which are discussed in Section 9.7, Coastal Wildlife. Table 7.1-5 presents the distribution of the remaining (non-coastal) special status species, according to taxonomic group and IUCN Red List status, that could experience potential impacts from planned Project activities.

Table 7.1-5: Number of (Non-Coastal) Special Status Species Potentially Affected by Planned Project Activities, Categorized by Taxonomic Group and IUCN Red List Status

Taxonomic Group	Number of Non-Coastal Special Status Species Known or Expected to Occur within Project AOI (IUCN Red List Status)
Marine turtles	4 (1 CR, 1 EN, 2 VU)
Marine mammals	1 (VU)
Marine fish	51 (4 CR, 6 EN, 20 VU, 21 NT)
Seabirds	2 (1 EN, 1 VU)

Potential impacts from planned Project activities on special status species are the same as those described in the taxa-specific impact sections of this EIA (Section 7.6.3, Impact Assessment—Marine Turtles; Section 7.5.3, Impact Assessment—Marine Mammals; Section 7.7.3, Impact Assessment—Marine Fish; and Section 7.4.3, Impact Assessment—Seabirds). As discussed in more detail in these resource-specific impact assessment sections, planned Project activities could result in a number of potential impacts on these receptors, including: localized changes in the distribution of marine species as a result of altered water quality; acoustic disturbance impacts from Project-induced underwater sound; localized changes in distribution and habitat usage due to disturbance from sound, lighting, human activity, or the presence of Project infrastructure; entrainment in water intakes; and the potential attraction to lighting from the Floating Production, Storage, and Offloading (FPSO) vessel, drill ships, and major installation vessels.

Potential impacts on these groups of receptors from unplanned events, including oil spills, discharges of untreated wastewater from the FPSO, contact with the FPSO flare or heat plume, and vessel and helicopter collisions with animals, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Magnitude of Impacts—Special Status Species

In the case of the resource-specific assessments for marine mammals and turtles (Sections 7.5, Marine Mammals, and 7.6, Marine Turtles, respectively), the assessments of impact significance assume the affected receptors are all special status species, so the analysis results for special status marine mammals and marine turtles are identical to that presented in Sections 7.5 and 7.6. In the case of seabirds and marine fish, the resource-specific assessments presented in Sections 7.4, Seabirds, and 7.7, Marine Fish, respectively, are not conducted on the basis of an assumed special status for the receptors. Accordingly, additional review of the magnitude ratings assigned in Sections 7.4 for seabirds and 7.7 for marine fish was warranted.

The impact magnitude rating describes the degree of change that the impact is likely to impart on the receptor, without regard to receptor sensitivity (see Section 4.6, Assessment of Impacts and Identification of Mitigation Measures). For almost all species, impact magnitude is the same for special status and non-special status species, because the rating describes the impact itself and the change it is likely to cause to the receptor. However, some special status species will have different levels of exposure to some impacts because of their behavior, habitat preferences, or biology, resulting in a different magnitude rating compared with non-special status species. This more detailed evaluation of impact magnitude is warranted for the CR and EN seabird and marine fish species given their elevated conservation status.

The two species of special status seabirds 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 magnitude ratings for special status species seabirds were not changed from those used for non-special status seabirds (Section 7.4).

In the case of marine fish, the more detailed evaluation identified differences in potential impact exposures, relative to marine fish as a whole, for the four CR marine fish species (Atlantic goliath grouper, daggernose shark, Caribbean electric ray, and largetooth sawfish)—principally because of their predominant behavior and habitat preferences. All of these species have the potential to occur in the nearshore and offshore areas of Guyana, but they spend most of their time in nearshore and estuarine environments, rather than offshore (where planned Project activities will occur). As such, their exposure to the impacts from planned Project activities is lower compared with marine fish as a whole. Hence, the magnitude ratings for potential impacts on these species are reduced relative to the magnitude ratings assigned for marine fish as a whole (Section 7.7). Specifically, the magnitude of potential impacts on these four CR marine fish species is considered **Negligible**.

In the case of the EN marine fish species, the Nassau grouper (*Epinephelus striatus*) is listed as occurring in Guyana waters, but this species is primarily a coral reef species. The PDA does not include coral reefs and this species is thus not likely to be present—resulting in a magnitude rating of **Negligible**. With the exception of golden tilefish (*Lopholatilus chamaelonticeps*), the other species are pelagic species that are not prone to congregating around offshore structures; accordingly, potential impacts that are predicated on marine fish occupying areas around Project vessels (i.e., those impacts related to marine discharges, vessel sound, attraction by light, and entrainment by seawater intake) are less of a concern than for other marine fish in general. Further, related to bottom habitat disturbance and Vertical Seismic Profile (VSP) or pile driving sound, potential impacts are not a concern for pelagic species. Golden tilefish are known to prefer clay substrates and would not be expected to congregate over the mud substrate that dominates the PDA. For this reason, the potential impacts listed in Section 7.7, Marine Fish, are all assigned a magnitude rating of **Negligible** for EN marine fish species.

Sections 7.4 through 7.7 provide the details for the basis of the magnitude ratings for all taxonomic groups; the magnitude ratings assigned for each impact and conservation status are provided below.

Sensitivity of Receptor—Special Status Species

The sensitivity of special status species to impacts is higher compared with non-special status species and require special consideration because special status species are assumed to have a diminished capacity to recover from impacts due to their elevated conservation status. With the exception described below, the designation of sensitivity ratings for special status species are based on the definitions provided in Table 7.1-6.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea (the only potential impact from planned Project activities with a magnitude higher than **Negligible**) is not known to be a major contributor to declines in listed turtle species. Accordingly, the sensitivity rating for this particular impact was not defined based on marine turtles' listing status, but rather on the basis of their anticipated propensity to adapt to occasional disturbance. Increased activity in the PDA and between the PDA and shorebase(s) could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route, but marine turtles are not known to be particularly sensitive to human activity while at sea and no publicly available research suggests that turtles would be more susceptible to disturbance in the nearshore environment when approaching nesting beaches. Deviation from normal movement patterns would likely be temporary during the disturbance period and would not be expected to result in a significant effect on nesting. On this basis, receptor sensitivity for marine turtles is considered **Low** for this potential impact.

Table 7.1-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Special Status Species

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species listed as LC on the IUCN Red List (or not meeting criteria for higher IUCN listing status), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as VU or NT on the IUCN Red List; species protected under national legislation; nationally restricted range species; regionally important numbers of migratory or congregatory species; species not meeting rating criteria as EN or CR; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List categorized as CR or EN. Species having a locally restricted range, low number of sites where they occur, or highly fragmented population (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 km^2), internationally important numbers of migratory or congregatory species, species exhibiting or undergoing key evolutionary processes, and species vital to the survival of high value species.

Impact Significance—Special Status Species

As summarized in Table 7.1-7, based on the ranges of magnitudes for potential impacts and the receptor sensitivity ratings applicable for the various IUCN listing levels, the pre-mitigation significance ratings for potential impacts on special status species range from **Negligible** to **Moderate**.

7.1.4. Mitigation Measures—Protected Areas and Special Status Species

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine fish, marine mammals, seabirds, and marine turtles. The same applies for members of these taxonomic groups that carry a special status designation. Table 7.1-7 summarizes the assessment of potential pre-mitigation and residual Project impacts on special status species. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the special status species-specific methodology described in Section 7.1.3.2 and the resource-specific methodologies described in Sections 7.4, Seabirds; 7.5, Marine Mammals; 7.6, Marine Turtles; and 7.7, Marine Fish.

Table 7.1-7: Summary of Potential Pre-Mitigation and Residual Impacts—Special Status Species

Group	IUCN Designation	Range of Magnitude Ratings [a]	Sensitivity Rating	Range of Pre-Mitigation Significance Ratings	Proposed Mitigation Measures	Range of Residual Significance Ratings
Marine Turtles	CR, EN	Negligible to Small	Low to High [c]	Negligible	None	Negligible
	VU	Negligible to Small	Low to Medium [c]	Negligible	None	Negligible
Marine Mammals	VU	Negligible to Medium	Medium	Negligible to Moderate	None	Negligible to Moderate
Marine Fish	CR (pelagic)	Negligible [b]	High	Negligible	None	Negligible
	CR (demersal)	Negligible [b]	High	Negligible	None	Negligible
	EN	Negligible [b]	High	Negligible	None	Negligible
	VU	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor
Seabirds	EN	Negligible	High	Negligible to Minor [d]	None	Negligible to Minor
	VU	Negligible to Small	Medium	Negligible to Minor	None	Negligible to Minor

[a] Magnitude ratings referenced from resource-specific sections (Sections 7.4, Seabirds; 7.5, Marine Mammals; 7.6, Marine Turtles; and 7.7, Marine Fish) unless otherwise indicated
[b] Magnitude ratings reduced relative to ratings used in Section 7.7, Marine Fish, as described in Section 7.1.3.2, Special Status Species
[c] Sensitivity rating of Low for potential impacts related to disturbance at sea; IUCN designation-based sensitivity ratings were used for other potential impacts
[d] Although the impact assessment methodology indicates an impact significance rating of Negligible (based on magnitude and sensitivity), a rating of Minor was assigned based on professional opinion of the Consultants.

7.2. COASTAL HABITATS

7.2.1. Administrative Framework—Coastal Habitats

Table 7.2-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on coastal habitats.

Table 7.2-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Coastal Habitats

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.

7.2.2. Existing Conditions—Coastal Habitats

There are four ecoregions in Guyana (Figure 7.2-1): coastal plain, interior savannas, hilly sand and clay, and forested highlands (EPA and MoNRE 2015). Neither the planned activities of the Project nor the unplanned events considered in relation to the Project will have an impact on the interior savannas, hilly sand and clay, and forested highlands; accordingly, this section focuses on habitats of the coastal plain (note that the only potential impacts on the coastal plain are those associated with unplanned events, i.e., an oil spill).

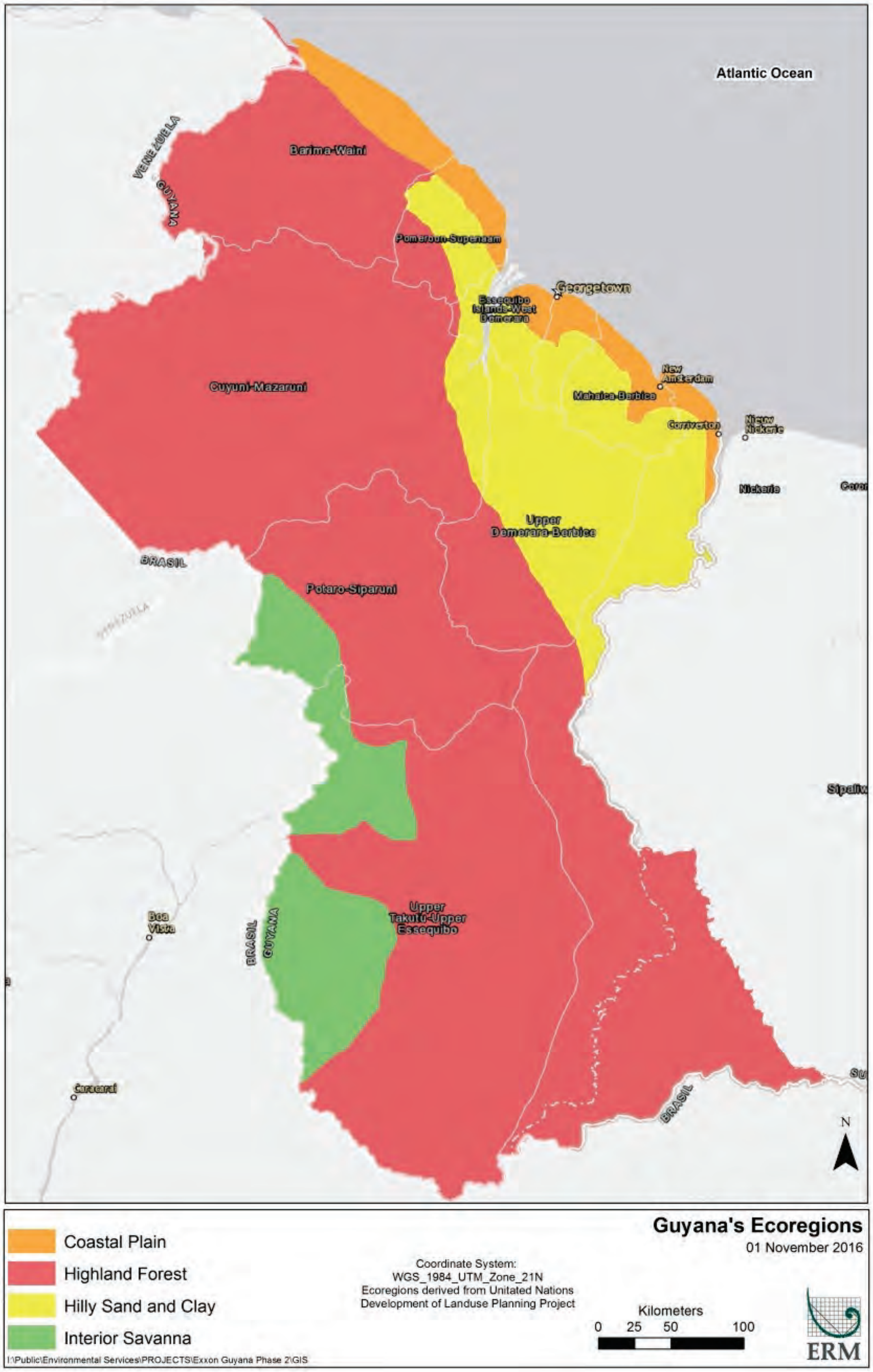


Figure 7.2-1: Guyana's Ecoregions

The coastal plain is a narrow belt of sediments with riverine and marine clays and silts stretching along Guyana's coastline. It occupies approximately 7 percent of the country's total area and extends along the entire length of the coastline - approximately 400 kilometers (approximately 250 miles) - of the Atlantic coast, varying in width from approximately 16 to 64 kilometers (approximately 10 to 40 miles) (Kalamandeen and Da Silva 2002) and in elevation from sea level to approximately 3 meters above sea level (approximately 10 feet) (EPA and MoNRE 2015). The coastal plain is a highly productive and sensitive environment that is subjected to marine and terrestrial influences. Guyana's coastal plain includes a network of plains and low hills, including mangroves, salt to brackish lagoons, brackish herbaceous swamps, swamp woods, and swamp forests. The coastal plain contains some of the world's most productive ecosystems, with rich biological diversity (Kalamandeen and Da Silva 2002). The swamps are an important source of freshwater to mangroves and other flora and fauna (WWF 2016).

Along the Guyana shoreline, which is the portion of the coastal plain with the most potential to be impacted by an unplanned event associated with the Project, the principal habitats are mangroves, beaches, and mudbanks, which are described below.

7.2.2.1. Mangroves

Mangroves are regarded as one of the most important ecosystems for the security of the biodiversity of the entire Guyana coast, as they protect coastlines from wave action and shoreline erosion (see Section 6.3.2, Existing Conditions—Marine Geology and Sediments). A 2008 Smithsonian report stated that mangroves occupied more than 81,000 hectares (approximately 200,155 acres) of Guyana's coast, in 6 of Guyana's 10 geopolitical regions. The Guyana Mangrove Restoration Project estimates that 75 percent of the country's mangroves are concentrated in Regions 1 and 2 (GMRP 2010), which are located along the northwestern coast and include the SBPA.

Figure 7.2-2 shows the distribution of coastal mangrove resources in Regions 1 through 6, based on interpretation of satellite imagery[1] and fieldwork conducted in November 2017 and April 2018. The fieldwork was conducted for all coastal mangroves not blocked by barrier islands (collectively, "the Mangrove Study Area") as part of a broader effort to field-verify the major features of the coastal sensitivity maps (Appendix P, Coastal Sensitivity Maps) that have been developed for the Project. Although the 2017-2018 fieldwork did not include riverine mangroves, the study did support the conclusion that coastal mangroves are heavily concentrated in the western portion of the coastline within Regions 1 and 2. Table 7.2-2 and Figure 7.2-3 summarize the estimated area covered by coastal mangroves in Regions 1 through 6 based on the results of the coastal mapping field verification effort.

[1] Sentinel 2 multispectral imagery from 2017; and Google Earth imagery ranging from 2009 to 2017. Sentinel 2 is a European Space Agency mission composed of two satellites that provide wide-swath, high-resolution, multi-spectral imaging. Google Earth aggregates imagery from a variety of publicly available sources.

Table 7.2-2: Distribution of Coastal Mangroves in Regions 1 through 6

Region	Area Covered by Mangroves (hectares)	Percentage of Area of All Mangroves in Mangrove Study Area
Region 1	43,170	80.1
Region 2	5,242	9.7
Region 3	1,055	2.0
Region 4	380	0.7
Region 5	1,841	3.4
Region 6	2,215	4.1
TOTAL	53,904	100

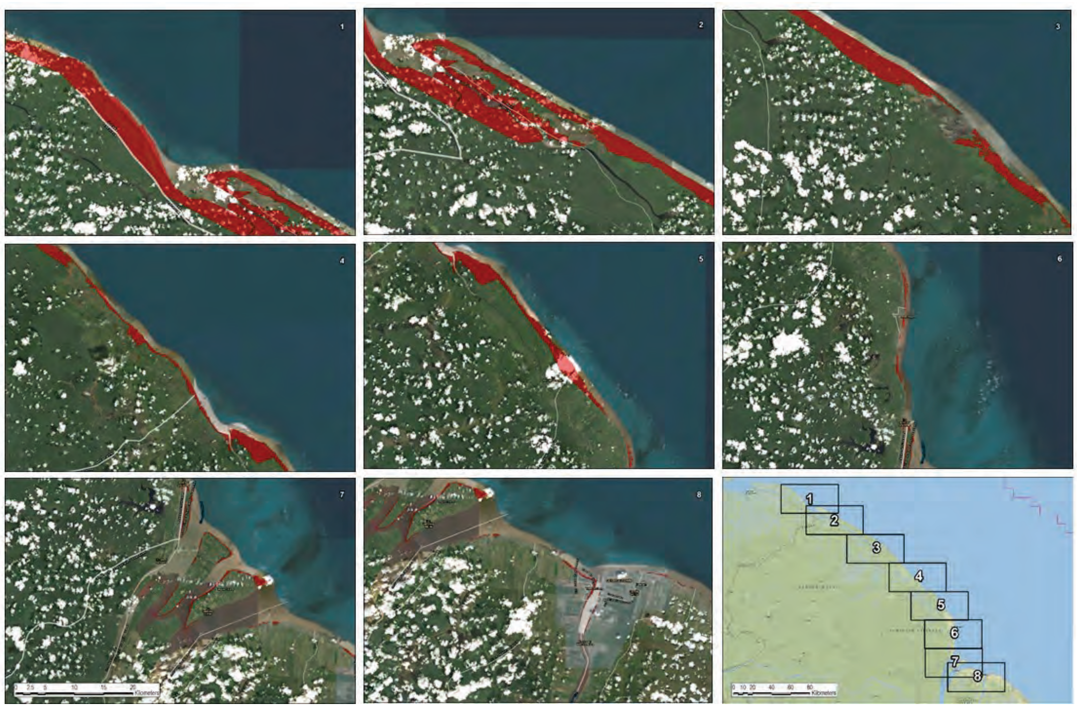


Figure 7.2-2: Guyana's Coastal Mangrove Distribution (Georgetown west to Venezuelan Border, Red Shading Indicates Mangroves)

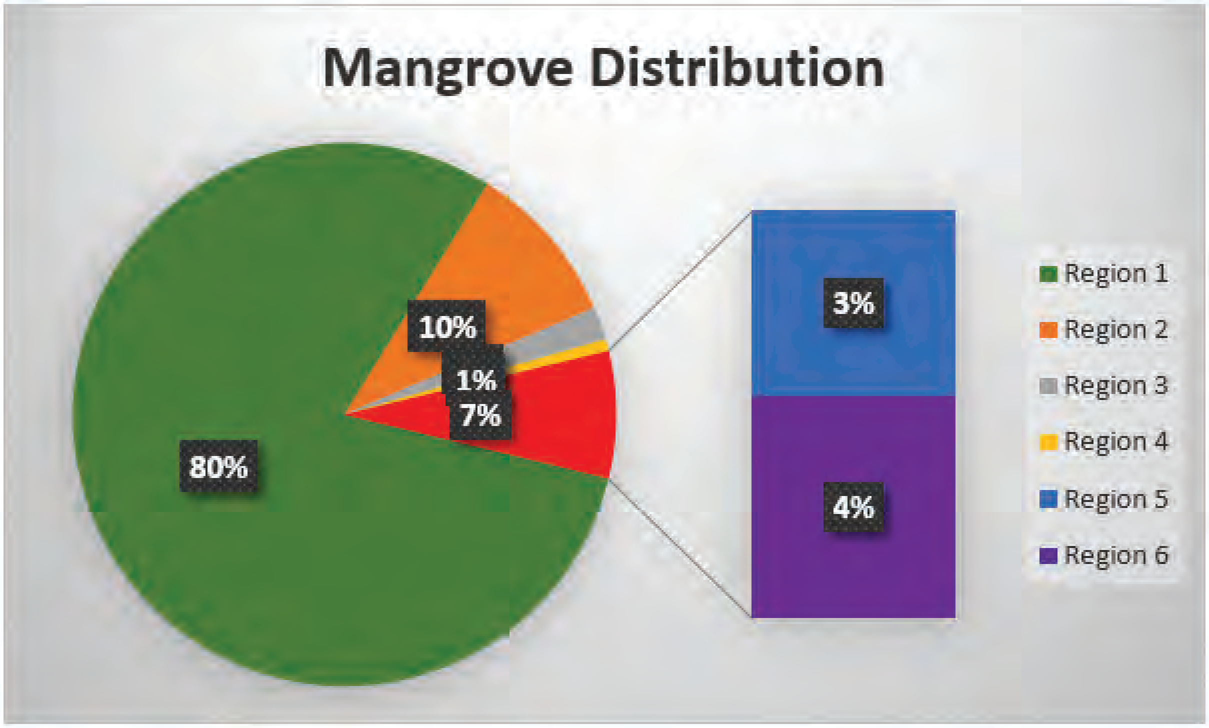


Figure 7.2-3. Distribution of Mangroves in Regions 1-6

This study classified mangroves in one of five categories of "sensitivity"[2] based on a combination of relative biomass, mangrove age, and stability (whether it was eroding, stable, or expanding). Table 7.2-3 and Figure 7.2-4 summarize the results of the mangrove sensitivity assessment in Regions 1 through 6. Figure 7.2-5 is a mosaic of photographs taken during the field verification process showing examples of the five ratings of mangrove sensitivity.

Table 7.2-3: Mangrove Sensitivity Classifications for Regions 1 through 6

Sensitivity Rating	Total Area for Sensitivity Rating (hectares)	Percentage of Area of All Mangroves in Mangrove Study Area
Critical Sensitivity	6,478	12.0
Very High Sensitivity	312	0.6
High Sensitivity	26,122	48.5
Medium Sensitivity	20,000	37.1
Low Sensitivity	992	1.8
TOTAL	53,904	

[2] The study was conducted in the context of mapping coastal "sensitivities" but with respect to mangroves, the "sensitivity" classification was equivalent to ecological value of the mangroves.

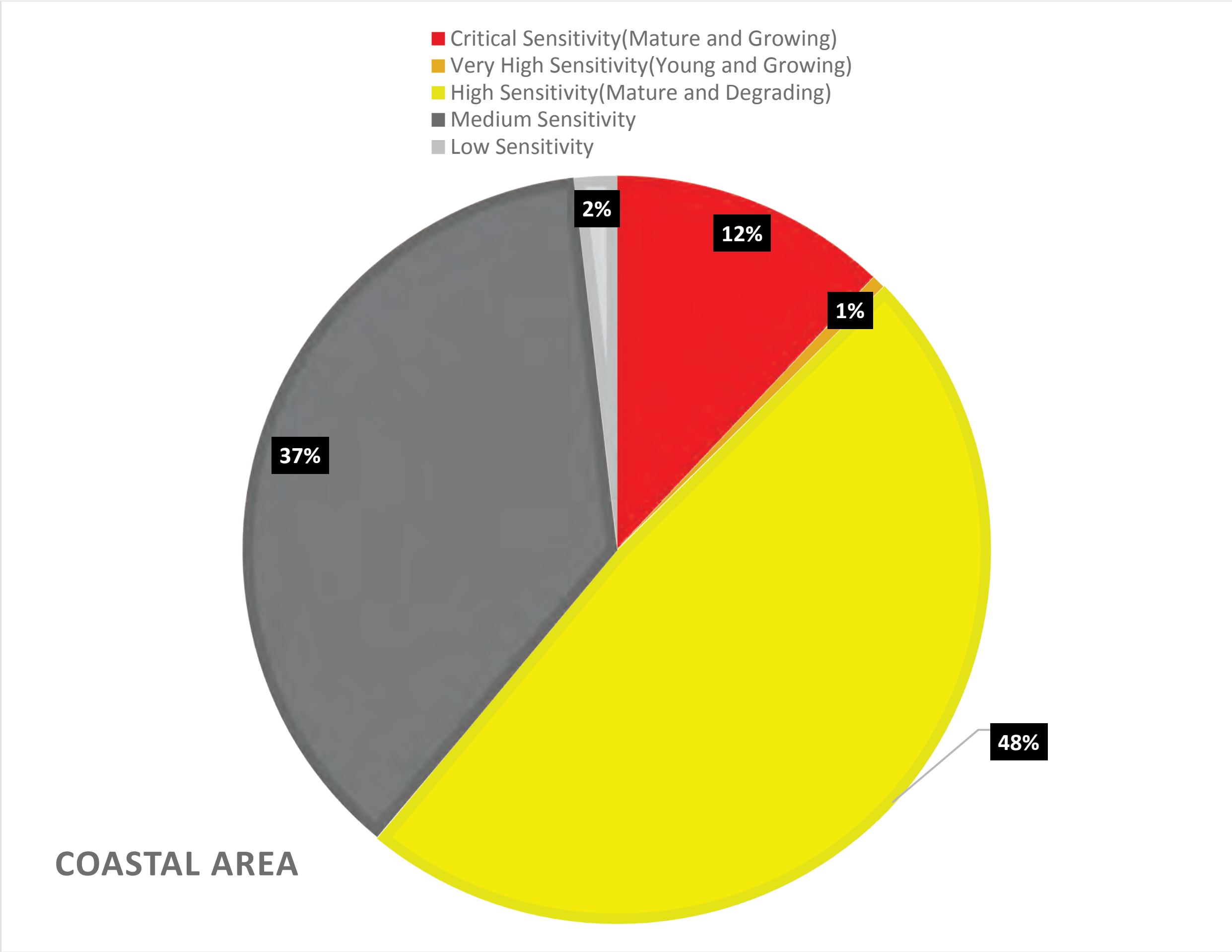


Figure 7.2-4. Sensitivity Ratings for Coastal Mangroves in Regions 1-6

Sensitivity Class	Representative Photograph
Critical	
Very High	

Sensitivity Class	Representative Photograph
High	
Medium	

Sensitivity Class	Representative Photograph
Low	

Source: ERM 2018

Figure 7.2-5: Examples of the Five Ratings of Mangrove Sensitivity

There are currently three species of mangrove in Guyana: red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), and white mangrove (*Laguncularia racemosa*). Mangroves in Guyana have a unique distribution pattern that is different from the norm in most other countries. The National Agricultural Research and Extension Institute (NAREI 2014) noted that in Guyana black mangroves typically colonize the coastal shorelines, while red mangroves establish further inland along the rivers. There is some overlap in the typical distribution of these species elsewhere, but in general the pattern in other countries is for red mangroves to establish along the shoreline, black mangroves to establish farther inland, and white mangroves to establish the farthest inland.

Like most coastal habitats, mangroves are dynamic habitats that are capable of rapid changes over time. As part of the coastal sensitivity verification study, the Consultants analyzed historical imagery to identify areas where mangroves have been lost along the coast. The analysis documented the loss of approximately 1,460 hectares (approximately 3,608 acres) of mangroves since 1980, based on comparison of imagery from 1980 against imagery from 2017. This represents a loss equivalent to 3 percent of the total estimated coastal mangrove coverage over a period of less than three decades.

Mangrove ecosystems are known to be among the most productive ecosystems in the world (Mann 1982), serving major habitats while providing shelter and feeding sites for many faunal species (Mestre et al. 2007). Coastal mangroves have been identified by numerous national and international stakeholders as vital to Guyana's biodiversity, physical security, and economy (WWF 2016; GMRP 2010; Ilieva undated). Many invertebrate inhabitants of mangrove ecosystems in Guyana live either on or in close proximity to mangrove roots and substrates and include snails, barnacles, tunicates, mollusks, polychaete worms, oligochaete worms, shrimp, crabs, sponges, jellyfish, amphipods, and isopods. These small organisms provide forage for birds, mammals, reptiles, amphibians, and fish. Herons, egrets, and ibises are the most conspicuous group of bird species found in mangroves, due to the abundant food sources in a relatively safe habitat (Da Silva 2014).

7.2.2.2. Beaches

Guyana has relatively few beaches and the largest expanse of beaches in the country lies within the SBPA. The SBPA beaches are critically important nesting habitats for marine turtles. They also provide habitat used by a variety of avian, herpetofauna, and mammalian species (see Figure 7.1-2 for the locations of beaches in the SBPA).

7.2.2.3. Mudbanks and Mudflats

See Section 6.3.2, Existing Conditions—Marine Geology and Sediments, for the description of the physical attributes and location of Guyana's mudbanks. "Mudbanks" generally refer to the submerged mud features below the low tide line as distinct from the intertidal mud "flats." No targeted biological surveys of Guyana' mudbanks have been conducted to date, but coastal mud bank habitats typically support burrowing invertebrates, such as marine worms, mollusks, crustaceans, amphipods, and copepods. This invertebrate community provides important forage for bottom-feeding fishes such as grunts, catfishes, and snappers (particularly during their early life stages).

Coastal mudflats, also referred to as tidal flats, are habitats along Guyana's coastline that have been formed by the deposition of mud as a result of tides. Mudflats occur within the intertidal zone so they are submerged under water and exposed twice daily with the tides. Mudflats are usually barren (without any vegetation) and the mud can range from very soft (almost liquid form) to highly compact. Mudflats protect inland landforms from erosion and they are a highly productive and important ecosystem. Mudflats are often associated with coastal mangroves and salt marshes and these areas together constitute an ecologically important ecosystem for fish and invertebrates, which provide an essential food base for birds, particularly migratory shorebirds that stop-over in Guyana during their bi-annual northward and southward migrations. Each year during spring and fall migration, hundreds (and sometimes thousands) of individual birds stop to feed in Guyana's most extensive mudflats located at Exmouth seaside, Walton Hall seaside, Anna Regina seaside, Ogle seashore, Enmore seaside, Maida seaside and Bush-Lot seaside (see Figure 7.2-6). These mudflats (some with adjacent mangrove habitats) can be termed as Important Bird Habitat (IBH) sites due to their importance for migratory shorebirds and resident coastal birds.

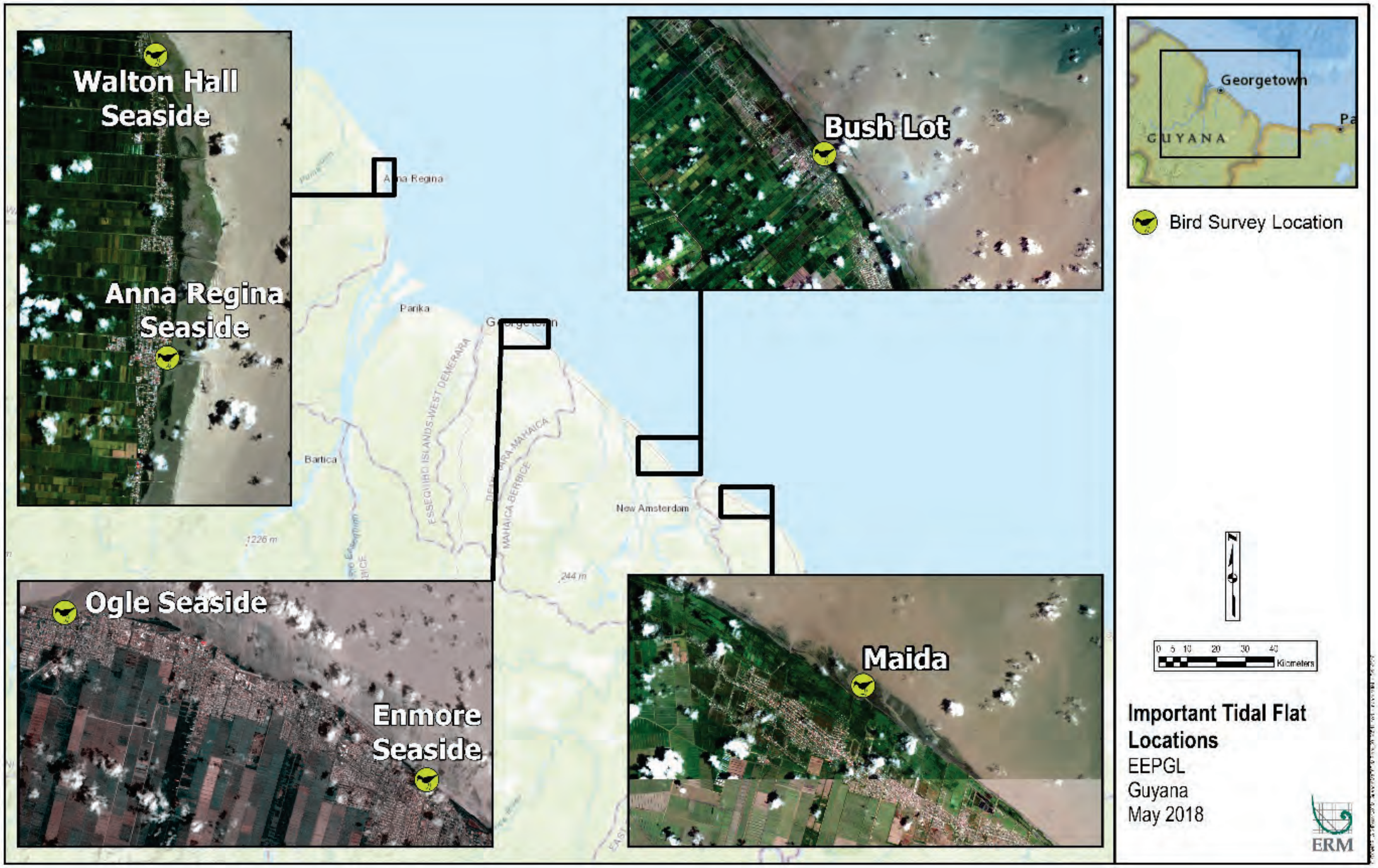


Figure 7.2-6: Guyana's Tidal Flat Distribution

Sandflats are another coastal habitat type that occurs in the intertidal zone. Sandflats are similar to mudflats except they are composed of sand rather than mud. When mud accretes on sandflats, a rapid change in the physical structure of the sandflat can occur. Compaction of the sand and mud over time facilitates rapid growth of vegetation, with complete vegetation coverage of the sandflat in potentially less than one year. For example, Affiance seashore in Region 2 changed from an unvegetated sandflat in August 2017 to a fully vegetated sandflat in April 2018. Vegetated sandflats are ecologically important habitats because they provide food for marine turtles and attract juvenile fish and invertebrates, which are important food sources for birds.

Figure 7.2-7: Mudflat at Bushlot Seaside—Important Bird Habitat

Figure 7.2-8: Wading Birds and Shorebirds Feeding on Mudflat Habitat at the Exmouth Seaside Important Bird Habitat, April 2018

7.2.3. Impact Assessment—Coastal Habitats

The planned Project activities and associated air emissions, effluent discharges, and sound generation, which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not impact any coastal habitats. Operation of the existing Guyana shorebase(s) on the east side of the Demerara River will have little to no impact on coastal habitat. Additional onshore facilities may be utilized by other companies. Any additional onshore facilities will be owned/operated by others and will not be dedicated to the Project. Should any new or expanded shorebase(s) or onshore support facilities be utilized, the construction/expansion and any required dredging of such facilities, as well as the associated environmental authorization, would be the responsibility of the owner/operator, and such work scope is therefore not included in the scope of the Project EIA.

The Project's only potential impact on coastal habitats would be as a result of an unplanned event, which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.2.4. Mitigation Measures—Coastal Habitats

As the planned activities of the Project are not anticipated to impact any coastal habitats, no mitigation measures are proposed. Mitigation measures to address potential impacts on coastal habitats from an unplanned event are discussed in Chapter 9.

7.3. COASTAL WILDLIFE

7.3.1. Administrative Framework—Coastal Wildlife

Table 7.3-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on coastal wildlife and shorebirds.

Table 7.3-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Coastal Wildlife

Title	Objective	Relevance to the Project
Legislation		
Wild Birds Protection Act, 1987	Protects listed wild birds in Guyana.	Sections 3 and 6 prohibit knowingly wounding or killing wild birds listed in the First and Second Schedule of the Act, and establishes penalties.
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Bill Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.

7.3.2. Environmental Conditions—Coastal Wildlife

Guyana occupies the west-central portion of the Guianan mangrove ecoregion, which extends from southeastern Venezuela southeast to French Guiana between the Orinoco River Deltas and the Oyapok River Delta in French Guiana. The ecoregion is a bio-geographical, rather than geopolitical, region and was designated as a distinct ecoregion by the World Wildlife Fund as part of their Terrestrial Ecosystems of the World project (Olsen et al. 2001). Despite supporting over 90 percent of the country's human population, Guyana's coastal region supports a diverse fauna. This section briefly describes bird, mammal, and herpetofauna (reptile and amphibian) species that are representative of Guyana's coastal region.

The planned Project activities will not impact any coastal wildlife. The Project will not involve any direct disturbance of these species and their habitats, and the Project's air emissions, water discharges, and sound generation, which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not impact these species. The use of the Guyana shorebase(s) will have little to no impact on coastal wildlife species, other than common generalist species that are adapted to living in developed areas. The shorebase(s) are expected to be located in existing developed areas. The Project's only potential impact on coastal wildlife would be as a result of an unplanned event, which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.3.2.1. Coastal Mammals and Herpetofauna

Numerous mammal and herpetofauna species occur in Guyana's coastal mangroves, agricultural areas, and forests. There are over 50 species of mammals present, including opossums; bats; primates such as capuchin monkey (*Cebus apella*), squirrel monkey (*Saimira sciureus*), howler monkey (*Alouatta seniculus*) and Guianan saki (*Pithecia pithecia*); giant anteater (*Myrmecophaga triactyla*); several species of cats including jaguar (*Panthera onca*), puma (*Puma concolor*), and ocelot (*Leopardus pardalis*); ungulates and rodents including the capybara (*Hydrochaeris hydrochaeris*), paca (*Agouti paca)*, red-rumped agouti (*Dasyprocta leporina*); red and grey brocket deer (*Mazama* sp.); the giant river otter (*Pteronura brasiliensis*), which is a freshwater species; and neotropical otter (*Lontra longicaudi*s), which is found in both freshwater and estuarine habitats. Reptiles that frequent this ecoregion are the green iguana (*Iguana iguana*), spectacled caiman (*Caiman crocodilus)*, and green anaconda (*Eunectes murinus*) (Figure 7.3-1). Amphibians are generally less common along the coast than in the interior, especially due to saline influence in the mangroves, but some of the species that occur along the coast include several species of tree frogs (*Hyla* sp.), the paradoxical frog (*Pseudis paradoxa*), cane toad (*Rhinella marina*), and pipa frog (*Pipa pipa*).

No targeted surveys for mammals or herpertofauna along Guyana's coast have been conducted. Two biodiversity surveys have been undertaken within and around the SBPA over roughly the past decade and these surveys included documentation of 27 mammal and 41 herpetofauna (28 reptile and 13 amphibian species) species, including many of those described above (Mendonca et al. 2006; EPA et al. 2004; see Appendix K, Flora and Fauna of Shell Beach). Incidental observations of mammals documented during EEPGL-commissioned coastal bird surveys in 2017 and 2018 documented some of the species above and also Guianan red howler monkey (*Aloutta macconnelli*), wedge-capped capuchin monkey (*Cebus albifrons*), and Indian grey mongoose (*Herpestes edwardsi*) (Figure 7.3-2).

Photo Credit: Waldyke Prince

Figure 7.3-1: Tricolored Heron (*Egretta tricolor*) Inspecting a Green Anaconda (*Eunectes murinus*) in the Water on Leguan Island, April 2018

Photo credit: Waldyke Prince

Figure 7.3-2: Indian Grey Mongoose (*Herpestes edwardsi)* Observed at Abary Seaside April 2018

7.3.2.2. Coastal Birds

Historical Data

Guyana's coastal bird community is abundant and diverse, with over 200 recorded species within 21 families representing multiple bird groups, including parrots and macaws, passerines, waterfowl, colonial waterbirds, shorebirds, and raptors. The bird groups that are most strongly affiliated with the coast are waterfowl, shorebirds, and colonial waterbirds. Waterfowl are species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese, etc.). Shorebirds are found mainly on beaches and mudflats between the low and high water marks and are typically migratory, utilizing Guyana's coastline during the course of their bi-annual migrations. Colonial waterbirds are birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons, etc.).

Braun et al. developed a comprehensive checklist of the 814 bird species within 11 habitats documented in Guyana (Braun et al. 2007). The coastal habitats surveyed include mangrove forests (47 species documented within 18 families) and mudflats (38 species documented within 8 families) (Braun et al. 2007). Another coastal bird survey conducted along the coast in the Georgetown region by Bayney and Da Silva (2005) documented 32 coastal bird species, 20 of which are migrants. The most abundant species documented in the survey were shorebirds including Least Sandpiper (*Calidris minutilla*), Spotted Sandpiper (*Actitis malcularia*), Ruddy Turnstone (*Arenaria interpres*), and Semipalmated Plover (*Charadrius semipalmatus*). Waterbird species including Cattle Egret (*Bulbulcis ibis*) and Snowy Egret (*Egretta thula*) were also abundant. A more recent bird survey within coastal mangrove habitats in southeast Guyana identified 37 species within 14 families (Da Silva 2014). In this 2014 survey, the most abundant species recorded were the Great Egret (*Ardea alba*), Greater Kiskadee (*Pitangus sulphuratus*), Pied Water Tyrant (*Fluvicola pica*), Rufous Crab-hawk (*Buteogallus aequinoctialis*), and Scarlet Ibis (*Eudocimus ruber*) (Da Silva 2014).

Two biodiversity surveys undertaken within SBPA over roughly the past decade documented over 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats of Shell Beach (Mendonca et al. 2006; EPA et al. 2004) (Appendix K, Flora and Fauna of Shell Beach). Many of the over 200 species documented are migrants, traveling from United States and Canada to spend the winter season in Guyana, primarily following the Atlantic and Central Flyways to South America. The most abundant coastal species recorded at and around Shell Beach during the two surveys included Blackbellied Whistling-duck (*Dendrocyna autumnalis*)[3], Laughing Gull (*Larus atricilla*), Least Tern (*Sterna antillarum*), Spotted Sandpiper, Lesser Yellowlegs (*Tringa flavipes*), Scarlet Ibis, and Yellow-billed Tern (*Sterna superciliaris*) (Mendonca et al. 2006; EPA et al. 2004).

Collectively, species accounts from all these reports document the presence of 95 species of coastal birds from 32 families in Guyana. Another 113 species of non-coastal birds have been documented in inland habitats of the SBPA (Mendonca et al. 2006; EPA et al. 2004). These 113 species occasionally occur in coastal areas as transients, but are not expected to occur there regularly, so are not considered coastal birds.

Coastal Bird Survey Data Collected in 2017 and 2018

EEPGL commissioned a series of coastal bird surveys along the Guyana coast in 2017 and 2018. The following three surveys were conducted by teams of international and Guyanese bird specialists:

- Survey of coastal birds within the Essequibo Islands and along the coast in Regions 4 and 5 from 23-27 September 2017;
- Survey of coastal birds at coastal sites in Regions 2-4 in from 19-22 October 2017; and
- Survey of coastal birds at Essequibo Islands and coastal sites within Regions 1-6 from 3-13 and 16-24 April 2018.

A total of 109 sites were surveyed throughout Regions 1-6 during these three surveys (Figure 7.3-3 and Table 7.3-2). Some sites were not sampled in 2017 because the scope of the surveys in 2017 only included Regions 2 through 4. Also, additional survey sites were added in 2018 in Region 2 and the Essequibo Islands to optimize survey coverage of these areas.

[3] Recorded as a freshwater species in Braun, et al 2007

Figure 7.3-3 Coastal Bird Survey Sites – September 2018 through April 2018

Table 7.3-2 Number of Coastal Bird Sampling Sites by Region for each Sampling Period

Region	September 2017	October 2017	April 2018	Total [a]
1	NS	NS	18	18
2	NS	5	6	6
3 (Coastal)	NS	3	3	3
3 (Essequibo Islands)	32	NS	50	51
4	11	13	13	20
5	6	NS	6	6
6	NS	NS	5	5
Total	49	21	101	109

[a] Total unique sites surveyed from the three surveys conducted between September 2017 and April 2018
NS = not sampled

The 2017 and 2018 coastal bird surveys (all island and coastal sites combined) documented a total of 227 species and 23,543 birds. Coastal sites documented 123 species and island sites documented 148 species, with 44 species found at both coastal and island sites. Of these 227 species, 71 were added during the 2018 surveys. The *Coastal Bird Study Report* (ERM 2018) lists the birds observed during the 2017 and 2018 surveys (Regions 1-4 only). All of the species documented during the 2017 and 2018 surveys have been previously recorded in Guyana, although this survey documented many species in the coastal region where they were previously undocumented. This is likely due to the lack of any comprehensive survey of coastal birds along the Guyana coast prior to this survey. Further, while this survey documented many more species than previously recorded in Guyana's coastal habitats (227 versus 208), 39 species previously known to occur along the Guyana coast, based on historical records, were not documented during the 2017 and 2018 surveys, indicating that the coastal bird community has even higher bird species richness (number of species) than documented in the 2017 and 2018 survey, as well as high variability across surveys, regions, and years. The most common shorebirds observed during the 2017 and 2018 surveys were Semipalmated Sandpiper (*Calidris pusilla*), White-rumped Sandpiper (*Calidris fuscicollis*), Lesser Yellowlegs, Sanderling (*Calidris alba*), and Ruddy Turnstone. The most common colonial waterbirds were Snowy Egret, Cattle Egret (Figure 7.3-4), Little Blue Heron (*Egretta caerulea*), Scarlet Ibis (Figure 7.3-5), Semipalmated Plover (Figure 7.3-6), and Tricolored Heron (*Egretta tricolor*). Bird diversity and abundance at the survey points were highly variable and influenced primarily by time of day (for forest birds) and tidal stage (for shorebirds). Fourteen species of migratory shorebirds (Charadriidae and Scolopacidae) were documented during the 2017 and 2018 surveys

Photo credit: Waldyke Prince

Figure 7.3-4: Cattle Egrets (*Bubulcus ibis*) on the Shoreline of Wakenaam Island, April 2018

Photo credit: Waldyke Prince

Figure 7.3-5: Scarlet Ibis (*Eudocimus ruber*) Roosting in the Mangroves near the Mahaica River in Region 4, October 2017

Photo credit: Waldyke Prince

Figure 7.3-6: Semipalmated Plovers (*Charadrius semipalmatus*) at Kingston Seaside in Region 4, October 2017

The coastal habitat types that were surveyed included mangrove (riverine and coastal), mudflats, and sandy beaches. Riverine mangrove sites had the highest average species richness (number of species) per site (24 species) followed by mudflats (17 species). Mudflats had the highest average bird abundance per site (260 birds) followed by riverine mangrove (101 birds).

Survey effort varied by region. However, based on the data collected, Region 4 had the greatest total abundance (number of birds observed) (6,527) followed by Region 2 (3,734) and Region 1 (2,739) (Table 7.3-3; Figure 7.3-7). When comparing the coastal bird communities across the six coastal regions, the regions with the greatest species richness (Table 7.3-3, Figure 7.3-8) were Region 1 (148 species) and Region 3 (Essequibo Island Sites) (104 species).

Regions 2 and 5 had the greatest average (per site) abundance, followed by Region 4 (Table 7.3-4; Figure 7.3-9). Region 1 had the highest average (per site) species richness (Table 7.3-4 and Figure 7.3-10), followed by Region 3 (coastal sites).

The higher total and average (per site) species richness in Region 1 were at least in part due to the survey effort in this region, which included more inland habitats than the other regions and the presence of a greater diversity of habitats being available (i.e., coastal and riverine mangroves, coastal wetlands, and riverine forests, which are not present in all regions).

Table 7.3-3: Total Species Richness and Abundance per Survey Event and Region

	Region 1	Region 2		Region 3 (Coastal)		Region 3 (Islands)		Region 4			Region 5		Region 6
	Apr-18	**Oct-17**	**Apr-18**	**Oct-17**	**Apr-18**	**Sep-17**	**Apr-18**	**Sep-17**	**Oct-17**	**Apr-18**	**Sep-17**	**Apr-18**	**Apr-18**
Total Species Richness	148	41	46	42	21	85	56	62	70	63	55	48	38
Total Abundance	2,739	1,981	1,753	122	62	1,364	1,368	2,182	2,179	2,166	1,082	4,729	1,816

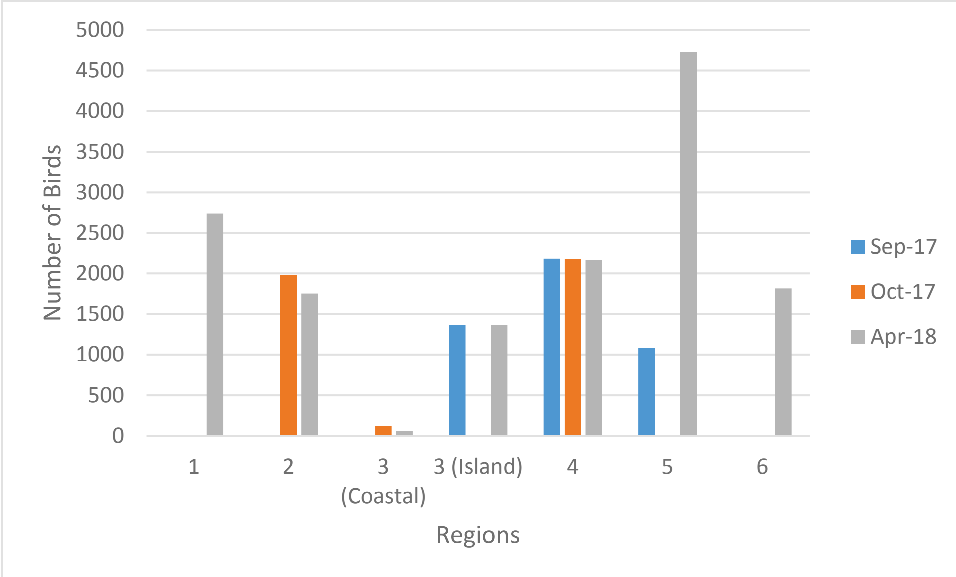


Figure 7.3-7: Total Species Abundance per Region

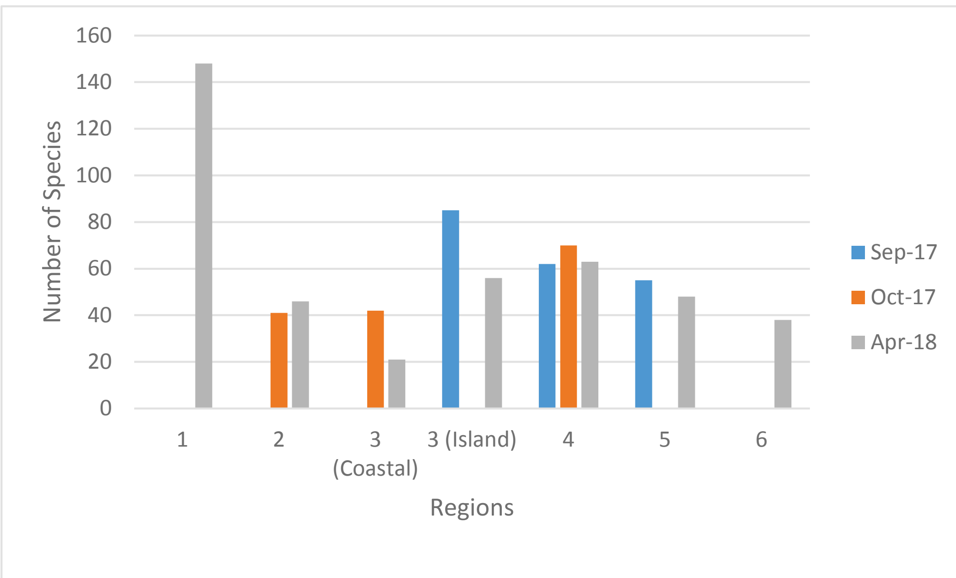
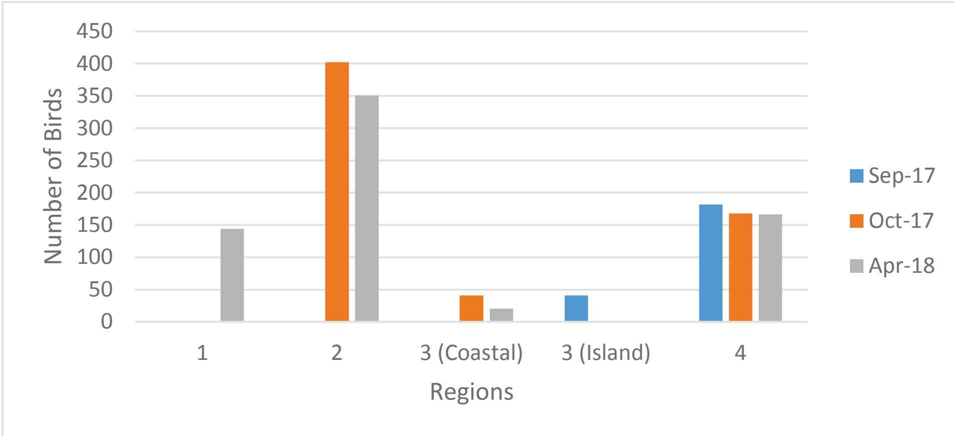


Figure 7.3-8: Total Species Richness per Region

Table 7.3-4: Average (Per-Site) Species Richness and Abundance per Survey Event and Region

	Region 1	Region 2		Region 3 (Coastal)		Region 3 (Islands)		Region 4			Region 5		Region 6
	Apr-18	**Oct-17**	**Apr-18**	**Oct**	**Apr-18**	**Sep-17**	**Apr-18**	**Sep-17**	**Oct-18**	**Apr-18**	**Sep-17**	**Apr-18**	**Apr-18**
Average Species Richness	23	19	19	20	12	10	NA [a]	17	16	13	18	15	13
Average Abundance	144	402	351	41	21	41	NA [a]	182	168	167	180	946	363

[a] Data for 2018 island surveys was not provided by survey point but rather by island sites as a group.



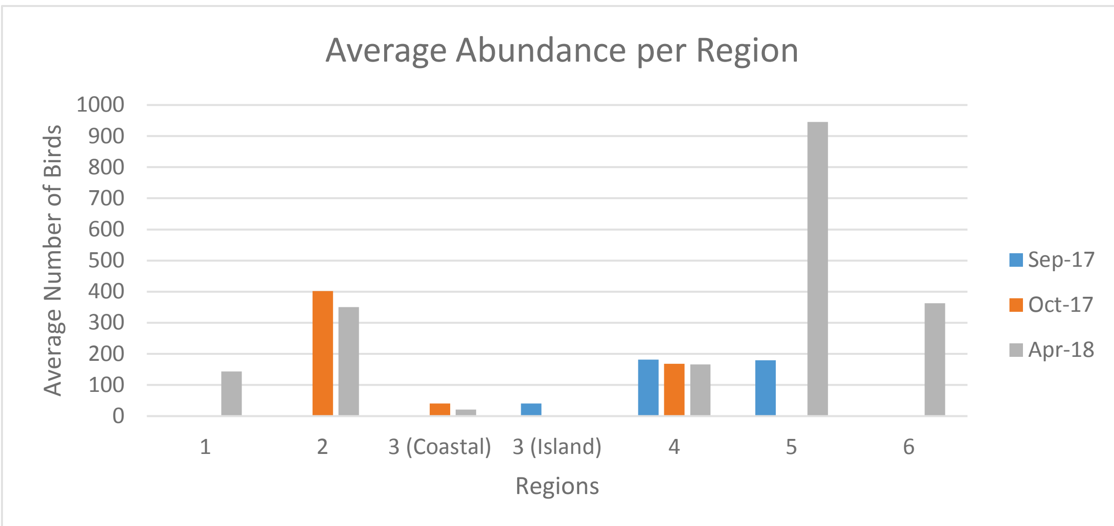


Figure 7.3-9: Average (Per Site) Species Abundance per Region

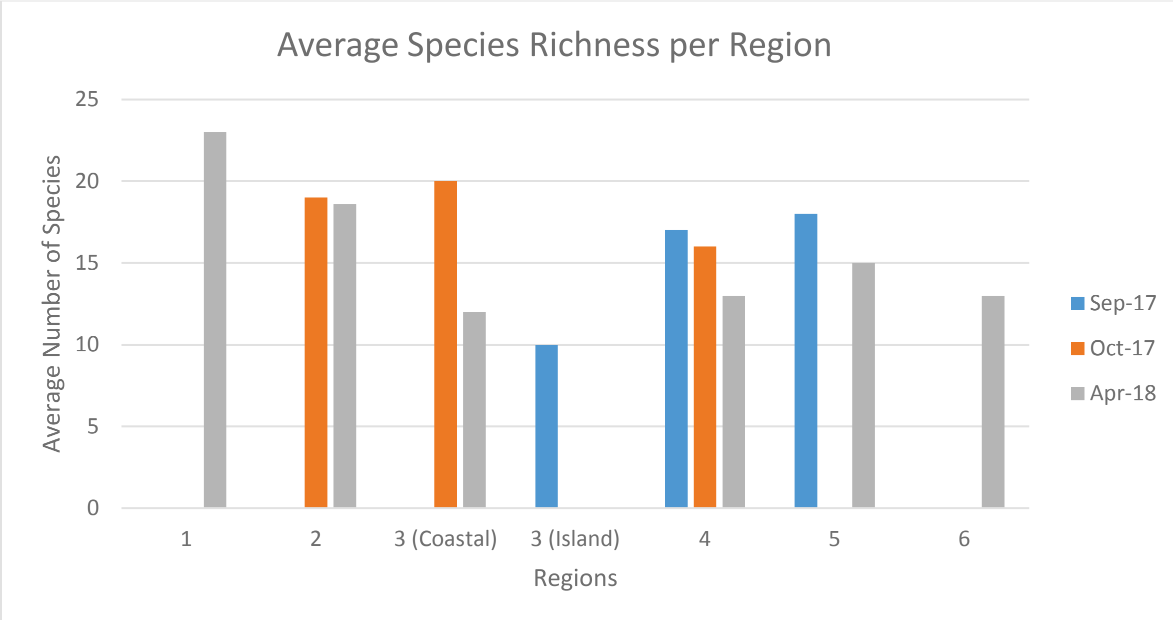


Figure 7.3-10: Average (Per Site) Species Richness per Region

7.3.2.3. Important Bird Habitats for Coastal Birds

BirdLife International (2016) has designated several Important Bird Areas (IBAs) in the neighboring countries of Suriname, Trinidad and Tobago, and Venezuela. These IBAs provide foraging, breeding, and nesting habitats similar to those found along Guyana's coastline. However, no IBAs have been designated in Guyana. However, several areas along the Guyana coastline meet the definition of a 'threshold site' by BirdsCaribbean (www.birdscaribbean.org) due to large numbers of individuals (criteria for threshold site is more than 3,000 individuals) that predictably occur there during migration (ERM Personal Communication 27).

Based on the data obtained during the coastal bird survey data collected during EEPGL-commissioned coastal bird surveys in 2017 and 2018 (ERM 2018), other available data collected as part of other historical or ongoing surveys (including information on the threshold sites), and knowledge of the local bird specialists involved in this survey, 14 coastal IBH sites were identified within Regions 1-6. These IBH sites support one or more of the following: (1) predictable congregations of migratory shorebirds, including threshold sites; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest. Figure 7.3-11 shows an example of birds observed at one of the IBH sites. Table 7.3-5 summarizes information for each of the 14 IBH sites identified in Regions 1-6. Figure 7.3-12 shows the locations of the 14 IBH sites.

Photo credit: Waldyke Prince

Figure 7.3-11: Wading Birds and Shorebirds Feeding on Mudflat Habitat at the Exmouth Seaside Important Bird Habitat, April 2018

Table 7.3-5: Important Bird Habitats Identified in Regions 1–6

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Shell Beach Protected Area	1	Sandy beach, mudflat, mangrove	SBPA contains critically important nesting and foraging habitats for over 200 species of waterbirds and land birds, including several globally threatened species.	
Pomeroon River Mouth	1	Mudflat, mangrove	Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds. Thousands of wading birds roost in the mangroves in this area.	

Important Bird Habitat	**Region**	**Primary Bird Habitat**	**Rationale for Designation as Important Bird Habitat**	**Photograph**
Kamwatta Beach, Iron Punt Beach, and Luri Beach	1	Sandy beach, mudflat, mangrove	These beaches host hundreds of Flamingos (multiple species) and thousands of other colonial waterbirds (ERM Personal Communication 28) for nesting and feeding. The photo depicts Luri Creek, which is located just inland from Luri Beach and is the location of the colonial waterbird roosting and nesting site.	
Waini River Mouth (west bank)	1	Mangrove	Pristine mangrove forest supporting large congregations of colonially roosting and nesting wading birds (herons, egrets, ibis, etc.).	
Exmouth Seaside	2	Mudflat	*Extensive tidal mudflat that is an important congregation and foraging site for shorebirds and wading birds, including over 3,000 shorebirds (Calidris sp) at a time, qualifying it as a Threshold Site[4] during the migratory season.*	

[4] BirdLife International's definition of a Threshold Site for migratory birds is one that is known or thought to hold congregations of ≥1 percent of the global population of one or more species (including species group or family) on a regular or predictable basis (BirdLife International 2011).

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Walton Hall Seaside	2	Mudflats and mangrove	Tidal mudflats and mangroves supporting large congregations of shorebirds and wading birds.	
Essequibo Island Complex	3	Mangrove	Unique transition zone between riverine forest and mangrove ecosystems that provides important roosting and nesting habitat for riverine birds and wading birds.	

Important Bird Habitat	**Region**	**Primary Bird Habitat**	**Rationale for Designation as Important Bird Habitat**	**Photograph**
Ogle Seaside	4	Mudflat	*Extensive mudflat that is heavily populated with foraging shorebirds (over 3,000 individuals at a time, qualifying it as a Threshold Site for Calidris sp) during the migratory season.*	
Triumph-BV Seaside	4	Mudflat and mangrove	Extensive mudflat and natural revegetation of mangroves that supports large numbers of migratory shorebirds and waterbirds and is also considered very important as a nesting site for Snail Kite.	

Important Bird Habitat	**Region**	**Primary Bird Habitat**	**Rationale for Designation as Important Bird Habitat**	**Photograph**
Enmore Seaside	4	Mudflat and mangrove	Tidal mudflats and mangroves that host large congregations of shorebirds and wading birds, and serve as nesting site for Snail Kite and other mangrove-dependent species including conebills.	
Hope Beach Seaside	4	Vegetated sand flat	*Fine sand flats overlain with compact mud at low tide that host large congregations of shorebirds and wading birds (including Scarlet Ibis [Eudocimus ruber]) and mangroves that support large numbers of nesting and roosting wading birds*	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Victoria Seaside	4	Mangrove and brackish marsh	Extensive mangrove and brackish marsh along the shoreline and inland that provides important roosting and breeding site for shorebirds and waterbirds, particularly Scarlet Ibis and mangrove-dependent species	
Bush Lot Seaside	5	Mudflat and mangrove	*Extensive mudflats used by thousands of shorebirds during migration (threshold site for Calidris sp.) and waterbirds throughout the year*	

Important Bird Habitat	Region	Primary Bird Habitat	Rationale for Designation as Important Bird Habitat	Photograph
Mangroves between Maida and Philippe	6	Mangrove	Important roosting and breeding area for thousands of colonial waterbirds	

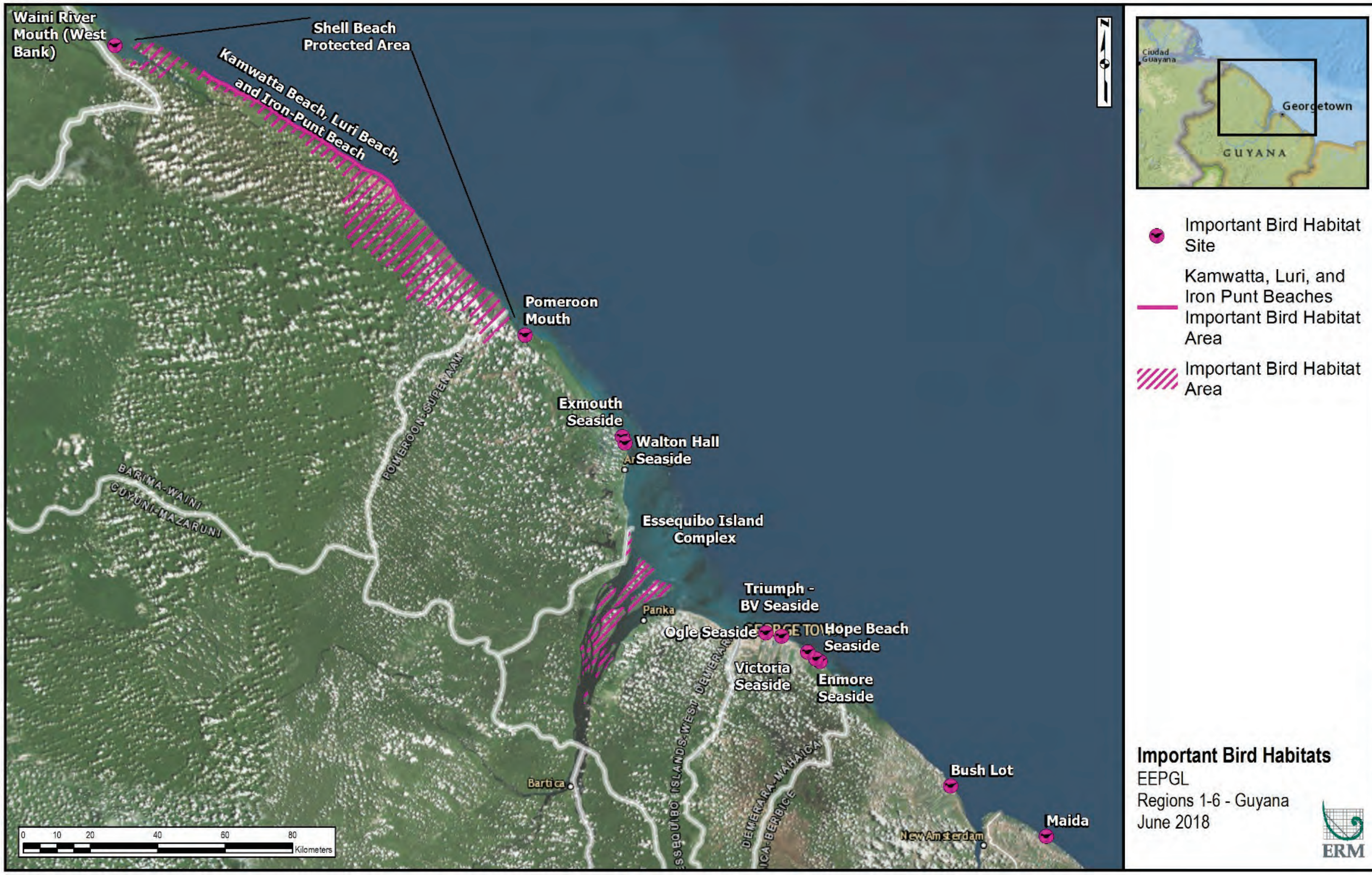


Figure 7.3-12: Locations of Important Bird Habitats Regions 1-6

7.3.2.4. Conservation Status of Guyana Coastal Wildlife Species

Of the coastal wildlife species known to occur in coastal Guyana based on historical data and the 2017/2018 survey records, most are currently listed on the IUCN Red List as Least Concern (LC), which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation (IUCN 2018) (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species). Eight of the wildlife species known to occur in coastal Guyana have elevated conservation status, as they are classified as Vulnerable (VU), Near Threatened, (NT), or Endangered (EN) as per the IUCN Red List (Table 7.3-6). These species include two mammal species and six bird species (Figures 7.3-13 and 7.3-14).

Table 7.3-6. Coastal Wildlife Species with Elevated Conservation Status Known to Occur in Coastal Guyana[5]

Species	Common Name	IUCN Red List Status
Pteronura brasiliensis	Giant otter	EN
Lontra longicaudis	Neotropical otter	NT
Agamia agami	Agami Heron	VU
Buteogallus aequinoctialis	Rufous Crab-hawk	NT
Calidris pusilla	Semipalmated Sandpiper	NT
Conirostrum bicolor	Bicolored Conebill	NT
Harpia harpyja	Harpy Eagle	NT
Morphnus guianensis	Crested Eagle	NT

[5] Excludes marine mammals and marine turtles, which are discussed in Sections 7.5 and 7.6

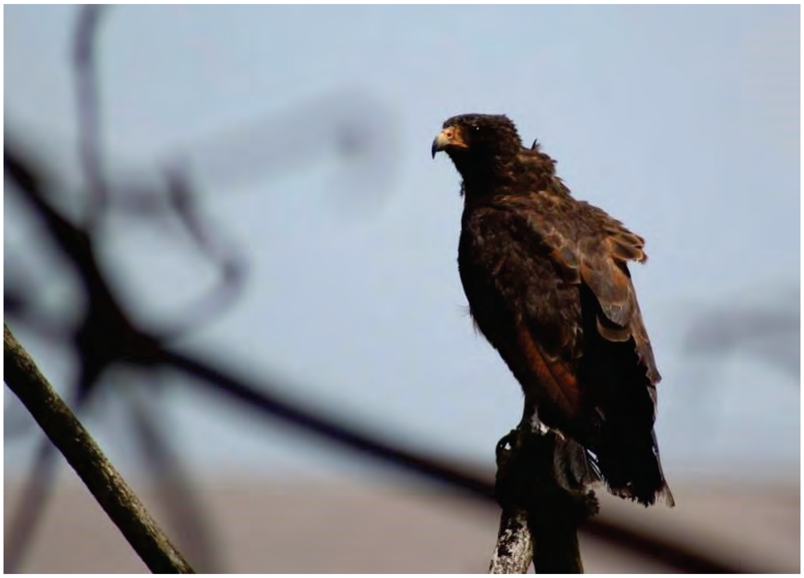


Photo Credit: Waldyke Prince

Figure 7.3-13: Rufous Crab-Hawk (*Buteogallus aequinoctialis*), a Non-Migrant Coastal Endemic Species that Occurs in Mangroves and Other Wetland Areas, Observed at Ruimzeight Seaside in 2017

Photo credit: Waldyke Prince

Figure 7.3-14: Immature Harpy Eagle (*Harpia harpyja*), a Non-Migrant Lowland Forest Species, Observed during Coastal Bird Surveys in Region 1 in April 2018

7.3.3. Impact Assessment—Coastal Wildlife

The planned Project activities will not impact any coastal wildlife. The Project will not involve any direct disturbance of these species and their habitats, and the Project's air emissions, water discharges, and sound generation, which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not impact these species. The use of the Guyana shorebase(s) will have little to no impact on coastal wildlife species, other than common generalist species that are adapted to living in developed areas. The shorebase(s) are expected to be located in existing developed areas. The Project's only potential impact on coastal wildlife would be as a result of an unplanned event, which is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

7.4. SEABIRDS

7.4.1. Administrative Framework—Seabirds

Table 7.4-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on seabirds.

Table 7.4-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Seabirds

Title	**Objective**	**Relevance to the Project**
Legislation		
Wild Birds Protection Act, 1987	Protects listed wild birds in Guyana.	Sections 3 and 6 prohibit knowingly wounding or killing wild birds listed in the First and Second Schedule of the Act, and establishes penalties.
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.4.2. Existing Conditions—Seabirds

7.4.2.1. Background

Seabirds are birds that spend extensive time in nearshore and/or offshore marine environments away from land, except when they are nesting. Types or groups of seabirds more prevalent in this region include albatrosses, petrels, shearwaters, storm-petrels, skuas, jaegers, tropicbirds, boobies, gulls, terns, and some species of phalaropes.

Birds in the Stabroek Block typically fit one or more of three characterizations: (1) birds that spend extensive time in waters of the Caribbean away from land or other structures (seabirds); (2) birds engaged in seasonal, usually latitudinal, migrations through the area (migratory birds or resident birds making seasonal movements between breeding and foraging sites); and (3) birds that have wandered outside their normal ranges, including birds affected by severe weather events including seasonal storms. The focus of this section is on seabirds, since they are the dominant bird type to occur in the Stabroek Block and they spend the most time of any birds within offshore Guyana.

Seabirds feed on fish and other marine organisms that concentrate on or near the surface of the water, either by surface feeding (from flight or swimming) or by diving. As such, the presence and availability of seabird prey in a given area, which is strongly influenced by the ocean's currents, is a major determinant in the occurrence of seabirds. Further, water clarity can impact a seabird's foraging success and some studies have suggested that seabirds in the Caribbean prefer areas with clear water where they can more easily see their prey (Schreiber 2001).

Seabirds in the PDA area are likely to be transients, moving opportunistically with schools of fish, oceanic arthropods, plankton, and other prey. The marine environment within the PDA is heavily influenced by the Guiana Current, which is a strong surface current that directs surface flows northwestward, drawing water from near Africa and feeding the Gulf Stream across the northern Caribbean. No slower moving or circular currents or areas of upwelling that could concentrate marine biota are known to occur in the PDA (see Section 6.4.2.1, Oceanographic Conditions). Further, no islands or near-surface submarine ridges that would be an attractant to foraging seabirds occur in the PDA. While a variety of fish occur in the PDA, including schooling fish such as tuna and mahi-mahi, and flying fish (Exocoetidae), which are an important prey for both, no evidence suggests that large concentrations of fish consistently occur in the PDA to the extent that they would promote regular use by foraging seabirds. The turbid conditions in the Stabroek Block further reduce the likelihood that the area has significant importance for foraging seabirds.

Hundreds of bird species have populations that migrate between North America and South America, most of which nest in the north and reside in the southern range until the next nesting season. Many of these birds fly over the Caribbean, and in some cases the Stabroek Block, during migrations. Although migration routes are well-defined for some bird species, the routes and timing of migration can vary markedly depending on climate and storms (McGrady et al. 2006).

7.4.2.2. Historical Data

Twenty-two species of seabirds are known to breed in the Caribbean and dozens more occur as migrants through the region. Seabird data specific to Guyana are extremely limited and no comprehensive survey of seabirds has ever been conducted in Guyana (BirdLife International 2016a). The authoritative, historical list for bird species present in Guyana, published by the Smithsonian Institution, lists 25 seabird species (Braun et al. 2007). Birdlife International lists 21 species of seabirds for Guyana (BirdLife International 2016a). The eBird-arbitrated observation list[6] for offshore Guyana contains 25 seabird species (eBird 2018). Combining all of these sources, a total of 28 seabird species are reported to occur in Guyana (Table 7.4-2).

This number is consistent with that of other countries in the region. For example, 32 and 29 species of seabirds are documented in Trinidad and Tobago and in Venezuela, respectively (BirdLife International 2016a). Any of the species could occur in the PDA at some time during the year (specific timing of occurrence is dependent on the species and environmental conditions).

Based on eBird reporting, an additional 29 species of seabirds are known to inhabit the southern Caribbean but have not been reported in Guyana (eBird 2018). These species could also occur in Guyanese offshore waters. Thus, the number of species that occur offshore Guyana is likely higher than reported in Table 7.4-2.

Table 7.4-2: Seabird Species Known to Occur in Guyana Based on Historical Data

Common Name	**Scientific Name**
Great Shearwater [a, b]	*Ardenna gravis*
Cory's Shearwater [a]	*Calonectris borealis*
Barolo Shearwater [d]	*Buffinus baroli*
Audubon's Shearwater [a, b]	*Puffinus lherminieri*
Wilson's Storm-Petrel [a, b]	*Oceanites oceanicus*
Leach's Storm-Petrel [a, b]	*Oceanodroma leucorhoa*
Brown Pelican [a, b]	*Pelecanus occidentalis*
Brown Booby [a, b, c]	*Sula leucogaster*
Masked Booby [c]	*Sula dactylatra*
Red-footed Booby [c]	*Sula sula*
Magnificent Frigatebird [a, b, c]	*Fregata magnificens*
White-tailed Tropicbird [c]	*Phaethon lepturus*
Parasitic Jaeger [b, c, d]	*Stercorarius parasiticus*
Pomarine Jaeger [a, b, c]	*Stercorarius pomarinus*
Great Skua [a, b]	*Stercorarius skua*
Lesser Black-backed Gull [c, d]	*Larus fuscus*
Laughing Gull [a, b, c]	*Leucophaeus atricilla*
Brown Noddy [a, c]	*Anous stolidus*
Black Tern [b, c, d]	*Chlidonias niger*
Gull-billed Tern [a, c]	*Gelochelidon nilotica*
Bridled Tern [c]	*Onychoprion anaethetus*
Sooty Tern [a]	*Onychoprion fuscatus*
Black Skimmer [a, c]	*Rhynchops niger*
Roseate Tern [a, c]	*Sterna dougalli*
Common Tern [a, b, c]	*Sterna hirundo*

[6] Country records in eBird are arbitrated by a team of local experts who are nonpaid volunteers managed by eBird. This arbitration process is conducted to ensure data quality and avoid erroneous records. Only the arbitrated country record list is considered scientifically valid.

Common Name	Scientific Name
Royal Tern [b, c, d]	*Sterna maxima*
Arctic Tern [c]	*Sterna paradisaea*
Sandwich Tern [c, d]	*Thalasseus sandvicensis*

[a] Braun et al. 2007
[b] BirdLife International 2016a
[c] eBird 2018
[d] Sight record only (Braun et al. 2007)

7.4.2.3. Seabird Survey Data Within and Near Stabroek Block

EEPGL commissioned a series of bird surveys within the Stabroek Block and in the area between the Stabroek Block and the Guyana coast in 2017 and 2018. The following three surveys were conducted by teams of international and Guyanese bird specialists aboard vessels conducting various types of work between Georgetown and the Starbroek Block or within the Stabroek Block:

- Survey of the area between Georgetown and the Stabroek Block and within Stabroek Block from 30 September through 7 October 2017;
- Survey of nearshore waters (greater than 1 kilometer from shore) between Georgetown and the Stabroek Block from 8 April through 15 April 2018; and
- Survey of the southeastern portion of the Stabroek Block from 9 April through 15 April 2018.

In addition, incidental seabird observations within and *en route* to the Stabroek Block have been recorded during the EEPGL seismic surveys conducted between 2015 and 2018 (RPS 2018).

Of the three survey events, the 9 April through 15 April 2018 survey spent the most time in and near the Stabroek Block; approximately 60 survey hours were conducted in the block during this survey. Table 7.4-3 presents the birds observed during these survey events. Figure 7.4-1 depicts the bird survey route and observations for the April 2018 survey within the Stabroek Block. It should be noted that the clustered appearance of bird records depicted in Figure 7.4-1 is not indicative of bird concentration areas but rather of time spent in those locations. The survey was conducted in conjunction with the EEPGL offshore fish survey, so the vessel movements (and hence the areas most intensively surveyed) were dictated by the fishing activities (e.g., setting and retrieving fishing gear and waiting for gear set times to be met in two fishing locations within the Stabroek Block). The boat moved between these locations at approximately 7 to 10 nautical miles per hour, and once at the fishing locations, its movement was very limited—so most of the bird survey time was at these two locations. In some cases, birds were attracted to the boat or the fishing activities (or both), but most observations of birds were unaffected by surveyor presence (e.g., birds were flying at a distance or overhead), indicating that the bird density and species composition observed during the surveys likely represents normal conditions in the survey area.

Table 7.4-3: Bird Species Observed during EEPGL-Commissioned Bird Surveys Conducted in 2017 and 2018

Common Name *Species Name*	**30 September–7 October 2017** **> 1 km Offshore**	**9 April–15 April 2018** **> 1 km Offshore**	**RPS Surveys 2015–2018**	**8 April–15 April 2018** **Stabroek Block**	**Incidental Observations 2015–2018** **Stabroek Block**	**Distance from Shore Where Observed 1–25 km**	**Distance from Shore Where Observed 25–100 km**	**Distance from Shore Where Observed >100 km**	**New Record for Guyana**
Neotropic Cormorant *Phalacrocorax brasilianus*		X	X			X			
Magnificent Frigatebird *Fregata magnificens*	X	X	X		X	X	X	X	
Northern Gannet *Morus bassanus*			X	X				X	X
Masked Booby *Sula dactylatra*			X	X	X		X	X	
Brown Booby *Sula leucogaster*			X	X	X			X	
Red-footed Booby *Sula*			X	X			X	X	
Masked/Red-footed Booby *Sula dactylatra/sula*								X	
Great Shearwater *Ardenna gravis*	X		X			X		X	
Audubon’s Shearwater *Puffinus lherminieri*			X					X	
Cory’s Shearwater *Calonectris borealis*			X					X	
Manx Shearwater *Puffinus puffinus*			X						
Sooty Shearwater *Ardenna grisea*			X						

Common Name *Species Name*	**30 September–7 October 2017** **> 1 km Offshore**	**9 April–15 April 2018** **> 1 km Offshore**	**RPS Surveys 2015–2018**	**8 April–15 April 2018** **Stabroek Block**	**Incidental Observations 2015–2018** **Stabroek Block**	**Distance from Shore Where Observed 1–25 km**	**Distance from Shore Where Observed 25–100 km**	**Distance from Shore Where Observed >100 km**	**New Record for Guyana**
White-tailed Tropicbird *Phaethon lepturus*			X					X	
Red-billed Tropicbird *Phaethon aethereus*			X	X				X	X
Bulwer's Petrel *Bulweria bulwerii*				X				X	X
Band-rumped Storm-Petrel *Oceanodroma castro*			X	X			X		X
Leach's Storm-Petrel *Oceanodroma leucorhoa*		X	X	X			X	X	
Wilson's Storm-Petrel *Oceanites oceanicus*		X	X	X				X	
Parasitic Jaeger *Stercorarius parasiticus*			X	X				X	
Pomarine Jaeger *Stercorarius pomarinus*	X	X	X	X		X	X	X	
Long-tailed Jaeger *Stercorarius longicaudus*			X						
Great Skua *Stercorarius skua*			X						
South Polar Skua *Stercorarius maccormicki*			X						
Ruddy Turnstone [a] *Arenaria interpres*				X				X	

Common Name *Species Name*	**30 September–7 October 2017** **> 1 km Offshore**	**9 April–15 April 2018** **> 1 km Offshore**	**RPS Surveys 2015–2018**	**8 April–15 April 2018** **Stabroek Block**	**Incidental Observations 2015–2018** **Stabroek Block**	**Distance from Shore Where Observed 1–25 km**	**Distance from Shore Where Observed 25–100 km**	**Distance from Shore Where Observed >100 km**	**New Record for Guyana**
Laughing Gull *Leucophaeus atricilla*	X	X	X			X			
Herring Gull *Larus smithsonianus*			X						
Ring-billed Gull *Larus delawarensis*			X						
Roseate Tern *Sterna dougallii*			X						
Common Tern *Sterna hirundo*	X	X	X			X	X	X	
Least Tern Sternula antillarum			X						
Royal Tern *Thallaseus maximus*	X	X	X			X			
Sandwich Tern *Thallaseus sandvicensis*	X		X			X	X		
Bridled Tern *Onychoprion anaethetus*	X					X	X	X	X
Sooty Tern *Onychoprion fuscata*	X		X					X	
Brown Noddy *Anous stolidus*	X		X				X		
Black Skimmer *Rynchops niger*	X					X			
Brown Pelican *Pelecanus occidentalis*			X						

Common Name *Species Name*	**30 September–7 October 2017 > 1 km Offshore**	**9 April–15 April 2018 > 1 km Offshore**	**RPS Surveys 2015–2018**	**8 April–15 April 2018 Stabroek Block**	**Incidental Observations 2015–2018 Stabroek Block**	**Distance from Shore Where Observed 1–25 km**	**Distance from Shore Where Observed 25–100 km**	**Distance from Shore Where Observed >100 km**	**New Record for Guyana**
Black-browed Albatross *Thalassarche melanophrys* [b]				X					X

km = kilometer

Note: Not all birds recorded in the table are reflected in the columns comparing distance from shore because in some surveys, the exact location data are not available. Nevertheless, the available results for distance from shore reflects the differences in bird communities according to the distance from shore.

[a] Not regarded as seabirds, but recorded at >1 kilometer from shore

[b] Provisional identification: Black-browed Albatross *Thalassarche melanophrys*

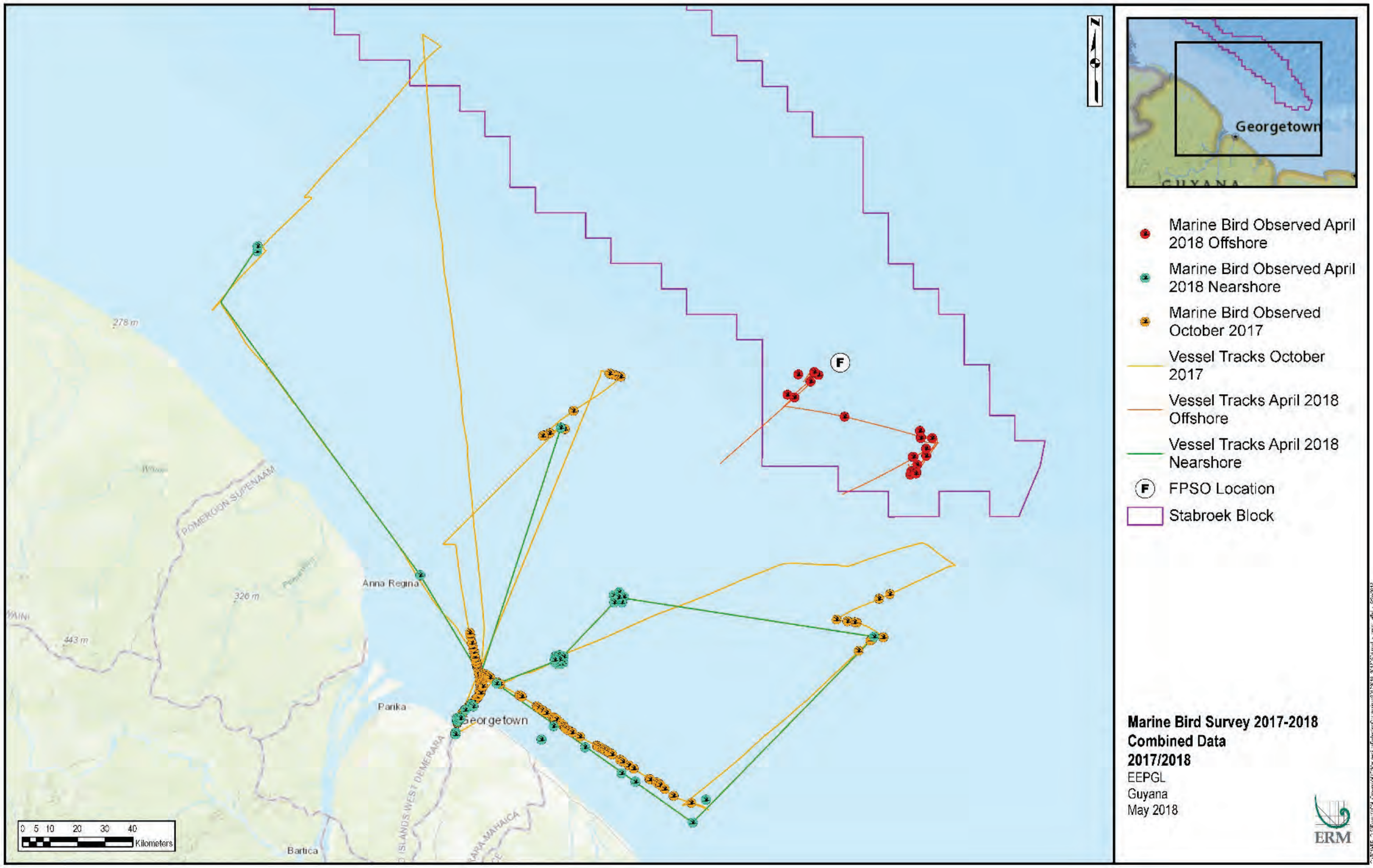


Figure 7.4-1: Map of Marine Bird Observations within and near the Stabroek Block during the 2017-2018 Marine Bird Surveys (Combined Data for the Three Surveys)

Most (24) of the seabird species observed during the three survey events in 2017 and 2018 or the incidental observations collected between 2015 and 2018 were previously known to occur in Guyana based on the historical record (Table 7.4-3). Only five of the bird species on the historical list were not observed during the three survey events or the incidental observations. Most notably, the surveys and incidental observations yielded six new records for Guyana (species never observed in the country previously), increasing the number of seabird species known to occur in Guyana from 29 to 35 (an increase of approximately 21 percent). The new records registered for Guyana include Bridled Tern (*Onychoprion anaethetus*), Black-browed Albatross (*Thalassarche melanophrys)*, Red-billed Tropicbird (*Phaethon aethereus)*, Northern Gannet (*Morus bassanus)*, Bulwer's Petrel (*Bulweria bulwerii)*, and Band-rumped Storm-Petrel (*Oceanodroma castro)*. With the exception of the Black-browed Albatross, all of these species have been identified in the Southern Caribbean.

Figure 7.4-2: Bridled Tern (*Onychoprion anaethetus*), New Country Record for Guyana, Observed near Stabroek Block, October 2017

Figure 7.4-3: Band-rumped Storm-Petrel (*Oceanodroma castro)*, New Country Record for Guyana, Observed within Stabroek Block, April 2018

The most commonly observed species in and near Stabroek Block (more than 100 kilometers from shore) during the three 2017 and 2018 surveys was the Magnificent Frigatebird (*Fregata magnificens*) in 2017 and Leach's Storm-Petrel (*Oceanodroma leucorhoa*) in 2018. In April 2018, Leach's Storm-Petrel accounted for 14 of the 35 individuals observed. The species was observed both within and just outside the Stabroek Block (Table 7.4-3). The number of Leach's Storm-Petrels observed in the April 2018 survey suggests its reluctance to move toward shore in rough waters, which is common for other species of seabirds. Its tendency to pick planktonic items from the surface may make it less vulnerable to turbulent waters than birds that depend more greatly on fish. The most commonly observed species (in descending order of number of sightings or frequency of occurrence) recorded through the incidental bird observations in the Stabroek Block collected during the period from 2015-2018 were the Masked Booby (*Sula dactylatra)*, Magnificent Frigatebird, and Brown Booby (*Sula leucogaster)* (RPS 2018).

All of the survey data indicate that seabird abundance offshore is low. For example, the April 2018 survey of the Stabroek Block consisted of 3,610 minutes (approximately 60 hours) of observation, during which 35 individuals of 11 species were observed (0.58 birds per hour of observation). The median interval between sightings for any two birds on the same day was 42 minutes. The rate varied by observation day from 0.24 to 1.00 individuals per hour (median 0.43 to 0.60 individual per hour). The October 2017 survey conducted just outside the Stabroek Block recorded slightly higher bird abundance (0.90 bird per hour of observation; 14 individuals in 15.5 hours) than the April 2018 survey. A potential explanation for the lower abundance observed during the 2018 survey is that offshore conditions were turbulent, with strong, steady, westward winds coinciding with the current direction, likely driving some birds landward and reducing the observation rate. Also, seasonal migration could have driven some birds toward nesting grounds already, as several individuals observed were in full breeding plumage, indicating that regional breeding sites were active at the time.

In contrast to the low abundance, the surveys documented higher overall species diversity and seasonal variation in species assemblage than expected based on historical records and expert knowledge. Differences in the bird species assemblage between the October 2017 and April 2018 surveys indicate that there is considerable seasonal variation in seabird diversity within and around the Stabroek Block. For example, the October 2017 survey documented 13 seabird species and the April 2018 surveys documented 11 seabird species (these numbers exclude non-seabirds). Most of the species identified were unique to one survey or the other, with only two seabird species overlapping (Table 7.4-3).

Bird observations within the Stabroek Block were largely of lone individuals, which is generally characteristic of seabirds when far offshore. The April 2018 survey of the Stabroek Block yielded only five sightings of doubles (two birds) and no larger groups. All other birds were seen alone and none within less than 8 minutes from the successive bird observation. Most birds observed were moving directionally, usually from northwest-southeast, roughly parallel to the coast and perpendicular to the vessel’s course.

Bird abundance typically decreases with distance to shore. During the 2017 survey, bird abundance was slightly greater (14 individuals over 8.5 hours of observation time, or 1.6 individuals per hour) at 25 to 100 kilometers distance from shore compared with areas greater than 100 kilometer from shore (just outside the block and just inside the block). During this same survey, bird abundance increased dramatically with increased proximity to shore: 377 individuals were observed over 8.25 hours of survey (46 individuals per hour) at distances of between 1 and 25 kilometers from shore (Figure 7.4-4). Abundance data based on distance to shore is not available for the April 2018 survey of the Stabroek Block because vessel transit in the nearshore regions (less than 100 kilometers from shore) occurred at night on both the departure and return trips—so bird data were not collected for the nearshore areas (1 to 25 and 25 to 100 kilometers from shore).

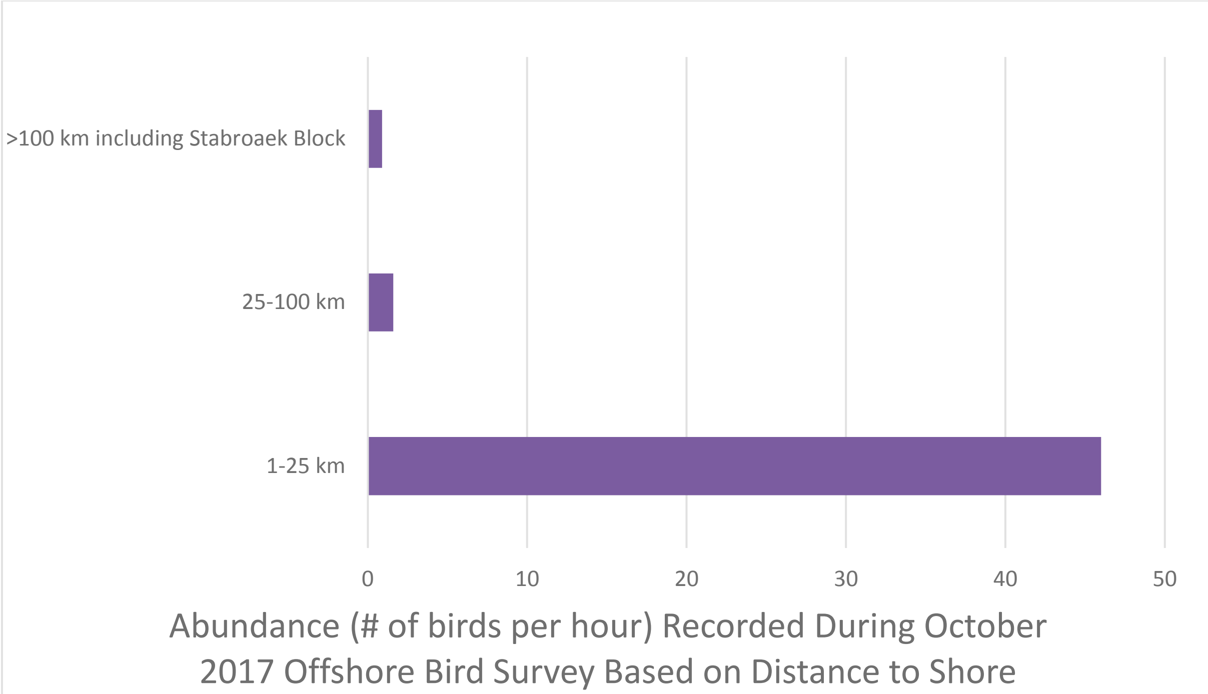


Figure 7.4-4: Abundance of Birds According to Distance from Shore Observed Recorded during the October 2017 Surveys

Of the species identified within the Stabroek Block during 2017 and 2018 surveys, one species (Ruddy Turnstone [*Arenaria interpres*]) is not a seabird, but rather a shorebird that flies over the Caribbean during migration (Table 7.4-3). Ruddy Turnstone populations from eastern North America nesting sites are known to fly northwesterly across northern South America and into the Caribbean during the northward migration, consistent with the observed individual (IWSG 2018). This individual, likely in its northward migration, was already in bright, breeding plumage. In contrast to seabirds, its capacity to rest in the open waters of the southern Caribbean is very limited. The migration of landbirds such as this individual across the Caribbean is poorly documented, with most data found from observations on the islands, or along the northern shore of South America and the southern shore of the United States.

Survey results indicate that the Stabroek Block and the surrounding offshore area is used by a variety of seabirds for regional dispersal (movements between non-breeding and breeding sites) and migration. The use of this area for seasonal movements to breeding sites such as the nearby IBAs in Tobago (see Section 7.4.2.5, Important Bird Areas for Seabirds near Stabroek Block) is demonstrated by the sightings of Red-billed Tropicbird, Magnificent Frigatebird, and booby species in breeding plumage flying in a northwesterly direction towards Tobago: all of these species are known to nest in the Tobago IBAs. The data also indicate that the Stabroek Block and surrounding region serves as habitat for seabirds undergoing multiple types of migrations: classic Nearctic-Neotropic migration (jaegers and Northern Gannet); transoceanic migration (Bulwer's Petrel, Band-rumped Storm-Petrel, Leach's Storm-Petrel); and austral migration (shearwaters, Wilson's Storm-Petrel [*Oceanites oceanicus*]).

In summary, the following points can be drawn from the 2017 and 2018 surveys and incidental bird data collected between 2015-2018: (1) a wide complement of seabirds (35 species), including one species of conservation importance (Leach's Storm-Petrel), occur in the Stabroek Block and surrounding waters; (2) seasonal, latitudinal migration of both seabirds and landbirds occurs in the Stabroek Block and surrounding waters; (3) seabird population density is low overall but the seasonality and population dynamics of seabirds in the area is not well-understood; (4) seabird population density increases markedly with proximity to shoreline; (5) populations of seabirds and other birds (migrating, vagrant, and storm-induced birds) in the Guyanese waters of the southern Caribbean are poorly studied to date, and the present set of studies constitutes a notable increase in the overall knowledge of the offshore bird communities as is confirmed by six new country records generated during the EEPGL-commissioned surveys.

7.4.2.4. Conservation Status of Seabirds Confirmed for Offshore Guyana

Of the 35 species of seabirds known to occur in Guyana based on historical and 2017/2018 survey records, 32 are currently listed on the IUCN Red List as Least Concern (LC), which means that the population status of the species does not meet the IUCN criteria for a Threatened or Near Threatened designation (IUCN 2016) (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species). The Barolo Shearwater (*Buffinus baroli*), a recently described species that was previously considered a population of the Little Shearwater, has not had its conservation status evaluated by IUCN. Of the two remaining species, Leach's Storm-Petrel is classified as Vulnerable (VU); and Black-capped Petrel (*Pterodroma hasitata*) is classified as Endangered (EN).

Leach's Storm-Petrel was the most common species observed during the April 2018 surveys within the Stabroek Block and this species was previously reported in Guyana in eBird and during prior EEPGL seismic surveys in the Stabroek Block (RPS 2018). It nests in cold, northern ocean waters, so these individuals were likely soon to depart on seasonal migration. Based on the number of sightings, the Stabroek Block can be considered to contain an appreciable population of this species, at least seasonally.

The Black-capped Petrel, classified by IUCN as EN, is known to occur offshore Guyana but was not observed during EEPGL-commissioned surveys. The Black-capped Petrel nests in holes on escarpments in highlands of Haiti and the Dominican Republic, and possibly Cuba, where fewer than 2000 nesting pairs and as few as 500 can be found (Jodice et al. 2015; Simons et al. 2013). Historical nesting areas in Guadeloupe, Martinique, and Dominica are considered to no longer be utilized. Birds nest from January through June, during which adults may make extended foraging trips at sea (Simons et al. 2013). Foraging expeditions of several days and up to thousands of kilometers have been demonstrated by satellite tagging of three nesting adults, which roamed the southern Caribbean in offshore Venezuela, near the Stabroek Block (Jodice et al. 2015). Visual sightings of adults in 2018 have occurred throughout the Caribbean, in the waters of Puerto Rico, Dominica, Aruba, and Martinique. Migration occurs after breeding, principally along the Gulfstream along the eastern U.S. shore (www.ebird.org).

The Black-capped Petrel tends to feed on vertically migrating nekton (Simons et al. 2013), of which myctophids (lanternfishes, a group of fish species that exhibit bioluminescence) are common to abundant in the waters of the Stabroek Block. The vertical migration of this prey resource at night may make the activity of this bird greater in hours of limited light and night, which could explain why the species was not observed during 2017 or 2018 surveys since surveys were not conducted during periods of low light. Other food items include Sargassum (a genus of macroalgae), crustaceans, squid, and fish (Simons et al. 2013).

Figure 7.4-5: Leach's Storm-Petrel (*Oceanodroma leucorhoa*), IUCN-Listed as Vulnerable, Observed within the Stabroek Block on 10 April 2018

7.4.2.5. Important Bird Areas for Seabirds near Stabroek Block

Since 2010, BirdLife International has focused its efforts on identifying Marine IBAs with specific significance to seabirds. The types of sites that qualify as Marine IBAs include seabird breeding colonies, foraging areas around breeding colonies, non-breeding (usually coastal) concentrations, migratory bottlenecks, and feeding areas for pelagic species (Birdlife International 2016b). No Marine IBAs have been identified in Guyana, but three Marine IBAs of global or regional importance to seabirds have been designated in neighboring countries:

St. Giles Islands and Little Tobago, both located off the northeastern tip of Tobago, and Isla de Aves in Venezuela (Lentino and Esclasans 2009; Birdlife International 2016b; Devenish et al. 2009). Figure 7.4-6 depicts the location of these IBAs relative to the Stabroek Block.

St. Giles Islands IBA includes one main island and several surrounding rock outcrops that support globally important numbers of breeding Red-billed Tropicbird and regionally important numbers of breeding Audubon's Shearwater (*Puffinus lherminieri*), Magnificent Frigatebird, Masked Booby, and Red-footed Booby (*Sula sula*). Other seabirds such as Brown Booby and Brown Noddy (*Anous stolidus*) also breed there (White 2008; Devenish et al. 2009).

Little Tobago IBA supports globally important breeding populations of Red-billed Tropicbird and Laughing Gull (*Leucophaeus atricilla*), and regionally important breeding populations of Audubon's Shearwater, Brown Booby, Red-footed Booby, and Bridled Tern (White 2008; Devenish et al. 2009).

Field surveys conducted as part of the coastal mapping of Trinidad and Tobago documented large colonies of seabirds at both St. Giles Island and Little Tobago, as well as along the northeastern cliffs of Tobago, from Corvo Point to Pedro Point (ERM and ECL 2016).

The Isla de Aves IBA in Venezuela supports the largest breeding colony of Brown Noddy known from the Caribbean (5,509 pairs), as well as the principal breeding colony of Sooty Tern (*Onychoprion fuscatus*) in Venezuela (12,182 pairs) (Lentino and Esclasans 2009).

7.4.3. Impact Assessment—Seabirds

This section discusses potential impacts on seabirds from planned Project activities. Thirty-four seabird species have been documented in Guyana's offshore waters, including the area in and around the PDA. Several resident seabird species occur in the area throughout the year and migratory seabirds typically occur in the area starting in late summer, with many remaining through winter and into early spring. When seabirds are not breeding, they primarily live in offshore environments, moving with prey resources and roosting and loafing on islands or artificial structures in the ocean or simply rafting[7] on the ocean surface. The presence of seabirds in a given area is heavily resource-driven, with individuals and groups of seabirds primarily attracted to prey concentrations. No evidence suggests that large concentrations of seabird prey (primarily fish) consistently occur in the PDA that would promote regular use by foraging seabirds. Rather, seabirds in the area are likely transients, moving opportunistically with schools of fish and other prey. The turbid conditions in the PDA further reduce the likelihood that the area has significant importance for foraging seabirds. Further, no islands or artificial structures occur in the PDA, so the area does not contain any known roosting or loafing areas where large numbers of seabirds might congregate. As such, it is expected that seabirds occur in the PDA throughout the year, but at a low density and for short (transient) periods depending on prey availability.

[7] Rafting is a common seabird behavior involving a tight aggregation of seabirds floating on the ocean surface to form a "raft."

Figure 7.4-6: Location of IBAs with Importance to Seabirds Relative to Stabroek Block

7.4.3.1. Relevant Project Activities and Potential Impacts

The Project has the potential to impact seabirds through injury (e.g., collision with Project features), disturbance leading to changes in behavior (e.g., via displacement or attraction from sound, lighting, and/or presence of the FPSO) or toxicological effects (e.g., as a result of exposures to Project vessel discharges).

Potential impacts on seabirds from unplanned events, including oil spills, contact with the FPSO flare (or plume), and vessel and helicopter strikes, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.4-4 summarizes the Project stages and activities that could result in potential Project impacts on seabirds.

Table 7.4-4: Summary of Relevant Project Activities and Key Potential Impacts—Seabirds

Stage	Project Activity	Key Potential Impact
Development Well Drilling Subsea, Umbilicals, Risers, and Flowlines (SURF)/FPSO Installation	Presence of drill ships and installation vessels	• Physical presence of drill ships and installation vessels (with lighting), potentially acting as an attractant to seabirds, exposing them to collision risks, additional energy expenditure, and compromised navigation for night-migrating birds • Vessels may be of benefit to some species that use the vessel for rest or shelter during long flights or adverse weather
	Operation of supply and support vessels	• Light and sound disturbance, leading to attraction to or avoidance of the exposed area
	Discharge of drill cuttings	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Discharge of wastewater effluents	
Production Operations	Presence of FPSO	• Physical presence of FPSO (with lighting), potentially acting as an attractant to seabirds, exposing them to collision risks, additional energy expenditure, and compromised navigation for night-migrating birds • Structures may be of benefit to some species that use the structure for rest or shelter during long flights or adverse weather, or as an attractant for seabird prey
	Discharge of cooling water and produced water	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Discharge of wastewater effluents	
	Operation of supply and support vessels	• Avoidance or attraction due to lighting and activity
Decommissioning	Decommissioning activities PDA and related vessel traffic	• Light and sound disturbance from decommissioning activities, potentially leading to attraction to or avoidance of the PDA • Removal of a resting place and reliable food source if the FPSO acts as an attractant for seabird prey

Potential impacts from seabird exposure to discharge of drill cuttings, produced water, and other wastewater effluents are expected to be negligible because the effluents are not highly toxic, the discharges will rapidly mix with ambient water, and the numbers of seabirds potentially exposed to the effluents are expected to be low. Accordingly, these impacts are not discussed further in this section. Sections 6.3.3, Impact Assessment—Marine Geology and Sediments, and 6.4.3, Impact Assessment—Marine Water Quality, provide further analysis of the impacts of these discharges on marine sediment and water quality, respectively.

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 acts as consistent attractants for seabird prey, providing a reliable food resource for seabirds. However, this is not expected to be a significant benefit to seabirds at the population level, and is not discussed further herein.

7.4.3.2. Magnitude of Impacts—Seabirds

Seabirds are known to aggregate around large offshore installations such as drill ships and can be present in above-average numbers due to artificially increased food concentrations, lighting, and attraction to the structure itself for roosting (Weise et al. 2001). The impacts of attraction and aggregation by seabirds around an offshore facility can be both positive and negative and can vary considerably by species and, more specifically, a species' typical behavior and the type and length of use of the impacted area. The structure may be beneficial to seabirds by providing a resting place or shelter during feeding, migration, or adverse weather in areas where these places would otherwise not be found.

The potential adverse impacts associated with seabird attraction to offshore facilities primarily relate to lighting. The drill ships, installation vessels, and FPSO will operate 24 hours a day, so at night there will be a considerable source of artificial light in an otherwise dark environment. The amount of light in the PDA will vary during the different stages of the Project. Lights on offshore oil platforms and other installations are known to act as an attractant to seabirds and typical offshore installation lighting extends roughly 3 to 5 kilometers (2 to 3 miles) around the source (Weise et al. 2001). Poor weather, such as fog, precipitation, and low cloud cover can exacerbate the impact of nocturnal attraction to lights, especially when coincidental with bird migrations (Ronconi et al. 2015).

Lighting on offshore facilities can be disorienting to night-migrating birds, particularly waterfowl, which migrate using stellar cues that can be obscured by lights (Gaston et al. 2013). Birds lose their stellar cues for nocturnal navigation under low cloud ceiling or other adverse weather conditions, and in these circumstances artificial lights become the strongest cues that birds have for navigation. As a result, they are attracted to the lights and will fly around them for extended periods, a phenomenon which is referred to in the scientific literature as the "trapping effect" or "light circling." The time individual birds spend circling can range from a few minutes to several hours to days, with an average of around 15 minutes (Marquenie 2007). The consequences of this may be: (1) energy wasted circling the installation, which can be problematic for individual birds undergoing long migrations; (2) collision with the structure or other birds, potentially resulting in mortality or injury—which can in turn cause individual birds to remain on the structure for long periods where there is no drinking water; (3) increased exposure to Project facilities and activities from the attraction to the area and potential exposure to radiant heat from flaring events, which can cause injury or death; and (4) increased risk of predation due to weakness, disorientation, or injury following long periods of circling or collision with a Project structure (Baird 1990; Ronconi et al. 2015; Platteeuw and Henkens 1997; Deda et al. 2007).

As an embedded control to manage lighting-related impacts from the Project, lighting on the FPSO and major vessels will be directed, where practicable, to required operational areas rather than at the sea surface or skyward. This will reduce the intensity and locations of lighting to which seabirds may be exposed by the Project. Further, the PDA is not located within a major seabird migratory flyway, nor is it known to support large numbers of seabirds; accordingly, the number of individuals that could be impacted by the potential impacts described above is expected to be limited, meaning the Project will not impact any seabird species at the population level. As such, the overall magnitude of the impacts from seabirds being attracted to Project facilities is considered to be **Small**.

Seabirds are not known to be particularly sensitive to human activity so increased human activity is expected to have little impact. Project activity related to potential disturbance will decrease during the production operations phase, so potential disturbance of seabirds will decrease as well. There will be a small increase in human activity during decommissioning, but that increase will be of relatively short duration and will not rise to the same level of activity associated with drilling and installation. On this basis, the magnitude of the potential Project disturbance impacts on seabirds is considered **Small**.

Decommissioning activities for the FPSO and related vessel traffic may impact seabirds in similar ways to that described for the installation and production operations stages, including light and sound disturbance from decommissioning activities leading to avoidance of the exposed areas or attraction to the activities. As stated previously in this section, these impacts are expected to impact individual seabirds but have negligible impacts on seabirds at the population level.

The drill ships, major installation vessels, and FPSO may be of benefit to some species that use the vessels for rest or shelter during long flights or adverse weather. Additionally, major vessels in the PDA could become an attractant for seabird prey (i.e., due to lighting) during the production operations stage. These are considered potential **Positive** impacts. These benefits will be most pronounced for the FPSO, as the FPSO will remain in the same location for the Project life cycle (i.e., at least 20 years). For this reason, seabirds are likely to become familiar with the location of this potential resting/prey location, and use would be expected to increase, as compared to vessels during the drilling and installation stages. However, once decommissioning activities are completed, the removal of the FPSO will reverse these potential benefits. Seabirds would be expected to adapt to this change in relatively short order, yielding a **Negligible** magnitude rating for these potential impacts.

7.4.3.3. Sensitivity of Receptor—Seabirds

Seabirds are expected to occur in the PDA throughout the year but at low densities and primarily as transients moving with prey resources. With the exception of Leach's Storm-Petrel, which is listed on the IUCN Red List as VU, and Black-capped Petrel, which is listed on the IUCN Red List as EN, all of the 35 species of seabirds known to occur in the area are listed on the IUCN Red List as LC. Taking into account the conservation status of the majority of the seabirds that could experience impacts from the Project (special status species are assessed in Section 7.1, Protected Areas and Special Status Species) and the fact that only a few individuals are likely to be impacted rather than whole populations, the sensitivity of seabirds to the potential impacts described above is considered **Low**.

7.4.3.4. Impact Significance—Seabirds

Based on the magnitude of impact of receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential (adverse) impacts on seabirds is **Negligible**.

7.4.4. Mitigation Measures—Seabirds

The embedded controls, such as use of directional lighting to the extent practicable, that are integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on seabirds. Table 7.4-5 summarizes the assessment of potential pre-mitigation and residual Project impacts on seabirds. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the seabird-specific methodology described in Sections 7.4.3.2 and 7.4.3.3.

Table 7.4-5: Summary of Potential Pre-Mitigation and Residual Impacts—Seabirds

Stage	Receptor—Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Seabirds—direct mortality or injury from attraction to offshore Project facilities	Small	Low	Negligible	None	Negligible
	Seabirds—light and sound disturbance from Project activities	Small	Low	Negligible	None	Negligible
Production Operations	Seabirds—benefit from use of major vessels as a resting place or attractant of prey	Not rated (Positive)	Low	Positive	None	Positive
Decommissioning	Seabirds—removal of FPSO as a resting place or attractant of prey	Negligible	Low	Negligible	None	Negligible

7.5. MARINE MAMMALS

7.5.1. Administrative Framework—Marine Mammals

Table 7.5-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine mammals.

Table 7.5-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Mammals

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country’s flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.5.2. Existing Conditions—Marine Mammals

A basic understanding of the existing composition and distribution of the marine mammal community in the vicinity of the PDA is provided by regional compilations (Ward et al. 2001; Ward and Moscrop 1999), Marine Mammal Observer (MMO) data collected during EEPGL’s exploration activities from 2014 to 2018 (Appendix M, Protected Species Observer Summary), studies on cetaceans in offshore waters of neighboring countries such as Suriname and Venezuela (de Boer 2015), and incidental reports associated with strandings and bycatch (Project GloBAL 2007). Information from these reports and other studies provides the foundation for this discussion of existing conditions, which is focused on cetaceans. One sirenian, the West Indian manatee (*Trichechus manatus*), and two pinniped groups (seals and sea lions), have been documented in the region, but are now considered to be locally extinct or extremely rare, and are not expected to be encountered in coastal waters adjacent to the PDA (Ward 2001). However, the manatee may be encountered in nearshore and riverine settings.

7.5.2.1. Regional Setting

The equatorial waters of Guyana are located within sub-region VI of the Wider Caribbean Region. This sub-region includes the countries of Guyana, Suriname, and French Guiana (Ward and Moscrop 1999). Many cetacean species are known to occur either seasonally or year-round in the waters of the wider Caribbean region, but there are minimal data concerning the life history and behavior of the majority of these species. The cetacean community is also under-recorded in waters off of French Guiana and Guyana (de Boer 2015; Mannocci et al. 2013). In contrast, more detailed records exist for Venezuela in the southern Caribbean region. The scarcity of cetacean records for sub-region VI can be attributed to a lack of survey effort rather than an absence of marine mammals (de Boer 2015).

7.5.2.2. Marine Mammal Data from the Project Development Area

Historical Marine Mammal Data

The 2007 Global Bycatch Assessment of Long-lived Species Country Profile of Guyana (Project GloBAL 2007) provides a list of marine mammals whose distributions overlap with Guyana's Exclusive Economic Zone (EEZ). The cetacean species documented in this report are listed in Table 7.5-2.

Table 7.5-2: Marine Mammals with Ranges that include Waters Offshore Guyana

Common Name	Scientific Name	IUCN Status	Notes
Sei whale	*Balaenoptera borealis*	EN	The sei whale is a baleen whale and is the third-largest after the blue whale and the fin whale. It inhabits most oceans and adjoining seas, and prefers deep offshore waters.
Bryde's whale	*Balaenoptera brydei*	DD	Bryde's whales are moderately sized and closely resemble their relative, the sei whale.
Blue whale	*Balaenoptera musculus*	EN	Blue whales are the largest mammals on earth. Their diet consists almost entirely of krill. Blue whales were hunted nearly to extinction.
Fin whale	*Balaenoptera physalus*	EN	Fin whales are the second largest mammal after blue whales. They are found worldwide and their food consists of small fish, squid, copepods, and krill.
Minke whale	*Balaenoptera acutorostrata*	LC	Minke whales are the second smallest baleen whale.
Short-beaked common dolphin	*Delphinus delphis*	LC	These dolphins occur throughout warm temperate and tropical oceans. Short-beaked common dolphins can occur in aggregations of hundreds or even thousands of dolphins. They sometimes associate with other cetacean species, such as pilot whales.

Common Name	Scientific Name	IUCN Status	Notes
Long-beaked common dolphin	*Delphinus capensis*	DD	The range of this dolphin is more geographically restricted (i.e., smaller in area) than that of the short-beaked common dolphin. It has a varied diet. One of the main threats to this dolphin is fishery by-catch
North Atlantic right whale	*Eubalaena glacialis*	EN	This is a baleen whale that was once a preferred target for whalers. They feed mostly on copepods and krill.
Pygmy killer whale	*Feresa attenuate*	DD	This is a poorly known and rarely seen dolphin that avoids human contact. They are often caught in drift gill nets.
Short-finned pilot whale	*Globicephala macrorhynchus*	DD	Short-finned pilot whales are very sociable and are rarely seen alone. They are found in groups of 10 to 30, though some pods are as large as 50. The species primarily feeds on squid, but will also feed on certain species of fish and octopus. They feed nearly 300 meters (approximately 984 feet) deep or more, and spend great lengths of time at depth. A pod may spread out up to 800 meters (approximately 2,640 feet) to cover more area to find food.
Risso’s dolphin	*Grampus griseus*	LC	These are found worldwide in temperate and tropical waters, just off the continental shelf on steep banks. Risso’s dolphins feed almost exclusively on neritic and oceanic squid, mostly nocturnally.
Pygmy sperm whale	*Kogia breviceps*	DD	The pygmy sperm whale is not much larger than many dolphins. Pygmy sperm whales are normally either solitary, or found in pairs. They feed mainly on cephalopods.
Dwarf sperm whale	*Kogia simus*	DD	The dwarf sperm whale is the smallest species commonly known as a whale. Dwarf sperm whales feed mainly on squid and crab. Their preferred habitat appears to be just off the continental shelf.
Fraser’s dolphin	*Lagenodelphis hosei*	LC	This dolphin is normally sighted in deep tropical waters. Fraser's dolphins swim quickly in large tightly packed groups of about 100 to 1,000 in number.
Humpback whale	*Megaptera novaeangliae*	LC	Found in oceans and seas around the world, humpback whales typically migrate up to 25,000 kilometers (approximately 15,534 miles) each year. Humpbacks feed only in summer, in polar waters, and migrate to tropical or subtropical waters to breed and give birth in the winter. Once hunted to the brink of extinction, its population fell by an estimated 90% before a 1966 moratorium. Since this time, stocks have partially recovered.
Blainville’s beaked whale	*Mesoplodon densirostris*	DD	This species of beaked whale is found in tropical and warm waters in all oceans, and has been known to range into very high latitudes. The whales are seen in groups of three to seven individuals. Dives have been measured as long as 22 minutes.
Gervais’ beaked whale	*Mesoplodon europaeus*	DD	These whales occur in small groups. They most likely feed on squid. Although this species frequently strands, until 1998, no one had made a confirmed sighting of the species at sea.

Common Name	Scientific Name	IUCN Status	Notes
True’s beaked whale	*Mesoplodon mirus*	DD	These have been seen in small groups, and are believed to be squid eaters. Little else is known.
Melon-headed whale	*Peponocephala electra*	LC	Closely related to the pygmy killer whale and pilot whale, collectively this dolphin species is known by the common name blackfish. It is also related to the false killer whale. The melon-headed whale is widespread throughout the world's tropical waters, although not often seen by humans because it prefers deep water.
Sperm whale	*Physeter macrocephalus*	VU	The largest of the toothed whales that can be found anywhere in the open ocean, females and young males live together in groups while mature males live solitary lives outside of the mating season. Females give birth every 4 to 20 years and care for the calves for more than a decade. A mature sperm whale has few natural predators. They feed on squid and fish and usually dive between 300 to 800 meters (984 to 2,625 feet) to forage.
False killer whale	*Pseudorca crassidens*	DD	This species lives in temperate and tropical waters throughout the world. As its name implies, the false killer whale shares characteristics, such as appearance, with the more widely known killer whale. Like the killer whale, the false killer whale attacks and kills other cetaceans.
Pantropical spotted dolphin	*Stenella attenuata*	LC	Found in all the world's temperate and tropical oceans, this species was threatened due to the killing of millions of individuals in tuna purse seines. In the 1980s, the rise of "dolphin-friendly" tuna capture methods benefited the species and it is now one of the most abundant dolphin species in the world.
Clymene dolphin	*Stenella clymene*	DD	Clymene dolphins spend most of their lives in waters more than 100 meters (330 feet) in depth, but occasionally move into shallower, coastal regions. They feed on squid and small schooling fish, hunting either at night, or in mesopelagic waters where there is only limited light.
Striped dolphin	*Stenella coeruleoalba*	LC	The striped dolphin inhabits temperate or tropical, offshore waters. It moves in large groups—usually up to thousands of individuals in number. The adult striped dolphin eats fish, squid, octopus, krill, and other crustaceans.
Spinner dolphin	*Stenella longerostris*	DD	The spinner dolphin is a small dolphin found in offshore tropical waters around the world. The species primarily inhabits coastal waters, islands, or banks.
Rough-toothed dolphin	*Steno bredanensis*	LC	These dolphins can be found in deep warm and tropical waters around the world and are typically social animals. An average group has between 10 and 20 members. They have also been reported to school together with other species of dolphin, and with pilot whales, false killer whales, and humpback whales.

Source: Project GloBAL 2007; de Boer 2015; IUCN 2001; Minasian et al. 1984

EN = Endangered; LC = Least Concern; VU = Vulnerable; DD (Data Deficient) = Inadequate information to make a direct, or indirect, assessment of a species’ risk of extinction based on its distribution and/or population status.

In 2015 the Dutch Institute for Marine Resources and Ecosystem Studies published a peer-reviewed account of marine mammal data collected in a targeted survey in 2012 offshore Suriname, and incidental observations from 2008-2012 from Surinamese and adjacent waters in (de Boer 2015). The data from this study were collected at similar depths and distances offshore as the PDA. De Boer (2015) documented the presence of 10 identifiable species in dedicated, surveys (shown in bold in de Boer 2015, Table 5-A). In addition, during transit to the survey area (Trinidad to Suriname), de Boer also documented incidental sightings of common bottlenose dolphins (*Tursiops truncatus*) off of Trinidad, other dolphins (*Stenella* sp.) off of Guyana, and Guiana dolphin (*Sotalia guianensis*) at the entrance of the Suriname River. These species may be encountered closer to shore where Project-related marine support vessel transits will occur.

The survey data from de Boer (2015) show that the cetacean community in the Suriname area is primarily composed of odontocetes (toothed whales, including sperm whales, beaked whales, killer whales, and dolphins). These are more common offshore of Suriname than the baleen whales (including Bryde's whales [*Balaenoptera brydei*] and sei whales [*Balaenoptera borealis*]). The occurrence of baleen whales is likely seasonal, with Bryde's/sei whales recorded only during June and July. Additional opportunistic records cited in de Boer (2015) show that large baleen whales have been observed in early October. Both shelf waters and offshore waters are important for the dolphin community.

De Boer (2015) notes that the most abundant species documented offshore Suriname were the sperm whale (*Physeter macrocephalus*) and melon-headed whale (*Peponocephala electra*). Spinner dolphins (*Stenella longirostris*) and pantropical spotted dolphins (*Stenella attenuata*) were also frequently encountered in large groups. The relative abundance index for all cetaceans was relatively low, as expected for the offshore survey location (approximately 1,190 to 3,350 meters [approximately 3,900 to 11,000 feet] water depths). Based on these data, when viewed together with other systematic surveys in tropical regions in the eastern Atlantic and western Africa, estimated densities were found to be much higher in areas that spanned both deep and shallow waters versus the deep water-only area surveyed offshore Suriname (de Boer 2010). For example, tropical shallow-shelf waters off of the Maldives in the Indian Ocean generally hold a much more diverse and abundant cetacean community (Clark et al. 2012).

Other older reports provide additional information for context. For example, the International Whaling Commission Scientific Committee has published data from Venezuela (Bolaños-Jiménez et al. 2006) and French Guiana (Ridoux et al. 2010), which are relevant to Guyana. Bottlenose dolphins are incidentally captured in both gillnet and trawl fisheries in these countries. Tucuxi or grey dolphin (*Sotalia fluviatilis*) are known to suffer incidental capture in gillnets and seines throughout their range, which includes the Guianas (French Guiana, Suriname and Guyana).

Project-Specific Marine Mammal Data

Data on marine mammals have been collected in the Stabroek Block since 2015, during various survey activities related to oil and gas activities. These activities have included three seismic surveys, one automated underwater vehicle (AUV) survey, seven vertical seismic profiles, and four environmental baseline surveys. Data on marine mammals have been collected on the basis of visual and auditory detections. Together, these efforts represent more than 15,000 hours of survey time (Milne and Richardson 2018) and have generated the most comprehensive dataset available on marine mammal activity off the coast of Guyana.

Over the approximately 5-year study period, there have been a total of 575 marine mammal detections recorded. To date, 12 cetacean species have been confirmed in the Stabroek Block on the basis of these detections. Table 7.5-3 summarizes the species visually documented during these surveys.

Table 7.5-3: Marine Mammal Species Visually Observed during EEPGL Activities since 2014

Common Name	Scientific Name
Bryde’s whale	*Balaenoptera brydei*
Sperm whale	*Physeter microcephalus*
Melon-headed whale	*Peponocephala electra*
Short-finned pilot whale	*Globicephala macrorhynchus*
Atlantic spotted dolphin	*Stenella frontalis*
Common bottlenose dolphin	*Tursiops truncates*
Common dolphin	*Delphinus delphis*
Fraser's dolphin	*Lagenodelphis hosei*
Pantropical spotted dolphin	*Stenella attenuate*
Risso’s dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Spinner dolphin	*Stenella longirostris*

Source: RPS 2018

Dolphins have accounted for a large majority of the total (visual + acoustic) detections (485 detections, or 84 percent of all detections). Acoustic detections of unidentifiable dolphins account for the majority of total detections (visual and acoustic, 59 percent). A total of 157 detections were identifiable to species across the entire study period (see Figure 7.5-1). Although whales accounted for only 16 percent of the total detections, sperm whales were the most commonly identified species of whale or dolphin during the entire study period as shown on Figure 7.5-1. Sperm whales accounted for 40 of the 157 individual detections verified to the species level. Pantropical spotted dolphin, common bottlenose dolphin, spinner dolphin, and Bryde’s whale complete the top five most common species verified to the species level and together they represent over 80 percent of the detections that produced a confirmed detection of a particular species.

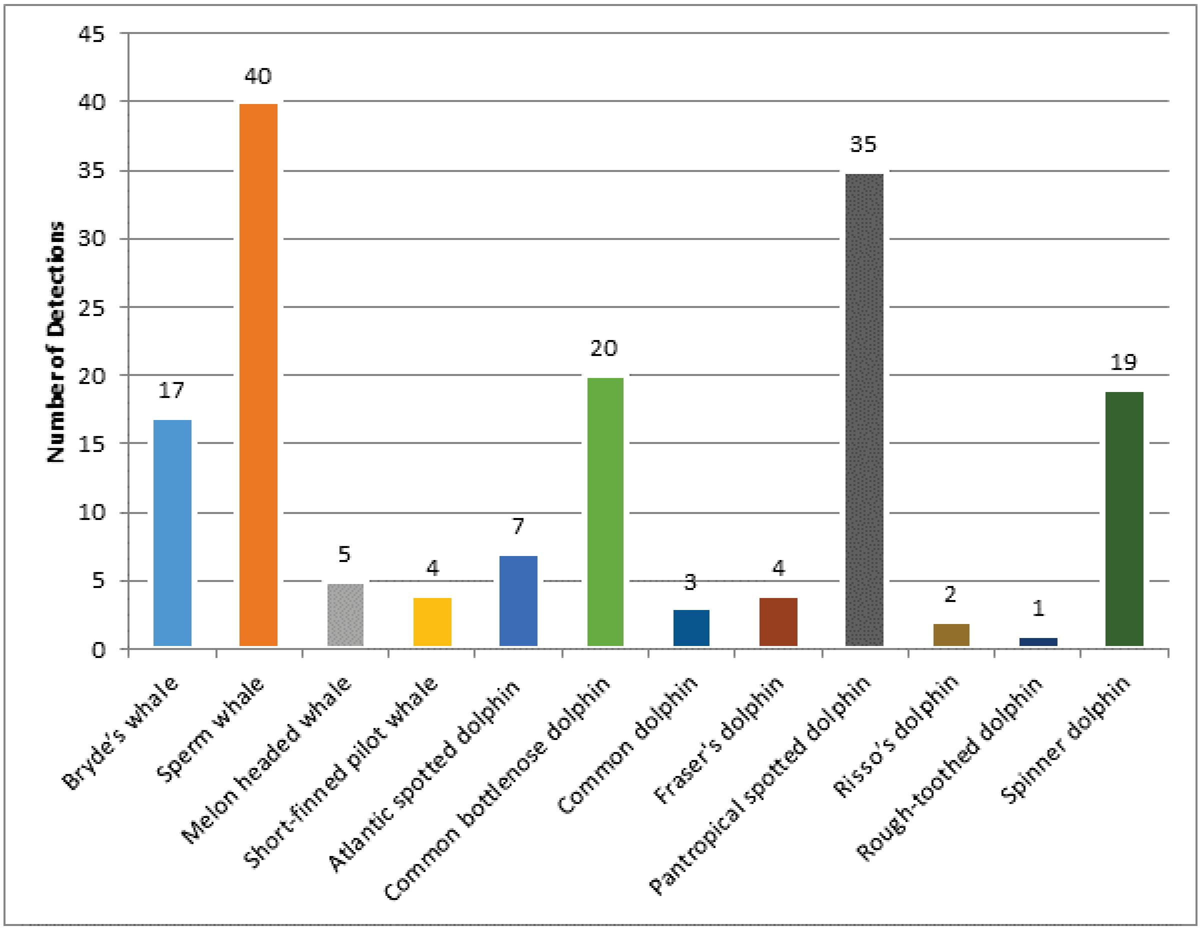


Figure 7.5-1: Visually Confirmed Marine Mammal Sightings in the Stabroek Block Marine Mammal Survey Area, by Species

Dolphin detections showed seasonal variability, with a peak in autumn and winter and a dip in spring and summer, as illustrated on Figure 7.5-2. Accounting for the amount of survey effort, the seasonal pattern in detections normalized per hour of observation was consistent across all years of the study. This apparent inter-annual consistency in seasonal trends may indicate a seasonal component to dolphin abundance offshore Guyana. Weaker seasonal variability is observed for the detection rate of whales, but the relatively small number of whale detections compared to dolphin detections makes comparisons between the two groups difficult.

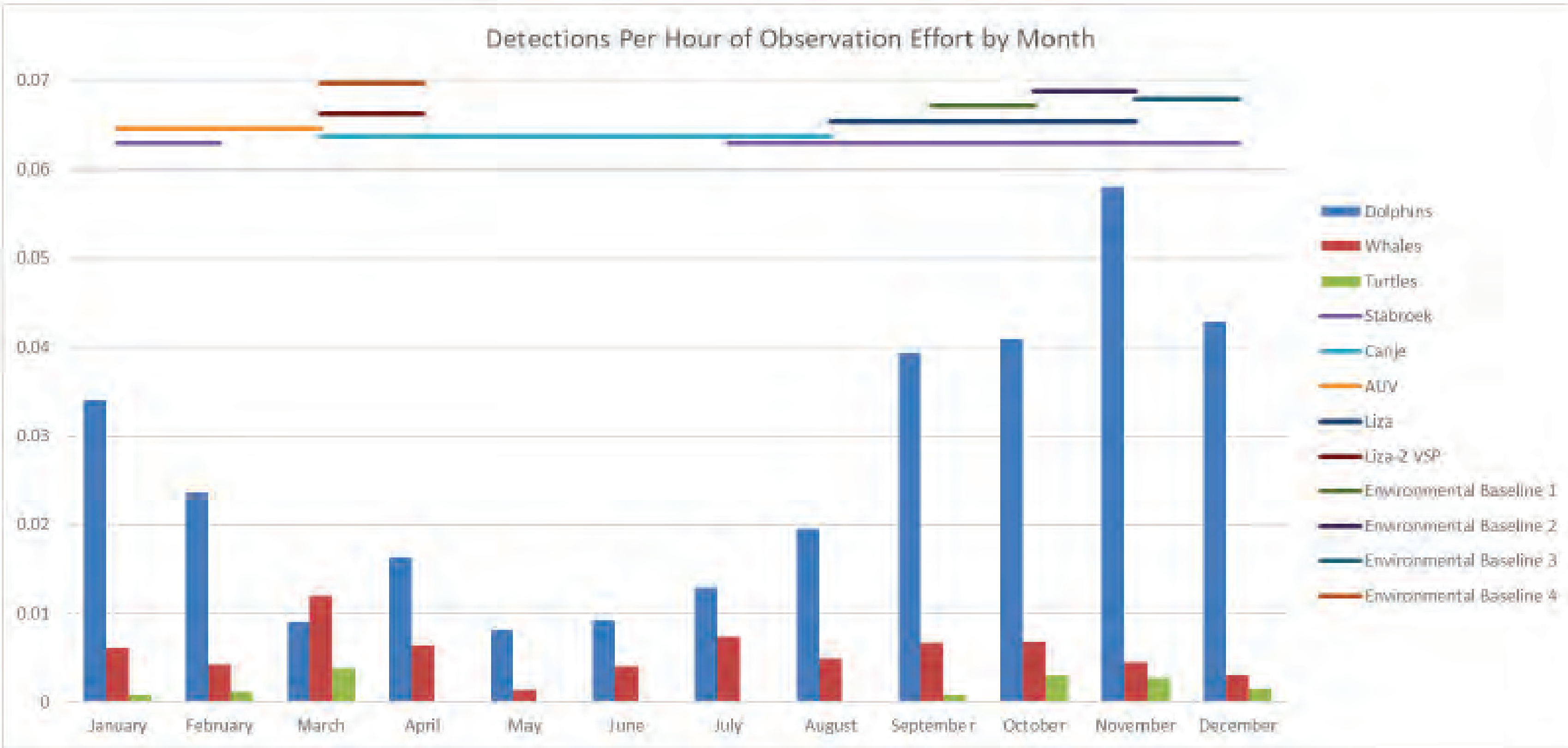


Figure 7.5-2: Season Variations in Marine Mammal Sightings in the Liza Marine Mammal Survey Area

Figure 7.5-3 summarizes the locations of marine mammal sighting across the various surveys.

A survey of nearshore waters conducted by Charles et al. (2004) of 125 Guyanese captains of trawl, drift seine, and red snapper fishing vessels found that these vessels usually encountered boto (*Inia geoffrensis*), tucuxi, spotted dolphin, common dolphin, spinner dolphin, and bottlenose dolphin. Although two of the six species mentioned in the captains' survey (botos and tucuxis) were not recorded in the Project-specific surveys, the findings of the captains' survey are consistent with the results from the Project-specific surveys, based on the following:

- Botos and tucuxis are typically considered more freshwater and estuary-oriented than the other species.
- The fishing boat captains did not mention frequent encounters with any whale species.
- The Guyana fishing fleet has historically concentrated its efforts in comparatively shallow continental shelf waters, south of the Project-specific survey area.
- The Project-specific survey did not document any whales farther south (i.e., shallower) than the 2,000-meter (approximately 6,561-foot) isobath.

The combined findings of the Project-specific studies and the 2004 survey of fishing captains (Charles et al. 2004) suggest that the Project, which will be located in depths ranging from 1,550 to 1,860 meters (approximately 5,085 to 6102 feet), is likely near the southern boundary of the primary habitat for whales offshore Guyana. These findings also suggest that dolphins may be present throughout the Project AOI and at all times of the year; however, they are likely to be more abundant in the Project AOI in the autumn and winter months.

Nearshore Project activities in or near the Demerara River could encounter West Indian manatees. A subspecies of the West Indian manatee is sometimes referred to as the Antillean manatee (*Trichechus manatus manatus*). Antillean manatees are sparsely distributed throughout the Caribbean and the Northwestern Atlantic Ocean, from Mexico, east to the Greater Antilles, and south to Brazil. They are found in French Guiana, Suriname, Guyana, Trinidad (though there has been a lack of recent sightings there), and Venezuela. Historically, Antillean manatees were hunted by local natives and sold to European explorers for food. Today, they are threatened by loss of habitat, poaching, entanglement with fishing gear, and increased boating activity.

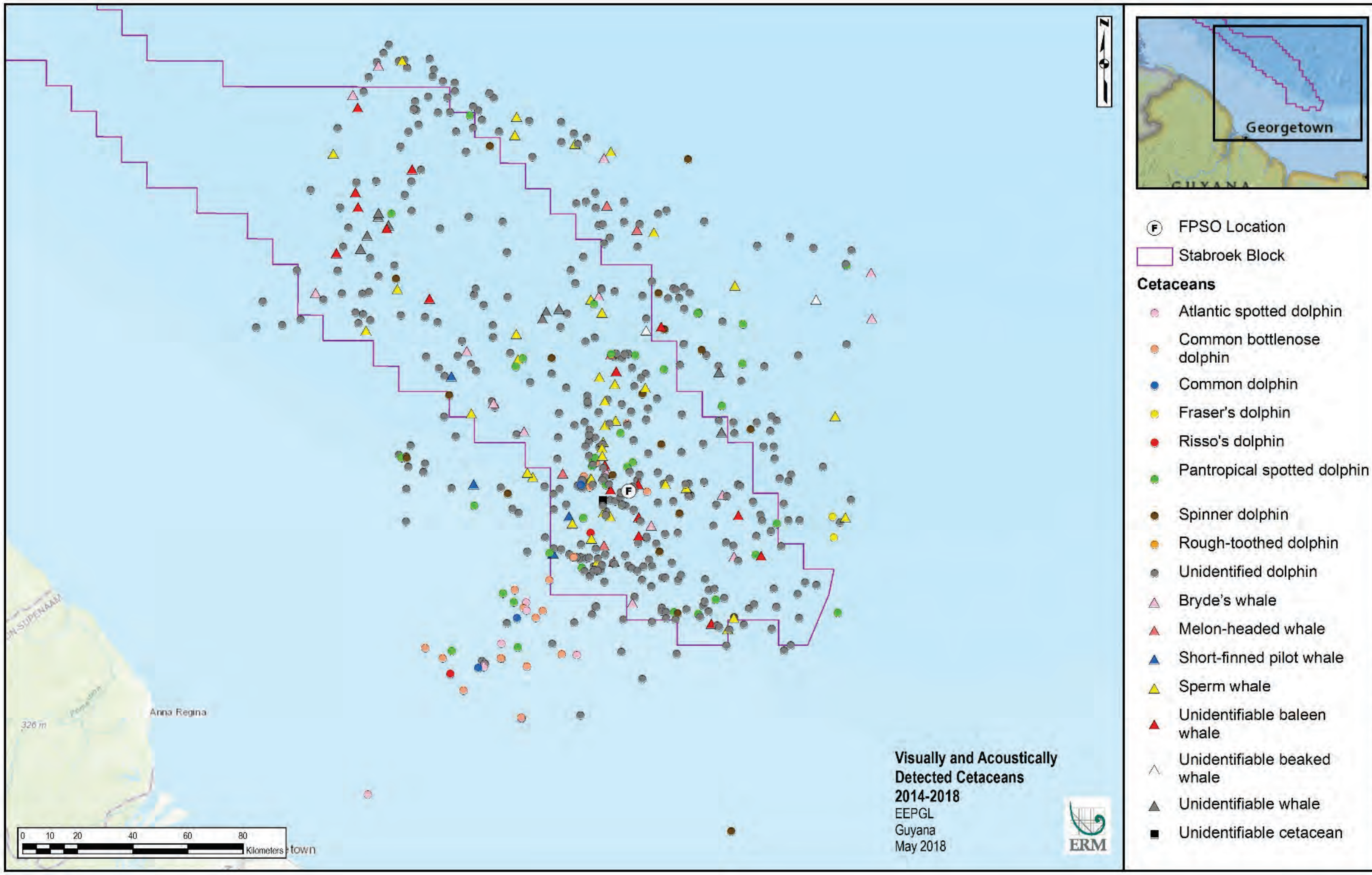


Figure 7.5-3: Locations of Marine Mammal Sightings Relative to the Stabroek Block

7.5.3. Impact Assessment—Marine Mammals

As described above, toothed whales (sperm, melon headed, and pilot whales) and dolphins (pantropical and bottlenose) are the marine mammal species most likely to be encountered in the PDA. Bryde's whales (*Balaenoptera brydei*) and other unidentified baleen whales have also been observed in offshore waters in the PDA. Nearshore, other dolphins such as common, spotted, and spinner dolphins may be encountered. The West Indian manatee is sparsely distributed in coastal and riverine waters of the region and may be encountered in the Demerara River area.

7.5.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.5-4, the impact assessment considers the potential for planned Project activities to impact marine mammals either through injury (e.g., as a result of exposure to sound from Project activities), toxicological effects (e.g., as a result of exposure to Project vessel discharges), or disturbance leading to changes in behavior and reduced vigor (e.g., as a result of light, sound and/or actions from Project activities).

Potential impacts on marine mammals from vessel strikes are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.5-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Mammals

Stage	Activity	Key Potential Impact
Development Well Drilling FPSO and Subsea, Umbilicals, Risers, and Flowlines (SURF) Installation	Vessel operations	• Sound disturbance leading to deviation from area
	Power generation	• Sound exposure leading to PTS injury • Sound disturbance leading to deviation from area
	Vertical Seismic Profile (VSP)	
	Remotely operated vehicle (ROV) operations	
	Pile driving	
	Lighting on drill ship and installation vessels	• Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fish, and therefore a secondary attractant for some marine mammals.
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted liquid waste discharge	
Production Operations	Well stream production, processing, and storage operations	• Sound disturbance leading to deviation from area
	Power generation	
	Permitted cooling and produced water discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted other liquid waste discharge	

Stage	Activity	Key Potential Impact
	Lighting on FPSO	• Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fish, and therefore a secondary attractant for some marine mammals.
	Operation of tankers, tugs, and supply and support vessels	• Sound disturbance leading to deviation from area
Decommissioning	Vessel operations	• Exposures to permitted discharges, potentially leading to toxicological impacts. • Sound disturbance leading to deviation from area

7.5.3.2. Magnitude of Impacts—Marine Mammals

Potential for Permanent Threshold Shift Injury from Underwater Sound

The main sources of underwater sound associated with development well drilling activities are from the VSP[8] activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). The primary sources of sound from FPSO and Subsea, Umbilicals, Risers, and Flowlines (SURF) installation activities are from impact pile drivers for the FPSO mooring system and for selected SURF equipment such as manifolds (generating impulsive sound) and marine vessels (generating non-impulsive sound). Sound sources from production operations and decommissioning activities are primarily limited to marine vessels (generating non-impulsive sound).

Underwater sound can potentially cause impacts on marine mammals due to behavioral changes impacting life functions (e.g., feeding, breeding, migration route deviations), direct physical impacts affecting auditory systems, or - in extreme cases - other physical damage or behavioral reactions leading to death.

Marine Mammal Auditory Functions

The potential for anthropogenic sound to impact marine animals depends on how well the animals can hear the sound. Sounds are less likely to disturb if they are at frequencies that the animals cannot hear well. However, when the sound pressure is high enough, it can cause physical injury through non-auditory mechanisms (i.e., barotrauma). For sound levels below such extremes, frequency weighting may be applied to scale the importance of sound components at particular frequencies in a manner reflective of an animal's sensitivity to those frequencies.

Auditory weighting functions for marine mammals, called M-weighting functions, were proposed by Southall et al. (2007) and modified by the U.S. National Oceanic and Atmospheric Administration (NOAA 2013) and Finneran (2015). For this assessment, values are presented for

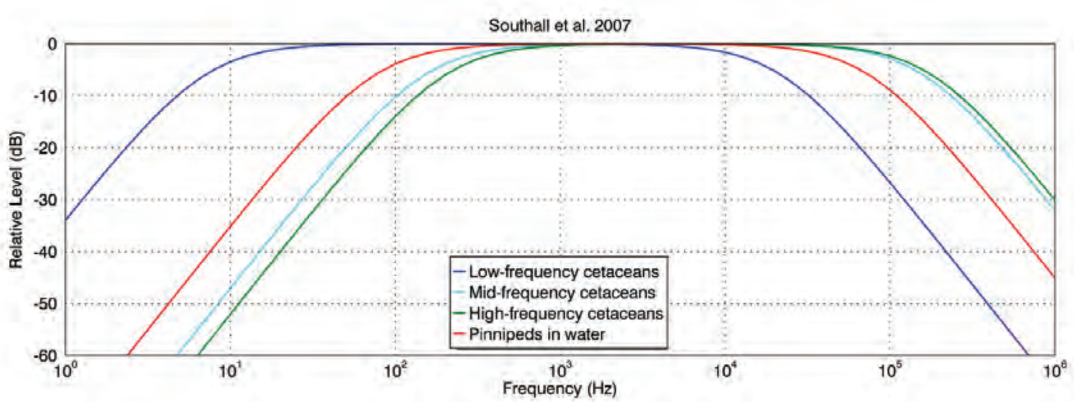
[8] The VSP has a small source that produces seismic impulses over a period of time (for the purposes of this assessment, it was assumed that the source will produce 20 to 40 seismic pulses, less than 1 second in length, over a 6- to 12-hour period). The wavefield generated by this source is recorded by instruments in the borehole.

both the Southall et al. (2007) M-weighting functions and the weighting functions suggested by Finneran (2015).

Southall et al. (2007) proposed M-weighting functions for five functional hearing groups of marine mammals:

- Low-frequency cetaceans (LFCs)—mysticetes (baleen whales);
- Mid-frequency cetaceans (MFCs)—some odontocetes (toothed whales);
- High-frequency cetaceans—odontocetes specialized for using high-frequencies;
- Pinnipeds in water[9]—seals, sea lions, and walruses; and
- Pinnipeds in air (not addressed here).

NOAA (2013) suggested further modifications to the LFC function, as well as two variations (for phocid and otariid pinnipeds) to the Southall et al. (2007) M-weighting function for pinnipeds in water. A U.S. Navy Technical Report (Finneran 2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follow the sensitivity of the human ear at low sound levels. Although the inclusion of some species changed (e.g., the addition of hourglass [*Lagenorhynchus cruciger*] and Peale's [*Lagenorhynchus australis*] dolphins to the high-frequency functional hearing group), the five recommended functional hearing groups remain those presented in NOAA 2013. More information on the marine mammal auditory weighting functions described above, including the analytical formulation of these metrics, is provided in Appendix F, Underwater Sound Modeling Report.[10] The auditory weighting functions recommended by Southall et al. (2007) and Finneran (2015) are shown on Figure 7.5-4 and 7.5-5, respectively.

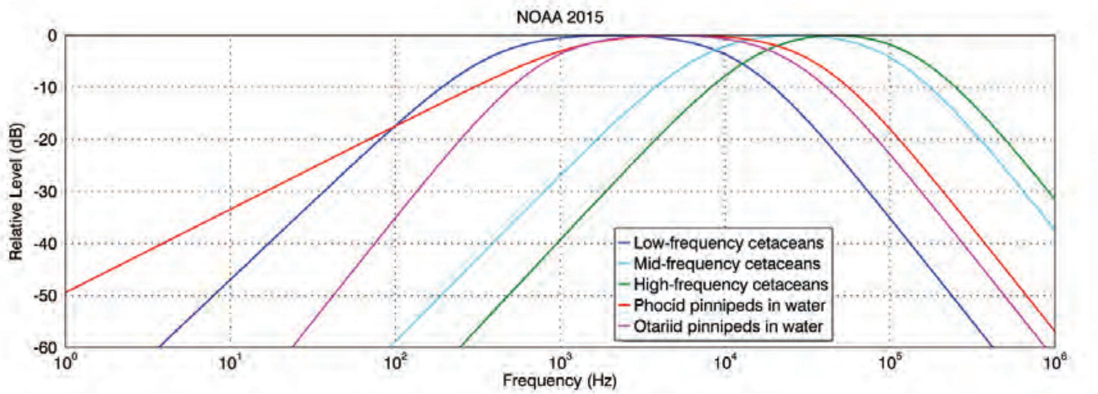


Source: JASCO 2016

Figure 7.5-4: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Southall el al. (2007)

9 Pinnipeds were included in Southall et al 2007, but are not relevant to the analysis of auditory impacts because pinnipeds are either likely extinct or extirpated offshore Guyana.

10 The results of the 2016 study provided in Appendix F (originally prepared for the Liza Phase 1 Project) have been determined to be appropriate for use in the underwater sound impact assessment for the Liza Phase 2 Project (see discussion below).



Source: JASCO 2016

Figure 7.5-5: Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Finneran (2015)

LFCs (including baleen whales) and MFCs (including dolphins and toothed whales) have been observed within or near the PDA, so this section focuses on these marine mammal hearing groups only.

JASCO conducted underwater sound modeling for the Liza Phase 1 Development Project EIA (JASCO 2016). For the purpose of the Liza Phase 2 Development Project EIA, JASCO compared the design, location, and layout of the Liza Phase 1 and Liza Phase 2 Development Projects and made the following determination:

> "Therefore, based on the close proximity of the Phase 1 and Phase 2 sound source locations, the homogeneous environmental properties over a large area that encompasses both the Phase 1 and Phase 2 Project Development Areas, and the similarity in noise-producing activities for Phase 1 and Phase 2, we estimate that model results for the Phase 2 scenarios would present little or no changes in the distances to marine mammal injury thresholds provided for Phase 1." (JASCO 2018)

JASCO provided a technical memorandum describing the basis for their determination, which is included in Appendix F, Underwater Sound Modeling Report. Based on JASCO's determination that the results of the modeling analysis completed for the Liza Phase 1 Development Project are applicable to the impact assessment for the Liza Phase 2 Development Project, the description of the modeling analysis below references JASCO's original analysis for the Liza Phase 1 Development Project.

The modeling was performed for two types of sources: impulsive and non-impulsive. Impulsive sources such as VSP and impact pile driver activities are typically brief and intermittent, with a rapid rise time and decay. Piles can be driven to the seabed using different types of impact hammer types, such as diesel hammer, air or steam hammer, and hydraulic hammer. Diesel hammers produce underwater sound waveforms with each pile strike that are similar to those of air hammers; hydraulic hammers produce a somewhat different waveform signature with a much more rapid rise time. Driven piles may be used *in lieu* of or in combination with suction piles. A suction pile (or suction caisson) can be conceptually described as an upturned bucket that is embedded in the marine sediment by pushing or by creating a negative pressure inside the caisson skirt. The suction caisson technology functions very well in a seabed with soft clays or other low-strength sediments and is in many ways easier and quieter to install than driven piles, which must be hammered into the seabed. For the purpose of this assessment, it was conservatively assumed that only impact pile drivers will be used (i.e., no suction piles).

In contrast, non-impulsive sources such as marine vessels' main propulsion systems and internal machinery (e.g., generators, cranes) can be brief or prolonged, and continuous or intermittent. However, non-impulsive sources do not have the high peak pressure and rapid rise time that impulsive sounds do.

Three complementary acoustic models (AASM[11], MONM[12], and FWRAM[13]) were used to predict underwater acoustic fields for the Project's potential sound sources. The model results were used to estimate distances to marine mammal injury (permanent threshold shift [PTS][14]) thresholds, based on best available science. Source levels for the VSP were predicted using JASCO's AASM.

The VSP source considered here is a six-element source array with a total volume of 1,200 cubic inches. The AASM produces a set of "notional" signatures for each array element based on:

- Source array layout;
- Volume, tow depth, and firing pressure of each element in the source array; and
- Interactions between different elements in the array.

For the modeling, source level spectra from measurements of surrogate vessels, including FPSOs, drill ships, pipelaying vessels, tugs, and support vessels, were adjusted to the specifications of the proposed Project vessels. Surrogate vessels were chosen based on similarity in vessel specifications and types of operation to those of the Project.

Underwater sound propagation (i.e., transmission loss) was modeled with JASCO's MONM and FWRAM. The 3D acoustic fields were computed by modeling transmission loss within multiple 2D vertical planes extending from the source. The underwater sound fields were modeled for water column sound speed profiles representative of the month of April. This time corresponds with the historically lowest surface temperatures, which lead to upward sound refraction and longer-distance sound propagation. Predicted sound fields were assessed across three dimensions, and the perceived sound level reported at each point in the horizontal plane is the maximum predicted sound level over all modeled depths for that point on the horizontal plane.

Based on these reported sound levels in the horizontal plane, two distance parameters were reported for each threshold:

[11] Air gun Array Source Model

[12] Marine Operations Noise Model

[13] Full Waveform Range-dependent Acoustic Model

[14] PTS is a sound-induced impact that results in a decrease in hearing sensitivity that is not expected to improve over time (OSHA 2013).

- R_{max}, the maximum horizontal distance from the source where the predicted sound level reaches a threshold; and
- $R_{95\%}$, the maximum horizontal distance from the source where the predicted sound level reaches the threshold after the 5 percent of the predicted threshold-exceeding area farthest from the source is excluded. Regardless of the geometric shape of the "maximum-over-depth" footprint, $R_{95\%}$ is the predicted range encompassing at least 95 percent of the area (in the horizontal plane) that will be exposed to sound at or above the threshold.

Six scenarios were considered in this modeling study:

1. The operation of an FPSO vessel;
2. The installation of the FPSO vessel, which includes mooring the FPSO and using several installation and service vessels;
3. The installation and operation of a drill center, which includes the operation of a drill ship and a pipelaying vessel for the installation of SURF at Drill Center 2-P, approximately 13 kilometers (approximately 8 miles) north of the FPSO,
4. The operation of a VSP in the vicinity of Drill Centers 2-P and 2-I;
5. The installation of manifold foundation piles for SURF equipment at Drill Center 2-P through underwater impact pile driving; and
6. The installation of anchor mooring piles at the FPSO location through underwater impact pile driving.

The sound footprint for each scenario was modeled to estimate the above-referenced distance parameters assuming thresholds are equal to the injury criteria prescribed by Southall et al. (2007) and Finneran (2015). The sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SELs) assuming 24 hours of operation. The sound footprints account for source-specific sound emission characteristics and site-specific environmental parameters.

Additional information on the underwater sound modeling methodology, including a detailed description of all model input parameters and approximate locations of modeled sources for all scenarios, is provided in Appendix F, Underwater Sound Modeling Report.

Underwater Sound Criteria

Potential auditory impacts of planned Project activities on marine mammals were evaluated using Southall et al. (2007) and Finneran (2015) acoustic threshold levels for onset of PTS in LFCs and MFCs (Table 7.5-5).

Table 7.5-5: Acoustic Threshold Levels for Onset of PTS in Low-Frequency Cetaceans and Mid-Frequency Cetaceans

Marine Mammal Hearing Group	Estimated Auditory Bandwidth	PTS Onset Acoustic Thresholds (Injury Criteria)			
		Impulsive		Non-impulsive	
		Peak Sound Pressure Level (unweighted) (dB peak)	SEL (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	Peak Sound Pressure Level (unweighted) (dB peak)	SEL (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)
Southall et al. 2007					
LFCs (baleen whales)	7 Hz to 22 kHz	230	198	230	215
MFCs (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	198	230	215
Finneran 2015					
LFCs (baleen whales)	7 Hz to 25 kHz	230	192	Not available	207
MFCs (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	187	Not available	199

μPa = microPascal; dB = decibel; Hz = hertz; kHz = kilohertz; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Modeling Results

Tables 7.5-6 to 7.5-11 present the above-referenced distance parameters describing modeled horizontal distances to the point that Project associated sound would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs, according to Southall et al. (2007) and Finneran (2015) criteria, for the six above-referenced scenarios, respectively. Decommissioning activities were not subjected to underwater sound modeling, as activities during the decommissioning stage will be similar to those of SURF installation activities in terms of types of sound sources (i.e., marine vessels only). Further, decommissioning activities will be shorter in duration and involve a smaller fleet of marine vessels; therefore, the potential underwater sound impacts on marine fauna for decommissioning are expected to be no greater than those of SURF installation activities (Scenario 3).

The results presented in the tables below account for embedded controls for underwater sound management. Specifically, EEPGL will use the following embedded controls for the Project (see Section 2.13, Embedded Controls):

- Gradually increasing intensity of seismic impulses to allow sensitive species to vacate the area before injury occurs (i.e., soft starts), use of MMOs during VSP, and implementation of other measures recommended by the Joint Nature Conservation Committee (JNCC 2017), as applicable; and
- Maintaining equipment, marine vessels, and helicopters in good working order and operating them in accordance with manufacturers' specifications so as to limit sound levels to the extent reasonably practicable.

Table 7.5-6: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 1—FPSO Operations

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Non-impulsive sources (marine vessels)						
Low-frequency cetaceans	215	6	6	207	<5	<5
Mid-frequency cetaceans	215	<5	<5	199	<5	<5

Source: JASCO 2016
µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-7: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 2—Installation of the FPSO Vessel, Including Mooring the FPSO and Using Several Construction and Service Vessels

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	215	<5	<5	207	<5	<5
Mid-frequency cetaceans	215	--	--	199	--	--

Source: JASCO 2016
µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level
"—" = predicted sound levels at all locations are below injury criteria.

Table 7.5-8: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 3—Installation of a Drill Center, Including Operation of a Drill Ship and a Pipelaying Vessel

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Non-impulsive sources (marine vessels)						
Low-frequency cetaceans	215	9	9	207	6	6
Mid-frequency cetaceans	215	<5	<5	199	--	--

Source: JASCO 2016
µPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-9: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 4—Completion of a Vertical Seismic Profile

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	73	68	192	39	36
Mid-frequency cetaceans	198	35	32	187	--	--

Source: JASCO 2016
μPa = microPascal; dB = decibel; m = meter; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-10: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 5—Installation of Manifold Foundation Piles

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	1,300	NV	192	1,025	NV
Mid-frequency cetaceans	198	762	NV	187	136	NV

Source: JASCO 2016
μPa = microPascal; dB = decibel; m = meter; NV = no value; s = second; SEL_{24h} = 24-hour sound exposure level

Table 7.5-11: Modeled Horizontal Distances to Below PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans and Mid-Frequency Cetaceans: Scenario 6—Installation of Mooring Piles for the FPSO

Marine Mammal Hearing Group	Injury Criteria and Distances to Criteria Levels					
	Southall et al (2007)			Finneran (2015)		
	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa^2.s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	1,375	NV	192	1,075	NV
Mid-frequency cetaceans	198	725	NV	187	100	NV

Source: JASCO 2016
μPa = microPascal; dB = decibel; m = meter; NV = no value; s = second; SEL_{24h} = 24-hour sound exposure level

The results for the six scenarios are discussed below. It is important to note these results assume that the sources are stationary for 24 hours, and that the marine mammal is present within the stated distance for the entire accumulation period (24 hours). This adds an element of conservatism to the assessment because no marine mammal would be expected to stay within the modeled injury zone for the entire 24-hour duration on which the threshold is based.

Scenario 1—FPSO Operation

Modeling predicted that non-impulsive underwater sound for Scenario 1 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 6 meters and less than 5 meters, respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 2—Marine Vessels during FPSO Installation

Modeling predicted that non-impulsive underwater sound for Scenario 2 would attenuate to below PTS onset acoustic thresholds for LFCs at a maximum horizontal distance of less than 5 meters (based on the more conservative injury criteria for the marine mammal hearing group). Modeling predicted that MFCs would not be impacted at any distance under this scenario because the predicted underwater sound in the mid-frequency range would be below PTS onset acoustic thresholds at all locations.

Scenario 3—Marine Vessels (Drill Ship, SURF installation vessels)

Modeling predicted that non-impulsive underwater sound for Scenario 3 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 9 meters and less than 5 meters, respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 4—Vertical Seismic Profile

Modeling predicted that impulsive underwater sound from the VSP for Scenario 4 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 73 meters and 35 meters (approximately 240 and 115 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 5—Pile Driving during Drilling and SURF Installation

Modeling predicted that impulsive underwater sound from pile driving for Scenario 5 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 1,300 meters and 762 meters (approximately 4,270 and 2,500 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 6—Pile Driving during FPSO Installation

Modeling predicted that impulsive underwater sound for Scenario 6 would attenuate to below PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 1,375 and 725 meters (approximately 4,510 and 2,380 feet), respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Summary of Potential for Injury Due to Underwater Sound

With respect to acoustic injury thresholds, 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 for both LFCs and MFCs are largest for pile driving, although the area within which injury could potentially occur would be over 40 percent smaller for MFCs than for LFCs. Regardless of which type of pile installation methodology is used (impact driven or suction), neither group of marine mammals would be expected to experience a population-level impact. Based on the premise that marine mammals will actively avoid physical discomfort associated with Project-related sound, if impact-driven piles are used, MFCs would be expected to generally avoid the portion of the water column within at least approximately 700 meters from the location where pile driving is taking place and LFCs would be expected to generally avoid the portion of the water column within at least approximately 1,400 meters of the activity. Both categories of cetaceans would be expected to avoid these areas for the duration of the pile-driving activity.

Figure 7.5-6 illustrates the vertical distances to acoustic injury thresholds for Scenario 6 (Installation of Mooring Piles for the FPSO). As shown in the figure, 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 3,900 feet] in tropical and subtropical latitudes) (Mate undated; Watwood et al. 2006; Amano and Yoshioki 2003) but not deep enough that they could potentially be exposed to injurious sound levels within the PDA. Even if an individual of an MFC species were to dive to a sufficient depth to encounter the acoustic injury threshold, it would be physiologically unable to dive to these depths for a sufficient duration to cause injury.

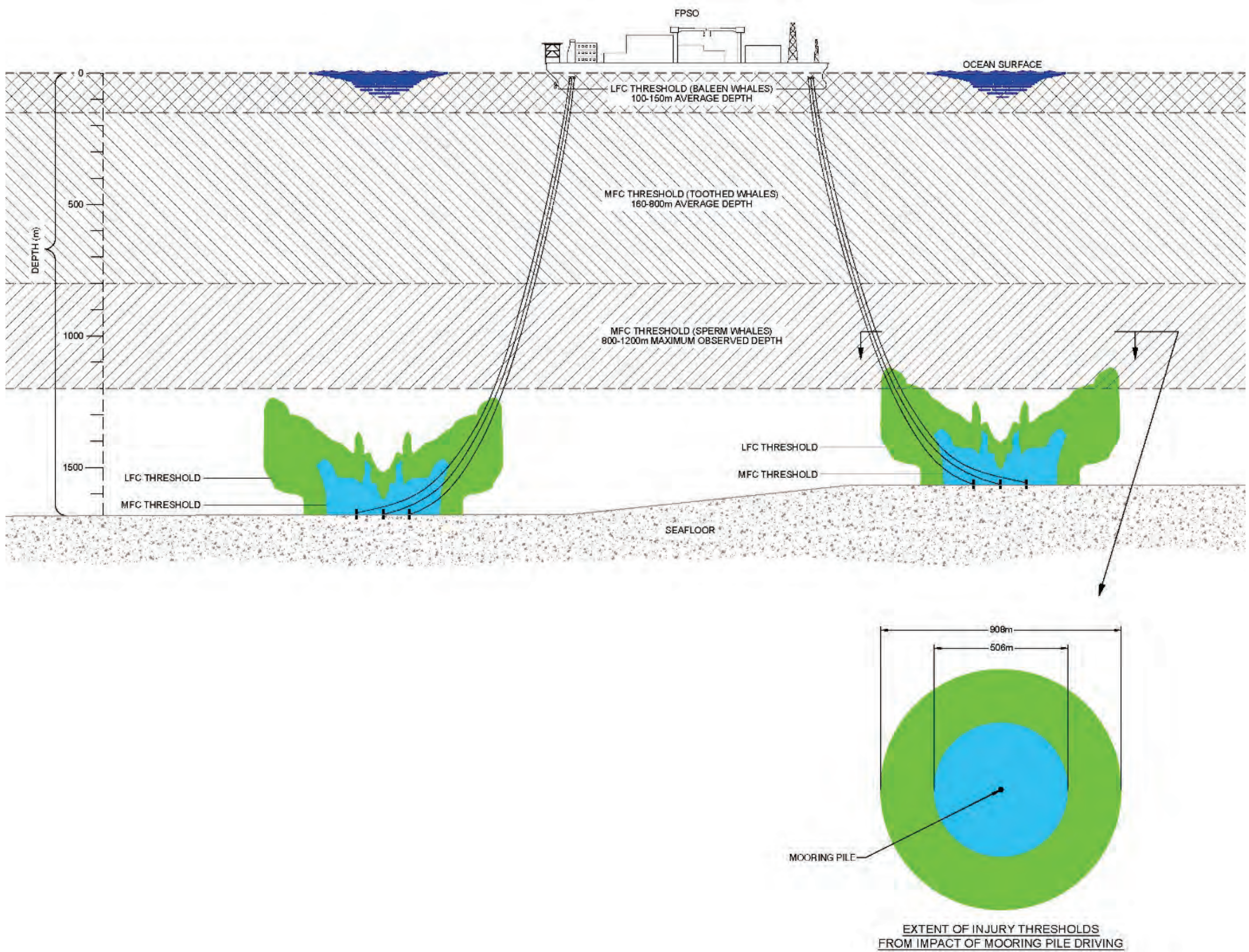


Figure 7.5-6: Vertical and Horizontal Distances to Acoustic Injury Thresholds from FPSO Mooring Pile Driving and Cetacean Dive Characteristics

PTS (were it to occur) would be irreversible by definition, but given the depth of the water in the PDA and the physiological limitations that would prevent marine mammals from diving deep enough and for a long enough period of time to experience PTS, pile driving is not expected to result in permanent injury to marine mammals passing through the PDA or irreversible effects on their hearing abilities.

Magnitude Rating—Potential Injury Due to Project Sound

The magnitude of potential acoustic injury impacts on marine mammals is considered **Negligible** because the potential for marine mammals to be exposed to sufficient sound levels for a sufficient duration to cause injury is extremely small. This conclusion is based on the following considerations:

- The activity that presents the greatest risk of acoustic injury to marine mammals (pile driving) will only occur during the initial installation stage, and therefore represents a relatively short-term source of potential impact.

- EEPGL has committed to using MMOs and soft-start procedures for VSPs in accordance with JNCC guidelines, and soft starts for pile driving to further reduce the potential for impacts on marine mammals.
- Most of the marine mammals expected to be present in the PDA do not dive to the depths that will be required or, if they do, to remain submerged at these depths for sufficient time to experience acoustic injuries.
- If an individual mammal were to approach an operating VSP or pile driver, they would experience disturbance prior to being exposed to sound levels above injury thresholds, and would be expected to divert away from the source.

Disturbance from Underwater Sound

Anthropogenic sounds below acoustic injury thresholds have the potential to mask relevant sounds in the animals' environment. This masking can occur due to both natural and anthropogenic sounds (Hildebrand 2005). The behavioral changes that can occur due to masking can have ecological consequences for marine mammals. These may include changes in biologically important behaviors (e.g., breeding, calving, feeding, or resting); changes in diving behavior (e.g., reduced or prolonged dive times, increased time at the surface, or changes in swimming speed); and changes in historical migration routes (NOAA undated).

Although the above changes could occur in the PDA as a result of Project-generated sound, findings from U.S. territorial waters suggest that the population-level significance of disturbance from impulsive sound over a small area such as the PDA will likely be minor. NMFS reported that;

> "…available data do not indicate that sound and disturbance from oil and gas exploration and development activities since the mid-1970s had lasting population level adverse impacts on bowhead whales. Data indicate that bowhead whales are robust, increasing in abundance, and have been approaching (or have reached) the lower limit of their historic population size at the same time that oil and gas exploration activities have been occurring in the Beaufort Sea and, to a lesser extent, the Chukchi Sea." (MMS and NOAA 2007)

The U.S. Bureau of Ocean Energy Management (BOEM) found that despite more than 50 years of oil and gas exploration and development in the Gulf of Mexico, there are no data to suggest that these activities are significantly impacting marine mammal populations (BOEM 2014). Furthermore, the PDA is not known to be an important feeding, breeding, or calving area. Individual animals may divert around an operating pile driver or VSP to avoid Project-generated sound, but no significant impacts on life functions or potential population-level implications from underwater sound are expected. However, the potential extent for disturbance impacts will be larger than the extent for potential injury effects, meaning some of the factors that contribute to limiting the magnitude of potential injury impacts are less relevant. Accordingly, as a conservative measure, magnitude of potential disturbance impacts on marine mammals is considered **Medium**.

Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges will begin during the development well drilling and FPSO/SURF installation stages and continue through the production operations stage and into the decommissioning stage. As described in Chapter 2, Description of the Project, and Section 6.4.3, Impact Assessment—Marine Water Quality, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine mammals will be transient in the PDA and the duration of their exposure to any discharges will be very limited. Any potential impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone. The magnitude of potential impacts on marine mammals from exposure to permitted discharges is therefore considered **Negligible**.

Impacts from Artificial Lighting

Artificial lighting is not known to directly attract or disturb marine mammals, so any potential impacts of artificial light on marine mammals are likely to be indirectly caused by a potential change in local forage availability through changes in prey distribution. Fish are known to be attracted to artificial light, and even plankton are sometimes capable of weak volitional movement through the water column in response to changing ambient light levels. Small fish and/or plankton make up a substantial part of most marine mammals' diets, so to the extent that Project vessels could facilitate the concentration of plankton and/or small fish at the surface or around the vessels, food density would increase and marine mammals may also be attracted to the vessels to feed more efficiently. This impact is expected to be limited to only the immediate vicinity of the vessels. Potential impacts on marine mammals from Project lighting are therefore considered to be **Positive**, due to the potential for attracting food sources and the lack of documented adverse effects on marine mammals from artificial lighting.

7.5.3.3. Sensitivity of Receptors—Marine Mammals

As discussed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species, because one of the marine mammals observed in the PDA is listed as Vulnerable (VU) by IUCN, the marine mammals impact assessment was conducted based on the conservative assumption that this VU species (i.e., sperm whale) would be the receptor for potential impacts. Accordingly, the receptor sensitivity ratings for special status species were used, as defined in Table 7.5-12.

Table 7.5-12: Definitions for Receptor Sensitivity for Potential Impacts on Special Status Species (Adopted for Potential Impacts on Marine Mammals)

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; species not meeting criteria for high value; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List as Critically Endangered or Endangered; species having a globally restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 km^2), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

Based on the definitions above, the representative species assumed to be the receptor for potential impacts is considered to have a **Medium** sensitivity.

7.5.3.4. Impact Significance—Marine Mammals

Based on the magnitude of impact and receptor sensitivity ratings described above, the significance ratings for potential impacts on marine mammals ranges from **Negligible** to **Moderate** (with one Positive rating).

7.5.4. Mitigation Measures—Marine Mammals

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine mammals. Table 7.5-13 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine mammals. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine mammals-specific methodology described in Sections 7.5.3.2 and 7.5.3.3.

Table 7.5-13: Marine Mammals - Pre-Mitigation and Residual Impact Significance Ratings

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, plus elevated temperature during production operations)	Negligible	Medium	Negligible	None	Negligible
	Offshore lighting as an attractant of food sources for marine mammals	Positive	Positive	Positive	None	Positive
Development Well Drilling FPSO/SURF Installation	Injury from sound exposure	Negligible	Medium	Negligible	None	Negligible
	Disturbance from sound exposure	Medium	Medium	Moderate	None, other than implementation of embedded controls (e.g., soft start procedures for VSP and pile driving)	Moderate

7.6. MARINE TURTLES

7.6.1. Administrative Framework—Marine Turtles

Table 7.6-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine turtles.

Table 7.6-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Turtles

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.6.2. Existing Conditions—Marine Turtles

According to the *Regional Sea Turtle Conservation Program and Action Plan for the Guianas* (Reichart et al. 2003), marine turtles are an important natural resource shared by the countries of the "Guiana Shield region," which encompasses the nations of Venezuela, Guyana, Suriname, French Guiana, and Brazil. Observations collected during exploration activities from 2015 to 2018 and turtle telemetry studies conducted at Shell Beach, as well as data from Reichart (2003) and more recent compilations from Project GloBAL (2007), represent the main sources of data for turtles in the Project AOI. In addition, information on the interaction between marine turtles and trawl fisheries on the Guianas shelf since the 1970s was reviewed (Pritchard 1973; 1991).

7.6.2.1. Regional Setting and Species Descriptions

Five marine turtle species are found in the region, all of which occur in Guyanese waters. Four of these species (green turtle [*Chelonia mydas*], leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], and olive ridley turtle [*Lepidochelys olivacea*]) nest on Guyana's beaches. Loggerhead turtles (*Caretta caretta*) also occur offshore Guyana, but rarely come ashore. In addition to sandy beaches for egg-laying, as a group, marine turtles require healthy coral reef, seagrass, and hard-bottom habitats for food and refuge, although the relative importance of these habitats varies by species. Based on each species' known habitat requirements, some green turtles likely remain in Guyana waters as juveniles to feed in the sargassum mats while the other species largely move to clearer waters and coral reefs to the north after hatching (Piniak and Eckert 2011).

Green turtles are generally found in tropical and subtropical waters along coastlines and continental islands between the latitudes of 30° North and 30° South. They are distributed worldwide, nesting in more than 80 countries and inhabiting the coastal waters of more than 140 countries (NMFS and USFWS 2007). Green turtles are listed as endangered by the IUCN and are protected from exploitation in most countries. Adult green turtles are benthic herbivores (Bjorndal 1997); they play an important role in seagrass ecosystems by pruning them, increasing the nutrient cycle and preventing the creation of sediment (Bjorndal and Jackson 2003; Jackson 2001). Their migrations have two phases: they travel rapidly to the open ocean in a straight line and then move more slowly toward the migration coasts (Troëng et al. 2005).

Leatherback turtles are the largest of all marine turtle species and do not have a hard shell like other marine turtles; instead, their shell is made of leathery tissue. Leatherbacks are found in pelagic tropical and temperate marine waters, where they spend most of the time feeding on jellyfish, salps, and siphonophores (Dass 2011); however, they are also known to forage along coastlines. Leatherbacks make extensive seasonal migrations between different feeding areas and nesting beaches at the same location every year (NOAA Fisheries undated). Leatherback turtles nest from March to mid-July along the Caribbean coast (Troëng et al. 2004). Young leatherback turtles can remain in tropical latitudes until the length of their shell reaches approximately 40 inches (Eckert 1999). The largest nesting colony in the Caribbean region is located in Yalimapo, French Guiana (IUCN 2012). Smaller numbers of nests can also be found in Guyana, Venezuela, Trinidad, and Colombia. This species is listed by the IUCN as Vulnerable (VU).

The hawksbill turtle is a small to medium-sized marine turtle that has an elongated head that tapers to a point with a beaklike mouth, which is how it received its name (NOAA 2014). These turtles are circumtropical and can be found in waters from latitudes of 30° North to 30° South in the Atlantic, Pacific, and Indian oceans and use a wide range of broadly separated localities and habitats during their lifetimes (Mortimer and Donnelly 2008). However, individuals located within the Atlantic Ocean primarily feed on sponges and are found within lagoons, ledges, and caves associated with coral reef environments (NOAA 2014). These types of habitats are generally found northwest of the PDA in the Caribbean Sea. This species is listed as Critically Endangered (CR) by the IUCN (Mortimer and Donnelly 2008).

The loggerhead turtle is an oceanic turtle distributed throughout the world. It is found in the Atlantic, Pacific, and Indian oceans, as well as the Mediterranean Sea. It spends most of its life in saltwater and estuarine habitats, with females briefly coming ashore to lay eggs. The loggerhead turtle has a low reproductive rate; females lay an average of four egg clutches and then become quiescent, producing no eggs for 2 to 3 years. The loggerhead turtle is omnivorous, feeding mainly on bottom-dwelling invertebrates. Its large and powerful jaws serve as an effective tool for dismantling its prey. Young loggerheads are exploited by numerous predators; the eggs are especially vulnerable to terrestrial organisms. This species is classified by the IUCN as Endangered (EN), with high risk of extinction (Casale and Tucker 2017).

The olive ridley turtle is a small turtle compared to the other species listed above, with a circumtropical distribution. It is classified as Vulnerable (VU) by the IUCN (Abreu-Grobois and Plotkin 2008). While populations have declined in prior decades, they have stabilized in more recent years. Olive ridley turtles are best known for their behavior of synchronized nesting in mass numbers, termed *arribadas*. Females return to the same beach at which they first hatched to lay their eggs. The olive ridley is predominantly carnivorous, especially in immature stages of the life cycle. Animal prey consists of protochordates or invertebrates which can be caught in shallow marine waters or estuarine habitats. Common prey items include jellyfish, tunicates, sea urchins, bryozoans, bivalves, snails, shrimp, crabs, rock lobsters, and sipunculid worms.

Large nesting aggregations of green and leatherback turtles are located in the Guianas (Suriname and French Guiana), while smaller nesting areas are located from northwestern Guyana (Shell Beach) to Venezuela and some Caribbean islands (which includes the Leeward, Lesser, and Greater Antilles); the Gulf of Mexico (Central America); and Atlantic Ocean (the Bahamas; and the southern coast of the United States) (Piniak and Eckert 2011). The hawksbill turtle's range is primarily in the Caribbean Sea, with small nesting areas in the Guianas and in eastern Brazil. The olive ridley turtle primarily nests along the French Guiana coast with small nesting areas along the northeastern coast of Venezuela to Suriname and in eastern Brazil (Piniak and Eckert 2011).

The primary nesting site for all these species in Guyana is Shell Beach, located on the northwestern coast of Guyana. The exact locations of secondary nesting sites change due to coastal erosion, which creates and destroys nesting areas continuously, but they are generally distributed along the northwest coast between the Pomeroon River and the Waini River estuaries. Leatherback turtles are the most common species on Guyana's nesting beaches, while nesting green and hawksbill turtles are less common. According to the Center for Rural Empowerment and the Environment, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) occurs at night from February to August (PAC 2014).

The primary threats to marine turtles are poaching of eggs and adults, intentional and accidental fishing, and habitat disturbance and degradation due to marine pollution, coastal zone development, shore erosion, lighting, and debris. Population monitoring and conservation activities are limited, primarily due to the logistical challenges associated with the remoteness of primary nesting sites.

Although leatherback and olive ridley turtles occur at higher densities and thus show a corresponding higher frequency in shrimp trawls, juvenile greens and loggerheads are also taken as bycatch (see Project GloBAL 2007). Tambiah (1994) estimated that trawl nets in the Guianas caught 1,300 turtles annually, with mortality rates of 60 percent. Tambiah (1994) also reported that gillnet fisheries in Guyana and Suriname are an even bigger threat than trawl fisheries, incidentally capturing 21,600 marine turtles per year. However, the report documents the highest incidences of olive ridley bycatch occurring during the period prior to the nesting arribadas in Suriname (January to March), coinciding with the peak period for shrimp fisheries (February to May).

7.6.2.2. Marine Turtle Data for the Project Development Area

Thirteen distinct marine turtle detections occurred in the Stabroek Block between 2015 and 2018: two confirmed visual detections each for green, hawksbill, loggerhead, and olive ridley turtles, and five visual detections of unidentified turtles (RPS 2018). Leatherback turtles are known to occur in the Project AOI, as described above, but have not been detected in the Stabroek Block by project personnel to date.

The Sea Turtle Conservation Society[15] actively maps marine turtle movements, by placing satellite transmitter tags on individual turtles after they finish nesting. Starting on 21 May 2012, the Society mapped movements of three leatherback turtles from their nesting place at Shell Beach. Each remained offshore of Shell Beach and in Guyana's equatorial waters for several weeks. By the second to third week of June, two had moved farther offshore in transit to waters off the coast of Nova Scotia, while one remained in Guyanese waters until the third week of July and eventually transited to Honduran waters. One passed through the Stabroek Block before moving northward. These movements are consistent with other accounts (Pritchard 1973) that most sea turtles migrate far from nesting beaches during inter-nesting periods. Although habitat use by juvenile turtles are generally poorly understood, green turtles and hawksbills are generally thought to occur move offshore as juveniles (NOAA Fisheries 2014, NOAA Fisheries 2016).

In March 2018, the Consultants placed satellite tags on four green turtles (designated as Sibille, Becky, Violet, and Karin for the purpose of tracking) at Shell Beach during the first component of a satellite tagging study being conducted to satisfy the conditions of the Environmental Permit for the Liza Phase 1 Development Project. The initial tracking data analysis (for data collected up until 30 April 2018) for the four turtles indicated that two turtles (Sibille and Becky) remained in the immediate vicinity of Almond Beach, making small near-shore loops. One turtle (Violet) moved moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops, and the other turtle (Karin) moved over a larger distance, making small near-shore loops in the vicinity of Almond Beach and offshore loops between Venezuela, Trinidad, and Guyana. After the nesting event during which the turtles were tagged, three of the four turtles (Sibille, Becky, and Karin) returned to nest on Almond Beach two to three additional times in intervals ranging from 10 to 19 days. The fourth turtle (Violet) nested on Almond Beach and across the Barima-Waini River mouth, and re-nested after a longer time interval than the other

[15] www.conserveturtles.org

turtles (Figure 7.6-1). The tagged turtles' movement patterns documented to date in this study were typical of inter-nesting intervals for their species, which usually consist of four or five nests spaced apart by approximately two-week intervals (ERM 2018).

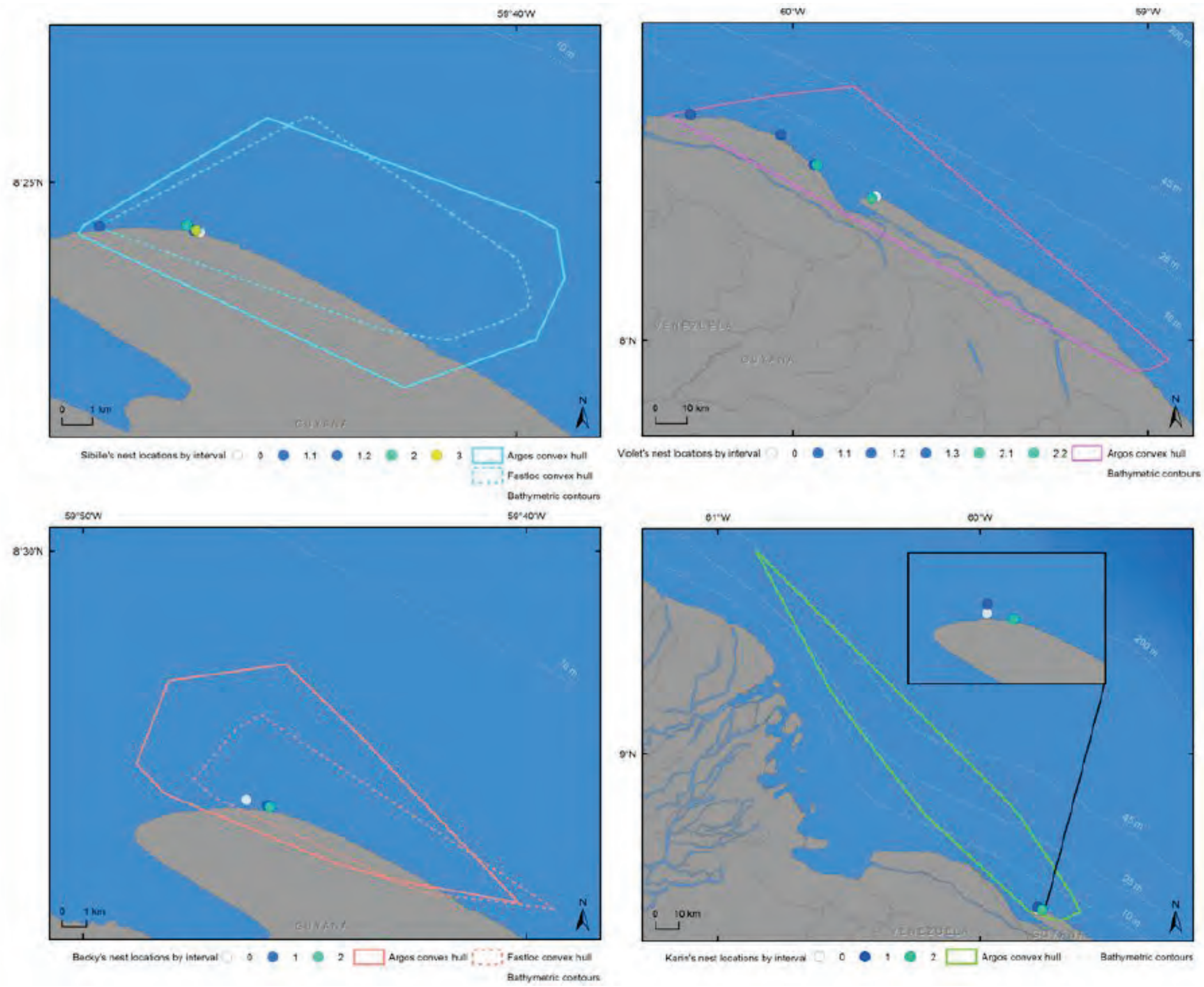
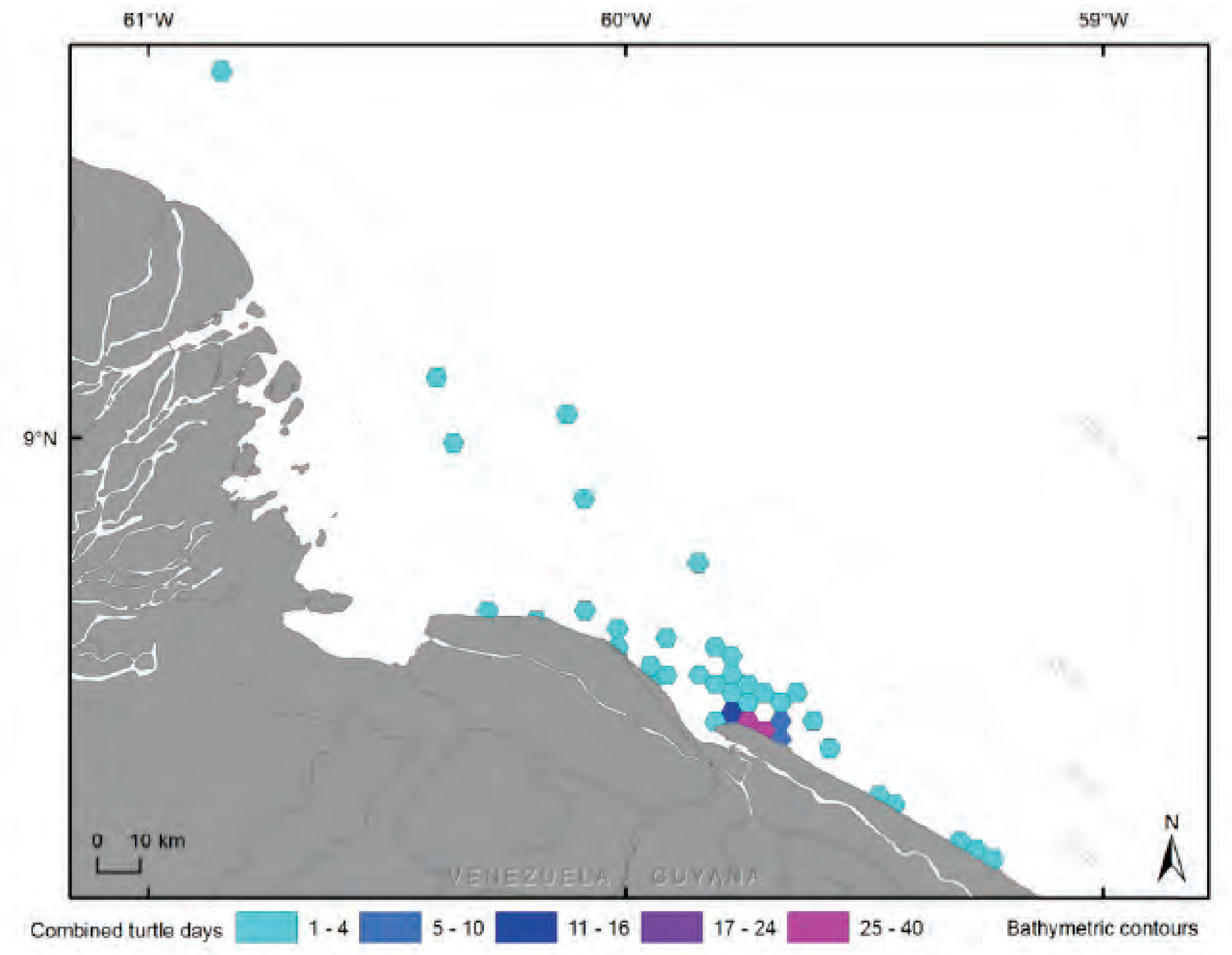


Figure 7.6-1: Probable Re-Nesting Locations of Four Green Turtles (*Chelonia mydas*) Tagged in March 2018 (data from 23-25 March 2018 through 30 April 2018)

While at sea between nesting, the turtles generally remained in shallow water. The greatest density of turtle locations occurred in less than 5 meters (approximately 16 feet) of water, very close to Almond Beach (Figure 7.6-2). The average water depths at which turtle satellite locations were recorded were less than 2 meters (approximately 6.6 feet) for two of the turtles, approximately 3 meters (approximately 10 feet) for one turtle, and approximately 12 meters (approximately 39 feet) for the fourth turtle. Analysis of the data available to date suggests the waters extending out to the 10 meter (approximately 33 foot) bathymetric contour are important habitat for nesting green turtles at Almond Beach during the nesting season. During this preliminary assessment of the inter-nesting period, turtles exhibited variable ranges in dispersal

(12 to 192 kilometers [approximately 7.5 to 119 miles]), but generally remained near the coast (ERM 2018).



Each hexagon represents an area of approximately 16.25 km^2

Figure 7.6-2: Habitat Use during Internesting Periods for Four Green Turtles (*Chelonia mydas*) Tagged during March 2018 (data from 23-25 March 2018 through 30 April 2018)

The two turtles that exhibited the widest internesting travels (Karin and Violet) were equipped with depth sensors in addition to GPS transmitters. These two turtles recorded maximum dives of up to 15 meters (approximately 49 feet), but data indicated that they spent most of their time in the upper 10 meters (approximately 33 feet) of the water column and spent between 25 percent and 50 percent of their time near the surface (less than 2 meters [approximately 6.6 feet]). Both of these turtles' tags returned more signals to the satellites than the other two turtles that remained closer to Almond Beach, indicating that they were at the surface and able to transmit more frequently than the other turtles. The two comparatively far-ranging turtles traveled well into Venezuelan waters, venturing 30 to 40 kilometers (approximately 18.6 to 25 miles) off the coast near the Orinoco Delta, and traveling approximately 60 kilometers (approximately 37.3 miles) southeast of Almond Beach (Figure 7.6-3). These two turtles very likely remained near the surface more than the others because the metabolic demands associated with their wider travels forced them to breathe more frequently than the other turtles. This finding implies that green turtles involved in long, cross-continental shelf movements before and after the nesting season are likely to remain near the surface where they will be relatively easy for shipboard observers to detect (ERM 2018).

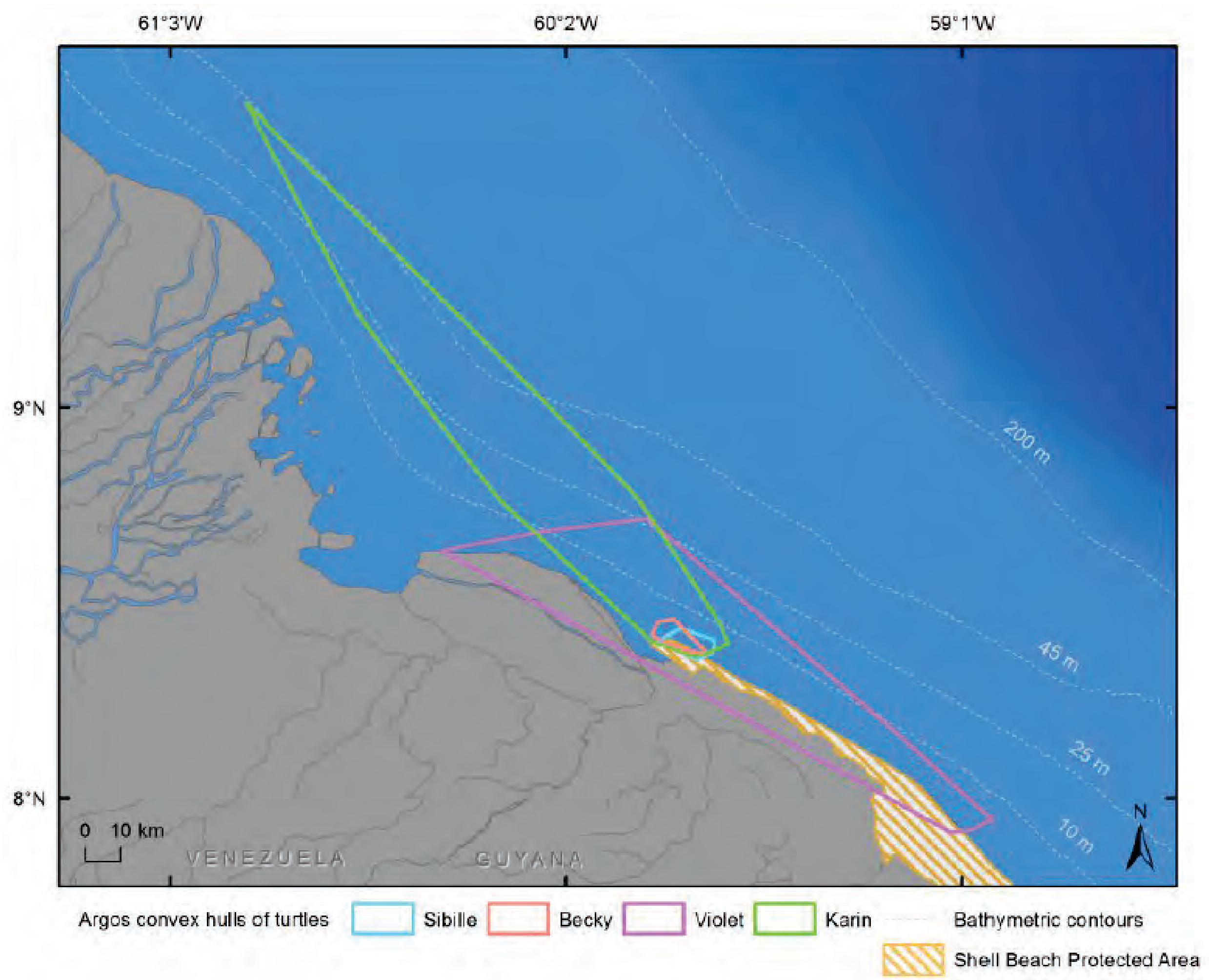


Figure 7.6-3: Approximate Ranges of Internesting Movements for Four Green Turtles (*Chelonia mydas*) Tagged in March 2018 (data from 23-25 March 2018 through 30 April 2018)

7.6.3. Impact Assessment—Marine Turtles

As described above, five marine turtle species are found in Guyanese waters and could be encountered in the PDA. Four of these species—green turtle, leatherback, hawksbill, and olive ridley turtle—nest on Guyana's beaches, particularly in the SBPA - located near Guyana's border with Venezuela. Loggerhead turtles also occur in offshore Guyanese waters, but rarely come ashore.

7.6.3.1. Relevant Project Activities and Potential Impacts

As shown in Table 7.6-2, planned Project activities could potentially impact marine turtles through injury (e.g., as a result of exposure to sound from Project activities), disturbance leading to changes in behavior (e.g., from underwater sound, lighting, and/or actions from Project activities) or toxicological effects (e.g., as a result of exposures to Project vessel discharges.

Potential impacts on marine turtles from vessel strikes are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 7.6-2: Summary of Relevant Project Activities and Key Potential Impacts—Marine Turtles

Stage	Project Activity	Key Potential Impact
Drilling and Installation	Vessel operations	• Displacement from habitat to avoid disturbance from vessel activity • Sound exposure leading to PTS injury
	Power generation	• Displacement from habitat to avoid disturbance from vessel activity • Sound exposure leading to PTS injury
	VSP and pile driving	
	Remotely operated vehicle (ROV) operations	
	Lighting on drill ship and installation vessels	• Disturbance leading to reduced reproductive success
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Permitted liquid waste discharge	
Production Operations	Vessel operations (e.g., FPSO supply barges, support vessels, drill ship, platform supply vessels, fast supply vessels, large crane vessel, fast supply vessel, field intervention vessel, light installation vessel, and multi-purpose support vessels)	• Displacement from habitat to avoid disturbance from vessel activity • Sound exposure leading to PTS injury
	Power generation	
	Operation of tankers, tugs, and supply and support vessels	
	Well stream production, processing, and storage operations	
	Permitted cooling water and produced water discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts
	Other permitted liquid waste discharge	
	Lighting on FPSO	• Disturbance leading to reduced reproductive success
Decommissioning	Vessel operations	• Exposures to permitted discharges, potentially leading to toxicological impacts • Displacement from habitat to avoid disturbance from vessel activity

7.6.3.2. Magnitude of Impacts—Marine Turtles

Potential for Permanent Threshold Shift Injury from Underwater Sound

Hearing capabilities have been studied in only a few individual marine turtles, but the available data suggest that turtles have limited hearing capacity compared to other marine taxa (e.g., cetaceans). Turtles have been shown to respond to low-frequency sound, with indications that they have the highest hearing sensitivity in the frequency range 100 to 700 hertz (Hz) (Bartol and Musick 2003). Startle responses to sudden sounds have also been observed in marine turtles. For example, McCauley et al. (2000) found that turtles showed behavioral responses to approaching seismic survey sound at approximately 166 decibels (dB) re 1 microPascal (µPa), and more significant disturbance at 175 dB re 1 µPa. Startle responses and other behavioral changes are more likely from high-level impulsive sound sources such as VSP activities, rather than from non-impulsive sound sources such as vessels.

Since marine turtles have been shown to respond to low-frequency sounds, modeling results pertinent to LFCs (see Section 7.5.3, Impact Assessment—Marine Mammals) were used as a proxy for potential acoustic injury predictions for marine turtles. As described in Section 7.5.3, Impact Assessment—Marine Mammals, modeling predicted that impulsive underwater sound from VSP would attenuate to PTS onset acoustic thresholds for LFCs at maximum horizontal distances of 73 meters (approximately 240 feet), based on the more conservative injury criteria for the LFC marine mammal hearing group.

Dive-profile data from tagged Kemp's ridleys (*Lepidochelys kempii*) showed that they spent an average of 97 percent (day) or 87 percent (night) of their time within 1 meter (approximately 3 feet) of the surface. Observational records, including dive profile data collected to date for the four green turtles tagged by a Consultant-led effort in 2018, suggest that most marine turtles show a similar pattern. The VSP source for the Project will be located within 5 meters (approximately 16 feet) of the ocean surface, so marine turtles may be present at the same general depth as this source. Consequently, marine turtles would be susceptible to PTS if they approached closer than 73 meters from an active seismic source, but they would presumably encounter sound levels sufficient to disturb them and cause them to avoid the area before they entered it. While the horizontal extent of the modeled potential auditory injury impact zone is significantly larger for pile driving than for VSP, the shallowest extent of this impact zone is over 1,500 meters (4,920 feet) below the sea surface, and turtles are not known to dive to this depth. The only other low-frequency sound that marine turtles could potentially be exposed to as a result of the Project, other than VSP, would derive from vessels operating in the PDA, and modeling indicates vessel sounds will decrease below the threshold for acoustic injury to LFCs at 5 to 6 meters (approximately 16 to 20 feet) from the source.

Anthropogenic sounds below injury thresholds have the potential to mask relevant sounds in the animals' environment (Hildebrand 2005); however, there are no quantitative data demonstrating masking impacts for marine turtles, and turtles do not vocalize or use sound for communications, so the potential risk of impacts from masking is considered insignificant.

Based on the above, the highest potential for auditory impacts on marine turtles is associated with VSP activities. With respect to the potential for injury of turtles from underwater sound, EEPGL will use the following embedded controls for underwater sound management (see Section 2.13, Embedded Controls):

- EEPGL has committed to using MMOs and soft-start procedures (i.e., gradually increasing intensity of seismic impulses to allow sensitive species to vacate the area before injury occurs) for VSPs in accordance with JNCC guidelines (although use of MMOs is more effective for identification of marine mammals, these individuals can also detect marine turtles depending on weather conditions.
- EEPGL will maintain equipment, marine vessels, and helicopters in good working order and operating them in accordance with manufacturers' specifications so as to limit sound levels to the extent reasonably practicable.

If an individual turtle were to approach an operating VSP, it would experience disturbance prior to being exposed to sound levels above injury thresholds and would be expected to divert away from the source prior to entering the zone where injury could occur. Considering this expected behavior, the above-referenced embedded controls, and the relatively small size of the PTS radius surrounding the VSP, the magnitude of the potential acoustic injury impact on marine turtles is considered **Negligible**.

Displacement from Habitat as a Result of Disturbance

During the Project life cycle, levels of human activity (e.g., vessel traffic, equipment, and materials in the water) will be higher than the very low levels that currently exist in the offshore portion of the AOI. Marine turtles are not known to be particularly sensitive to human activity while at sea, so this increase in human activity is expected to have little or no potential impact on them. Project activity related to potential disturbance will decrease during the production operations phase, so potential impacts on marine turtles will decrease as well. There will be a small increase in human activity during decommissioning, but that increase will be of relatively short duration and will not rise to the same level of activity associated with drilling and installation. While the addition of Project-related traffic is incrementally insignificant versus current vessel traffic (see Section 8.4.3, Impact Assessment—Marine Use and Transportation), Project-related vessel traffic between the shorebase(s) and PDA could cause some additional level of avoidance by turtles passing through the PDA or marine transit corridor. On this basis, the magnitude of the potential Project disturbance impacts on marine turtles is considered **Small**.

Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges will begin during the development well drilling and FPSO/SURF installation stages, and continue through the production operations stage and into the decommissioning stage. As described in Chapter 2, Description of the Project, and Section 6.4.3, Impact Assessment—Marine Water Quality, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine turtles will be transient in the PDA and their exposure to any discharges will be very limited. Any potential impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone. The magnitude of potential impacts on marine turtles from exposure to permitted discharges is therefore considered **Negligible**.

Disturbance to Nesting from Artificial Lighting

Marine turtles are known to be sensitive to artificial light in close proximity to nesting beaches because artificial light can cause a variety of potential impacts on the behavior of nesting turtles and hatchlings; these potential impacts include reduced nesting rates, premature abandonment of nests/interruption of the egg laying process, and disorientation of hatchlings (Witherington and Martin 2003; NOAA 2014). There will be artificial lights in the PDA from various vessel types and the amount of light in the PDA will vary between stages of the Project. However, at no point is offshore light expected to have potential significant impacts on marine turtles as (1) marine turtles are not known to be sensitive to artificial light in the open ocean and (2) the PDA is located 183 km offshore and the light from the PDA will not be visible from the shore (i.e., where nesting activities will occur). As disturbance impacts on marine turtles are only relevant in the context of nesting activities, the magnitude of potential impact was characterized for potential nearshore impacts only. As the PDA is located 183 km offshore, the light from the PDA will not be visible from the shore, yielding a magnitude rating of **Negligible** for the nearshore environment.

7.6.3.3. Sensitivity of Receptors—Marine Turtles

As discussed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species, because the marine turtles occurring in the Project AOI are listed as CR, EN, or VU by IUCN, the marine turtles impact assessment was conducted based on the conservative assumption that the CR or EN species (i.e., hawksbill, green, loggerhead) would be the receptor for potential impacts. Accordingly, with the exception of potential disturbance impacts, the receptor sensitivity ratings for special status species were used, as defined in Table 7.6-3. Based on the definitions above, for potential impacts other than disturbance, the representative species assumed to be the receptor for potential impacts is considered to have a **High** sensitivity.

Contrary to other potential impacts, anthropogenic disturbance of turtles at sea is not known to be a major contributor to declines in listed turtle species. Accordingly, the sensitivity rating for this particular impact was not defined based on marine turtles' listing status, but rather on the basis of their anticipated propensity to adapt to occasional disturbance. Increased activity in the PDA and between the PDA and shorebase(s) could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route, but marine turtles are not known to be particularly sensitive to human activity while at sea and such deviation would not be expected to result in a significant ultimate effect on nesting. On this basis, receptor sensitivity is considered **Low** for this potential impact.

Table 7.6-3: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Special Status Species (Adopted for Potential Impacts on Marine Turtles)

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to potential Project-related impacts.
	Medium: Species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List; species protected under national legislation; nationally restricted range species; nationally important numbers of migratory or congregatory species; species not meeting criteria for high value; and species vital to the survival of a medium value species.
	High: Species on IUCN Red List as Critically Endangered or Endangered. Species having a globally restricted range (i.e., endemic species to a site, or found globally at fewer than 10 sites, fauna having a distribution range less than 50,000 km^2), internationally important numbers of migratory or congregatory species, key evolutionary species, and species vital to the survival of high value species.

7.6.3.4. Impact Significance—Marine Turtles

Based on the magnitude of impact of receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on marine turtles ranges from **Negligible** to **Minor**.

7.6.4. Mitigation Measures—Marine Turtles

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine turtles. Table 7.6-4 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine turtles. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine turtle-specific methodology described in Sections 7.6.3.2 and 7.6.3.3.

Table 7.6-4: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Turtles

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Disturbance from artificial lighting (nearshore focus)	Negligible	High	Negligible	None	Negligible
Development Well Drilling FPSO/SURF Installation	Acoustic injury from sound exposure	Negligible	High	Negligible	None, other than implementation of embedded controls (e.g., soft start procedures for VSP)	Negligible
	Displacement from habitat to avoid disturbance from vessel activity	Small	Low	Negligible	None	Negligible
	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, discharge of hydrotesting fluids, elevated total suspended solids (TSS) levels)	Negligible	High	Negligible	None	Negligible
	Displacement from habitat to avoid disturbance from vessel activity	Small	Low	Negligible	None	Negligible
	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, and elevated temperature streams)	Negligible	High	Negligible	None	Negligible

7.7. MARINE FISH

7.7.1. Administrative Framework—Marine Fish

Table 7.7-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine fish.

Table 7.7-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Fish

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.7.2. Existing Conditions—Marine Fish

Scientific data on marine fish in the PDA are sparse. Prior to a recent study of marine fishes and fisheries conducted in 2017 and 2018 by ERM (ERM 2018), much of what had been known about marine fishes offshore Guyana was known from studies of commercial landings.

Guyana's marine fish community exemplifies the ecological connectivity among the mangroves, estuaries, and offshore zones, because many fish species are dependent on different habitats at specific life stages or occur in more than one habitat type. Several species that occur in the inshore and offshore zones as adults are dependent on coastal mangroves and estuaries as juveniles, particularly drums, croakers, marine catfishes, and snappers. Catfishes occur in the mangroves, estuaries, and oceanic waters as adults. Some other species, including snooks

(*Centropomus undecimalis*) and tarpon (*Megalops atlanticus*), may occur occasionally in the ocean, but are specifically adapted to completing their entire life cycles in mangrove-lined estuaries (MOA 2013). Further offshore, near the interface of the turbid North Brazil Current with oceanic water, the fish community is more complex, consisting of pelagic, highly migratory species such as tunas, jacks, and mackerels in the upper water column and snappers and groupers in the demersal zone (lowest section of the water column, near the seafloor) (MOA 2013). Sharks are found across the continental shelf.

7.7.2.1. Deepwater and Offshore Pelagic Fish Community

The deepwater fish survey conducted as part of the 2017-2018 fish study (Figure 7.7-1) sampled demersal fish on the continental slope between depths of 800 and 1,500 meters (approximately 2,600 and 4,900 feet) and documented three deepwater species: Robinson's hagfish (*Myxine c.f. robinsorum*), sharp-tailed eel (*Coloconger meadi*), and lanternfish (Myctophidae) (ERM 2018). Compared to the shallower environments sampled during this study, the deepwater environment was lacking in numbers or variety of species. Population studies for fish in deep sea environments (demersal) are scarce, but the low productivity of deep sea environments, compared to more shallow water environments, is thought to limit reproductive potential of deepwater organisms in general, so the low numbers of fish in the samples are expected. According to Guyana's Centre for the Study of Biodiversity, Robinson's hagfish and short-tailed eel are both new species records for Guyana. Robinson's hagfish was the most abundant of the deepwater fishes caught in the study, accounting for over 90 percent of the total catch. Robinson's hagfish was most common near the 1,000-meter (approximately 3,300-foot) isobath. No fish were captured deeper than 1,000 meters (approximately 3,300 feet). A study of deepwater habitats using ROVs and drop cameras also produced images of putative grenadiers (Macrouridae), skates/rays, and tripodfish (*Bathypterois* sp.) within the Stabroek Block, although none were identifiable to species (ERM 2018).

Pelagic sampling of the top 50 meters (approximately 164 feet) of the water column within the Stabroek Block in 2017 documented only one species of fish, dolphinfish (*Coryphaena hippurus*), although other oceanic/pelagic species that are known from Guyana's continental shelf including bigeye scad (*Selar crumenophthalmus*), king mackerel (*Scomberomorus cavalla*), and various species of sharks (*Carcharinus* spp.) could also occur in the pelagic zone of the block. Smalleye smoothhound (*Mustelus higmani*) is known to occur as deep as the southern edge of the Stabroek Block, and southern red snapper (*Lutjanus purpureus*) support a small targeted deepwater trap fishery that reportedly extends to the edge of the continental shelf. All of these species were captured at the outer continental shelf stations during the fish study and should be considered as possibly occurring in the PDA. Additional information on pelagic species within the PDA is available from visual observations made during EEPGL's activities in the southeastern half of the Stabroek Block since 2015 (Figure 7.7-2). Twenty-three species of fish have been observed in this area during these activities. Based on the combination of the surveys and opportunistic observations made since 2015, a total of 31 species of fish are considered present in the Stabroek Block at least on an occasional basis (Table 7.7-2).

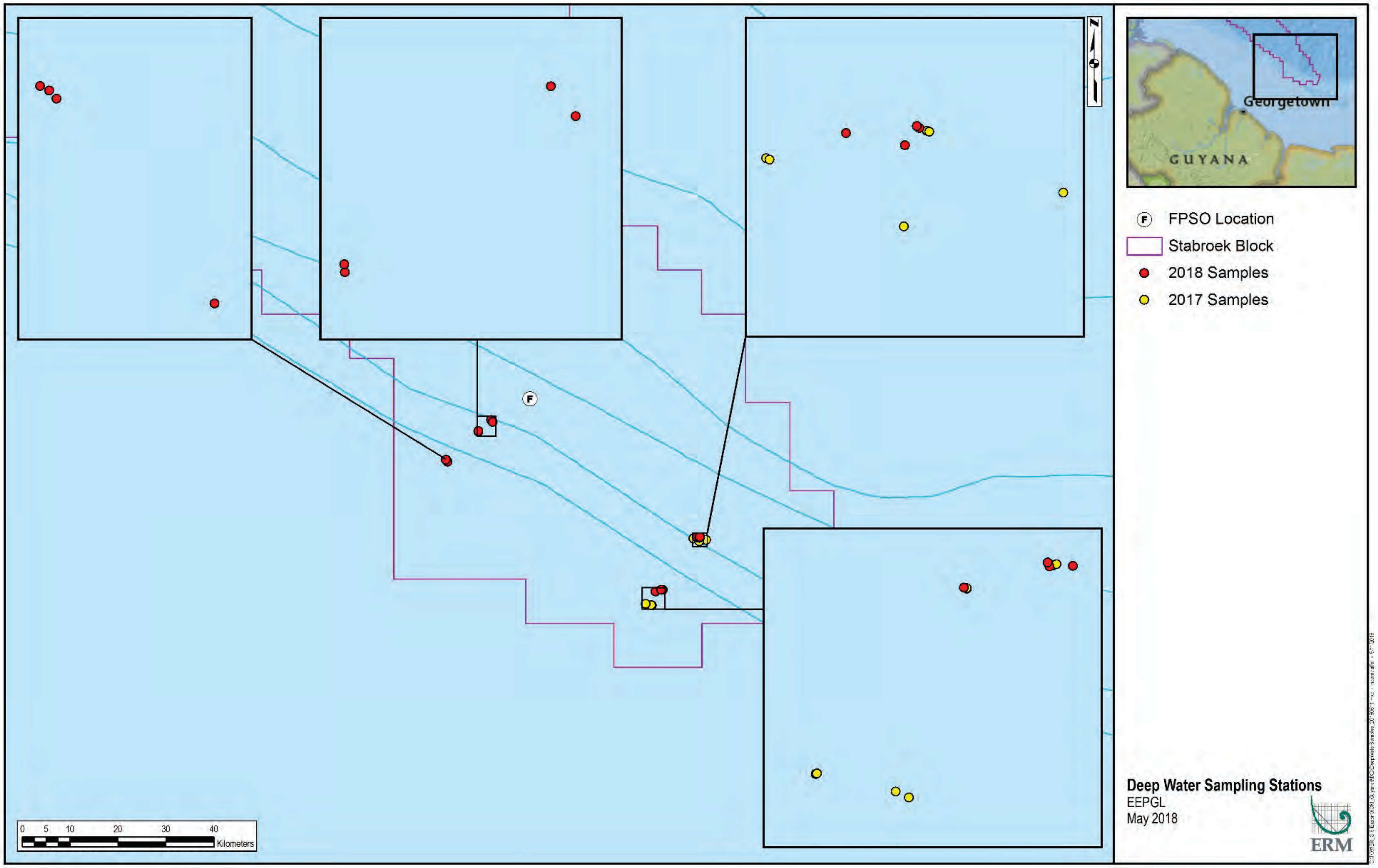


Figure 7.7-1: Location of 2017-2018 Deepwater and Pelagic Fish Sampling Stations

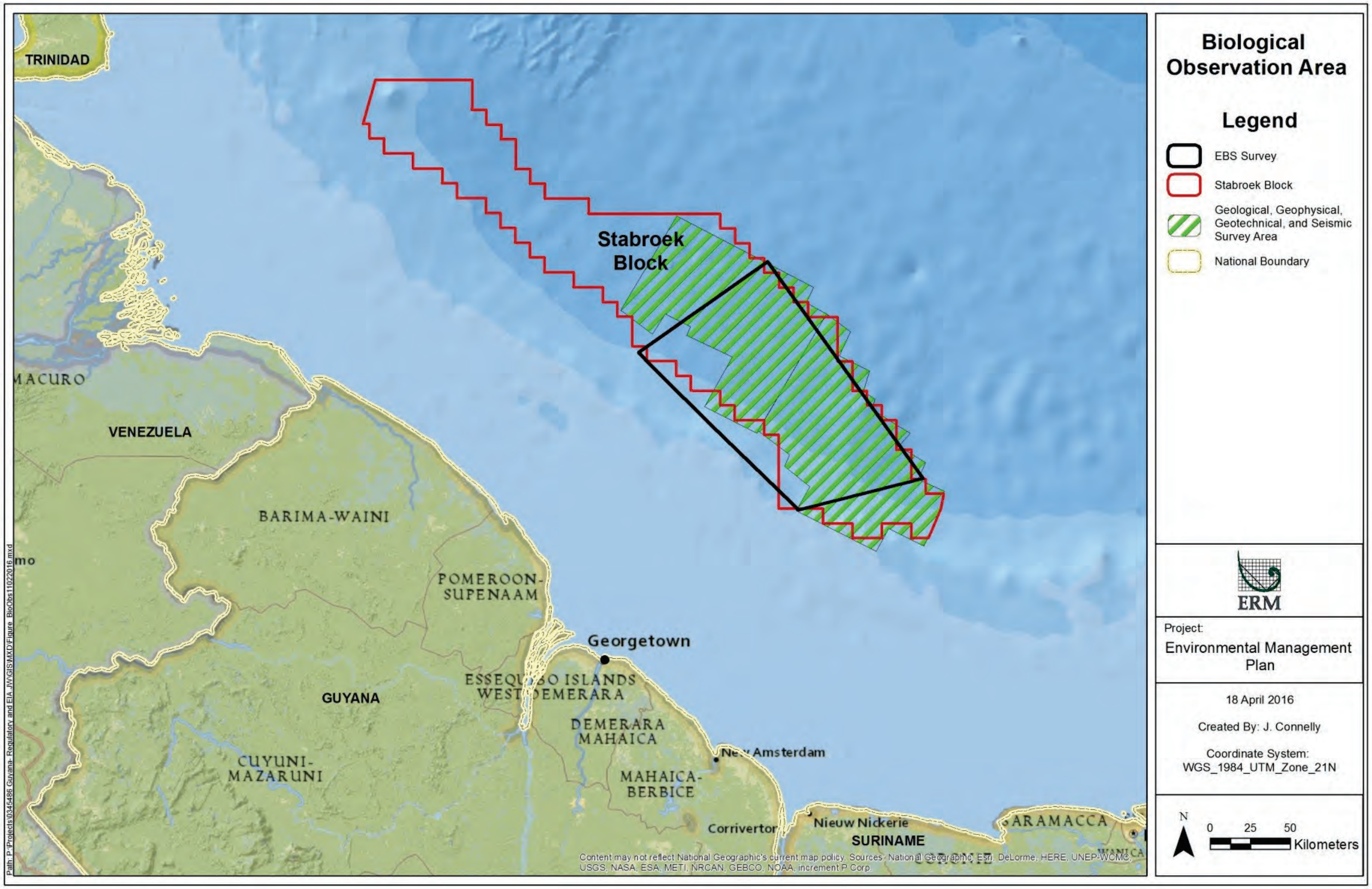


Figure 7.7-2: Approximate Area of Visual Fish Observations since 2015

Table 7.7-2: Fish Species Observed in the Stabroek Block during EEPGL Activities Since 2015

Common Name	**Scientific Name**
Atlantic bonito	*Sarda sarda*
Atlantic flying fish	*Chellopogon melanurus*
Atlantic tripletail	*Lobotes surinamensis*
Bar jack	*Caranx ruber*
Blackfin tuna	*Thunnus atlanticus*
Blackwing flying fish	*Hirundichthys rondeletii*
Blue marlin	*Makaira nigricans*
Clearwing flying fish	*Cypselurus comatus*
Four-wing flying fish	*Hirundichthys affinis*
Jack crevalle	*Caranx hippos*
King mackerel	*Scomberomorus cavalla*
Lanternfish	Myctophidae
Largehead hairtail	*Trichiurus lepturus*
Little tunny	*Euthynnus alletteratus*
Dolphinfish/Mahi-mahi	*Coryphaena hippurus*
Manta ray	*Manta sp.*
Margined flying fish	*Cheilopogon cyanopterus*
Ocean sunfish	*Mola mola*
Planehead filefish	*Stephanolepis hispidus*
Porcupinefish	*Diodon hystrix*
Rainbow runner	*Elagatis bipinnulata*
Robinson’s hagfish	*Myxine c.f. robinsorum*
Sailfish	*Istiophrous albicans*
Sharptail eel	*Coloconger meadi*
Skipjack tuna	*Katsuwonus pelamis*
Smalleye smoothhound	*Mustelus higmani*
Southern red snapper	*Lutjanus purpureus*
Swordfish	*Xiphiaa gladius*
Tiger shark	*Galeocerdo cuvier*
Yellowfin tuna	*Thunnus albacares*

In the summer of 2011, several islands in the eastern Caribbean (e.g., Anguilla, Antigua and Barbuda, Barbados, British Virgin Islands, Guadeloupe, Martinique, St. Lucia, St. Maarten/ St. Martin) experienced large amounts of sargassum washing ashore. In 2012 and 2014, Barbados, Guadeloupe, Dominica, Antigua & Barbuda, St. Croix, and Puerto Rico reported moderate episodes of the phenomenon. The sargassum consisted of two species: common gulfweed (*Sargassum natans*) and broad-toothed gulfweed (*Sargassum fluitans*) (CRFM undated). A large amount of sargassum was also documented in the Stabroek Block in 2015. Subsequent analysis of satellite imagery revealed that although sargassum densities were unusually high offshore Guyana in 2015, sargassum concentrations fluctuate annually and have a seasonal peak between April and September (Palandro 2016).

The presence of such large amounts of sargassum is significant from a fish biodiversity perspective, because sargassum has several important ecological roles related to marine fishes, including:

- Concentrating forage fish that are preyed upon by large pelagic fishes (including juvenile swordfish, dolphinfish, filefishes, jacks, flying fishes, triggerfishes, and various tunas);
- Spawning habitat for flying fish (Exocoetidae); and
- Habitat for unique fishes and other organisms that spend most or all of their lives in floating mats of sargassum, including the sargassum fish (*Histrio histrio*).

7.7.2.2. Continental Shelf Fish Community

The continental shelf survey conducted as part of the 2017-2018 fish study (Figure 7.7-3) sampled pelagic fish on the continental shelf in water from 11 to 2,340 meters (approximately 36 to 7,700 feet), although most sites were less than 100 meters (approximately 328 feet) deep. The continental shelf sampling also included demersal sampling in depths from 10 to 85 meters (approximately 33 to 280 feet). The continental shelf was the most diverse environment sampled during this assessment (compared to nearshore and deepwater environments), accounting for 110 fish species. The largest catch in biomass (39.9 percent) was obtained along the easternmost continental shelf transect, which is located offshore of the SBPA in Region 1. The remoteness of this area from commercial fishing harbors and its proximity to the SBPA are both likely playing a role in conserving the fishery resource on the far northwestern Guyanese continental shelf. The relatively high biomass documented on this transect was related more to abundance than to size of individual fish, indicating this area may be playing an important role as nursery habitat.

The most complete historical data on marine fish in Guyana’s territorial waters come from a 2-year trawl survey conducted in 1958 and 1959. The survey consisted of 35 cruises lasting 4 to 11 days each, and included data from 1,070 stations comprising 2,246 fishing hours (Lowe-McConnell 1962). The study documented the presence of 213 species of fish, comprised primarily of drums, croakers, catfishes, jacks, grunts, and snappers. In general, this study described catfishes, jacks, and grunts as dominating the nearshore zone; and snappers and various other demersal species, including some that are typical of clearwater tropical reef systems, as more abundant at deeper sites further offshore. The results of the continental shelf survey are largely consistent with these findings. In 2017 and 2018, the sea catfishes, including gillbacker catfish (*Sciades parkerii*), curass (*Sciades proops*), highwater catfish (*Hypophthalmus edentatus*), and several croakers/seatrouts, including bangamary (*Macrodon ancylodon*), bashaw (*Cynoscion acoupa*), and seatrout (*Cynoscion virescens*), were all prevalent at depths of 10 to 15 meters (approximately 33 to 49 feet) (Figure 7.7-4). The snappers and grunts, represented chiefly by barred grunt (*Conodon nobilis*), Caesar grunt (*Haemulon carbonarium*), mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), and southern red snapper (Figure 7.7-4) occurred deeper, primarily between 45 and 60 meters (approximately 148 to 197 feet), although they likely extend deeper based on their known depth ranges elsewhere.

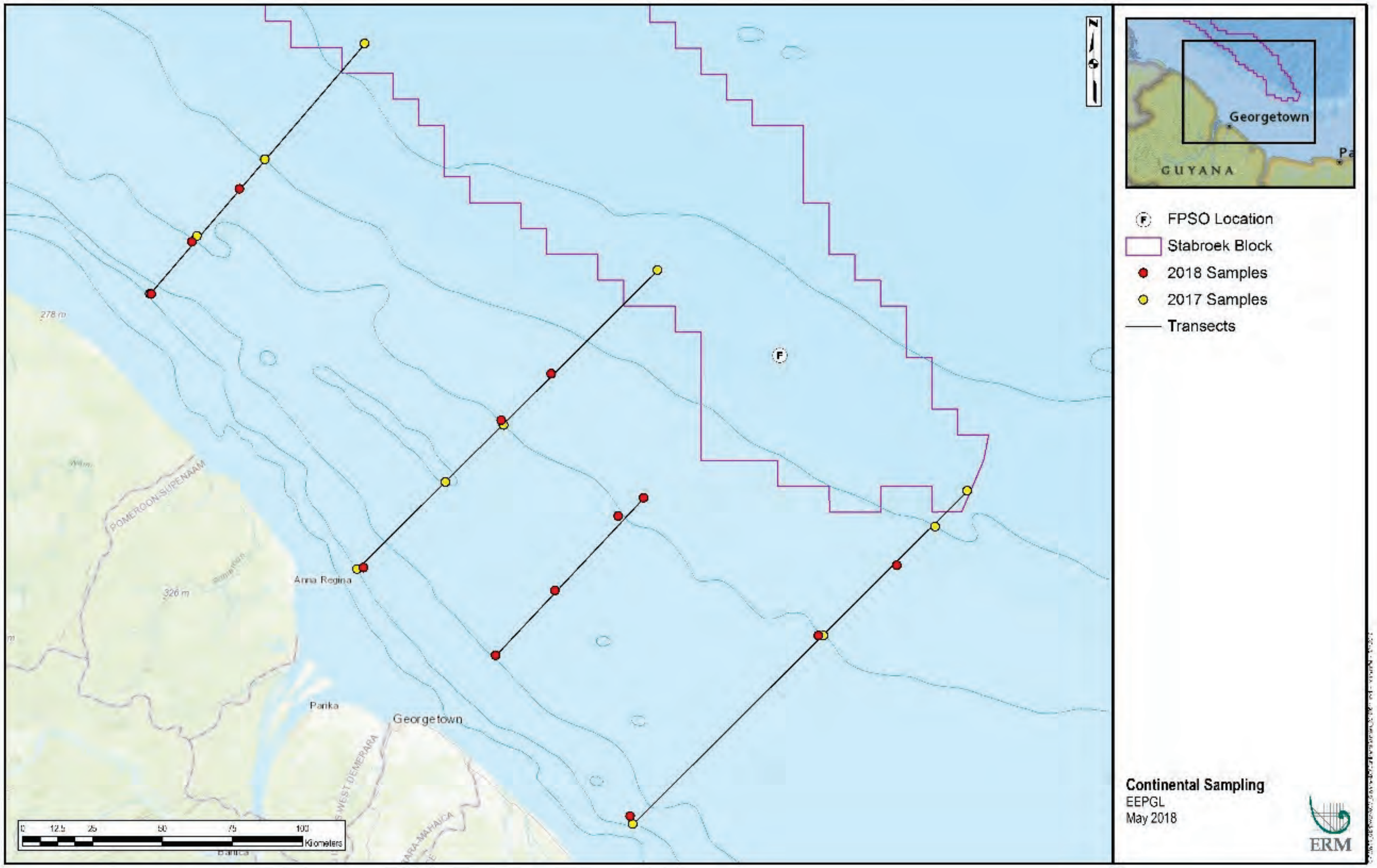


Figure 7.7-3: Location of 2017-2018 Continental Shelf Fish Sampling Stations

		
Highwater catfish (*Hypophthalmus edentatus*)	**Gillbacker catfish (*Sciades parkeri*)**	**Lane snapper (*Lutjanus synagris*)**
		
Curass (*Sciades proops*)	**Bangamary (*Macrodon ancylodon*)**	**Mutton snapper (*Lutjanus analis*)**
		
Seatrout (*Cynoscion virescens*)	**Southern red snapper (*Lutjanus purpureus*)**	**Luna lionfish (*Pterois lunulata*)**

Figure 7.7-4: Characteristic Fishes from Guyana's Continental Shelf

Based on comparisons with species lists from nearby countries, Lowe-McConnell determined that about 50 percent of Guyana's marine fish species were widely distributed coastal species, about 10 percent were clear-water associated species more typical of the Caribbean Islands, about 5 percent were more southerly species typical of the Brazilian coast, and the balance were habitat generalists with no defined regional habitat associations. Lowe-McConnell also noted that the North Atlantic Continental Shelf is continuous from the Gulf of Mexico to Brazil and that there were no major barriers to migration through this area, so Guyana's marine fish community would be expected to have many species in common with other countries in the region. This finding is consistent with the findings of the 2017-2018 fish study and likely explains the presence of so many widespread species in the dataset.

Lowe-McConnell's study and the demersal component of the 2017-2018 fish study both documented several species of typically reef-associated fish, although some notable differences between the two studies suggest the clear-water fish community on the outer continental shelf has undergone significant changes in the last half century. Lowe-McConnell's paper on Guyana's fishery resources noted the presence of coral fragments in trawl samples but described those coral fragments as dead; no living corals were mentioned. As described in Section 7.8.2, Existing Conditions—Marine Benthos, the 2017-2018 fish study documented the presence of living hard corals (*Madrepora oculata* and *Solenosmilia variabilis*) at depths of 40 to 90 meters (approximately 131 to 295 feet) on three of the four continental shelf transects (Figure 7.7-3). Lowe-McConnell noted the presence of some typically reef-associated fishes in her samples, including butterflyfishes, angelfishes, wrasses, and parrotfishes (Lowe-McConnell 1962). The study also documented a few reef-associated species, including ocellated moray (*Gymnothorax ocellatus*), French angelfish (*Pomacanthus paru*), and spotfin butterfly fish (*Chaetodon ocellatus*), in the same depth ranges as the living corals, but no parrotfishes or wrasses. Although it is unlikely that significant recovery of Guyana's hard corals has occurred since the time of Lowe-McConnell's study, given the intensity of the trawling activity on the continental shelf, the 2017-2018 study clearly shows that living hard corals do persist on Guyana's continental shelf and that coral-associated fishes occur in these habitats.

The study also documented the exotic luna lionfish *Pterois lunulata* in the same depth range as the corals and reef-associate native species. The presence of invasive lionfish in the tropical Western Atlantic Ocean and Caribbean Sea has been a topic of conservation concern for more than three decades since they first appeared in southern Florida (FWC 2018) and began threatening native fishes and commercial ground-fisheries (NOAA 2017). Although most of the attention in the conservation community since the mid-1980s has been on the closely related *P. volitans* and *P. miles*, which are much more widespread in the region than *P. lunulata*, the presence of luna lionfish offshore Guyana and the apparently coincident decline of coral-associated fishes offshore may suggest a broader susceptibility of Guyana's native fishes to pressure from this invasive species. A time series of the expansion of lionfish throughout the Western Atlantic region provided by the U.S. Geological Survey suggested that as of 2017, lionfish had not been found in Guyana, despite having been found in neighboring Tobago and Venezuela (USGS 2018); however, these data are subject to revision, so it is unclear whether the presence of lionfish in the 2017-2018 fish study samples represents a novel invasion.

Pelagic sampling of the continental shelf during the 2017-2018 fish study also documented the importance of the continental shelf as a nursery area for sharks (Figure 7.7-5). Spinner shark (*Carcharinus brevipinna*) comprised a significant component of the longline samples during the wet and dry seasons. Spinner sharks accounted for nearly 20 percent of the total abundance in the 2017 longline samples from the continental shelf, second only to the spearfish remora (*Remora brachyptera),* which are often associated with sharks and other large pelagic marine animals. No spinner sharks were positively identified in the 2018 samples, but juvenile *Carcharinus* that were too small to identify comprised 50 percent of the total longline catch on the continental shelf in 2018, possibly indicating a seasonal component to the value of the area as nursery habitat for the species. Although the sharks in the study were identified in the field as spinner sharks, field identification of *Carcharinus* species (especially of immature specimens) can be very difficult. A recent genetic study of sharks in Guyanese fish markets did not document spinner sharks but did identify the very similar smalltail shark (*C. porous)* and blacktip shark (*C. limbatus)*, which together comprised over 25 percent all samples in the study (Kolman et al. 2017); accordingly, the identification of the sharks in the 2017-2018 fish study should be viewed as provisional. Regardless of the species, the presence of large numbers of immature *Carcharinus* sharks is significant both in terms of the ecology of the area—as sharks are apex predators on the continental shelf—and in terms of fishery management. Sharks are a target species for the demersal longline (locally referred to as Caddell lines) fishery, and shark stocks are well-known to be highly sensitive to fishing pressure due to their low reproductive success rates and long generation times. There are no official management plans or quotas in place for the Guyanese shark fishery, so the fishery may be susceptible to over-exploitation, particularly if large numbers of juveniles are being removed from the population before having the opportunity to reproduce.

Figure 7.7-5: Juvenile *Carcharinus* sharks from Guyana's Continental Shelf in March 2018

7.7.2.3. Nearshore and Estuarine Fish Community

The nearshore and estuarine surveys conducted as part of the 2017-2018 fish study (Figures 7.7-6 and 7.7-7, respectively) sampled coastal fish communities in Regions 1 through 5. The nearshore fish community was the second-most diverse environment sampled during this assessment (compared to deepwater and continental shelf environments), accounting for 42 fish species. The estuarine fish community accounted for nine species sampled at five estuarine stations in 2018.

Based on the data from the 2017-2018 fish study, the composition of the nearshore fish community is strongly influenced by seasonal fluctuations in freshwater input. Twenty-five species were captured during the dry season, and the two most common species (bangamary and highwater catfish) were also common on the inner continental shelf during this period, underscoring the importance of marine influence during periods of low riverine discharge. The nearshore community shifts to a more freshwater/oligohaline community in the wet season; in fact, eight of the nine species captured in the 2018 wet season estuarine surveys also appeared in the wet season nearshore dataset. Most of the species captured in the nearshore zone during the wet season (April 2018) were anadromous or euryhaline species.

A noteworthy aspect of the estuarine surveys was the prevalence of leptocephalus larvae in the samples. Leptocephali are slim, transparent larvae of eels and other more distantly related species including tarpon, known as “cuffum” in Guyana, and ladyfish *(Elops saurus)* known as “silverfish” in Guyana. The larvae were not identified to species but they comprised over 30 percent of the entire catch across the five estuarine stations and were the most common species in the estuarine dataset. Tarpon and ladyfish are both nearshore marine/estuarine species, but the leptocephali could also have been the larvae of a marine eel, such as a moray. Regardless of which species represented, their ubiquity and abundance in the estuarine stations underscores the importance of the estuaries as fish nursery habitats.

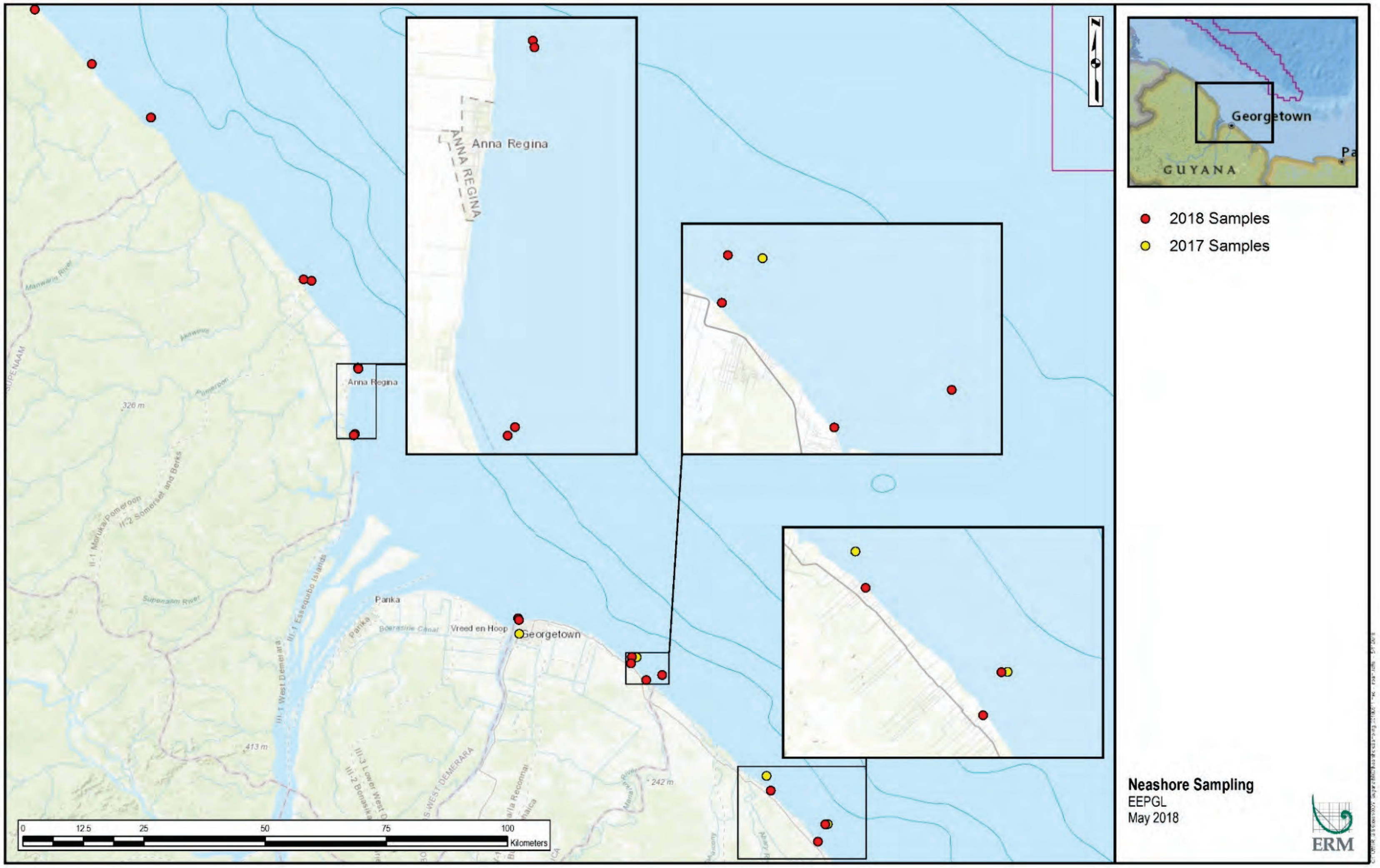


Figure 7.7-6: Nearshore Fish Sampling Stations

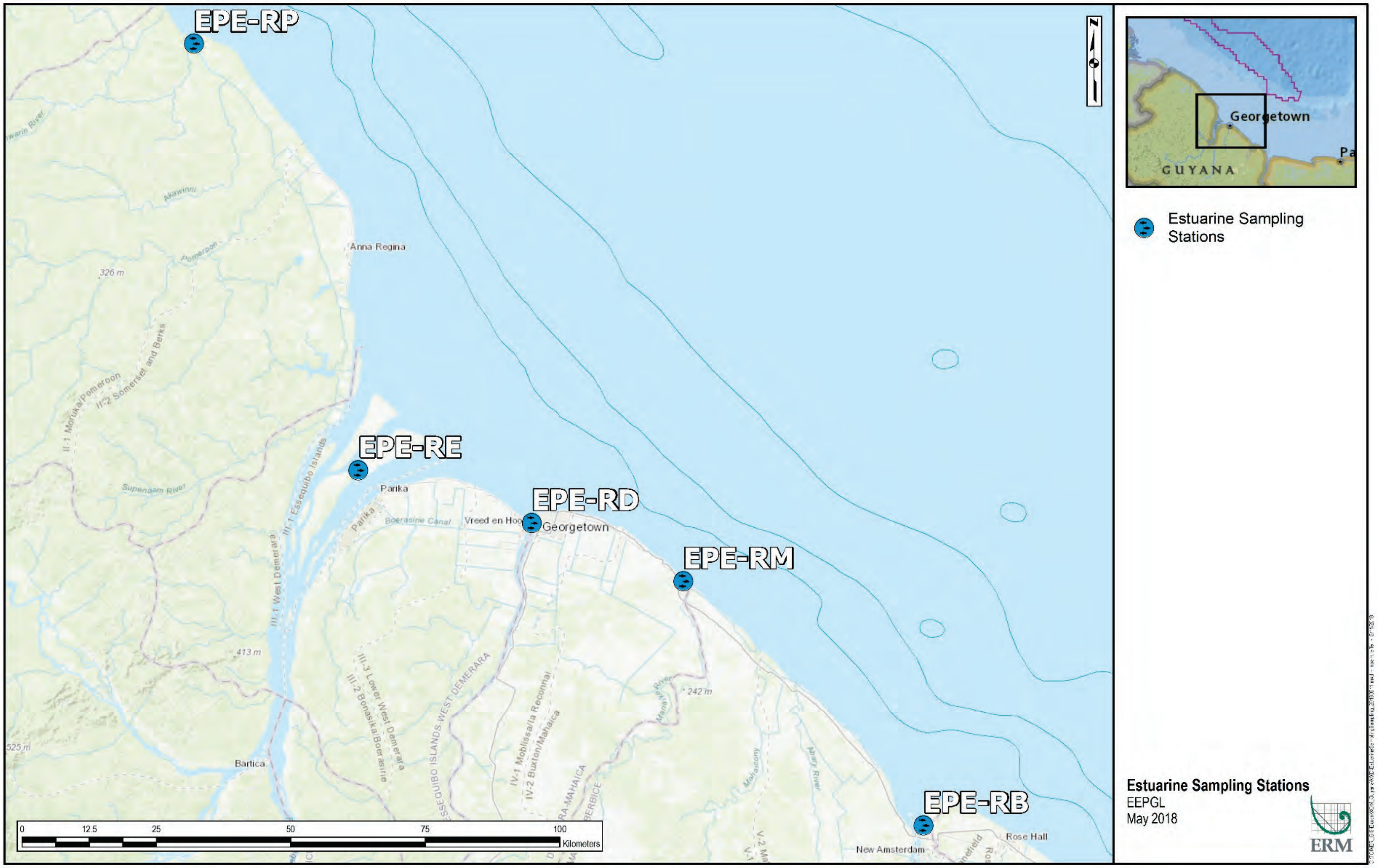


Figure 7.7-7: Estuarine Fish Sampling Stations

7.7.3. Impact Assessment—Marine Fish

This section addresses the potential impacts of planned Project activities on marine fish. Key potential impacts on marine fish assessed include localized changes in the distribution of pelagic species as a result of altered water quality; localized changes in distribution and habitat usage due to altered bottom habitats and the presence of Project infrastructure; entrainment in water intakes; auditory impacts from vessel traffic and installation activities; and the attractive potential of artificial lights on the FPSO, drill ships, and major installation vessels.

Potential marine fish receptors will include pelagic and demersal marine fishes. These groups include a combination of migratory and resident species. Some receptors will have a greater potential for experiencing certain types of impacts than others. For example, surface-dwelling pelagic fish will have a greater potential to experience water quality changes related to planned discharges, as compared to bottom-dwelling species, and bottom-dwelling species will have a greater potential to experience changes in physical habitat structures, as compared to pelagic species.

7.7.3.1. Relevant Project Activities and Potential Impacts

Table 7.7-3 summarizes the planned Project activities that could potentially impact marine fish. The greatest number of potential impact types are associated with the development that included well drilling and SURF/FPSO installation stages of the Project, when most habitat-disturbing activities take place and human/vessel activity in the PDA will be highest. At this stage, potential impacts will occur throughout the water column and at the seafloor. Once drilling and installation and hook-up/commissioning are complete and production operations are the only activities occurring offshore, biological conditions at the seafloor will be naturally restored and any ongoing potential impacts will be isolated to the upper portions of the water column and to the pelagic segment of the fish community.

Table 7.7-3: Summary of Relevant Project Activities and Key Potential Impacts—Marine Fish

Stage	Project Activities	Key Potential Impact
Development Well Drilling SURF/FPSO Installation	Drilling operations and VSP Artificial lighting on drill ship and major installation vessels Installation of FPSO moorings and SURF equipment, including pile driving Permitted liquid waste discharge Permitted drill cuttings and fluids discharge	• Gill fouling and reduced visibility caused by increased total suspended solids (TSS) concentrations • Auditory impacts from vessel sound • Auditory impacts from sound from VSP and pile driving • Attraction of structure-oriented species • Localized improved access to forage for predatory fish due to prey species' attraction to artificial light • Exposures to permitted discharges, potentially leading to toxicological impacts
Production Operations	Permitted liquid-waste discharge (primarily cooling water and chlorinated effluent)	• Exposures to permitted discharges, potentially leading to toxicological impacts

Stage	Project Activities	Key Potential Impact
	Tanker and tug operations	• Auditory impacts from vessel sound • Attraction of structure-oriented species
	Intake of seawater for cooling water, injection water, and ballast water	• Loss of fish eggs and larvae due to entrainment of immature life stages
Decommissioning	Abandonment and removal activities	• Temporary disturbance of deepwater fish communities and possible gill fouling during decommissioning (i.e., due to increased TSS concentrations) • Permanent loss of structural habitat (only the FPSO-related habitat will be lost) and artificial light due to decommissioning
	Permitted liquid waste discharge	• Exposures to permitted discharges, potentially leading to toxicological impacts

7.7.3.2. Magnitude of Impacts—Marine Fish

The assessment of the Project's magnitude of impacts on marine fish from the potential impacts described above is determined based on the size of the impact relative to natural variations in the impacted population (where known), the temporal scale of the impact, and the population level at which the impact is anticipated to occur. The magnitude of potential impacts on marine fish is defined according to the definitions provided in Table 7.7-4.

Table 7.7-4: Definitions for Magnitude Ratings for Potential Impacts on Marine Fish

Criterion	Definition
Magnitude	Negligible: Impact is within the normal range of variation for the population of the species.
	Small: Impact does not cause a substantial change in the population of the species, or other species dependent on it.
	Medium: Impact causes a substantial change in abundance and/or reduction in distribution of a population over one or more generations, but does not threaten the long term viability/function of that population, or any population dependent on it.
	Large: Impacts entire population or a significant part of it, causing a substantial decline in abundance, and/or recovery of the population (or another population dependent on it) due to natural recruitment (reproduction, immigration from unaffected areas) is not possible either at all, or within several generations

The Project includes several embedded controls that will reduce the magnitude of impacts on marine fish:

- FPSO onboard treatment of produced water, bilge water, and sanitary wastewater prior to discharge;
- Use of oil/water separators to ensure compliance with an oil in water content of less than 15 parts per million (ppm) (per the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 [MARPOL 73/78]) for bilge water;
- Use of Water Based Drilling Fluids (WBDF) and low-toxicity International Oil and Gas Producers (IOGP) Group III non-aqueous base fluid (NABF);

- Use of solids control and drill cuttings dryer systems to treat cuttings prior to discharge;
- Gradual increase in intensity of seismic pulses during VSP and hammer energy (during pile driving) to allow sensitive species to vacate the area before injury occurs; and
- Screening on vessels for cooling water and ballast water intakes for FPSO and drill ship to reduce the impingement and entrainment of fish.

On the basis of the definitions and embedded controls described above, the magnitude of the various potential impacts on marine fish are discussed below.

Changes in the Distribution of Fish Due to Altered Water Quality

The Project will routinely discharge several waste streams to the sea. These discharges will begin during the drilling and installation stages and continue into the decommissioning stage. Drilling fluids and cuttings discharges will be unique to the drilling phase. The initial well sections will use WBDF, and the cuttings and fluids will be discharged either at the seafloor, causing turbidity around the immediate vicinity of each well, or from the drill ships. For subsequent well sections, cuttings and residual drilling fluids will be discharged from the drill ships. For discharges from the drill ships, turbidity plumes will impact a larger area as the cuttings fall through the water column; however, the turbidity plume in this case will be diluted across a larger area, thereby reducing potential related impacts in any single location. Fish are expected to generally avoid these turbidity plumes while drilling is occurring, reducing potential respiratory impacts associated with gill fouling, but are expected to return after drilling is complete. WBDF and the residual quantities of low-toxicity NABF adhered to discharged cuttings are expected to have no measureable impacts on fish.

As described in Section 6.4.3, Impact Assessment—Marine Water Quality, and Appendix J, Water Quality Modeling Report, most of the planned discharges that will occur during production operations are not known to have adverse impacts on marine life or will comprise negligible volumes; however, the increased temperature and chlorine concentrations in the cooling water discharges have the potential to adversely impact marine life. Elevated temperature is known to have several potential physiological lethal and sub-lethal impacts on fish, including reduced reproductive success, reduced early life-stage survivorship, and increased metabolic stress. Thermal thresholds for such impacts vary widely by species, but thresholds from the scientific literature range from about +1.5 degrees Celsius (˚C) to +6˚C (Donelson et al. 2014; Pankhurst and Munday 2011). Under the conservative assumptions described in Section 6.4.3, Impact Assessment—Marine Water Quality, localized sea surface temperatures are expected to increase as a result of the Project, but these increases are predicted to be no more than 3˚C above ambient temperatures within 100 meters (approximately 330 feet) horizontal distance from the discharge outlet. This finding indicates that within 100 meters (approximately 330 feet) of the FPSO, the thermal impact of routine discharges will diminish to near the lower end of the range within which thermal impacts on fish are expected to occur. Most of the research on thermal thresholds for these types of impacts has focused on reef or structure-oriented species that spend their entire adult lives in a small area rather than the open-ocean pelagic species that will occur near the surface in the PDA. Pelagic species will be much more likely to move away from a thermal mixing zone that exceeds their optimum range than will structure-oriented species, so not only will thermal impacts affect a very small area of the ocean surface, but the species that occur within the PDA will also be resilient to these thermal impacts based on their propensity to actively avoid suboptimal water temperatures.

Similar to temperature increases, hypochlorite can also induce a range of negative impacts on fish, including disruption of cardiac function, respiration, and growth. There are no regulatory limits for residual hypochlorite in marine discharges in Guyana. Toxicity depends not only on dosage (concentration and exposure time) but also on individual species' sensitivity to hypochlorite. This makes defining a single impact threshold for hypochlorite exposure difficult. Most studies indicate harmful effects on fish have been observed at mean concentrations above 0.2 ppm (Kegley et al. 2016). Although the available studies cite a variety of exposure times and toxicity endpoints, residual chlorine from hypochlorite poses the greatest risk to aquatic species if they are exposed to elevated concentrations for extended periods of time (72 to 96 hours) (see Appendix J, Water Quality Modeling Report). While hypochlorite concentrations immediately adjacent to the discharge point could transiently exceed levels that pose fish toxicity concerns (assuming the fish remained in the area long enough to experience the impact), concentrations are expected to decrease to less than 0.16 ppm within 100 meters (approximately 328 feet) of the discharge point.

The combined impact of increased temperature and chlorine concentrations will make the localized mixing zone inhospitable to some species. However, unless fish are physically confined or otherwise prevented from escaping unfavorable water quality conditions (e.g., in the case of fish eggs), fish are usually capable of detecting and avoiding harmful water quality conditions, thereby minimizing potential toxicological impacts. This is especially true of water quality conditions that cause discomfort or are otherwise physically apparent at sub-lethal levels like hypochlorite.

Decommissioning will cause small turbidity plumes near the seafloor if selected components of the SURF are removed and as mooring lines from the FPSO are placed on the seafloor. Impacts from these turbidity plumes will be similar to those associated with drilling and installation, although they will be smaller and have a shorter duration.

For these reasons, declines in water quality are expected to negatively impact fish abundance in the immediate vicinity of the well heads, SURF, and drill ships during drilling and installation, the FPSO and tanker(s) during production operations, and the SURF during decommissioning, but are not expected to cause significant fish mortality. Limited, localized impairments in water quality will not be significant enough to cause substantial changes in fish populations, nor will they significantly impact sensitive or important species (see Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species), but they will likely cause minor changes in the distribution and composition of the fish community within parts of the PDA. As discussed below, the physical attraction that offshore facilities can exert on fish could actually result in net increases in the local abundance of certain fish species, thereby offsetting any potential negative impacts associated with localized water quality impairment. The net impact in this case is often a localized shift away from sensitive species (including some pelagic and sedentary species) toward sedentary or structure-oriented species that are more tolerant of minor water quality impairments. Any impacts on transient fish swimming through the mixing zone are expected to be acute, and affected individuals are expected to recover quickly after exiting the mixing zone.

On the basis of the factors discussed above, the magnitude of impact associated with changes in the distribution of marine fish due to altered water quality is considered **Negligible** during drilling and installation (i.e., due to exposure to permitted discharges [elevated total suspended solids (TSS) concentrations, liquid effluent discharges, discharge of hydrotesting fluids]) and **Small** during production operations (i.e., due to on-going exposures to permitted liquid effluent discharges and elevated temperatures).

Auditory Impacts on Fish from Vessel Activity, Vertical Seismic Profile Activities, and Pile Driving

The same sound sources associated with the Project that could impact marine mammals (Section 7.5.3, Impact Assessment—Marine Mammals) could also impact marine fish. These can be broadly separated into non-impulsive sources (e.g., vessel sound) and impulsive sources (pile driving and VSP). Hearing abilities and sensitivities differ significantly among fish species. Certain species can be classified as hearing generalists or specialists[16] based on differences in hearing ability conveyed by specific anatomical traits. Although hearing specialists are thought to be more susceptible to auditory impacts within certain audio frequencies than other species, there are no generally accepted thresholds for auditory impacts in either specialist or generalist species, and many species' hearing abilities have yet to be quantified.

Non-Impulsive Sound

A 2014 EIS conducted by the U.S. Department of the Interior as part of a Programmatic Environmental Impact Statement for proposed geological and geophysical investigations in the Atlantic Outer Continental Shelf off the southeastern United States (BOEM 2014) contained a comprehensive review of auditory impacts on fish from non-impulsive and impulsive sources (including seismic surveys). This study found that fish may experience a range of impacts from non-impulsive sound, including increased stress and threshold shift, and fish may employ behavioral strategies to avoid the sound source (BOEM 2014). However, the extent to which these impacts will actually occur is highly dependent on the hearing abilities and sensitivities of the species of fish that occur within the PDA, and these abilities and sensitivities are currently unknown.

Impulsive Sound

The impact of impulsive sounds on hearing specialists is the most important factor to consider when assessing potential Project-related auditory impacts on fish:

[16] Hearing specialists are species that have developed heightened sensitivities to sounds in a specific frequency range. This adaptation occurs in some species to facilitate feeding or social behavior. Hearing generalists hear equally well across a wider range of frequencies but do not possess the acuity of the specialists within their specific frequency range.

- Impulsive sound is usually considered more important than non-impulsive sound in terms of impacts on fish because impulsive sound is the category most often associated with hearing loss, injury, or death of fish.
- Impulsive sources also tend to have more severe impacts on hearing specialist species and those species with well-developed swim bladders[17] because they tend to be more sensitive to auditory impacts especially within the range of frequencies that they are specially adapted to detect.
- High peak pressures and rapid onset and decay tend to be associated with the most severe auditory impacts on fish, and are characteristic of impulsive sources.
- As described in Appendix F, Underwater Sound Modeling Report, impulsive sound from driven piles and VSP will impact a larger area of the ocean than the non-impulsive sources modeled by JASCO (especially to the north of the source) and therefore could impact a larger number of species and individual fish than would the non-impulsive sources.

Larson (1985) concluded that lethal impacts in the most sensitive taxa can occur at peak pressures exceeding 229 dB re 1 µPa with onset/decay times less than 1 millisecond. Turnpenny and Nedwell (1994) reviewed historical studies of seismic impacts on fish and determined that for exposures at close range (less than 10 meters [approximately 33 feet]), transient behavioral impacts began appearing at 192 dB re 1 µPa, a variety of injuries appeared at about 220 dB re 1µPa, and mortality began appearing at exposures above 230 dB re 1 µPa. However, these impacts did not always occur and some exposures up to 240 dB re 1 µPa resulted in no observable adverse impacts.

There have been no published reports to date documenting a lasting impact on fishing or fish stock as a result of seismic surveys. BOEM (2014) concluded that although hearing specialists are more susceptible than hearing generalists to hearing loss from impulsive sound, such impacts do not always occur and are generally not permanent. Impacts are expected to be most severe in resident fish that are oriented to structural bottom habitats and are therefore exposed to repeated impulses at a given location over time. One such genus (*Sebastes* spp), showed startle and alarm responses to 10-minute exposures of seismic impulses at 180 dB re 1 µPa at ranges of 11 meters (approximately 36 feet) to several kilometers, but the impacts appeared to be transitory (Pearson et al. 1992). Another study of the reef-oriented pollack (*Pollachius pollachius*) documented only minor changes in behavior when exposed to seismic impulses with peak sound pressures between 195-218 dB re 1 µPa at ranges of 5.3-109 meters (Wardle et al. 2001). Documented recovery times vary, but generally range from a few hours to a few days.

The available literature described above suggests that behavioral impacts from impulsive sound sources may begin to occur at peak sound pressures between 180 and 195 dB re 1 µPa, and that injury could occur at peak sound pressures around 220 dB re 1 µPa.

[17] Caged exposure tests have determined that species with large swim bladders or other highly vascularized, low density organs or structures tend to be more susceptible to acute acoustic injury than species that lack these features when exposed to such sources within a few meters (Amoser and Ladish 2005; Wysocki and Ladich 2005).

Given that most sensitive receptors do not always experience impacts from impulsive sound (and they usually recover from such impacts) and that impulsive sound will only occur during the initial phases of the Project, population-level impacts on marine fish from auditory impacts are highly unlikely. Auditory impacts will not significantly impact any rare, sensitive, or important species (see discussion in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species). On this basis of the above factors, the magnitude of potential auditory impacts on pelagic species from vessel activity (during all Project stages) and on demersal species from pile driving and VSP (during development well drilling and FPSO/SURF installation) is considered **Negligible**.

Changes in Distribution and Habitat Usage Due to Altered Bottom Habitats and the Presence of Project Infrastructure

Installation of moorings for the FPSO, installation of SURF equipment, and drilling wells will disturb the seafloor temporarily within the PDA. These disturbances will create turbidity plumes and alter localized bottom contours within the area. The main potential impacts of turbidity plumes on fish are gill fouling and reduced visibility. Visibility is a minor factor at the depths that occur in the PDA because the species that live at these depths are naturally adapted to what is essentially total darkness, but fouled gills can lead to respiratory distress over long exposures. The turbidity plumes are expected to dissipate rapidly downcurrent, and fish are expected to temporarily vacate the immediate vicinity of activities at the seafloor until turbidity reaches acceptable levels. This behavioral response will limit fishes' exposure to turbidity, and fish are expected to return to the vicinity of the Project subsea infrastructure once seafloor disturbance activities are complete.

None of the fish species that have been documented to date in the deepwater fish surveys, either with fish traps or with remotely operated vehicles (ROVs) or drop cameras (chimeras/rattails, hagfish, lanternfish, short-tailed eel), are known to be habitat specialists. Nevertheless, some of the deepwater species from the "red fish" zone and all of the reef-associated species identified in the McConnell study (1962; see Section 7.7.2, Marine Fish—Existing Conditions) are structure-oriented species. Physical structures provide many benefits to these species, including refuge from currents and predators as well as foraging opportunities. These species are expected to congregate around the well heads and manifolds once the disturbance associated with installation has abated and the Project enters the production operations stage. The isolated marine communities that develop around the SURF components could contain some species that are rare or absent elsewhere offshore Guyana due to the apparent lack of hard substrate outcrops in the area. These communities could be disturbed temporarily during decommissioning if the flowlines are disconnected from the manifolds and retrieved. However, the manifolds and well heads may remain in place in perpetuity (subject to the decommissioning plan), so these facilities will continue to provide habitats for the fish community over the long term. Minor, localized impairment in water quality will not be significant enough to cause substantial changes in fish populations, nor will they significantly impact sensitive or important species (see discussion in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species), but they will cause small changes in the distribution and composition of the fish community within the PDA.

On the basis of the above factors, the magnitude of potential impacts associated with distribution and habitat changes from altered bottom habitats and presence of Project infrastructure (relevant for demersal species only) is considered **Small**.

Attraction to Artificial Light

Artificial light has been known for many years to attract fish in a variety of settings, and this phenomenon has been documented around lights on offshore petroleum infrastructure (Hastings et al. 1976; Stanley and Wilson 1997; Lindquist et al. 2005). Results from studies of platforms in the northern Gulf of Mexico suggest that platforms benefit all life stages of predatory species by attracting and concentrating prey and providing sufficient light to locate and capture them (Keenan et al., 2007). While this may benefit predatory species in the short term, artificially lit structures have the potential to alter predator–prey interactions by creating conditions that favor predatory species at night and disadvantaging the prey while simultaneously attracting the prey species. This could ultimately have long-term negative impacts on predatory species if localized depletion of prey resources occurs (Becker et al. 2012). The artificial light produced from the Project vessels will not be substantial enough to alter fish populations, nor will it be expected to significantly impact sensitive or important species (see discussion in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species); however, it may cause small changes in the distribution and/or behavior of fish in the immediate vicinity of the FPSO and possibly the drill ships and installation vessels. On this basis, the magnitude of potential impacts associated with attraction to artificial light (relevant for pelagic species only) is considered **Small**.

Entrainment in Water Intakes

Seawater will be withdrawn from the ocean to provide water to inject into the reservoir, cool the FPSO's processing equipment during the production operations stage, and provide ballast for vessels. Larval and juvenile fish have the potential to be entrained in the intake or impinged on the screens that will be installed to remove particulates from the water before it is pumped into the treatment unit on the FPSO. Most research on entrainment and impingement involves site-specific studies at onshore power plants conducted in North American and European estuaries or nearshore coastal areas where immature fish are concentrated (Barnthouse 2013). Nearshore intakes generally pose a higher risk of entrainment and impingement than offshore intakes (WaterReUse 2011). Information on the entrainment and/or impingement rates at offshore intakes is sparse, but there is some recent evidence that losses from entrainment and impingement are insignificant at the population level, even at power plants in coastal and estuarine settings (Barnthouse 2013). The U.S. Minerals Management Service noted that coastal power plants require much higher volumes of water than individual offshore oil and gas facilities (approximately 10 million gallons per minute for a nuclear power plant; Martinez-Andrade and Baltz 2003), meaning that the entrainment losses at oil and gas facilities would likely be much lower than at power plants. In most cases, extrapolation of the losses of larval fish and eggs at power plant intakes to an equivalent number of adults indicates that entrainment losses are insignificant compared to natural and fishing-related mortality (Barnthouse 2013; WaterReUse 2011). As an embedded control, cooling and ballast water intakes on the FPSO and drill ships will be equipped with screens to reduce entrainment. Entrainment will not significantly impact sensitive or important species (see discussion in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species). On this basis, the magnitude of potential impacts associated with entrainment of marine fish in water intakes is considered **Small**.

7.7.3.3. Sensitivity of Receptor—Marine Fish

The assessment of marine fish as a receptor of impacts from the Project is based on the conservation status of the marine fish expected to occur in the vicinity of the Project. The sensitivity of marine fish is defined according to the definitions provided in Table 7.7-5.

Table 7.7-5: Definitions for Receptor Sensitivity Ratings for Impacts on Marine Fish

Criterion	Definition
Sensitivity	Negligible: Species with no specific value or importance attached to them.
	Low: Species and sub-species without specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts.
	Medium: Species with one of the following characteristics: specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts; importance to local or regional fisheries; or vital importance to the survival of another medium-sensitivity species, but not meeting criteria for high value sensitivity.
	High: Species with two of more of the following characteristics: specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts; importance to local or regional fisheries; or vital importance to the survival of another medium-sensitivity species.

Based on the sensitivity rating definitions above, the receptor sensitivity for marine fish is considered **Low** for pelagic species and **Medium** for demersal species. This is principally due to the fact that demersal species are less mobile than pelagic species and would therefore be more susceptible to Project impacts.

7.7.3.4. Impact Significance—Marine Fish

Based on the magnitude of impact of receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on marine fish ranges from **Negligible** to **Minor**.

7.7.4. Mitigation Measures—Marine Fish

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on marine fish. Table 7.7-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine fish. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine fish-specific methodology described in Sections 7.7.3.2 and 7.7.3.3.

Table 7.7-6: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Fish

Stage	Potential Impact	Magnitude Rating	Sensitivity Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Auditory impacts on fish from vessel activity (pelagic species)	Negligible	Low	Negligible	None	Negligible
All Project Stages	Disturbance from or attraction to offshore lighting (pelagic species)	Small	Low	Negligible	None	Negligible
Drilling and Installation	Distribution and habitat changes from altered bottom habitats and presence of Project infrastructure (demersal species)	Small	Medium	Minor	None	Minor
	Auditory impacts from pile driving and VSP (demersal species)	Negligible	Medium	Negligible	None	Negligible
	Exposure to permitted discharges (elevated TSS concentrations, liquid effluent discharges containing various chemical substances, discharge of hydrotesting fluids)	Negligible	Low	Negligible	None	Negligible
Production Operations	Distribution changes due to altered water quality (liquid effluent discharges containing various chemical substances, and elevated temperature streams [pelagic species only])	Small	Low	Negligible	None	Negligible
	Entrainment via water withdrawals (pelagic species)	Small	Low	Negligible	None	Negligible
	Attraction to artificial light (pelagic species)	Small	Low	Negligible	None	Negligible

7.8. MARINE BENTHOS

7.8.1. Administrative Framework—Marine Benthos

Table 7.8-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine benthos.

Table 7.8-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Benthos

Title	Objective	Relevance to the Project
Legislation		
Species Protection Regulations, 1999	Provides for the establishment of a Management Authority and a Scientific Authority in compliance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).	Provides for wildlife protection, conservation, and management.
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in CITES Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism to achieve the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provides a framework for international protection and development of the marine environment across the Caribbean region.	Sets general goals for protection of the marine environment, especially from possible pollution. Guyana acceded and ratified in 2010.

7.8.2. Existing Conditions—Marine Benthos

The benthic communities inhabiting the Guyana Basin are influenced by the dominant environmental conditions that characterize the area, including sediment composition, water turbidity, and nutrient loads. This section describes the marine benthic habitat within the Project AOI.

7.8.2.1. Methodology

This section draws on information provided in the scientific literature; maps; AUV photographs; and field data collected by box coring and sediment profile imaging during environmental baseline surveys completed in 2014, 2016, and 2017; benthic incidental catch from the 2017 and

2018 fish surveys; environmental DNA (eDNA) samples collected in 2016 and 2017; and images collected from ROV/drop cameras on select transects along the continental shelf and in the Stabroek Block in 2017. The locations of these samples are depicted relative to the PDA in Figure 7.8-1

7.8.2.2. Regional Setting

Marine benthic biological resources offshore of Guyana are poorly studied, but do not include the matrix of shallow coral reefs and seagrass meadows that are often considered emblematic of coastal tropical Atlantic environments elsewhere. This is due to the highly turbid offshore conditions, which do not permit the growth of warm water corals that rely on symbiotic photosynthetic algae for nourishment.

Two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) are known to occur offshore of Guyana. Both species occur in a wide range of depths, *M. oculata* from 55 to 1,950 meters (approximately 180 to 6,400 feet) and *S. variabilis* from approximately 219 to 2,165 meters (approximately 719 to 7,103 feet). The locations and the extent of deepwater corals offshore of Guyana have not been published (Freiwald et al. 2004), but both species were documented as inhabiting the shallow continental shelf based on fragments of live coral found during the 2017-2018 fish study. Many cold-water corals construct reefs that support highly diverse invertebrate and fish fauna (NOAA 2014). Both *M. oculata* and *S. variabilis* are technically considered reef-building corals, but *M. oculata* is particularly fragile and does not often form deepwater reefs. It more frequently occurs as a commensal[18] species living within or on reefs that were originally constructed by more robust species such as *S. variabilis*. Neither species has been documented to date inhabiting the Stabroek Block.

Several species of bentho-pelagic shrimp occur in Guyanese waters, including shallow water species such as the Atlantic seabob (*Xiphopenaeus kroyeri*), the southern brown shrimp (*Penaeus subtilis*), and the southern white shrimp (*Penaeus schmitti*). The red-spotted shrimp (*Penaeus brasiliensis*) and the southern pink shrimp (*P. notialis*) are found in deeper waters (EPA 2010). While these species are free swimming, they are often found at or near the bottom. To date, three macrobenthic species, the giant isopod (*Bathynomus giganteus*), red deepsea crab (*Chaceon quinquedens*), and flatback lobster (*Stereomastis sculpta*) have been documented to occur in the Stabroek Block and are discussed further below.

Other species that are common to deepsea Caribbean environments, and may be present but have yet to be documented in the Stabroek Block, include several species of isopods (such as *Leptanthura guianae* and *Malacanthura truncata*) (Poore and Schotte 2009, 2015) and amphipods (including *Ampelisca mississippiana*, and *Thaumastasoma* sp.). There are also numerous species of annelids, including the polychaetes *Tharyx marioni*, *Aricidea suecia*, *Levinsenia uncinata*, and *Paraonella monilaris*, as well as bivalves, such as *Vesicomya vesical* and *Heterodonta* sp. (Wei et al. 2010).

[18] Living in close association, such that one species benefits without harming the other

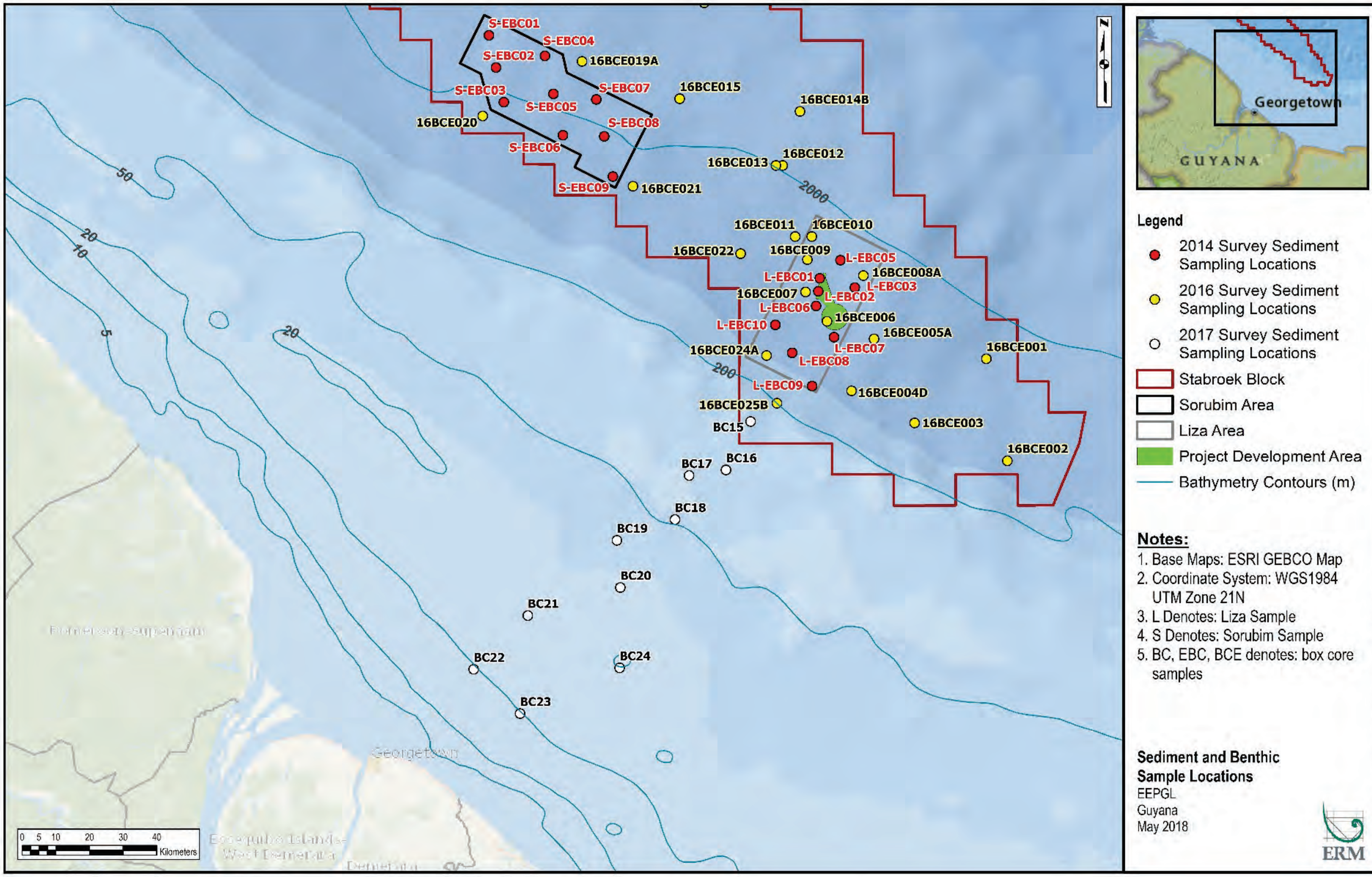


Figure 7.8-1: Locations of Benthic Sampling Stations in the Stabroek Block and along the Continental Shelf

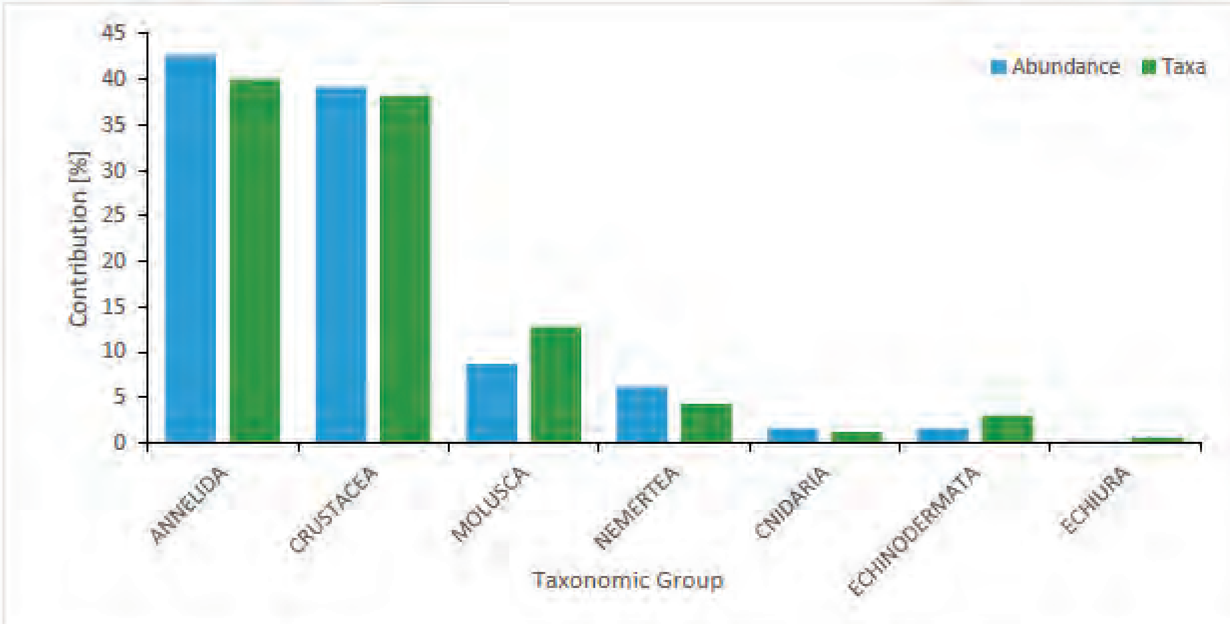
7.8.2.3. Existing Conditions in the Project Development Area

Environmental Baseline Survey Data

Results of the 2014 environmental survey revealed that the total abundance of benthic infauna in the PDA was low, averaging 116 organisms per square meter (m^2). This organism density is below the range of typical abundances reported from other continental slopes (Rowe et al. 1982; Flach et al. 1999). The most abundant major taxonomic groups were polychaete worms, crustaceans, and mollusks. The overall prevalence of these three groups is typical for marine sediments. Polychaetes were the numerically dominant group identified (average density 47 per m^2, representing 41 percent of the total groups). Polychaetes typically comprise about half of all species and a third of macrofaunal species from deepwater marine habitats worldwide. Aside from polychaetes, no other individual major taxa were abundant, with each of the other taxa groups individually representing less than 14 percent of total abundance. The observed paucity of macrofauna is likely ascribed to limited organic food sources, indicated by the low organic carbon content in the sediment.

A total of 50 distinct families were identified during the 2014 environmental survey, with approximately half represented by either one or two individuals. This is a relatively high level of diversity considering the low abundance of macrofauna. Dominant families were typical cosmopolitan inhabitants of shelf and slope sediments worldwide. These included spionid, cirratulid, paraonid polychaetes, phoxocephalid amphipods, and thyasirid and nuculanid (bivalve) mollusks.

Similar to the 2014 data, the 2016 data showed an overall prevalence of annelids (including polychaetes), crustaceans, and mollusks typical for marine sediments as well as low macrofaunal densities. The 2016 sample density averaged 20 organisms per 0.1 m^2, which can be extrapolated to 200 organisms per m^2 for the purposes of comparison to the 2014 data. While the 2014 survey did not categorize the macrofauna organisms beyond the family level, the 2016 survey further classified the macrofauna to the order and species level and covered a larger sampling area. Results from the 2016 sampling showed macrofaunal communities within the survey area to be diverse. In 2016, a total of 165 taxa were identified across 7 phyla and 27 families, with 36 identified to species level (including 15 species of polychaetes, 10 crustaceans, 8 mollusks, and 3 sipunculid worms). Annelida were the numerically dominant group (phylum), in terms of species composition (40 percent) and abundance (42.7 percent). Crustaceans accounted for the second highest species composition (38.2 percent) and abundance (39.1 percent), followed by mollusks (12.7 percent and 8.7 percent, respectively) and other taxa (collectively 9.1 percent and 9.5 percent, respectively) (Figure 7.8-2).



Source: FUGRO 2016

Figure 7.8-2: Abundance and Taxa of Major Taxonomic Groups Identified in 2016 Environmental Baseline Survey

Environmental genomics was applied to sediment and water samples collected during the 2016 Environmental Baseline Survey. Based on the environmental genomics data, the most species-rich phyla in both water and sediment included Annelida, Arthropoda, Cnideria, and Nematoda. In general, the species richness was higher in surface water samples than in deeper water samples or sediment samples. Approximately 69 percent of the full diversity was captured by surface water and sediment samples.

The 2017 environmental baseline survey data showed a sample density ranging from 8 to 932 organisms per 0.1 m^2, with an average of 136.7 organisms per 0.1 m^2. For the purpose of comparison to 2014 and 2016 data, this equates to approximately 1,367 organisms per m^2, substantially higher than what was recorded in either 2014 or 2016. This reflects a higher abundance of organisms on the continental shelf (sampled in 2017) compared to the area in the Stabroek Block (sampled in 2014 and 2016). A total of 11 phyla were identified, with arthropods being the most prevalent, followed by annelids (polychaetes). Within these 11 phyla, a total of 133 taxa and 4,101 species were identified.

No deepwater coral growth was detected in the 2014, 2016, or 2017 environmental baseline surveys or in the ROV surveys in the vicinity of the PDA (Maxon Consulting and TDI Brooks 2014; FUGRO 2016; ESL 2018); however, *M. oculata* and *S. variabilis* have been documented from the outer continental shelf south of the Stabroek Block.

Table 7.8-2 summarizes macrofauna families identified in the 2014, 2016, and 2017 surveys. As the 2014 survey did not categorize the macrofauna organisms beyond the family level, the commonalities between the 2014, 2016, and 2017 surveys were identified based on equivalent families. The 2014 and 2016 surveys characterized the surveyed area to have a diverse macrofauna community, with polychaete worms as the most abundant major taxonomic group. The 2014 survey additionally recognized that overall macrofaunal abundance within the surveyed area was at the lower end of the macrofaunal densities reported for continental slope sediments around the world (Rowe et al. 1982; Flach et al. 1999). The 2016 survey similarly reported that numbers identified in all taxonomic groups were low. The 2017 survey reported a higher density of organisms, although densities observed varied widely between individual samples. The 2017 survey also recorded a greater diversity of organisms, with malacostracan arthropods being the most abundant type, followed by polychaete worms.

Table 7.8-2: Macrofauna Families Observed in 2014, 2016, and 2017 Environmental Baseline Surveys

Phylum	Class	Order	Family
Annelida	Polychaeta	Amphinomida	Amphinomidae
		Eunicida	Dorvilleidae
			Eunicidae
			Lumbrineridae
			Oenonidae
			Onuphidae
		Phyllodocida	Acoetidae
			Eulepethidae
			Glyceridae
			Goniadidae
			Hesionidae
			Nephtyidae
			Nereididae
			Pholoidae
			Phyllodocidae
			Pilargidae
			Polynoidae
			Sigalionidae
			Syllidae
		Sabellida	Oweniidae
		Spionida	Spionidae
			Magelonidae
			Serpulidae
			Poecilochaetidae
			Trochochaetideae
		Terebellida	Cirratulidae
			Ampharetidae
			Terebellidae
			Trichobranchidae
		Not assigned	Orbiniidae
			Paraonidae

Phylum	**Class**	**Order**	**Family**
			Capitellidae
			Maldanidae
			Opheliidae
			Orbiniidae
			Chaetopteridae
			Scalibregmatidae
		Eunicida	Lumbrineridae
			Onuphidae
	Arachnida	Prostigmata	Microtrombidiidae
Arthropoda	Hexanauplia	Calanoida	Aetideidae
			Bathypontiidae
			Calanidae
			Centropagidae
			Clausocalanidae
			Heterorhabdidae
			Lucicutiidae
			Metridinidae
			Paracalanidae
			Scolecitrichidae
			Temoridae
		Cyclopoida	Cyclopidae
			Oithonidae
		Harpacticoida	Tachidiidae
		Poecilostomatoid	Corycaeidae
			Oncaeidae
			Sapphirinidae
	Insect	Coleoptera	Dermestidae
		Diptera	Empididae
		Lepidoptera	Nymphalidae
	Malacostraca	Amphipoda	Ampeliscidae
			Aoridae
			Caprellidae
			Chevaliidae
			Corophiidae
			Isaeidae
			Ischyroceridae
			Lysianassidae
			Oedicerotidae
			Photidae
			Phoxocephalidae
			Platyischnopidae
			Scopelocheiridae
			Synopiidae
			Unknown Amphipod

Phylum	**Class**	**Order**	**Family**
		Cumacea	Bodotriidae
			Diastylidae
			Nannastacidae
			Unidentified
		Decapoda	Axiidea*
			Brachyura*
			Paguroidea*
			Alpheidae
			Anomura*
			Callianassidae
			Caridea*
			Crangonidae
			Decapoda*
			Diogenidae
			Micheleidae
			Palaemonidae
			Panopeidae
			Pasiphaeidae
			Pilumnidae
			Pinnotheridae
			Porcellanidae
			Processidae
			Pseudorhombilidae
			Sergestidae
		Euphausiacea	Euphausiidae
		Isopoda	Anthuridae
			Anthuroidea*
			Cirolanidae
			Hyssuridae
			Leptanthuridae
			Serolidae
		Leptostraca	Nebaliidae
		Mysida	Mysida
		Tanaidacea	Apseudidae
			Apseudomorpha*
			Kalliapseudidae
			Leptocheliidae
			Metapseudidae
			Parapseudidae
			Tanaellidae
			Tanaidomorpha *
	Ostracoda	Halocyprida	Halocyprididae
		Myodocopida	Myodocopid
	Pycnogonida	Pantopoda	Phoxichilidiidae

Phylum	Class	Order	Family
Brachiopoda	Lingulada	Lingulida	Lingulidae
Bryzoa	Gymnolaemata	Cheilostomatida	Celleporidae
			Scrupariidae
Chordata	Actinopterygii	Ophidiiformes	Bythitidae
	Anthrozoa	**	Branchiostomatidae
Cnidaria	Anthozoa	Actiniaria	Diadumenidae
			Edwardsiidae
		Spirularia	Cerianthidae
		Zoantharia	Zoantheria
	Hydroz	Leptothecata	Campanulariidae
			Lafoeidae
			Sertulariidae
		Siphonophorae	Agalmatidae
		Siphonophorae	Clausophyidae
		Siphonophorae	Diphyidae
		Trachymedusae	Geryoniidae
Echinodermata	Holothuroidea	**	Holothuroidae
		Apodida	Synaptidae
	Ophiuroidea	Ophiurida	Amphiuridae
			Ophiocomidae
			Ophiuridae
			Ophiuroidae*
Hemichordata	**	**	Hemichordata
Mollusca	Not assigned	**	Mactribae
		**	Ungulinidae
		Not assigned	Cardiidae
			Semelidae
			Tellinidae
		Limida	Limidae
		Lucinida	Lucinidae
			Thyasiridae
		Myida	Corbulidae
		Nuculida	Nuculidae
		Ostreida	Pteriidae
		Pectinida	Pectinidae
		Venerida	Arcticidae
	Caudofoveata	Chaetodermatida	Limifossoridae
	Gastropoda	Littorinimorpha	Naticidea
		Neogastropoda	Muricidae
			Olividae
	Scaphopoda	Dentaliida	Dentaliidae
Nematoda	Unidentified	Unidentified	Unidentified
	Adenophorea	Desmodorida	Haliplectidae
		Desmoscolecida	Desmoscolecidae

Phylum	Class	Order	Family
		Enoplida	Campgdoridae
		Enoplida	Rhabdodemaniidae
		Monhysterida	Diplopeltidae
			Linhomoeidae
			Monhysteridae
			Siphonolaimidae
			Sphaerolaimidae
		Trichocephalida	Trichinellidae
	Chromadorea	Araeolaimida	Aulolaimidae
	Secernentea	Tylenchida	Paratylenchidae
Porifera	**	**	Porifera
Sipuncula	Phascolosomatidea	Aspidosiphonida	Aspidosiphonidae
	Sipunculidea	Golfingiiformes	Unidentified
			Golfingiidae
			Phascolionidae

Source: Maxon Consulting and TDI Brooks 2014

Notes: "Not assigned" indicates that the scientific community has not specifically classified the organism to a given categorization. The symbols "*" and "**" and the term "unidentified" refer to the surveyors' inability to further identity the categorization of an organism.

All three surveys reported that there was not a strong correlation between macrofaunal communities or number of species and any single physical parameter such as sediment characteristics or water depth.

Environmental DNA Samples

In addition to direct sampling of whole benthic organisms and subsequent analysis of those specimens by traditional morphological means, the 2016 survey also included collection of complimentary environmental DNA samples. Morphological analysis of the 2016 survey samples identified 197 distinct taxa[19]. The environmental DNA analysis was partially consistent with the morphological analysis, as 112 of the 197 distinct taxa were confirmed through DNA analysis (CEGA 2016). The DNA data were also consistent with the 2016 morphological data in terms of taxonomic dominance. Both data sets identified annelids and arthropods as dominant taxa, although the DNA samples also contained large numbers of taxa in the Bacillariophyta (diatoms), Chlorophyta (green algae), Chytridiomycota (fungi), Nematoda (round worms), Platyhelminthes (flat worms), and Xenacoelomorpha[20] phyla.

[19] These taxa were mostly identified to the species rank, but some were only identifiable to family level.

[20] Xenacoelomorphs are bilaterally symmetrical but otherwise very primitive microorganisms that have no generic common name.

Most of the 85 remaining taxa that were identified from the morphological analysis but not identified in the DNA analysis have not had their DNA sequence information entered into a reference database (CEGA 2016). In addition to these taxa, 77 taxa detected and identified to at least the genus rank were not documented in the morphological analysis.

The results of the 2016 eDNA analysis revealed a total of 37.5 million unique operational taxonomic units (OTUs) in water and sediment samples, with approximately 16 percent of the OTUs receiving at least some taxonomic designation. OTUs are DNA sequences that are clustered together based on a 100 percent sequence similarity, which can be considered a rough approximation for subspecies. The OTUs with unassigned taxonomies represent organisms whose DNA may not have been sequenced yet by the general scientific community and would therefore not be in the publicly available databases. Using the OTUs for which a taxonomy could be assigned, more than 40 phyla were represented in the water and sediment samples. Of those phyla identified, 27 phyla had organisms that could be identified at the species level. These results were then compared to the 2016 environmental baseline survey data, where benthic species were identified by taxonomists (morphological approach). In most cases, the eDNA analysis was able to identify specimens down to the species level, whereas only family level or higher identifications were achieved using the morphological approach. These findings are summarized on Table 7.8-3.

Table 7.8-3: Taxonomic Groups Identified at the Species Level in Sediment and Seawater Samples using eDNA Analysis

Phylum	Order	Species	Sediment	Water	2016 Environmental Baseline Survey Morphological ID
Amoebozoa	Dactylopodida	*Vexillifera expectata*	X		
	Himatismenida	*Parvamoeba rugata*	X	X	
	Tubulinida	*Hartmannella cantabrigiensis*	X		
		Saccamoeba sp.	X		
Annelida	Phyllodocida	*Anguillosyllis capensis*	X		Phyllodocidae
		Eumida alkyone	X		
		Glycera capitata	X		Glycera capitata
	Eunicida	*Eurythoe complanata*	X		*Eunicida, Onuphis sp.*
	Sabellida	*Manayunkia aestuarina*	X		Sabellidae
Arthropoda	Amphipoda	*Scopelocheirus schellenbergi*		X	Amphipoda
	Calanoida	*Aetideopsis carinata*	X		Copepoda
		Bestiolina similis	X	X	
		Boeckella bergi	X		
		Centropages furcatus	X	X	
		Clausocalanus furcatus	X	X	
		Clausocalanus mastigophorus	X	X	
		Clausocalanus parapergens	X	X	
		Eurytemora affinis		X	
		Heterorhabdus papilliger		X	
		Lucicutia flavicornis	X	X	
		Nannocalanus minor		X	
		Paracalanus parvus		X	
		Paracalanus tropicus		X	
		Pleuromamma abdominalis		X	
		Pseudocalanus acuspes	X		
		Scolecithrix danae		X	
		Temora stylifera		X	
		Temora turbinata	X	X	
		Temorites brevis		X	
		Undinula vulgaris		X	

Phylum	**Order**	**Species**	**Sediment**	**Water**	**2016 Environmental Baseline Survey Morphological ID**
	Coleoptera	*Attagenus smirnovi*		X	
	Cyclopoida	*Cyclops kolensis*	X	X	Copepoda
		Oithona plumifera		X	
	Diptera	*Hemerodromia sp.*		X	
	Halocyprida	*Halocypris inflata*	X		
		Porroecia spinirostris		X	
	Harpacticoida	*Euterpina acutifrons*	X		Copepoda
	Lepidoptera	*Heteronympha merope*	X		
	Poecilostomatoida	*Copilia mirabilis*		X	Copepoda
		Ditrichocorycaeus anglicus		X	
		Oncaea media		X	
		Oncaea parabathyalis		X	
		Oncaea prendeli	X	X	
		Sapphirina scarlata		X	
	Prostigmata	*Microtrombidium cooki*	X		
Ascomycota	Eurotiales	*Penicillium capsulatum*		X	
	Glomerellales	*Colletotrichum acutatum*		X	
Bacillariophyta	Bacillariales	*Fragilariopsis cylindrus*		X	
		Nitzschia cf. promare	X		
		Nitzschia palea	X	X	
		Pseudo-nitzschia cuspidata	X		
		Pseudo-nitzschia lineola	X	X	
		Pseudo-nitzschia lundholmiae		X	
	Chaetocerotales	*Attheya longicornis*		X	
		Chaetoceros socialis		X	
	Cymatosirales	*Minutocellus polymorphus*		X	
	Fragilariales	*Asterionellopsis maritima*		X	
	Lithodesmiales	*Ditylum brightwellii*		X	
	Melosirales	*Melosira ambiqua*	X		
	Naviculales	*Navicula cryptocephala*	X		
		Sellaphora bacillum		X	
		Sellaphora laevissima	X		

Phylum	**Order**	**Species**	**Sediment**	**Water**	**2016 Environmental Baseline Survey Morphological ID**
		Sellaphora pupula	X		
	Thalassiosirales	*Skeletonema ardens*	X		
		Skeletonema cf. pseudocostatum	X		
		Skeletonema costatum	X		
		Skeletonema grevillei	X	X	
		Skeletonema pseudocostatum	X		
		Skeletonema tropicum	X	X	
Basidiomycota	Cantharellales	*Rhizoctonia solani*		X	
	Polyporales	*Fibroporia vaillantii*		X	
		Ganoderma lucidum		X	
		Trametes hirsuta		X	
	Tilletiales	*Tilletia indica*		X	
	Tremellales	*Kockovaella imperatae*		X	
Cercozoa	Cryomonadida	*Protaspis grandis*	X		
	Thaumatomonadida	*Thaumatomonas sp.*	X		
Chaetognatha	Aphragmophora	*Sagitta enflata*	X	X	
Chlorophyta	Chlorellales	*Nannochloris sp.*		X	
	Dolichomastigales	*Dolichomastix tenuilepis*	X	X	
	Mamiellales	*Mantoniella squamata*		X	
	Prasinococcales	*Prasinococcus capsulatus*	X		
		Prasinoderma coloniale	X	X	
Chordata	Beloniformes	*Cheilopogon cyanopterus*		X	
	Copelata	*Oikopleura sp.*		X	
	Enterogona	*Ascidia ahodori*		X	Ascidiacea
	Myctophiformes	*Diaphus dumerilii*		X	
	Primates	*Homo sapiens*	X	X	
	Syngnathiformes	*Upeneus parvus*	X		
Chytridiomycota	Rhizophydiales	*Rhizophlyctis harderi*	X		
		Rhizophlyctis rosea	X		
Cnidaria	Actiniaria	*Diadumene leucolena*		X	Actiniaria
	Leptothecata	*Clytia hemisphaerica*		X	
	Siphonophorae	*Agalma okeni*		X	

Phylum	Order	Species	Sediment	Water	2016 Environmental Baseline Survey Morphological ID
		Chuniphyes multidentata		X	
		Diphyes dispar		X	
		Nanomia bijuga		X	
	Trachymedusae	*Liriope tetraphylla*		X	
	Zoantharia	*Nanozoanthus harenaceus*		X	
Gastrotricha	Chaetonotida	*Musellifer delamarei*	X		
	Macrodasyida	*Apistobranchus typicus*		X	
Haptophyta (unranked)	Phaeocystales	*Phaeocystis pouchetii*		X	
	Prymnesiales	*Chrysochromulina sp.*		X	
Heterokontophyta	Bacillariales	*Nitzschia sp.*		X	
	Chattonellales	*Fibrocapsa japonica*		X	
	Chromulinales	*Pedospumella sinomuralis*		X	
	Developayellales	*Develorapax marinus*	X		
	Dictyochales	*Vicicitus globosus*		X	
	Florenciellales	*Florenciella parvula*		X	
		Pseudochattonella farcimen		X	
	Haptoglossales	*Haptoglossa sp.*		X	
	Ochromonadales	*Ochromonas sp.*		X	
	Pedinellales	*Pseudopedinella elastica*	X	X	
	Pelagomonadales	*Aureococcus anophagefferens*		X	
	Peronosporales	*Hyaloperonospora nasturtii- aquatici*		X	
		Peronospora phacae		X	
		Phytophthora cocois		X	
		Phytophthora crassamura		X	
		Phytophthora frigida	X	X	
		Phytophthora gonapodyides	X		
		Phytophthora heveae		X	
		Phytophthora ilicis		X	
		Phytophthora insolita		X	
		Phytophthora kernoviae	X		
		Phytophthora megasperma	X		
		Phytophthora multivora	X	X	

Phylum	Order	Species	Sediment	Water	2016 Environmental Baseline Survey Morphological ID
		Phytophthora quininea		X	
		Phytophthora rosacearum		X	
		Phytophthora sp. napoensis	X		
		Phytophthora taxon Pgchlamydo	X		
		Phytophthora taxon Pgchlamydo		X	
		Phytopythium chamaehyphon	X		
	Pythiales	*Halophytophthora exoprolifera*		X	
		Halophytophthora mycoparasitica		X	
		Pythium acanthicum		X	
		Pythium aff. acanthophoron		X	
		Pythium aff. iwayamai	X	X	
		Pythium aff. perplexum	X		
		Pythium anandrum		X	
		Pythium aphanidermatum	X	X	
		Pythium apleroticum		X	
		Pythium arrhenomanes	X	X	
		Pythium camurandrum	X		
		Pythium carolinianum	X	X	
		Pythium cederbergense	X	X	
		Pythium contiguanum		X	
		Pythium deliense		X	
		Pythium helicandrum	X	X	
		Pythium iwayamai	X		
		Pythium jasmonium	X	X	
		Pythium junctum	X		
		Pythium mamillatum	X		
		Pythium marsipium	X		
		Pythium myriotylum	X	X	
		Pythium paroecandrum	X		
		Pythium periplocum		X	
		Pythium perplexum	X	X	
		Pythium rostratifingens	X		

Phylum	Order	Species	Sediment	Water	2016 Environmental Baseline Survey Morphological ID
		Pythium sylvaticum	X		
		Pythium tracheiphilum		X	
		Pythium uncinulatum	X		
		Pythium violae	X		
		Pythium volutum		X	
	Rhizochromulinales	*Rhizochromulina cf. marina*		X	
	Saprolegniales	*Achlya ambisexualis*	X		
		Achlya americana		X	
		Saprolegnia ferax	X		
		Saprolegnia parasitica		X	
		Saprolegnia turfosa	X		
	Unplaced at order level	*Chaetoceros affinis*		X	
Loricifera	Nanaloricida	*Pliciloricus sp.*	X		
		Rugiloricus sp	X		
Mollusca	Veneroida	*Coelomactra antiquata*	X		Bivalvia
	Chaetodermatida	*Chaetoderma felderi*		X	Caudofoveata
	Littorinimorpha	*Colobostylus nuttii*	X		Gastropoda
		Echinolittorina trochoides	X		
	Pectinoida	*Mimachlamys varia*		X	Bivalvia
	Thecosomata	*Cuvierina atlantica*		X	Gastropoda
		Limacina inflata		X	
Nematoda	Monhysterida	*Astomonema sp.*	X		Nematoda
		Diplolaimelloides meyli	X		
		Diplopeltula sp.	X		
		Halomonhystera sp.	X		
		Sphaerolaimus hirsutus	X		
		Terschellingia longicaudata	X		
	Araeolaimida	*Aulolaimus oxycephalus*	X		
	Desmodorida	*Haliplectus sp.*	X		
	Desmoscolecida	*Desmoscolex sp.*	X		
	Enoplida	*Campydora demonstrans*	X		
		Rhabdodemania sp.	X		

Phylum	**Order**	**Species**	**Sediment**	**Water**	**2016 Environmental Baseline Survey Morphological ID**
	Trichocephalida	*Trichinella pseudospiralis*		X	
	Tylenchida	*Paratylenchus sp.*	X		
Nemertea	Monostilifera	*Ototyphlonemertes fila*	X		Nemertea
	Unplaced at order level	*Cephalothrix hermaphroditicus*		X	
Neocallimastigomycota	Neocallimastigales	*Piromyces finnis*	X		
Phaeophyceae	Ectocarpales	*Petalonia fascia*		X	
	Fucales	*Sargassum muticum*	X		
Platyhelminthes	Proseriata	*Lithophora gen. n. sp.*	X		
Proteobacteria	Oceanospirillales	*Alcanivorax sp.*		X	
Rhodophyta	Bangiales	*Pyropia haitanensis*		X	
Telonemia	Telonemida	*Telonema subtile*	X	X	
Unplaced at phylum level	Choanoflagellida	*Diaphanoeca grandis*	X	X	
		Didymoeca costata		X	
		Monosiga brevicollis		X	
		Salpingoeca kvevrii	X		
Xenacoelomorpha	Acoela	*Haplogonaria sp.*	X		
		Kuma viridis	X		
		Proporus bermudensis	X		

Notes:

1. The data is presented at the phylum level with additional taxonomic detail provided when available
2. Data cutoff for taxonomic assignment was set at >80% sequence identity and >80% sequence alignment coverage
3. Organisms listed are not the dominant taxa but instead those to which the environmental genomics analysis could assign a species name.
4. There are thousands of other taxa that were identified. However, those taxa were assigned names at higher taxonomic levels (e.g., class, order, or family).
5. Listed in the "2016 Environmental Baseline Survey Morphological ID" column are groups that were also found in the morphology-based analysis and the corresponding ID is provided.

Benthic Bycatch from the 2017 and 2018 Fish Surveys

The deepwater samples from the 2017 and 2018 fish surveys produced three benthic species, giant isopod, red deepsea crab, and flatback lobster, none of which were captured in the 2014, 2016, or 2017 environmental baseline surveys. Giant isopods were overwhelmingly the most prevalent benthic organism caught in the deepsea traps. Over 100 individuals were caught in a single trap in some locations, and baits were entirely consumed by the time some traps were retrieved, indicating that higher catches may have been attained if more bait had been used. Neither giant isopods nor red deep sea crabs were documented to be present in Guyanese waters prior to this survey (Liverpool et al. 2018), although both species are widespread in the temperate and tropical western Atlantic Ocean (Lowry and Dempsy 2006; Liverpool et al. 2018). There were no apparent spatial or seasonal patterns in the distribution of these species other than their apparently uneven distribution across the Study Area.

ROV Footage and Seabed Photography

Benthic imagery from the Stabroek Bock is available from three surveys. The 2014 survey produced a limited number of still images of macrobenthos from drop cameras; the 2016 survey produced a mosaic of still images of the seafloor; the 2017 ROV survey produced approximately nine hours of video of the seafloor.

The seabed photography from the 2016 survey indicated that the survey area primarily consists of one broad benthic habitat type: sublittoral sediment (EUNIS[21] code A5). This marine benthic habitat can encompass a wide range of sediments from boulders, cobbles, pebbles and shingles, coarse sands, sands, fine sands, muds, and mixed sediments (Davies et al. 2004). The footage from the ROV survey is broadly consistent with the findings of the 2016 survey. Each sediment type hosts characteristic biological communities, which together define biotopes. Within the sublittoral sediment habitat, one biotope was identified: circa-littoral sandy mud (A5.35) with aspects of deep sea mud. Benthic epifauna were scarcely observed in the photographs taken in 2016; however, the 2017 ROV footage showed some areas with abundant evidence of burrowing infauna. Figure 7.8-3 provides representative photographs of the circa-littoral sandy mud biotope taken from five of the 2016 sample stations. Epifauna were sparse in the photographs and videos, but evidence of habitation by tube-building polychaetes (possibly Sabellidae and Terebellidae), burrowing shrimp, and foraminifera can be observed in all of the images of the seafloor. Mud shrimp burrows were evident in most photographs, and some photographs showed other taxa including tusk shells, gastropods, and hydroids.

[21] The European Nature Information System (EUNIS) is a habitat classification system developed by the European Environment Agency in collaboration with international experts. The EUNIS includes all types of natural and artificial habitats, both aquatic and terrestrial.

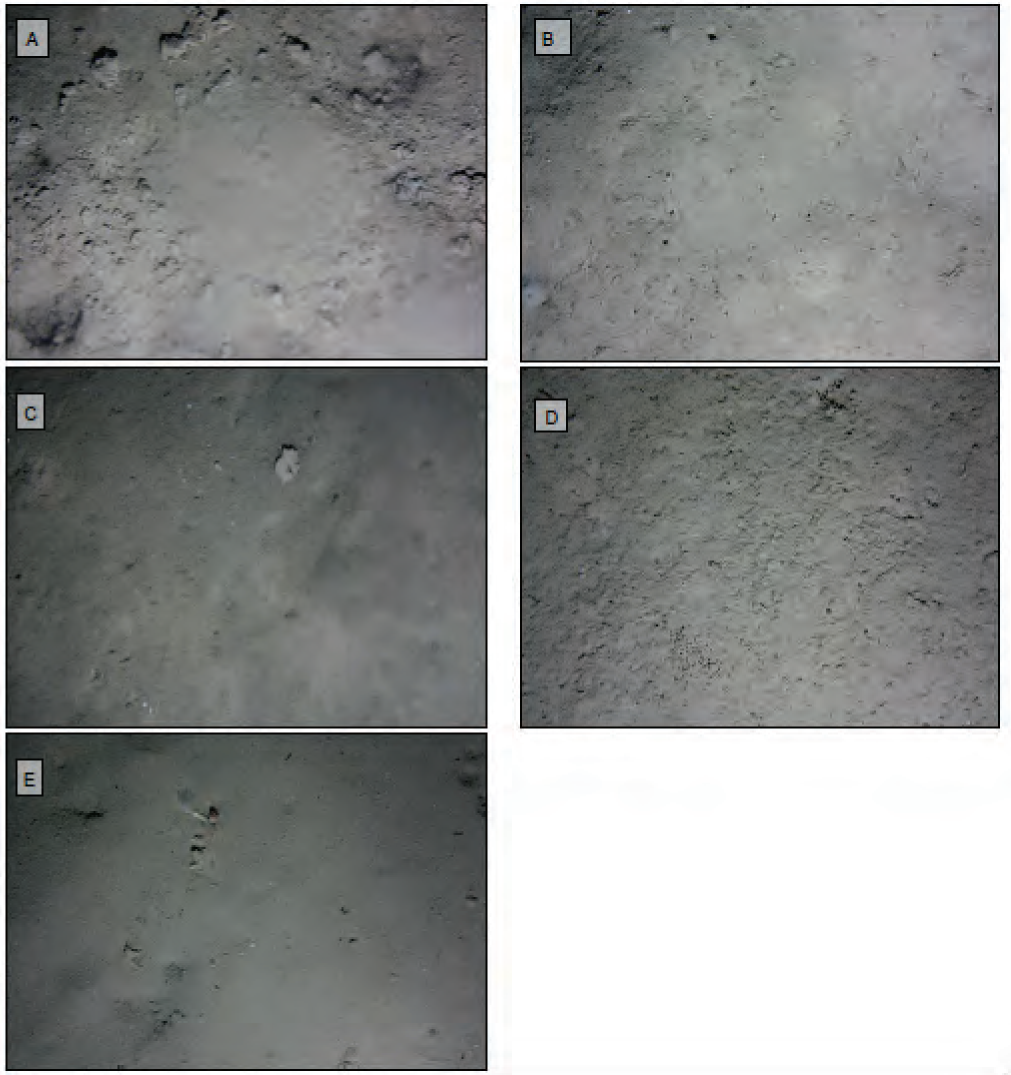


Figure 7.8-3: Representative ROV Photographs of Benthic Habitat from the Stabroek Block

Source: FUGRO 2016
Photo A: Station NC21_BCE002—mud, tube-building polychaetes and amphipods, mud shrimp burrows, Scaphopoda (tusk shells), gastropods, foraminiferans
Photo B: Station NC21_BCE004—sandy mud, tube-building polychaetes and amphipods, mud shrimp burrows, foraminiferans, unidentified hydroid
Photo C: Station NC21_BCE005—sandy mud, tube-building polychaetes and amphipods, foraminiferans, Scaphopoda
Photo D: Station NC21_BCE024—sandy mud, tube-building polychaetes and amphipods, foraminiferans
Photo E: Station NC21_BCE025—muddy sand, Sabellids and other tube-building polychaetes, mud shrimp burrows, foraminiferans

The only photographs of live benthic macrofauna on the seafloor are a few opportunistic photos taken during the 2014 survey and a small number of still images extracted from the deepwater ROV footage in 2017, as depicted in Figure 7.8-4. Neither giant isopods nor flatback lobsters have been captured live on film in the Stabroek Block to date; however, they are known to occur in the block on the basis of their capture in the deepwater fish survey, and the isopods are believed to be locally common in at least some parts of the block based on the high numbers that were captured in the deepwater fish traps. Representative photos of giant isopods are included in Figure 7.8-5.

Figure 7.8-4: Representative ROV Photographs of Macrobenthos from the Stabroek Block

Figure 7.8-5: Representative Photographs of Macrobenthos from the Deepsea Traps in the Stabroek Block

7.8.3. Impact Assessment—Marine Benthos

This section addresses the potential impacts on marine benthic biological resources (i.e., "benthos") resulting from planned Project activities. The key potential impacts assessed include injury to benthos as a result of deposition of drill cuttings (via smothering and/or toxicity impacts from residual oil contained on discharged cuttings), injury or disturbance of benthos as a result of disturbance of the seafloor during installation of Project components, and changes to benthic habitat as a result of the initial placement of Project components on the seafloor, as well as the abandonment-in-place of additional components during decommissioning.

7.8.3.1. Relevant Project Activities and Potential Impacts

The PDA is located in the eastern portion of the Stabroek Block in water depths ranging from approximately 1,500 to 1,900 meters (approximately 4,900 to 6,200 feet). As described above, this area's macrofauna community is dominated by polychaete worms and crustaceans as the most abundant major taxonomic groups, followed by, molluscs and other taxa. Benthic microepifauna were generally scarce in the environmental baseline survey samples, with the exception of tube-building polychaetes (possibly Sabellidae and Terebellidae) and burrowing shrimp; however, red crabs and giant isopods were locally abundant as bycatch in the deepwater fish samples.

The Project has the potential to cause localized impacts on benthos through smothering (from deposition of drill cuttings), toxicological impacts (from NADF adhered to deposited cuttings), and crushing or displacement (from placement of subsea infrastructure). These potential impacts will be balanced somewhat by the creation of artificial substrate in the form of manifolds, wellheads, and other infrastructure permanently installed on the seafloor, which will have the potential to benefit benthos by providing additional hard substrate for colonization.

Table 7.8-4 summarizes the Project stages and activities that could result in potential Project impacts on marine benthos.

Table 7.8-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Benthos

Stage	Project Activity	Key Potential Impacts
Development Well Drilling SURF/FPSO Installation	Discharge of drill cuttings and accumulation on seafloor Installation of FPSO anchor structures and SURF infrastructure on the seafloor	• Smothering of benthos as a result of accumulation of drill cuttings • Toxicological impacts on benthos from NADF adhered to deposited drill cuttings • Crushing of benthos where subsea infrastructure is placed
Production Operations	Presence of (non-moving) infrastructure on the seafloor	• Creation of artificial substrate for use by benthos during production operations (positive)
Decommissioning	Abandonment of infrastructure on the seafloor	• Creation of artificial substrate for use by benthos indefinitely (positive)

7.8.3.2. Characterization of Impacts—Injury Due to Drill Cuttings Deposition

Magnitude of Impact—Injury Due to Drill Cuttings Deposition

Planned discharges of drill cuttings and fluids will impact marine benthos as a result of accumulation of cuttings on the seafloor around the well locations. Potential routes of impact include physical and toxicological pathways.

With regard to potential physical impacts, discharged drill cuttings will accumulate on the seafloor close to the individual wells, and some benthic fauna will likely be impacted through burial and smothering. Smothering is a biological impact on benthos induced by the physical impact of burial. The severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen depleting material (and the resulting anoxic conditions beneath the depositional layer), and the duration of the burial. Thickness thresholds vary by species and sediment permeability. A threshold deposition rate of 5 centimeters per month for smothering impacts on benthic communities is recommended based on publications by Ellis and Heim (1985) and MarLIN (2011). Smaller threshold values (as low as 1 millimeter) have also been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering impacts.

As described in Section 6.3.3, Impact Assessment—Marine Geology and Sediments, modeling of drill cuttings discharges for eight well/current combination scenarios indicated the maximum depositional thickness of cuttings on the seafloor is predicted to be between 16.2 and 98.3 centimeters, depending on currents and drill center locations. The model-predicted extent of cuttings deposition above the 5 centimeters per month threshold will be confined to within a relatively short distance from the drill center locations, with the area above 5 centimeters accumulation thickness predicted to be approximately 97 meters (approximately 318 feet) in diameter for the scenario with the greatest modeled maximum thickness. Figure 7.8-6 depicts the maximum total thickness of deposited cuttings for this scenario.

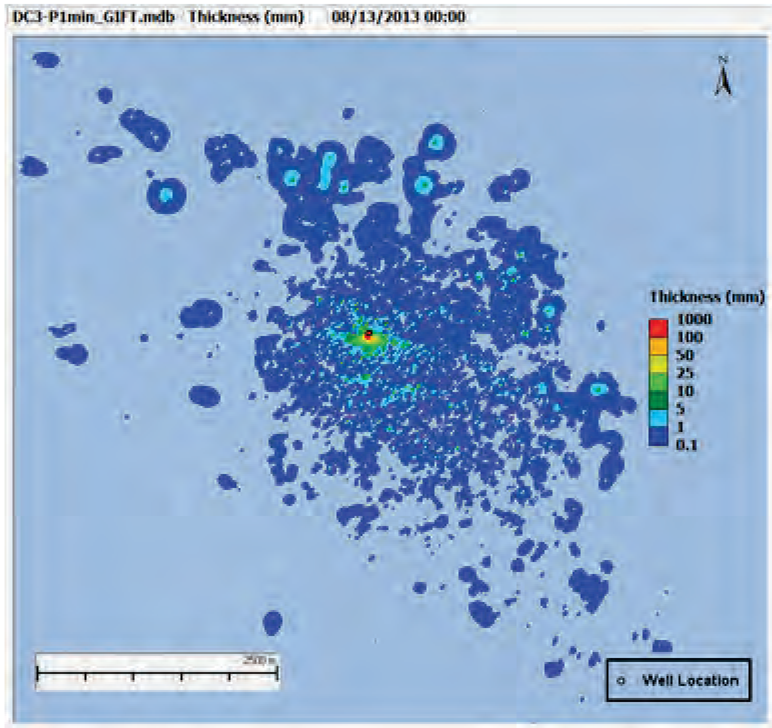


Figure7.8-6: Accumulated Cuttings based on Model Results

With respect to potential toxicological effects, deposited cuttings and additional (non-cutting) sediments will gradually mix with and overlay the cuttings over time, gradually returning the surficial sediment layer to a chemical state similar to existing conditions. Additionally, the NADF used by EEPGL will be a low-toxicity substance, reducing the potential that changes in sediment quality will lead to toxicological impacts on benthic fauna.

Assuming no more than two drill ships could be drilling at any one time, the conservative approach is to double the highest total area predicted to be subjected to a cuttings deposition rate greater than 5 centimeters per month at any one time. This results in a predicted area of approximately 14,800 m^2 (approximately 159,310 square feet), which represents approximately 0.02 percent of the area of the Subsea PDA (which itself covers approximately 0.3 percent of the Stabroek Block). Further, the currents are expected to redistribute the cuttings away from their initial deposition sites over time, gradually reducing their thickness on the seafloor at these locations. Finally, biodegradation of NADF will result in natural attenuation of toxicity to marine benthos. Considering the extremely limited scale of potential impact relative to the overall sediment resource of the Stabroek Block and the limited extent of potential toxicological impacts, the magnitude of impact on marine benthos from drill cutting deposition is considered **Negligible**.

Sensitivity of Receptor—Injury Due to Drill Cuttings Deposition

A study of benthic megafauna in a similar environment offshore Venezuela found that abundances in the vicinity of offshore development sites were significantly reduced after drilling. Highly mobile organisms returned to the area soon after drilling was completed. However, the species composition of sessile taxa was altered, with analyses suggesting that their density increased further away from areas that had been disturbed. The recovery potential of deepsea marine benthic biological resources, particularly sessile taxa, following cessation of drilling activities is unknown (Jones et al. 2012). Sessile individuals will likely experience injury or mortality in areas where drill cuttings deposition exceeds the above-referenced threshold; however, long-term impacts on the benthos population are not expected as a result of smothering of these individuals. Benthic macrofauna, including shrimp and red crabs, are capable of moving rapidly away from impacted areas, so these species will be expected to mostly avoid injury and mortality due to smothering. Giant marine isopods are comparatively less mobile and will therefore be comparatively more sensitive to potential impacts from smothering than crabs and shrimp.

With respect to toxicity impacts, contaminants deposited on the seafloor can pose risks to those deepsea benthos living within or in close association with bottom substrates that are unable to avoid exposure due to their relatively sedentary existence. These benthos perform functional roles in the deep-sea ecosystem, including sediment bioturbation and stabilization, organic matter decomposition, and nutrient regeneration, and serve as food sources to higher trophic levels; accordingly, toxicity could impact the population size as well as move up the food chain via bioaccumulation.

Based on consideration of the above, the overall sensitivity of marine benthos to drill cuttings deposition impacts was rated as **Low**.

Impact Significance—Injury Due to Drill Cuttings Deposition

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos associated with injury from discharge of drill cuttings is considered **Negligible**.

7.8.3.3. Characterization of Impacts—Injury or Disturbance Due to FPSO and SURF Installation

Magnitude of Impact—Injury or Disturbance Due to FPSO and SURF Installation

The shallow sediment layer will be disturbed during installation of subsea infrastructure (SURF and FPSO mooring structures) on the seabed. In addition to disturbance of the habitat, individual benthic organisms are likely to be crushed, dislocated from the substrate (sessile organisms), or dismembered as a result of these occurrences. As indicated in Table 7.8-5, which summarizes the area that will be disturbed by installation of various infrastructure components, approximately 770,000 m^2 (77 hectares, approximately 190 acres) (incorporating a 50 percent contingency factor) will be subject to essentially one-time disturbance by the installation activities. The use of anchors by vessels other than the FPSO is not expected; other vessels will use dynamic positioning to maintain station offshore.

Table 7.8-5: Area of Benthic Habitat Disturbed by FPSO and SURF Subsea Infrastructure Installation

Equipment	Quantity	Unit Area / Width	Subtotal (m^2)
Trees	30	21 m^2	630
Flying Leads	10,152 meters	1-meter width	10,152
Production Manifolds	4	135 m^2	540
Production Flowline Structures	8	100 m^2	800
Water Alternating Gas Injection Manifolds	3	135 m^2	405
Water Injection Pipeline Structures	2	100 m^2	200
Gas Injection Pipeline Structures	2	100 m^2	200
Gas Injection Line	20,978 meters	3-meter width	62,934
Production Line	61,882 meters	3-meter width	185,646
Umbilical Line	40,560 meters	3-meter width	121,680
Water Injection Line	20,626 meters	3-meter width	61,878
SDUs	12	60 m^2	720
FPSO Anchor Piles and Chains	20	250 m^2	5,000
FPSO Mooring Leg Prelay	20	3000 m^2	60,000
		Subtotal	510,785
	Total with approximately 50% contingency		770,000

The mortality of benthos, particularly sessile taxa, which are directly contacted during installation of subsea infrastructure within this area is anticipated to be high. Although some organisms will survive, they may be left with injuries that may impair their survival by making them prone to infection or vulnerable to predators. In addition, the population structure in the specific disturbance areas may temporarily change as more motile benthos taxa enter the disturbed area to scavenge organisms that did not survive. However, this impact will only occur within a small percentage of the Subsea PDA (approximately 1 percent by area) or approximately 0.003 percent of the Stabroek Block. From a benthic population standpoint, this leads to an impact magnitude rating of **Negligible**.

Sensitivity of Receptor—Injury or Disturbance Due to FPSO and SURF Installation

The sensitivity of the marine benthos population to FPSO and SURF installation impacts is considered **Low**. While the mortality rate of sessile taxa individuals from physical disturbance resulting from installation of the subsea infrastructure will be high, the population is not anticipated to be sensitive to the reduction in individuals within the limited area affected.

Impact Significance—Injury or Disturbance Due to FPSO and SURF Installation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos associated with injury or disturbance due to FPSO and SURF installation is considered **Negligible**.

7.8.3.4. Characterization of Impacts—Presence (and Abandonment) of Subsea Infrastructure

Magnitude of Impact—Presence (and Abandonment) of Subsea Infrastructure

As described in Section 2.11, End of Phase 2 Operations (Decommissioning), at the end of operations some subsea infrastructure, including the SURF equipment that is connected to the FPSO (e.g., risers, umbilical), SURF equipment sited on the seafloor, and FPSO mooring system, may be disconnected and abandoned in place on the seafloor in accordance with standard industry practice, consistent with the decommissioning plan. This would constitute an irreversible loss of natural, soft, bottom habitat within the collective footprint of these structures, but some species of benthos may colonize this hard substrate or be attracted to it as an artificial reef, as found in shipwrecks in the Gulf of Mexico (Kilgour and Shirley 2008). This will only occur within the immediate footprint of the abandoned infrastructure and is expected to affect a relatively small number of organisms. This positive impact is also relevant for the production operations stage, as benthic organisms will have the opportunity to colonize elements of subsea infrastructure that remain stationary through the production operations stage. These positive impacts will be temporary for any infrastructure that is removed at the time of decommissioning.

The addition of small amounts of hard substrate will likely increase the diversity of the local benthic community as species that require hard substrate colonize the area where none existed before, but this must be balanced with the loss of soft substrate that will continue to be unavailable within the footprint of the subsea infrastructure. While these effects will occur over a small area of the PDA, the potential net effect on marine benthos is considered **Positive**.

Sensitivity of Receptor—Presence (and Abandonment) of Subsea Infrastructure

The sensitivity of the marine benthos to this impact is considered **Low**, as only a small number of organisms will be impacted and those are species that are accustomed to colonizing hard substrate, in an area where this type of surface is not common.

Impact Significance—Presence (and Abandonment) of Subsea Infrastructure

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential impacts on marine benthos from the presence and abandonment of subsea infrastructure is considered **Positive**.

7.8.4. Mitigation Measures—Marine Benthos

Based on the **Negligible** significance of potential marine benthos impacts, no mitigation measures are proposed.

Table 7.8-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on marine benthos. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment.

Table 7.8-6: Summary of Potential Pre-Mitigation and Residual Impacts - Marine Benthos

Stage	Potential Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Smothering and/or toxicity impacts	Negligible	Low	Negligible	None	Negligible
SURF/FPSO Installation	Injury or disturbance	Negligible	Low	Negligible	None	Negligible
Production Operations Decommissioning	Creation of artificial substrate	Not Rated (Positive)	Low	Positive	None	Positive

7.9. Ecological Balance and Ecosystems

7.9.1. Administrative Framework—Ecological Balance and Ecosystems

Table 7.9-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on ecological balance and ecosystems.

Table 7.9-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Ecological Balance and Ecosystems

Title	Objective	Relevance to the Project
Legislation		
Wildlife Management and Conservation Regulations, 2013 (recently supplemented by passing of Wildlife Conservation and Management Act, 2016)	Provides for the establishment of a Management Authority and the management of the country’s flora and fauna. Provides for classification of some species as vulnerable, endangered, or critically endangered; 2016 Act specifies that the Act applies to all species in Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) Appendices I, II and III unless otherwise reserved by Guyana.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management, and sustainable use.
International Agreements Signed/Acceded by Guyana		
Convention on Biological Diversity	Promotes biological conservation within the framework of sustainable development and use of biological resources, and the fair and equitable sharing of benefits of genetic resources.	Discourages activities that would negatively impact biodiversity. Guyana signed in 1992, ratified in 1994.

7.9.2. Existing Conditions—Ecological Balance and Ecosystems

In cooperation with the University of Rhode Island, NOAA developed the Large Marine Ecosystem (LME) concept as a model to assess and manage ecological functions at the regional scale. LMEs are defined as relatively large areas of ocean space of approximately 200,000 square kilometers (km^2) (20,000,000 hectares or approximately 80,000 square miles [mi^2]) or greater. These areas are adjacent to continents in coastal waters where primary productivity is generally higher than in open ocean areas. The PDA is located in the northwestern portion of the North Brazil Shelf LME, which comprises the coastal waters adjacent to northeastern South America from the eastern edge of the Caribbean Sea to the Parnaiba River in Brazil (see Figure 7.9-1. Its width varies, but it extends roughly 500 kilometers (approximately 300 miles) off the coast of Guyana (Marineregions.org 2005).

7.9.2.1. Marine Nutrient Cycle

The three most important nutrients in the marine nutrient cycle are nitrogen, phosphorous, and silicon (Nihoul and Chen 2008). The primary source of all of these nutrients in the marine food web is phytoplankton, which assimilate the nutrients from the surrounding seawater. Nitrogen and phosphorous are essential nutrients to all plant life, and silicates enter the marine nutrient cycle largely through diatoms, a specific class of phytoplankton that construct hard silicate exoskeletons.

The LME concept was initially based on differences in primary productivity between coastal and open ocean waters (URI 2018). The 66 LMEs that have been delineated are placed in one of five productivity categories, from Very Low to Very High. The North Brazil Shelf LME is in the "Highly Productive" category (indicating more than 300 grams of carbon produced per square meter of ocean surface per year [$gC/M^{-2}year^{-1}$]) and daily primary productivity rates can occasionally exceed 8 $gC/M^{-2}day^{-1}$ in the LME owing to large nutrient inputs from the Amazon Basin as well as complimentary inputs from smaller rivers that drain the Guiana Shield (Heileman 2009). High turbidity, particularly near the coast in waters directly influenced by these rivers, is both a function of the high nutrient load and a control on the primary production that these nutrients promote. As such, primary productivity has been found to be highest in the transition zone between nutrient-rich coastal waters with low sunlight transmission and clearer offshore waters where light is transmitted more readily but nutrients are comparatively scarce (Heileman 2009).

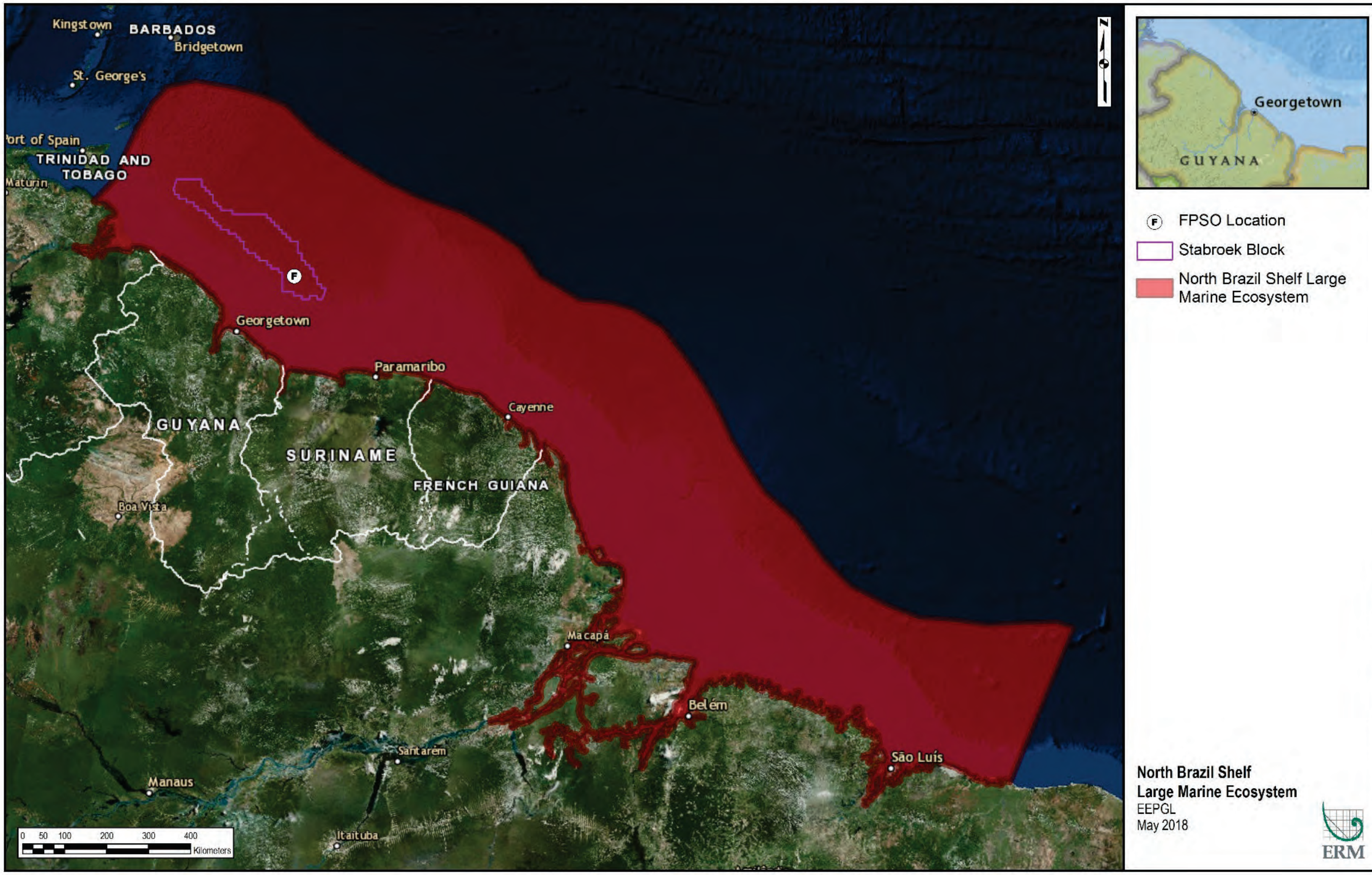


Figure 7.9-1: The North Brazil Shelf Large Marine Ecosystem

7.9.2.2. Gene Flow

Marine environments (particularly open-ocean environments such as the Stabroek Block) are often considered homogenous across large geographical distances. Consistent with this view, several studies have shown significantly lower genetic differentiation among populations of marine fish species as compared to freshwater fishes. Based on observed rates of genetic differentiation between generations, genetic exchange between marine fish populations has been estimated to occur at 10 to 100 times the rate of exchange in freshwater populations (Ward et al. 1994). Nevertheless, since the late 1990s, studies have increasingly documented genetic differentiation among populations of marine organisms. Genetic boundaries between populations tend to occur along geomorphic and current boundaries (Ruzzante et al. 1998; Nielsen et al. 2003; Johannesson et al. 2006). Genetic exchange across large expanses of open ocean is aided by the prevalence of planktonic early life stages in numerous taxa.

Several studies of marine biota have been conducted within or in the vicinity of the PDA in recent years, including studies of marine mammals, turtles, fish, and benthos, and none have detected the presence of endemic species. In 2016, environmental DNA was collected from sediment and seawater samples during a baseline survey of the Liza-1 Field. No regionally endemic species were reported. These results are consistent with the concept that genetic isolation is much rarer in the open ocean than on land (CEGA 2016).

7.9.2.3. Biodiversity

Although the marine LME concept was initially based on primary productivity, one of the most readily apparent characteristics of a marine LME is the biodiversity it contains. Detailed information on the biodiversity aspects of the Stabroek Block are provided in Section 7.4.2, Existing Conditions—Seabirds; Section 7.5.2, Existing Conditions—Marine Mammals; Section 7.6.2, Existing Conditions—Marine Turtles; Section 7.7.2, Existing Conditions—Marine Fish; and Section 7.8.2, Existing Conditions—Marine Benthos.

7.9.3. Impact Assessment—Ecological Balance and Ecosystems

All planned Project activities that could affect the physical or biological attributes of the Project AOI are broadly relevant to an assessment of impacts on ecological balance and ecosystems because the potential impacts will occur within the North Brazil LME. Therefore, rather than focusing on individual Project activities and their separate impacts on specific ecosystem components, this section identifies key ecosystem components and functions, and assesses the ecosystem-level implications of the potential impacts identified in the resource-specific impact assessments discussed in prior sections of Chapter 7 that could potentially impact those key components and functions. Although there is no universally accepted definition of key ecological functions (in generic terms or with respect to the North Brazil Shelf LME), they generally include such basic processes as nutrient cycling, gene flow, and maintenance of biodiversity.

7.9.3.1. Magnitude of Impacts—Ecological Balance and Ecosystems

The Project's predicted ecosystem-level impacts are indirect impacts that will potentially occur as a result of direct impacts on specific abiotic and abiotic components of the larger ecosystem. The assessment of the Project's magnitude of impacts on the North Brazil LME is determined based on the geographic extent of the impact compared to the size of the North Brazil LME, and the initial rating of the direct impact that will drive the indirect ecosystem-level impact. The magnitude of potential ecosystem-level impacts is defined according to the definitions provided in Table 7.9-2.

Table 7.9-2: Definitions for Magnitude Ratings for Potential Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Magnitude	Negligible: Impact is within the normal range of variation for the ecosystem as a whole.
	Small: Impact is predicted to be outside the range of natural variation, but does not cause a substantial change in any of the key ecosystem functions identified in Section 7.9.2, Existing Conditions—Ecological Balance and Ecosystems.
	Medium: Impact is predicted to be outside the range of natural variation, and causes a substantial change in one or more of the key ecosystem functions identified in Section 7.9.2.
	Large: Impact is predicted to be outside the range of natural variation, and causes a substantial change in two or more of the key ecosystem functions identified in Section 7.9.2.

Many of the embedded controls identified in Section 2.13, Embedded Controls, will serve to reduce the potential for or magnitude of impacts on one or more physical, biological, or chemical attributes of the ecosystem, and will therefore play a role in reducing the initial magnitude of impacts on ecological balance and ecosystems.

On the basis of the definitions and embedded controls described above, the magnitude of the various potential impacts on ecological balance and ecosystems are discussed below.

Changes in the Marine Nutrient Cycle

The Project could potentially indirectly impact the marine nutrient cycle through its impacts on marine water quality, which could in turn impact phytoplankton growth. As discussed in Section 6.4.3, Impact Assessment—Marine Water Quality, the Project is predicted to have negligible impacts on water quality, and these potential impacts are predicted to be limited to a relatively small, localized mixing zone around the FPSO. These potential impacts are likely to change the species composition of the phytoplankton community to species that are tolerant of elevated water temperatures and this may increase rates of photosynthesis within the mixing zone; however, based on the negligible significance of water quality impacts, and the very small portion of the North Brazil Shelf LME that will be exposed to these impacts, the Project is predicted to have little if any measureable ecosystem-level impacts on nutrient cycling. On this basis, the magnitude of potential impact on ecological balance and ecosystems associated with changes to the marine nutrient cycle is considered **Small**.

Impacts on Gene Flow

Maintaining gene flow is critical to supporting the genetic diversity in marine biological populations, which in turn is an important factor in the general resilience and vigor of marine flora and fauna. Obstacles to efficient gene flow occur whenever physiochemical barriers to migration, breeding, or dispersal/colonization occur. Oceanic currents are a key driver of biological dispersal because many marine species spend all or part of their lives drifting as part of the plankton. A project could potentially have significant impacts on gene flow if it impacts large-scale current patterns, alters the geological boundaries of ocean basins, or prevents site-specific reproductive events (such as spawning aggregations) from occurring. The Project is not predicted to have any appreciable impact on regional current patterns that define the North Brazil Shelf LME, nor is it predicted to impact any site-specific reproductive activities that could be considered significant at a regional or ecosystem scale. On this basis, the magnitude of potential impact on ecological balance and ecosystems associated with impacts on gene flow is considered **Negligible**.

Impacts on Biodiversity

The Project is predicted to have numerous potential impacts of varying levels of significance on marine species, but is not expected to impact large-scale distribution of species or cause the loss of any species from within the North Brazil Shelf LME. Some benthic species may be locally displaced from the footprint of the FPSO and SURF seabed components and some pelagic species may be locally displaced from the surface mixing zone that will form around the FPSO liquid effluent discharges, but these potential impacts will be insignificant at the ecosystem scale. Additionally, there is a negligible risk of the Project causing the extinction or extirpation of any species from the North Brazil Shelf LME, or measurably exacerbating any of the risk factors that have contributed to the listing of the special status species assessed in Section 7.1.3, Impact Assessment—Protected Areas and Special Status Species.

The greatest potential to affect biodiversity in the LME is associated with the potential introduction of exotic species from ballast exchanges by export tankers visiting the LME during production operations. The global movement of ballast water is considered to be the largest transfer mechanism for marine non-indigenous species (Ruiz et al. 2005). Ballast water is water carried in ships' ballast tanks to improve vessel stability, balance, and trim; it is essential for the safe operations of oceangoing ships. It is taken onboard or discharged when cargo is unloaded or loaded, or when a ship needs extra stability in foul weather. When ships take on ballast water, aquatic plants and animals may also be entrained into the ballast tanks. These organisms are transported in the ballast tanks of the ships, and, upon being discharged, some non-native species may survive and establish themselves in the new environment if the habitat conditions are suitable. If the non-native species become invasive, they may result in ecological, economic, and public health impacts (MCA 2008). If the invasive species become dominant in the new environment, they can displace native species, change local/regional biodiversity, and affect local economies based on fisheries. In addition, these invasive species may also affect industries that withdraw coastal water and affect public health (EMSA 2017).

The Caribbean Invasive Alien Species Working Group, of which Guyana is a member, has identified one species, the green mussel (*Perna virdis*), as having been introduced to the Caribbean and South American coastal waters via ballast water (CIASNET 2010).

The Project has the potential to contribute to the spread of marine invasive species as the discharges of ballast water will be required for initial FPSO installation and recurring tanker offloading during production operations. As discussed in Section 2.7.8.3, Ballast System, ballast water will be required for FPSO transit from the shipyard to the PDA. Once in the PDA, the unneeded ballast water from the FPSO may be discharged overboard. EEPGL's planned ballast water management program will be consistent with international best practice, including provisions in the International Convention for the Prevention of Pollution from Ship. The initial FPSO ballast discharge will occur only during a limited time period during SURF installation and commissioning activities. It is estimated that no more than 550,000 barrels of ballast water will be discharged into Guyanese waters (Table 2.12-5) during this time. To mitigate the risk of invasive species, the ballast water taken on at the FPSO's point of origin will be exchanged with water from deep international waters. This practice is generally thought to reduce the likelihood of introducing invasive species to new coastal habitats because oceanic organisms are considered unlikely to colonize coastal habitats (Ruiz et al. 2005). The environmental conditions at the point where the water is withdrawn will likely be at least moderately saline water and therefore somewhat similar to the conditions in the PDA, which means that at least some organisms discharged into the PDA will be likely to survive the event; however, this also means that these organisms will likely include many of the same open-ocean species that occur naturally in the PDA.

During production operations, offloading tankers will routinely discharge ballast water in Guyanese waters as oil from the FPSO is loaded. It is estimated that a maximum of 1,200,000 bbl of ballast water (Table 2.12-5) will be discharged during each loading. These ballast water discharges will be conducted in accordance with internationally recognized standards and in compliance with IMO requirements. The ecological effect will be similar to the effect of the ballast discharge from the FPSO in the sense that organisms from the open ocean could be discharged at the FPSO. However, ballast discharges from tankers will occur routinely during the production phase as opposed to the one-time FPSO ballast discharge during the installation phase.

Based on the factors above, the magnitude of potential impact on ecological balance and ecosystems associated with impacts on biodiversity is considered **Small**.

7.9.3.2. Sensitivity of Receptor—Ecological Balance and Ecosystems

The assessment of the ecosystem as a broad receptor of indirect impacts from the Project is based on the sensitivity of the receptor to the initial direct impact that will drive the ecosystem-level impacts. Ecosystem level sensitivity is defined according to the definitions provided in Table 7.9-3.

Table 7.9-3: Definitions for Receptor Sensitivity Ratings for Impacts on Ecological Balance and Ecosystems

Criterion	Definition
Sensitivity	Negligible: Biological impacts affect receptors with no specific value or importance attached to them.
	Low: Biological impacts affect species and sub-species of Least Concern on the IUCN Red List (or not meeting criteria for medium or high value), or without specific anatomical, behavioral, or ecological susceptibilities to Project-related impacts.
	Medium: Biological impacts affect species listed as Vulnerable, Near Threatened, or Data Deficient on the IUCN Red List, species protected under national legislation, nationally restricted range species, nationally important numbers of migratory or congregatory species, species not meeting criteria for high value, and species vital to the survival of a medium value species.
	High: Biological impacts affect species on IUCN Red List as Critically Endangered or Endangered. Species having a globally restricted range (e.g., fauna having a distribution range less than 50,000 km^2 (20,000 mi^2), internationally important numbers of migratory, or congregatory species, key evolutionary species, and species vital to the survival of high value species.

Based on the sensitivity rating definitions above, the receptor sensitivity for the ecosystem is considered **Low** for impacts on nutrient cycling and gene flow, and **Medium** for impacts on biodiversity. The ratings for nutrient cycling and gene flow are principally due to the assimilative capacity of the LME afforded by its large size, and the assumption that genetic exchange between the North Brazil LME and adjacent LMEs is robust due to the general lack of obstacles to gene flow in the ocean. The sensitivity to impacts on biodiversity is principally due to the numerous species in the LME that are listed as Data Deficient by the IUCN, and the fact that the plankton community (which forms the basis of the marine food web) would likely be the first element of the ecosystem to be impacted by introduction of non-indigenous species.

7.9.3.3. Impact Significance—Ecological Balance and Ecosystems

Based on the magnitude of impact of receptor sensitivity ratings described above, the pre-mitigation significance ratings for potential impacts on ecological balance and ecosystems ranges from **Negligible** to **Minor**.

7.9.4. Mitigation Measures—Ecological Balance and Ecosystems

The embedded controls integrated into the Project design and operational procedures constitute the practicable measures that are available to reduce the significance of potential impacts on ecological balance and ecosystems. Table 7.9-4 summarizes the assessment of potential pre-mitigation and residual Project impacts on ecological balance and ecosystems. The significance of impacts was rated based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, and the resource-specific methodology described above.

Table 7.9-4: Summary of Potential Pre-Mitigation and Residual Impacts – Ecological Balance and Ecosystems

Stage	Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution	Low	Small	Negligible	None	Negligible
	Impacts on gene flow	Low	Negligible	Negligible	None	Negligible
Production Operations	Introduction of invasive species via ballast water	Medium	Small	Minor	None	Minor

8. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM PLANNED ACTIVITIES—SOCIOECONOMIC RESOURCES

For the purposes of this EIA, "socioeconomic environment" is intended to encompass the human aspects of the affected environment, with specific emphasis on the social and economic characteristics of society that could be affected by the Project. This section identifies and assesses the potential impacts on the existing socioeconomic environment in the Project Area of Influence (AOI), including community health and cultural heritage, as a result of Project-related activities. The methodologies specific to the assessment of socioeconomic impacts build upon the general assessment methodology outlined in Chapter 4, Methodology for Preparing the Environmental Impact Assessment. This general approach and methodology have been adapted for use in evaluating impacts on socioeconomic resources/receptors. The evaluation criteria used to determine impact magnitude and sensitivity for specific socioeconomic resources/receptors are summarized in Figure 4.6-2.

Stakeholder engagement is critical to a robust impact assessment process. A range of stakeholders were interviewed to deepen understanding of the existing socioeconomic conditions. The information gathered was also used to inform the magnitude and sensitivity designations used in this assessment. The following socioeconomic resources/receptors with the potential to be impacted by the Project within the Project AOI are assessed in this section:

- Economic conditions
- Employment and livelihoods
- Community health and wellbeing
- Marine use and transportation
- Social infrastructure and services
- Waste management infrastructure and capacity
- Land use
- Ecosystem services
- Indigenous peoples
- Cultural heritage

Because the Project's primary planned activities are located approximately 183 kilometers (approximately 114 miles) offshore, potential impacts on socioeconomic resources/receptors as a result of planned Project activities are expected to be limited. The following are the main planned Project activities with the potential to result in socioeconomic impacts within Guyana:

- Installation and operation of the Floating Production, Storage, and Offloading (FPSO) vessel and Subsea, Umbilicals, Risers, and Flowlines (SURF);
- Drilling of development wells;
- Government revenue generation from the Project;
- Project-related employment and procurement;
- Foreign Project worker presence in the Georgetown area;
- Project use of emergency and health services in the Georgetown area;
- Project-related road and air transportation activity in the Georgetown area;

- Project use of utilities and accommodations in the Georgetown area;
- Project use of waste management infrastructure in the Georgetown area; and
- Marine vessel transits between the Project Development Area (PDA) and shorebase facilities in Guyana and between the PDA and shorebase facilities in Trinidad (in Guyanese territorial waters).

The categories of receptors considered in the assessment of potential socioeconomic impacts from planned Project activities are outlined in Table 8-1, along with the rationale for their inclusion and the potential impacts that could affect them:

Table 8-1: Socioeconomic Receptors and Associated Potential Impacts from Planned Project Activities

Receptor	Rationale for Inclusion	Potential Impacts
General Guyanese population	The Project could have far-reaching economic impacts throughout the country, which could potentially affect all segments of the population.	• Increased government revenues, potentially leading to increased social spending and investment throughout the country • Increased business activity and related employment
General population of Georgetown	The limited amount of time offshore-based foreign Project workers will be on shore will likely be spent in transit (e.g., to/from the airports or hotels). Onshore-based foreign Project workers will principally reside in Georgetown, where they will interact with the local population and make use of the same resources and infrastructure as the local population.	• Changes to community dynamics, identity, and sense of safety/security
	Project procurement and Project worker spending level may result in higher demand for goods and services.	• Increased cost of living
	The Project may result in induced influx of job seekers from other areas of Guyana to the Georgetown area.	• Increased risk of communicable disease transmission • Increased competition for employment
	The Project may rely, in a very limited manner, on some medical and health facilities in the Georgetown area to address worker illness and injury.	• Decreased accessibility of medical and health services
Road users in Georgetown (both motorized and non-motorized [e.g., cyclists, pedestrians])	The Project will use existing roads for transporting workers, materials, equipment, and wastes to/from the shorebase(s) and offices/residences.	• Increased traffic congestion • Increased risk of property damage and injury from vehicle accidents
Marine vessel operators in the Georgetown Harbour and along the coast	The Project will involve transit of various marine vessels, such as support vessels and tugs, from the Georgetown area shorebase facilities to the PDA.	• Increased marine traffic congestion (on the order of 1-3%) in Georgetown Harbour and coastal waters between Georgetown shorebase facilities and the PDA • Increased risk of marine accidents

Receptor	Rationale for Inclusion	Potential Impacts
Marine vessel operators in the vicinity of the PDA	The Project will establish marine safety exclusion zones around the FPSO, drill ships, and major installation vessels, precluding use of this area for other activities such as fishing.	• (Negligible) reduced availability of ocean areas for non-Project livelihood activities such as fishing
Archaeology and heritage resources	The Project will disturb the seafloor in the process of drilling development wells, installing FPSO components, and installing SURF components.	• Damage to underwater archaeological or heritage sites, if present

8.1. SOCIOECONOMIC CONDITIONS

This section describes the existing socioeconomic characteristics of the Project AOI, with a focus on the shore zone, or coastal areas. It was developed based on secondary information contained in Project-related materials, socioeconomic reports and data obtained through government entities and other stakeholders, and other relevant data received from public sources. It is also based on information obtained directly from key informant interviews with members of national, regional, and local governments; civil societies and non-governmental organizations (NGOs); local community members; and other Project stakeholders. Specific stakeholder engagement information can be found in Section 4.5, Stakeholder Engagement.

8.1.1. Administrative Framework—Socioeconomic Conditions

Table 8.1-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on economic conditions.

Table 8.1-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Socioeconomic Conditions

Title	Objective	Relevance to the Project
Policies and Strategies		
Framework of the Green State Development Strategy and Financing Mechanisms (2017)	Aims to reorient and diversify Guyana's economy, reducing reliance on traditional sectors, and creating new sustainable income and investment opportunities in higher-value adding and higher-growth sectors. The Strategy is expected to be finalized in 2018.	Introduces government's goal of establishing a Sovereign Wealth Fund (SWF) for using oil revenues from the hydrocarbon sector. The SWF will be invested in infrastructure, among other areas.
Draft National Energy Policy of Guyana (2017)	Update of the 1994 National Energy Policy of Guyana. Reflects current national, regional, and international commitments. Addresses concerns related to the dependence on imported fossil fuels, the need to address the efficiency and sustainability of energy supply and demand, and considers the recent discovery of offshore petroleum reserves.	Outlines the government's priorities for the development of the oil and gas sector, including the establishment of a new regulatory agency for the sector; implementation of local content policy; and establishment of a SWF. Includes government plans for upgrading energy infrastructure including oil and gas pipelines; storage facilities; oil refineries; and marine transport for oil and gas.

Title	Objective	Relevance to the Project
Local Content Policy (under development)	Would provide for preferential treatment of Guyanese where capability exists; building local capacities for the sector; international partnerships to enable technology and knowledge transfer and access to investment opportunities; extending Guyanese participation to support national development; and leveraging the petroleum sector's strategic assets, and skills for the lateral development of other sectors.	Would provide government guidance on Guyanese participation in the petroleum sector. Expected to directly influence Guyanese service provision and employment in the sector. A second draft of the Policy is under consideration by the government.

8.1.2. Existing Conditions—Socioeconomic Conditions

8.1.2.1. Administrative Divisions in Guyana

Guyana is divided into 10 administrative regions, pictured on Figure 8.1-1, which are overseen by Regional Democratic Councils (RDCs). These regions are further subdivided into 65 Neighbourhood Democratic Councils (NDCs), except for Region 1, which is subdivided into Community Development Councils (CDCs)/Town Councils (TCs). Within the NDCs and CDCs/TCs are villages run by village councils, the smallest administrative unit. In addition, there is one city that serves as the capital (Georgetown) and eight other townships. In 2015, three of these townships were gazetted as new townships by the Ministry of Communities as part of an administrative decentralization effort. Georgetown and the eight townships have mayors and councils, and serve as an administrative hub for government services, such as passports and driver's licenses. They also provide utilities and public services, such as water and sanitation and banking.

Figure 8.1-1: Guyana's Administrative Regions and Townships

Of the 10 Regions in Guyana, this EIA is focused on the shore zones or coastal areas in Regions 1, 2, 3, 4, 5, and 6. Together, these regions account for 49 NDCs and 14 Region 1 CDCs/TCs:

Region 1

- Father's Beach Community
- Manawarin Community
- Haimacobra Community
- Waramuri Community
- Santa Rosa Community
- Assakata Community
- Warapoka Community
- Three Brothers Community
- Mabaruma Town Council
- Aruka Mouth Community
- Morawhanna Community
- Smith's Creek Community
- Imabataro Community
- Almond Beach Community

Region 2

- Charity/Urasara
- Evergreen/Paradise
- Aberdeen/Zorg-en-Vlygt
- Anna Regina Town Council
- Annandale/Riverstown
- Good Hope/Pomona

Region 3

- Wakenaam (island)
- Leguan
- Mora/Parika
- Hydronie/Good Hope
- Greenwich Park/Vergenoegen
- Tuschen/Uitvlugt
- Stewartville/Cornelia Ida
- Hague/Blankenburg
- La Jalousie/Nouvelle Flanders
- Best/Klien/Pouderoyen

Region 4

- Georgetown
- Industry/Plaisance
- Better Hope/La Bonne Intention
- Beterverwagting/Triumph
- Mon Repos/La Reconnaissance
- Buxton/Foulis
- Unity/Vereeniging
- Haslington/Grove
- Enmore/Hope

Region 5

- Woodlands/Farm
- Hamlet/Chance
- Profit/Rising Sun
- Mahaicony/Abary
- Union/Naarstigheid
- Seafield/Tempie
- Bath/Woodley Park
- Woodlands/Bel Air
- Zeelugt/Rosignol

Region 6

- Ordinance/Fort Lands
- Kintyre/No. 37
- Gibraltar/Fyrish
- Kilcoy/Hampshire
- Rose Hall Town Council
- Port Mourant/John
- Bloomfield/Whim
- Lancaster/Hogstye
- Black Bush Polder
- Good Hope/No.51
- Macedonia/Joppa
- Bushlot/Adventure
- Maida/Tarlogie
- No. 52/No. 74
- Corriverton Town Council

8.1.2.2. Population Distribution

Most of Guyana's population is located in the six coastal regions; according to the 2012 national census (BSG 2002; BSG 2012), nearly half of the country's population lives in Region 4 (Demerara-Mahaica), which includes the capital city of Georgetown. Table 8.1-2 summarizes the distribution of population within the 10 regions in 2012, the last year for which complete national census data are available.

Table 8.1-2: Regional Population Distribution in Guyana

Region		Population 2002	Population 2012	Population Change Since 2002	Percent of Guyana's Total Population
1	Barima-Waini	24,275	27,643	+13.9%	3.7%
2	Pomeroon–Supenaam	49,253	46,810	-5.0%	6.3%
3	Essequibo Islands—West Demerara	103,061	107,785	+4.6%	14.4%
4	Demerara-Mahaica	310,320	311,563	+0.4%	41.7%
5	Mahaica—Berbice	52,428	49,820	-5.0%	6.7%
6	East Berbice—Corentyne	123,695	109,652	-11.4%	14.7%
7	Cuyuni-Mazaruni	17,597	18,375	+4.4%	2.5%
8	Potaro—Siparuni	10,095	11,077	+9.7%	1.5%
9	Upper Takutu—Upper Essequibo	19,387	24,238	+25.0%	3.2%
10	Upper Demerara—Berbice	41,112	39,992	-2.7%	5.3%
	Guyana	748,084	746,955	-0.6%	100.0%

Sources: BSG 2012; BSG 2002

Note: Each region's change in population should be weighted based on that region's percent of the total population; therefore, the sum of population changes in each region do not add up to the total national population change.

Population and other demographic information has not been historically collected or available at the NDC/CDC/TC level; however, informal data collected from engagement with NDCs and CDCs/TCs by the Consultants in late 2017 and early 2018 (ERM/EMC 2018) provide some estimates of the population ranges for coastal communities as described below:

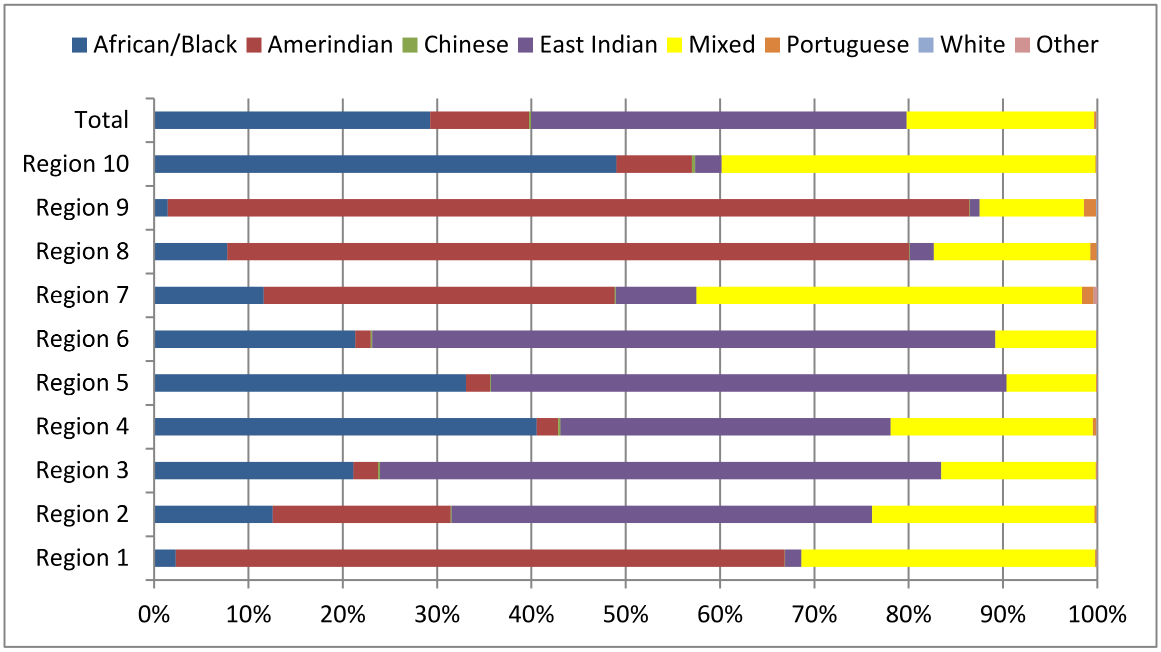
- Region 1: Each CDC/TC population ranges from approximately 50 to 500 people, with the exception of Waramuri and Manawarin (approximately 1,800 to 1,900) and Santa Rosa and Mabaruma Town Council (approximately 7,000).
- Region 2: Each NDC population ranges from 1,500 to 6,000, with the exception of Annandale/Riverstown (approximately 9,400) and Anna Regina Town Council (approximately 19,000).
- Region 3: NDCs have several thousand people each. The larger coastal NDCs range in population from Mora/Parika at approximately 10,000, to Best/Klien/Pouderoyen at approximately 20,000, and Tuschen/Uitvlugt and Stewartville/Cornelia Ida at approximately 30,000 each.

- Region 4: Georgetown's population is estimated at 132,000. The populations of Better Hope/La Bonne Intention and Mon Repos/La Reconnaissance are estimated at 50,000 and 40,000, respectively. The other NDC populations range from 2,000 to 22,000.
- Region 5: The Zeelugt/Rosignol NDC population is estimated at 18,000; the other NDC populations average a few thousand each, up to an estimated 8,000.
- Region 6: The Kilcoy/Hampshire NDC population is estimated at 30,000. Several other NDCs average in population between 10,000 and 15,000; most of the smaller NDCs have an average population of a few thousand each.

Ethnic Composition

Data from the 2012 national census (BSG 2012) indicate that the majority of the population is from two ethnic groups: East Indian descent (39.8 percent) and African descent (29.3 percent). These are followed by populations of mixed ethnicity (19.9 percent) and indigenous peoples who are referred to as Amerindians (10.5 percent). Other ethnicities, including Chinese, white, and Portuguese, collectively make up less than one percent of the population.

Figure 8.1-2 shows the ethnic composition of each region and indicates notable differences between interior and coastal regions and between regions that are highly rural versus more urban. The more populated and urban Regions 3, 4, 5, and 6 are dominated by populations of East Indian and African descent, followed by populations of mixed ethnicity. Amerindian population numbers in these regions are low. The majority residing in the more remote and rural Regions 1, 8, and 9 are of Amerindian ethnicity.



Source: BSG 2012

Figure 8.1-2: Regional Distribution of Ethnicity, 2012

Indigenous Peoples

See Section 8.10.2, Existing Conditions—Indigenous Peoples, for information on existing conditions for Indigenous Peoples.

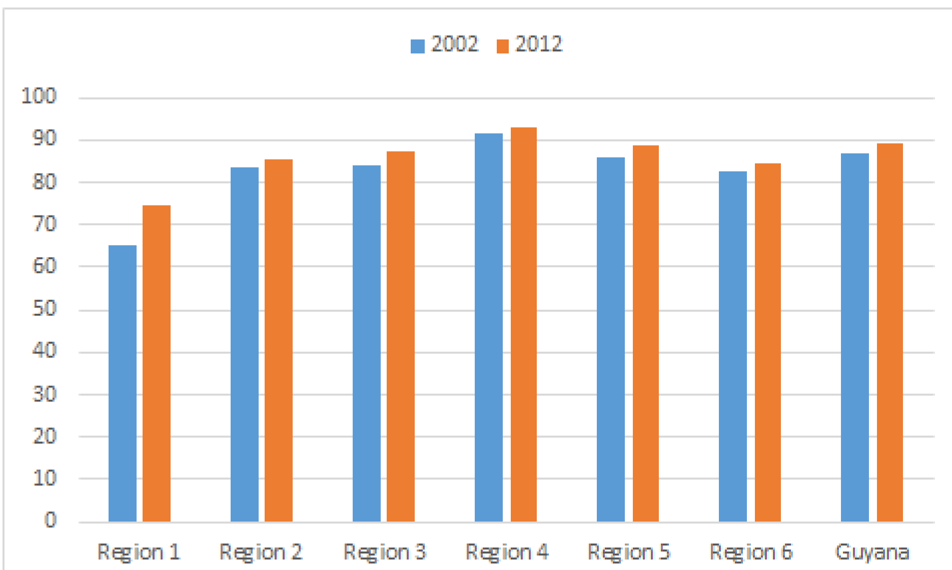
8.1.2.3. Education

Guyana's Constitution states that school attendance is compulsory up to the age of 15. Primary and secondary school are free. The Ministry of Education controls education budgets, policies, and standards and administers these by district. The country is divided into 11 education districts, 10 of which correspond with the administrative regions; Georgetown makes up the eleventh district.

In the years 2009–2013, an average of 15 percent of the national budget, or approximately 4.7 percent of gross domestic product (GDP), was allocated to education (Ministry of Education 2014).

Literacy

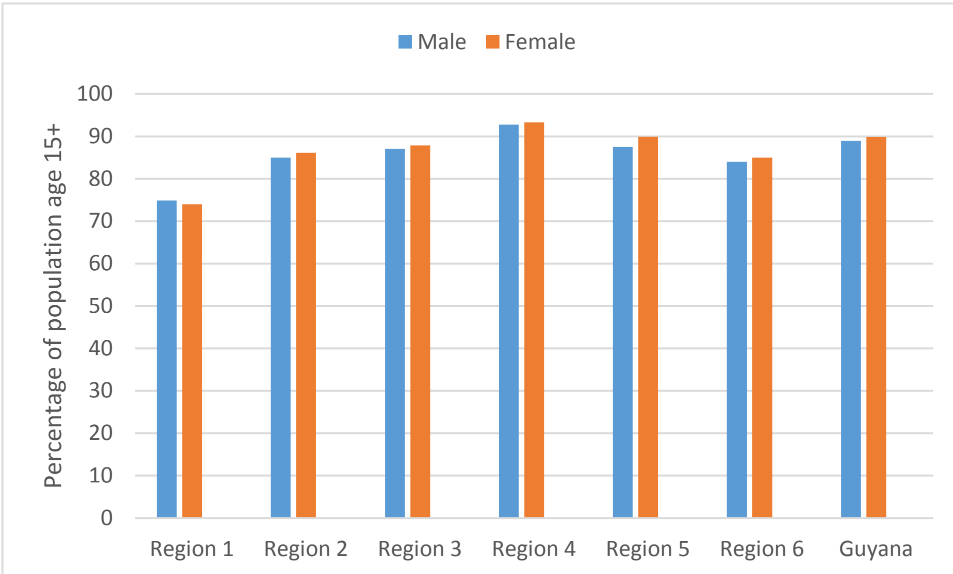
The adult literacy rate (defined as the percent of population age 15 and above that can read and write) increased by 2.5 percent between the 2002 and 2012 censuses. The lowest level of literacy occurs in Region 1, but the 2012 census showed considerable improvement (a 9.4 percent increase) over the rate measured in the 2002 census (BSG 2002; BSG 2012; see Figure 8.1-3).



Source: BSG 2012

Figure 8.1-3: Adult Literacy Rate, 2002 and 2012

Gender differences in literacy are minimal among the regions, with the female population showing a slightly higher rate of literacy than males across most of the coastal regions, and the country as a whole (Figure 8.1-4).

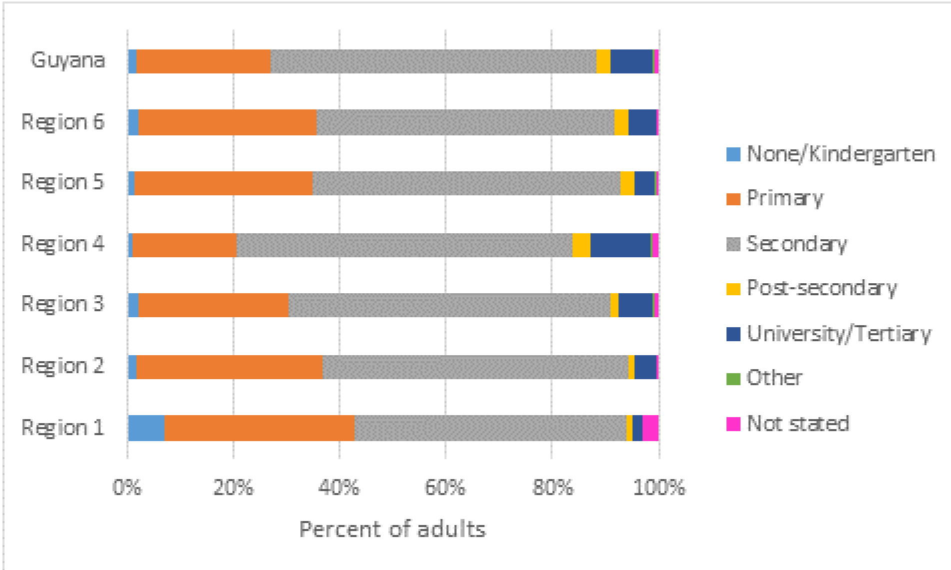


Source: BSG 2012

Figure 8.1-4: Adult Literacy Rate by Gender, 2012

Educational Attainment

Guyana has made progress in achieving universal primary education, but the education system still faces important access issues at the secondary level and quality issues across all levels of schooling. The percentage of children in Guyana attending secondary school was estimated at 84.5 percent in 2014 (World Bank 2016). Data in 2012 on the highest level of education attained by the adult population indicate that the majority of adults in Guyana at the time had attained the secondary level as their highest level (Figure 8.1-5). Of the coastal regions, educational attainment is lowest in Region 1.



Source: BSG 2012

Figure 8.1-5: Educational Attainment Level, 2012

The levels of primary education for the indigenous population are typically lower than for non-indigenous groups of the population. In Amerindian communities, the attendance rate at primary schools has been reported to be 50 percent lower than the average for Guyana (Minority Rights International 2008). This is partly attributable to a shortage of infrastructure, utilities, and qualified teachers (Ministry of Education 2014), as well as standardized teaching methods and curricula that limit appreciation for indigenous culture and values. While access to education in Amerindian communities continues to be limited, the stated government policy is to provide indigenous children with the same educational opportunities available to the rest of the population (Minority Rights International 2008).

8.1.2.4. Economic Conditions

Guyana's nominal GDP in 2016 was $723.6 billion Guyanese dollars (GYD), or approximately $3.5 billion U.S. dollars (USD). The per capita GDP in 2016 was approximately $803,250 GYD ($3,883 USD) (BSG 2018). Guyana was reclassified by the World Bank from a lower middle-income country to an upper middle-income country in 2016 (World Bank 2016). Guyana's economy grew by 3.3 percent in 2016 (up from a 3.1 percent growth performance in 2015), and has exhibited a positive trend in economic growth over the last 10 years (PSC 2017a). Guyana's main sectors by contribution to GDP are summarized in Table 8.1-3.

Table 8.1-3: Economic Sectors and Contribution to GDP, Mid-Year 2017

Sector	Percent of GDP
Agriculture, Fishing, and Forestry	19.0%
Mining and Quarrying	15.3%
Wholesale and Retail Trade	14.2%
Transportation and Storage	8.7%

Sector	Percent of GDP
Construction	7.4%
Manufacturing	7.0%
Public Administration	7.5%
Information and Communication	4.9%
Financial and Insurance Activities	4.8%
Education	4.6%
Other Services	4.6%
Health and Social Services	2.1%
Electricity and Water	2.0%
Real Estate	1.2%

Source: PSC 2017a

Note: Percentages add to more than 100 (likely in part due to rounding) but have been verified by the Consultants to be as-reported in the referenced source.

Guyana relies heavily on trade, with exports totaling $297.95 billion GYD ($1.44 billion USD) in 2017 (BSG 2017), up from $238.3 billion GYD ($1.15 billion USD) in 2015 (BSG 2015). The main export products for the country are sugar, rice, bauxite, gold, forest products, and fish (FAO 2015).

The investment climate and financial infrastructure in Guyana is underdeveloped, which means the country faces challenges in attracting investments and diversifying the economy. According to the World Bank, the overall business regulatory framework remains complex and cumbersome, and Guyana ranks 137 out of 189 economies, below Latin America and the Caribbean's regional average of 104. A challenging regulatory environment for businesses particularly affects micro-, small-, and medium-sized enterprises, which account for most businesses in Guyana (World Bank 2016).

Guyana is positioned to become a significant oil producer by the mid-2020s. Accounting for currently known discoveries, future output is conservatively estimated at 100,000 BPD for up to eight years; however, offshore exploration activities are ongoing. In addition to impacts on GDP through fiscal revenue, there will also be opportunities to boost economic growth through increased foreign direct investment in supporting goods and services in the time leading up to oil production, which will present the country with opportunities to diversify production and trade. Nonetheless, the economy's increased dependence on natural resources will also increase its vulnerability to commodity price fluctuations and could reduce the competitiveness of other sectors (IDB 2017).

Sectors that are particularly important for the coastal areas (where the potential for socioeconomic effects of the Project is higher, as compared to the rest of the country) and the mining and wholesale/retail trade sectors (which are important sectors for the country as a whole) are described in further detail below.

Agriculture

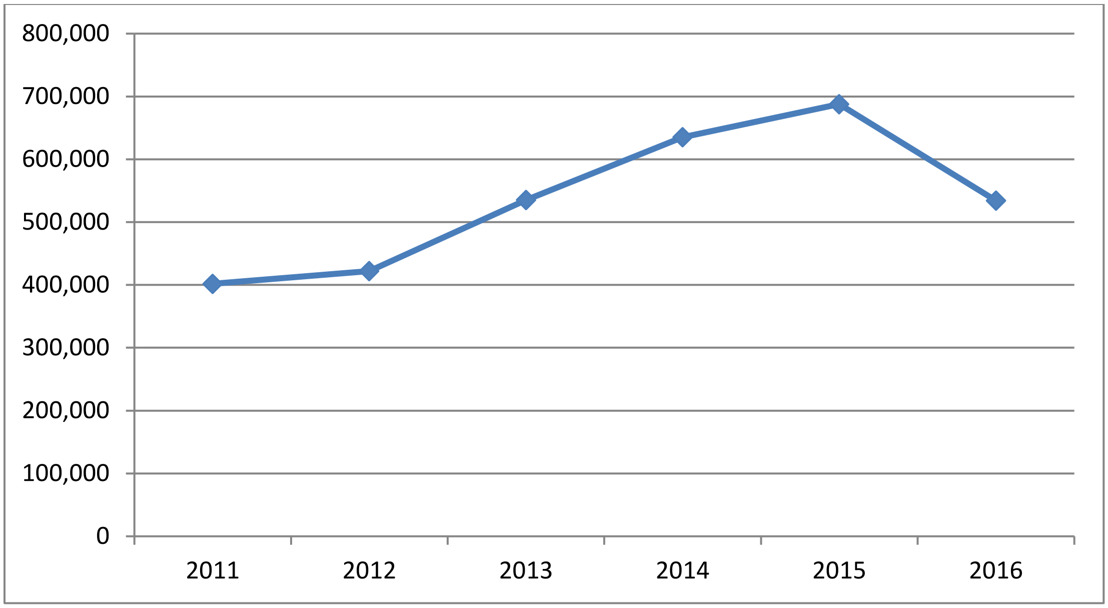
According to the Private Sector Commission (PSC), Guyana has a relatively strong agricultural sector and is the only net exporter of food in the Caribbean. In 2016, agriculture contributed $66.97 billion GYD (approximately $323.5 million USD) to the GDP; however, the contribution decreased by 10.4 percent as compared to 2015 (PSC 2017a). By mid-2017, agriculture, fishing, and forestry grew by 6.4 percent and accounted for 19 percent of the country's GDP (PSC 2017b).

Rice

Rice farming is the predominant agricultural activity in the coastal areas of Regions 2, 3, 5, and 6, accounting for an estimated 85 percent of the overall economy in Region 2 and 55 to 60 percent of the economy in Region 3 (ERM Personal Communication 1). Rice fields dominate the landscape in many coastal areas in these regions (Figure 8.1-6).

Figure 8.1-6: Rice Field in Region 2 Pomeroon-Supenaam

The rice sector yield grew by 8.3 percent in 2015 (see Figure 8.1-7). However, rice output decreased drastically in 2016, contracting by 22.2 percent (PSC 2017a), but recovered in the first half of 2017 by 35.4 percent. This recovery was a result of higher acreage cultivated, higher yields per hectare, and better disease management (PSC 2017b).



Sources: Bank of Guyana 2011, 2012, 2013, 2014, 2015, 2016

Figure 8.1-7: Annual Rice Production, 2011-2016

Rice was determined to be especially important by several coastal NDCs, where it is cultivated for both commercial and subsistence use (ERM/EMC 2018).

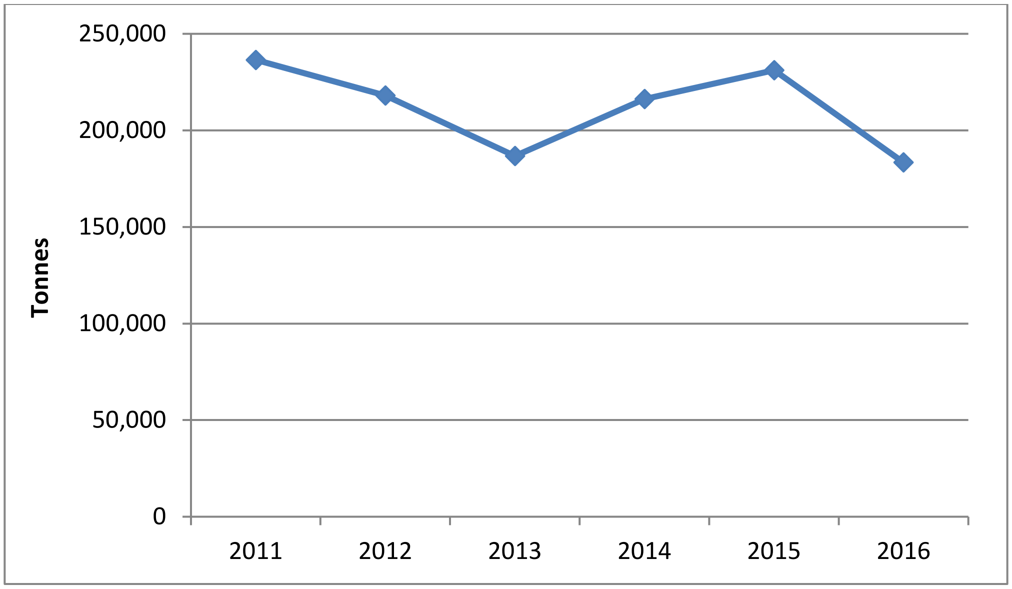
According to the president of the Guyana Rice Producers' Association, industrial rice production requires the ability to precisely control water levels in the rice fields. The rice growers in coastal Guyana achieve this by operating two separate systems of canals, one dedicated to irrigation and another dedicated to drainage. The irrigation canals convey fresh water from water conservancies or rivers via gravity to the rice fields. The rice fields are contained within a dike system that has separate gates for irrigation and drainage systems. The fields drain to a separate network of canals constructed to provide general drainage to the surrounding coastal landscape (ERM Personal Communication 1). These canals drain to the Atlantic Ocean via manually operated mechanical sluice gates (locally called kokers; see Figure 8.1-8) or by pump stations installed along the coastline. The drainage canals are generally constructed at or very near sea level to achieve the gradient necessary for drainage of the surrounding landscape. Therefore, the drainage canals are tidally influenced and the kokers control inflow from the sea. This system ensures that the rice fields remain upgradient of tidally influenced water in the drainage canals and prevents salt water from intruding into the fields (ERM Personal Communication 1; ERM/EMC 2018).

Figure 8.1-8: Sluice Gate (Koker) in Charity (Region 2) at High Tide

Sugar

Sugar production increased in 2014 and 2015 after declining in previous years (Figure 8.1-9). In addition, sugar production declined from 231,076 tonnes in 2015 to 183,491 tonnes in 2016. This 20.6 percent decline in sugar output represents the largest recorded annual contraction in the history of the Guyana sugar industry and also the lowest quantity of sugar produced over the last decade in Guyana. This outcome can be attributed to poor weather conditions and, most notably, industrial strikes and union unrest, which led to operational inefficiencies within the sugar industry (PSC 2017a). This decline continued during the first half of 2017 due to government review of various estates, closures, and industry privatization (PSC 2017b).

Guyana's Demerara sugar is exported to markets in the European Union, the U.S., and Caribbean Community (CARICOM) countries. Commercial farms growing sugarcane are found primarily along the coastal areas in Regions 4 and 6 (see Figure 8.1-10; ERM/EMC 2018).



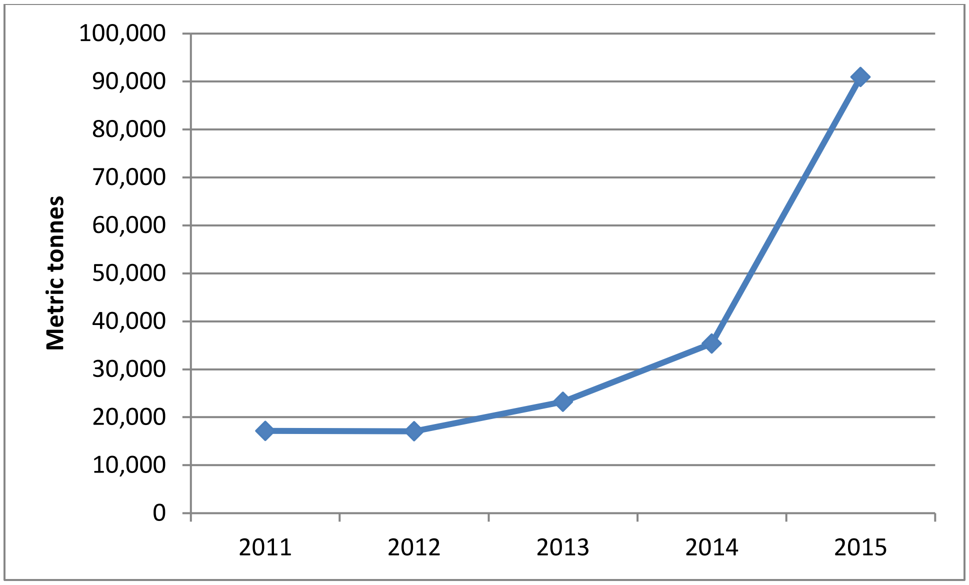
Sources: Bank of Guyana 2011, 2012, 2013, 2014, 2015, 2016

Figure 8.1-9: Annual Sugar Production, 2011-2016

Figure 8.1-10: Aerial View of Sugar Plantations

Coconut

The coconut industry in Guyana has grown in recent years (Figure 8.1-11) and shows potential for continued growth due to high international demand for products such as coconut oil and coconut water. It ranks third after rice and sugar in terms of acreage cultivated and is grown primarily in the coastal regions, including along the Pomeroon River and the Essequibo Coast in Region 2. According to news media articles, the amount of land in the Pomeroon area being converted to coconut cultivation is increasing (Guyana Chronicle 2016; Stabroek News 2016).



Source: Ministry of Agriculture 2016a

Figure 8.1-11: Annual Coconut Production, 2011-2015

The coconut industry is active in all six of the coastal regions (ERM/EMC 2018), including those coastal NDCs listed in Table 8.1-4.

Figure 8.1-12: Coconut Plantation, Region 2

Table 8.1-4: Coastal NDCs/CDCs with Coconut Farming

Region	NDC/CDC Name
Region 1	Father's Beach
	Almond Beach
Region 2	Charity/Urasara
	Anna Regina Town Council
Region 3	Wakenaam (island)
	Leguan
	Mora/Parika
	Tuschen/Uitvlugt
	Stewartville/Cornelia Ida
Region 4	Industry/Plaisance
	Unity/Vereeniging
Region 5	Seafield/Tempie
	Union/Naarstigheid
	Bath/Woodley Park
	Woodlands/Bel Air
Region 6	No. 52/No. 74 Villages

In most cases, coconut farming is conducted for commercial reasons and subsistence, and ranges in reported importance by stakeholders from low to essential. However, there are instances where the expansion of coconut estates has resulted in the clearing of large swathes of mangrove forests, as is the case at the mouth of the Pomeroon River. That said, coconut farming supports Guyana's sea defense along sea dams through vegetative stabilization of the earthen coastal seawall.

Other Cash Crops

Non-traditional crops (crops other than sugar cane and rice) grown in Guyana include tubers such as cassava, sweet potato, and eddo; vegetables such as eggplant, pumpkin, and okra; spices such as hot peppers, sweet peppers, and ginger; and fruits including banana, papaya, mango, and pineapple. Data from the Ministry of Agriculture (2016a) show that production for most tuber and vegetable crops has increased in recent years, while yields for fruits have been more variable, with some fruit crops showing declines from 2014 to 2015.

Similar to coconut farming, cash crops are grown in all six of the coastal regions (ERM/EMC 2018). In some cases, farmers, who are usually squatters, use the sea defense walls for agricultural purposes for subsistence and small-scale commercial sale. In Region 1, cassava is a primary staple in the diet, and villages that grow cash crops typically only sell them within their own villages (as transportation challenges restrict access to other markets). In many villages, cash crops are a primary source of both income and subsistence, supplementing fishing activities (ERM/EMC 2018).

Value-added Agricultural Products

According to various interviewed stakeholders, establishing manufacturing operations to develop value-added products such as pepper sauce, beverages, and canned fruit are priorities at both community and strategic policy levels (ERM Personal Communications 5, 10, 14, and 15). Several agricultural co-ops in Regions 2 and 3 have achieved varying levels of success in producing and marketing such products. National-level agencies such as the Ministry of Agriculture and the PSC emphasize the importance of developing markets for such products to provide better stability and security to farmers. However, there are a number of challenges associated with this, including high energy costs, difficulty locating or establishing markets for products, maintaining quality control and standards, packaging and labeling, and obtaining financing for start-up costs.

The private sector, through the Guyana Manufacturing and Services Association, in partnership with the Ministry of Business, has been executing the *UncappeD initiative*, which has provided the opportunity for large and small agro-producers and processors from across the country to showcase their products at national-level expos and regional marketplace events. Several other related initiatives are also underway, including an Inter-American Development Bank (IDB)-supported project to improve the quality of national infrastructure, which would assist agro-processors.

Fisheries and Aquaculture

Marine Fisheries

There are four main types of marine fisheries in Guyana (Ministry of Agriculture 2013), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place. Table 8.1-5 summarizes the characteristics of these fisheries. Tuna, such as yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), have also been identified as a potential oceanic target species of commercial interest (Issac and Ferrari 2017).

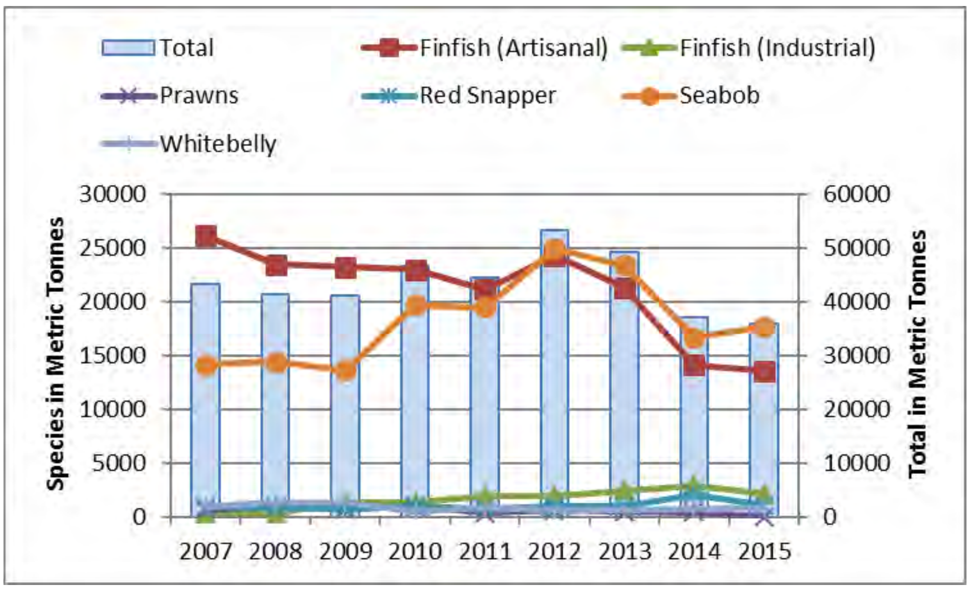
Table 8.1-5: Primary Characteristics of Marine Fisheries in Guyana

Type of Fishery	Species	Gear	Depth
Industrial	Seabob, shrimps, and prawns	Trawls	Primarily from 13–16 meters, but can occur from 0–75 meters
Semi-industrial	Red snapper and vermillion snapper	Fish traps and lines	Edge of continental shelf
Artisanal	Mixed fish and shrimp	Gillnets, seines, and others (e.g., Caddell line)	0–18 meters
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

According to data from the PSC and the Ministry of Agriculture, fishery yields declined between 2014 and 2015. The PSC attributes this to El Niño-related weather phenomena, while the Ministry of Finance characterizes this as part of a longer-term decline caused by unsustainable overfishing, including illegal fishing by foreign vessels (Ministry of Finance 2015). However, the sector recovered in 2016 with growth in both fish and shrimp outputs. Fish output improved by 20.5 percent, and (total) shrimp output grew by 9 percent. However, prawn output fell by 17.8 percent (PSC 2017a). The improvement in production continued into the first half of 2017 with an increase of 33.2 percent. This performance was attributed to significant increases in prawn and small shrimp catches, which grew by 47.2 percent and 24.2 percent, respectively, and greater catches of fish species, such as red snapper (PSC 2017b).

Fishing interests and the Fisheries Department personnel also acknowledged the prevalence of illegal fishing by both foreign and domestic vessels, but did not specifically implicate illegal fishing in the recent declines (ERM Personal Communications 2, 14, 15, and 16).

Fishing catches for 2007 to 2015 are shown on Figure 8.1-13. The data indicate a declining trend for fish and seabob shrimp catches in recent years, although the recent decline follows an increasing trend for 2010 through 2012. The prawn industry has been voluntarily scaled back in response to limited catches resulting from overfishing in previous years, with approximately 15 Guyanese-registered boats in operation in 2016. Prawn fishing boats operate from the coast out to about 40 fathoms (ERM Personal Communication 2).



Source: Ministry of Agriculture 2016a

Note: Whitebelly is a species of shrimp and is included in the artisanal shrimp fishery in Table 8.1-5.

Figure 8.1-13: Commercial Fisheries Catch Volumes, 2007-2015

The industrial seabob shrimp sector continues to be an important commercial fishery, and industry leaders are currently in the process of applying for Marine Sustainability Council certification (an internationally recognized voluntary process used to assess and certify the sustainability of wild-capture marine and freshwater species). The seabob fleet currently operates under a voluntary management plan (the only fishery-specific management plan for fisheries operating in Guyana's territorial waters) that calls for a 7-week-long closed season each year. Seabob sector representatives expect the management plan to be adopted by the government and made compulsory in the near future (ERM Personal Communication 2).

Bycatch of endangered turtles, sharks, and rays as a result of fishing operations represents a recognized challenge for the industry and is the subject of increasing targeted study (Kolmann et al. 2017; Garstin and Oxford 2018)

Fishing is important to the all of the coastal NDCs in Regions 2 through 6, providing direct employment and income for numerous fisherfolk and indirect employment for numerous others in supporting services. In Region 1, fishing is important for subsistence across most villages, as well as small-scale commercial sale where there is access to markets. The importance of fishing to the local community varies across NDCs. For example, in Charity/Urasara (Region 2), approximately six commercial fisherfolk were identified as part of a field survey, while in Zeelugt/Rosignol (Region 5), 175 boats were identified (ERM/EMC 2018). Table 8.1-6 provides an overview of the commercial fishing communities identified as part of the late 2017 and early 2018 field work by the Consultant team.

Table 8.1-6: Estimated Size of Commercial Fishing Communities in Coastal Regions

Region	NDC Name	Fishing Community
Region 1	Morawhanna	3 boats/1 person
Region 2	Charity/Urasara	20 persons
Region 3	Wakenaam (island)	60 persons
Region 4	Georgetown City	20 boats
	Better Hope/ La Bonne Intention	35 boats
	Enmore/Hope	20 boats
Region 5	Hamlet/Chance	30 boats
	Profit/Rising Sun	60 boats
	Bath/Woodley Park	12 boats
	Zeelugt/Rosignol	175 boats
Region 6	Macedonia/Joppa	100 persons

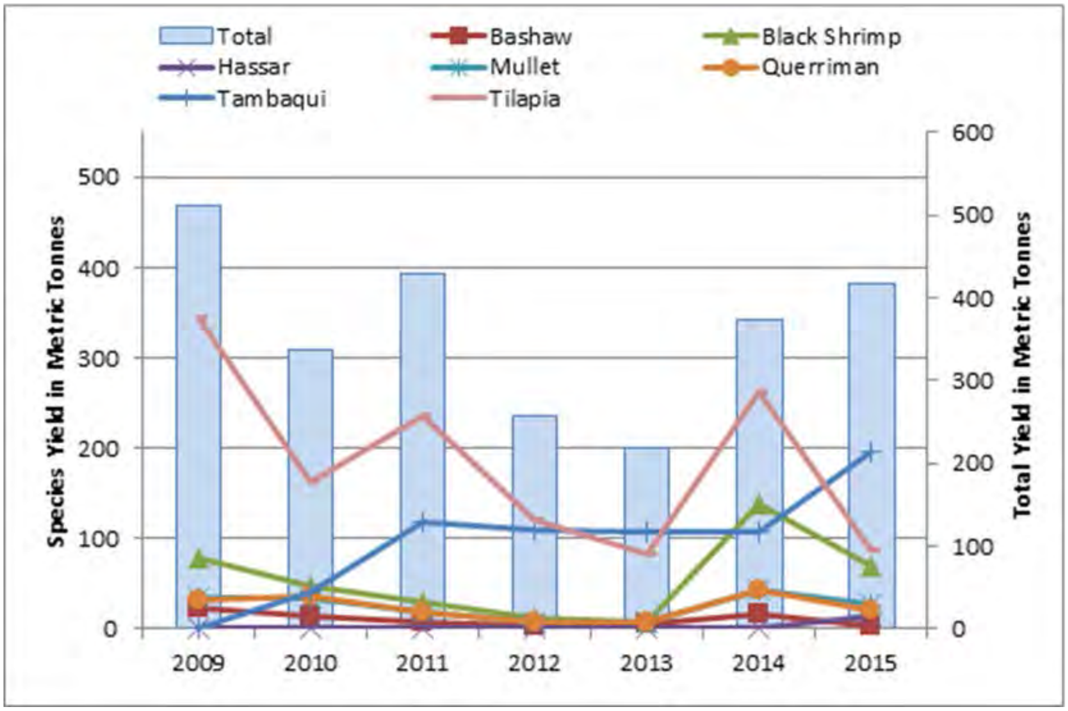
Source: ERM/EMC 2018

Data obtained during informal engagement with fisherfolk suggest that the economies of Regions 5 and 6 are generally more dependent on commercial fishing than those coastal NDCs in other regions (ERM/EMC, 2018).

A large percentage of fish captured using artisanal methods is sold to third parties. Sale prices are subject to short-term fluctuations. According to the fisherfolk interviewed as part of the Liza Phase 1 post-permitting fish study, the price of the fish is seasonally influenced. Interviewees commented that the prices generally decline during the rainy season due to higher catches and increased supply. At the time this assessment was conducted, seasonally influenced fish were being sold at the following retail prices ($207 GYD=$1 USD): shark $160 GYD per pound; snapper: $300 to $390 GYD per pound; cuffum: $30 GYD per pound; curass: $60 GYD per pound; gillbacker: $350 to $550 GYD per pound; trout: $160 to $200 GYD per pound; grey snapper: $360 GYD per pound; and highwater (*Hypophthalmus edentatus*): $200 GYD per pound (ERM 2018).

Aquaculture

According to data from the Ministry of Agriculture (2016a), the main species produced in aquaculture establishments are the bashaw, hassar, mullet, querriman, tambaqui, tilapia, and black shrimp. Data show that tilapia once dominated aquacultural yields, but have declined in production, while yields of tambaqui and black shrimp have increased considerably in recent years. The total yield of aquaculture product has been variable in the period from 2009-2015 (Figure 8.1-14).



Source: Ministry of Agriculture 2016a

Figure 8.1-14: Fish Yields from Aquaculture, 2009-2015

According to the president of the National Aquaculture Association, aquaculture is still a small industry in Guyana. Establishments are typically set up in abandoned rice fields. By using the same water supply and drainage configuration used for rice production, the aquaculture operations avoid dependency on brackish water and can raise freshwater species despite their coastal locations. Freshwater species currently being raised in rehabilitated rice fields include hassa, arapaima, tilapia, and tobaki (pacu) (ERM Personal Communication 18).

Although aquaculture is considered a small industry by the National Aquaculture Association, it was assessed by stakeholders as critical to livelihoods in many coastal NDCs throughout Regions 2 through 5 (ERM/EMC 2018). It appears to be most important to Regions 5 and 6, and can provide a livelihood for farmers. For example, in Bloomfield/Whim (Region 6) it was reported that six crabs can be sold for $500 GYD ($2.42 USD) in season, while one bucket of shrimp can be sold for $10,000 GYD ($48 USD).

Mining and Quarrying

The mining sector is an important sector for Guyana and contributed more than half of exports in 2017. Most notably, raw gold, bauxite, and diamonds equated to 56.8 percent, 7.3 percent, and 0.9 percent, respectively, of export totals in 2017 (BSG 2017). The Bank of Guyana estimated that mining and quarrying accounted for 15.4 percent of real GDP in 2016 (Bank of Guyana 2016). In 2013, this sector employed more than 17,363 persons directly and almost 21,626 indirectly, which accounted for 14 percent of the total labor force (ITA 2018). Due in large part to the mining sector, Guyana's economy in recent years has reflected the path of global commodity prices. Real GDP growth decelerated to 3.8 percent in 2014 and to 3 percent in 2015, as global commodity prices collapsed for Guyana's major mining exports (World Bank 2016).

Wholesale and Retail Trade

Wholesale and retail trade accounted for 14.2 percent ($24.75 billion GYD; $119.6 million USD) of Guyana's half year GDP, growing by 2.7 percent compared to the significant decline of 11.3 percent during the same period in the previous year (PSC 2017b).

Manufacturing

Manufacturing contributed 7.4 percent of GDP in 2015 and grew by 5.3 percent from 2014 to 2015. However, it contracted by 9.5 percent in 2016 due mainly to the considerable underachievement in both the sugar and rice industries. With the exclusion of sugar processing and rice milling, the manufacturing sector marginally increased by 0.6 percent in 2016 (PSC 2017a). The sector rebounded during the first half of 2017, growing by 9.9 percent, which was attributed mainly to a recovery in rice milling activities (PSC 2017b). The most important manufactured products in terms of volume include laundry soap, detergent, paints, putty, whitewash, oxygen, and acetylene, as well as edible goods including rice, sugar, and rum (PSC 2015). Many of the country's manufacturing facilities are located in coastal areas (ECLAC 2005).

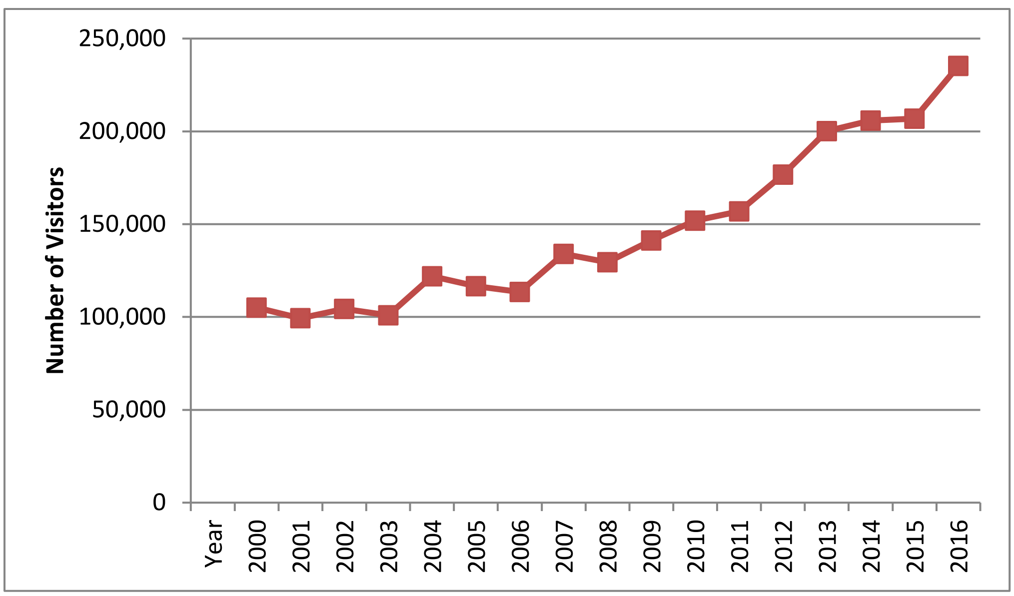
Tourism

According to the World Travel and Tourism Council (2017), tourism directly contributed 2.6 percent to the country's GDP in 2016. Although most tourism infrastructure (e.g., hotels) is located in the most populated townships such as Georgetown, Linden, and Berbice, many of Guyana's tourist attractions are located in the country's hinterland. These attractions offer nature, culture, and adventure-based experiences such as trips to waterfalls and Amerindian villages. These trips range from same-day to multiple-night excursions.

Guyana is not a popular destination for cruise ships and receives only a few small ships each year. The country does not have the berthing capacity for large cruise ships (ERM Personal Communication 3).

Sediment deposition from the mouth of the Amazon River along Guyana's coast means that there are few beach offerings for tourists. The highly turbid water along the coast also likely contributes to the relatively small numbers of tourists that visit Guyana relative to other locations in the region with clearer water. Some tourism occurs at the Shell Beach Protected Area (SBPA) during the marine turtle nesting season, but this is limited because infrastructure and systems have not yet been established to facilitate travel or provide convenient accommodations. In general, however, Guyana is thought to have considerable ecotourism potential, and development of tourism infrastructure at the country's protected areas, including SBPA in Region 1, is considered a key part of the Protected Areas Commission's current strategic plan (PAC 2014).

Data from the Guyana Tourism Authority (2018) indicate that the number of international visitors to Guyana has doubled since the early 2000s (see Figure 8.1-15), with the largest number of visitors originating from the United States, followed by the Caribbean, Canada, and Central and South America. Because the majority of visitors consist of Guyanese expatriates returning to visit family, visitor numbers peak during the summer vacation (July and August) and key holidays (e.g., Christmas in December). According to representatives of the Department of Tourism, increases in tourism in recent years are also attributable to increased regional sporting tournaments in the Georgetown area, particularly cricket events. This has brought many international visitors, particularly those from the Caribbean. During major events such as the Cricket World Cup, increased traffic congestion has been observed in the Georgetown area (ERM Personal Communication 3).



Source: Guyana Tourism Authority 2018

Figure 8.1-15: Annual International Visitors to Guyana, 2000-2016

Most of the major tourist attractions are located in Georgetown, such as museums, the zoo, parks, public gardens, and the Stabroek Market. Georgetown and surrounding areas are known for their many historic buildings, which date from the late eighteenth century through the mid-nineteenth century, when Guyana was first a Dutch colony and then an English colony (National Trust of Guyana 2018). Guided tours of Georgetown's historic buildings and sites are available, as are guided tours of the Essequibo River, the El Dorado Rum Factory, the Georgetown City Centre, and other attractions.

Local tourism and recreation is also important to the local economy in the coastal NDCs in Regions 2 through 5, including those outside Georgetown. Some regions are less dependent on tourism (e.g., Region 2), with their coastline and beaches being frequented by ten or fewer locals daily. Other regions have economies that are more established and well-linked to local tourism. Region 3 and 4, specifically Best/Klien/Pouderoyen and Haslington/Grove, respectively, are known for their eco-tourism, with diverse bird species and protected mangroves. Regions 5 and 6, on the other hand, have beaches or other recreational areas (e.g., horse tracks) frequented by hundreds weekly (ERM/EMC 2018).

Some NDCs are looking to invest in local tourism and expand its economic return. For example, Rose Hall Town Council (Region 6) has control over a long stretch of beach that is frequented daily by 20 to 50 persons and hundreds on weekends, and is seeking development of further tourism opportunities.

8.1.3. Impact Assessment—Socioeconomic Conditions

8.1.3.1. Relevant Project Activities and Potential Impacts

The Project will not have any direct impact to the administrative divisions, population distribution, or education systems as described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions. Therefore, this section assesses potential Project impacts on economic conditions in the Project AOI. The key potential impacts considered for planned Project activities include the following:

- Project-related revenue generation and increased tax revenues for the government, potentially resulting in increased government spending (typically on social services and infrastructure);
- Potential increased local business activity and related employment as a result of Project procurement and employment;
- Potential increased Project worker spending levels; and
- Potential increased cost of living to citizens due to higher demand for goods and services.

The Project will contribute directly and positively to increased national revenues through a Production Sharing Agreement between the Government of Guyana and EEPGL. As such, development of the oil and gas sector represents a critical point in Guyana's development trajectory, with the government pledging to use funds accrued from the sector for development of the country's infrastructure, including investments in health, education, agriculture, and power for domestic and industrial use (in alignment with Guyana's Green State Development Strategy) (DPI Guyana 2018; Oil Now Guyana 2018).

The Project will also benefit the economy through local procurement of select goods and services, limited direct local employment, and spending in local communities by Project workers. As of the first quarter of 2018, EEPGL's Liza Phase 1 Development Project employed a total of 585 Guyanese nationals, constituting 52 percent of its total workforce. Modest increases in total employment, including a doubling of EEPGL's office staff to about 180 workers (for all EEPGL activities), are expected with the development of the Liza Phase 2 Development Project, and EEPGL intends to continue hiring Guyanese nationals to the extent reasonably practicable, in alignment with its Liza Development Local Content Plan. These potential local jobs will contribute positively to economic conditions by generating income taxes, increasing household purchasing power, and generating increased sales tax revenue. In terms of local procurement, the majority of EEPGL's 410 suppliers supporting in-country work scopes in 2017 were Guyanese-owned (309 total) and CARICOM-owned (58 total). Similarly, in the first quarter of 2018, more than 88.5 percent of EEPGL's 296 suppliers were Guyanese-owned (227 total) and CARICOM-owned (35 total). Business with Guyanese-owned suppliers amounted to $4.9 billion GYD ($23.7 million USD)[1] in 2017 and $2.8 billion GYD (USD $14 million) in the first quarter of 2018 in local expenditures. As part of the Liza Phase 2 Development Project, EEPGL intends to continue procuring select Project goods and services from Guyanese businesses to the extent reasonably practicable.

As part of its efforts to optimize local content during the Liza Phase 1 Development Project, EEPGL and its contractors implemented a range of training programs for workforce and local business-capacity building in 2017. This included close to 30,000 workforce training hours on administration, leadership and management, health and safety, technical, and trade and crafts training courses. In addition, energy literacy courses that included Offshore Oil and Gas; Procurement and Health, Safety and Environment modules were provided to workers from up to 274 local companies through the Centre for Local Business Development. It is anticipated that beyond direct employment and service to EEPGL and its contractors, these capacity-building efforts will contribute to improved employment and business opportunities for participants over the long term. Similarly, a range of government capacity-building programs on topics such as waste management, oil spill response, protective species observer training, gas and power, energy literacy, local content, etc., have been conducted as part of the Liza Phase 1 Development Project, and these should contribute to enhanced administrative efficiency that will further facilitate business activity in Guyana. As part of the Liza Phase 2 Development Project, EEPGL intends to continue on the same course with its workforce, supplier, and government capacity-building efforts.

In addition to direct expenditures and employment, the Project will also likely generate induced economic benefits, as other non-Project-related businesses benefiting from direct Project purchases. Worker spending and increased purchase power by locals with additional income will likely expand spending in the local area. This will generate more local value-added tax. These beneficial "multiplier" impacts will occur throughout the Project life.

Potential adverse impacts of the Project on economic conditions associated with planned Project activities could include potential cost of living increases due to a higher demand for some goods and services, either through direct Project procurement or through Project worker purchases. Additionally, increased competition for skilled workers and support services could result from

[1] Exchange rate of USD $1=207 GYD is used throughout this section.

EEPGL and its contractor's hiring and procurement activities, and could present a potential adverse impact for other companies and sectors that may not be able to pay salaries comparable to those of the oil and gas sector. It is therefore likely that other sectors and the economy overall will need to adjust to the changes brought about by the growing oil and gas sector, which may include upward pressure on salaries. While this may cause short-term challenges for other sectors, the long-term effects should be positive overall; Guyana is known for having a high level of "brain drain," whereby a large percentage of the tertiary-educated population emigrates from the country, mostly to Organisation for Economic Co-operation and Development nations (World Bank 2000; World Bank 2016; Guyana Chronicle 2015). Provided that a more robust employment environment can be demonstrated, an increase in high-skilled, high-paying jobs associated with the oil and gas sector should contribute to the attenuation of this phenomenon, creating a larger pool of advanced workers for all areas of the economy. EEPGL's ongoing capacity-building and training initiatives will remain attentive to the need to foster a more qualified workforce and to enhance the capacity of local suppliers to serve a larger and more diverse clientele, rather than focusing only on the immediate needs of the oil and gas sector.

Table 8.1-7 summarizes the Project stages and activities that could result in potential Project impacts on economic conditions, as well as the receptors that could potentially experience these impacts.

Table 8.1-7: Summary of Relevant Project Activities and Key Potential Impacts—Economic Conditions

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Guyanese population—principally in the Georgetown Area	Project revenue generation	• Potential government investment in social services and economic development/diversification • Potential government infrastructure projects
		Project hiring and workforce training	• Direct hiring of Guyanese nationals for a limited number of positions • Hiring of Guyanese nationals by Project contractors and subcontractors • Increased experience, capacity and skills of local workers and subcontractors • Competition with other local businesses for qualified workers
		Project procurement of selected goods and services	• Increased sales tax revenues • Increased local business activity and growth • Increased demand for services and infrastructure, leading to increased cost of living and/or
		Project capacity building programs for prospective local suppliers	
		Project worker spending	

Stage	Receptor(s)	Project Activity	Key Potential Impacts
		Limited local direct employment and increased opportunities through indirect employment	procurement challenges for other companies

8.1.3.2. Magnitude of Impact—Socioeconomic Conditions

The Project has the potential to impact economic conditions both positively and adversely. Project revenues to the government through its Petroleum Agreement with EEPGL can allow for increased government spending on social infrastructure, services, and programs, as well as investment in infrastructure programs and different economic sectors. Economic conditions can also be impacted positively by local hiring for a limited number of new positions, local Project procurement, and Project worker spending.

A potential adverse impact could occur from increases in the cost of living due to higher demand for some goods and services. Given the Project's small workforce and predominantly offshore footprint, such increases are expected to be limited.

Although the Project's local hiring and procurement will be overwhelmingly positive for the country, it could present challenges for other companies and sectors if it creates competition with other local businesses for workers, goods, and services. This potential adverse effect is expected mostly over the short to medium term. As the oil and gas sector adds more jobs and increased demand for workers and services exerts upward pressure on salaries in some sectors, it is expected that the availability of a more robust and high-paying employment situation will contribute to reduced emigration of tertiary educated and otherwise qualified workers from the country. This should provide a more qualified workforce for all sectors of the economy over the medium to long term.

Considering the factors above, potential economic benefits of the Project are expected to outweigh potential negative impacts such that overall impact on the economy is expected to be **Positive**. As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop magnitude ratings for positive impacts.

8.1.3.3. Sensitivity of Receptors—Socioeconomic Conditions

The receptors with the potential to be affected by potential impacts on economic conditions include the full Guyana population, but those most likely to be potentially impacted are residents in the Georgetown area. As discussed below, vulnerable (lower-income) populations are considered to be more sensitive to these potential impacts and are therefore considered separately. The receptor sensitivity ratings for economic conditions are defined in Table 8.1-8.

Table 8.1-8: Definitions for Receptor Sensitivity for Potential Impacts on Socioeconomic Conditions

Criterion	Definition
Sensitivity	Low: The local and regional economies are highly diversified and not highly dependent on any one sector. The workforce is highly skilled, would not experience major challenges in shifting to different occupations, and is well positioned to benefit from the Project.
	Medium: The local and regional economies are somewhat diverse and dependent on a few key industrial sectors that are not all natural resources-based. Alternate economic opportunities, including from the Project, are possible, but the workforce may require additional training to be able to pursue such opportunities.
	High: The local and regional economies are highly dependent on one or a few industrial sectors that are largely natural resources-based. There are few alternate economic opportunities in the area and/or the workforce does not have the skills to shift to pursue alternate economic opportunities.

Receptors in the Georgetown area (Region 4) are considered to have a **Medium** level of sensitivity to economic impacts, since the economy in this region is relatively diverse and less dependent on natural resources than in other areas of the country, with 12 percent of jobs in the primary sector, 21 percent in the secondary sector and 67 percent in the tertiary sector[2].

Individuals and households of lower socioeconomic status are considered to have a **High** level of sensitivity to economic impacts due to their lower capacity to benefit from the Project and the business opportunities it may bring, and to their higher level of vulnerability to an increased cost of living. However, this vulnerable population will stand to benefit from increased government revenues along with the general population, should such government revenues be invested in social infrastructure, services, and programs, as well as investment in infrastructure programs and different economic sectors.

8.1.3.4. Impact Significance—Socioeconomic Conditions

Based on the discussion above, the potential impacts on economic conditions are rated as **Positive** overall for both the general population and the low-income subpopulation, with potential impacts on receptors in the Georgetown area likely to be more highly impacted (i.e., benefitted). As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop significance ratings for positive impacts.

8.1.4. Mitigation Measures—Socioeconomic Conditions

As the expected potential impact to economic conditions is net positive, no mitigation measures are required. However, to enhance the benefits from this positive impact, the Project intends to continue its current local hiring and procurement practices, with ongoing capacity-building initiatives to optimize local content to the extent practicable.

[2] According to the Bureau of Statistics Guyana (BSG 2002), the primary industrial sectors (e.g., agriculture, fishing, forestry, and mining) make direct use of natural resources and include the production of raw materials and basic foods. The secondary sector is engaged in manufacturing using raw products from the primary sector and includes processing, construction, textile production, brewing and bottling, etc. The tertiary sector provides services to the general population and businesses, including retail and wholesale trade, transportation and distribution, entertainment, tourism, healthcare, etc.

Table 8.1-9 summarizes the assessment of potential pre-mitigation and residual Project impacts on economic conditions. The potential impacts are rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the economic conditions-specific methodology described in Sections 8.1.3.2 and 8.1.3.3.

Table 8.1-9: Summary of Potential Pre-Mitigation and Residual Impacts—Socioeconomic Conditions

Stage	Potential Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Guyanese population including lower income subpopulation (in particular Georgetown population) - increased government revenues, increased employment, increased local business activity, potential for increased cost of living, potential for competition with other local businesses for qualified workers.	Not rated (Positive) [a]	Medium (general population) High (lower income groups)	Positive	None	Positive

[a] While some potential of the identified potential impacts are adverse and some are positive, the overall potential impact is expected to be (net) positive.

8.2. EMPLOYMENT AND LIVELIHOODS

8.2.1. Administrative Framework—Employment and Livelihoods

Table 8.2-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on employment and livelihoods.

Table 8.2-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Employment and Livelihoods

Title	Objective	Relevance to the Project
Legislation		
Occupational Safety and Health Act (1997) Cap. 99:06.	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Generally applies to Project workers and Project-related activities.
Food & Drug Regulations (Food and Drug Act, 1971) Cap. 34:03.	Regulates the sale, advertisement, preparation, and handling of food products; regulates the manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.	Governs the preparation of food and provision of medications at Project facilities.

Title	**Objective**	**Relevance to the Project**
Prevention of Discrimination Act (1997) Cap. 99:08.	Provides for the elimination of discrimination in employment, training, recruitment, and membership in professional bodies and the promotion or equal remuneration to men and women in employment who perform work of equal value.	Prevents discrimination in employment practices.
National Insurance and Social Security Act (1969) Cap. 36:01.	Establishes a system of national insurance and social security providing pecuniary payments by way of old age benefit, invalidity benefit, survivor's benefit, sickness benefit, maternity benefit, and funeral benefit, and to substitute for compensation system of insurance against injury or death caused by accident arising in the course of employment or resulting from disease due to the nature of employment; establishes a National Insurance Fund.	Provides the overarching framework for workers' insurance and other benefits.
Employment of Young Persons and Children Act. Cap. 99:01.	Seeks to implement certain conventions relating to the employment of young persons and children.	Restricts the ages of young persons who may be employed by the Project.
Termination of Employment and Severance Pay Act (1997, 1999) Cap. 96:01.	Makes provision for the conditions governing termination of employment and grant of redundancy or severance payment to employees.	Governs payments to employees or the termination of employment. This could be relevant to contractors and sub-contractors to the Project.
Policies		
Occupational Safety and Health Policy (under development)	Aims to promote and improve the quality of life of workers by preventing social and economic losses, work-related accidents, and injury to health by eliminating hazards, reducing the number of accidents, and injuries, and combating stresses and incidence of occupational diseases. Its implementation will be supported by the ILO.	When completed, will generally apply to the Project and Project workers.
Local Content Policy (under development)	Makes provisions for preferential treatment of Guyanese where capability exists; building local capacities for the sector; international partnerships to enable technology and knowledge transfer and access to investment opportunities; extending Guyanese participation to support national development; and leveraging the hydrocarbon sector's strategic assets, and skills for the lateral development of other sectors.	Would provide government guidance on Guyanese participation in the petroleum sector. Expected to directly influence Guyanese service provision and employment in the sector. A second draft of the Policy is under consideration by the government.

8.2.2. Existing Conditions—Employment and Livelihoods

Results of the most recent national census (2012) indicate that 87.5 percent of the labor force was employed and 12.5 percent was unemployed at this time (BSG 2012). Data from the 2002 census indicate that the unemployment rate did not change significantly in this 10-year period (BSG 2012; BSG 2002).

In 2012, the Region 1 unemployment rate was the highest in the country, at 19.3 percent of the labor force. Region 2 had the lowest unemployment rate, at 10.6 percent. Regions 3 and 4 had rates of 11.8 percent and 11.3 percent, respectively.

Statistics from the 2012 census indicate that 23 percent of the employed population 15 years of age and over in Region 1, 27.9 percent in Region 2, and 18.8 percent in Region 3 had occupations in the Agriculture, Forestry, and Fishing industry group (BSG 2016). This was the industry group employing the largest number of workers in Regions 2 and 3; in Region 1, this group was second to Mining and Quarrying. After the Agriculture, Forestry, and Fishing category, Mining and Quarrying employed the second largest group in Region 2 (14.9 percent), while in Region 3, Construction employed the second largest group (12.1 percent). In general, the primary sector industries[3] are dominated by male workers, with female workers making up less than 10 percent of the workers employed in these industries in these regions.

Census data show that tertiary (service) sector jobs such as wholesale and retail trade, public administration, and accommodation and food services are dominant in Region 4 (including Georgetown), making up 67 percent of jobs there. Female representation in this sector is high, with women making up 48.2 percent of workers in the sector (BSG 2016). Secondary and primary sector jobs make up 21 percent and 12 percent of employment, respectively, in Region 4.

Due to the recent emergence of Guyana's oil sector, employment impacts associated with the sector are not currently well characterized. However, it is understood that oil production operations generate a much larger number of indirect jobs than direct employment (Oil Now Guyana 2017). EEPGL's employment of Guyanese nationals for a limited number of positions, as well as EEPGL's local procurement—including a diverse range of goods and services such as transportation, catering, office supplies, accommodations, security, engineering, and housekeeping—have had positive impacts on employment, particularly in the tertiary sector.

The issues facing indigenous groups are typically related to lack of empowerment and inclusion into the mainstream economy. The standard of living for the indigenous minority continues to be lower than for the majority of the country's citizens. A larger proportion of the Amerindian population is classified as socioeconomically disadvantaged (Minority Rights Group International 2008), with a lack of formal employment opportunities representing a significant

[3] According to the Bureau of Statistics Guyana, the primary sector industries (e.g., agriculture, fishing, forestry, and mining) make direct use of natural resources and include the production of raw materials and basic foods. The secondary sector is engaged in manufacturing using raw products from the primary sector and includes processing, construction, textile production, brewing and bottling, etc. The tertiary sector provides services to the general population and businesses, including retail and wholesale trade, transportation and distribution, entertainment, tourism, healthcare, etc.

contributing factor. Income-generating opportunities in the indigenous coastal communities of Regions 1 and 2 are scarce and include heart of palm harvesting and the wildlife trade, including sale of aquarium fish (IDB 2007). In the past, the Region 2 village of Mainstay operated an organic pineapple farm and processing facility; however, the plant was shut down several years ago (ERM Personal Communication 4). Some residents of indigenous communities in Regions 1 and 2 also work in mining and logging camps in the hinterland (IDB 2007).

Many of the residents in the coastal NDCs/CDCs in Regions 1 through 6 are directly employed by or linked to the fishing industry due to their proximity to the coast. For example, the primary provisioning service in all six regions is fishing; and fishing accounts for approximately 25 percent of the ecosystem services in the study area, based on field assessments in these communities (ERM/EMC 2018).

Similarly, fishing support services include boat building, ship repairs, fuel services, entertainment, and household products needed by sailors and fisherfolk—and these provide numerous employment opportunities to residents.

8.2.2.1. Fishing

Fishing along the Guyanese coast varies in scale and type. At the easternmost end of Region 2, fishing occurs at a relatively small scale, and catch is typically sold locally at roadside stands or out of vehicles (See Figure 8.2-1). Artisanal boats are still used because the coastal mudflats in this area do not allow for the use of larger boats. Artisanal boats venture only a few kilometers out from the coastline, and fisherfolk typically only go out for the day. Species caught include catfish, bangamary, and bashaw (ERM Personal Communication 19). Preliminary information from the National Vessel Census of Region 2 (ERM 2018) indicates 149 artisanal vessels in the region. Among the vessels for which home ports were reported, home ports were distributed as follows: 5 vessels in Charity, 2 in Hampton Court, 6 in Golden Fleece, 6 in Better Success, 6 in Lima, 2 in Anna Regina, and 15 in Cullen.

Farther west in Region 2 at Lima, larger-scale fishing is practiced about 8 kilometers (approximately 5 miles) offshore. Larger boats involved in industrial scale fishing go out for 10 to 12 days at a time and fish for snapper, snook, trout, catfish, bangamary, and butterfish. Some fish are sold locally, while others are sold wholesale for resale in Georgetown (ERM Personal Communications 16, 20, and 21) (see Figure 8.2-2). There are no landing areas for commercial fishing vessels in Region 1; however, fishing by commercial vessels from Georgetown, in addition to small-scale fishing activity, occur along the Region 1 coast. Fishing yields vary by season, with interviewed fisherfolk reporting the highest yields in June through August. From September to January, catches are at their lowest due to high winds.

Figure 8.2-1: Salted Fish Drying outside a Fisherperson's Home in Region 2

Figure 8.2-2: Fresh Fish Being Sold at Stabroek Market in Georgetown

Challenges for the Fishing Industry

When asked about changes in fishing yields over the years, responses from artisanal Region 2 fisherfolk varied, with most reporting no noticeable change in catch volume. However, an individual with a relatively large-scale operation of three boats operating out of Charity stated that catches are declining and attributed this to an over-allocation of fishing licenses by the government (ERM Personal Communication 17). As indicated in Section 8.1.2.4, Economic Conditions, annual yields in the fishery sector have declined in the last 4 years for fish, and 3 of the last 4 years for seabob, although seabob yields recovered slightly between 2014 and 2015. Although there are no data available to quantify the impact of Illegal, Unreported, and

Unregulated[4] fishing in Guyana, its role in threatening the sustainability of the country's fishery is considered to be significant (Ministry of Finance 2015; Ministry of Agriculture 2016b).

Another challenge faced by fisherfolk is piracy. Most of the fisherfolk interviewed by the Consultants in Region 2 have been victimized by pirates at some time. This typically consists of the theft of boats and/or engines, and fisherfolk are sometimes assaulted in these confrontations. Most respondents perceived that piracy had gone down in the last 5 or 10 years. Some believe the recent establishment of a Coast Guard Station at the mouth of the Pomeroon River has influenced the decrease in piracy. Of those who have encountered pirates, they were typically unsure of their assailants' nationalities, but speculated that they could be Venezuelan, Guyanese, Surinamese, or a mixed group from different countries. There are reported incidents of piracy from villagers and fisherfolk in Region 1 on the remote and hard-to-access coastal plains in SBPA, from Tigers Beach to Almond Beach (ERM/EMC 2018).

The economics of the fishing industry can pose challenges to fisherfolk, especially artisanal fisherfolk who tend to operate their businesses on a cash basis and are more susceptible to short-term downturns due to a lack of cash reserves. In interviews conducted as part of the Liza Phase 1 post-permit marine fish survey, some fisherfolk mentioned their operating costs as an economic challenge. Several indicated that fuel represents the most significant expense, which can vary from $1,200 to $3,000 GYD ($6 to $15 USD) per trip for coastal fishing (less than 5 nautical miles from shore), while for more distant operations (greater than 5 nautical miles from shore), fuel cost can vary from $10,000 to $50,000 GYD ($48 to $242 USD) per trip. In addition to fuel, ice, bait, food, net repairs, and miscellaneous expenses were mentioned as contributing to operating costs (ERM 2018).

Reported weekly income from the fourth quarter of 2017 from sales of fish ranged from $2,000 to $22,000 GYD ($10 to $106 USD) after covering operating costs. This period was considered to be a "good season" by most of the interviewees, but there was a consensus that it is necessary to raise the sale prices of fish to improve their family economies. Additionally, there was a general consensus that the sizes of the fish have not varied much in recent years, so the economic pressures being felt by fishing families may be related to macroeconomic factors that are external to the fishing industry, rather than the condition of fisheries resources or other industry-related factors (ERM 2018).

The dynamic accretion and erosion of the Guyanese coastline as a result of natural forces can also pose challenges for fisherfolk. During the August/September 2016 field visit, as well as in late-2017 and early-2018 field visits, the Consultants observed considerable mudflat and beach accretion at most coastal access points along the Region 2 coast, which prevents fisherfolk from landing their boats in some areas (Figure 8.2-3). Saltwater intrusion also occurs up the Moruca and other smaller rivers in Region 1 in dry season. It was noted as having impacts on fishing livelihoods in several villages in Region 1 (ERM/EMC 2018).

[4] Illegal, Unreported, and Unregulated fishing takes place where vessels operate in violation of the laws of a fishery. This can apply to fisheries that are under the jurisdiction of a coastal state or to high-seas fisheries regulated by regional organizations.

Figure 8.2-3: Fishing Boat Landed on a Coastal Mudflat in Region 2, September 2016

8.2.2.2. Farming and Agricultural Processing

As discussed above, agriculture is a major livelihood activity in Region 2. Rice farming dominates agricultural production in Region 2, but other crops, such as red beans, plantains, bananas, eggplants, and other vegetables, are grown on a smaller scale as well. Most households also raise livestock, such as cattle, hogs, poultry, and small ruminants. The Amerindian community of Mainstay, located approximately 6 kilometers (approximately 3.5 miles) from the coast in Region 2, is known for its organic pineapples, which for a number of years were processed into canned chunks for export to European markets (ERM Personal Communication 4). As discussed above, coconut cultivation is becoming increasingly popular in the Pomeroon area, as demand for coconut water and other value-added coconut products continues to grow. A number of farms produce coconut water for export to Trinidad and Tobago, while others produce coconut oil. A group established in 2001, the Pomeroon Women's Agro-Processors Association, also produces a number of value-added products, including virgin coconut oil, pepper sauce, cooking sauce, wine, and carambola cake mix (ERM Personal Communication 5).

In the Amerindian communities of Region 1, agricultural activities occur on a small scale and include cultivation of tubers, corn, cucumber, eggplant, ginger, peppers, plantains, bananas, watermelon, beans, okra, pumpkin, and coconut. At least one community engages in cassava processing, including cassava bread, starch, and cassareep (PAC 2014), but lack of access to markets prevents larger-scale development of this commercial activity. In general, it appears that agriculture is also very important in Region 6, with the highest employment opportunities for agriculture as compared to other coastal NDCs in Regions 1 through 5 surveyed as part of the Consultant field studies in late 2017 to early 2018 (ERM/EMC 2018).

Challenges for Farmers and Agricultural Processors

Climate change is perceived as a challenge for some agricultural producers. For example, changes in sunshine and rain patterns are thought to have contributed to decreased pineapple yields in recent years (ERM Personal Communication 4). Sea-level rise potentially associated with climate change is also considered a threat for coastal farmers, given that the coastal plains, where the majority of the country's agricultural activity occurs, lie below sea level (ECLAC 2011). Outside of flood events, saltwater sometimes enters into the irrigation canals through sluice gates at high tide or up the Pomeroon River during the dry season. This can adversely impact some crops, such as most vegetables, but may be beneficial to others, such as fruit trees (ERM Personal Communication 5). As noted above, however, the irrigation canal system for rice fields and fish farms are separated from the drainage system and draw from the water conservancies.

8.2.2.3. Speedboat Operation

Guyana's unique geography means that boating is an important mode of transport for travel between the coastal regions. Other than air travel, the most rapid and direct means of accessing Region 2 from the east coast of the Essequibo River is by speedboat, although a ferry service is also available. Speedboat operators servicing the route between Parika in Region 3 and Supenaam in Region 2 belong to the Supenaam-Parika Speedboat Owners' Association, which currently numbers 91 boats (See Figure 8.2-4). According to a member of the association, the majority of customers for this route are business owners, such as shopkeepers who travel to Georgetown for supplies (ERM Personal Communication 6). Speedboats are also used for transportation to communities upriver in the Essequibo and Pomeroon Rivers, and to areas of Regions 1 and 2 that are not accessible by road (i.e., areas west of Charity). More information on speedboat use in the coastal areas is provided in Section 8.4, Marine Use and Transportation

Figure 8.2-4: Speedboats Docked in Parika, Region 3

Challenges for Speedboat Operators

Although natural forces (e.g., wind, waves, sea currents, and sediments transported from the mouth of the Amazon River) create a dynamic and ever-changing coastline, speedboats are typically able to maneuver through mud and sandbanks where ferries would be unable to traverse (ERM Personal Communication 6). As a result, there are no notable seasonal factors that impact business or safety for speedboat operators. However, some stakeholders noted that along the Pomeroon River where there are many coconut plantations and processing plants, the practice of discarding coconut shells in the river poses a danger to speedboat operators and passengers (ERM Personal Communication 5 and 6). For speedboat operators plying the Region 1 route, and through the Moruca Sub-Region in particular, the dry season conditions, which can include low water levels in the creeks, can pose a challenge and cause considerable delays.

8.2.3. Impact Assessment—Employment and Livelihoods

This section assesses potential Project impacts on employment and livelihoods in the Project AOI. The following are the key impacts considered for planned Project activities:

- Potential increased local business activity and employment due to select Project employment and select Project procurement and due to Project worker spending;
- Potential for restricted access to remote offshore fishing locations, and damage to fishing vessels and equipment from Project vessel movements; and
- Potential occupational health and safety impacts on Project workers.

8.2.3.1. Relevant Project Activities and Potential Impacts

The primary Project activities will occur approximately 183 kilometers (approximately 114 miles) offshore and are not expected to significantly impact non-Project activities occurring on the Guyana coast. The only planned Project activities that will be perceptible from the shore will be support vessel trips originating from and returning to shorebase facilities in Georgetown, and helicopter transits between onshore aviation bases and the FPSO and drill ships offshore.

With respect to increased local business activity and employment, the Project will have direct and indirect potential impacts resulting from employment of Guyanese nationals and use of local companies to supply various goods and services. The local workforce and local suppliers will also benefit from capacity-building training programs currently being undertaken by EEPGL. As described in Section 8.1, Socioeconomic Conditions, EEPGL intends to continue the current approach to optimizing use of local content to the extent practicable.

Planned Project activities and presence of Project vessels are not expected to have significant impacts on fishing livelihoods given the remote location of the activities. Potential impacts on fishing vessels as a result of unplanned events (e.g., collisions between Project vessels and non-Project vessels) is discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Project workers onboard the FPSO and other Project vessels will be exposed to occupational hazards typical of offshore oil and gas operations. As discussed in Chapter 2, Description of the

Project, as well as in the Environmental and Socioeconomic Management Plan (ESMP), these will be managed through implementation of EEPGL's Operations Integrity Management System (OIMS), a robust and effective management system to protect its Project workforce.

Table 8.2-2 summarizes the Project stages and activities that could result in potential Project impacts on employment and livelihoods, as well as the receptors that could potentially experience these impacts.

Table 8.2-2: Summary of Relevant Project Activities and Key Potential Impacts—Employment and Livelihoods

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Population of Georgetown and vicinity	Project procurement of select goods and services	• Increased local business activity and growth • Increased employment
		Worker spending	
		Limited local employment (direct and indirect)	
	Fishing vessel operators in the Project AOI	Transit of Project vessels between the PDA and shorebase(s) in Georgetown and in Guyanese waters between the PDA and shorebase(s) in Trinidad and Tobago; establishment of marine safety exclusion zones around major project vessels in the PDA	• Disruption of fishing activities due to presence of Project vessels • Minor limitations on fishing access in remote offshore areas due to marine safety exclusion zones (500 meters [approximately 0.3 miles] around the drill ship and 3.2 kilometers [2 miles] around the FPSO during offloading)

8.2.3.2. Magnitude of Impact—Employment and Livelihoods

The assessment of the Project's magnitude of potential impacts on employment and livelihoods is determined based on consideration of geographic extent, frequency, duration, and scale. The scale of potential impacts on employment and livelihoods is defined according to the definitions provided in Table 8.2-3.

Table 8.2-3: Definitions for Scale Ratings for Potential Impacts on Employment and Livelihoods

Criterion	Definition
Scale	Negligible: The changes do not bring about any loss of livelihood or employment.
	Small: The changes impact some individual receptors' ability to engage in their current livelihood(s) at the same level of productivity.
	Medium: The changes impact some receptors' ability to engage in their current livelihood(s) at the same level of productivity, and/or cause a loss of working days. An entire sector within a community may be impacted in this way.
	Large: The changes cause the receptors to cease their current livelihood activities for an extended period of time, or indefinitely. An entire sector within a community or region may be impacted in this way.

In addition to direct employment, the Project will result in the indirect employment of workers through procurement of select local goods and services. Local and foreign workers that are off-shift also will spend a portion of their salaries in the Georgetown area on local accommodations, food, transportation, and entertainment. This increase in business for these local service providers could potentially lead to increased incomes, additional hiring, and continued investment in these local businesses, allowing for further growth. Additionally, beyond ensuring appropriate capacity to perform work or deliver services to EEPGL and its contractors, the capacity-building initiatives delivered to workers and local suppliers will strengthen local workers' and entrepreneurs' skills and employability, providing employment and livelihood benefits over the longer term. This impact is considered to be **Positive** and as such, a magnitude rating is not assigned.

Few potential adverse impacts on employment or livelihoods are expected as a result of planned Project activities. Current fishing activities (both industrial and artisanal) rarely occur as far offshore as the PDA, and according to various members of the industrial and artisanal fishing community as well as the Fisheries Department, the marine safety exclusion zones are expected to have little or no impact on existing fishing activity (ERM Personal Communication 24). There is at least one commercial fishing company with less than 10 vessels that partakes in deepwater tuna fishing (Personal Communication 26, 2018) that may approach the southern boundary of the PDA, and abandoned fishing gear has been found entangled in the mooring lines for metocean instruments installed by EEPGL in the same area. There are also reportedly Venezuelan vessels that fish on occasion at depths as far out as 190 kilometers (118 miles) near the PDA, but no further information was known (ERM Personal Communication 25). If deepwater fishing continues to develop in the vicinity of the PDA, the number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future but would still be a relatively small amount of vessels compared to the overall fishing fleet in Guyana.

Considering the small number of operators that are currently participating in deep-sea fishing, the ability to provide information in advance about EEPGL operations and marine safety exclusion zones, fishing and the relatively small area of ocean that will be affected, the magnitude of the Project-related impacts on industrial fishing operations is considered **Small**.

The highest potential for Project interactions with fisherfolk may be encounters with support vessels transiting between the PDA and the shorebase(s) in Georgetown. This could result in some limited and temporary disruption to fishing activity. Unlike deepwater industrial fisheries, the artisanal fisheries will not lose access to any fishing areas as a result of marine safety exclusion zones within the PDA (as these are in areas where artisanal fishing does not occur). However, increased Project-related vessel traffic near the coast and within the Demerara Harbour carries a small increase in the potential for support vessels to disrupt fishing vessel activities. Considering the occasional and temporary nature of potential impacts on subsistence fishing activity from Project-related marine traffic, the magnitude of the potential impact on these receptors is considered to be **Small**.

8.2.3.3. Sensitivity of Receptors—Employment and Livelihoods

Potential receptors for employment and livelihood impacts are the general population in Georgetown and its vicinity (for positive impacts related to increased business and employment); and subsistence and commercial fisherfolk operating on the Guyanese coast (for impacts related to fishing activity). The receptor sensitivity ratings for employment and livelihoods are defined in Table 8.2-4.

Table 8.2-4: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Employment and Livelihood

Criterion	Definition
Sensitivity	Low: The receptor can easily adapt to the change without assistance or can shift to alternate livelihood opportunities without impacting ability to subsist and/or earn income.
	Medium: The receptor may adapt to the change or shift to alternate livelihood activities with assistance and with some disruption to ability to subsist and/or earn income.
	High: The receptor cannot adapt to the change without difficulty and cannot easily transition to alternate livelihood activities. Impacts on current livelihood activities will pose a threat to the receptor's ability to subsist, earn income, and maintain current quality of life.

Receptors in the Georgetown area (Region 4) are considered to have a **Medium** level of sensitivity to employment and livelihood positive impacts, since the workforce in this region has a comparatively higher likelihood to take advantage of increased employment activities, relative to the greater Guyanese population.

Artisanal fisherfolk engaging in fishing on the Guyanese coast have a limited ability to adapt to potential fishing disruption impacts from Project activities and are thus considered to have a **Medium** level of sensitivity to such impacts. Industrial fisherfolk are generally better able to adapt to increased vessel activity and limited decreases in accessibility to offshore areas for fishing. However, as a conservative measure and in recognition of the variability in ability to adapt across the sector, industrial fisherfolk are considered to also have a **Medium** level of sensitivity to potential impacts on fishing activity.

8.2.3.4. Impact Significance—Employment and Livelihoods

As discussed above, the potential positive impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending is considered to be **Positive**. As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, this assessment does not develop significance ratings for positive impacts.

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential livelihood and employment impacts on industrial fisherfolk and artisanal fisherfolk operating in the coastal area is rated as **Minor**.

8.2.4. Mitigation Measures—Employment and Livelihoods

The Project will seek to enhance positive benefits to employment and livelihoods by procuring select goods and services locally (potentially leading to enhanced local employment and livelihood benefits) to the extent reasonably practicable.

As a mitigation measure to address the potential for adverse impacts on fishing activities, the Project intends to issue notices to mariners via Maritime Administration Department (MARAD), as well as via the Fisheries Department, Trawler's Association, and fishing co-ops for major marine vessel movements, including movements of the FPSO, drill ship, and major installation vessels. The Project will also continue to communicate major vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators, including those vessels known to operate in the vicinity of the PDA, who might not ordinarily receive Notices to Mariners, and where possible, communicate Project activities to those individuals to aid them in avoiding Project vessels through the stakeholder engagement process. This will allow fishing boat operators to adjust their fishing locations if needed to avoid these offshore locations with higher densities of Project vessels. With implementation of this mitigation measure, the significance of potential impacts on industrial fisherfolk is considered to be reduced to **Negligible**.

Many of the artisanal craft engaged in subsistence fishing activities do not carry radios, may use remote ports, and/or may not receive notices of increased vessel activity issued by the Project through the channels described above. Accordingly, this mitigation measure is likely to be somewhat less effective for artisanal fisherfolk. For this reason, while the same mitigation measure described above will be applied to address potential impacts on artisanal fisherfolk, including regular engagement on project-related activities, the significance of potential impacts is maintained at a rating of **Minor**.

Table 8.2-5 summarizes the assessment of potential pre-mitigation and residual Project impacts on employment and livelihoods. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the employment and livelihoods-specific methodology described in Sections 8.2.3.2 and 8.2.3.3.

Table 8.2-5: Summary of Potential Pre-Mitigation and Residual Impacts—Employment and Livelihoods

Stage	**Resource/ Receptor Impact**	**Magnitude**	**Sensitivity**	**Pre-Mitigation Significance Rating**	**Proposed Mitigation Measures**	**Residual Significance Rating**
All Project stages	Population of Georgetown and vicinity—increased employment, local business activity, and household incomes	Not assessed	Medium	Positive	None	Positive
	Industrial Fisherfolk—impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)	Small	Medium	Minor	• Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones • Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners	Negligible
	Artisanal Fisherfolk—impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)	Small	Medium	Minor		Minor

8.3. COMMUNITY HEALTH AND WELLBEING

8.3.1. Administrative Framework—Community Health and Wellbeing

Table 8.3-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on community health and wellbeing.

Table 8.3-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Community Health and Wellbeing

Title	**Objective**	**Relevance to the Project**
Legislation		
Food & Drug Regulations (Food and Drug Act, 1971)	Regulates the sale, advertisement, preparation, and handling of food products; regulates the manufacture, advertisement, trade, and administration of pharmaceuticals; provides the Ministry of Health authority to inspect facilities to establish compliance with sanitation standards.	Governs the preparation of food and provision of medications at Project facilities.
Ministry of Health Act (2005)	Sets out the functions of the Ministry of Public Health (previously the Ministry of Health) and the duties of the Minister. Among the responsibilities conferred to the Ministry by the Act are to provide oversight of health care services including mental health; provide advice to government and establish policies on health; develop and ensure the implementation of the National Health Plan and other action plans and directives including human and all other resource requirements; enter into service agreements with the Regional Health Authority and review and approve their health plans and budgets; and facilitate the accreditation and regulation of the health care professionals, hospitals, and other health facilities in the public and private sectors.	Generally applies to health care services supplied to Project workers.
Regional Health Authority Act (2005)	Provides the Regional Health Authority with the responsibility for providing for the delivery and administration of health services and health programs in specified geographic areas and for matters incidental thereto or connected therewith.	Establishes the regional regulations under which health services would be provided to Project workers.
Health Facilities Licensing Act (2007)	Under the act, all health facilities must be licensed by the Minister of Public Health. The Act also provides for inspectors who are authorized to enter any facility and conduct inspections. Offenses are outlined with fines and imprisonment upon summary conviction. Importantly, the act also provides for the Minister to make regulations related to licenses, renewals, standards for health facilities, record keeping, prescribing and governing the construction, establishment, location, equipment, maintenance, and repair of, additions and alterations to, and operations of health facilities.	Sets the requirements for health facilities at which services would be available to Project workers.

Title	Objective	Relevance to the Project
Policies		
Health Vision 2020: National Health Strategy for Guyana (2013)	Creates an enabling framework for the integrated delivery of quality, effective, and responsive health services and prevention measures to improve the physical, mental and social wellbeing of all people in Guyana.	Seeks to improve service delivery; managing communicable and non-communicable diseases; and improving health outcomes.
Workers' Health Policy (under development)	Intended to align with the Occupational Safety and Health guidelines of the World Health Organization. The Policy is expected to encompass the Sustainable Development Goals related to the health sector; non-communicable diseases and workers' health; and occupational safety and health, among others.	The draft of this Policy is not publicly available, but when completed, it is expected to guide the Government's approach to workers' health.

8.3.2. Existing Conditions—Community Health and Wellbeing

8.3.2.1. Health Status

According to the Ministry of Public Health, health outcomes in Guyana continue to improve steadily, with life expectancy at birth increasing from 64 years from 1990 to 2002 for all births to 71.1 years for females and 66.5 years for males in 2011. The crude death rate[5] has decreased from 6.6 per 1,000 persons in 2003 to 6.1 per 1,000 persons in 2011 (Persaud 2013). The leading causes of mortality in 2010 were chronic diseases (including cardiovascular and cerebrovascular diseases), cancers, diabetes, and hypertension (Ministry of Public Health 2013b). The major causes of illness in 2012 were acute respiratory infection (84,000 registered cases), gastroenteritis (38,421 cases) and unspecific fevers (62,321 cases) (Persaud 2013).

Burden of Disease

As with many other developing countries, Guyana is undergoing an epidemiological transition by which non-communicable diseases are beginning to replace communicable diseases as the leading causes of illness and mortality. This shift is largely due to trends toward more sedentary occupations and lifestyles, as well as unhealthy diets and habits such as tobacco and alcohol use. The most common non-communicable diseases and causes of illness/mortality in 2013 were diabetes, cardiovascular diseases, heart diseases, hypertension, cancers, chronic lung diseases, gastroenteritis and liver disease, accidents, violence-related injuries, and mental illnesses (Persaud 2013).

Obesity is on the rise in the country, along with other forms of malnutrition. Although Guyana is considered self-sufficient for food, accessibility and utilization of the right types of food to maintain health are of concern, leading the Ministry of Agriculture to develop the Guyana Food and Nutrition Security Strategy 2011-2020 Plan. This plan aims, among other goals, to integrate agricultural practices with improved food security and nutrition (Ministry of Public Health 2013a). According to the Ministry of Public Health, in 2013, 6.2 percent of the population had

[5] The crude death rate is the number of deaths occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013b).

been diagnosed with diabetes, with an estimated incidence rate of 4,000 new cases annually. Type 2 (non-insulin dependent) diabetes accounted for 92 percent, with Type 1 (insulin-dependent) making up the other 8 percent (Persaud 2013).

Hypertension is also on the rise, with a 2013 prevalence rate of 9 percent of the population over 30 years old and with an estimated 16,000 new cases reporting annually. Hypertension is the major contributing cause of strokes for persons over 40, as well as for heart attacks, disability, and others health issues affecting productivity of working age adults (Persaud 2013).

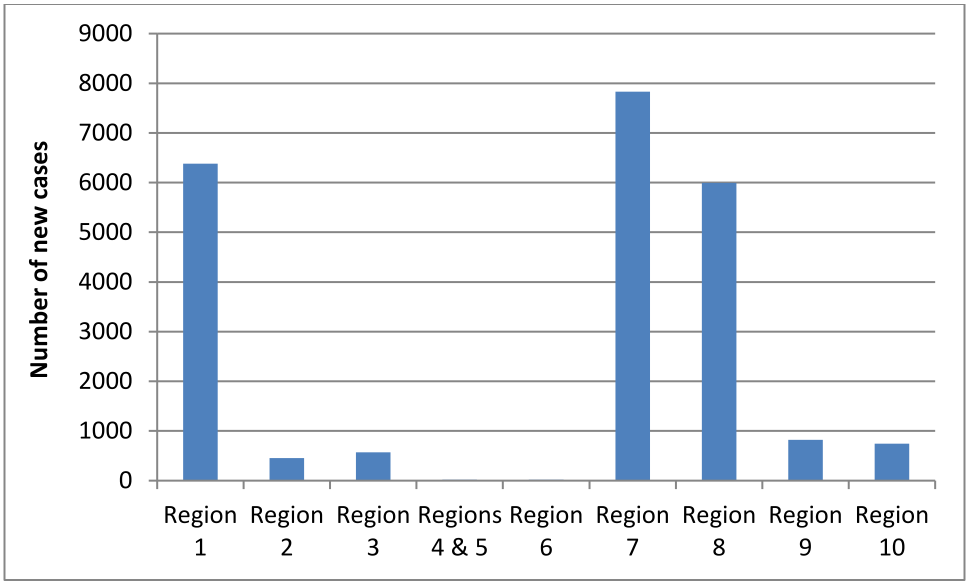
Communicable diseases also continue to impact productivity, quality of life, and wellbeing in Guyana, particularly in the hinterland regions. This is due to a number of interrelated factors including poverty, nutritional deficiency, and inadequate access to health services. In 2012, the most common communicable diseases were malaria (31,876 cases), tuberculosis (TB; 725 cases), and human immunodeficiency virus (HIV; 8,263 cases out of 106,492 tested) (Persaud 2013). Malaria is found in much of Guyana and is most prevalent in Regions 1, 7, 8, and 9. Malaria control efforts, such as distribution of insecticide-treated bed nets and indoor residual spraying[6], have been ongoing in these regions for decades. After an initial reduction in malaria prevalence in the early 2000s, the number of cases increased from 2007 to 2012. Data indicate a correlation with mining activities in the hinterland areas, and the country's Central Vector Control Service now sends mobile teams to work directly with populations residing in mining camps (USAID 2014). There was a decrease in 2013, with figures released by the Ministry of Public Health showing that in 2013, there were 23,489 reported cases of malaria, compared to 31,876 for the previous year (Persaud 2013). Figure 8.3-1 shows the number of reported new malaria cases for each region in 2010, the most recent year for which data broken down by region are available.

Dengue fever, chikungunya, lymphatic filariasis, and Zika are also locally transmitted in Guyana (i.e., they are present in the community and passed from Guyanese to Guyanese). Unlike malaria, transmission of these diseases tends to be common in populated and urbanized areas.

TB continues to be a priority health concern in Guyana. It was nearly eradicated in the 1980s, but saw a resurgence in the 1990s due to its association with the HIV/acquired immunodeficiency syndrome (AIDS) epidemic. In 2014, the national average for TB incidence was 10.3 per 10,000 people. Regional distribution of cases in 2010 is shown on Figure 8.3-2.

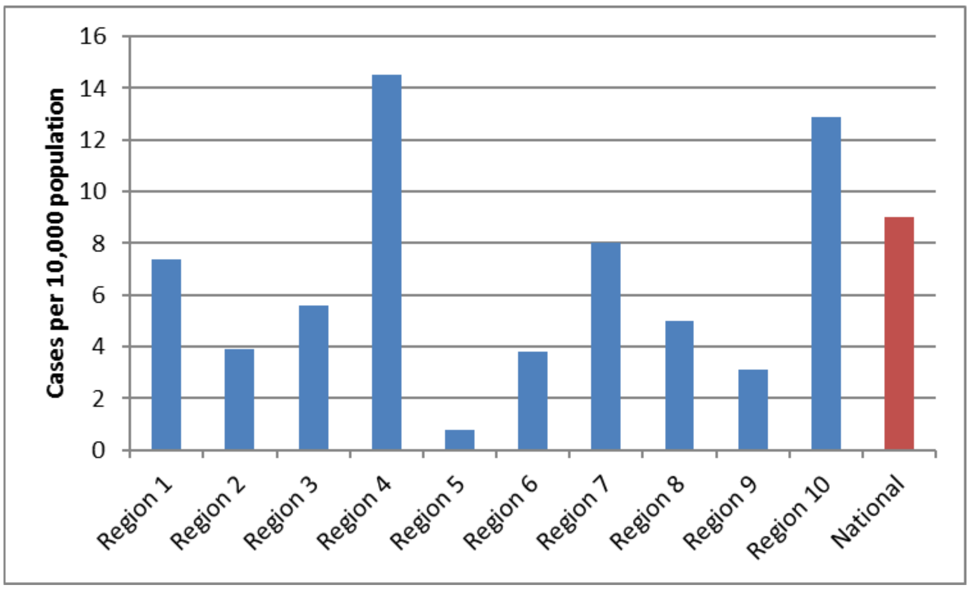
In 2016, the number of people living with HIV in Guyana was estimated at 8,500, and the prevalence rate in the population aged 15 to 49 was 1.6 percent. According to the Joint United Nations Program on HIV/AIDS (UNAIDS 2015), progress has been made in addressing the HIV epidemic in the country, with a reduction in the number of HIV cases reported since 2009, as well as a reduction in the number of AIDS cases (Figure 8.3-3) and AIDS-related deaths.

[6] Indoor residual spraying involves coating the walls and other surfaces of a house with an insecticide that has residual activity (i.e., continues to work over several months, killing mosquitos on contact with the sprayed surfaces) (Centers for Disease Control and Prevention 2012).



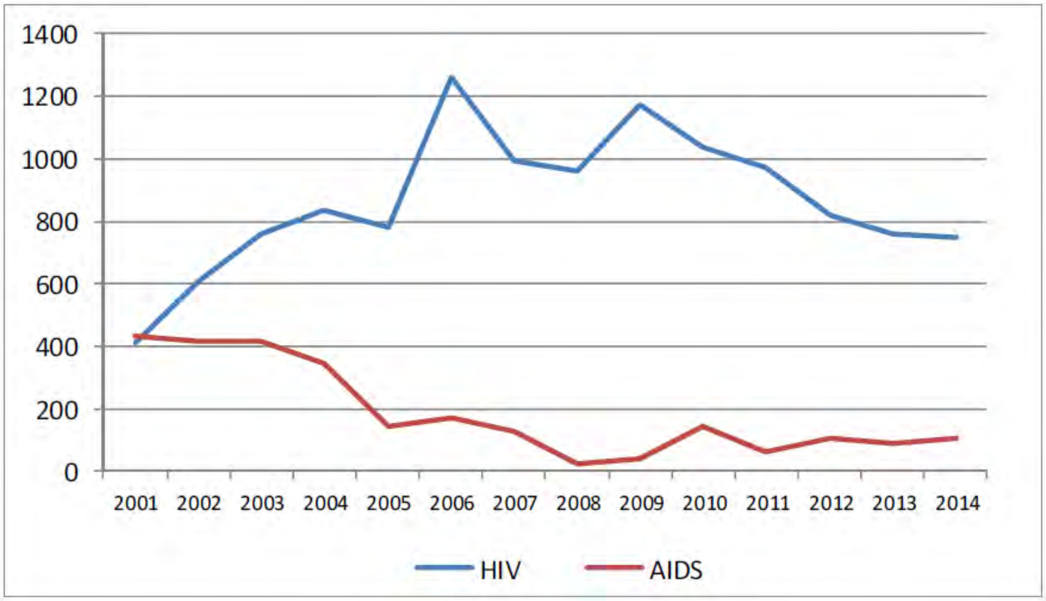
Source: Ministry of Public Health 2013b

Figure 8.3-1: Malaria Incidence by Region, 2010



Source: Ministry of Public Health 2013b

Figure 8.3-2: TB Incidence Rate, 2010



Source: UNAIDS 2015

Figure 8.3-3: Annual Number of HIV and AIDS Cases, 2001-2014

The tropical diseases lymphatic filariasis and soil-transmitted helminthiasis continue to be problematic in Guyana, leading to deformity, malnutrition, and social stigma in impacted populations. Efforts to combat these diseases in the country include mass drug administration campaigns and improvements in sanitation in endemic areas.

Maternal and Child Health

Guyana has made improvements in maternal and child health in recent years, but has not achieved its Millennium Development Goal targets of reducing child mortality rates by two thirds, and maternal mortality ratio by three quarters between 1990 and 2015. The crude birth rate[7] is down from 22.8 per 1,000 persons in 2003 to 17.7 per 1,000 persons in 2011, and the infant mortality rate has also declined from 17 to 15.1 per 1,000 live births during this same time period (Persaud 2013). However, marked disparities exist in rural and hinterland areas, with the rate of under age 5 mortality at 48 per 1,000 live births in rural areas and 11 per 1,000 live births in urban areas (BSG et al. 2015).

The primary causes of infant death at birth include premature birth and respiratory distress, both of which are preventable, with the secondary causes being congenital deformity and birth defects that are not preventable (Persaud 2013). According to interviews with health workers as part of the late 2017 and early 2018 Consultant field work, home deliveries are common in many remote areas due to lack of ambulatory services and general access to transportation to neighboring healthcare facilities. In some remote healthcare facilities, the lack of basic medical supplies

[7] The crude birth rate is the number of live births occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year (OECD 2013a).

means that health workers must rely on rudimentary equipment to perform births (e.g., scalpel to cut umbilical cords, no electricity) (ERM/EMC 2018).

Mental Health

Guyana has a high suicide rate, but has seen notable decreases in recent years. According to the WHO, Guyana had the highest rate of suicide of any country in the world in 2014, at 44.2 deaths per 100,000 people, versus the global average of 16 deaths per 100,000 people (WHO 2014). However, this dropped to 29 deaths per 100,000 people in 2015, against a global average of 10.7 deaths per 100,000 people (WHO 2016). This decline can be attributed to several initiatives being implemented by the Ministry of Public Health with support from WHO/Pan American Health Organization, including a National Mental Health Action Plan for 2015–2020 and a national suicide prevention plan. According to Guyana's Chief Medical Officer, rates are particularly high in Regions 2, 3, and 6, with the most common method being ingestion of poisons such as pesticides. No single reason is pinpointed for this phenomenon, but the shortage of mental health workers and the stigma associated with mental illness - leading to untreated depression - are thought to be contributing factors, as well as the ease of access to pesticides and other toxic agricultural substances (ERM Personal Communication 7).

8.3.2.2. Healthcare System

The Ministry of Public Health is responsible for setting national policy, regulation, and standards; building and refurbishing of healthcare facilities; and financing the employment of doctors, nurses, and emergency response workers. At the regional level, the Regional Health Authorities have the autonomy to assess, plan, and implement health services and manage the facilities for a defined population in a defined geographic area, including day-to-day management of the facilities and employment of all other staff working in the health sector. The country's main framework for health is the Health Vision 2020, which sets the strategy and overall planning for the health sector.

Government health spending compares favorably with that of other Latin American and Caribbean countries, and has averaged about 3 percent of GDP in recent years, equivalent to $11.5 billion GYD annually ($55.6 million USD) (Ministry of Public Health 2013b). The healthcare system in the country is highly decentralized, with RDCs and Regional Health Authorities managing, financing, and providing health services. However, the system continues to have a number of challenges related to human resources capacity and infrastructure capacity, which is especially acute in remote areas, such as Region 1.

The Ministry of Public Health established priorities in 2013 for the national healthcare system to increase financial and technical support to improve the following (Persaud 2013):

- Family health (child, adolescence, women, men, elderly);
- Disease eradication and mental health;
- Violence, accidents, and injury rates;
- Healthcare facilities at all levels (community centers to city hospitals);

- Nutrition and food security; and
- Access to health for frontier, migrant, remote, and vulnerable populations.

Health Care Facilities

Health care facilities in the coastal regions are summarized in Table 8.3-2 below. In addition to these facilities, there is one National Ophthalmology Center and one National Psychiatric Hospital in the country, both located in Region 6.

Table 8.3-2: Health Care Facilities in the Coastal Regions

Region	Regional Hospital	District Hospital	Diagnostic Center	Health Center	Health Post
Region 1	1	4	-	4	44
Region 2	-	2	1	11	17
Region 3	1	2	1	17	22
Region 4	1	1	1	39	7
Region 5	-	1	1	14	1
Region 6	1	3	-	21	2

Source: Ministry of Public Health 2016

According to Guyana's Chief Medical Officer, one of the biggest health system shortfalls for Guyana is unreliable emergency care services. This includes the lack of a functioning air ambulance system, which is needed to adequately respond to mining injuries in the country's interior and to the large number of vehicle accident-related injuries. There are also shortages of blood at times, and capacity in hospitals is inadequate. The public hospital in Georgetown once had 900 beds, but due to fires and dilapidation over the years, this has been reduced to 450 (ERM Personal Communication 7). In 2012, there were 28 hospital beds per 10,000 people in the country, up slightly from 25 beds per 10,000 people in 2003 at Region 1 coastal health facilities (Persaud 2013; ERM/EMC 2018). The most common reasons for clinic visits were hypertension, diabetes, antenatal, and family planning. Medical supplies, including medicines, are in short supply and those that are provided to village health centers from larger cities (such as Mabaruma and Georgetown) are typically close to, if not past, the expiration date.

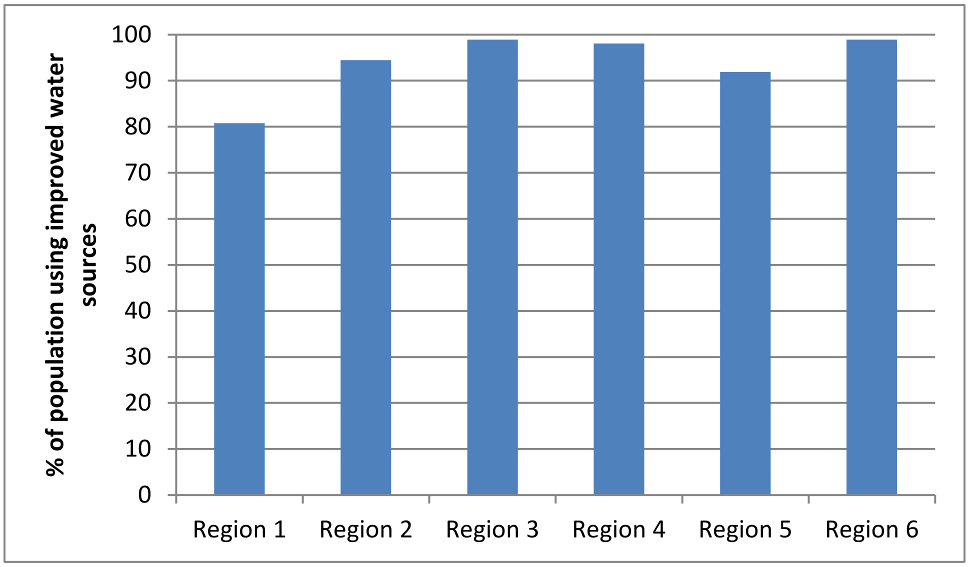
Health Human Resources

Retention of healthcare professionals in Guyana is a challenge, as in many other developing countries that see emigration of skilled workers to developed countries. The most recent available statistics from the Ministry of Public Health indicate that there were nine physicians and 13.3 nurses per 10,000 people in the country in 2012 (Ministry of Public Health 2013a). Guyana currently has a Health Human Resource Action Plan for Guyana 2011-2016 that is aimed at addressing this issue.

8.3.2.3. Quality of Life

Water and Sanitation

According to the most recent Guyana Multiple Indicator Cluster Survey (MICS)[8], 94 percent of Guyana's population had sustainable access to improved drinking water sources[9] as of 2014, and 95.4 percent used an improved sanitation facility[10] (UNICEF 2014). Figure 8.3-4 shows the percentage of the population with access to improved sources of drinking water, by region. However, while access to improved water sources has improved over the years, wastewater and sanitation coverage and infrastructure in the country are limited, thus hampering efforts to improve health conditions (World Bank 2016).



Source: UNICEF 2014

Figure 8.3-4: Percent of Population with Access to Improved Water Sources by Region, 2014

In 2012, approximately 97 percent of the population in both urban and rural areas used an improved drinking-water source (as compared to 83 percent in rural areas in 2000). However, an assessment conducted by multilateral partners in 2014 points out that the quality of water supply services is hindered by decaying distribution networks, with 50 percent to 70 percent of wastewater going unaccounted for at the national level (and more than 70 percent in Georgetown) (World Bank 2016).

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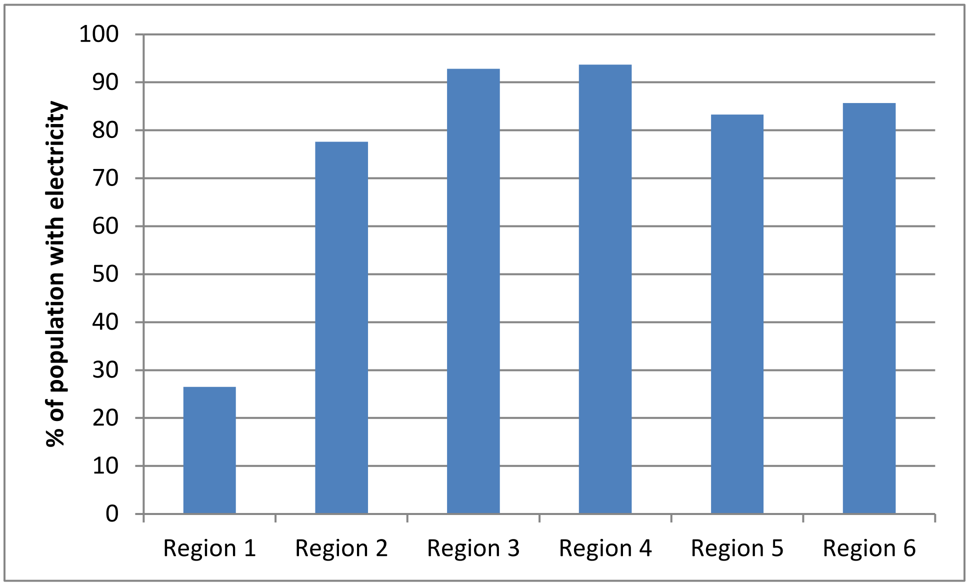
[8] The MICS program was developed by the United Nations Children's Fund and serves as an international household survey program to collect internationally comparable data on a wide range of indicators on the situation of children and women.
[9] Improved water sources refer to any of the following types of supply: piped water into dwelling, compound, yard, to neighbor, or to public tap/standpipe; tube well/borehole; protected well; protected spring; and rainwater collection. Bottled water is considered as an improved water source only if the household is using an improved water source for handwashing and cooking.
[10] An improved sanitation facility is defined as a facility that flushes or pour-flushes to a piped sewer system, a septic tank, a pit latrine, a ventilated improved pit latrine, or a pit latrine with slab.

Electricity

Results of the MICS indicate that an estimated 91.2 percent of the coastal population and 56.2 percent of the interior population have access to electricity. Figure 8.3-5 shows the percent of the population with electricity in each of the coastal regions.

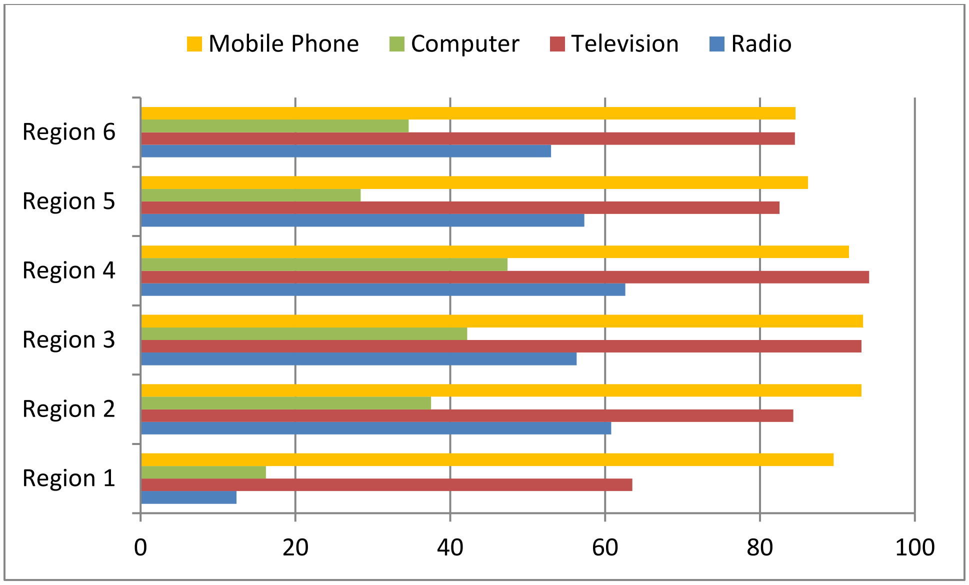


Source: UNICEF 2014

Figure 8.3-5: Percent of Population with Electricity by Region, 2014

Telecommunications

In terms of telecommunications, mobile telephone coverage is quite comparable among coastal regions, and an average of 88.6 percent of households in the country has at least one member with a mobile phone. There is more disparity in other forms of telecommunications, with Region 1 in particular showing lower levels of access to computers, television, and radio, relative to other regions (Figure 8.3-6).



Source: UNICEF 2014

Figure 8.3-6: Household Access to Telecommunications, 2014

8.3.2.4. Natural Hazards

Guyana is not threatened by many natural hazards, but due to its low-lying coastal plain, the northern areas of Regions 1 to 6 face severe risk of flooding. The World Bank (2016) estimates that Guyana is one of the most vulnerable countries to global climate change due to the low-lying coastal areas, many below mean sea level, and a high percentage of the population and critical infrastructure located along the coast. A recent study identified Guyana as exhibiting high climate vulnerability to effects on marine fisheries and food security (Ding et al. 2017). Both changes in rainfall patterns and predicted sea-level rise associated with climate change pose threats to the Guyanese population and its livelihoods. As such, the country invests continuously in the construction and maintenance of sea and river defense infrastructure, as well as a system of reclaimed lands, drainage and irrigation canals, pumping stations, and conservancy dams to protect agriculture in the vulnerable coastal areas. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems.

Despite this investment, floods continue to threaten public safety and infrastructure along the coast. In 2005, torrential rains caused many rivers and water conservancies in the coastal plain to overflow, causing severe flooding in Regions 1, 2, 3, 5, and 6. The floods resulted in the direct or indirect deaths of 19 people, from either drowning, acute dehydration, or succumbing to an outbreak of leptospirosis that occurred in the aftermath of the flooding (PAHO 2005). Direct economic losses of agricultural crops, livestock, fisheries, forestry, and roads in the coastal area were estimated to total over $10 billion GYD (approximately $48 million USD) (ECLAC 2005). More recently, in early March 2018, floodwaters breached the sea defense network in the West Coast Demerara area, damaging local businesses and homes and forcing the temporary evacuation of some residents.

8.3.3. Impact Assessment—Community Health and Wellbeing

This section assesses potential impacts from Project planned activities on community health and wellbeing in the Project AOI. The key potential impacts considered 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, and decreased availability of emergency medical and health services.

Some of the mitigation measures proposed in other EIA sections address other potential impacts on community health and wellbeing. Therefore, these potential impacts have been scoped out of the community health and wellbeing impact assessment. A summary of these "scoped out of community health and wellbeing" potential impacts and the sections where they are discussed is presented in Table 8.3-3.

Table 8.3-3: Potential Impacts Discussed in Other EIA Sections and Scoped out of the Community Health and Wellbeing Impact Assessment

Potential Impact	Relevant EIA Section
Air quality emissions from Project sources	Air Quality (Section 6.1)
Offshore Project activity-related discharges to water column (altering water chemistry and turbidity)	Marine Water Quality (Section 6.4)
Local job creation, contributing to positive physical and mental health outcomes	Socioeconomic Conditions (Section 8.1)
Waste generation, storage, and disposal	Waste Management Infrastructure and Capacity (Section 8.6)
Hydrocarbon spills from Project vessels operating near shore or off shore	Unplanned Events (Chapter 9)
Marine or vehicle accidents involving non-Project individuals	Unplanned Events (Chapter 9)
Workforce exposure to a number of hazards and risks	Worker Health and Safety (Section 2.14)

In determining the potential community health and wellbeing impacts of the Project, the WHO's definition of health was applied: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO 2006). Factors that affect health are commonly called "determinants of health," which are defined by the International Finance Corporation (IFC 2009) as "individual, social and environmental, and institutional factors that are directly, indirectly, or cumulatively affected by the proposed project" as described in Table 8.3-4.

Table 8.3-4: Determinants of Health

Categories of Determinants of Health	Examples of Specific Health Determinants
Individual factors: genetic; biological; lifestyle; behavioral; and/or circumstantial, of which some can be influenced by proposals and plans	Gender; age; dietary intake; level of physical activity; tobacco use; alcohol intake; personal safety; sense of control over own life; employment status; educational attainment; self-esteem; life skills; stress levels; etc.
Social factors: community, economic and/or financial conditions	Access to social and health-related services and community; social support or isolation; housing; income; distribution of wealth; sexual customs and tolerance; racism; attitudes to disability; trust; sites of cultural and spiritual significance; local transport options available; etc.

Categories of Determinants of Health	Examples of Specific Health Determinants
Environmental factors: physical	Quality of air, water and soil; access to safe drinking water and adequate sanitation; disease vector breeding places; land use; urban design
Institutional factors: the capacity, capabilities and jurisdiction of public sector services	Availability of services, including health, transport and communication networks; education and employment; environmental and public health legislation; environmental and health monitoring systems; laboratory facilities; etc.

8.3.3.1. Relevant Project Activities and Potential Impacts

The Project will involve a range of activities that could potentially impact community health and wellbeing, across all of the aforementioned categories of determinants of health. Shifts in demographic patterns, including the influx of foreign workers or the spatial concentration of working-age populations, has the potential to cause changes in disease transmission patterns and to impact public safety. Project onshore and nearshore transportation activities could increase the risk for vehicular and marine accidents, respectively. The potential for these impacts are limited due to the Project's limited onshore footprint. Table 8.3-5 summarizes the Project stages and activities that could result in potential Project impacts on community health and wellbeing, as well as the receptors that could potentially experience these impacts.

Table 8.3-5: Summary of Relevant Project Activities and Key Potential Impacts—Community Health and Wellbeing

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	General population of Georgetown and vicinity	Project worker presence Project use of medical and health resources in the Georgetown area	• Increased risk of communicable disease transmission. • Impacts on public safety. • Overburdening of medical and health services.
	General population throughout coastal communities	Overall presence of oil and gas development activities, principally related to the perceived risk of an oil spill	• Public anxiety over oil and gas sector risks

8.3.3.2. Magnitude of Impact—Community Health and Wellbeing

In the case of community health and wellbeing, there are a wide range of illnesses and disabilities are already present in the population and this is the baseline prevalence rate. However, as people value their health, even a small increase in the prevalence rate of a disease or disability that is attributed to the Project would be considered a high magnitude event. The assessment of the Project's magnitude of impacts on community health and wellbeing is determined based on consideration of geographic extent, frequency, duration, and scale. The scale of potential impacts on community health and wellbeing is defined according to the definitions provided in Table 8.3-6.

Table 8.3-6: Definitions for Scale Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Scale	Negligible: No discernible change in health status of the population. Anticipated frequency of a health-related risk at an individual level is "never."
	Small: Changes to health status occur in some individuals and households, but changes are minor, temporary, and reversible without medical or public health intervention. Anticipated frequency of a health-related risk at an individual level is "very rare."
	Medium: Changes to health status occur at the population level and are reversible over time or with medical or public health intervention. Anticipated frequency of a health-related risk at an individual level is "rare."
	Large: Profound and measurable changes to health status are evident at the population level. Some health impacts may be severe or permanently debilitating, requiring medical or public health intervention or other forms of assistance for treatment and recovery. Anticipated frequency of a health-related risk at an individual level is "occasional."

Population shifts caused by the influx of workers from other parts of the country or from foreign countries have the potential to cause changes in transmission patterns of some communicable diseases, particularly if workers originate from countries with higher rates of diseases that are transmitted person-to-person, such as TB and sexually transmitted infections. At this time, the countries of origin of the Project workers are primarily the United States, various European countries, and a few countries in southeast Asia, including Malaysia and the Philippines. Guyana has a lower rate of TB incidence than the global average (90 cases per 100,000 population, versus the global average of 133) but has a higher rate than most developed countries. Guyana's rate of HIV prevalence is comparable to the global average. Potential communicable disease transmission risks will vary according to the workforce's primary countries of origin; however, as an embedded control, regardless of worker origin, the Project will establish a worker health-screening program and take precautions to avoid both internal and external communicable disease risks. 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 onshore presence, and the embedded health controls in place to further reduce risk, the magnitude of potential impacts related to communicable disease transmission is considered **Negligible**.

Increases in population and the presence of transient populations have the potential to contribute to increased rates of crime. Georgetown has a high crime rate, with reported cases on the rise in recent years. This is attributed largely to high rates of poverty and unemployment. It is not expected that the influx of Project workers to/through the Georgetown area will contribute significantly to an increase in local crime rates. Furthermore, the Project workforce will represent less than 1 percent of the population of Georgetown, and workers' onshore presence will be limited and occasional. As such, the magnitude of potential impacts related to public safety is considered **Negligible**.

Oil and gas represents the newest sector in Guyana's economy and concerns naturally exist among those living in coastal communities about Project activities and their perceived potential impact on livelihoods and the environment. Certain vulnerable sub-populations (e.g., indigenous populations in Region 1 coastal communities who are concerned about potential oil spills affecting the Shell Beach Protected Area, people with existing mental health or anxiety type disorders, etc.) may be more concerned about these perceived impacts than others, and may experience an associated increase in level of anxiety. However, any changes in health as a result of anxiety are expected to be minor and reversible, especially as more Project information continues to be made available to mitigate such concerns. As such, the magnitude of potential impacts related to public anxiety is considered **Small**.

The Project will have a medical facility onboard the FPSO to treat minor medical issues. Installation vessels will also have their own medical facility and a medical professional. In the event an offshore worker requires medical evacuation/referral onshore, Project medical professionals will be available offshore and onshore to support the response/referral. In the event of more serious illness or injury that cannot be handled by the offshore medical professionals, patients will be medically evacuated to a healthcare facility in Georgetown and potentially outside of Guyana, depending on the type of medical issue. Project use of Guyanese healthcare facilities could potentially compromise availability and access for the Guyanese local population. The Project currently plans to make use of a designated local private Guyanese clinic supported by an international medical provider, as well as hospitals in Georgetown, in the event of both work-related and non-work-related medical and health emergencies. However, for the most part, these hospitals will be relied upon only for initial evaluations or, in the case of life-threatening emergencies, stabilization before evacuation of foreign workers out of country to another facility. Given that reliance on local Guyanese medical facilities will be limited, the magnitude of potential impacts related to Project use of medical services is considered **Small**.

8.3.3.3. Sensitivity of Receptors—Community Health and Wellbeing

The receptor sensitivity ratings for community health and wellbeing are defined in Table 8.3-7.

Table 8.3-7: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Community Health and Wellbeing

Criterion	Definition
Sensitivity	Low: The population does not have many areas of health vulnerability. Individuals and households have the personal resources and capacity to protect and promote health. The community is well equipped with resources and infrastructure to provide routine medical and health care and address medical and health emergencies. There is a predominant absence of concern regarding the impact of the Project on personal wellbeing.
	Medium: The population has multiple areas of health vulnerability, due either to environmental or social factors. Portions of the population face socioeconomic challenges that act as barriers to health protection and promotion. There are shortfalls in local medical and health resources and infrastructure that compromise ability to provide timely and appropriate medical and health care in some situations. The population contains some who express concerns regarding the impact of the Project on their wellbeing.
	High: The population has many areas of health vulnerability due to environmental and social factors. A large proportion of the population is disadvantaged, which acts as a barrier to protecting and promoting health. Adequate medical health resources and infrastructure are lacking, often not allowing for timely and appropriate medical and health care. The population contains a significant proportion of individuals who express concerns regarding the impact of the Project on their wellbeing.

The Guyanese population is in epidemiological transition whereby the burden of illness has begun to shift from communicable disease to non-communicable (chronic) diseases and injury. However, communicable disease including HIV/AIDS, TB, pneumonia, and arboviruses still also make up a considerable burden of illness. This transition is characteristic of most developing countries as they experience demographic changes including lower fertility and longer life expectancy, as well as improvements in health and sanitation systems. In general, urban populations have measurably higher health status than rural populations. They have better access to health services, higher levels of immunization coverage, and are less likely to suffer from some communicable diseases such as malaria, lymphatic filariasis, and soil-transmitted helminths. However, densely populated urban settings, including Georgetown, are disproportionately affected by other types of communicable diseases such as dengue fever, HIV/AIDS, and TB. As such, sensitivity of the population of Georgetown to communicable disease risks is considered **Medium**.

The Guyana Police Force is responsible for maintaining security and order in the greater Georgetown area. Georgetown tends to have high-crime "hotspots," where Guyana Police Force officials experience challenges ensuring sufficient manpower and other resources. The majority of crimes are robberies and break-ins and are believed to be related to high rates of poverty and unemployment (ERM Personal Communication 23). The sensitivity of the Georgetown population to public safety-related risks is considered **Medium**.

Public anxiety related to perceived impacts from oil and gas operations has been evident in isolated instances during communications with community members (e.g., during the scoping consultation meetings for the Project Terms of Reference [ToR]). These can reasonably be expected to decrease as the local population begins to better understand the nature of the Project and the system of embedded controls to prevent unplanned events, and to experience the lack of significance of some potential impacts from planned activities. For example, fisherfolk may no longer fear impacts on their livelihoods as Notice to Mariners and other communication materials show that marine safety exclusion zones do not affect their fishing zones. Continued disclosure of Project-related activities, as well as continuous engagement with the fishing community and targeted engagement with certain vulnerable populations, will help lessen anxiety. Georgetown residents have relatively high levels of literacy and multiple means of accessing information on the Project and the country's developing oil and gas sector on a continual basis, which will help to reduce anxiety related to misconceptions about Project risks. Residents of Georgetown are also relatively well positioned to experience socioeconomic benefits of the Project, which will serve to counteract anxiety related to the Project and oil and gas sector in general. For these reasons, sensitivity of the Georgetown population to anxiety-related concerns is considered **Low**. However, as there may be some residents in other regions who may still express concerns and anxieties regarding the impact of the Project on their wellbeing, the overall sensitivity is considered **Medium.**

Georgetown has a high concentration of medical and health facilities relative to other parts of Guyana, although emergency care capacity and health-related human resources are considered lacking throughout the country. Guyana's emergency medical system is in transition at this time; until recently, the country did not have an ambulance system to respond to emergencies. As of

2014, an ambulance pilot program had been established through the Georgetown Public Hospital Corporation, with assistance from Vanderbilt University, and had seven ambulances and 21 trained emergency medical technicians. According to Guyana's Chief Medical Officer, the country's emergency medical services are still insufficient to respond to the needs of the population. The country does not have an air ambulance to respond to serious vehicle collisions that occur on Guyana's roads. Hospital capacity is also lacking; at this time, the hospital has 450 beds but requires about 600 beds to adequately serve the population (ERM Personal Communication 7). Given these health system gaps in several critical areas, sensitivity to health services impacts is considered to be **Medium**.

8.3.3.4. Impact Significance—Community Health and Wellbeing

Based on the magnitude of impact and receptor sensitivity ratings, the significance of increased potential impacts on community health and wellbeing are rated as **Negligible** for communicable disease transmission, and public safety; and **Minor** for public anxiety and overburdening of medical health services.

8.3.4. Mitigation Measures—Community Health and Wellbeing

Given the **Negligible** significance of potential impacts on community health and wellbeing for communicable disease transmission, and public safety, mitigation measures are not required. That said, EEPGL is committed to working closely with police and other public safety authorities as needed to address concerns regarding Project linkages to these types of impacts. With respect to public safety concerns, EEPGL will require Project workers to adhere to a worker code of conduct, including when they are onshore (residents, visitors, transits).

With respect to public anxiety concerns, EEPGL's ongoing stakeholder engagement programs will continue to provide means of informing the community about the Project; this is expected to contribute to decreasing public anxiety about perceived Project risks. Although this sensitivity is expected to decrease over time as the country becomes more accustomed to the presence of the oil and gas industry, it may not be possible to alleviate concerns across the entire population.

With respect to potential impacts on community health and wellbeing related to overburdening of medical facilities due to Project use, EEPGL has reduced the magnitude of this potential impact to the extent reasonably practicable (i.e., through the embedded control of having trained medical personnel on board the FPSO and major installation vessels to minimize reliance on medical infrastructure and facilities in Guyana). Also, the Project will utilize an international medical provider to complement the services of the local private medical clinic utilized by the Project, and will procure a dedicated ambulance to avoid overwhelming the local medical infrastructure.

Table 8.3-8 summarizes the assessment of potential pre-mitigation and residual Project impacts on community health and wellbeing. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the community health and wellbeing-specific methodology described in Sections 8.3.3.2 and 8.3.3.3.

Table 8.3-8: Summary of Potential Pre-Mitigation and Residual Impacts - Community Health and Wellbeing

Stage	Resource/Receptor Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	**Social Factors**					
	General population of Georgetown and vicinity—increased risk of communicable disease transmission	Medium	Negligible	Negligible	None	Negligible
	General population of Georgetown and vicinity—impacts on public safety	Medium	Negligible	Negligible	Worker code of conduct, including when workers are onshore	Negligible
	Individual Factors					
	Public anxiety over oil and gas sector risks, including perceived impacts associated with oil spills and seismic events	Medium	Small	Minor	None	Minor
	Institutional Factors					
	General population of Georgetown and vicinity—reduced access to emergency and health services	Medium	Small	Minor	Onshore medical provider with international medical provider support, and dedicated ambulance	Minor

8.4. Marine Use and Transportation

8.4.1. Administrative Framework—Marine Use and Transportation

Table 8.4-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on marine use and transportation.

Table 8.4-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Marine Use and Transportation

Title	Objective	Relevance to the Project
Legislation		
Guyana Shipping Act (1998) Cap. 49:01.	Establishes the framework for the regulation of vessels and sets out MARAD and its functions.	MARAD is the principal regulator for vessels operating in the marine environment and all vessels associated with the Project will fall under the purview of MARAD.

Title	Objective	Relevance to the Project
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves and mariculture, the protection and preservation of the marine environment and for related matters.	Relevant to the Project as it makes provisions for passage in the territorial sea, and the discharge of harmful substances and hazardous waste. In addition, relevant when specific maritime zones are established for the protection and preservation of the marine environment and also for mariculture activities, for which one project is currently being pursued by others.
International Agreements Signed/Acceded by Guyana		
International Convention for the Safety of Life at Sea (1974)	Specifies minimum standards for the construction, equipment, and operation of vessels compatible with their safety; allows governments of participating states to inspect vessels flagged in other participating states to ensure compliance.	Affects construction, operation, and equipment on board the drill ships, FPSO, installation vessels, and support vessels. Guyana acceded in 1997.
Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation (1988)	Promotes safety at sea by criminalizing actions that would endanger a vessel or its cargo, or that contribute to activities that would do so.	Would apply to any activity intended to endanger vessels while conducting Project-related activities. Guyana acceded in 2003.
Dock Work Convention (1973)	Regulates activities associated with the loading and unloading of cargo onto/from oceangoing vessels when at port.	Applies to loading and offloading activities at shorebase(s) used by the Project. Guyana acceded in 1983.
Convention on the International Regulations for Preventing Collisions at Sea (1972)	Officially recognizes the importance of traffic separation in the marine environment and codifies basic measures to accommodate traffic separation, including safe speed, signalling conventions, and general vessel conduct.	Governs maritime operation of drill ships, FPSO, installation vessels, and support vessels. Guyana acceded in 1997.
International Convention on Standards of Training, Certification and Watchkeeping (1978)	Obligates crews operating vessels flagged in signatory states to adhere to minimum standards relating to training, certification, and watchkeeping; requires signatory states to submit detailed information to the International Maritime Organization (IMO) concerning administrative measures taken to ensure compliance with the convention.	Impacts required capabilities of crew on board the drill ships, FPSO, installation vessels, and support vessels, and provides for inspection by authorities to ensure compliance. Guyana acceded in 1997.

Title	Objective	Relevance to the Project
Convention on Facilitation of International Maritime Traffic (1965)	Prevents unnecessary delays in maritime traffic arising from burdensome documentation requirements and establishes uniform formalities and other procedures to permit transboundary maritime commerce and travel.	Facilitates entry of drill ships, FPSO, installation vessels, and support vessels into Guyana. Guyana acceded in 1998.

8.4.2. Existing Conditions—Marine Use and Transportation

This section describes Guyana's existing marine and coastal transportation infrastructure, with particular focus on the Project AOI. Data and information in this section were obtained from key informant interviews, reports, studies, and other publicly available information, as well as direct observations of vessel activity in Georgetown Harbour.

8.4.2.1. Regional Setting

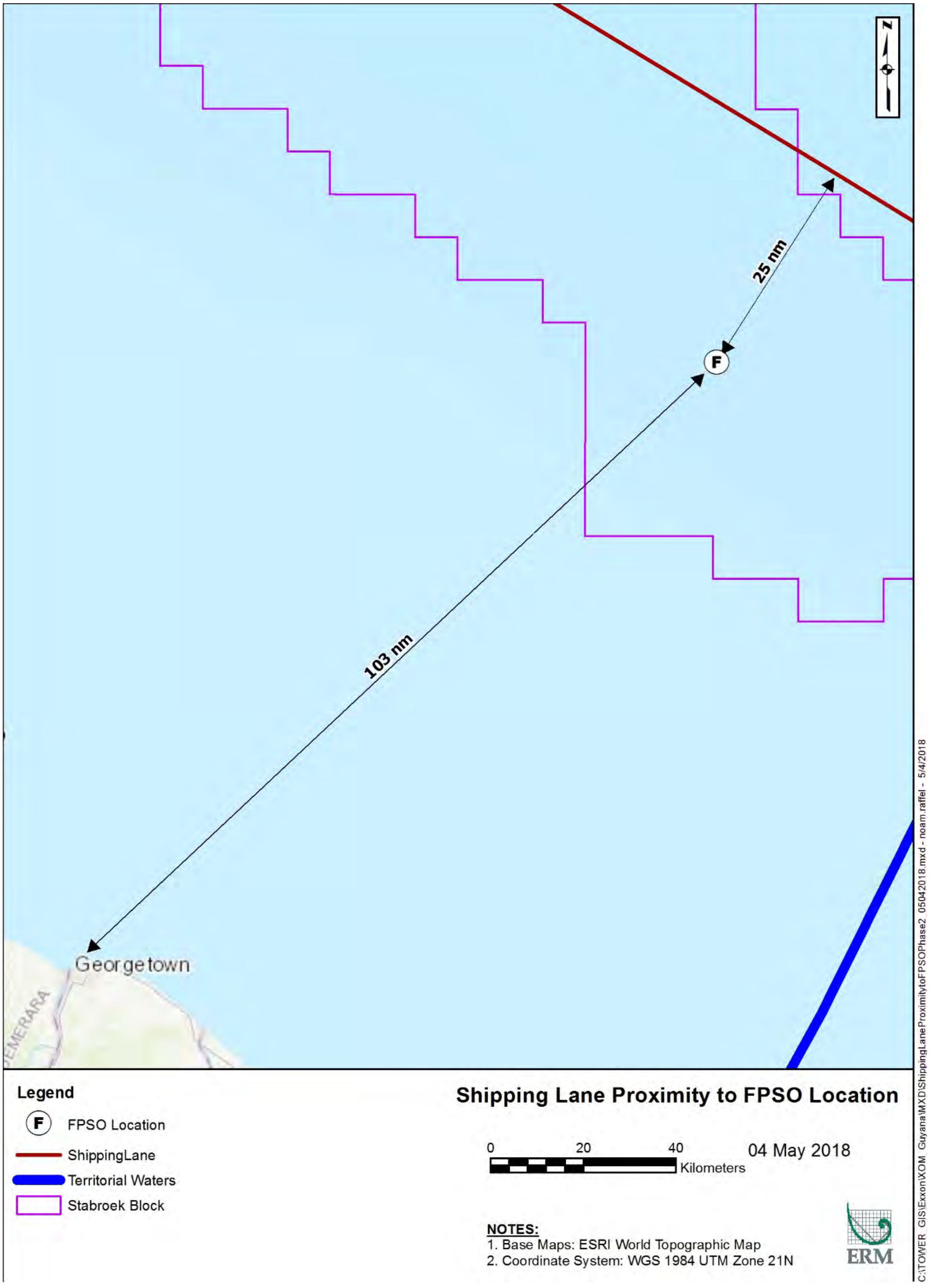
The Environmental Protection Act requires EIAs to assess impacts on material assets. Nearly all the Project-related activities will occur at designated shorebase(s) on the coast, in coastal marine waters, or offshore. Therefore, for the purposes of this EIA, "material assets" include marine infrastructure within the Project AOI, which consists of waterways, coastal shipping channels, ports, and offshore shipping lanes. Guyana has approximately 1,000 kilometers (approximately 620 miles) of navigable rivers, which provide water access to most population and economic centers. Subsea telecommunications cables are also present in the Project AOI.

8.4.2.2. Existing Conditions in the Project Area of Influence

Marine Transportation

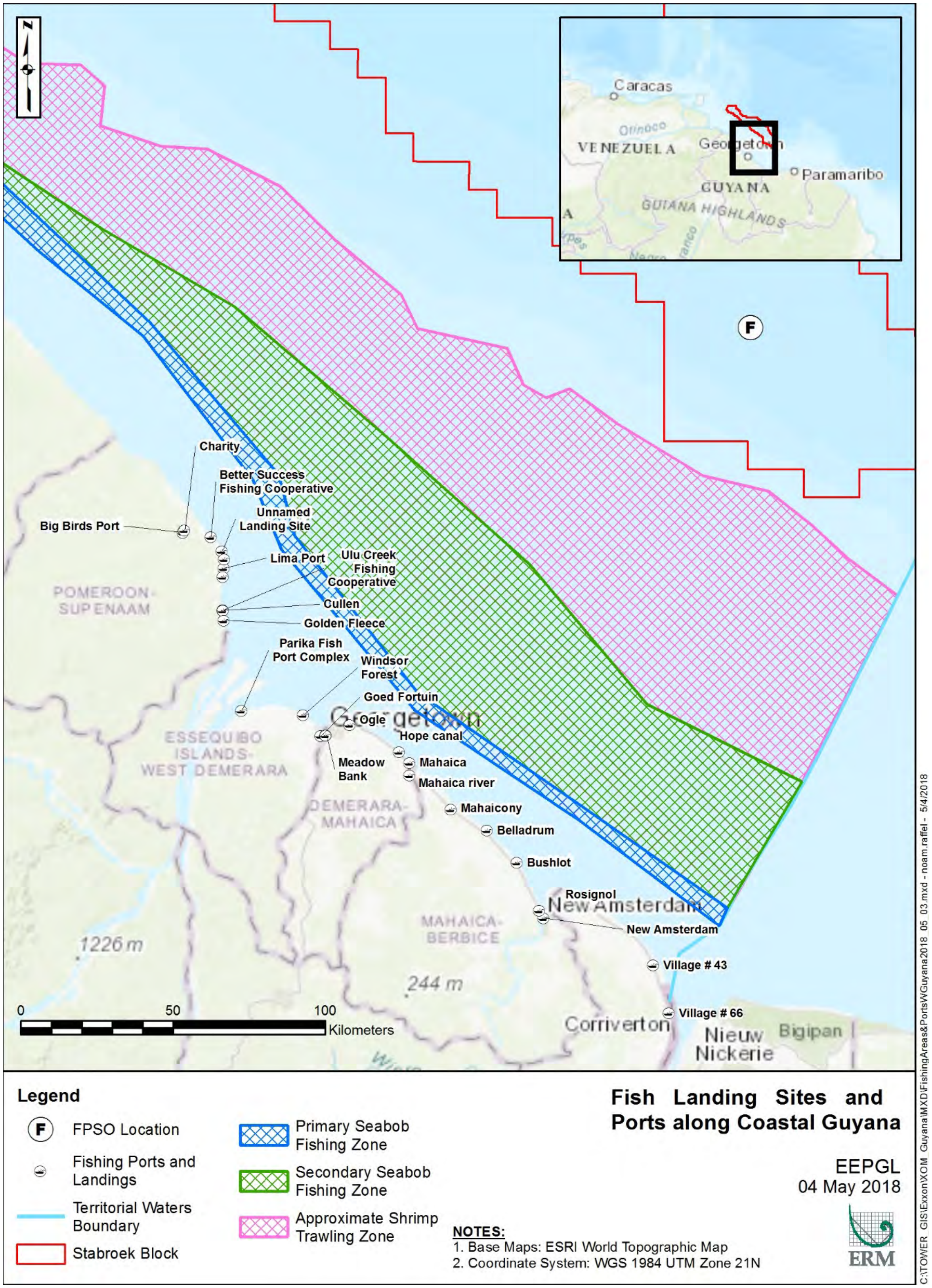
MARAD is responsible for ensuring the safe and efficient operation of shipping activities in Guyana territorial waters. The Stabroek Harbour Master has advised EEPGL that Jamaican and Trinidadian shipping lanes cross the Stabroek Block. Figure 8.4-1 shows the location of the shipping lane, as indicated on the pilot chart for the Caribbean and Gulf of Mexico.

As described in Section 8.1.2.4, Economic Conditions, fisheries are of significant importance to Guyana's economy, particularly in coastal areas. Marine fisheries and subsistence fishing occur throughout Guyana coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers (approximately 93 miles) from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. Figure 8.4-2 depicts the primary fishing zones offshore Guyana, by fishery type, and the primary fishing ports or fish landing sites in Regions 2–6. There are no formal fish landing sites in Region 1.



Note: Map does not represent a depiction of the maritime boundary lines of Guyana.

Figure 8.4-1: Proximity of Liza Phase 2 FPSO to Offshore Shipping Lanes



Note: Map does not represent a depiction of the maritime boundary lines of Guyana.

Figure 8.4-2: Fishing Zones and Ports

The Port of Georgetown contains more than 40 separate wharves, including "six primary cargo wharves, ranging from approximately 127 to 247 meters [approximately 417 to 810 feet] in length, with depths alongside ranging from 4.8 to 7.4 meters [15.7 to 24.3 feet]", as well as "four tanker berths, with depths of 3.1 to 6.7 meters [10.2 to 22.0 feet] alongside" (NGIA 2017). Other privately owned docks and portside facilities near Georgetown and the mouth of the Demerara River have staging areas or storage yards, although these facilities are congested and space is limited. Historic vessel call data for the Port of Georgetown are not available.

A shipping channel is maintained on the lower Demerara River for the use of private, commercial, and military vessels. Pilotage is required to access the channel, and is provided by the Harbour Master. The Demerara River channel has a dredged depth of 5.9 meters (approximately 19 feet), and has historically been dredged weekly to maintain this depth (Stabroek Harbour Master 2018).

From 16 April to 30 April 2018, a study was undertaken to record vessel traffic in Georgetown Harbour between the mouth of the harbour and an existing shorebase that is planned to be used by the Project. Observations were made from two locations: one at the Kingston Outfall Channel, near the mouth of the harbour, and one at the Quick Shipping Wharf (Figure 8.4-3). Observations were made on a 24-hour basis, recording the time of day, type of vessels observed and direction of travel.

Table 8.4-2 summarizes the vessel traffic recorded during this period. Almost 1,800 vessel movements were counted at the Kingston Outfall observation location, yielding an average of 126 vessels per day. More than 2,100 vessel movements were recorded at the Quick Shipping Wharf observation location, yielding an average of 153 vessels per day. The Quick Shipping Wharf count included 178 east-west movements across the harbor, primarily from speedboat trips, small private boats, and barges travelling across the river. Many of the vessels movements were counted at both locations (i.e., as they passed them successively). While some of these instances were definitively "linked," the difficulty in accomplishing this linking (in particular at night) prevents a precise count of these instances.

Fishing vessels accounted for most of the marine traffic. At the Kingston Outfall observation location, 76 percent of vessel movements were either fishing boats or trawlers. At the Quick Shipping Wharf observation location, fishing boats and trawlers accounted for 71 percent of the traffic, while passenger boats and "other" vessels (primarily small, private boats) made up 11 percent of the traffic. Larger vessels, including ocean-going vessels, coastal vessels, and oilfield service vessels, comprised a higher proportion of the vessel traffic at the Kingston Outfall observation location, totaling 14 percent of the vessels counted at this location.

Marine traffic activity was nearly continuous throughout each day. The highest volumes of marine traffic consistently occurred between 9:00 a.m. and 6:00 p.m. daily, although other times were also quite active. From 10:00 p.m. until 6:00 a.m., local fishing boats made up 78 percent of the marine traffic observed from the Quick Shipping Wharf location.

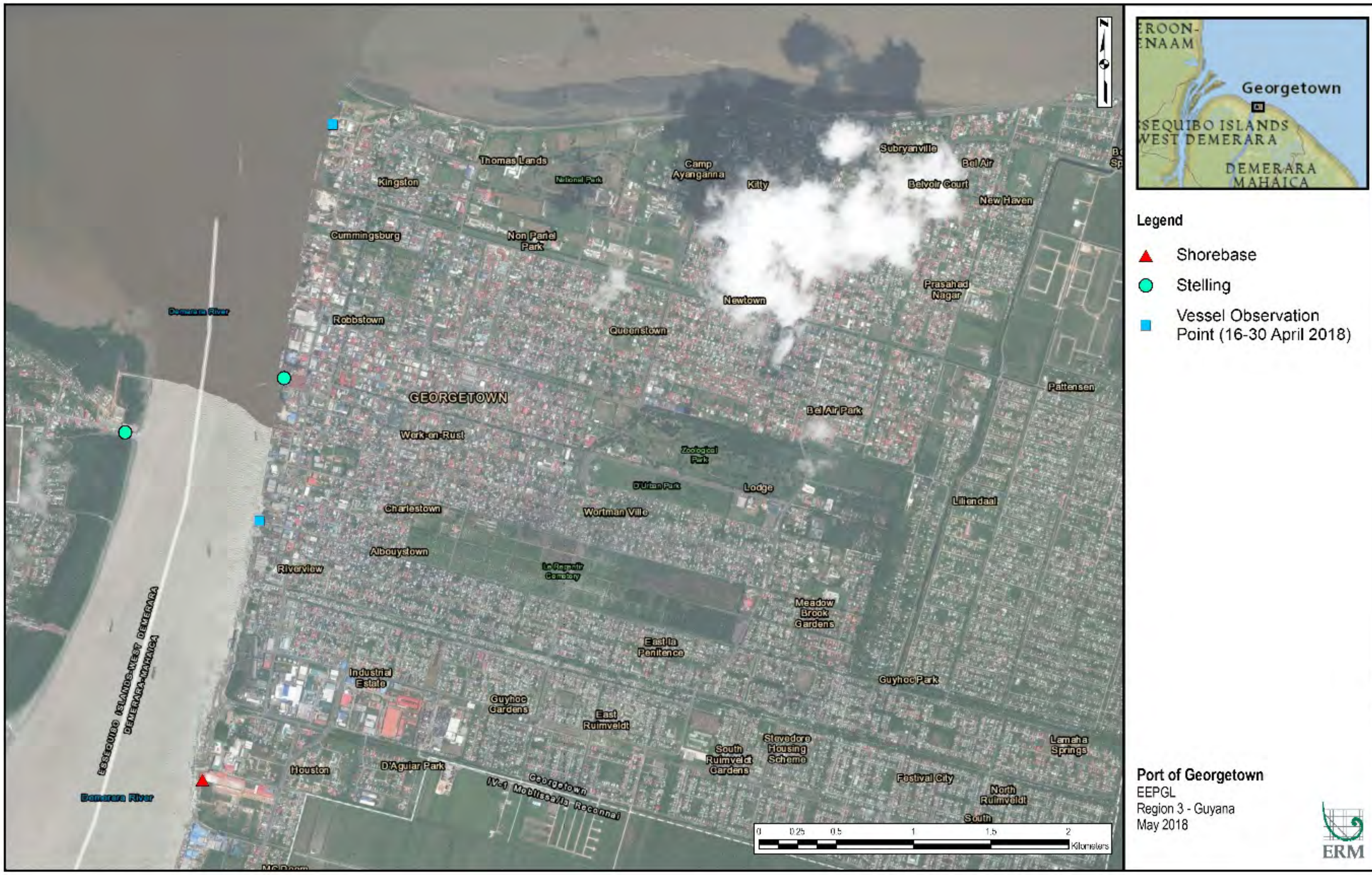


Figure 8.4-3: Georgetown Harbor Vessel Observation Points (16-30 April) and Speedboat Stellings

Table 8.4-2: Vessel Traffic Observed in Georgetown Harbour, 16–30 April 2018

	Kingston Outfall Channel			Quick Shipping Wharf [a]				
Vessel Type	**Northbound (Outbound)**	**Southbound (Inbound)**	**Total**	**Northbound (Outbound)**	**Southbound (Inbound)**	**Eastbound (across channel)**	**Westbound (across channel)**	**Total**
Oceangoing (cargo, tanker, etc.)	42	59	101	38	32	1	1	72
Coastal vessel	51	70	121	34	33	1	4	72
Oilfield service vessel	12	12	24	12	11			23
Tug and barge	31	27	58	23	24	18	17	82
Tug alone	20	20	40	1	4			5
Trawler	195	204	399	155	155	1	1	312
Fishing vessel (other than trawler)	484	454	938	617	566	13	17	1,213
Government vessel (Coast Guard, police, GRA, harbor boat)	7	8	15	21	26	7	9	63
Pilot boat	26	34	60	32	37	1	1	71
Passenger boat (speedboat)	0	0	0	17	13	26	27	83
Other vessel	5	3	8	56	62	14	19	151
Total	873	891	1,764	1,006	963	82	96	2,147

[a] In addition, the Quick Shipping Wharf site counted 73 movements in which a Coast Guard vessel moved out of its dock and into the channel, and then immediately returned to dock. These are not included in the counts in this table.

Day-to-day variations, particularly in fishing vessel movements, resulted from tides and weather. The local fishing boats tend to go to sea on a rising tide so that they can set their nets at the high tide, and return with their catch when the tide is falling. The observations period included a neap tide that resulted in lower volumes of fishing boats during the middle of the counting period, from 21–25 April. Tidal conditions resulted in high traffic volumes during some night or early morning hours.

The Transport and Harbours Department is responsible for the management of the national ferry service. The Department has four ferry vessels, three of which operate in the Essequibo River and one of which operates in the Berbice River. The ferries on the Essequibo River serve several ports (also known as “stellings”) on either side of the Essequibo River and on Leguan and Wakenaam Islands, as shown on Figure 8.4-4.

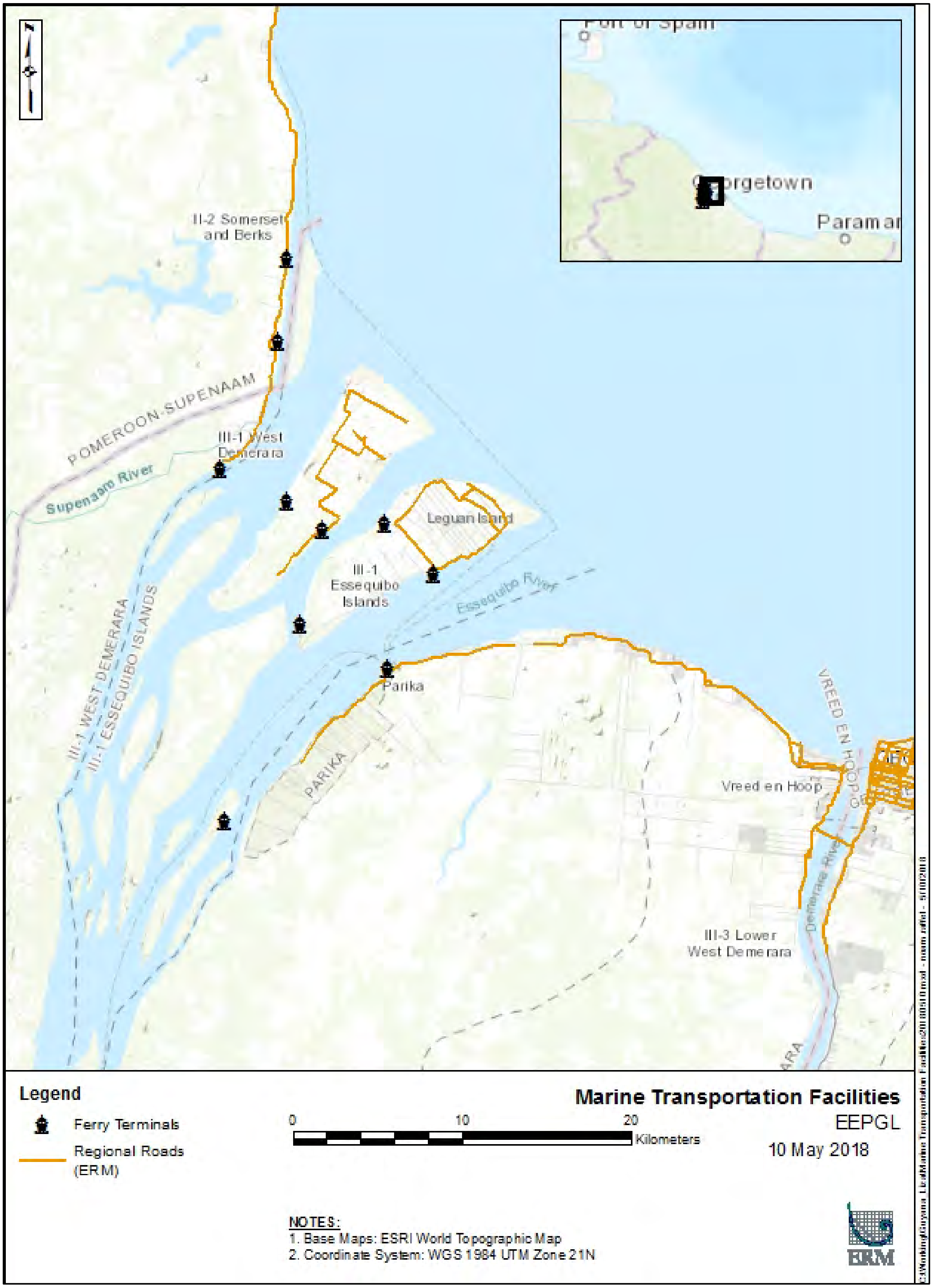


Figure 8.4-4: Essequibo River Ferry Terminals

In addition to the national ferry service, many smaller vessels provide transportation between Regions 2 and 3 across the Essequibo River, as well as across the Demerara River, between the Stabroek Market stelling in Georgetown (Region 4) and Vreed-en-Hoop stelling (Region 3) on the west bank of the river. These smaller vessels are collectively and informally known as “speedboats” because they typically travel faster than the ferries. These speedboats vary in size, power, and capacity, but can typically carry from 5 to 15 passengers. The locations of the speedboat stellings on the Demerara River are shown on Figure 8.4-3. Across the Essequibo River, speedboats operate at the same ports as the national ferry service, and may also call at smaller informal landings as clients demand and conditions warrant.

Speedboats are an important element in the transportation system between Georgetown and West Demerara. Speedboats serving the Demerara River crossing operate from 6:00 a.m. to 8:00 p.m. There are 57 speedboats registered with the Speedboat Association, of which 50 to 53 are operational on any given day. Registered Demerara River speedboats generally share a common design, with a legal capacity of 33 passengers in a covered compartment, plus two crewmembers. Monitors at the Vreed-en-Hoop and Stabroek Market stellings record speedboat crossings and are meant to ensure that registered boats adhere to a set of rules developed by the Speedboat Association. The Speedboat Association has also developed and enforces a disciplinary system that requires registered speedboats to take turns, and also requires passengers to be seated and wearing a life vest before the boat casts off from the dock (Gonsalves 2018).

During the morning rush period, at least five speedboats load simultaneously at Vreed-en-Hoop and discharge at Stabroek. Table 8.4-3 summarizes 2017 speedboat passenger volumes. Passenger volumes are substantially lower on Saturdays and Sundays. In 2017, approximately 590 school children commuted daily from Vreed-en-Hoop to Georgetown. This represented a 5 percent increase over 2016. Docking facilities at both Vreed-en-Hoop and especially at Stabroek Market are generally considered to be inadequate (Gonsalves 2018). Tenders are presently being evaluated for improvements to both docks (Gonsalves 2018; MoPI 2018).

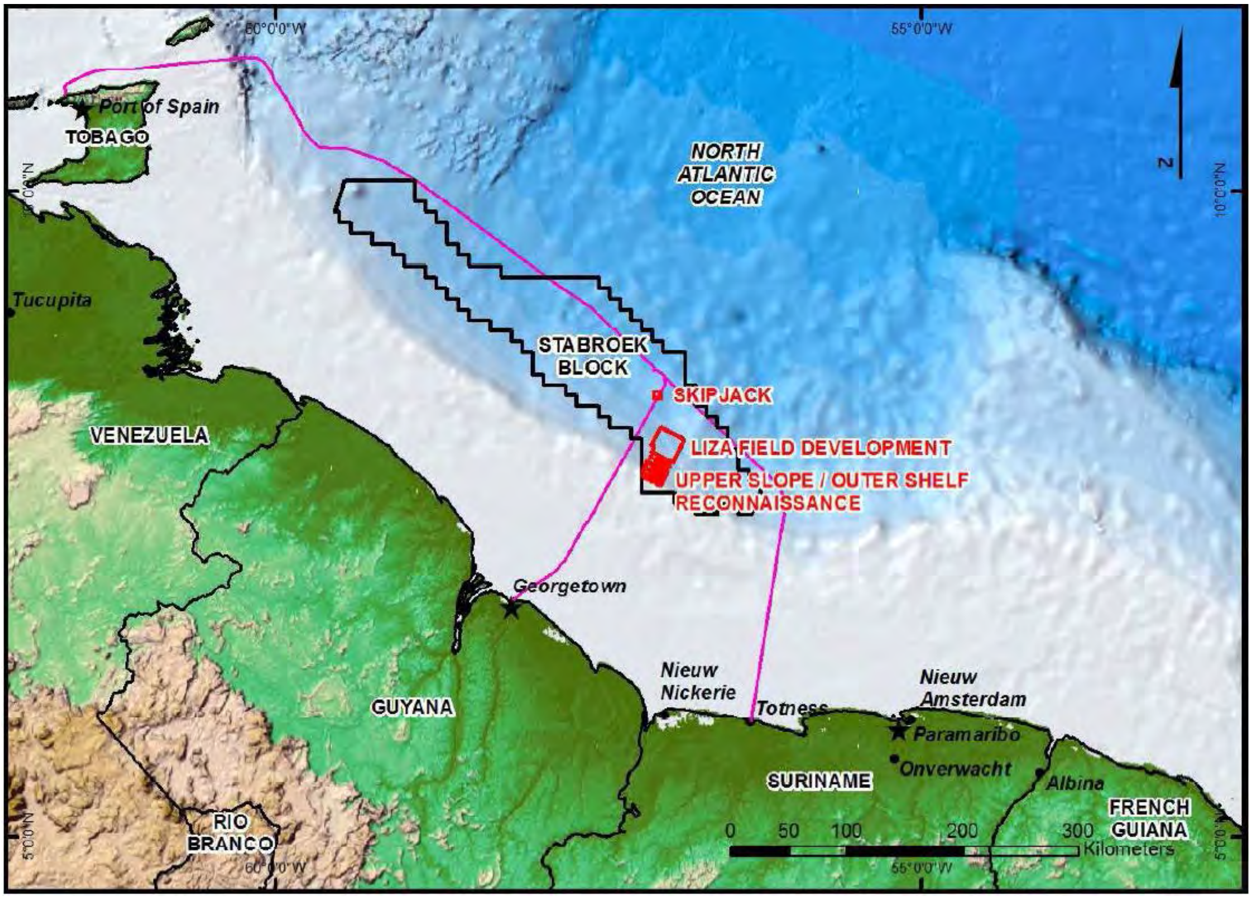
Table 8.4-3: 2017 Stabroek Market Weekday Speedboat Passenger Activity

Vessel Type	All Weekdays	Mondays
Average daily disembarkations	9,233	10,211
Rush hour (0600-0900 hours) disembarkations	5,225	5,808
Afternoon embarkations	1,815	ND

Source: Gonsalves, 2018
ND: No data available

Telecommunications

A Guyana Telephone & Telegraph subsea telecommunications cable, which is part of the Suriname Guyana Submarine Cable System (SGSCS), runs through the Stabroek Block, but is outside of the PDA. Figure 8.4-5 shows the mapped route of the SGSCS compared to the location of a geophysical survey conducted for an area encompassing the PDA (the PDA is located inside of the area labeled as "Liza Field Development"). Since the SGSCS is outside the PDA, planned Project activities will not interact with it; accordingly, the SGSCS is not discussed further in this EIA.



Source: Fugro 2016

Figure 8.4-5: Mapped Route of SGSCS

8.4.3. Impact Assessment—Marine Use and Transportation

This section assesses potential Project impacts on marine use and transportation in the Project AOI. The Project will involve the drilling of development wells, installation and long-term operations of an FPSO and SURF, and transit of Project support vessels between the PDA and the Guyana shorebase(s), as well as between the PDA and shorebases in Trinidad and Tobago. The assessment of potential impacts on marine use and transportation from these Project activities was based on the following assumptions:

- Most Project support vessel trips will originate from (and return to) shorebase facilities in Georgetown, while larger-draft vessels could transit between the PDA and shorebases in Trinidad and Tobago.
- The development well drilling stage could potentially utilize up to two drill ships on station simultaneously.
- The marine safety infrastructure available in Guyana (e.g., navigation aids) is adequate.

8.4.3.1. Relevant Project Activities and Potential Impacts

The FPSO will be anchored to the seafloor for the duration of the production operations stage, which is planned to last at least 20 years. During this stage, the FPSO will have a 2-nautical mile radius marine safety exclusion zone (covering approximately 4,300 hectares), in which no unauthorized vessels will be allowed to enter during offloading. In addition, the drill ships will each have a 500-meter radius marine safety exclusion zones during drilling operations and well workovers, and a 500-meter radius marine safety exclusion zone will be maintained around each major installation vessel during the installation stage. Notices to mariners will be issued via MARAD to the Trawler's Association and fishing co-ops for planned Project marine vessel movements, including the FPSO, drill ships, and major installation vessels to be used during the installation stage. Additionally, through the stakeholder engagement process, EEPGL will also communicate plans for major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, to aid them in avoiding Project vessels through the stakeholder engagement process.

The Project will generate a variety of marine support vessel trips throughout the Project life. Support vessel activities will consist of:

- Multiple platform-supply vessels and a fast-supply vessel conducting re-supply trips to the FPSO and drill ships;
- Tanker movements and tugs supporting tanker loading activities;
- Multi-purpose vessels supporting subsea installation and maintenance activities; and
- Multi-purpose vessels supporting decommissioning activities.

Based on current drilling activities and past experience with similar developments, it is estimated that the Project will generate an average of 12 vessel round-trips (between the PDA and shorebase[s]) per week during development drilling and FPSO/SURF installation, and 7 such vessel round-trips per week during FPSO/SURF production operations. Note that these numbers are combined for Liza Phase 1 and Liza Phase 2 operations, as the vessel trips will be optimized to support both developments. These vessel round-trips will be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad and Tobago.

As described in Section 2.11, End of Phase 2 Operations (Decommissioning), EEPGL has not prepared detailed plans for the decommissioning phase. As such, the number of vessel trips associated with decommissioning cannot be reliably estimated at this time. For the purposes of the impact analysis, vessel traffic associated with Project decommissioning is assumed to be similar to that for the drilling and installation stage (i.e., on the order of 12 vessel round-trips per week).

For the purposes of the impact assessment, marine safety exclusion zones are considered an embedded control (i.e., part of the Project design). Accordingly, the "pre-mitigation" impact significance ratings considered the inclusion of this measure.

Table 8.4-4 summarizes the Project stages and activities that could result in potential Project impacts on marine use and transportation, as well as the receptors that could potentially experience these impacts.

Table 8.4-4: Summary of Relevant Project Activities and Key Potential Impacts—Marine Use and Transportation

Stages	Receptor(s)	Project Activity	Key Potential Impacts
Development Well Drilling SURF/FPSO Installation	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of FPSO, drill ships, and major installation vessels	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, drill ship, and major installation vessels
Production Operations	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between ports and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of FPSO, tanker, drill ships, and workover vessel	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tanker, drill ship, and workover vessel
Decommissioning	• Commercial cargo vessels • Commercial fishing vessels • Subsistence fishing vessels	Maritime transport of Project materials, supplies, and personnel	Increased vessel traffic in Georgetown Harbour, coastal waters between ports and the PDA, and along transit routes leading to Georgetown
	• Commercial cargo vessels • Commercial fishing vessels	Presence of decommissioning vessels	Reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the major decommissioning vessels

8.4.3.2. Magnitude of Impact—Marine Use and Transportation

The assessment of the Project's magnitude of potential impacts on marine use and transportation is determined based on consideration of geographic extent, frequency, duration, and scale. The scale of potential impacts on marine use and transportation is defined according to the definitions provided in Table 8.4-5.

Table 8.4-5: Definitions for Scale Ratings for Potential Impacts on Marine Use and Transportation

Criterion	Definition
Scale	Negligible: No discernible change in transportation activity or demands on other infrastructure.
	Small: Increased transportation activity or marine infrastructure demand is perceptible, but does not measurably impact the capacity of transportation or other infrastructure.
	Medium: Increased transportation activity or marine infrastructure demand is perceptible or reduces transportation system or infrastructure capacity. These impacts do not require a change in typical travel behavior.
	Large: Increased transportation activity or marine infrastructure demand causes substantial delay or congestion on waterways, to the point where vessel operators or other users of infrastructure must consistently and frequently change their typical daily behavior.

The Project's 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 the Georgetown Harbour. As described above, Project-related vessel traffic will be higher during the development well drilling stage than during the production operations stage.

Vessels transiting the PDA will need to avoid the marine safety exclusion zones around the drill ships, major installation vessels, and FPSO. The FPSO marine safety exclusion zone will require non-Project vessels to avoid approximately 4,300 hectares (approximately 10,600 acres) (approximately 0.2 percent) of the Stabroek Block's approximately 2.7 million hectares (approximately 6,671,845 acres) for at least 20 years. Because the FPSO will be anchored to the seafloor, its marine safety exclusion zone will essentially be a permanent navigation feature until the decommissioning stage. The marine safety exclusion zones around each of the drill ship(s) will be comparatively smaller (approximately 79 hectares), and will be in force only during development drilling activities, which is anticipated to last approximately 4 years, and occasionally during well workover activities in later years. Similar-sized marine safety exclusion zones around major installation vessels will occur only during the FPSO/SURF installation stage, or in the event repairs or maintenance are required.

The Stabroek Harbour Master has advised EEPGL that Jamaican and Trinidadian vessel shipping lanes cross the Stabroek Block (ExxonMobil Personal Communication 1). As such, commercial shipping traffic could potentially intersect the PDA, as well. However, shipping lane maps indicate the FPSO will likely be on the order of 26 nautical miles from the nearest generalized shipping lane (see Figure 8.4-1). More important, the shipping lanes in question are traditional, and are not precisely demarcated. Accordingly, even if Project vessels are in close proximity of mapped lanes, shipping lane users will have ample warning and space to navigate, and there is no reason to believe Project activities in the PDA will meaningfully impede non-Project shipping traffic. No interference with shipping traffic was experienced during previous seismic surveys or the Liza exploration drilling activities.

Fishing vessels near the PDA will lose use of the defined marine safety exclusion zones for fishing activities. As described in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, and Section 8.2.2, Existing Conditions—Employment and Livelihoods, most subsistence fishing occurs in nearshore areas and most commercial fishing occurs between the coast and the edge of the continental shelf (i.e., shoreward of the PDA). As described in Section 8.2.3.2, Magnitude of Impact—Employment and Livelihoods, there is at least one commercial fishing company with less than 10 vessels that partakes in deepwater tuna fishing that may approach the southern boundary of the PDA, and abandoned fishing gear has been found entangled in the mooring lines for metocean instruments installed by EEPGL in the same area. There are also reportedly Venezuelan vessels that fish on occasion at distances as far out as 190 kilometers (118 miles) from shore, but no further information was known. If deepwater fishing continues to develop in the vicinity of the PDA, the number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future, but would still be a relatively small amount of vessels compared to the overall fishing fleet in Guyana.

The highest potential for interactions between non-Project vessels and Project vessels in Guyana waters is near Georgetown Harbour and the Demerara River mouth, where vessel traffic is already present. The Project's potential impacts on marine use and transportation for subsistence activity are likely to be limited, but challenges in communicating with the subsistence fishing fleet may limit the effectiveness of efforts to advise the fleet of Project operations. The potential social and economic impacts of the Project's marine safety exclusion zones on commercial and subsistence fishing and recommendations to manage these impacts are described in Sections 8.1.3, Impact Assessment—Socioeconomic Conditions, and 8.2.3, Impact Assessment—Employment and Livelihoods.

With respect to commercial fishing, the majority of the PDA is in waters deeper than those used most often for commercial fishing, and the size of the FPSO marine safety exclusion zone is insignificant relative to the area available for fishing. As a result, the Project's potential impacts on marine use and transportation for current commercial fishing activities also are likely to be limited.

During development well drilling and again during decommissioning, the Project could generate one or two daily vessel departures and arrivals from the Port of Georgetown. Based on the vessel surveys summarized in Section 8.4.2, Existing Conditions—Marine Use and Transportation, this frequency of activity is a small fraction of the existing vessel activity in Georgetown. Additionally, Project support vessels will typically be smaller and more maneuverable than the cargo or tanker vessels that call on the Port of Georgetown or ports in Trinidad and Tobago, further supporting the conclusion that and Project vessels will not present significant incremental navigation hazards within or near these ports.

Considering the factors above, the magnitude of potential Project-related impacts on marine use and transportation is considered **Small**.

8.4.3.3. Sensitivity of Receptors—Marine Use and Transportation

Potential receptors for marine use and transportation impacts include current users of Georgetown Harbour and Guyanese coastal waters. The receptor sensitivity ratings for marine use and transportation are defined in Table 8.4-6.

Table 8.4-6: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Marine Use and Transportation

Criterion	Definition
Sensitivity	Low: The receptor is accustomed to or specifically anticipates the type of activity proposed by the Project; existing transportation activities can easily adapt to additional transportation activity with no outside assistance or mitigation.
	Medium: The receptor is not specifically accustomed to the type of activity proposed by the Project. The receptor can adapt to additional transportation activity and maritime safety risks with outside assistance or mitigation.
	High: The receptor is poorly suited to the type of activity proposed by the Project, and cannot fully adapt to increased transportation activity and maritime safety risks, even with outside assistance or mitigation.

Table 8.4-7 summarizes the sensitivity ratings assigned for the various types of receptors that could potentially experience marine use and transportation impacts from planned activities of the Project.

Table 8.4-7: Sensitivity Ratings for Receptors of Potential Impacts on Marine Use and Transportation

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
Commercial cargo vessels	Includes all international and regional commercial cargo vessel activity making calls at Georgetown Harbour, as well as traversing the northern coast of South America. Project activities will occur in areas potentially used by commercial shipping organizations, and will require use of Georgetown Harbour.	Low	Georgetown Harbour is an active commercial port, where vessel traffic—such as Project-related traffic—is expected. Commercial vessels in international waters are expected to be able to safely navigate around other vessels (whether in transit or stationary).
Commercial fishing vessels	Includes commercial fishing vessels (i.e., those who sell their product to local or international markets) that operate in Guyana coastal waters. These vessels may interact with Project vessels, or may currently conduct fishing operations in or near defined marine safety exclusion zones in the PDA.	Medium	Commercial fishing vessels 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; however, operators are likely to be aware of Project activities, or at least of commercial shipping activity in the vicinity of Georgetown, and can alter their fishing grounds to avoid defined marine safety exclusion zones in the PDA.

Receptor	Definition and Rationale for Inclusion	Sensitivity Rating	Rationale for Rating
Subsistence fishing vessels	Includes individuals whose fishing activity is primarily or solely to feed themselves, their family, or their community, and not for commercial sales. These individuals generally operate near shore.	Medium	Subsistence fishing vessels are usually small, with limited ability to identify or avoid Project vessels. They will not lose access to existing fishing areas or encounter Project-related vessel traffic outside of existing areas of high vessel traffic, but may not receive notice of Project related activities.

8.4.3.4. Impact Significance—Marine Use and Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of potential Project impacts on marine use and transportation ranges from **Negligible** to **Small**.

8.4.4. Mitigation Measures—Marine Use and Transportation

To reduce the magnitude of potential marine use and transportation impacts, EEPGL will issue Notices to Mariners via MARAD, the Trawler’s Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active. Additionally, EEPGL will augment its ongoing stakeholder engagement process (and will work with government authorities through their existing notification/control processes) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, and communicate planned Project activities to those individuals/entities to aid them in avoiding major Project vessels where possible, as further mitigation. While these mitigations are expected to reduce the magnitude of impacts on commercial and subsistence fishing vessels, the significance of potential impacts on both receptors is maintained at **Minor**.

Table 8.4-8 summarizes the assessment of potential pre-mitigation and residual impacts on marine use and transportation. The significance of impacts was rated based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the marine use and transportation-specific methodology described in Sections 8.4.3.2 and 8.4.3.3.

Table 8.4-8: Summary of Potential Pre-Mitigation and Residual Impacts—Marine Use and Transportation

Stage	Resource/ Receptor Impact	Embedded Controls	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation Decommissioning	Commercial cargo vessels—port and channel operations	Marine safety exclusion zones around FPSO, drill ship, and major installation vessels.	Small	Low	Negligible	• Notices to Mariners and other communication materials regarding major vessel movements and marine safety exclusion zones • Augment ongoing stakeholder engagement process to communicate Project activities to the fishing community, including individuals who might not ordinarily receive Notices to Mariners	Negligible
	Commercial fishing vessels—exclusion from PDA		Small	Medium	Minor		Negligible
	Commercial cargo vessels—offshore navigation		Small	Low	Negligible		Negligible
	Commercial fishing vessels—offshore navigation		Small	Medium	Minor		Minor
	Subsistence fishing vessels—nearshore navigation		Small	Medium	Minor		Minor
Production Operations	Commercial cargo vessels—port and channel operations	Marine safety exclusion zones around FPSO and major installation vessels.	Small	Low	Negligible		Negligible
	Commercial fishing vessels— exclusion from PDA		Small	Medium	Minor		Negligible
	Commercial cargo vessels—offshore navigation		Small	Low	Negligible		Negligible
	Commercial fishing vessels—offshore navigation		Small	Medium	Minor		Minor
	Subsistence fishing vessels—nearshore navigation		Small	Medium	Minor		Minor

8.5. SOCIAL INFRASTRUCTURE AND SERVICES

8.5.1. Administrative Framework—Social Infrastructure and Services

Table 8.5-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on social infrastructure and services.

Table 8.5-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Social Infrastructure and Services

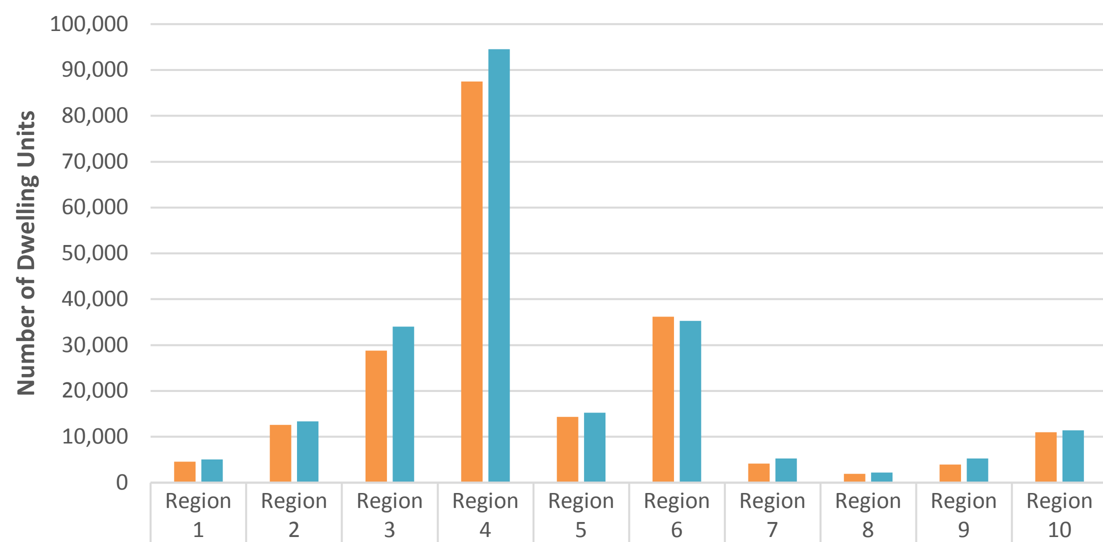
Title	Objective	Relevance to the Project
Legislation		
Town and Country Planning Act (1996) Cap. 20:01.	Provides for the orderly and progressive development of urban and rural lands and the preservation and improvement of amenities pertaining to such development. Development under the Act is restricted to buildings and roadworks incidental to buildings.	Could be relevant if the Project builds commercial, industrial or residential structures. It would also be relevant for the land use clearance process (within the building permit process) within the Central Housing and Planning Authority.
Sea Defence Act (1953, 1988, 1992) Cap. 64:03.	Aims to make better provision for the maintenance and construction of sea defenses in Guyana.	Covers the protection of mangroves, which serve as a natural sea defense mechanism; there are fines and penalties for the unpermitted destruction of mangroves. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.
Water and Sewerage Act (2002) Cap. 30:01.	Provides for the ownership, management, control, protection and conservation of water resources, the provision of safe water, sewerage and advisory services and the regulation thereof.	Has no direct applicability to the Project, as water resources are defined as water systems, conservancies, canals and water from rainfall or runoff from the land.
Ministry of Health Act (2005)	Outlines the responsibilities and functions of the Ministry of Public Health, including responsibilities in relation to health care facilities.	Generally applies to health care services supplied to Project workers.

8.5.2. Existing Conditions—Social Infrastructure and Services

This section describes existing conditions for social infrastructure and services in the Project AOI. The section addresses two broad aspects of social infrastructure services: housing, utilities and other social services (excluding medical services, which are addressed under in this EIA under Section 8.3, Community Health and Wellbeing), and ground and air transportation. The existing conditions associated with these two aspects are assessed separately in this section.

8.5.2.1. Housing

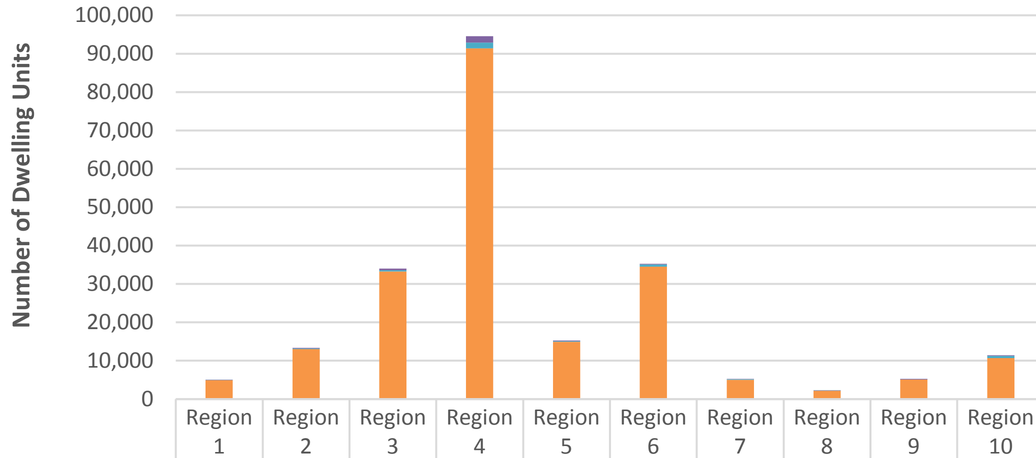
According to the 2012 census results (BSG 2012), a total of 221,741 dwelling units were recorded in the country, which was an increase of 8.1 percent in comparison to the 2002 census results. Regions 3, 4, and 6 represent the largest proportion of the population and, as expected, recorded the highest number of dwelling units in both the 2002 and 2012 census years. Figure 8.5-1 shows the number of dwelling units by region. According to the 2012 data, 214,999 of the total 221,741 dwelling units were occupied, suggesting that only 3 percent were either vacant or closed dwelling units, compared to 8.8 percent in the 2002 census. Occupancy rates were high for all ten administrative regions according to the 2012 census (see Figure 8.5-2).



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
2002	4,556	12,629	28,819	87,475	14,347	36,189	4,173	1,933	3,963	11,013
2012	5,042	13,368	34,042	94,531	15,274	35,297	5,266	2,227	5,257	11,437

Source: BSG 2012

Figure 8.5-1: Regional Distribution of Dwelling Units: 2002 and 2012



	Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7	Region 8	Region 9	Region 10
Closed Dwellings	57	203	411	1,663	166	221	107	31	104	127
Vacant Dwellings	44	158	362	1,497	205	589	138	13	64	582
Occupied Dwellings	4,941	13,007	33,269	91,371	14,903	34,487	5,021	2,183	5,089	10,728

Source: BSG 2012

Figure 8.5-2: Number of Occupied, Closed and Vacant Dwelling Units: 2012

The results of the 2002 census indicate that detached houses are the most common type of housing in all regions, and a majority of homes in the coastal area are owned by their occupants. However, the census data report that Regions 3 and 4 have a higher proportion of rented and squatted homes, which is consistent with data obtained during the late 2017 and early 2018 ecosystem services field work completed by ERM and EMC (ERM/EMC 2018). Informal housing settlements increased in the 1980s and 1990s due to housing supply constraints, causing many people to squat on vacant parcels (IDB 2016). The Ministry of Communities has worked in recent years to regularize informal settlements, particularly in the Georgetown area, by providing services such as paved streets, drainage, septic tanks, and water supply. If settlement sites are not suitable for permanent neighborhoods, they are moved to other locations (ERM Personal Communication 8; IDB 2016a, 2016b). There are currently 216 squatting areas in the country, of which 154 have been brought under the regularization program (IDB 2016a).

Data from the Bureau of Statistics' Multiple Indicator Cluster Survey (Bureau of Statistics et al. 2015) indicate that the majority of homes in Guyana have a finished floor (81.2 percent), roof (97.0 percent), and walls (93.2 percent). However, housing stock in some regions is aging and in need of upgrade (IDB 2016). According to the 2002 census, more than 30 percent of the housing stock in Regions 3, 4, 5, and 6 was built before 1970.

8.5.2.2. Water and Sanitation

According to the Food and Agriculture Organization, 95 percent of water usage in Guyana in 2010 was for irrigation and livestock, with 4 percent used by municipalities and 1 percent by industry (FAO 2015).

Potable Water

Most potable water is obtained from the deeper aquifers that underlie Georgetown and the coastal plain. Guyana Water Inc. (GWI), a commercial public enterprise distributes water in five service areas along the coast, and has a separate program to serve communities in the hinterland. GWI derives 90 percent of its water from ground sources and the remaining 10 percent from surface sources. Groundwater is extracted from 137 wells and is processed in 24 treatment plants (GWI 2017).

In rural areas not served by GWI, domestic water is obtained from a mix of ground, surface, and rainwater sources. Rainwater is often used for potable household use, while river water is typically used for cleaning and other non-potable uses. The Food and Agriculture Organization estimated that in 2012, 98 percent of the population had access to improved water sources (FAO 2015)

Businesses that use large quantities of water, such as beverage bottling and food processing plants, generally have their own wells to meet their needs (FAO 2015).

Agricultural-Use Water

Declared Drainage and Irrigation Areas (areas with fully developed drainage and irrigation systems) are found in Regions 2, 3, 4, 5, and 6. In these regions, irrigation is conducted via gravity flow from surface water resources trapped by shallow earthen dams known as "conservancies." These are located in the upper stream catchment areas and store water at higher elevations than those of the surrounding fields. In other schemes, water is pumped from rivers into the irrigation canals. The Tapakuma Conservancy, a large human-made conservancy, serves Region 2 and has been designed to provide irrigation to about 12,000 hectares (29,650 acres). During times of water shortage, this conservancy is supplemented by pumping from the Pomeroon River (FAO 2015).

The National Drainage and Irrigation Authority has responsibility for the maintenance and delivery of the irrigation water supply throughout the country. The Authority works with the conservancies' boards, water users associations, farmer groups, and local government bodies to maintain irrigation and drainage systems in an operational and efficient manner.

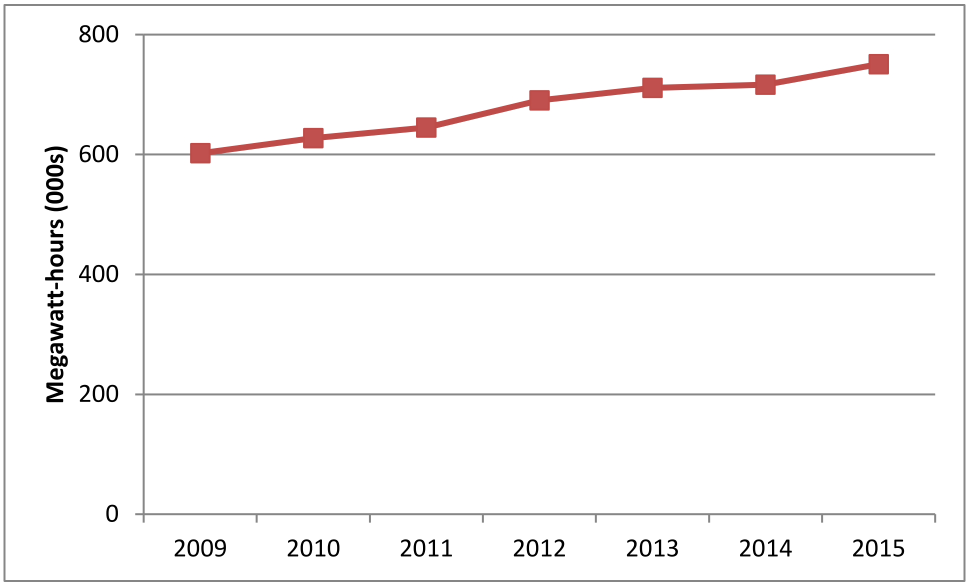
8.5.2.3. Power

Most of the electricity in the coastal plain of Guyana is generated, transmitted, and distributed by the state-owned utility Guyana Power & Light Inc. However, due to poor reliability, many users also have their own diesel generators. Coastal areas that are not serviced by Guyana Power & Light are the Region 2 area west of Charity, and Region 1. Most areas of the hinterland do not have electric service, and the government has implemented a number of hinterland energy development projects in recent years, including solar system installations and feasibility studies for hydropower and wind projects (GPL 2011).

The PSC has noted that the high cost of electricity in Guyana is a major challenge for business. During the late 2017 and early 2018 ecosystem services field work, this was raised as an issue by representatives of agricultural processing associations as well as local community leaders (ERM Personal Communications 1, 5, and 10; ERM/EMC 2018).

According to the PSC, hydroelectricity development should be a major priority for the country. The plan for the 165-megawatt Amaila Falls hydroelectric plant was cancelled in 2015 due to delays and the potential for cost overruns (ERM Personal Communication 10).

Figure 8.5-3 shows the total electricity generation output in Guyana in thousands of megawatt-hours for the period 2009 through 2015.



Source: Ministry of Finance 2015

Figure 8.5-3: Electricity Generation in Guyana, 2009-2015

Although Guyana has significant potential for hydroelectric and biomass-fueled electricity generation, in 2015, 85 percent of its installed generation capacity was thermal, relying on expensive imported liquid fuels and making average electricity prices among the highest in Latin America and the Caribbean. The remaining 15 percent of installed capacity was biomass-based, using bagasse (sugarcane fibers remaining after cane juice is extracted) as fuel to self-generate power at Guyana Sugar Corporation's sugarcane factories. There are plans to enhance the generation capacity of the factories such that excess power is available and can be exported to the National electrical grid, and the government is working towards a strategy to diversify Guyana's energy mix with renewable energy technologies focused on wind, solar and small hydroelectric (GEA 2016; ClimateScope 2017).

8.5.2.4. Telecommunications Infrastructure

The majority of households in the coastal regions have access to mobile phone service. However, the lack of 4G network access has been a major barrier to increased business investment in Guyana, and an issue that the PSC has prioritized. In 2016, the first 4G network in the country was installed. Fiber optic cable is also a pressing need to improve reliability and accessibility (PSC 2015) of mobile phone services.

8.5.2.5. Educational Facilities

Table 8.5-2 shows the number of nursery, primary, secondary, and post-secondary schools in each of the coastal regions. The majority of post-secondary institutions (technical schools, colleges, and universities) are found in Georgetown.

Table 8.5-2: Number of Educational Facilities in Guyana's Coastal Regions

	Nursery	Primary	Secondary	Technical/ Vocational	Special Schools	College/ University
Region 1	17	53	3	0	0	0
Region 2	36	42	8	1	0	0
Region 3	45	58	13	1	0	0
Region 4	58	55	48	10	2	15
Region 5	31	30	7	3	0	0
Region 6	57	56	18	2	0	2

Source: EMC Personal Communication 1, 2, 3; NAC 2018; Ministry of Education 2013, 2018

The distribution of schools in the coastal regions compared with other areas reflects population trends along the coast. Schools are found all along the coast of Regions 3, 4, and 6, which are the most populated regions. In Region 2, schools are found along the coast until the coastal road ends, and there are fewer schools in Region 2 areas west of Charity and in Region 1.

At the tertiary level, the country has one sole national higher education institution, the University of Guyana. The university has two campuses in the country, the Turkeyen Campus in Region 4 and the Tain Campus in Region 6, both of which offer undergraduate and graduate programs. In addition, through its Institute of Distance and Continuing Education, the University offers extramural classes and online programs in Regions 2, 4, 6 and 10. Approximately 20,000 students (including both local and international) have graduated from this institution (University of Guyana 2018).

8.5.2.6. Security Facilities

The Guyana Defense Force is the military service of Guyana and has land, sea (Coast Guard), and air (Air Corps) units responsible for defending the territorial integrity of Guyana. In terms of internal security, the Guyana Police Force operates as a semiautonomous agency under the Ministry of Public Security. The Guyana Police Force has seven geographic policing divisions, each with its own headquarters, stations, and outposts, as summarized in Table 8.5-3.

Table 8.5-3: Policing Divisions in Guyana

Division	Geographic Area	Headquarters Location	Number of Stations	Number of Outposts
A	City of Georgetown and the East Bank of the Demerara River, including the Cheddi Jagan International Airport, Timehri, 25 miles from Georgetown	Brickdam, Georgetown	9	7
B	County of Berbice but excluding Kwakwani	Coburg Street, New Amsterdam	12	5
C	County of Demerara, east of the Demerara River but excluding A Division	Cove & John, East Coast Demerara	8	4
D	County of Demerara, west of the Demerara River and a portion of the East Bank of the Essequibo River	Leonora, West Coast Demerara	6	1
E & F	Upper Demerara including the area surrounding the bauxite holdings of Linden, Ituni, and Kwakwani, and the interior	Rabbit Walk, Eve Leary, Georgetown	30	6
G	Essequibo Coast including the islands of the Essequibo and Pomeroon Rivers	Anna Regina, Essequibo Coast	6	0

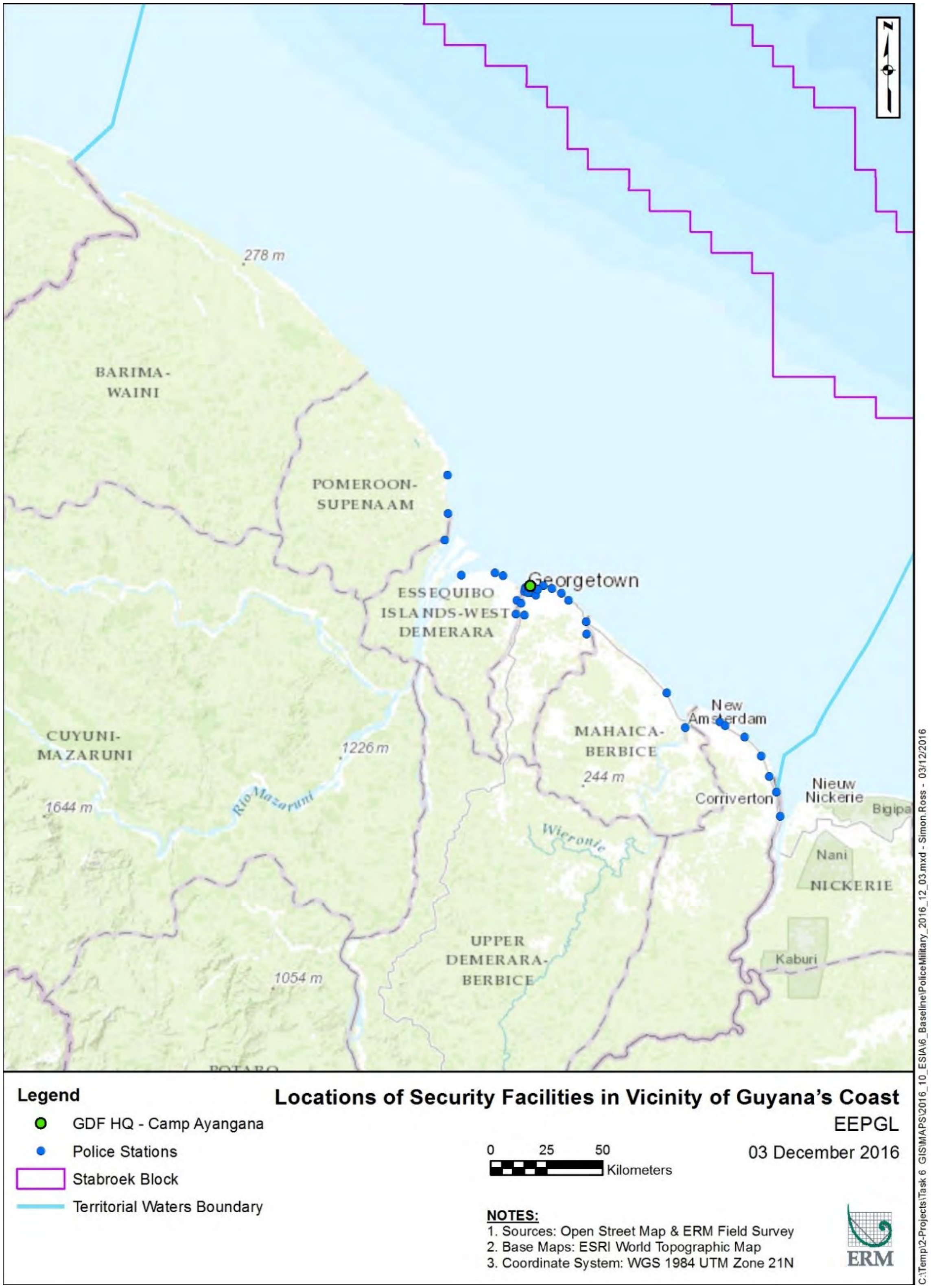
Figure 8.5-4 shows the locations of 35 (approximately 50 percent) of the total reported police stations in Guyana listed in the table above (locational data were not available for the interior outpost locations).

8.5.2.7. Ground Transportation Infrastructure

Road Network

Guyana has an approximately 3,990-kilometer (approximately 2,480-mile) road network that is used by the approximately 100,000 vehicles in the country. There are six main national paved roads that each have two lanes, except for four-lane segments along the East Bank and East Coast Demerara. The road network is dependent on a system of bridges and culverts that provide crossings over a dense system of canals, drains, and sluices throughout the coastal lowlands.

Georgetown has a compact, grid-based street network. Road conditions vary widely and can be poor in some locations. The port area is linked to central Georgetown via the East Bank Demerara Road. Most intersections are not signal-controlled; where signals do exist, they are frequently out of service. Pedestrian overpasses were recently installed at several areas along the East Bank Demerara Road to improve pedestrian safety and assist in reducing traffic congestion.



Note: Map does not represent a depiction of the maritime boundary lines of Guyana.

Figure 8.5-4: Locations of Security Facilities in Immediate Vicinity of Guyana's Coast

Existing Traffic Volumes and Congestion

Traffic congestion is a chronic problem in and around Georgetown. Many different types of vehicles, including cars, large commercial vehicles, mini-buses, horse-drawn carts, bicycles, mopeds, scooters, and motorcycles, all share the same travel lanes. Traffic congestion occurs frequently, in particular just before and just after school hours.

In March 2018, the Consultants retained Caribbean Transportation Consultancy Services Company Limited (CARITRANS) to complete a survey of existing traffic conditions along the East Bank Demerara Road, in the general vicinity of an existing shorebase facility that is planned to be used by the Project. The study involved five turning movement counts and two average daily traffic counts along the East Bank Demerara Road.

Table 8.5-4 provides a summary of traffic volume information collected from the survey, specifically focused on morning and afternoon peak hour (maximum hour of activity) traffic volumes at each survey location. Morning peak hours generally occur between 7:00 and 8:00 a.m., while afternoon peak hours vary considerably between 1:15 and 7:45 p.m. Morning peak-hour traffic volume is generally higher than during the afternoon peak hour.

Table 8.5-4: Peak Hour Traffic, East Bank Demerara Road (Surveyed March 2018)

	Morning Peak Hour		Afternoon Peak Hour	
Location	**Time**	**Traffic Volume**	**Time**	**Traffic Volume**
Houston Split (Intersection)	7:30–8:30	5,324	4:30–5:30	4,484
Houston Village [a]	7:00–8:00	3,705	2:00–3:00	3,107
Eccles Intersection	7:00–8:00	3,627	4:15–5:15	3,328
Demerara Harbour Bridge	6:30–7:30	2,752	1:15–2:15	2,709
Nandy Park Intersection	7:00–8:00	2,678	1:45–2:45	2,309
Massey Intersection	6:45–7:45	2,850	6:45–7:45	2,259
Providence Village [a]	9:00–10:00	2,087	6:00–7:00	2,179

Source: CARITRANS 2018

[a] Traffic counts at Houston Village and Providence Village measured only straight-line traffic (counts at all other locations measured all intersection turning movements). Data for Houston Village and Providence Village reflect the average weekday traffic recorded between 15 March and 20 March 2018.

In addition to surveying existing traffic volumes, CARITRANS used the traffic analysis model VISSIM to complete an assessment of the Level of Service (LOS) for each of the study intersections, for the various movements (through, right turn, left turn, U-turn) completed at each intersection. LOS is a standard numerical measure of the delay expected to be experienced at an intersection, compared to expected norms; it is expressed as a letter grade between A (least delay) and F (most delay, gridlock). Modeling was completed for morning peak hours, afternoon peak hours and afternoon peak hours when the Demerara Harbour Bridge was closed. Table 8.5-5 summarizes the findings of the LOS modeling.

Table 8.5-5: Results of Level of Service Modeling; East Bank Demerara Road Intersections

Location	Direction	Movement	Level of Service		
			Morning	Afternoon	Afternoon, Bridge Closed
Massey Intersection	Northbound	Through	A	A	A
		Right	A	A	A
		U-Turn	A	A	A
	Southbound	Left	A	A	A
		Through	A	A	A
	Westbound	Right	A	A	A
		U-Turn	A	A	A
		Left	A	A	A
Demerara Harbour Bridge	Demerara Harbour Bridge (Exit)	Right	F	C	NA
		Left	D	A	NA
	Northbound	U-Turn	C	NA	A
		Left	A	F	A
		Through	D	A	A
	Southbound	Through	E	A	A
		Right	F	F	A
		U-Turn	F	A	A
Houston Split (Intersection)	Southbound	Through	A	A	A
	Northbound	Right	E	A	A
		Left	F	A	A
Nandy Park Intersection	Northbound	Through	B	A	A
		Right	D	B	A
	Southbound	U-Turn	C	A	A
		Through	A	A	A
		Left	A	A	A
	Westbound	Right	A	B	A
		Left	F	A	A
Eccles Intersection	Southbound	Through	D	B	C
		Left	E	D	C
	Northbound	Right	F	D	C
		Through	D	A	C
	Westbound	Left	F	E	B
		Right	F	E	A

Source: CARITRANS 2018
NA = LOS data not available

East Bank Demerara Road is particularly susceptible to congestion due to backups at the Demerara Harbour Bridge, the only road crossing of the Demerara River (Figure 8.5-5). Daily retraction of the bridge for a period of about 1 hour causes severe traffic congestion at both ends of the bridge. As shown in Table 8.5-5, when the bridge is open (i.e., when vehicles cannot cross), several movements at the intersection of the Demerara Harbour Bridge with the East Bank Demerara Road operate at an LOS rating of "F", indicating significant delays and near-gridlock conditions. When the bridge is closed, the entire East Bank Demerara Road system operates at an LOS rating of "C" or better, typically considered acceptable conditions for urban traffic.

The limited number of bridge openings causes delays and inconvenience to ocean going vessels. The Government of Guyana has investigated replacing the existing bridge with a new bridge (with an elevated central span that would reduce or eliminate the need for drawbridge openings) further downstream. A feasibility study for the proposed new bridge was completed in August 2017 (LievenseCSO 2017). The proposed new bridge would be located further north than the existing bridge and would connect Houston on the East Bank with Versailles on the West Bank; the feasibility study indicates the new bridge would consist of three lanes, one of which would be reversible.

Driving behavior also contributes to poor and dangerous land transportation conditions. Speeding, aggressive driving, and driving under the influence of alcohol contribute to traffic accidents in Georgetown. Driving at night poses additional concerns due to poor street lighting and road conditions, as well as livestock and pedestrians congregating near the roadside or, in the case of livestock, occasionally standing in the traffic lanes (OSAC 2016).

The Ministry of Public Infrastructure is working with the IDB to develop a Sustainable Urban Transport Plan for Georgetown. This will focus more on management of current traffic than on addition of significant new infrastructure (e.g., separation of slower-moving traffic from vehicular traffic in designated lanes; ERM Personal Communication 9).

Figure 8.5-5: Demerara Harbour Bridge

8.5.2.8. Air Transportation Infrastructure

Air transport in Guyana supports a variety of sectors including agriculture, tourism, and the extractive sectors. Air transportation infrastructure is therefore critical to sustain and enhance economic competitiveness. Guyana ranks 131 out of 211 countries on the Air Connectivity Index (World Bank 2011), and 49 out of 141 economies for the quality of its air transportation infrastructure (World Economic Forum 2015). In 2017, at the World Aviation Forum, Guyana was awarded for moving from 44.24 percent to 64.66 percent effective implementation of the Standards and Recommended Practices of the International Civil Aviation Organization (Stabroek News 2017). Compliance with the standards advances Guyana's efforts to be classified as a Federal Aviation Administration International Strategy Assessment Programme Category 1 country and facilitates direct flights to the United States.

Guyana's air transportation infrastructure comprises two international airports: the Cheddi Jagan International Airport (CJIA) and the Eugene F. Correira International Airport (ECIA; also commonly referred to as Ogle Airport). In addition, nearly 100 aerodromes serve smaller towns and villages, principally in the hinterland region (IDB 2016c). The CJIA and ECIA provide direct international flights to the English- and Dutch-speaking Caribbean, South America, Central America, and North America. A 2016 IDB tender document for development of a National Civil Aviation Master Plan for Guyana notes that approximately 478,000 passengers and 6,148,000 kilograms of cargo moved through the CJIA and approximately 43,700 passengers moved through the ECIA (IDB 2016c). In 2017, 664,000 international passengers used Guyana's airports, representing a 6 percent annual growth rate from the prior year (GCAA 2018).

The CJIA is located at Timehri, 40 kilometers south of Georgetown. The CJIA is managed by a Chief Executive Officer who reports, through a Board of Directors, to the Minister of Public Infrastructure (GoG 2006). The airport's existing terminal building has been operational since the 1970s, runways are short, and parking facilities congested. Further, over the period 2000–2012, passenger traffic at the CJIA increased 42 percent, from 384,000 to 544,000 (MoPI 2018). Given these circumstances, in 2013 a project for the expansion and modernization of the CJIA commenced and is expected to conclude by December 2018. The expansion project includes extension of the North and South runways, construction of new departure and arrival terminals, passenger boarding bridges, new aircraft parking bays, a diesel generator room, and a fire pump station.

The ECIA is located approximately 6 kilometers from Georgetown. In late 2001, the government leased the management and operation of the aerodrome to a local consortium of airline operators, Ogle Airport Inc. The lease is for a minimum period of 25 years with extension periods of 25 years on request of the lessee. The objective of the lease is to ensure compliance with International Civil Aviation Organization standards and to serve as a back-up to the CJIA in the event of an emergency, disaster, accident or other unserviceable situation (GoG 2006). The ECIA has developed into the principal domestic air hub providing commercial and cargo transport services, primarily between Georgetown and the hinterland regions. In 2009, ECIA received International Port of Entry certification and now serves direct flights to three Caribbean Community member states: Barbados, Suriname, and Trinidad. Currently, with a runway of 1,280 meters, ECIA is capable of handling small aircraft, such as business jets, and the ATR-72 and Dash 8 operated by Leeward Islands Air Transport (Ogle 2018). ECIA is also the base of EEPGL's local air transportation contractor, Bristow. By comparison, when completed, the CJIA runways will measure up to 3,200 meters (approximately 2 miles), making it a Code 4E runway able to accommodate a Boeing 747-400 (MoPI 2018).

Only a small number of the nearly 100 aerodromes principally serving smaller towns and villages in the hinterland region have asphalt, concrete, or bitumen surfaces, including Ebini, Holiptu, Kaieteur, Kamarang, Kimbia, Lethem, Linden, Mabaruma, Mahdia, and Maards. Along the coast, there are other airstrips at Skeldon, Albion, Rose Hall, Von Betta, Bath, Maards, Hampton Court, Kwebanna, and Mabaruma.

8.5.3. Impact Assessment—Social Infrastructure and Services

This section assesses potential Project impacts on social infrastructure and services in the Project AOI. The planned Project activities that have the potential to impact social infrastructure and services are Project worker presence (with the potential to impact availability or cost of housing and utilities) and ground and air transportation (with the potential to increase traffic congestion). These potential impacts are assessed separately in this section.

Potential impacts related to decreased availability of emergency medical and health services as a result of Project use of these services are assessed in Section 8.3.3, Impact Assessment—Community Health and Wellbeing. Potential impacts related to vehicle accidents involving non-Project individuals are assessed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

8.5.3.1. Housing and Utilities

Relevant Project Activities and Potential Impacts

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. Table 8.5-6 summarizes the Project stages and activities that could result in potential impacts on housing and utilities, as well as the receptors that could potentially experience these impacts.

Table 8.5-6: Summary of Relevant Project Activities and Key Potential Impacts—Social Infrastructure and Services (Housing and Utilities)

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project Stages	General population of Georgetown and vicinity	Project worker presence in Georgetown area	Increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost
		(Induced) influx of job-seekers to Georgetown area	

Magnitude of Impact—Housing and Utilities

The assessment of the Project's magnitude of impacts on housing and utilities is determined based on consideration of geographic extent, frequency, duration, and scale. The scale of potential impacts on housing and utilities is defined according to the definitions provided in Table 8.5-7.

Table 8.5-7: Definitions for Scale Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Scale	Negligible: There is no discernible change in demand for housing or utilities.
	Small: Limited increases in demand for housing and utilities are perceptible, causing slight changes in the availability, quality, and/or cost of these resources and services.
	Medium: Increases in demand for housing and utilities are evident and lead to frequent and widespread shortfalls in availability or quality of housing and utilities, or measurable increases in costs.
	Large: Increases in demand for housing and utilities are sufficient to cause conditions of chronic shortage and inflated costs.

The Project will require up to approximately 1,200 workers during the peak drilling and installation stages and up to a peak of approximately 140 workers during the production operations stage. The majority of the workforce for these stages will be based offshore; for these workers, the limited time spent onshore will predominantly be in temporary accommodations such as hotels. Approximately 150 to 200 persons will be based onshore on a permanent basis, providing shorebase and marine logistical support as well as supporting EEPGL's other activities in Guyana (including those related to the Project and other EEPGL exploration and production activities). EEPGL will optimize the use of local content to the extent practicable, so it is likely that a significant portion of these permanent onshore jobs will be filled by individuals currently residing in the Georgetown vicinity. However, even with the conservative assumption that most of these jobs will be filled by individuals not currently residing in Georgetown, the additional number of inhabitants is insignificant compared to the Georgetown population of more than 130,000.

As such, the Project workforce is not expected to impact for-sale or rental housing stock, and thus will not be expected to require any new utilities connections. Furthermore, it is not anticipated that the Project's worker presence onshore at any given time will be enough to drive development of new temporary housing/hotel establishments. Some induced population influx from other regions of Guyana may occur as job seekers move to the Georgetown area seeking direct or indirect employment from the Project. This incoming population could access for-sale or rental housing stock. This influx is expected to be limited and short-term in nature, given EEPGL's continuous efforts to communicate the Project's limited workforce requirements to stakeholders.

Based on the definitions presented in Table 8.5-7, the magnitude of impact on housing and utilities is considered to be **Small** during the drilling and installation stages of the Project and **Negligible** during the production operations and decommissioning stages.

Sensitivity of Receptors—Housing and Utilities

The receptors that potentially could experience impacts on housing and utilities are the current general population of the Georgetown vicinity. The receptor sensitivity ratings for housing and utilities are defined according to the definitions provided in Table 8.5-8.

Table 8.5-8: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Sensitivity	Low: Existing infrastructure and services have excess capacity and/or the community has the resources and capability to expand in a timely manner.
	Medium: Existing infrastructure and services have little excess capacity and the community has limited resources or capability to expand in a timely manner and thus would require assistance in upgrading or supplementing current infrastructure and service provision in the community.
	High: Existing infrastructure and services have little or no excess capacity and the community does not have the resources or capability to respond to a potential increase in population.

As the capital of Guyana, Georgetown has a relatively high concentration of social services and infrastructure; however, according to a study by the Inter-American Development Bank (IDB), there are currently shortfalls of housing and appropriate utilities infrastructure in Georgetown, which the government is addressing with regularization initiatives for informal communities. Given these shortfalls, the population are considered to have a **Medium** level of sensitivity to increased demand for housing and utilities infrastructure.

Impact Significance—Housing and Utilities

Based on the magnitude of impact and receptor sensitivity ratings, the significance of housing and utilities impacts for the drilling and installation stages is **Minor**. During the production operations and decommissioning stages, this is reduced to a **Negligible** level of significance.

8.5.3.2. Ground and Air Transportation

Relevant Project Activities and Potential Impacts

Planned Project activities will generate additional vehicular traffic entering and exiting the existing shorebase to be used by the Project in Georgetown, as well as additional air traffic (helicopters) between ECIA (Ogle Airport) and the PDA. Table 8.5-9 summarizes the Project stages and activities that could result in potential impacts on ground or air transportation.

Table 8.5-9: Summary of Relevant Project Activities and Key Potential Impacts—Social Infrastructure and Services (Ground and Air Transportation)

Stage	Receptors	Project Activity	Key Potential Impacts
All Project stages	Road users, including drivers, cyclists, and pedestrians	Onshore movement of Project materials, supplies, and personnel	Increased vehicle traffic on public roads in and around Georgetown
All Project stages	Other aircraft and users of ECIA	Helicopter flights between ECIA and PDA	Increased air traffic leading to potential impacts on ECIA capacity

Magnitude of Impact—Ground Transportation

Project-related vehicles using the shorebase(s) will travel along the East Bank Demerara Road. Current projections are that Project-related shorebase activities will result in approximately 20 additional (one-way) vehicle trips per day across the Project life cycle (at least 20 years). In addition to modeling LOS ratings for existing conditions along the East Bank Demerara Road, the CARITRANS traffic study (see Section 8.5.2.7, Ground Transportation Infrastructure) modeled LOS ratings for the following scenarios:

- Existing conditions under current road network, with the inclusion of additional Project traffic (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions under current road network in 2023, with assumed non-Project traffic growth (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions under current road network in 2023, with assumed non-Project traffic growth, with the inclusion of additional Project traffic (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023, with assumed non-Project traffic growth (a.m. peak, p.m. peak, Bridge Closed); and
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023, with assumed non-Project traffic growth—with the inclusion of additional Project traffic (a.m. peak, p.m. peak, Bridge Closed).

LOS ratings are summarized in Appendix O, Traffic Impact Assessment Report.

The LOS modeling for the various projected scenarios confirms that the additional Project-related traffic will not meaningfully change LOS ratings along the East Bank Demerara Road; therefore, it is expected Project traffic will not measurably change existing traffic congestion in Georgetown. This holds true for existing traffic conditions, either currently or in 2023, as well as the scenario that envisions construction of a new Demerara Harbour Bridge, which is itself expected to improve traffic congestion along the East Bank Demerara Road once operationally ready. On this basis, the magnitude of impact on ground transportation as a result of planned Project activities is considered to be **Negligible**.

Sensitivity of Receptors—Ground Transportation

The receptors that could potentially experience impacts on ground transportation include current users of the Georgetown road network. Existing drivers will have a **Medium** level of sensitivity. This rating reflects the relatively high existing traffic volumes and congestion in the vicinity of the shorebase(s), as well as the lack of travel alternatives (i.e., other travel routes or modes of transportation) for non-Project drivers. Drivers already experience substantial traffic congestion and road safety risks in parts of Georgetown. Additional traffic will likely be viewed as incremental, but not a fundamental shift in conditions.

Impact Significance—Ground Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of ground transportation impacts on community stakeholders is **Negligible**.

Magnitude of Impact—Air Transportation

It is estimated that during development drilling and FPSO/SURF installation for the Project, helicopter flights from ECIA will (at peak) total approximately 30 to 35 round-trip flights per week (combined for Liza Phase 1 and Liza Phase 2). During FPSO/SURF production operations for the Project, an estimated maximum of 20 to 25 round-trip flights per week (combined for Phase 1 and Phase 2) will be necessary to support FPSO/SURF production operations and continued development-drilling activities. As described in Section 2.11, End of Phase 2 Operations (Decommissioning), EEPGL has not prepared detailed plans for the decommissioning stage. As such, the level of air-transportation activity associated with decommissioning is not known. For purposes of impact analysis, air traffic associated with Project decommissioning is assumed to be similar to that of the drilling and installation stage. This level of activity is unlikely to meaningfully impact ECIA's capacity or operations; accordingly, the magnitude of potential impacts on air transportation as a result of the Project is considered **Negligible**.

Sensitivity of Receptor—Air Transportation

Receptors for air transportation impacts include airport and airspace users and commercial, cargo, and private pilots, crew, and passengers. The aviation environment is highly regulated. Other air traffic, such as Project-related flights, is expected. All pilots are expected to be able to navigate in the presence of the limited additional Project-related aircraft. On this basis, air transportation users at ECIA are considered to have a **Low** level of sensitivity to increased air traffic from the Project.

Impact Significance—Air Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of air transportation impacts is **Negligible**.

8.5.4. Mitigation Measures—Social Infrastructure and Services

8.5.4.1. Housing and Utilities

No mitigation measures are required to address potential impacts on housing and utilities. However, the Project will proactively manage messaging about the Project's limited workforce needs to stakeholders to reduce the potential for induced population influx.

Table 8.5-10 summarizes the assessment of potential pre-mitigation and residual Project impacts on housing and utilities. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the housing and utilities-specific methodology described above.

8.5.4.2. Ground and Air Transportation

No mitigation measures are required to address potential impacts on ground and air transportation.

Table 8.5-11 below summarizes the assessment of potential pre-mitigation and residual Project impacts on ground and air transportation. The significance of impacts was assessed based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, as well as the ground and air transportation-specific methodology described above.

Table 8.5-10: Summary of Potential Pre-Mitigation and Residual Impacts—Housing and Utilities

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Drilling SURF and FPSO Installation	General population of Georgetown and vicinity—decreased availability/increased cost of housing and utilities	Small	Medium	Minor	Proactive messaging regarding Project employment opportunities	Minor
Production Operations Decommissioning	General Georgetown population and vicinity—decreased availability/increased cost of housing and utilities	Negligible	Medium	Negligible	None	Negligible

Table 8.5-11: Summary of Potential Pre-Mitigation and Residual Impacts—Ground and Air Transportation

Stage	Resource/ Receptor - Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Non-Project drivers—increase in traffic congestion	Negligible	Medium	Negligible	None	Negligible
All Project stages	Non-Project users of ECIA—interference with airport use	Negligible	Low	Negligible	None	Negligible

8.6. WASTE MANAGEMENT INFRASTRUCTURE AND CAPACITY

8.6.1. Administrative Framework—Waste Management Infrastructure and Capacity

Table 8.6-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on waste management infrastructure and capacity.

Table 8.6-1: Legislation, Policies, Treaty Commitments and Industry Practices—Waste Management Infrastructure and Capacity

Title	Objective	Relevance to the Project
Legislation		
Environmental Protection Hazardous Waste Regulations (2000)	Establishes requirements for generating, handling, and disposing of hazardous waste as well as penalties for violations of these requirements.	Identifies wastes subject to regulation, including several types of waste that could be generated as part of the Project.
Pesticides and Toxic Chemicals Control Act Cap. 68:09 (2000, as amended in 2007)	Provides for the formation of a Pesticides and Toxic Chemicals Control Board; establishes requirements for registration, licensure, and trade in pesticides and toxic chemicals. Amended in 2007 to provide rules for the exportation of pesticides and toxic chemicals.	Establishes regulations pertaining to the use of toxic chemicals and pesticides. Pesticides will not be required for the Project, but small amounts of toxic chemicals may be used. Will regulate the importation, registration, and use of these chemicals.
Policies and Strategies		
National Solid Waste Management Strategy (Under Development)	Guides the Government of Guyana’s agenda on waste collection, transportation, and disposal; goals include to improve the waste management infrastructure, enforce existing legislation, and promote waste-to-energy initiatives. Will inform the country’s integrated efforts at converting waste material into useful resources and aims to ensure their full utilization and eventual exploitation as by-products. Currently under development.	Once the Strategy is approved, it is expected to apply to the collection, transportation, and disposal of Project-generated waste.
International Agreements Signed/Acceded by Guyana		
International Convention for Safe Containers (1972)	Promotes the safe transport and handling of containers through generally acceptable test procedures and related strength requirements, and facilitates the international transport of containers by providing uniform international safety regulations, equally applicable to all modes of surface transport.	Regulates the manufacture, use, and integrity of containers used on board the drill ships, FPSO, and support vessels. Guyana acceded in 1997.
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969)	Confirms the right of coastal member states to take specific actions when necessary to prevent pollution from oil following a maritime casualty.	Would protect Guyana’s rights to respond to an oil spill if such an event were to occur. Guyana acceded in 1997.

Title	Objective	Relevance to the Project
Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal (1989)	Reduces and controls the movements of hazardous waste between nations and discourages transfer of hazardous waste from developed to less developed countries.	Would apply to the Project only if hazardous waste generated in Guyana is disposed outside Guyana. Guyana acceded in 2001.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998)	Provides a mechanism for formally obtaining and disseminating decisions of party nations as to whether they wish to receive future shipments of listed chemicals, and for ensuring compliance with these decisions by exporting party nations.	Would apply to the Project only if chemicals and/or pesticides used by the Project and listed under the Convention are shipped into or out of Guyana. Guyana acceded in June 2007.
Stockholm Convention on Persistent Organic Pollutants (2001, amended in 2009)	Requires party nations to take measures to eliminate or reduce the release of persistent organic pollutants.	Would apply to the Project only if persistent organic pollutants are released to the environment during the course of Project-related. Guyana acceded in September 2007.
International Convention on Oil Pollution Preparedness, Response and Cooperation (1990)	Establishes measures for dealing with marine oil pollution incidents.	Requires ships to have a shipboard oil pollution emergency plan. Guyana ratified in 1997.

Currently, several public sector agencies are involved in waste management in Guyana, including the EPA, Ministry of Communities, Solid Waste Management Authority, Ministry of Public Health, RDCs, NDCs, and town councils, and there are some overlaps in roles and responsibilities. The two key organizations involved in waste management are the EPA and the Ministry of Communities; their roles in waste management are further elaborated below.

8.6.1.1. EPA

Waste management is one of the EPA's program areas. Under the Guyana Environmental Protection Act (amended in 2005), the Waste Management Program Area is responsible for managing the policies, guidelines, and standard operational procedures regarding waste management and resource recovery. The stated aim of the program is to realize maximum value from natural resources and ensure a "green environment".

The core function of the Waste Management Program Area is to manage waste entering into the environment in an environmentally sound manner. It provides technical assistance in the development, management and operation of waste management facilities, conducts research and analysis on the recovery of useful energy from solid waste, and develops guidelines and standards for the disposal of hazardous waste and other types of waste. It also coordinates and implements the obligations of the Basel Convention and controls the import and export of hazardous waste through granting of authorizations. The program area focuses on three sub-program areas:

- Solid waste management
- Hazardous waste management
- Waste reduction and recovery

8.6.1.2. Ministry of Communities

The Ministry of Communities is the primary government agency that links the various authorities with the Government of Guyana. It facilitates, coordinates, and monitors the execution and implementation of a number of projects, programs, and activities in the various local government arms/organs and ensures that these activities are in conformity with the legal framework and the policies of the Government. The Ministry of Communities is responsible for the Solid Waste Disposal Program that is aimed at enhancing Guyana's garden city image and improving its solid waste management structure (Ministry of Communities 2018). This ministry is also leading development of the National Solid Waste Management Strategy referenced in Table 8.6-1.

The ministry has been directly involved in the upgrading of the municipal landfill site that serves Georgetown and is planning similar projects in other regions (see below).

8.6.2. Existing Conditions—Waste Management Infrastructure and Capacity

8.6.2.1. Municipal/Non-hazardous Waste Management Facilities

Most regions in Guyana rely on dumpsites for the disposal of municipal waste, with each region having at least one dumpsite. In addition to receiving municipal waste from household collections, these dumpsites are also used for the disposal of commercial and industrial waste. Although the dumpsites are intended only for the disposal of non-hazardous wastes, the control over incoming waste is generally not rigorous, so it is likely that some of these facilities have received hazardous wastes.

The Government of Guyana wants to develop a more coordinated approach to waste infrastructure planning that is compatible with land use planning and promotes coordination and optimization of waste management facilities across all regions. The Ministry of Communities' stated strategy is to progressively rehabilitate illegal dumpsites, disused dumpsites, and poorly operated dumpsites (Gilkes 2017).

In Georgetown, the Haags Bosch engineered municipal landfill site was designed and constructed some years ago. The facility had operational problems, including a fire in 2015. It was also the subject of several non-compliance notices from the EPA relating primarily to leachate management. Since then, a new operator has been appointed and remediation of the site and upgrading of the operation is underway. The landfill is lined and now has a leachate collection system and a leachate treatment system. Although waste pickers are operating at the site, controls have been put in place by the landfill operator to minimize the health and safety risks of their activities and to reduce their interference with the operation of the site. Other controls (e.g., safe venting of landfill gas) and environmental monitoring are also planned for the site.

8.6.2.2. Industrial/Hazardous Waste

There are very limited facilities for the treatment of hazardous waste in Guyana, although interest in developing such facilities is growing following the planned expansion of oil and gas activities. A private sector operator has the only existing facility in Guyana capable of treating hazardous wastes. EEPGL used this contractor to manage a range of wastes generated during the Liza Phase 1 Development Project and has plans to continue using this contractor for the Project. The Project may also potentially utilize tank cleaning services from other contractors out of Guyana and Trinidad.

The contractor has an authorization issued by the EPA and has been assessed by EEPGL as operating to good environmental, health, and safety standards, comparable with good international standards. The facility plans to use a vertical infrared thermal unit (VIR) for management of wastes. The VIR will have the ability to treat solid and semi-solid/sludge wastes (drill cuttings, oily sludges, slops and tank bottoms) with less than 6 percent oil and can manage small quantities of completion fluids. The VIR capacity has been upgraded recently and will have the capacity to treat up to 13.4 tonnes/day once fully operational (currently anticipated to be mid-2018 to late-2018). The facility can also treat wastewater by injecting a limited amount of wastewater into the VIR. The contractor has also installed an incinerator that will have the ability to process up to 150 kilograms per hour of non-hazardous solids wastes once it is fully operational (currently anticipated to be mid-2018 to late-2018).

Residues/wastes not treated with the VIR are taken to the Georgetown landfill site. This includes:

- Food waste
- Scrap wood
- Glass (e.g., bottles)
- Plastic (e.g., scrap, shredded drums, buckets and kegs)
- Aerosol cans (depressurized)

The Project may also potentially utilize tank cleaning services from other contractors located in Guyana and Trinidad.

8.6.3. Impact Assessment—Waste Management Infrastructure and Capacity

Various waste streams generated offshore will be discharged directly to sea in accordance with the International Maritime Organization (IMO) International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78):

- Water-based drill cuttings and fluids
- Excess cement from the first casing string of each well
- Well completion and treatment fluids
- Treated produced water
- Cooling water
- Brine from water purification (membrane) processes
- Drainage from topsides facilities (after passing through traps to remove hydrocarbons)
- Commissioning fluids
- Ballast water
- BOP testing fluids
- Treated black water and food waste

Further details about these wastes are presented in Section 2.12.3, Discharges. Potential impacts of Project discharges to sea are discussed in Section 6.4.3, Impact Assessment—Marine Water Quality, and Section 6.4.4, Mitigation Measures—Marine Water Quality.

The types and quantities of other Project-generated wastes (i.e., those not discharged to the sea after appropriate treatment) are summarized in Section 2.12.4, Wastes. All wastes generated by the Project will be managed in accordance with a Waste Management Plan (WMP) that has been developed by EEPGL, a copy of which is included as part of the ESMP. The WMP lists in detail the range of wastes that will be generated by the Project and their sources. It specifies primary and alternative treatment/disposal methods for each waste, as well as the associated monitoring and reporting requirements. The WMP also indicates the roles and responsibilities of the different organizations in terms of managing Project wastes and details the national and international waste management regulations that are applicable to the Project.

The WMP indicates that the Project will follow the principles of the waste management hierarchy[11] and, as far as practical, steps will be taken to avoid and minimize the generation of waste, maximize the amount of waste that is reused and recycled, and minimize the amount of waste that needs to be disposed (and in particular landfilled). The WMP provides details as to how different types of waste are to be handled, stored, and transported to shore to avoid potential environmental, health, and safety issues. Specifically, it describes how different types of waste will be segregated, the types of containers that will be used, and the labeling requirements. All transfers of waste from offshore Project facilities to shorebase(s) will be covered by Marine Transport Manifests and will be undertaken in suitably licensed vessels. Any on-land transfers of waste will similarly be covered by use of waste transfer notes to ensure that all movements of waste can be tracked through to the point of final disposal.

A range of different treatment and disposal methods will be used for different types of waste as follows:

- The drill ships may be equipped with incinerators designed to handle the range of combustible wastes that will be generated offshore.
- Third-party waste contractor(s) will treat wastes that cannot be treated offshore. The contractors will use thermal treatment methods, such as thermal desorption, to treat hydrocarbon-contaminated sludge, and thermal oxidation to treat wastewaters. Only contractors that are appropriately licensed by the EPA and which have been assessed by EEPGL as being of a sufficient standard will be utilized to treat the Project's wastes.
- Ash from the incineration of waste, treated sludge, and general non-hazardous wastes will be taken to a landfill that has been appropriately licensed by the EPA and assessed by EEPGL as being of a sufficient standard. Currently, the only facility EEPGL has identified as meeting

[11] The waste management hierarchy used by EEPGL is as follows: (1) Generation of waste should be Avoided, Prevented, or Reduced at the source whenever feasible; (2) Wastes that are not Prevented should be Reused or Recycled in an environmentally safe manner, whenever feasible; (3) Wastes that are not Prevented or Recycled should be Treated in an environmentally safe manner, whenever feasible; and (4) Finally, Disposal should be employed as a last option and when employed, should be conducted in an environmental responsible manner (OGP 2009).

these requirements is the Haags Bosch landfill in Georgetown. This landfill is under contract to the Ministry of Communities and is licensed by the EPA.

- Specific wastes that can be recycled locally, such as plastic, scrap metal, and used oil, will be taken to approved local recyclers.

Any new or unanticipated wastes, such as from an emergency response, will be assessed to determine the most appropriate handling/on-site management and treatment/disposal methods.

The proposed way in which Project wastes will be managed is in accordance with good international practice. Specifically, EEPGL is proposing to use waste contractors that are licensed by the authorities, and to undertake its own assessments to assess whether contractors are operating to good, international, environmental and health and safety standards.

The onshore waste facility in Georgetown is licensed and with a design capacity to treat all of the anticipated Project-generated wastes appropriate for treatment at this facility. The VIR unit is modular and can be expanded with additional boxes. The contractor's permit is not volume-limited and the operation can thus be expanded as needed. The Haags Bosch landfill is a large facility with ample capacity for the disposal of the treated residues and other non-hazardous wastes that are expected to be generated by the Project during its planned operating life cycle (at least 20 years).

Based on the multiple waste management-related embedded controls the Project will adopt, including a rigorous waste-tracking system, use of licensed and approved transporters for waste movements, and use of licensed, EEPGL assessed onshore facilities for waste treatment and disposal, it is concluded that the potential impacts of Project-related waste management on the environment will be of **Negligible** significance.

8.6.4. Mitigation Measures—Waste Management Infrastructure and Capacity

Based on the **Negligible** significance of potential waste management impacts on the environment, no mitigation measures are proposed. In addition to the information presented above regarding EEPGL's waste management practices and associated embedded controls are summarized in Chapter 12, Conclusions and Summary of Impacts. Details are further elaborated in the WMP, which is attached to the ESMP (which is itself provided as an attachment to the EIA in Volume III of the regulatory submittal).

8.7. Cultural Heritage

"Cultural heritage" is an umbrella term for many heritage-related resources defined by international organizations as well as national laws and regulations. Guyana's National Trust Act of 1972 protects national monuments, defined as resources of "historic, architectural or archaeological interest attaching to it or its national importance." According to this law, the National Trust of Guyana is responsible for declaring resources to be national monuments.

Cultural heritage can be both tangible and intangible (e.g., oral histories), and tangible cultural heritage can be both portable (i.e., objects) and non-portable (i.e., sites). Non-portable, tangible cultural heritage, the type typically most susceptible to impacts from development projects, can be further subdivided into archaeological, architectural, and living heritage sites. Archaeological sites are areas where human activity has measurably altered the earth or deposits of physical remains are found (e.g., artifacts). Archaeological sites can be prehistoric or historic, and can be underwater or terrestrial. Architectural sites include standing buildings, bridges, dams, and other structures of historic or aesthetic significance. Living heritage consists of resources of traditional, religious, or cultural significance. Living heritage sites can include archaeological resources, sacred sites, sacred structures, and prominent topographical features essential for the preservation of traditional cultures.

8.7.1. Administrative Framework—Cultural Heritage

Table 8.7-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Cultural Heritage

Title	Objective	Relevance to the Project
Legislation		
National Trust Act (1972) Cap. 20:03.	Stewardship of historic resources and places of cultural significance.	Governs the management of any building, structure, object, or other manmade or natural feature that is of historic or national cultural significance that could be impacted by the Project. Includes shipwrecks and other marine features. Would only apply to the Project in the event of a chance find, in which case the Act would require EEPGL to work cooperatively with the National Trust to manage any resources discovered.
Maritime Zones Act (2010) Cap. 63:01.	Incorporates certain provisions of the United Nations Convention on the Law of the Sea and the United Nations Educational, Scientific and Cultural Organization (UNESCO) Convention on the Protection of the Underwater Cultural Heritage, to provide for marine scientific research, maritime cultural area, eco-tourism, marine parks and reserves, the protection and preservation of the marine environment and for related matters.	Relevant to the Project as it makes provisions for passage in the territorial sea, and the discharge of harmful substances and hazardous waste. In addition, relevant when specific maritime zones are established for the protection and preservation of the marine environment and also for mariculture activities, for which one project is currently being pursued by others.
International Agreements Signed/Acceded by Guyana		
United Nations Educational, Scientific and Cultural Organization Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)	Created the UNESCO list of World Heritage Sites.	Would only apply if the Project had the potential to impact a World Heritage Site (it does not).

Title	Objective	Relevance to the Project
United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage (2001)	Protects "all traces of human existence having a cultural, historical, or archaeological character" that have been underwater for over 100 years.	Would apply to any shipwrecks or other submerged cultural heritage in the Project AOI. Guyana ratified in 2014.

8.7.2. Existing Conditions—Cultural Heritage

8.7.2.1. Underwater Cultural Heritage

Prior to EEPGL's interest in the Stabroek Block, no previous cultural surveys had been undertaken within the vicinity of the PDA. In 2016, EEPGL retained Fugro Marine Geoservices, Inc. (Fugro) to conduct a geophysical and remote sensing survey of the seafloor within the Liza Field (Fugro 2016). The 2016 survey encompassed the Liza Phase 2 Subsea PDA and the data from the survey are therefore relevant for the purpose of the Project. The objective of the study was to identify the occurrence of any potential cultural resources that may impact, or be impacted by, the design and placement of planned subsea equipment within the survey area.

Submerged archaeological sites are not expected in waters deeper than approximately 125 meters (approximately 410 feet), which was the approximate sea level during the Last Glacial Maximum (20,000 years before present). Since all Project components with the potential to disturb the seafloor will be deeper than approximately 125 meters (approximately 410 feet), the only cultural resources with a reasonable potential to be present in the Project area are human-made objects that have sunk, most notably shipwrecks.

Remote sensing surveys employ various instruments that use high and/or low frequency sound waves to collect information from the seafloor. The 2016 Fugro survey used several of these including the following:

- Multi-beam echo sounders, which collect bathymetric data via a wide band of high-frequency sound waves and can detect abnormal shapes (which could potentially include objects of cultural interest) against the surrounding landscape (both autonomous underwater vehicle [AUV]-mounted and hull-mounted were used);
- Side-scan sonars (SSS), which employ high frequency sound waves to collect textural data from the seafloor and provide high resolution images of objects on the seafloor surface (AUV-mounted was used); and
- Sub-bottom profilers, which collect data on subsurface sediments and objects located beneath the seafloor via low frequency sound waves and are capable of locating buried shipwrecks beneath the seafloor surface (both AUV-mounted and hull-mounted were used).

The model types of the remote sensing instruments used and the settings employed for each instrument are provided in Table 8.7-2. The survey was divided into three areas: the Liza Field Development Area (Main AUV Survey Area); the Upper Slope and Outer Shelf Reconnaissance Area (USOS Survey Area); and the Skipjack Survey Area. These are shown on Figure 8.7-1.

Table 8.7-2: Remote Sensing Instruments and Survey Settings

Type of Instrument	Model	Survey Settings	Hull- or AUV-Mounted	Survey Areas in which Equipment was Used
Multi-beam echo sounders	Kongsberg EM2040 bathymetric system	Frequency of 200 kHz swath coverage of 150 degrees	AUV-mounted	• Main AUV Survey Area • USOS Survey Area (where possible) • Skipjack Survey Area
	Kongsberg EM302 bathymetric system	Frequency of 30 kHz	Hull-mounted	• USOS Survey Area
SSS	EdgeTech model 2200 full-spectrum system	Dual frequencies of 105 kHz and 410 kHz	AUV-mounted	• Main AUV Survey Area • USOS Survey Area (where possible) • Skipjack Survey Area
Sub-bottom profilers	EdgeTech model DW-106 full spectrum system	Frequency range of 1 kHz to 10 kHz	AUV-mounted	• Main AUV Survey Area • USOS Survey Area (where possible) • Skipjack Survey Area
	EdgeTech 3300 full spectrum system	Frequency range of 1 kHz to 10 kHz	Hull-mounted	• USOS Survey Area
Underwater Digital Camera	Prosilica Allied Vision GE4000	35 millimeter digital imagery, approximately 8 meters (approximately 26 feet) above seafloor	AUV-mounted	• As needed for ground-truthing in all survey areas

kHz = kilohertz

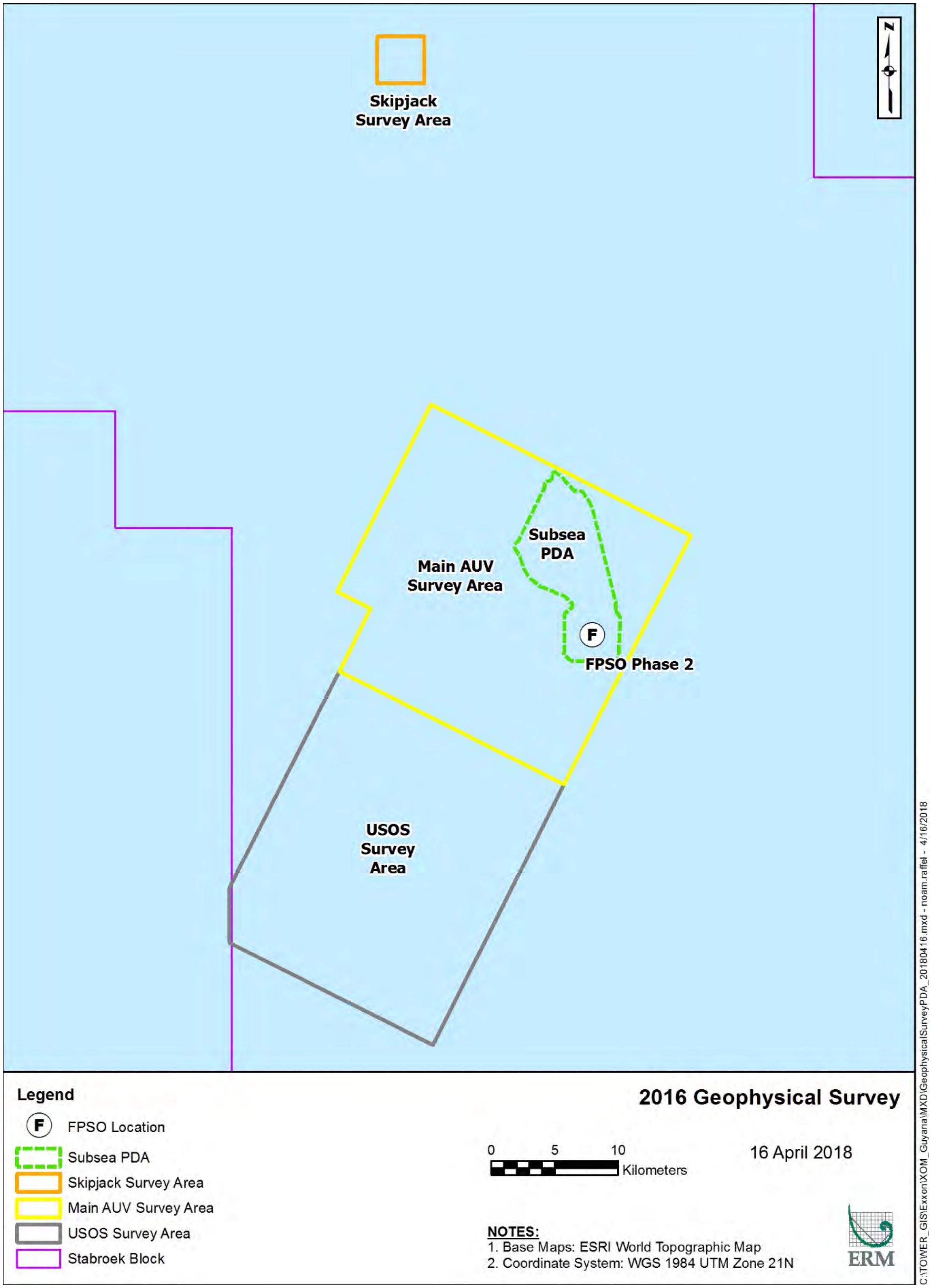


Figure 8.7-1: Geophysical Survey in Stabroek Block

The Consultants assessed Fugro's remote sensing survey methodology, including the remote sensing equipment and instrument settings employed and the results produced, according to internationally recognized standards. The Consultants found that the methods used by Fugro and the results yielded by their survey are sufficient to provide existing cultural heritage data for the area of potential impact, as the methodology and quality of data produced met the guidelines and requirements for nearshore and offshore remote sensing cultural surveys as defined by the U.S. Bureau of Ocean Energy Management and Historic England. Together, these guidelines help frame "internationally recognized practices" for remote sensing surveys designed to locate and assess cultural heritage (BOEM 2017; Historic England 2013).

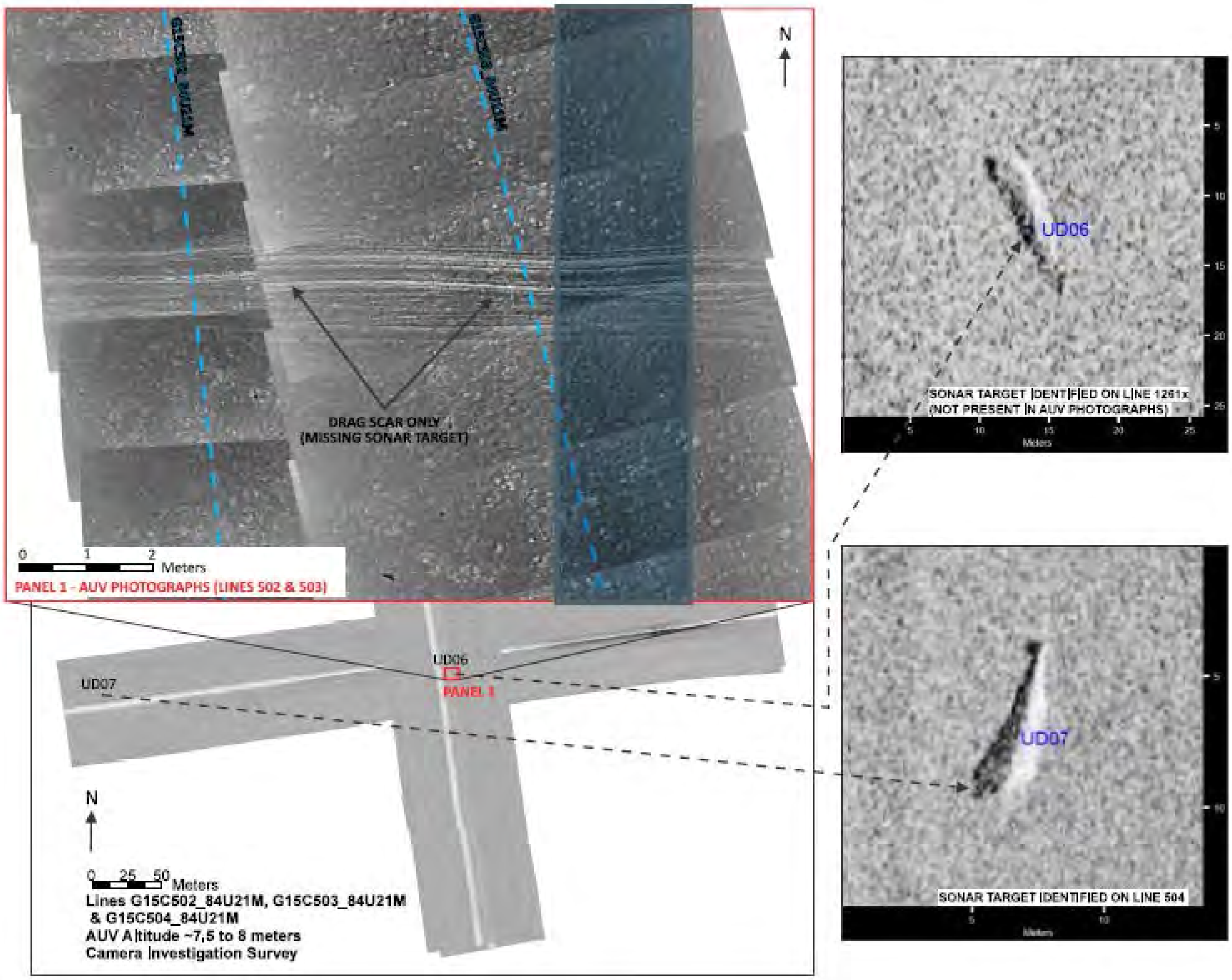
Within the Main AUV Survey Area (which includes the Liza Phase 2 Subsea PDA), the low-frequency and high-frequency SSS survey identified 73 sonar contacts (designated UD01 through UD073); these were assessed further as potential marine hazards and/or cultural resources.

One contact (UD06) was initially considered to be a possible vessel and thus was subjected to follow up surveys using high-frequency SSS and digital photography. During this second inspection, however, UD06 could not be located, although the seafloor at its previously recorded location showed signs of the object having moved downslope (drag scars). A follow-up survey identified contact UD07, which was interpreted as being the same contact (see Figure 8.7-2). This indicates that the object is not culturally sensitive because, even if it were a cultural resource, it no longer maintains its original context (greatly diminishing its potential research value).

Contact UD047 was also initially considered to be a potential vessel, but upon second inspection was identified as likely being a fishing net (see Figure 8.7-3).The remaining 71 contacts in the Main AUV Survey Area were judged to be geologic features (e.g., rock clusters or formations) or man-made debris (e.g., debris associated with previous well development projects or cable-laying efforts) of no significant cultural value. Figure 8.7-4 shows examples of modern debris from three of the contacts (UD08, UD011, and UD021), such as discarded chain or cable coils.

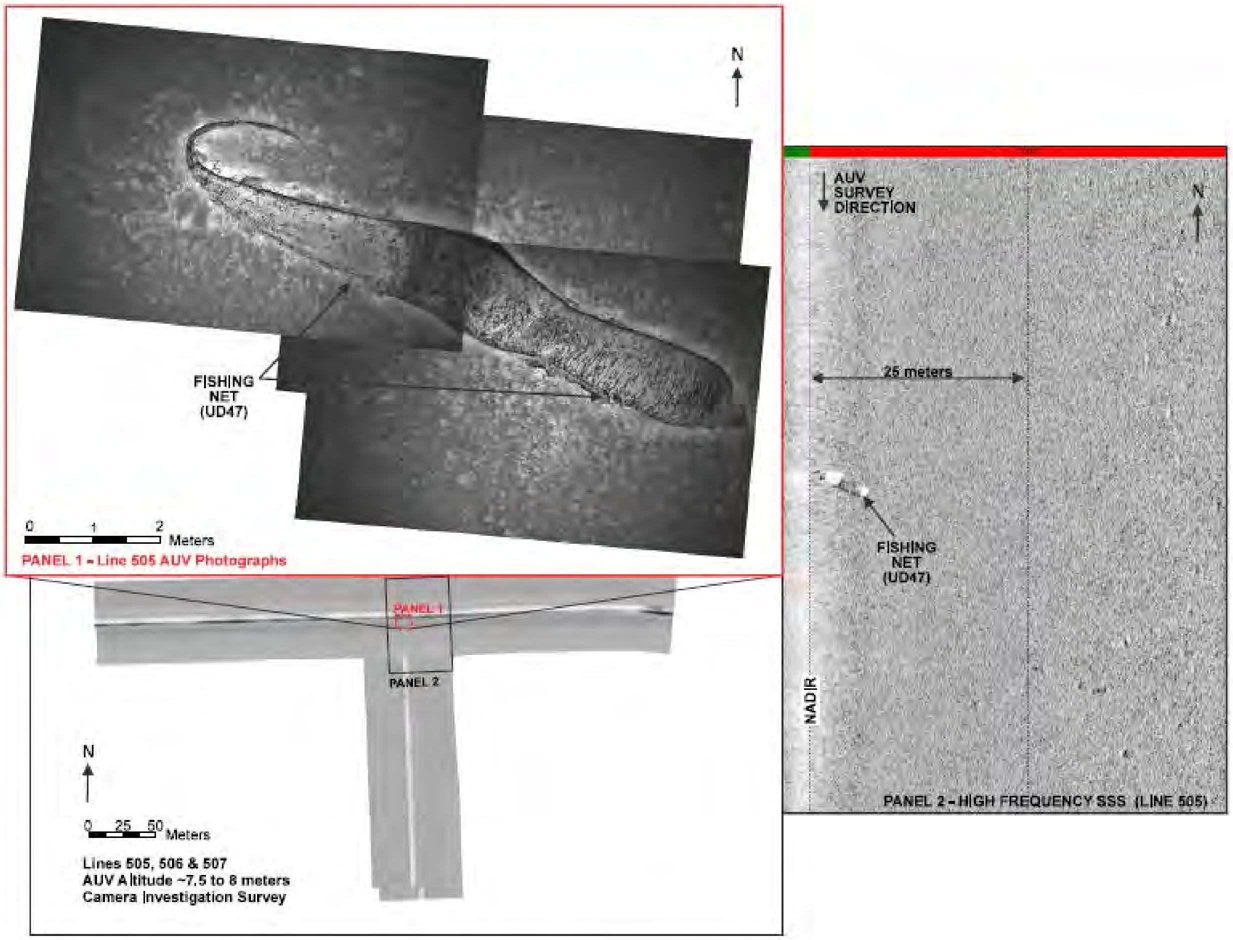
After reviewing the SSS imagery and data collected, the Consultants concluded that the 73 SSS contacts are likely modern debris, fishing nets, chain or cable coils, or geological features of no significant cultural value.

Additionally, an unidentified subsea cable has mapped across the Liza Development area (see Figure 8.7-5). The subsea cable will be categorized and assessed to confirm that the cable is no longer in use. The subsea cable may be removed as part of the infield flowline installation. With respect to cultural heritage, the subsea cable does not have any cultural significance.



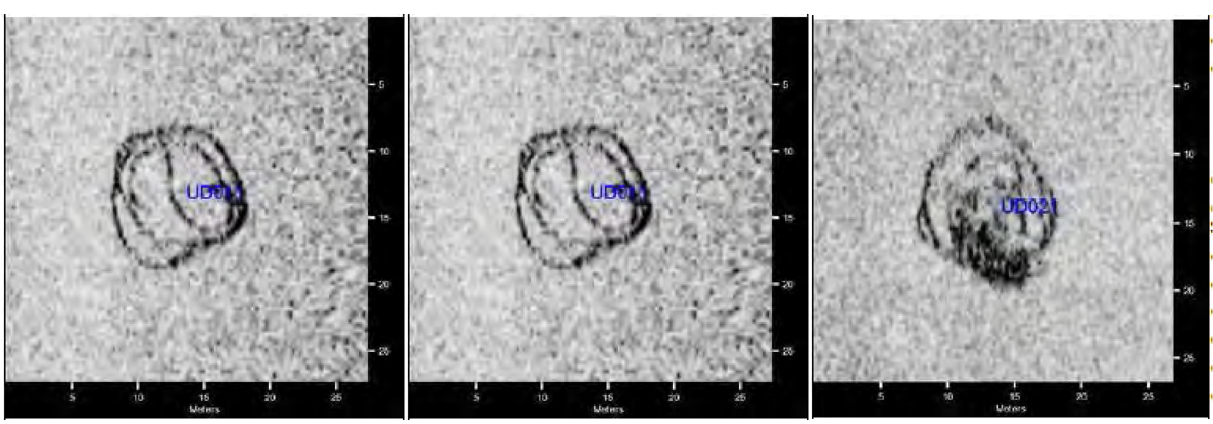
Source: Fugro 2016

Figure 8.7-2: AUV High-Frequency SSS Data and Photographs Showing Interpreted Movement of Sonar Contact UD06 (UD07 Presumed to be New Position of Same Contact)



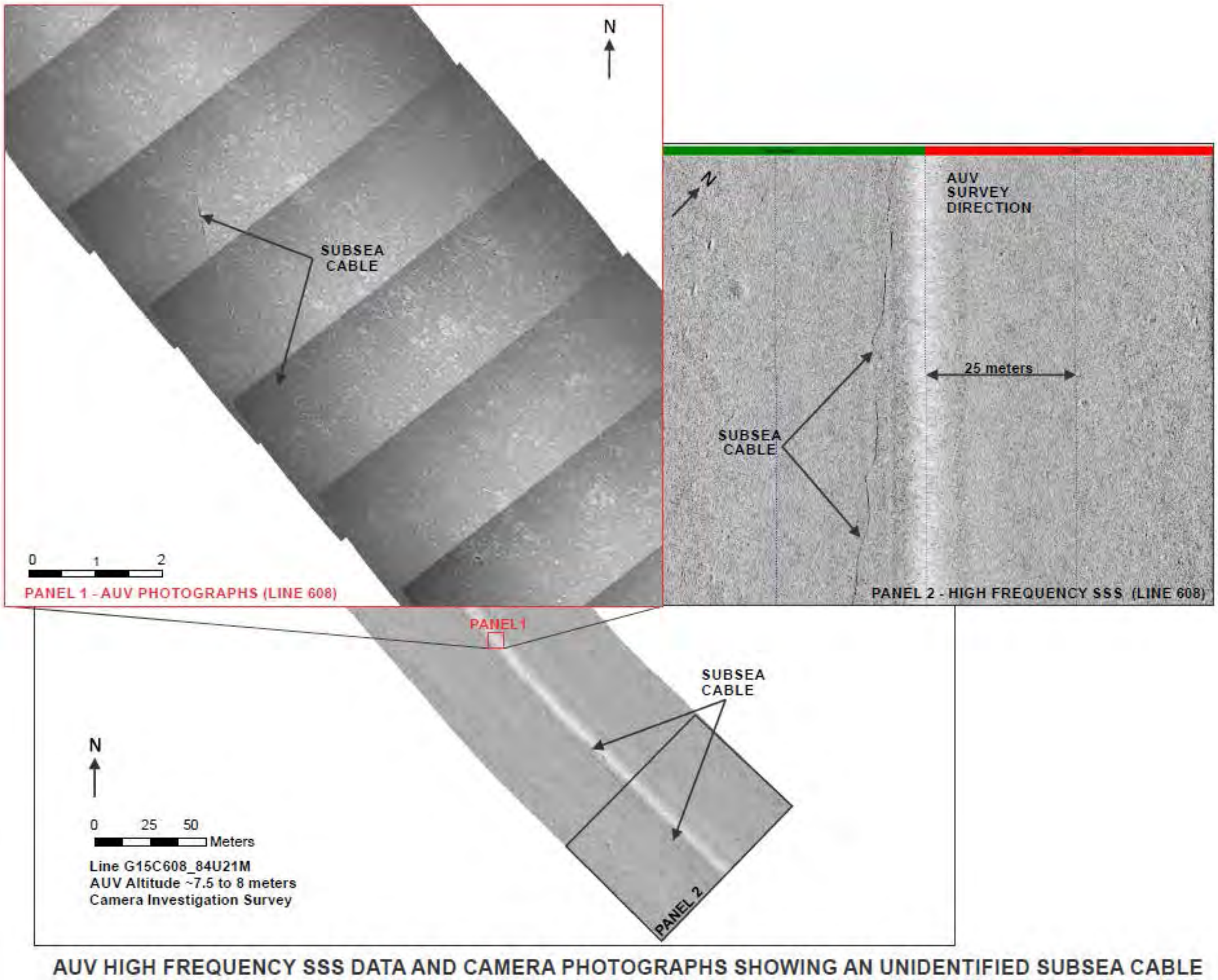
Source: Fugro 2016

Figure 8.7-3: AUV High-Frequency SSS Data and Photograph Showing Sonar Contact UD047 and Corresponding Photograph of Fishing Net



Source: Fugro 2016

Figure 8.7-4: SSS Contacts UD08, UD011, and UD021 Found within the Main AUV Survey Area



Source: Fugro 2016

Figure 8.7-5: AUV High-Frequency SSS Data and Photographs Showing Unidentified Subsea Cable

Remote-sensing efforts in the USOS Survey Area revealed no discernable objects, either geological or manmade in origin, and thus Fugro concluded that there are no cultural concerns for the USOS Survey Area. The Consultants concur with this conclusion.

8.7.2.2. Coastal Cultural Heritage

Maps obtained from the National Trust of Guyana show the presence of several shell mounds, seashell deposits, quarries, and ceramic/pottery sites (i.e., scatters) along the Guyana coast, including archaeological sites found near Moruka, Uitvlugt, Stewartville, and Leonora. These sites are of significant cultural value to both the people of Guyana and researchers, as they offer insight into the material culture of native peoples inhabiting the land before, during, and after contact with Europeans. However, only two of the ceramic/pottery sites on the maps are shown to be located near the shoreline.

As part of the late 2017 and early 2018 Ecosystem Services engagement fieldwork by the Consultants, coastal communities from Regions 1 to 6 were engaged about known archeological sites as well as any locations of cultural significance to each community (e.g., Hindu prayer flag locations, burial and cremation sites). In addition, in the Amerindian coastal communities in Regions 1 and 2, community members were asked about intangible forms of culture heritage along the coast (e.g., cultural knowledge, innovations, and practices of embodying traditional lifestyles). The information on cultural heritage related to this engagement are discussed in Section 8.9.2, Ecosystem Services—Existing Conditions.

8.7.3. Impact Assessment—Cultural Heritage

8.7.3.1. Relevant Project Activities

Planned Project drilling and FPSO/SURF installation activities that have the potential to adversely impact cultural heritage located on or beneath the seafloor include the drilling of development wells, the installation of FPSO anchoring structures, and the installation of SURF components.

Planned Project activities do not require ground-disturbance in onshore areas that have not already been disturbed by prior development. Onshore logistical support will involve use of Guyana port facilities, warehouses, pipe yards, and waste management facilities (e.g., landfills). Use of these facilities will not impact any archaeological sites, as these lands have already been disturbed and therefore are unlikely to contain intact archaeological sites. Any construction/expansion of onshore facilities by others, which could potentially disturb new onshore areas, will be performed by the owners/operators of such facilities, and are outside of the scope of this EIA. In summary, planned Project activities will not impact any terrestrial cultural heritage resources, and the impact assessment in this section thus focuses on potential impacts on marine cultural heritage. Potential impacts on terrestrial (coastal) cultural heritage resources from unplanned events (i.e., an oil spill) are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

Table 8.7-3 summarizes the Project stages and activities that could result in potential Project impacts on marine cultural heritage.

Table 8.7-3: Summary of Relevant Project Activities and Potential Key Impacts—Cultural Heritage

<table>
<tr><th>Stage</th><th>Project Activity</th><th>Key Potential Impact</th></tr>
<tr><td>Development Well Drilling</td><td>Drilling of development wells</td><td rowspan="3">Damage to shipwrecks or submerged archaeological sites</td></tr>
<tr><td rowspan="2">FPSO and SURF Mobilization, Installation, and Hook-up</td><td>Installation of FPSO anchoring structures</td></tr>
<tr><td>Installation of SURF components</td></tr>
</table>

8.7.3.2. Magnitude of Impact—Cultural Heritage

The assessment of the Project's magnitude of potential impacts on cultural heritage in the Project AOI is determined based on consideration of geographic extent, frequency, duration, and scale. The scale of potential impacts on cultural heritage is defined according to the definitions provided in Table 8.7-4.

Table 8.7-4: Definitions for Scale Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Scale	Negligible: No discernible change in the physical condition, setting, or accessibility of sites.
	Small: A small part of a site is lost or damaged, resulting in a loss of scientific or cultural value; setting undergoes temporary or permanent change that has limited impact on the site's perceived value to stakeholders; stakeholder/public or scientific access to the site is temporarily impeded.
	Medium: A significant portion of a site is lost or damaged, resulting in a loss of scientific value; setting undergoes permanent change that permanently diminishes the site's perceived value to stakeholders; site become inaccessible for the life of the Project to stakeholders, including traditional users or researchers.
	Large: Entire site is damaged or lost, resulting in a nearly complete or complete loss of scientific or cultural value; setting is sufficiently impacted to cause the site to lose all, or nearly all, cultural value or functionality; site becomes permanently inaccessible to stakeholders, including traditional users or researchers.

Based on the 2016 geophysical survey described above, the Project will not impact any known underwater cultural heritage. However, previously unrecorded cultural remains, or "chance finds", could be encountered and impacted during Project drilling and installation activities. Underwater chance finds could include shipwrecks and associated artifact scatters that were not identified during the geophysical survey. It is conservatively assumed that the scale of impact on a previously unidentified cultural resource could be as high as **Medium** if seabed-disturbing activities took place in the location of such a resource. If this were to occur, the Project would most likely relocate the SURF component (up to a few meters) to the extent practicable. Given this, and considering the low likelihood that surveys failed to identify significant cultural heritage in the planned disturbance area, the magnitude of impact for drilling and installation stages is considered **Low**.

8.7.3.3. Sensitivity/Importance of Resource

The resource sensitivity/importance ratings for cultural heritage are defined in Table 8.7-5.

Table 8.7-5: Definitions for Sensitivity/Importance Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Sensitivity	Low: Site is not specifically protected under local, national, or international laws or treaties; site can be moved to another location or replaced by a similar site, or is of a type that is common in surrounding region; site has limited or no cultural value to local, national, or international stakeholders; and/or site has limited scientific value or similar information can be obtained at numerous sites.
	Medium: Site is specifically or generally protected by local or national laws, but laws allow for mitigated impacts; site can be moved or replaced, or data and artifacts recovered in consultation with stakeholders; site has considerable cultural value for local and/or national stakeholders; and/or site has substantial scientific value but similar information can be obtained at a limited number of other sites.
	High: Site is protected by local, national, and international laws or treaties; site cannot be moved or replaced without major loss of cultural value; legal status specifically prohibits direct impacts or encroachment on site and/or protection zone; site has substantial value to local, national, and international stakeholders; and/or site has exceptional scientific value and similar site types are rare or non-existent.

Depending on the nature of the specific resources encountered, shipwrecks and/or submerged archaeological sites could be specifically protected by national laws such as Guyana's National Trust Act of 1972, or international conventions such as the 2001 United Nations Educational, Scientific and Cultural Organization Convention on the Protection of the Underwater Cultural Heritage and could possess research and cultural value. For the purpose of this assessment, it was assumed that an as-of-yet unidentified cultural resource could have a sensitivity rating as high as **Medium**.

8.7.3.4. Impact Significance

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential cultural resource impacts during the Drilling or FPSO/SURF Installation stages is rated as **Minor**.

8.7.4. Mitigation Measures—Cultural Heritage

As discussed in Section 8.7.2, Existing Conditions—Cultural Heritage, the planned seabed disturbance area for the Project has been subjected to a geophysical survey to assess the presence of any marine cultural heritage. After reviewing the survey data collected, the Consultants concluded that no resources of significant cultural value are present within the planned seabed disturbance area. This has increased the level of certainty that planned Project activities will not disturb significant cultural heritage.

Nevertheless, as part of the ESMP developed in conjunction with the EIA, EEPGL will adopt a Chance Finds Procedure (approved by Guyana National Trust; ERM/EMC Personal Communication 1), which requires temporary cessation of Project activities in the event of a chance find, assessment of the chance find by a cultural heritage specialist, and the development of a treatment plan for significant chance finds in consultation with the National Trust of Guyana and other cultural heritage stakeholders, as appropriate. The Chance Finds Procedure also addresses monitoring and training requirements.

Considering the implementation of the measures outlined in the Chance Finds Procedure, the scale of impact would be expected to be reduced to **Negligible**, as activities would be adjusted/curtailed upon discovery of a previously unidentified cultural resource. This would reduce the impact significance rating to **Negligible**.

Table 8.7-6 summarizes the assessment of potential pre-mitigation and residual Project impacts on cultural heritage. The significance of impacts was rated based on the general impact assessment methodology described in Chapter 4, Methodology for Preparing the EIA, as well as the cultural heritage-specific methodology described in Sections 8.7.3.1 and 8.7.3.2.

Table 8.7-6: Summary of Pre-Mitigation and Residual Impacts – Cultural Heritage

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Development Well Drilling	Marine cultural heritage—damage from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible
FPSO and SURF Mobilization, Installation, and Hook-up	Marine cultural heritage—damage from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible

8.8. LAND USE

8.8.1. Administrative Framework—Land Use

Table 8.8-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on land use.

Table 8.8-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Land Use

Title	Objective	Relevance to the Project
Legislation		
Town and Country Planning Act (1996) Cap. 20:01.	Provides for the orderly and progressive development of urban and rural lands and the preservation and improvement of amenities pertaining to such development. Development under the Act is restricted to buildings and roadworks incidental to buildings.	Would be relevant if the Project builds commercial, industrial, or residential structures. It would also be relevant for the land use clearance process (within the building permit process) within the Central Housing and Planning Authority.
Policies		
National Land Policy (being developed)	Intended to serve as a guide for sustainable and equitable use of land for development by assisting in the management of both public and private lands under the purview of the Guyana Lands and Surveys Commission.	Will likely not be directly relevant to the Project as it is still in draft and also does not cover the marine environment.

8.8.2. Existing Conditions—Land Use

Guyana is divided into the following four main geographic zones:

- The low-lying coastal plain, occupying about 5 percent of the country's land area. This zone stretches 440 kilometers (273 miles) from the Corentyne River in the east to Waini Point in the west and ranges from approximately 5 to 65 kilometers (approximately 3 to 40 miles) wide along the coast.
- The "white sand belt," a largely vegetated zone dominated by white, sandy soils lying inland from the coastal zone. This zone ranges from approximately 150 to 250 kilometers (approximately 93 to 155 miles) wide and contains most of the country's mineral deposits.
- The interior highlands, extending from the white sand belt to the country's southern borders. This zone makes up the largest land area in the country.
- The Interior Savannahs, which consist of two main savannah complexes: the Rupununi Savannahs and the Intermediate Savannahs. The Rupununi Savannahs cover 15,540 square kilometers (km^2) (6,000 square miles [mi^2]) and lie in the southwestern part of the country. The Intermediate Savannahs cover over 5,180 km2 (2,000 mi^2) and lie 97 kilometers (60 miles) from the mouth of the Berbice River.

As described above, Guyana is a sparsely populated country, with the majority of the population concentrated in the coastal plain region. In 2012, the area considered as agricultural lands in Guyana was 1,678,000 hectares (4,146,000 acres), with the cultivated area estimated at 448,000 hectares (1,107,000 acres). Most of the cultivated land is also concentrated in the coastal plain, where the majority of the population resides (FAO 2015). Figure 8.8-1 shows land cover in the coastal and white sand belt areas. In the coastal plain areas, cultivated areas are evident in Regions 2, 3, 4, 5, and 6 (southeast of SBPA) and occur to a lesser extent in Region 1 (including SBPA). The landscape in these areas is dominated by sugar, rice, and coconut plantations, interspersed with smaller-scale establishments of cash crops, non-traditional crops, and livestock.

The SBPA is a notable feature in the coastal area. It was designated a Protected Area with the passage of the Protected Areas Act of 2011, and is the only Protected Area on Guyana's coast. More information on the SBPA is provided in Section 7.2.2, Existing Conditions—Coastal Habitats.

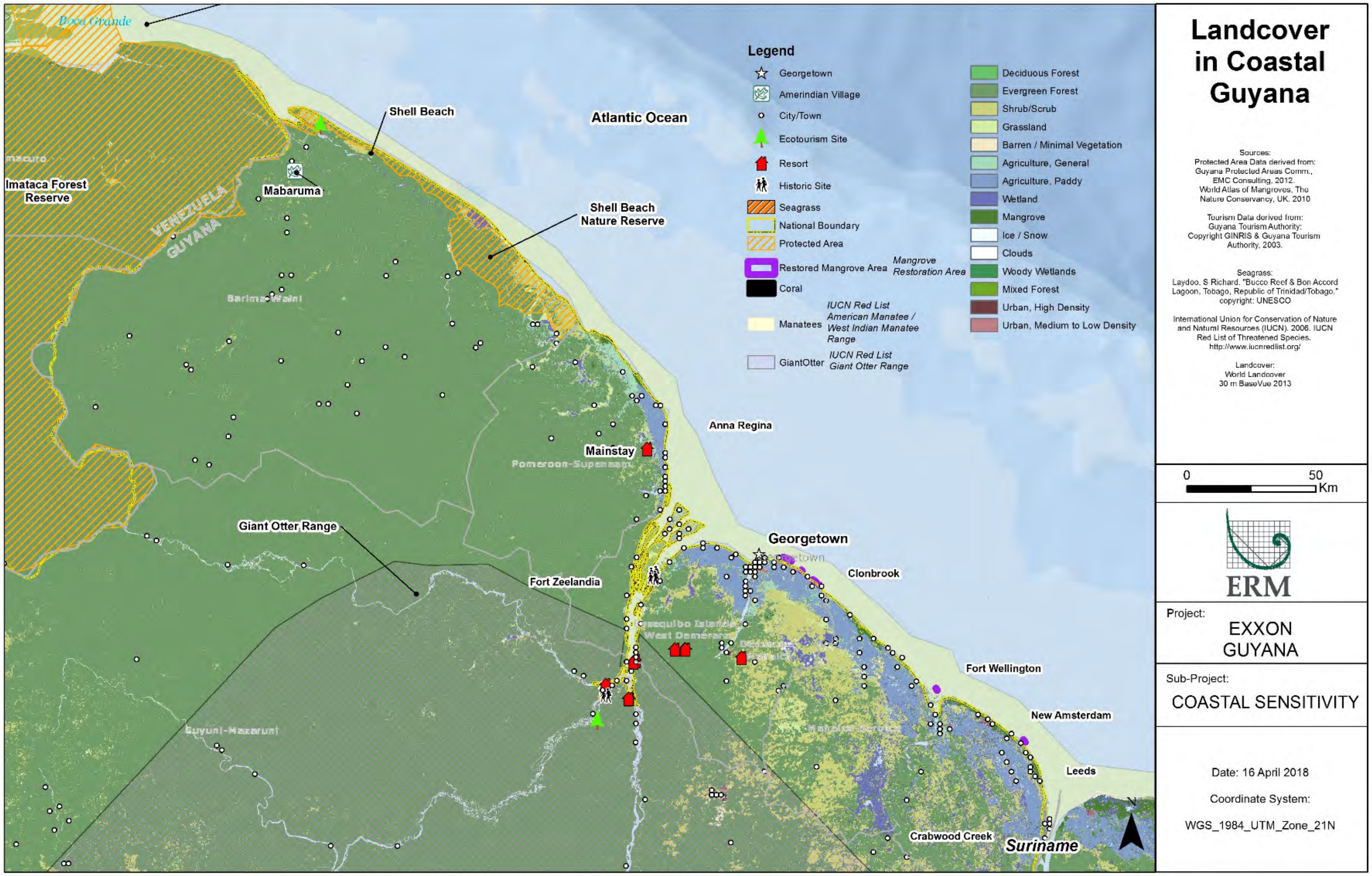


Figure 8.8-1: Land Cover in Coastal Guyana

8.8.2.1. Land Ownership

Land in Guyana today is approximately 85 percent government-owned, approximately 14 percent Amerindian-owned, and 1 to 2 percent privately owned. There are two land markets: one consisting of freehold properties and one consisting of the lease of state-owned land. Amerindian lands are owned collectively and are not subject to transfer or sale. Approximately half of the farms in the coastal area are freehold properties (owned by the land user, not leased) and these tend to be small properties of 5 to 15 acres each (Government of Guyana 1997). Leases of government-owned lands are issued by the Guyana Lands and Surveys Commission or other designated authorities.

According to a study of the land registration system in Guyana conducted by the IDB, the country's dual property registration systems (title registration and deed registration) have regulations that overlap and conflict, and are considered complex and bureaucratic. The systems are also considered ineffective in managing and enforcing rights. As a result, a large number of land owners do not register their properties or do not keep their ownership rights up to date (IDB 2010).

8.8.3. Impact Assessment—Land Use

This section assesses potential Project impacts on land use and ownership. The key potential impacts considered are conversion of land from one use to another and change of land ownership type.

8.8.3.1. Relevant Project Activities and Potential Impacts

The majority of the Project's activities will occur offshore. Most of the major SURF equipment will be preassembled, pretested, and shipped directly to the Liza Phase 2 PDA from their points of origin. Other minor equipment, supplies, and materials may be temporarily staged at shorebase(s), laydown yards, and warehouses until transferred offshore for installation or use. Onshore facilities will not be owned or operated by EEPGL, and they will not be dedicated to the Project. If the owners/operators of such facilities find it necessary to expand the existing sites onto adjacent land or in separate, new areas, potential land use impacts associated with these expansions will be addressed by the owners/operators of such facilities, and would be out of the scope of this EIA.

Table 8.8-2 summarizes the Project stages and activities that could result in potential Project impacts on land use, as well as the receptors that could potentially experience these impacts.

Table 8.8-2: Summary of Relevant Project Activities and Key Potential Impacts—Land Use

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Current owner(s) and/or user(s) of land in Georgetown	Use of land for onshore Project-related activities	Conversion of land from other use(s) Change of land ownership

8.8.3.2. Magnitude of Impact—Land Use

The assessment of the Project's magnitude of potential impacts on land use is based on consideration of geographic extent, frequency, duration, and scale. The scale of potential impacts on land use is defined in Table 8.8-3.

Table 8.8-3: Definitions for Scale Ratings for Potential Impacts on Land Use

Criterion	Definition
Scale	Negligible: No change in land use type or ownership type.
	Small: Land use change occurs for one or multiple parcels, but consists of change to a land use type similar to the current use (e.g., change from one type of agricultural activity to another or from industrial to commercial). No changes occur in ownership type (government-owned, Amerindian-owned or privately owned).
	Medium: Land use changes occur for multiple land parcels or tracts and may consist of profound changes (e.g., clearing of forest or other vegetation, loss of residential units). Changes to ownership type (government-owned, Amerindian-owned or privately owned) do not occur.
	Large: Land use changes occur for large areas of land and may consist of profound changes (e.g., clearing of forest or other vegetation, loss of residential units). Changes may occur to ownership type.

The Project will require the use of onshore storage facilities and laydown areas for Project materials (e.g., drilling fluid, pipe joints). At this time, EEPGL plans to use the existing Guyana shorebase(s) to support the Project in a non-dedicated manner. Other potential storage facility locations are not known, but it is expected that any such facility will be located as near to the existing shorebase(s) as reasonably practicable to minimize hauling time. Although EEPGL is planning to use an existing waste management facility in Georgetown (permitted by EPA), alternative Guyanese or regional waste management services may also be considered in the future.

Given that the storage, laydown, and waste management facilities will likely be located in an industrial area, as is the case with the Guyana shorebase(s) and existing Georgetown waste management facility, rather than an undeveloped, residential, or agricultural area, it is not expected that major changes in land use types, or any change in land ownership type, will occur. The magnitude of potential impact is therefore considered to be **Negligible**.

8.8.3.3. Sensitivity of Receptors—Land Use

If the Project was intending to convert land use or change land ownership, receptors for this potential impact would be the current owner(s) of the land to be used for onshore Project-related activities, as well as the user(s) or beneficiaries of that land, if any. In this case, the receptor sensitivity ratings for land use would be determined as defined in Table 8.8-4.

Table 8.8-4: Definitions for Receptor Sensitivity Ratings for Potential Impacts on Land Use

Criterion	Definition
Sensitivity	Low: Receptor(s) do not currently reside on the land or make use of it for subsistence or primary livelihood activities, or recreation.
	Medium: Receptor(s) do not currently reside on the land or make use of it for subsistence but may rely on it for income generation or recreation.
	High: Receptor(s) currently reside on the land and/or use it for subsistence, or for their primary/sole means of livelihood.

At this time, EEPGL does not intend to convert land use or change land ownership as part of the Project. Accordingly, it is not relevant to assign a receptor sensitivity for a potentially impacted land user/owner.

8.8.3.4. Impact Significance—Land Use

Based on the magnitude of potential impact (irrespective of a potential receptor sensitivity rating), the significance of potential land use impacts is rated as **Negligible**.

8.8.4. Mitigation Measures—Land Use

Table 8.8-5 summarizes the assessment of potential pre-mitigation and residual Project impacts on land use. The significance of potential impacts was assessed based on the impact assessment methodology described in Chapter 4, Methodology for Preparing the EIA, as well as the land use-specific methodology described in Section 8.8.3.2.

Table 8.8-5: Summary of Potential Pre-Mitigation and Residual Impacts – Land Use

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Current owner(s) or user(s) of land – conversion of land use or change in land ownership	Negligible	Not rated	Negligible	None	Negligible

8.9. Ecosystem Services

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment. Ecosystem services are divided into provisioning, regulating, cultural, and supporting services, as defined below (Millennium Ecosystem Assessment 2005):

- **Provisioning services**: goods or products obtained from ecosystems such as food, freshwater, timber, fiber, and other goods;
- **Regulating services**: benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards;
- **Cultural services**: non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment; and
- **Supporting services**: natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

8.9.1. Administrative Framework—Ecosystem Services

Table 8.9-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on ecosystem services.

Table 8.9-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Ecosystem Services

Title	Objective	Relevance to the Project
Legislation		
Forests Act (2009) Act. No. 6 of 2009	Consolidates the law relating to forests and makes provisions for sustainable forest management and forest conservation.	Covers mangroves, which are classified as a forest type and subject to protection measures under the Act. Mangrove ecosystem makes up a significant portion of Guyana's coastal zone, and could potentially be affected in the unlikely event of an oil spill event which reaches the shore.
Sea Defence Act (1933)	Makes provisions for the construction, maintenance and protection of sea defenses, which includes manmade structures as well as natural defenses.	Covers the protection of mangroves, including fines and penalties for the unpermitted destruction of mangroves. Relevant to the Project in the unlikely event of an oil spill reaching the shore and causing mangrove damage.
Protected Areas Act (2011)	Provides for the protection and conservation of Guyana's natural heritage and natural capital by the creation, management, and financing of a national system of protected areas; the maintenance of ecosystem services of national and global importance, including of climate regulation; the establishment of a protected areas commission; the establishment and management of a protected areas trust fund; and the fulfilment of Guyana's international environmental responsibilities.	Under this Act, terrestrial and marine protected areas could be established. However, currently there are no known initiatives towards setting up marine protected areas.

Title	**Objective**	**Relevance to the Project**
Environmental Protection Act (1996)	Provides for the management, conservation, protection, and improvement of the environment; the prevention or control of pollution; the assessment of the impact of economic development on the environment; and the sustainable use of natural resources.	As part of its mandate, in addition to environmental permitting, the EPA also has the responsibility of coordinating Integrated Coastal Zone Management (ICZM) and implementing the ICZM Plan, which has provisions for shorezone monitoring, mangrove management, aerial photography, etc. Data from the Project EIA, such as the ecosystem services-related information, could support the enhancement of the ICZM Plan.
International Agreements Signed/Acceded by Guyana		
Bilateral Agreement between Guyana and the Kingdom of Norway (2009)	Supports Guyana's efforts at moving towards a low-carbon, climate resilient economy by establishing a mechanism for payment for forest climate services, whereby Guyana receives performance-based payments for avoided deforestation.	Has no direct relevance to the Project since the agreement does not place a cap on Guyana's development aspirations or the extraction and/or use of fossil fuel resources.
United Nations Convention on Biological Diversity (1992)	Objectives are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including appropriate access to genetic resources and appropriate transfer of relevant technologies, considering all rights over those resources and technologies, and by appropriate funding.	In fulfilling obligations under this Convention, Guyana has enacted Protected Areas legislation and established a National System of Protected Areas, which includes the SBPA. Under normal circumstances and operations, the Project will not have any impacts on Guyana's protected areas. However, in the unlikely event of an oil spill that reaches the shores of Guyana, the SBPA could be affected. One of the requirements is the setting up of marine protected areas. However, at this time there is no decision to proceed in this direction.

8.9.2. Existing Conditions—Ecosystem Services

In late 2017 and early 2018, a field team consisting of socioeconomic and biodiversity experts conducted an Ecosystem Services Screening and Scoping exercise involving all 63 coastal NDCs, CDCs, and Town Councils in Regions 1 through 6 (see Section 8.1.2.1, Administrative Divisions in Guyana, for a list of the NDCs, CDCs, and Town Councils). The purpose of the exercise was to identify the ecosystem services that are potentially present along the coastline and shore zones in Regions 1 to 6 using Community-based Participatory Research and traditional knowledge. The team interviewed more than 300 neighborhood and village council members about the relationship between people and the environment along the shore zones, and the locations of specific ecosystems services. Representatives from the groups of interviewees then aided the team in field-verifying the locations of the services and mapping the information in the Liza Project Geographic Information System database.

The team used a screening checklist to determine whether a service was likely to be present or not in each coastal or shore zone. For a service to be considered present, it needed to meet two criteria:

- Habitats present in the study area (immediate coastal area throughout Regions 1 through 6, up to a distance of 500 meters from the shoreline) are believed to provide the service or are similar to habitats elsewhere that provide the service; and
- People are believed to benefit from the service, either at the local, national, or global level.

Following completion of the screening exercise, the team, including members of the neighborhood and village councils, along with local community members, used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This scoping step aimed to:

- Establish a list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify and map the habitats and resources that provide ecosystem services in the study area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The screening and scoping information provided an ecosystem services baseline, which revealed that the marine and coastal environments in Guyana provide all four categories of ecosystem services, some of which are critical for the wellbeing and livelihoods of coastal communities. These are described by category and by region below.

8.9.2.1. Provisioning Services

As described above, marine fishing for various species of fish and shellfish is a vital source of protein and income to coastal communities. In coastal areas, especially in Regions 5 and 6, nearshore inland fishing and shrimping is also significant. Agriculture is also prevalent along the coastal areas in all regions, including cultivated coconuts, cash crops and livestock grazing. Some communities in the coastal area (particularly Amerindian communities in Region 1) harvest a range of naturally occurring resources for household use and sale. This includes manicole (heart of palm), mangrove bark and wood, timber, medicinal plants, and crabwood seeds that are processed to make crabwood oil. In addition, trapping and hunting of local wildlife is also practiced. Throughout the coastal areas, the waterways facilitate transportation and trade, and in some situations are the only means of transportation available, especially in Region 1 and between Regions 2 and 3.

Based on the findings of the ecosystem services assessment exercise, provisioning services are the primary service provided by the coastal ecosystem throughout all regions, accounting for 68.8 percent of the location-specific services identified in all six regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants; and
- Animals hunted primarily for food.

8.9.2.2. Cultural Services

Cultural services were the second-most prevalent ecosystem service, representing 19.9 percent of the location-specific services identified in the six regions. The most common cultural services identified include:

- Cultural value placed on traditional practices, such as use of a location for prayer services (primarily in Regions 2–6).
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing, picnicking, games, etc.; and
- Value placed on the aesthetics provided by landscapes and seascapes.

As mentioned above, throughout Guyana's populated coastal regions in Regions 2–6, the seashore is often used in religious Hindu funeral and cleansing ceremonies. The Hindu community in Guyana has a number of crematoriums along the coast, and ashes are disposed in the ocean as part of funeral ceremonies. In addition, prayer and bathing ceremonies are performed informally by members of the Hindu community year around, but especially during the holy festival of Kartik Snan, which occurs in October or November each year (ERM Personal Communication 12; ERM/EMC 2018).

In Region 1, the SBPA has high aesthetic and educational value and potential for ecotourism due to its importance as a marine turtle nesting area, even though infrastructure in the area is not well developed and tourism activity is limited.

8.9.2.3. Regulating Services

Regulating services represented 10.0 percent of the location-specific services identified in the six regions. The most common regulating services identified include:

- Shoreline and riverbank protection and the role of mangroves in protecting crops, buildings, and recreation areas from waves, wind, and flooding; and
- Erosion protection and the role of vegetation in regulating erosion on slopes.

Guyana's coastal plain is vulnerable to coastal flooding due to its low elevation, and mangrove forests, with their dense root systems, are an important component of the country's natural and manmade sea defense system. Mangroves also filter sediments, protecting sensitive seagrass beds from being smothered.

8.9.2.4. Supporting Services

Mangrove forests along the coast play an active role in nutrient cycling and act as nurseries for ecologically and commercially important fish and shellfish species. Mangrove and other coastal ecosystems, such as brackish lagoons, brackish herbaceous swamps, and swamp forests, also provide habitat for a diversity of flora and fauna, including those with tourism value and potential, such as migratory shorebirds (WWF 2016).

Supporting services are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. The service "habitat provision" is typically an exception, which is sometimes valued as an "end-use" service by stakeholders in addition to its supporting role. Therefore, the relatively low prevalence of identified supporting services, representing 1.3 percent of the location-specific services identified for the six regions, is not atypical; the services identified relate primarily to the fact that some stakeholders value mangroves for their maintenance of species populations and their ability to allow ecological communities to recover from disturbances, in addition to their regulating role of shoreline protection.

Figure 8.9-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories.

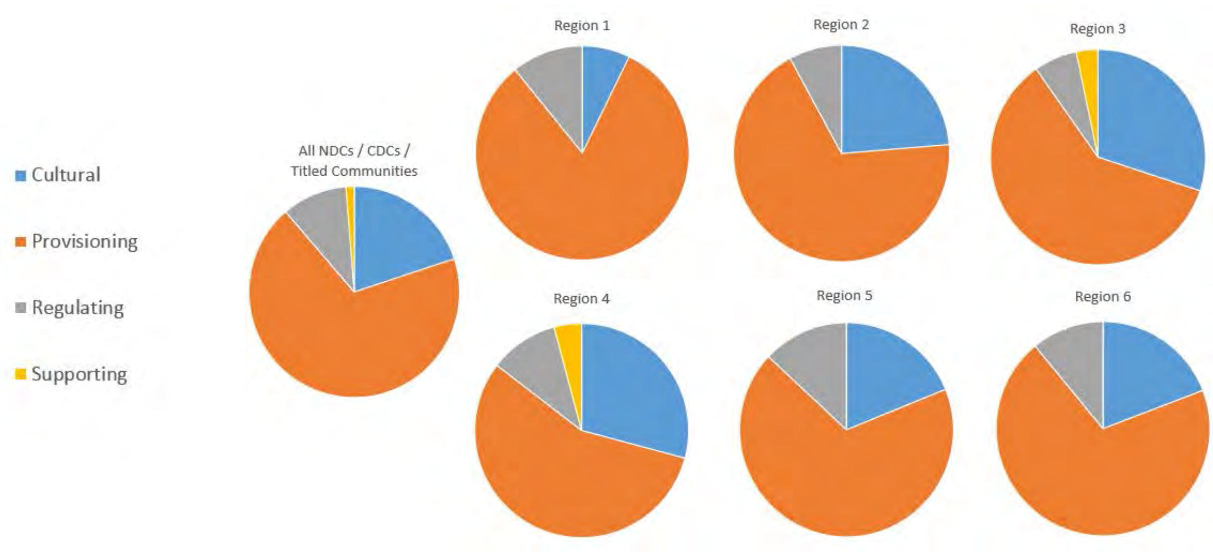


Figure 8.9-1: Distribution of Ecosystem Service Categories

After establishing the ecosystem services baseline, the Millennium Ecosystem Assessment 2005 methodology then calls for an ecosystem services prioritization, which has been designed to be consistent with international best practice, using the 2012 IFC Performance Standards as guidance (IFC 2012). The prioritization process focuses on identifying services that are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

- **Importance of ecosystem services:** Importance to beneficiaries was assessed according to the following criteria and assigned one of four ratings from *low* to *essential* based on:
  - Intensity of use (e.g., daily, weekly or seasonal use); quantitative data were used if available and relevant;
  - Scope of use (e.g., household versus community level, commercial use only, subsistence only or both);
  - Degree of dependence (e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community); and
  - The importance expressed by stakeholders and beneficiaries, including cultural and historical importance.

  Determining the importance rating includes quantitative elements (intensity, scope, and degree); however, the actual importance expressed by stakeholders and beneficiaries takes precedence over other criteria. (For example, if trapping appeared to occur at a location on a monthly basis for subsistence by a few villagers in a community, it may be rated as low. However, if various beneficiaries and stakeholders claimed that trapping was of greater importance, the rating would be moderate.) Where a service was of greater or lesser importance to different beneficiary groups, two (or more) ratings were assigned so that impacts on these groups could be assessed individually.

- **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The “replaceability” of a service was assessed according to the following criteria and assigned one of three ratings from *high* (many alternatives) to *low* (few or no alternatives):
  - The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and manmade substitutes (e.g., availability of manmade items as an alternative to handicrafts);
  - The accessibility, cost, and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
  - Preference / appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign an overall priority rating to the service (see Table 8.9-2). Ecosystem services with *high* or *critical* priority ratings are considered to be “priority” ecosystem services. As noted above, some services may have different importance ratings for different beneficiary groups, and therefore may be rated priority services for some beneficiaries but not for others.

Figure 8.9-2 summarizes the distribution of specific ecosystem service types depending upon priority ranking.

Table 8.9-2: Assigning a Priority Rating to Ecosystem Services

		Replaceability of Service		
		High (many spatial alternatives)	**Moderate** (some spatial alternatives)	**Low or Not Replaceable** (few to no spatial alternatives)
Importance of Service to Beneficiaries	Essential	High	Critical	Critical
	High	Medium	High	Critical
	Moderate	Low	Medium	High
	Low	Low	Low	Medium

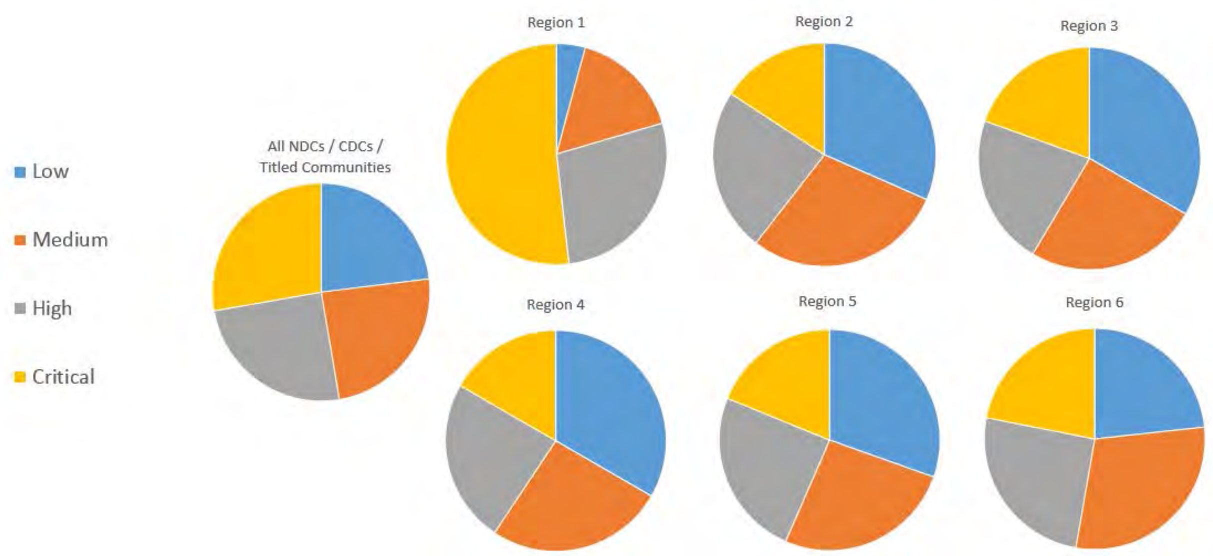


Figure 8.9-2: Distribution of Ecosystem Service Priorities

8.9.2.5. Summary of Findings by Region

As one of the primary goals of the baseline study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 1–6, the ratings vary depending on the responses from each neighborhood or village council. For example, in one council in Region 2, livestock farming along the coastal wall was reported to be low priority, whereas in an adjacent council, the same service was considered a critical priority, since a larger number of families rely on the livestock and there are no other locations for livestock to graze. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figures 8.9-3 to 8.9-10 show how the ecosystem type and priority are depicted in the Liza Project Geographic Information System database. These maps also provide a visual representation along the coastline for all ecosystem services type and priority rankings. The figures show the ecosystem service locations, by type, identified by the interviewees during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology described above. In the case of Region 1, Figure 8.9-4 shows the ecosystem service "general areas," by type, identified by Region 1 village leaders and villagers during the engagement process. The mapping to show general areas is provided for only Region 1 due to the fact that some areas identified by village leaders and villagers could not be field-verified (based on limitations to access along the SBPA and Region 1 coast). The general areas are intended to provide additional context for the location of ecosystem services in the region.

Table 8.9-3 summarizes the highest priority rating assigned in each region for each ecosystem service.

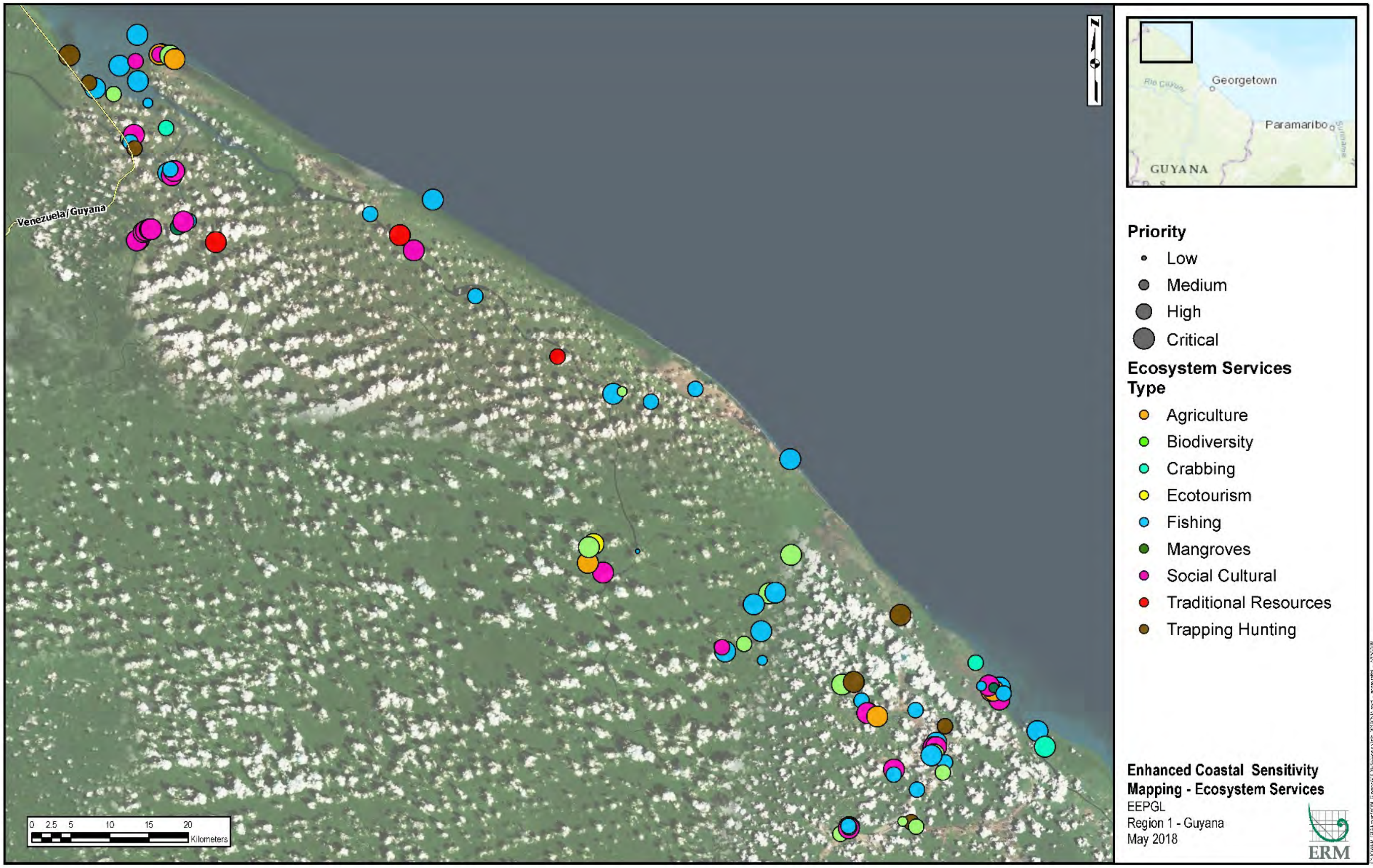


Figure 8.9-3: Region 1 Identified Locations of Ecosystem Services

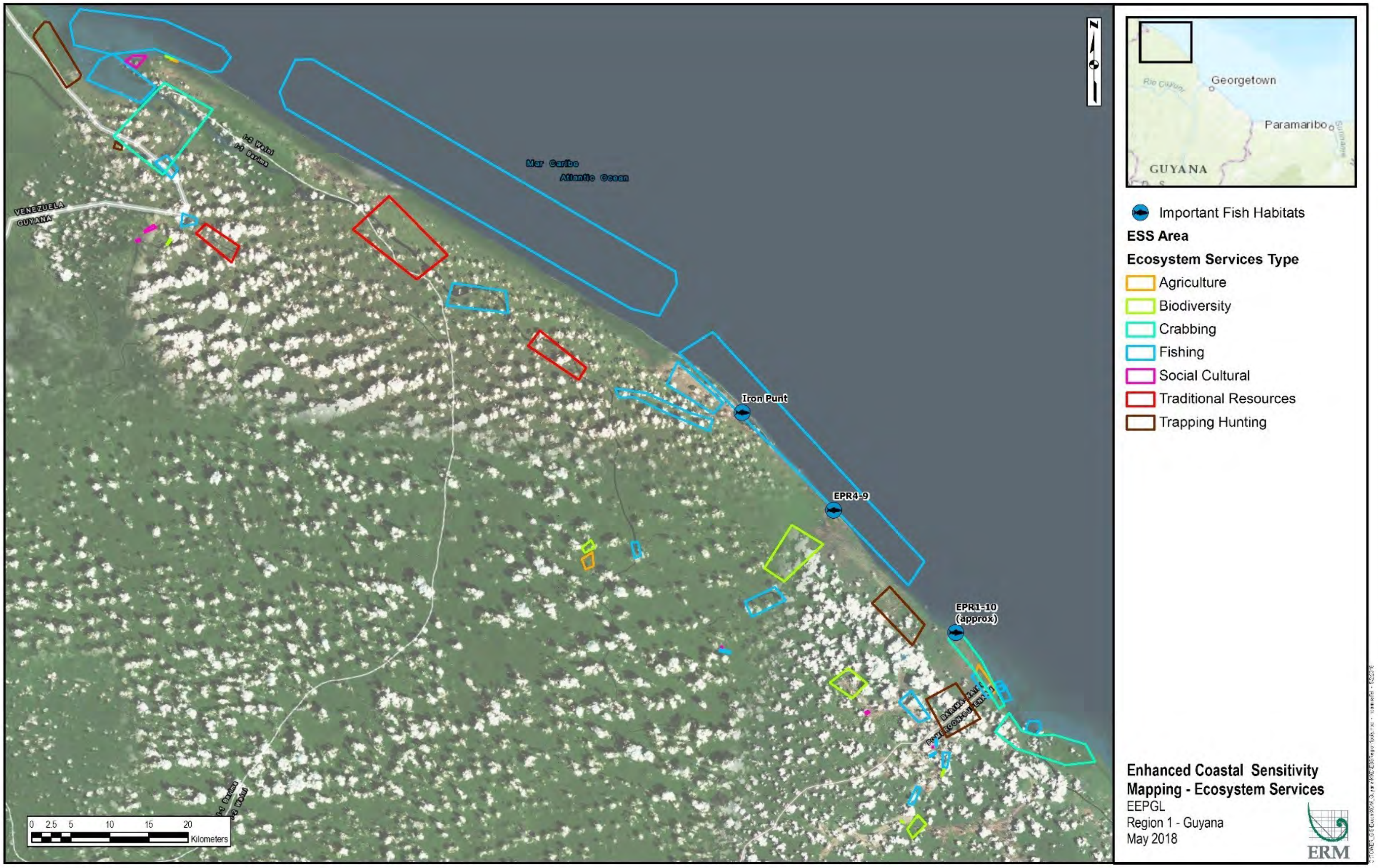


Figure 8.9-4: Region 1 Identified General Areas of Ecosystem Services

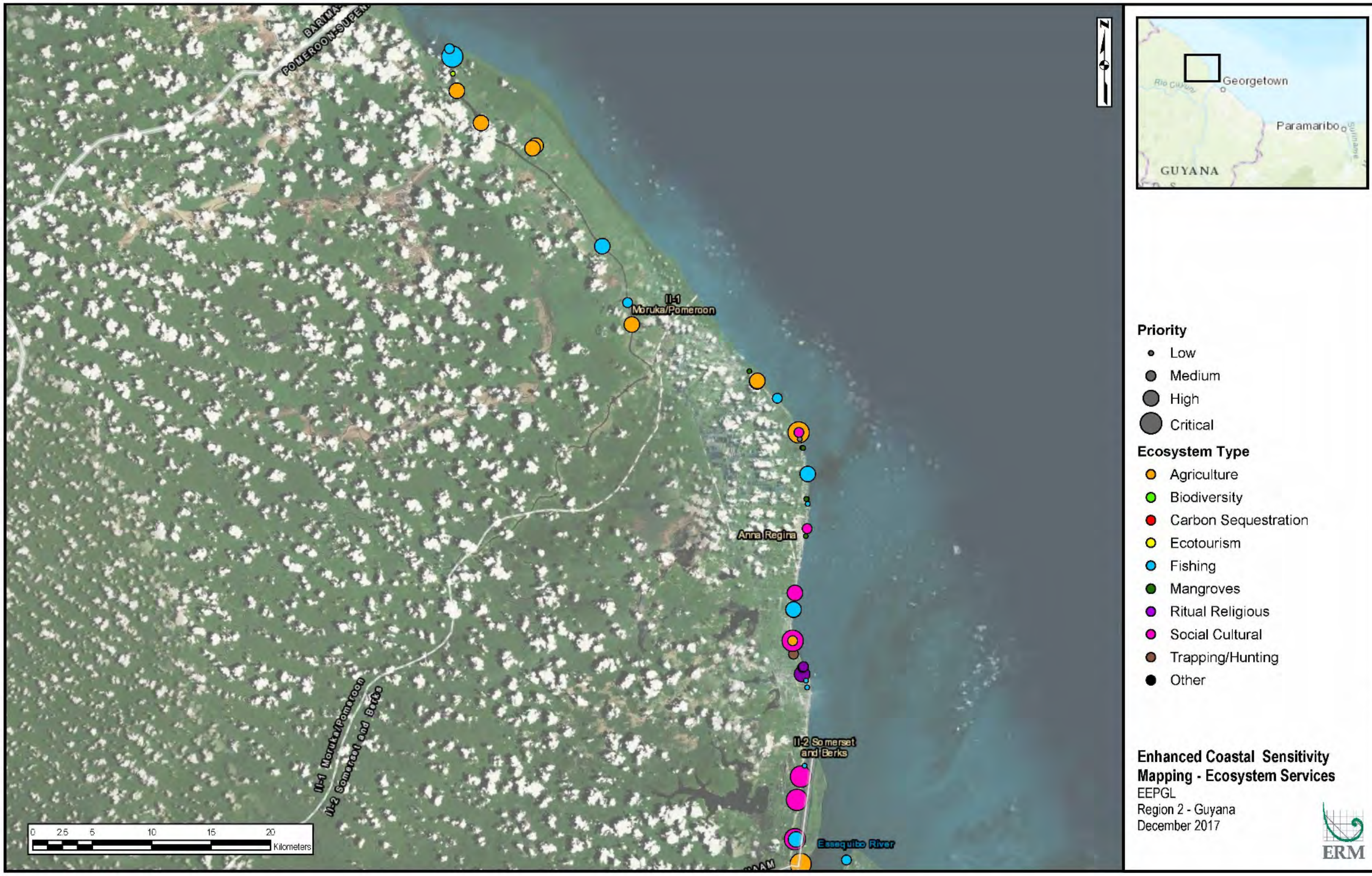


Figure 8.9-5: Region 2 Identified Locations of Ecosystem Services

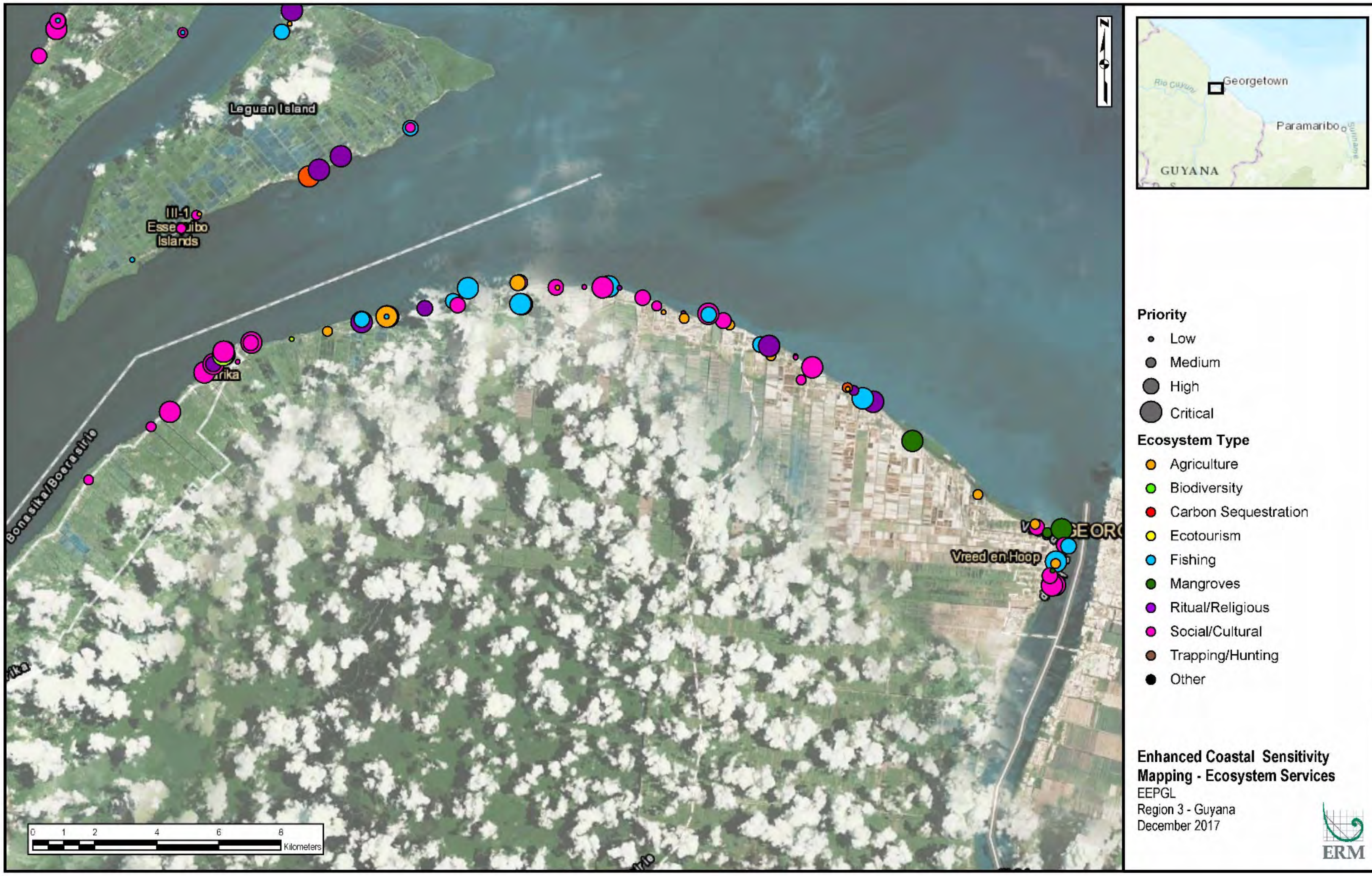


Figure 8.9-6: Region 3 Identified Locations of Ecosystem Services

Figure 8.9-7: Region 3 Islands Identified Locations of Ecosystem Services

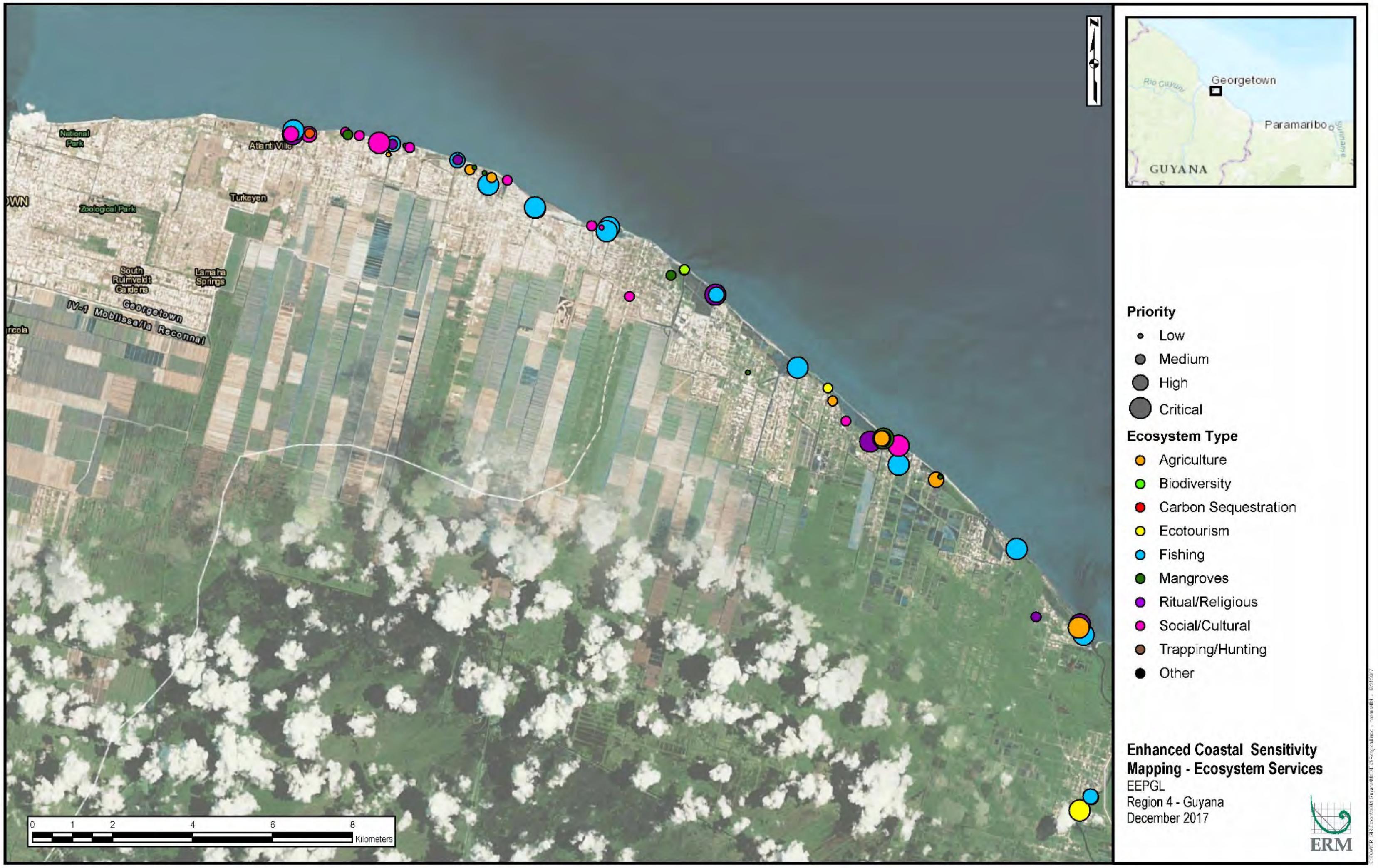


Figure 8.9-8: Region 4 Identified Locations of Ecosystem Services

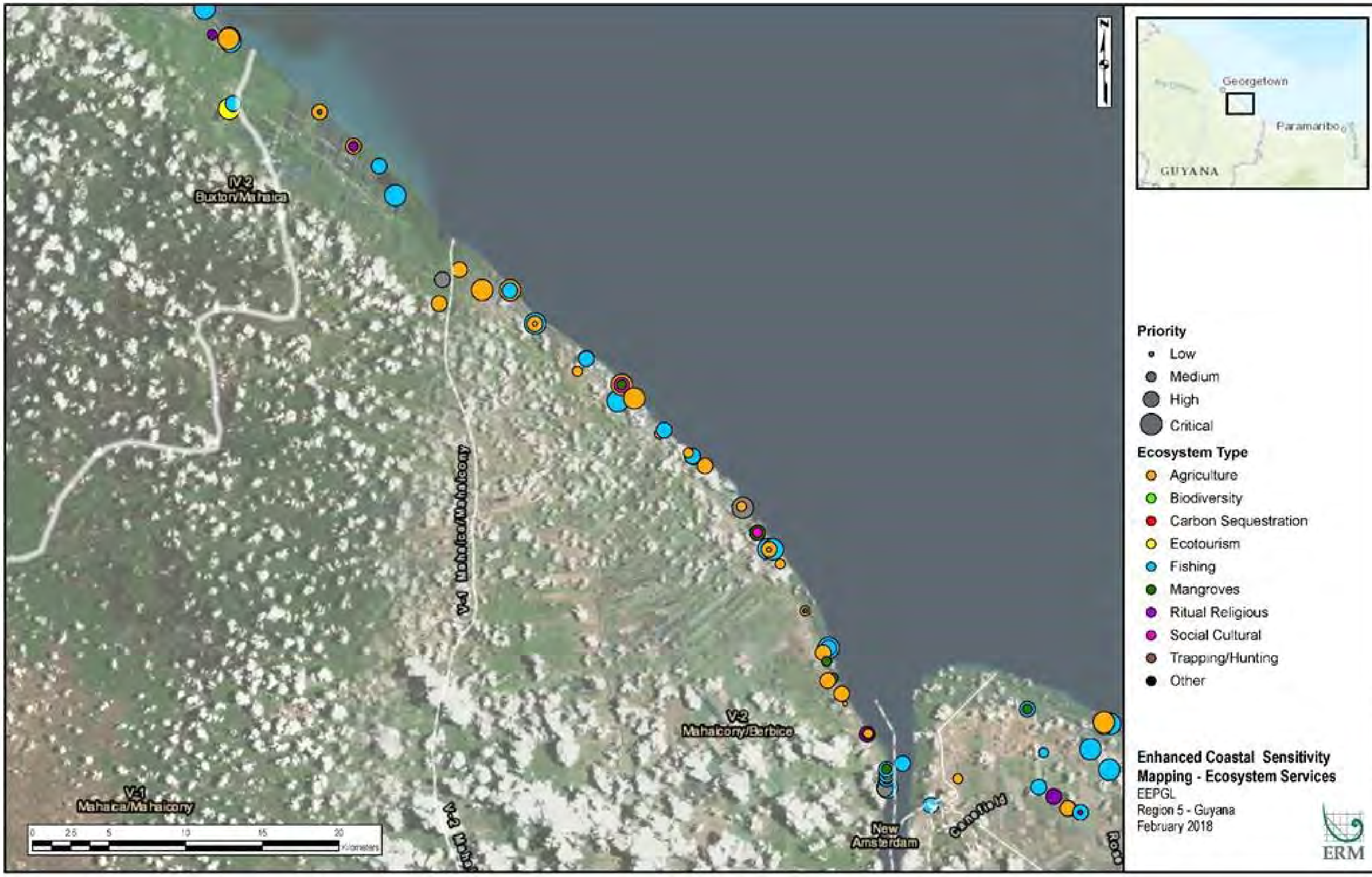


Figure 8.9-9: Region 5 Identified Locations of Ecosystem Services

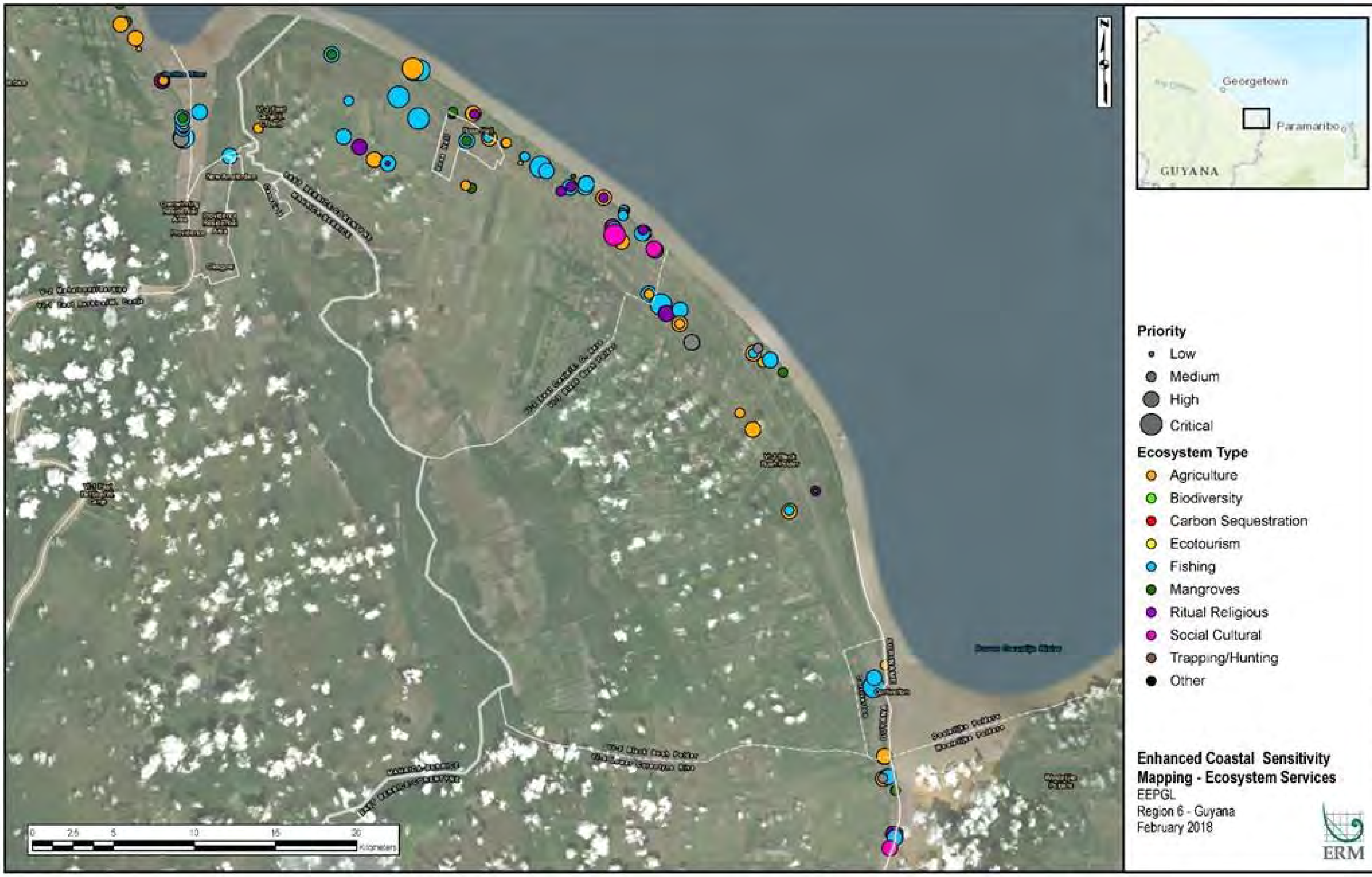


Figure 8.9-10: Region 6 Identified Locations of Ecosystem Services

Table 8.9-3: Highest Ecosystem Service Priority Ratings for each Region

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4
Provisioning Services				
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Critical	Critical	Critical	Critical
Cultivated crops	Critical	Critical	High	High
Livestock farming	Low	High	Medium	High
Food: wild plants and honey	Medium	NA	NA	Medium
Food: wild meat	High	Medium	Low	Medium
Biomass fuel	Low	NA	Medium	Low
Timber and wood products	Medium	NA	Low	Low
Non-wood fibers and resins	NA	NA	Low	NA
Traditional Resource Use/ Traditional Medicine	High	NA	NA	NA
Freshwater for household use	Critical	NA	High	NA
Freshwater for irrigation use	NA	NA	Critical	NA
Aquatic transportation/ports	Critical	Critical	Critical	Critical
Social/Economic commercial activity	Critical	Medium	Critical	High
Social/Housing	High	NA	High	High
Regulating Services				
Global climate regulation	NA	NA	NA	NA
Regulation of water timing and flows	NA	NA	NA	NA
Flood regulation	NA	NA	NA	NA
Erosion regulation	Critical	Critical	Critical	Critical
Shoreline protection / Mangroves / River defense	Critical	High	Medium	High
Pest regulation	NA	NA	NA	NA
Pollination	NA	NA	Medium	Medium
Disease regulation	NA	NA	NA	NA
Cultural Services				
Cultural, religious, or spiritual value	Medium	Medium	High	High
Aesthetic value of natural landscapes, historical landmarks	Low	Medium	Low	High
Tourism and recreation	High	High	Critical	Critical
Non-use value of biodiversity	NA	NA	Low	NA
Supporting Services				
Habitat provision, coastal protection	Critical	NA	Critical	Medium
Primary production, biodiversity	Critical	NA	Critical	NA
Nutrient cycling	NA	NA	NA	NA
Water cycling	NA	NA	NA	NA
Soil formation	NA	NA	NA	NA

NA = not applicable as not deemed present or valuable by beneficiaries or stakeholders during screening and scoping exercises

8.9.3. Impact Assessment—Ecosystem Services

Although the planned Project activities will have potential minor impacts on water quality, benthic communities, and marine wildlife, these potential impacts are not expected to significantly impact offshore ecosystem services[12]. Specifically, the Project's planned offshore activities are not expected to impact the processes that regulate the physico-chemical attributes of the North Brazil Shelf Large Marine Ecosystem (LME) as a whole (e.g., water quality, currents, oceanographic conditions, bathymetry), nor are they expected to cause significant impacts on fishery production offshore Guyana.

The only potential impacts from planned Project activities in nearshore marine waters will be those related to an incremental increase in ship traffic in and out of Georgetown Harbour as ships transit between the shorebase(s) and the PDA. This incremental increase is not expected to result in an impact to marine fish that would lead to any significant impacts on the availability of marine fish as an ecosystem service. Therefore, it is concluded that the Project's planned activities will have no impacts on ecosystem services provided by the nearshore marine ecosystem.

The planned Project activities will not involve any direct disturbance of coastal habitats and the Project's air emissions, water discharges, and sound generation, all of which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not result in significant impacts on these habitats. Project use of the Guyana shorebase(s) and onshore support facilities will have no impact on ecosystem services.

The Project's potential impacts on ecosystem services as a result of an unplanned event are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events.

8.9.4. Mitigation Measures—Ecosystem Services

As there are no potential impacts on ecosystem services as a result of planned Project activities, no mitigation measures are proposed.

8.10. INDIGENOUS PEOPLES

8.10.1. Administrative Framework—Indigenous Peoples

Table 8.10-1 summarizes the legislation, policies, treaty commitments, and industry practices that are specifically relevant to the assessment of potential impacts on indigenous peoples.

[12] Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities, and provide cultural fulfilment.

Table 8.10-1: Legislation, Policies, Treaty Commitments, and Industry Practices—Indigenous Peoples

Title	Objective	Relevance to the Project
Legislation		
Amerindian Act (2006) Cap. 29:01.	Provides for the recognition and protection of the collective rights of Amerindian villages and communities, the granting of lands to Amerindian villages and communities, and the promotion of good governance with Amerindian villages and communities.	Within the broad context of protection of the collective rights of Amerindian villages, this could include the right of use of coastal resources for traditional and subsistence activities, which could be affected in the unlikely event of an oil spill from the Project.
International Agreements Signed/Acceded by Guyana		
United Nations Declaration on the Rights of Indigenous Peoples (2007)	A comprehensive statement addressing the rights of indigenous peoples. It emphasizes the rights of indigenous peoples to maintain and strengthen their own institutions, cultures, and traditions and to pursue their development in keeping with their own needs and aspirations. Further, it addresses both individual and collective rights, cultural rights and identity, rights to education, health, employment, and language, among others.	Aligning with these declarations commits Guyana to complying with the relevant provisions. As it regards the Project, these would include engagements with indigenous peoples and also taking necessary measures to ensure protection of the environment.
American Declaration on the Rights of Indigenous Peoples (Organisation of American States) (2016)	Offers specific protection for indigenous peoples in North America, Mexico, Central and South America, and the Caribbean. Affirms the right of self-determination; rights to education, health, self-government, culture, lands, territories, and natural resources; and it includes provisions that address the particular situation of indigenous peoples in the Americas, including protections indigenous women and children, and those living in voluntary isolation, among others.	Aligning with these declarations commits Guyana to complying with the relevant provisions. As it regards the Project, these would include engagements with indigenous peoples and also taking necessary measures to ensure protection of the environment.

8.10.2. Existing Conditions—Indigenous Peoples

Guyana’s indigenous peoples, referred to as Amerindians, numbered 78,492 as of the 2012 census, and their population is on the rise, with growth of 12.8 percent seen in the period 2002–2012 (BSG 2012). According to the 2012 census, Amerindians comprised 10.5 percent of the population and their numbers have nearly doubled since 1980. This is illustrated in Table 8.10-2.

Table 8.10-2: Distribution of Population by Ethnic/Nationality Group (1980-2012)

Ethnicity Background	Population				Percentage			
	1980	1991	2002	2012	1980	1991	2002	2012
African/Black	234,094	233,465	227,062	218,483	30.8	32.3	30.2	29.3
Amerindian	40,343	46,722	68,675	78,492	5.3	6.5	9.1	10.5
Chinese	1,864	1,290	1,396	1,377	0.3	0.2	0.2	0.2
East Indian	394,417	351,939	326,277	297,493	51.9	48.6	43.4	39.8
Mixed	84,764	87,881	125,727	148,532	11.2	12.1	16.7	19.9
Portuguese	3,011	1,959	1,498	1,910	0.4	0.3	0.2	0.2
White	779	308	476	415	0.1	0.04	0.06	0.06
Other	294	107	112	253	0.04	0.01	0.01	0.03
Total	759,566	723,671	751,223	746,955	100	100	100	100

Source: BSG 2012

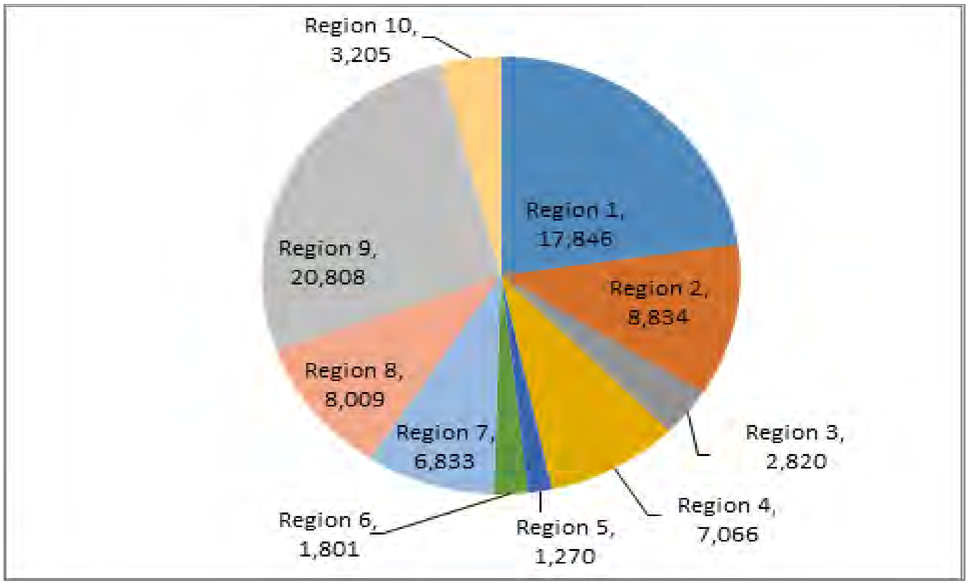
Amerindians are found in significant numbers in the Hinterland Regions. For instance, Amerindians make up 85.8 percent of the resident population in Region 9; 72.3 percent in Region 8; 64.6 percent in Region 1; and 37.2 percent in Region 7. This is outlined in Table 8.10-3.

Table 8.10-3: Percentage Distribution of Ethnic/Nationality Group by Region (2012)

	Region										
Ethnic Background	1	2	3	4	5	6	7	8	9	10	Total
African/Black	2.30	12.58	21.13	40.56	33.06	21.32	11.62	7.75	1.46	49.02	29.25
Amerindian	64.56	18.87	2.62	2.27	2.55	1.64	37.19	72.30	85.85	8.01	10.51
Chinese	0.05	0.09	0.18	0.24	0.09	0.16	0.14	0.08	0.04	0.32	0.18
East Indian	1.71	44.57	59.55	35.02	54.66	66.03	8.54	2.55	1.04	2.82	39.83
Mixed	31.17	23.60	16.38	21.45	9.51	10.69	40.89	16.59	11.17	39.63	19.88
Portuguese	0.17	0.22	0.08	0.37	0.08	0.07	1.21	0.69	0.30	0.10	0.26
White	0.04	0.07	0.03	0.06	0.03	0.05	0.05	0.05	0.12	0.08	0.06
Other	0.01	0.00	0.05	0.03	0.01	0.02	0.36	0.00	0.02	0.03	0.03
Total	100	100	100	100	100	100	100	100	100	100	100

Source: BSG 2012

According to Minority Rights Group International (2008), there are nine main Amerindian groups in Guyana, of which three are coastal: the Carib, Warrau, and Arawak tribes. Other groups tend to inhabit the country’s hinterland regions. Many of the Amerindians in the coastal area have culturally integrated with the general population. They share many of the same livelihoods as the Afro- and Indo-Guyanese coastal populations; however, as a whole, the standard of living for the Amerindian population is lower than for the general population, particularly for those in remote areas where providing infrastructure and services is a challenge. The distribution of Amerindian population among the regions is shown on Figure 8.10-1.



Source: BSG 2012

Figure 8.10-1: Amerindian Population by Region, 2012

Region 1 and parts of Region 2 are not accessible by road. Amerindian communities in these areas are remote and are generally underserved by public infrastructure and services. These populations make use of a range of coastal resources for subsistence and livelihoods, including fishing and crabbing, as well as small-scale agriculture and hunting. Amerindian communities that are directly adjacent to the coast include Father's Beach and Almond Beach, which are untitled communities, as well as the titled community of Three Brothers along the Waini River, directly inland from Shell Beach. The principal titled indigenous communities located 5 to 10 kilometers (approximately 3 to 6 miles) inland from the coast include Santa Rosa, Waramuri, Manawarin, and Assakata in Region 1, and Wakapau, Mainstay/Whyaka and Capoey in Region 2 (although these communities have limited interaction with the shore zones or associated coastal ecosystem) (ERM Personal Communication 22).

In the SBPA, fishing and crabbing occur at the westernmost end of Shell Beach, at the mouth of the Waini River. Many communities from Regions 1 and 2, and inland from the coast, also venture to the Shell Beach easternmost coastline near the mouth of the Pomeroon River to engage in these activities (ERM/EMC 2018). Also in this area, near Father's Beach, there are coconut plantations used for manufacturing oil, and just northwest of this is a forested area where hunting, trapping, fishing, crabbing, crabwood seed harvesting, and lumbering occurs (PAC 2014). See Figure 8.10-2 for a map of these communities.

Figure 8.10-2: Region 1 Amerindian Communities

In the other regions, titled indigenous communities are located inland and not in proximity to the shore zone or coastal areas.

8.10.3. Impact Assessment—Indigenous Peoples

Planned Project activities will not impact indigenous peoples (typically referred to as Amerindians in Guyana). The Project will not involve any direct disturbance of any indigenous communities, or coastal habitats upon which they rely, and the Project's air emissions, water discharges, and sound generation, all of which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not significantly impact their communities or the habitats on which they rely. Project use of the Guyana shorebase(s) and onshore support facilities in Georgetown will have no impact on indigenous peoples, as these facilities are well removed from any traditional indigenous communities.

The Project's potential impacts on indigenous peoples as a result of an unplanned event, are discussed in Chapter 9, Assessment and Mitigation of Potential Impacts from Unplanned Events

8.10.4. Mitigation Measures—Indigenous Peoples

As there are no potential impacts on indigenous peoples as a result of planned Project activities, no mitigation measures are proposed.

9. ASSESSMENT AND MITIGATION OF POTENTIAL IMPACTS FROM UNPLANNED EVENTS

9.1. INTRODUCTION

An unplanned event is defined as an event that is not planned to occur as part of the Project (e.g., accidents), but that has the potential to occur. Since such events are not planned, they are evaluated in a different manner from planned events, specifically by evaluating the consequence of a realistic scenario for an unplanned event and taking into consideration the likelihood that the event could occur. Three levels of likelihood are used: unlikely, possible, and likely, as defined in Table 9.1-1.

Table 9.1-1: Levels of Likelihood for an Unplanned Event Impact Assessment

Likelihood	**Definition**
Unlikely	Considered a rare event, and there is a small likelihood that an event could occur.
Possible	The event has a reasonable chance to occur at some time during normal operating conditions.
Likely	The event is expected to occur during the life of the facility.

As described in Chapter 4, Methodology for Preparing the Environmental Impact Assessment, a risk matrix using the likelihood and consequence/severity of the event is used to evaluate the potential significance of unplanned events. The consequence/severity of the unplanned event is measured in terms of the importance/ vulnerability/sensitivity of the resource/receptor and the magnitude of the impact (Table 9.1-2).

Table 9.1-2: Unplanned Events Risk Matrix

Risk Matrix		**Consequence/Severity**		
		Low	**Medium**	**High**
Likelihood	Unlikely	Minor	Minor	Moderate
	Possible	Minor	Moderate	Major
	Likely	Moderate	Major	Major

For the purposes of the EIA, the following unplanned events are considered as having the potential to occur during the Project life, should a combination of standard and Project-specific safety controls fail concurrently:

- Hydrocarbon spill (potentially resulting from any of several different unplanned events);
- Marine vessel collision (focused on potential physical damage to other vessels or structures, and/or injuries);
- Offshore discharge of untreated wastewater from the Floating Production, Storage, and Offloading (FPSO) vessel; and
- Onshore vehicular accident.

These potential unplanned events are described in more detail below. There are other minor unplanned events (e.g., dropped objects, small spills on deck that do not enter the ocean) that have a credible potential to occur, but which would not significantly impact any resources/ receptors considered in this EIA. These other unplanned events would occur on the drill ships, installation vessels, supply vessels, or the FPSO, and their impacts would tend to be limited to Project employees and contractors (e.g., a variety of accidents that could result in worker injury, but no measurable impact on natural resources or the public). These events are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures, which are discussed in Chapter 2, Description of the Project; Chapter 11, Environmental and Social Management Plan Framework; and the Project's Environmental and Socioeconomic Management Plan (ESMP), but are otherwise beyond the scope of this EIA.

The Consultants have performed the impact assessment for unplanned events on the basis that the Project will use existing shorebase(s) located in Georgetown, which are not dedicated to the Project. Should any new or expanded shorebase(s) or onshore support facilities be used, the construction/expansion and any required dredging, as well as the associated permitting, of such facilities, would be the responsibility of the owner/operator, and such work scope would not be included in the scope of this EIA.

9.1.1. Hydrocarbon Spill

Producing, processing, storing, and offloading crude oil are core Project activities. Additionally, the Project will use marine vessels, aircraft, and processing equipment that use petroleum products for fuel and lubrication. There are multiple layers of control in place with respect to these activities; however, if multiple controls fail, there is the potential for a hydrocarbon oil spill to occur. EEPGL categorizes oil spills into three tiers:

- Tier I—Spill is small, the source of spill is under control, and response would be managed by EEPGL and its contractors using local resources;
- Tier II—Spill is moderate, the source can be quickly brought under control, local response equipment immediately available, and broader response would be managed in a coordinated manner using regional resources as needed; and
- Tier III—Spill is large and/or the source of the spill is not under control, and response would be managed in a coordinated manner with regional and internationally sourced resources.

Hydrocarbons that could potentially be released include crude oil, marine diesel, fuel oil, aviation fuel, lubricating oil, and non-aqueous drilling fluid (NADF). Releases of hydrocarbons could result from a number of different unplanned events. Discussions of the unplanned events considered are provided below.

9.1.1.1. Helicopter Ditching

The Project will involve the use of helicopters to support drilling, installation, production operations, and decommissioning activities. It is estimated that during development drilling and FPSO/ Subsea, Umbilicals, Risers, and Flowlines (SURF) installation for the Project, flights may peak at a total of approximately 30 to 35 round-trip flights per week (combined for Liza Phase 1 and Liza Phase 2). During FPSO/SURF production operations for the Project, an estimated maximum of 20 to 25 round-trip flights per week (combined for Phase 1 and Phase 2) will be necessary to support FPSO/SURF production operations and continued development-drilling activities. Flights during the decommissioning stage would likely be similar to those during the FPSO/SURF installation stage.

Although aviation accidents are rare events, there is the potential for a helicopter to ditch at sea. A ditching incident could be the result of a number of factors, which may potentially include loss of power, severe weather, or bird strike. Worker safety-related aspects are addressed primarily through EEPGL's and its contractors' health and safety policies and procedures, and these are not otherwise addressed in this EIA. However, a ditching could potentially result in a spill of aviation fuel or lube oils from the helicopter and related potential localized environmental impacts.

9.1.1.2. FPSO or Drill Ship Fire

Although an **Unlikely** event, there are a number of potential scenarios that could lead to a fire event on the FPSO or a drill ship (e.g., inadvertent ignition of oily rags or related materials, electrical panel fault, etc.). To reduce the possibility and consequence of a fire, EEPGL or the drill ship operator will implement a series of fire prevention controls (design-based and operations) in alignment with common industry practice. There are multiple automated safety features designed into the FPSO and drill ships to minimize the risk of any fire (e.g., fire detection, automated shut-off valves, alarms, deluge system, fire protection) as well as trained operations and maintenance crew. Additionally, the FPSO and drill ships will have a robust emergency response plan to direct activities in the event of such a fire. Any fire would likely be quickly detected and extinguished, via either an automated and/or manual system. Further escalation of a fire event would be a rare event.

The firewater used in a response would likely be captured within the deck open-drain system, but some could potentially wash over the deck to the sea. While these measures would significantly reduce the potential for a fire to occur in the first place, operational procedure and engineering design systems would further limit the potential for a release of hydrocarbon-containing firewater overboard during response. The possible washover of firewater from the FPSO or drill ship deck to the sea could result in the discharge of relatively minor amounts of hydrocarbons, with the potential for related, localized environmental impacts.

9.1.1.3. Offshore Collision between FPSO and Offloading Tanker

During offloading of crude oil from the FPSO to a conventional tanker, the offloading tanker must approach at a controlled, safe speed to about 120 meters (approximately 390 feet) of the FPSO. To minimize the risk of collision during the approach to the FPSO and during offloading, EEPGL will use a Mooring Master on the offloading tanker. The Mooring Master will guide the offloading tanker to the FPSO for offloading, remain on board during offloading, and then guide the offloading tanker away from the FPSO after offloading. Up to three assistance tugs will help position the offloading tanker during the approach to the FPSO to maintain a safe separation distance. During offloading, the tanker will be connected to the FPSO via a hawser (a taut line) and the tugs will be connected to the tanker via hawser lines to help ensure the offloading tanker maintains a safe distance from the FPSO at all times (see Figure 2.9-1).

Offloading will only occur when weather and sea conditions allow for safe operations. If the environmental conditions prior to the tanker approaching the FPSO are not suitable, the tanker will stand by at a safe distance away until conditions are within acceptable limits. If unexpected adverse weather (e.g., a squall) occurs during offloading, the offloading operations will be stopped and the tanker disconnected and moved away from the FPSO until conditions are within approved, safe limits. With these precautions, the potential for a collision between the FPSO and the offloading tanker is considered **Unlikely**. In the unlikely event of a collision during the tanker approach to or departure from the FPSO, the risk of a cargo tank breach on either vessel is greatly reduced by the design of the FPSO (double hull protected on sides) and the tankers (double hulled), and the fact that the FPSO is stationary and the offloading tanker would be travelling at a very slow maneuvering speed (assisted/pulled back by tugs). Therefore, there is not expected to be sufficient collision energy to breach the hulls, and a spill scenario from a tank breach was therefore not considered in relation to this unplanned event.

9.1.1.4. Nearshore Collision between a Project Supply Vessel and Another (Third-Party) Vessel or Structure, or Grounding

There are a variety of Project vessels that will supply and support drilling, installation, and production operations activities. These vessels will transit between the Guyana shorebase(s) and the Project Development Area (PDA). There is a potential for collisions between these vessels and other third-party vessels/structures in the Georgetown Harbour/Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Fuel oil or lubricating oil spills resulting from an event could potentially cause environmental impacts.

A number of controls will be implemented to prevent these types of vessel incidents from occurring. EEPGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EEPGL will provide active oversight over its contractors to verify they are complying with its requirements. Contractors are required to regularly inspect their vessels, which addresses marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability. In addition, vessels operating within the Georgetown Harbour or other coastal areas will be required to adhere to speed restrictions and navigation aids.

9.1.1.5. Other Shorebase-Related Events

Spills of hydrocarbons at the shorebase(s) could also occur from the following initial unplanned events:

- Partial loss of onshore diesel storage tank contents; and
- Hose failure, mechanical failure, or human error during bunkering operations, resulting in a release of fuel to the water.

9.1.1.6. Offshore Collision between Project Vessels or between a Project Vessel and Another (Third-Party) Vessel

Other vessel collisions (e.g., collisions between drill ships, installation vessels, or the FPSO and other vessels) are not considered reasonably foreseeable scenarios given the following safety measures that will be put in place:

- The Maritime Administration Department (MARAD) will issue notices to mariners concerning safety at sea and the location of the drill ships, installation vessels, and the FPSO. EEPGL will also communicate major Project vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners. Through a stakeholder engagement process, EEPGL will communicate Project activities, where possible, to those individuals to aid them in avoiding Project vessels. Marine safety exclusion zones with a 500-meter (approximately 1,640-foot) radius will be established around the drill ships during drilling operations and around drill centers during well workovers, in accordance with industry standards and practices. No unauthorized vessels will be allowed to enter these marine safety exclusion zones. Similar marine safety exclusion zones will be established for the major installation vessels.
- A marine safety exclusion zone of 2 nautical miles will be established around the FPSO. No unauthorized vessels will be allowed to enter this marine safety exclusion zone during offloading.
- EEPGL will utilize what is known as a Simultaneous Operations procedure to safely manage Project marine vessels that are performing work in the same vicinity of each other, which will include considerations to avoid vessel collisions.
- Marine vessels will have industry-proven station-keeping systems (e.g., FPSO mooring system, dynamic position systems on drill ships) to maintain station in the offshore environment.

9.1.1.7. Drilling-Related Spills

Spills of hydrocarbons during drilling could occur from the following unplanned events:

- A failure in containment or breach of fuel storage tank on a drill ship, resulting in a release of fuel;
- A spill of NADF due to a loss of riser contents resulting from an emergency disconnect between the riser and Lower Marine Riser Package connected to the drill ship and the blowout preventer (BOP) (e.g., due to dynamic positioning (DP) station keeping failure);
- A limited well control event with loss of containment (e.g., if the well becomes unbalanced during the drilling process and begins flowing) that is contained within a relatively short period of time (i.e., within a matter of minutes or hours); and
- A larger well control event with loss of containment where a release continues for a longer (i.e., up to a multi-day) period of time while activities are undertaken to bring the well under control.

9.1.1.8. Production-Related Spills

Spills of hydrocarbons during FPSO production operations could occur from the following unplanned events:

- A failure in containment on the FPSO topsides, resulting in a release of crude oil to the deck and/or sea;
- A failure in containment or breach of fuel or chemical storage tank on the deck of the FPSO, resulting in a release of fuel to the deck and/or sea; and
- A failure of an offloading hose during offloading from the FPSO to a conventional offloading tanker, resulting in a release of crude oil into the sea.

9.1.1.9. Summary of Spill Scenarios Considered

Based on the considerations of unplanned events discussed above, the potential spill scenarios considered further for the purpose of the EIA include the following:

- Spills of fuel at the Guyana shorebase(s) (Georgetown area) into the Demerara River, or at other locations near the coast, which could result from:
  - An onshore spill from fuel storage at the shorebase facility (Scenario 1);
  - An on-water spill of fuel (e.g., during bunkering of a supply vessel; Scenarios 2 and 3); and
  - An on-water spill of fuel resulting from nearshore collision of a supply vessel with another third party vessel or structure or from grounding of a supply vessel (Scenario 4).
- Spills of fuel offshore, which could result from:
  - Releases of marine diesel from a supply vessel (e.g., due to human error or equipment failure; Scenario 5);
  - Releases of marine diesel from a drill ship or the FPSO (e.g., due to human error or equipment failure; Scenarios 6 and 7);
  - Helicopter ditching into the ocean during transit between the shore and the FPSO or drill ships and resultant loss of fuel to the ocean (Scenario 8); and
  - A minor FPSO or drill ship deck fire and resultant loss of hydrocarbons along with firewater that washes overboard during firefighting (Scenario 9).
- Spills of crude oil during production operations, which could result from:
  - Releases of crude oil from the FPSO topsides (e.g., due to failure of topsides equipment; Scenario 10); and
  - Releases of crude oil during offloading (e.g., resulting from failure of offloading hose during offloading from FPSO to tanker; Scenario 11).

- Spills during development drilling operations, which could result from:
  - Spills of crude oil as a result of loss of well control with loss of containment (Scenarios 11 and 13); and
  - Spills of NADF (e.g., as a result of loss of riser contents after emergency disconnect due to DP station keeping failure; Scenario 12).

These are summarized, together with reasonable assumptions for associated spill volumes, in Table 9.1-3.

Table 9.1-3: Hydrocarbon Spill Scenarios Considered for Impact Assessment

#	Tier	Location	Possible Scenario	Potential Impact
1	I	Shorebase	Onshore spill of less than 10 bbl (e.g., partial loss of diesel storage tank contents)	Contained onshore; no shoreline impact
2	II	Shorebase	On-water spill of less than 100 bbl (e.g., shore to vessel bunkering spill)	Diesel enters Demerara River estuary; possible minor shoreline impact
3	II	Supply vessel at shorebase	On-water release of less than 500 bbl of diesel (e.g., shore to vessel bunkering)	Diesel enters Demerara River estuary; possible shoreline impact
4	II	Supply vessel at shorebase or nearshore	On-water spill of less than 100 bbl (e.g., resulting from grounding or collision with a non-Project vessel or structure)	Diesel enters Demerara River estuary or nearshore waters; possible minor shoreline impact
5	I	Supply vessel offshore	Offshore spill of less than 50 bbl of fuel	Hydrocarbons enter water, creating sheen on the water surface; no shoreline impact likely
6	I	Drill ship or FPSO offshore	Offshore spill of less than 50 bbl of fuel (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
7	II	Drill ship or FPSO offshore	Offshore spill of less than 250 bbl of fuel (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
8	I	Helicopter offshore	Offshore spill of less than 50 bbl of fuel resulting from helicopter ditching and resultant release of fuel tank contents	Enters offshore Atlantic Ocean; no shoreline impact likely
9	I	FPSO offshore	Offshore spill of less than 50 bbl of fuel resulting from discharge of hydrocarbons along with washover of firewater	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely
10	I	FPSO offshore	Offshore spill of less than 50 bbl of crude oil from FPSO topsides (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely

#	Tier	Location	Possible Scenario	Potential Impact
11	II	Drill ship/well offshore	Well control release of less than 250 bbl (e.g., well becomes unbalanced during the drilling process and begins flowing at a low rate prior to containment)	Hydrocarbons enter Atlantic Ocean; no shoreline impact likely
12	II	FPSO, offloading tanker offshore	Offshore release of 2,500 bbl of oil (e.g., failure of offloading hose during offloading from FPSO to tanker)	Oil enters Atlantic Ocean; no shoreline impact likely
13	III	Drill ship /well offshore	Offshore release of oil from well control event (30 day duration at 20,000 BOPD)	Oil enters Atlantic Ocean; possible shoreline impact
14	II	Drill ship / well offshore	Offshore release of up to 2,200 bbl of NADF due to loss of riser contents after emergency disconnect due to DP station keeping failure	NADF enters water near the seafloor; no shoreline impact likely

bbl = barrels; BOPD = barrels of oil per day

Hydrocarbon releases of less than 100 barrels (bbl) (Scenarios 1, 2, 4, 5, 6, 8, 9, and 10) would be expected to be quickly brought under control, and would be managed with locally available spill control equipment. A temporary, visible sheen on the water surface may occur, water quality would be temporarily impaired in a localized area, and sensitive receptors (e.g., plankton and possibly some seabirds or shorebirds) may be locally affected. However, there is not considered to be potential for any long-term or ecosystem level impacts on ecologically important or protected species. These spills are, therefore, not considered further in the impact assessment.

A hydrocarbon release under Scenario 14 would involve a spill of up to approximately 2,200 bbl of NADF into the ocean near the seafloor. Under this scenario, the spill is limited to the capacity of the drilling riser. The potential impacts of a release of this nature would primarily occur at or near the seabed, and may include localized smothering and toxicity that would affect benthic species, although this disturbance would occur in the same area where disturbance from drilling and cuttings discharges have already occurred. Any dispersion of the NADF would also result in localized impacts on water quality and sensitive planktonic or fish species. Other than a localized area where the material has deposited, any water quality or other effects would be short-term, as the product would disperse within the water column.

A hydrocarbon release under Scenario 3 would involve a spill of approximately 500 bbl of diesel into the Demerara River. There would be a potential for impacts on several resources/receptors, such as water quality and coastal fish and wildlife. However, due to the rapid natural dispersion and evaporation of diesel, combined with dilution by water movement and tidal exchange, impacts would be limited in duration and would reduce with distance from the spill site. Additionally, the majority of effects would occur in a more developed urban harbor setting.

Hydrocarbon releases under Scenarios 11 (minor well control release during drilling), 12 (release during offloading from FPSO to tanker), and 13 (a larger well control incident) would all involve a crude oil spill in the PDA, either at a well or at the FPSO. Although the potential spill volumes vary (i.e., from 250 bbl total to 600,000 bbl [20,000 BOPD for a duration of 30 days]) and the location of the spill differs (i.e., at seafloor or ocean surface), the resources/receptors at risk are similar and the magnitude of the potential impacts increases from Scenario 11 to Scenario 13. Oil spill modeling and coastal sensitivity mapping have been conducted to identify and characterize the resources/receptors with the potential to be exposed to the spilled oil. An overview of the modeling approach and results for Scenarios 12 and 13 is provided in Section 9.1.4, Oil Spill Modeling Overview, and Section 9.1.5, Oil Spill Modeling Results. The potential risks associated with the smaller volume offshore oil spills are encompassed within the modeling.

It should be noted, however, that an oil spill and release of NADF are considered highly unlikely primarily because of controls EEPGL and its contractors put in place to prevent a spill from occurring. Section 2.13, Embedded Controls, provides a description of the embedded controls related to spill prevention; further detail is provided in Section 9.1.7, Oil Spill Prevention, Control, and Emergency Response Measures.

Despite the unlikely probability of an oil spill, the impacts assessment addresses potential impacts associated with Scenario 3, which is referred to as a "coastal oil spill," as well as Scenarios 11, 12, and 13, which are collectively referred to as a "marine oil spill." Scenario 14 is referred to as an "NADF release" and impacts on relevant receptors are assessed as a separate category of release.

9.1.2. Factors Impacting Severity of Hydrocarbon Spills

Several factors impact the severity of hydrocarbon spills and the options for, and effectiveness of, a range of spill response measures. These factors include the hydrocarbon properties, volume and location of the spill, metocean conditions, and seasonal factors impacting the presence of wildlife (Dicks 1998).

Hydrocarbon products vary widely in their physical and chemical properties, as well as their potential impacts on marine organisms (Figure 9.1-1). Heavy oils have the potential to cause more significant and longer-term impacts, as they may persist along shorelines and cause smothering of intertidal plants and coral reef habitats. In contrast, light oils tend to be more toxic, but dissipate much more quickly through evaporation and dispersion, so they are generally less impactful overall and their potential toxic impacts are likely to be localized and short-lived (ITOPF 2014; Dicks 1998).

Source: ITOPF 2014

Figure 9.1-1: Typical Impacts on Marine Organisms across a Range of Oil Classes

The oil that will be produced from the Liza field is categorized as a "light crude" oil with a specific gravity less than water. For a release near the top of the water column, the majority of this oil would rise quickly to the water surface. For a release near the seabed, the oil would rise, and the plume containing the oil droplets and gas bubbles would entrain seawater as it moves upwards. In the PDA, the water depth is sufficient to cause these plumes to terminate (trap) within the water column. Once the plume traps, the oil droplets would rise only through buoyancy until they reach the surface or dissolve, with the rise rate of the oil droplets varying depending on the droplet size (i.e., with larger droplets rising faster than small) (RPS 2018b). As a result, the potential for persistent slicks, shoreline impacts, and smothering is reduced relative to heavy crude or heavy fuel oil products.

The Project will use low-toxicity NADF in its drilling operations, which is denser than the light crude oil in the Liza field and contains specific weighting materials used during the drilling process. As such, the NADF would tend to remain near the seafloor if released from the bottom of the riser (e.g., during an emergency disconnect scenario).

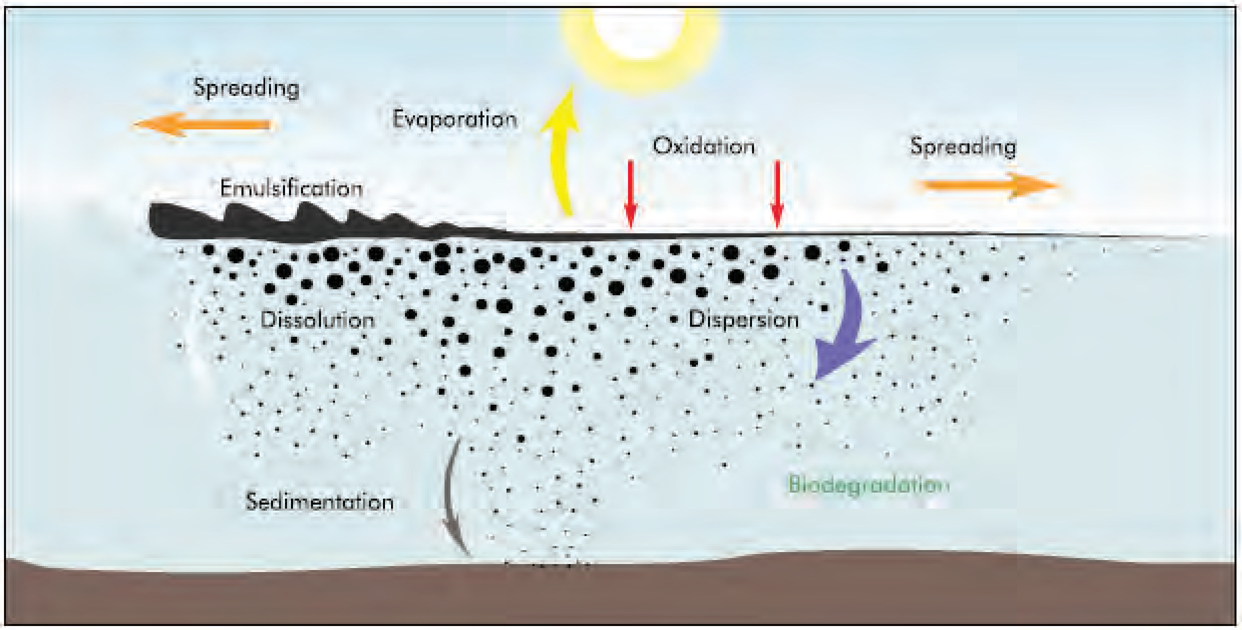
The well control events considered for the purpose of this EIA would occur in the ocean approximately 183 kilometers (approximately 114 miles) offshore from Guyana. The open waters of the ocean, and associated pelagic and seabed communities, are typically more resilient to spills than shoreline environments (Dicks 1998).

Climate and weather can also impact the behavior of an oil spill. For example, oils become more viscous (i.e., flow less readily) at lower sea surface and air temperatures. In this case, the surface waters in the Project Area of Influence (AOI) are relatively warm, typically ranging from 24 to 30 degrees Celsius (°C), which would result in the oil remaining fluid, enhance evaporation of the lighter fractions (as discussed below), and improve spill response options such as dispersant application and *in situ* burning.

9.1.3. Weathering Process

As soon as hydrocarbons are introduced into the ocean, advection and spreading begin immediately and result in a rapid increase in the area of exposure of the hydrocarbons to subsequent "weathering" processes (Figure 9.1-2). These processes include evaporation, dissolution, vertical dispersion, emulsification, and sedimentation. All of these processes are influenced by the specific composition of the introduced hydrocarbon. In addition, some components are degraded by photochemical oxidation induced by sunlight.

These processes may result in vaporized hydrocarbon fractions and reaction products in the atmosphere, slicks and tar lumps on the surface of the ocean, dissolved and particulate hydrocarbon materials in the water column, and similar components in the sediments. While physical and chemical weathering processes are occurring, biological processes, including degradation of the hydrocarbons by microorganisms to carbon dioxide or organic components in intermediate oxidation stages and uptake by larger organisms and subsequent metabolism, storage, or discharge, can also act on the hydrocarbons.



Source: ITOPF 2013

Figure 9.1-2: Weathering Processes Acting on Hydrocarbons in an Ocean Environment

Although some of these processes (e.g., photochemical oxidation, evaporation) would not occur at the depths at which an NADF release could occur, the NADF would be subject to biological degradation. Biological degradation proceeds more slowly under anoxic conditions than under well-oxygenated conditions, so biological degradation would tend to occur most rapidly where the NADF is thinly distributed over a wide area of seafloor rather than in thicker clumps over a small area.

9.1.4. Oil Spill Modeling Overview

Oil spill models have been in use for more than 30 years to support the development of oil spill response planning. Trajectory and fate models simulate oil transport and predict the changes the oil undergoes (i.e., its fate) as it interacts with water, air, and land. The models simulate spill events based on a characterization of the wind and hydrodynamic (marine currents) forces that influence oil transport. The predictions from the models can be used to quantify the potential consequences of a spill, which can then be used to guide response planning and prioritize response asset deployment. There are two principal modes in which oil spill models can be used:

1. **Stochastic** (statistical) mode, which examines *many potential releases* from the same point using the full range of historical data for wind and currents; and
2. **Deterministic** mode, which examines a *single potential release* using specific historical wind and hydrodynamic data selected from a range of historical data, or using forecasted wind and hydrodynamic data for an ongoing or future event.

Extreme weather events typically are considered qualitatively in oil spill modeling. The PDA is not in a seismically active area, so seismic events such as tsunamis do not factor into oil spill modeling. The Project infrastructure is designed to withstand other potential extreme events (e.g., squalls); in fact, these extreme events have little to no effect on the wells, which are located approximately 1,500 to 1,900 meters below the ocean surface. In any case, weather forecasts would provide advance notice of these events and would enable EEPGL to take appropriate operational precautions to reduce the chance of an oil spill under such conditions. Accordingly, the oil spill modeling conducted for the purpose of this EIA was based on historical environmental (wind, wave, and current) and hydrodynamic data.

A typical approach to using oil spill models in oil spill response planning is to first apply the stochastic mode to determine the most likely trajectory for the spill scenarios of interest. The stochastic approach captures variability in the trajectory by simulating hundreds of individual spills (i.e., under different environmental (wind, wave, and current) and hydrodynamic conditions) and generating a map that is a composite of all of the predicted trajectories, thus providing a *probability footprint* showing the most likely path for a given spill scenario. Spill scenarios are typically modeled in stochastic mode to estimate probability that a specific area would be impacted by the spill and timing of arrival of the spill at a particular area for each season or wind regime in the region.

Each stochastic model run results in a map showing the probability of a specified thickness of oil on the sea surface across the study area, and the minimum time of oil arrival across the study area. Examples of stochastic maps are shown in Section 9.1.5, Oil Spill Modeling Results.

The specified thickness threshold on which the probabilities are based is chosen based on the purpose of the modeling or the types of impacts being considered, including ecological and socioeconomic impacts. Modeling is then used to determine the probability that oil would be present at a location in a thickness at or exceeding the designated threshold. For example, a surface slick thickness threshold can be based on the minimum thickness that can be mechanically recovered or on the minimum thickness that is thought to cause ecological or socioeconomic impacts. When applied in this way, a trajectory and fate model can quantify the likelihood of specific spill consequences, which is supportive of spill response planning and preparedness and environmental impact analysis.

Surface oil thickness thresholds are typically expressed in units of mass per unit area (e.g., grams per square meter [g/m^2]). Table 9.1-4 summarizes the range of thicknesses relative to their appearance on water.

Table 9.1-4: Oil Thicknesses (g/m^2) and Appearance on Water

Code	Description	Layer Thickness Interval (g/m^2)	Liters per km^2
1	Sheen	0.04–0.3	40–300
2	Rainbow	0.3–5.0	400–5,000
3	Metallic	5.0–50	5,000–50,000
4	Discontinuous True Oil Color	50–200	50,000–200,000
5	Continuous True Oil Color	200 +	200,000 +

Source: Bonn Agreement 2007

For the purpose of this Project EIA and oil spill response planning, a threshold of 1.0 g/m^2 has been used for the modeling of spills. This represents an oil thickness where ecological effects on very sensitive species may potentially occur and select spill response and recovery methods could be applied in suitable circumstances (e.g., wind and sea state).

Oil spill modeling in the deterministic mode is used to predict where spilled oil from a single release would go and how quickly it would arrive at given locations. The trajectory of the spill is determined by the specific modeled wind and hydrodynamic conditions. The model predicts the spill pathway by calculating the movement of the oil for individual short increments of time over the spill's duration, which cumulatively results in what is known as the spill trajectory. Knowing the distance traveled by the oil over a period of time also provides a prediction of the time of travel for the spill to reach specific areas. Consequences from the spill are determined by running the model within a geospatial framework so that interactions between the oil and elements of the environment (e.g., habitats) can be considered. Given an adequate definition of currents, winds, and the environment, a deterministic model can provide comprehensive predictions of the trajectory, fate, and effects of the oil.

Oil spill trajectory and fate models provide a quantifiable and consistent means to quantify spill consequences. A trajectory and fate model can also simulate the effects of spill response activities such as mechanical recovery, dispersant application, and *in situ* burning. Model simulations with and without spill mitigation measures are used to calculate the effectiveness of different response strategies and equipment and can be used to help validate and improve spill response plans and contribute to a Net Environmental Benefit Analysis (NEBA) process. The NEBA process examines the benefit of using various spill response technologies against the effect of the oil spill itself prior to deploying the preferred technologies in a spill event.

Once individual spill events have been defined based on the selected criteria, a deterministic map for each event, showing the predicted trajectory and fate of the spilled oil, is generated. These deterministic maps can be generated for a range of spill scenarios and included in an Oil Spill Response Plan (OSRP) for use in planning responses to different scenarios. Examples of deterministic maps are shown in Section 9.1.5, Oil Spill Modeling Results.

When applied to spill response activities, an oil spill model is used to simulate scenarios selected to be representative of anticipated spill events. These typically include operational spills, smaller volume releases to the water surface, and larger volume spills related to production or drilling operations originating either at the sea surface or from near the seabed. In both cases, the oil spill model is applied to determine the most likely pathway for a spill from each scenario and to quantify the oil's fate.

9.1.5. Oil Spill Modeling Results

From the list of oil spill scenarios described in Section 9.1.1, Hydrocarbon Spill, oil spill modeling results are presented in this section for Scenarios 12 and 13 (the marine oil spill scenarios with the largest release volumes). Modeling results for additional (smaller release volume) scenarios are included in the OSRP. Scenario 12 is a 2,500 bbl surface spill associated with FPSO offloading to a conventional tanker. Scenario 13 is a 30-day loss of well control event, with oil released to the ocean from near the seafloor at a rate of 20,000 barrels per day (BPD).

The initial deterministic model runs for each scenario predict potential impacts in the absence of spill response measures, a baseline that response activities may be measured against. Subsequently, additional deterministic model runs were conducted with implementation of response measures, which significantly reduces the severity and extent of a spill and its impacts, as demonstrated by the modeling.

Spills originating near the seafloor were simulated using the OILMAP Deep model (RPS 2018a) to predict the discharge plume geometry, droplet size distribution discharged into the water column, and fate of the oil plume. The SIMAP model system (RPS 2018c) was used to predict the probability of oil reaching the 1 g/m^2 thickness on the sea surface across the study area, taking into account the weathering profile of the oil (which would result in a proportion of the oil evaporating or dispersing into the water column). Spills were simulated taking into consideration the quantity of oil released, the type of oil and its characteristics (e.g., density), historical seasonal wind and current patterns, and water depth, among other factors.

For each of these scenarios, modeling was performed for the summer season (June through November), as well as the winter season (December through May). The results are described below, including modeling under stochastic, deterministic, and deterministic-with-response modes.

9.1.5.1. Scenario 12—FPSO Release of 2,500 bbl of Crude Oil

Figure 9.1-3a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 12 (a 2,500 bbl surface spill originating from the FPSO location) in the summer season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-3b shows the same stochastic map, zoomed in.

Figures 9.1-4a and 9.1-4b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 12 in the winter season.

Figure 9.1-5a shows a deterministic map (without mitigation by response activities) resulting from Scenario 12 in the summer season. The gray area shows the "swept area," which is the aggregated area across with the oil spill is projected to travel. The black areas show the oil predicted to be remaining on the surface above a minimum thickness of 1.0 g/m^2 at the end of the 10-day modeling simulation. The red areas show the oil predicted to have made shoreline contact above a minimum thickness of 1.0 g/m^2 at the end of the 10-day modeling simulation. Figure 9.1-5b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-6a and 9.1-6b show the deterministic maps (without mitigation by response activities) resulting from Scenario 12 in the winter season.

Figures 9.1-7a and 9.1-7b show the deterministic maps (with mitigation by response activities) resulting from Scenario 12 in the summer season. Figures 9.1-8a and 9.1-8b show the deterministic maps (with mitigation by response activities) resulting from Scenario 12 in the winter season. As shown by the modeling results, with the application of spill response measures, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on any coastlines.

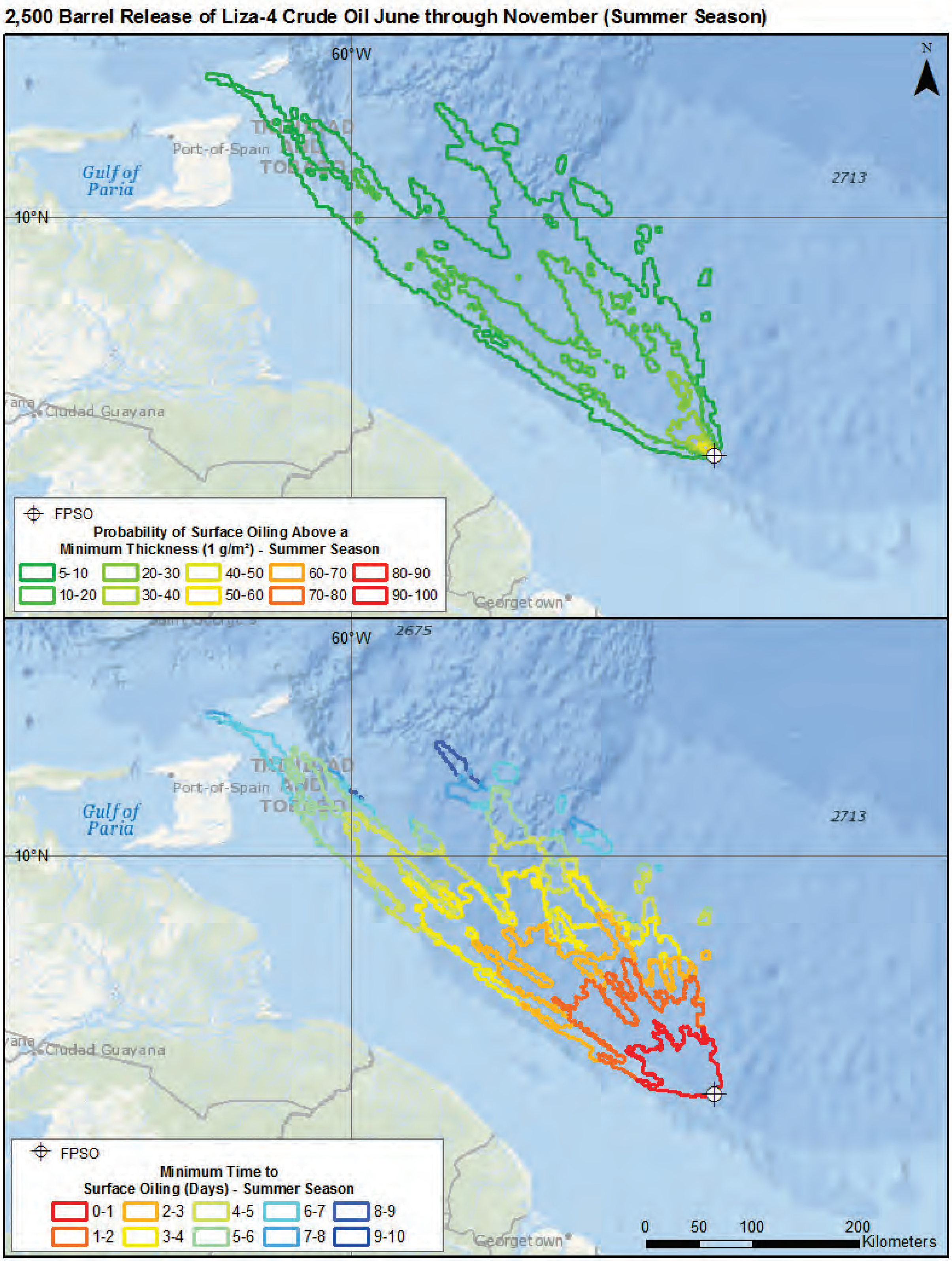


Figure 9.1-3a: Stochastic Map for Scenario 12—Predicted Surface Oiling from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Summer)

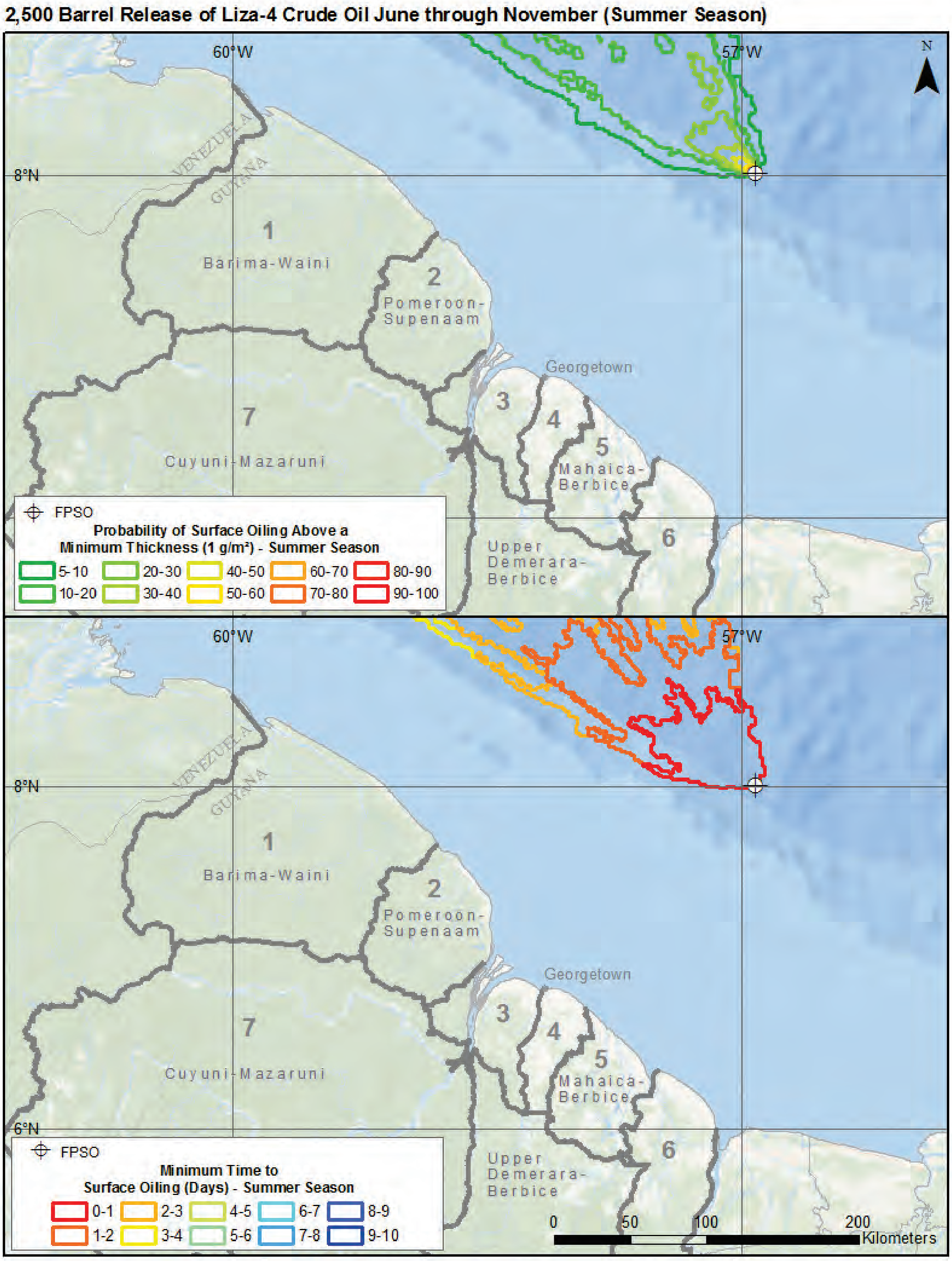


Figure 9.1-3b: (Zoomed In) Stochastic Map for Scenario 12—Predicted Surface Oiling from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Summer)

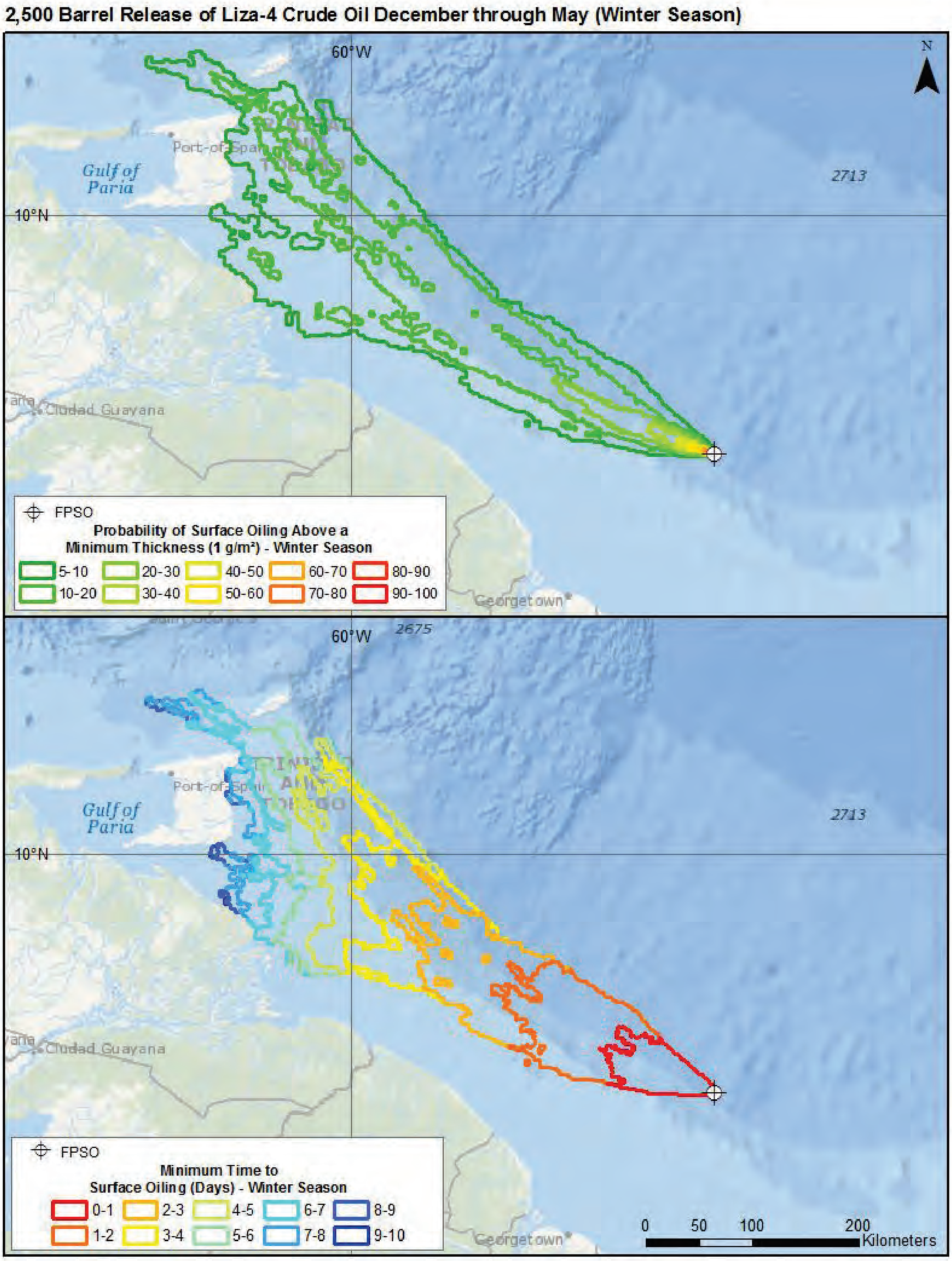


Figure 9.1-4a: Stochastic Map for Scenario 12—Predicted Surface Oiling from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Winter)

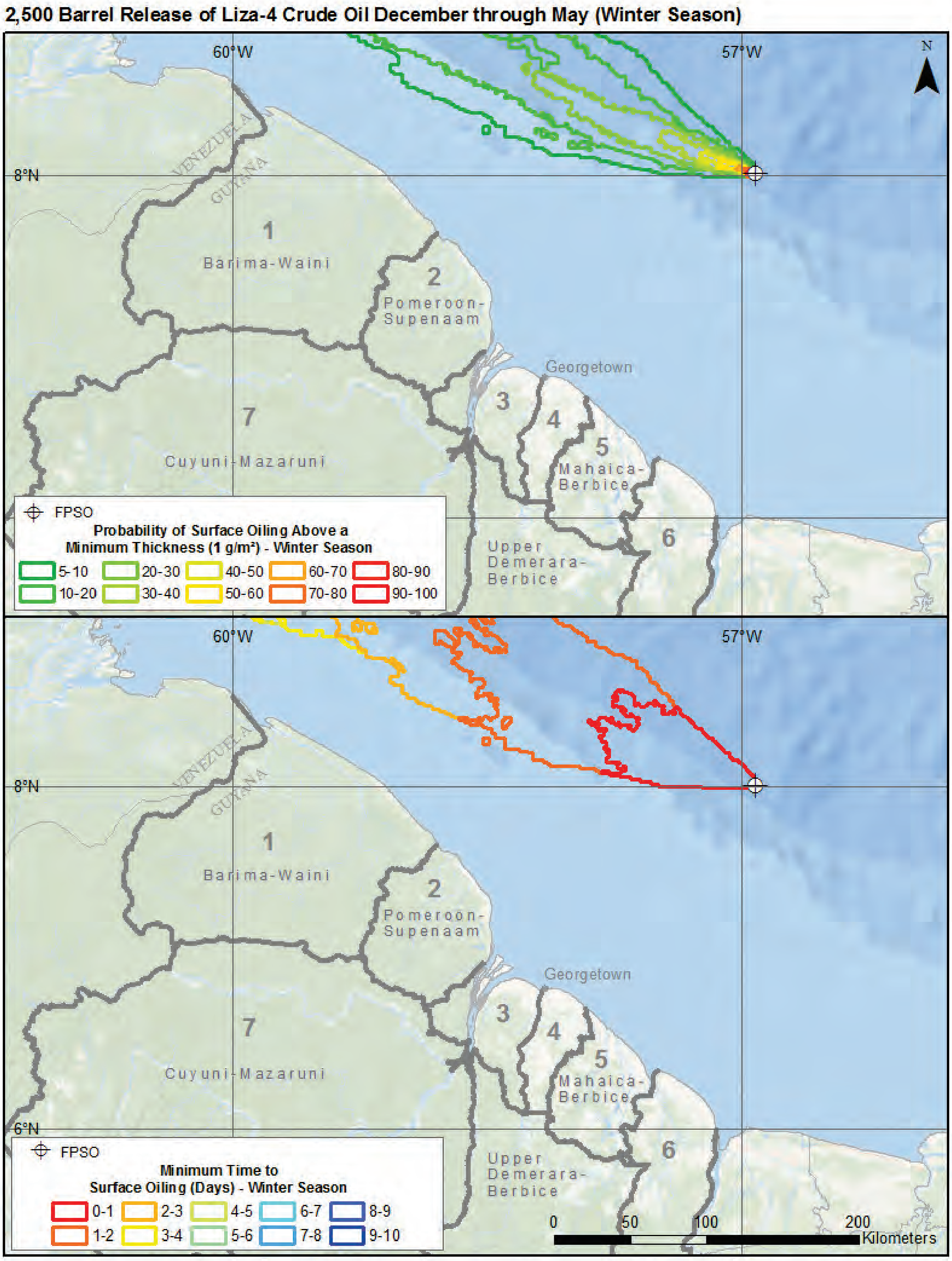


Figure 9.1-4b: (Zoomed In) Stochastic Map for Scenario 12—Predicted Surface Oiling from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Winter)

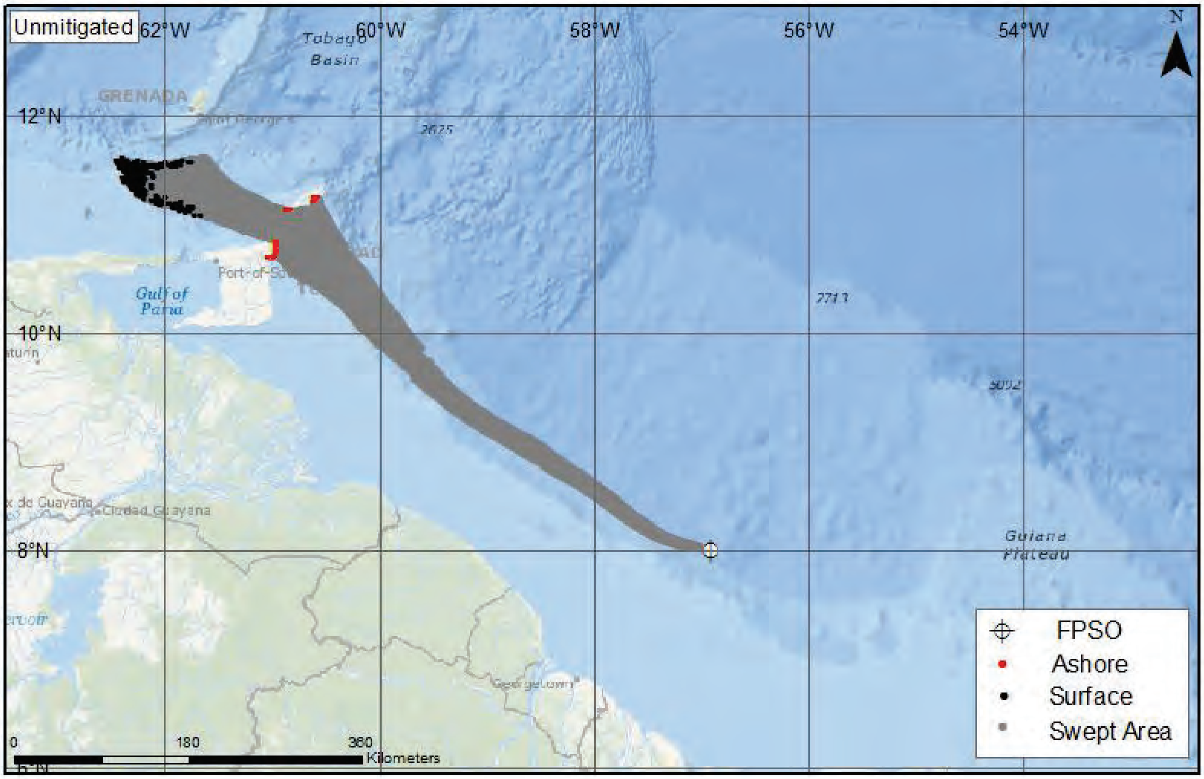


Figure 9.1-5a: Deterministic Map for Scenario 12—Predicted Transport and Fate from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Summer)

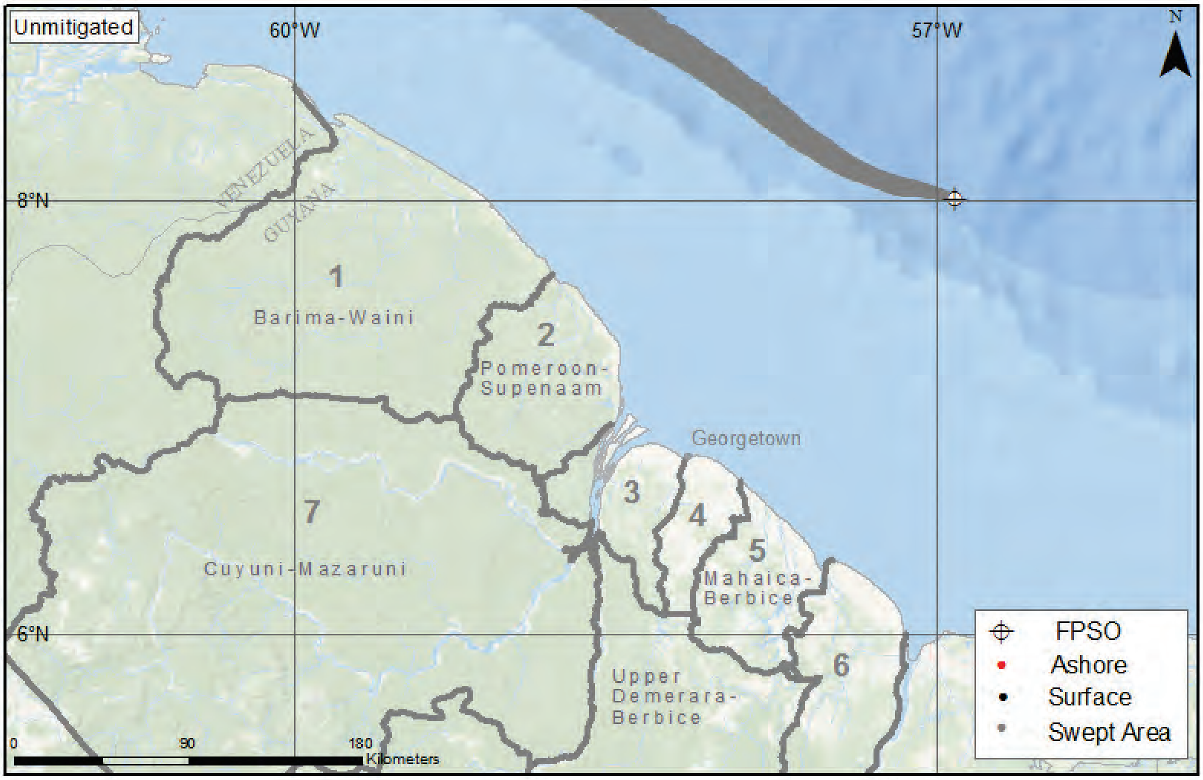


Figure 9.1-5b: (Zoomed in) Deterministic Map for Scenario 12—Predicted Transport and Fate from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Summer)

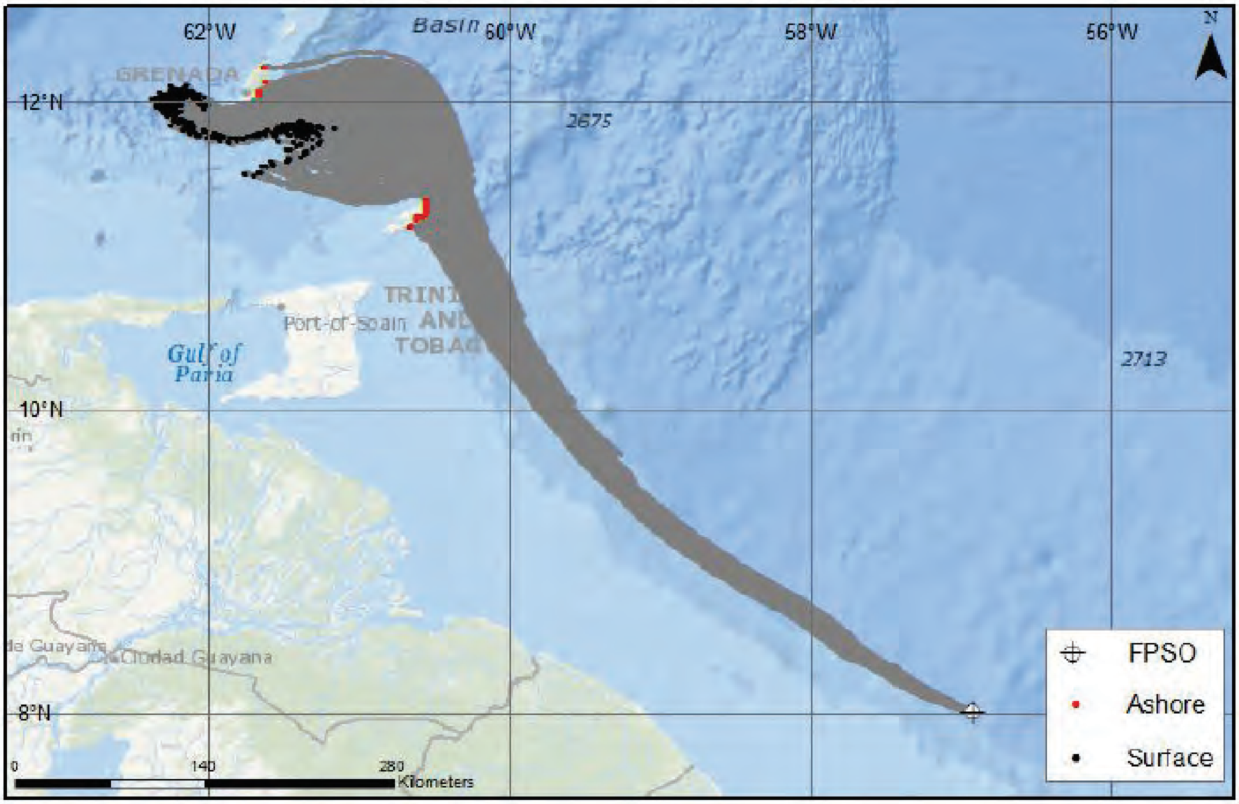


Figure 9.1-6a: Deterministic Map for Scenario 12—Predicted Transport and Fate from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Winter)

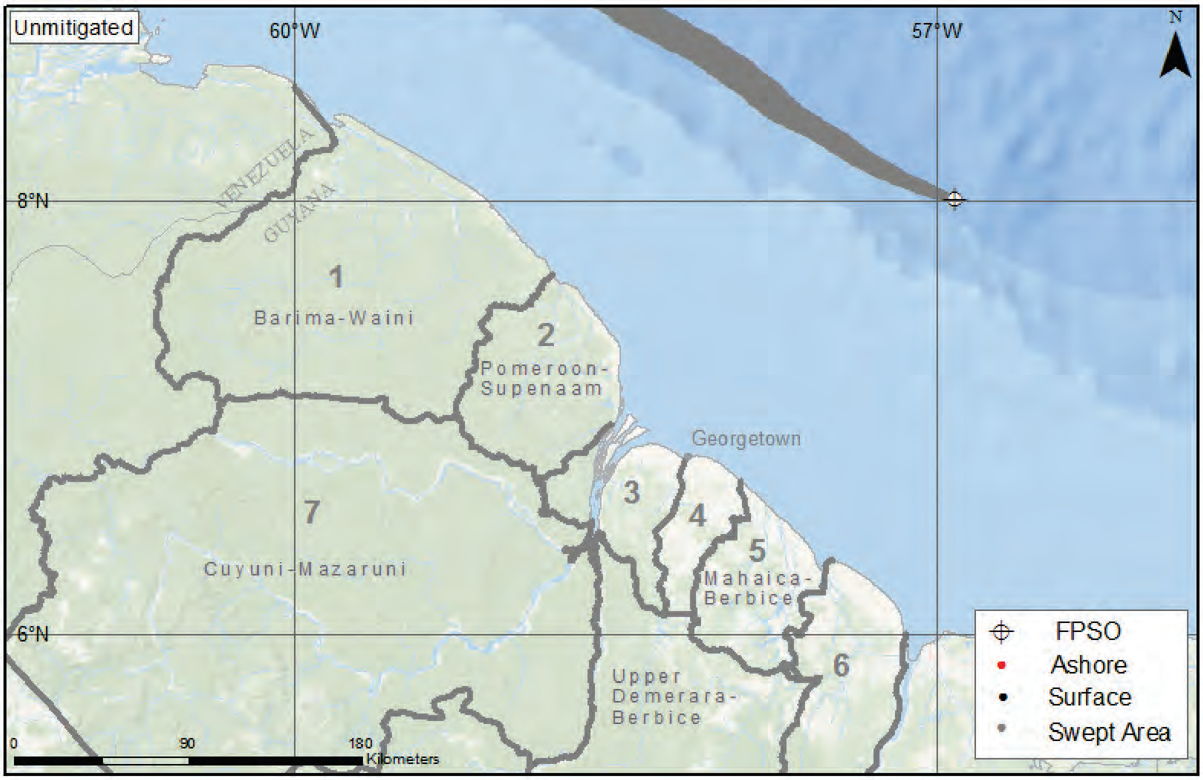


Figure 9.1-6b: (Zoomed in) Deterministic Map for Scenario 12—Predicted Transport and Fate from an Unmitigated 2,500-Barrel Surface Release of Crude Oil (Winter)

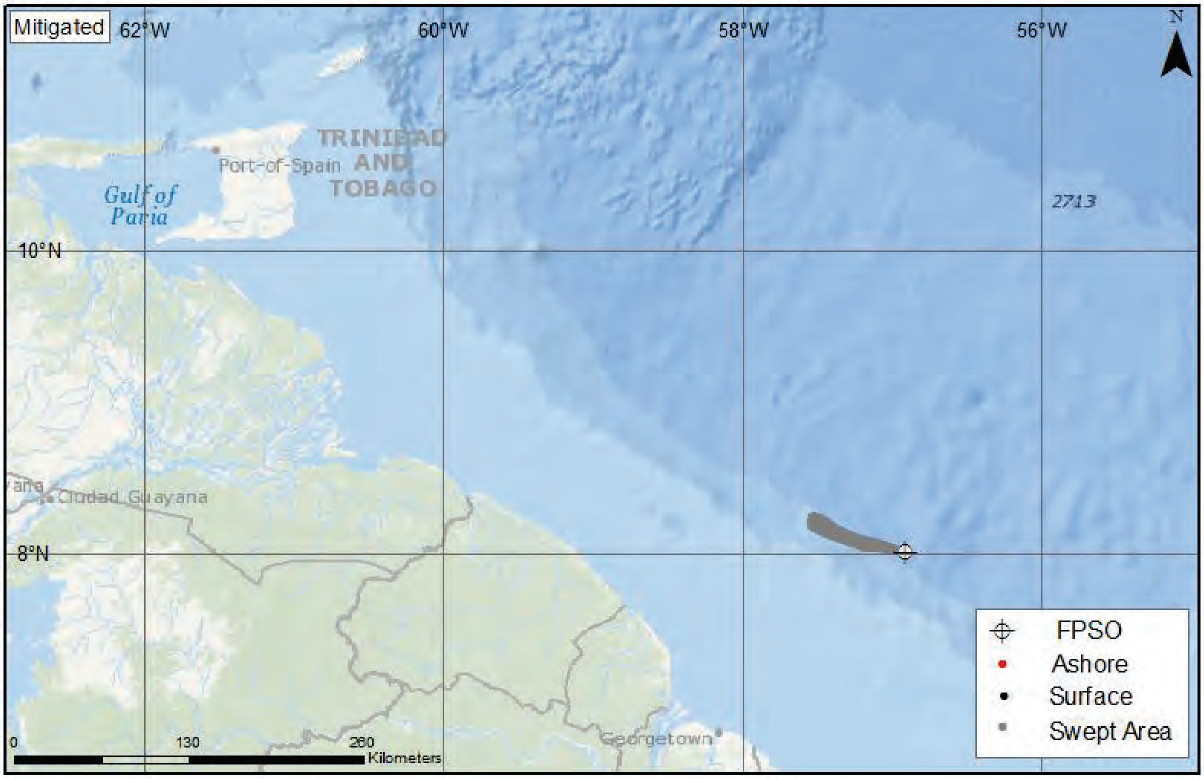


Figure 9.1-7a: Deterministic Map for Scenario 12—Predicted Transport and Fate from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Summer)

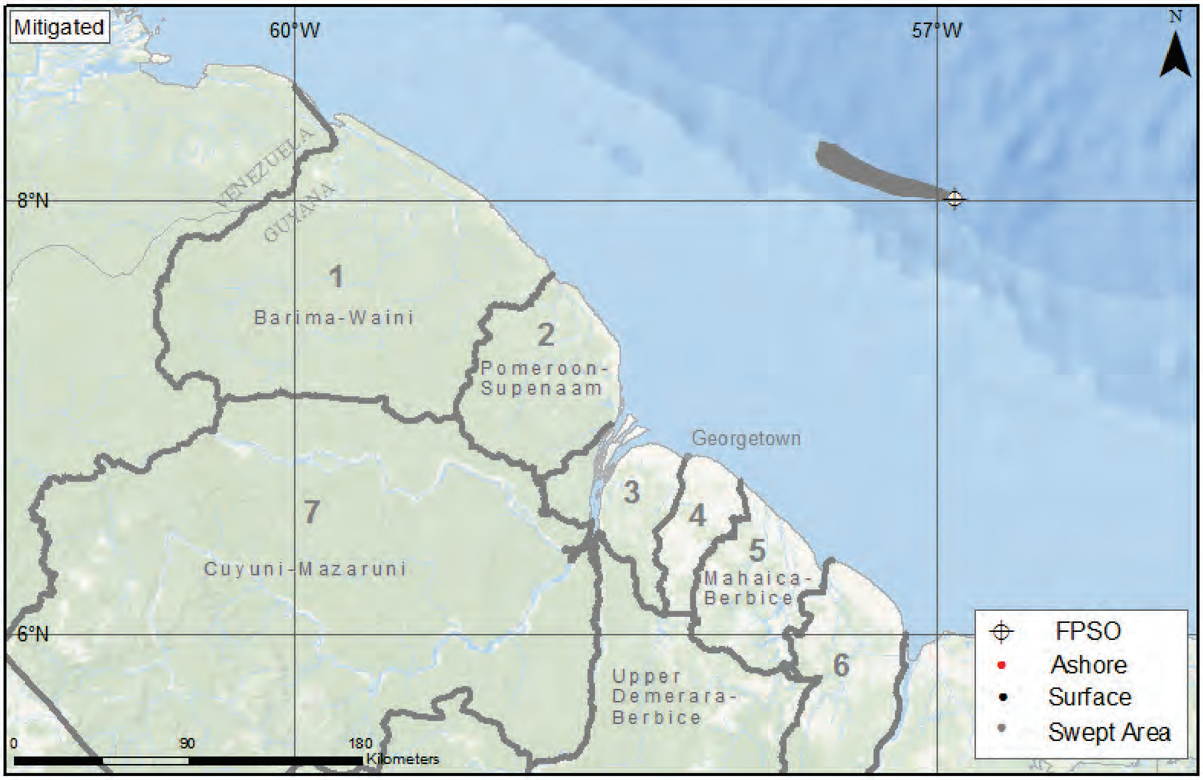


Figure 9.1-7b: (Zoomed In) Deterministic Map for Scenario 12—Predicted Transport and Fate from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Summer)

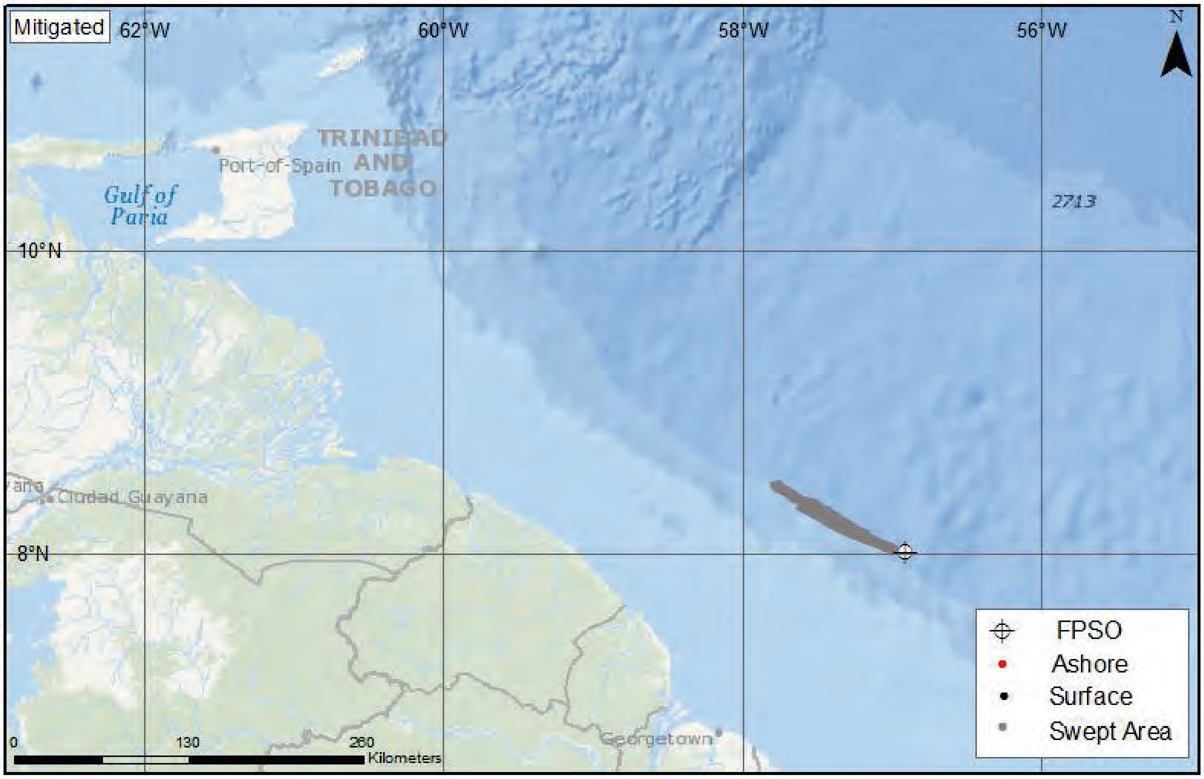


Figure 9.1-8a: Deterministic Map for Scenario 12—Predicted Transport and Fate from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Winter)

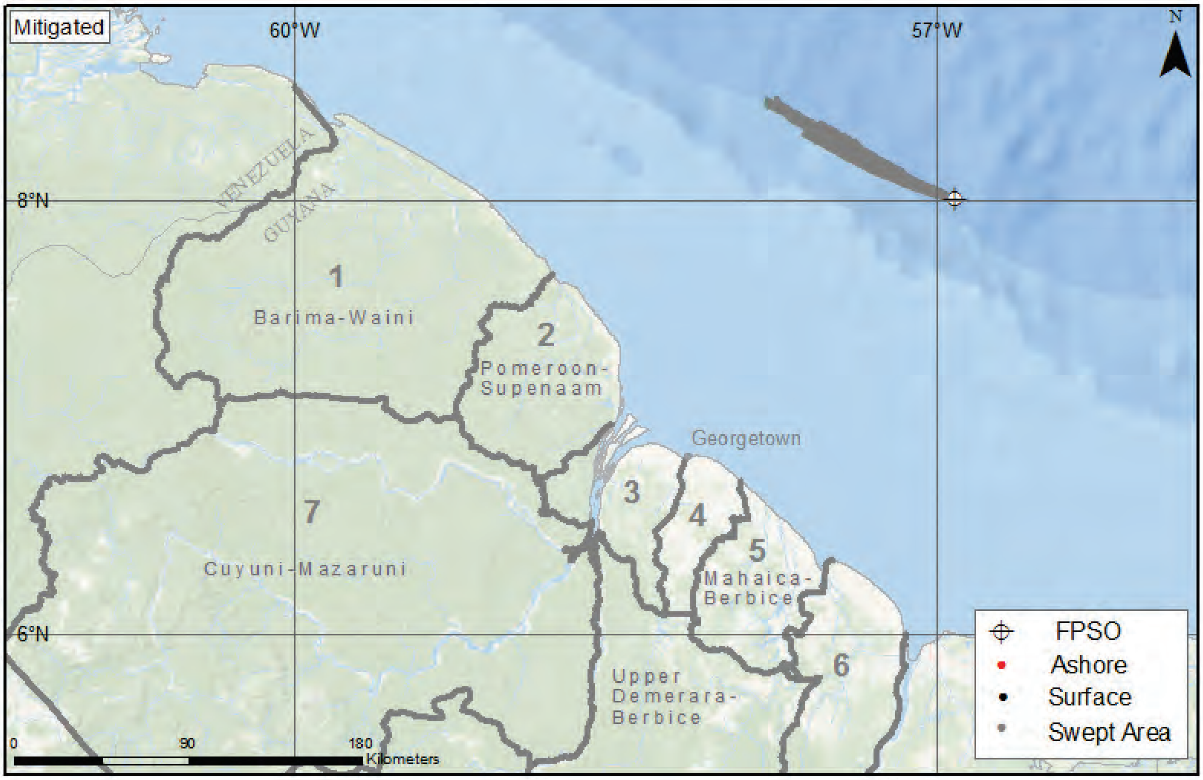


Figure 9.1-8b: (Zoomed In) Deterministic Map for Scenario 12—Predicted Transport and Fate from a Mitigated 2,500-Barrel Surface Release of Crude Oil (Winter)

9.1.5.2. Scenario 13—Loss of Well Control Resulting in 30-Day Subsea Release of Crude Oil at 20,000 BPD

Figure 9.1-9a shows a stochastic map for sea surface oiling (without mitigation by response activities) resulting from Scenario 13 (a loss of well control event that results in a 20,000 BPD subsea release lasting for 30 days) in the summer season. The top panel shows the probability of sea surface oiling above a minimum thickness of 1.0 g/m^2, and the bottom panel shows the minimum amount of time for sea surface oiling above a minimum thickness of 1.0 g/m^2. Figure 9.1-9b shows the same stochastic map, zoomed in on the Guyanese coast.

Figures 9.1-10a and 9.1-10b show the stochastic maps for sea surface oiling (without mitigation by response activities) resulting from Scenario 13 in the winter season.

Figure 9.1-11a shows a deterministic map (without mitigation by response activities) resulting from Scenario 13 in the summer season. The gray area shows the “swept area,” which is the area across which the oil spill is projected to travel. The black areas show the oil predicted to be remaining on the surface at the end of the 45-day modeling simulation. The red areas show the oil predicted to have made shoreline contact at the end of the 45-day modeling simulation, all based on the minimum thickness. Figure 9.1-11b shows the same deterministic map zoomed in on the Guyanese coast.

Figures 9.1-12a and 9.1-12b show the deterministic maps (without mitigation by response activities) resulting from Scenario 13 in the winter season.

Figures 9.1-13a and 9.1-13b show the deterministic maps (with mitigation by response activities) resulting from Scenario 13 in the summer season. Figures 9.1-14a and 9.1-14b show the deterministic maps (with mitigation by response activities) resulting from Scenario 13 in the winter season. As shown by the modeling results, on the basis the release has been stopped within a period of 21 days, and with the application of spill response measures, the modeling predicts a significantly reduced extent of surface movement of the spill and no impacts on any coastlines.

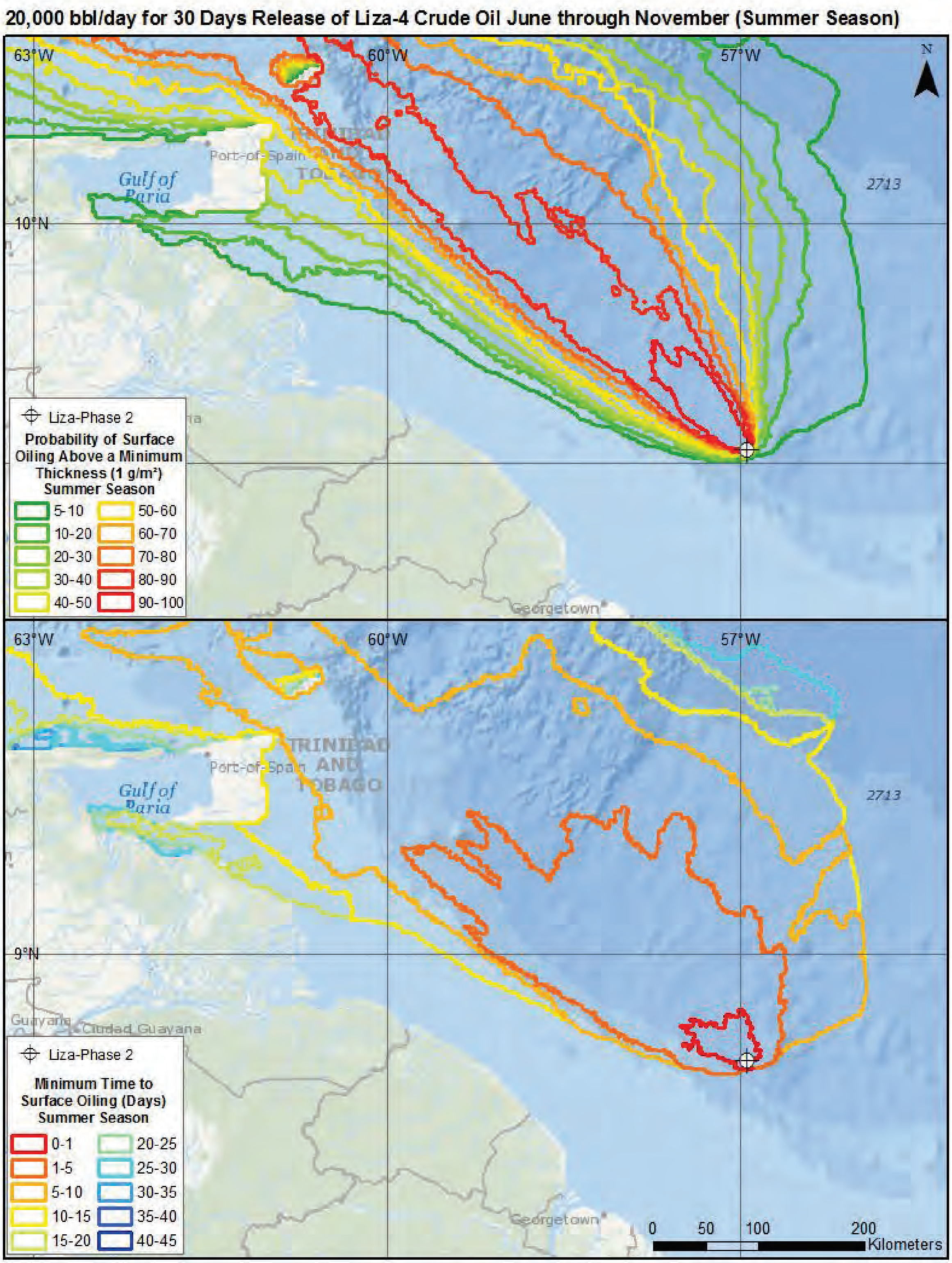


Figure 9.1-9a: Stochastic Map for Scenario 13—Predicted Surface Oiling from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Summer)

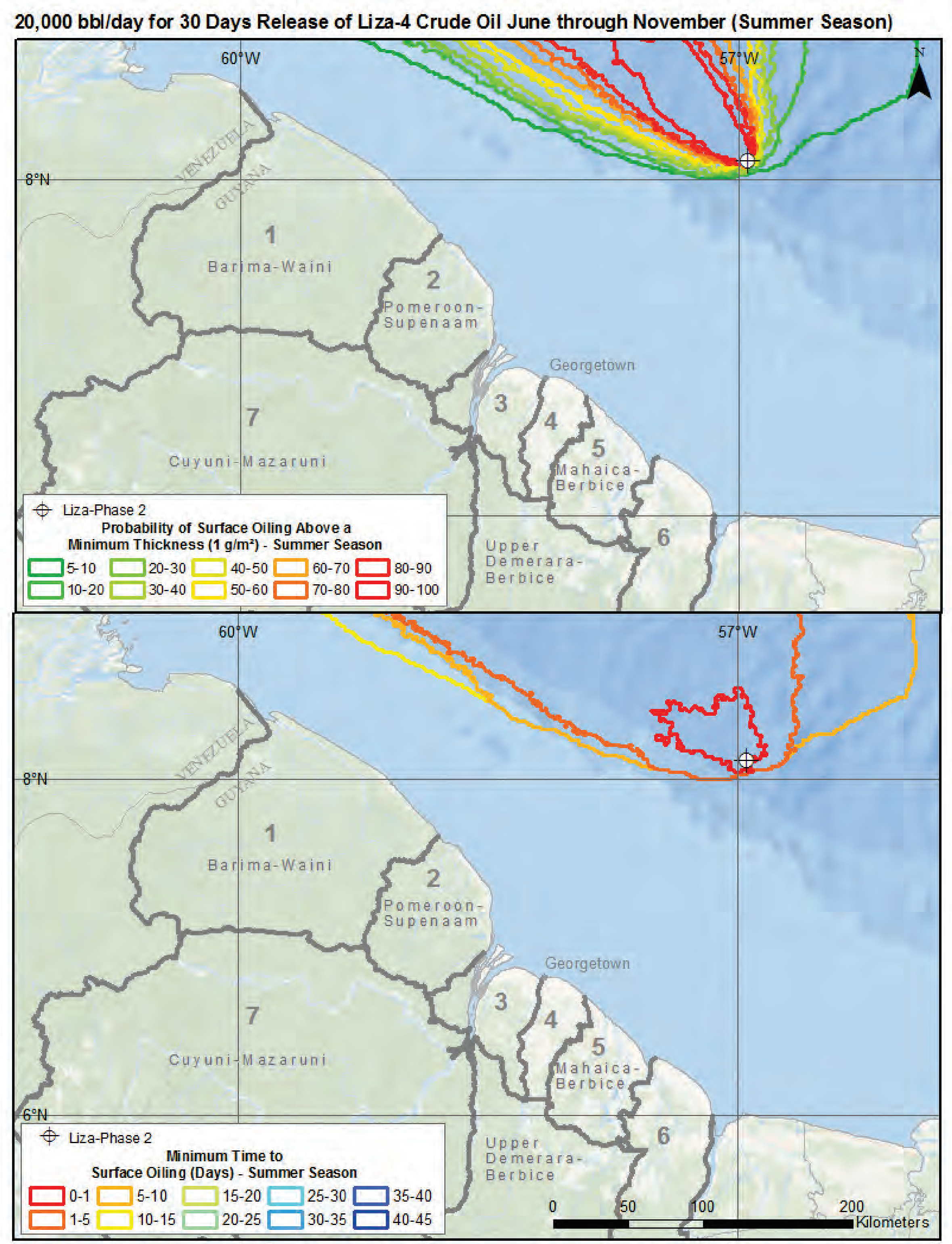


Figure 9.1-9b: (Zoomed In) Stochastic Map for Scenario 13—Predicted Surface Oiling from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Summer)

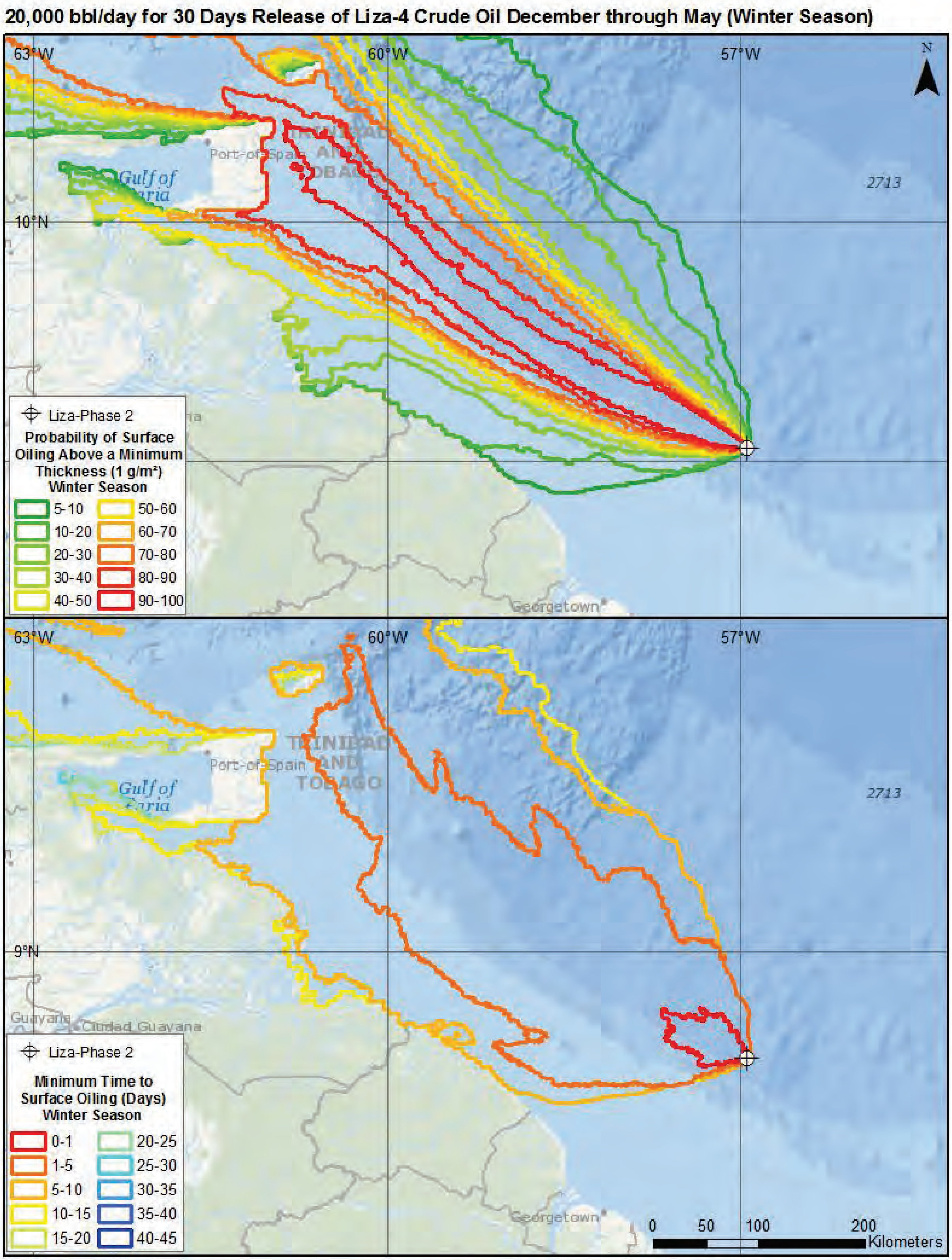


Figure 9.1-10a: Stochastic Map for Scenario 13—Predicted Surface Oiling from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Winter)

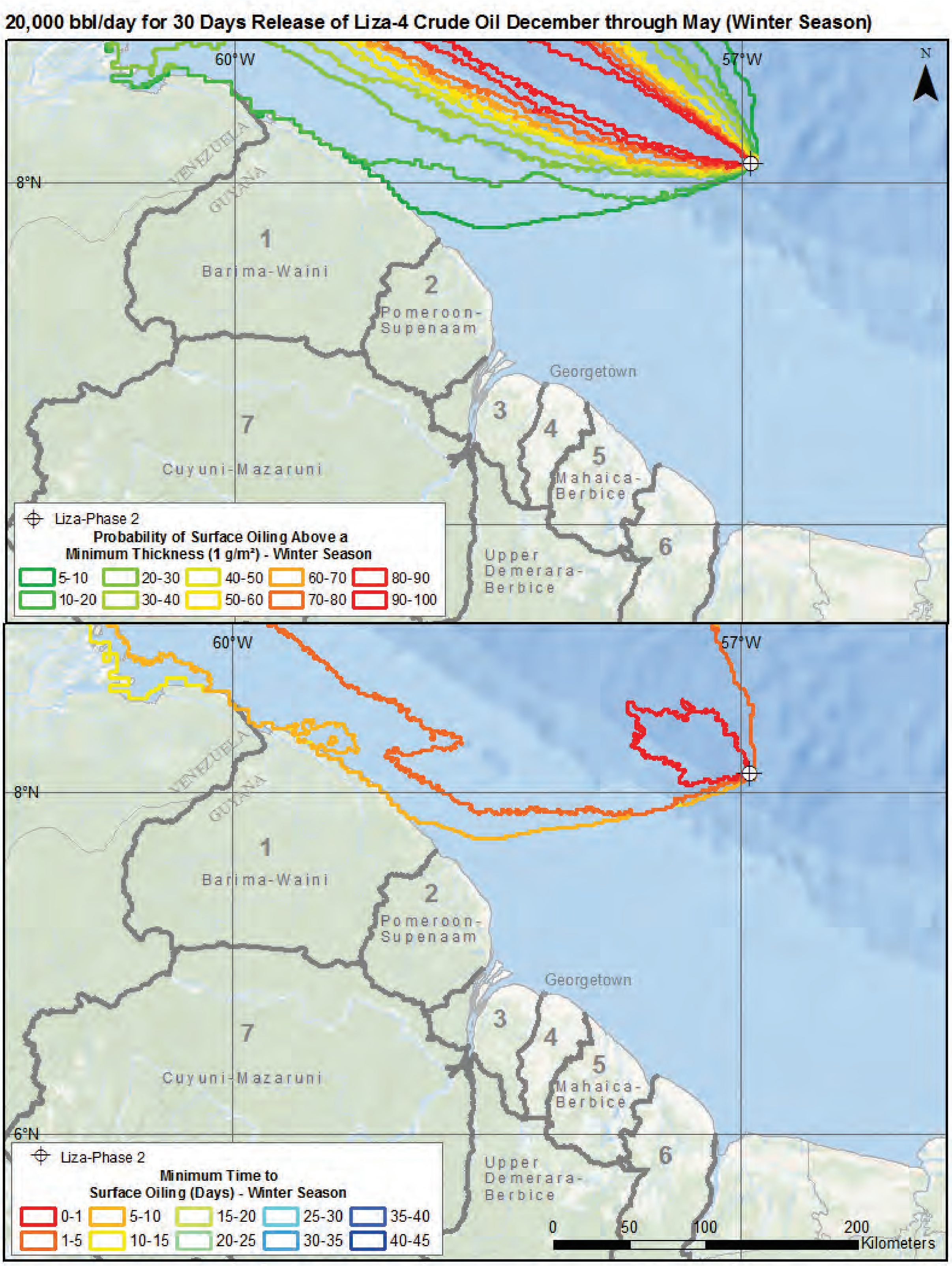


Figure 9.1-10b: (Zoomed In) Stochastic Map for Scenario 13—Predicted Surface Oiling from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Winter)

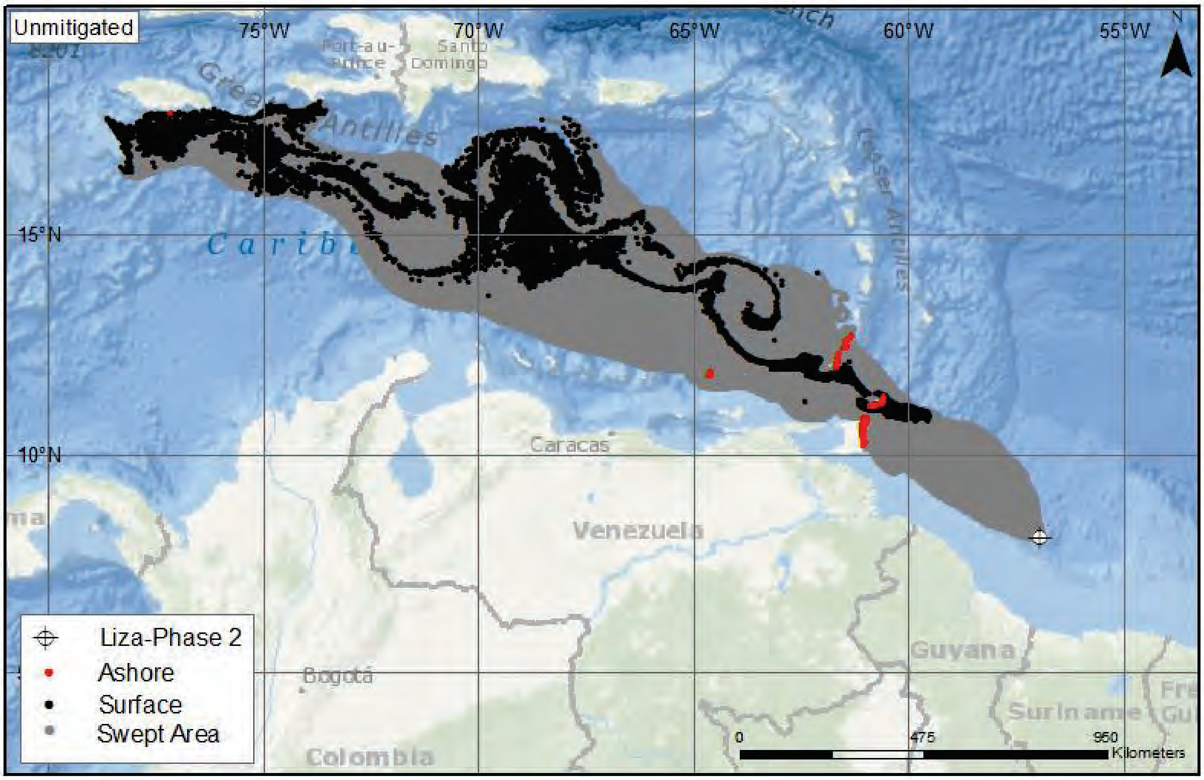


Figure 9.1-11a: Deterministic Map for Scenario 13—Predicted Transport and Fate from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Summer)

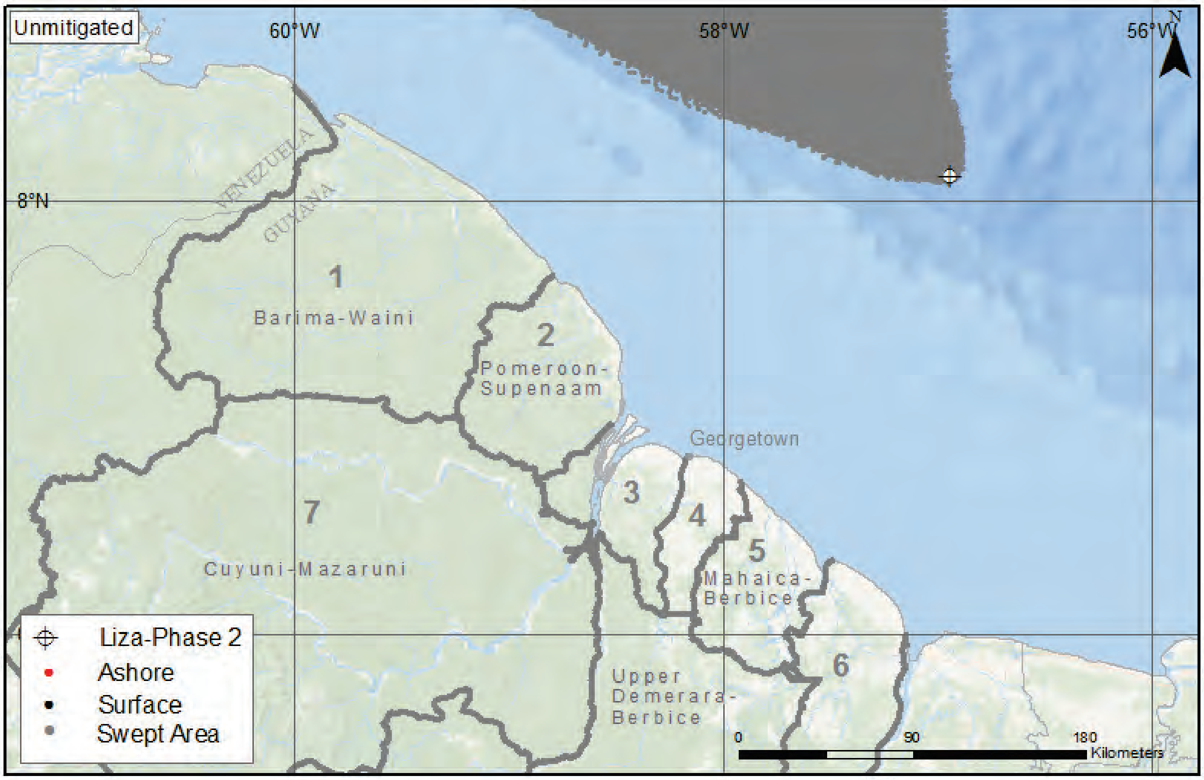


Figure 9.1-11b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport and Fate from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Summer)

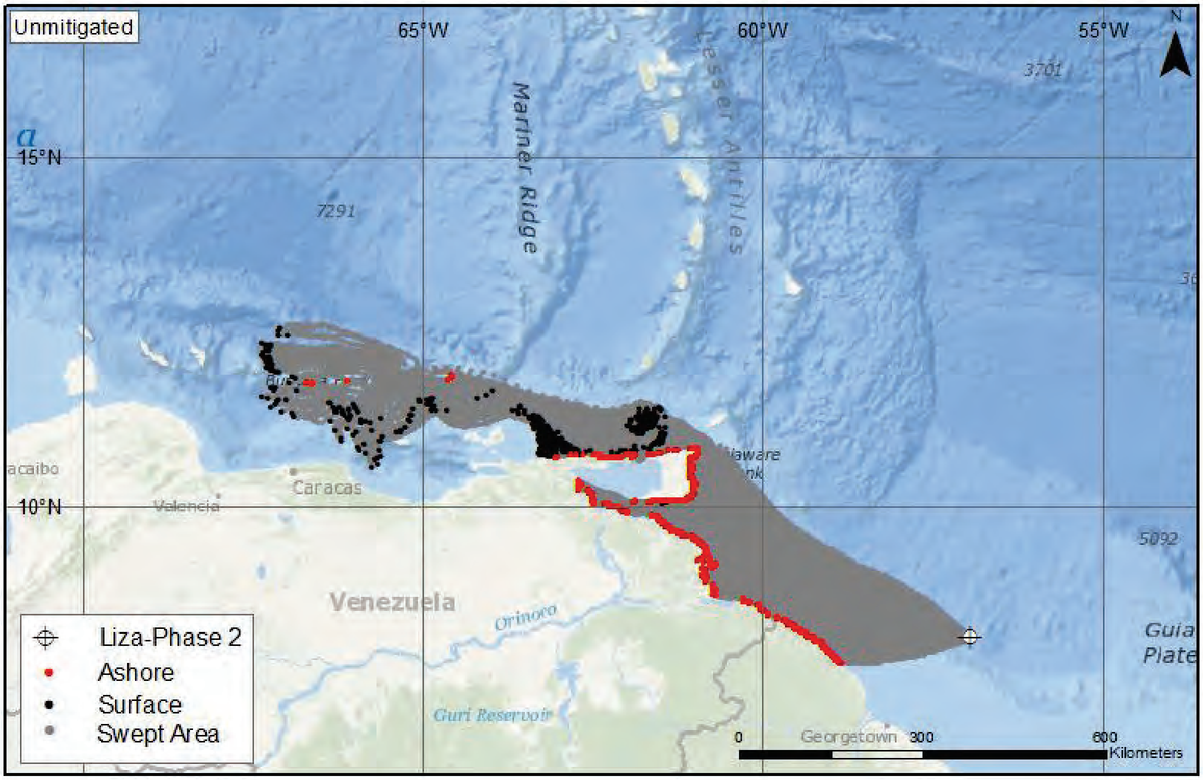


Figure 9.1-12a: Deterministic Map for Scenario 13—Predicted Transport and Fate from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Winter)

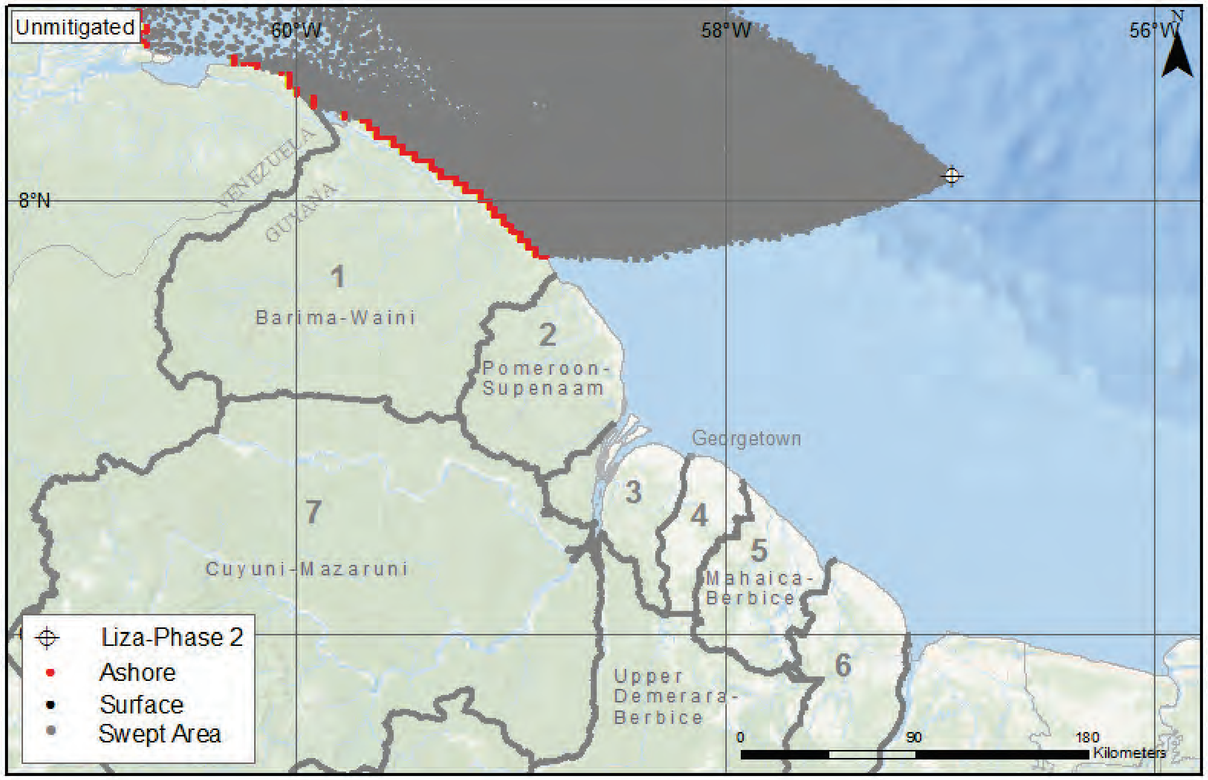


Figure 9.1-12b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport and Fate from an Unmitigated 20,000-BPD Subsea Release of Crude Oil Lasting 30 Days (Winter)

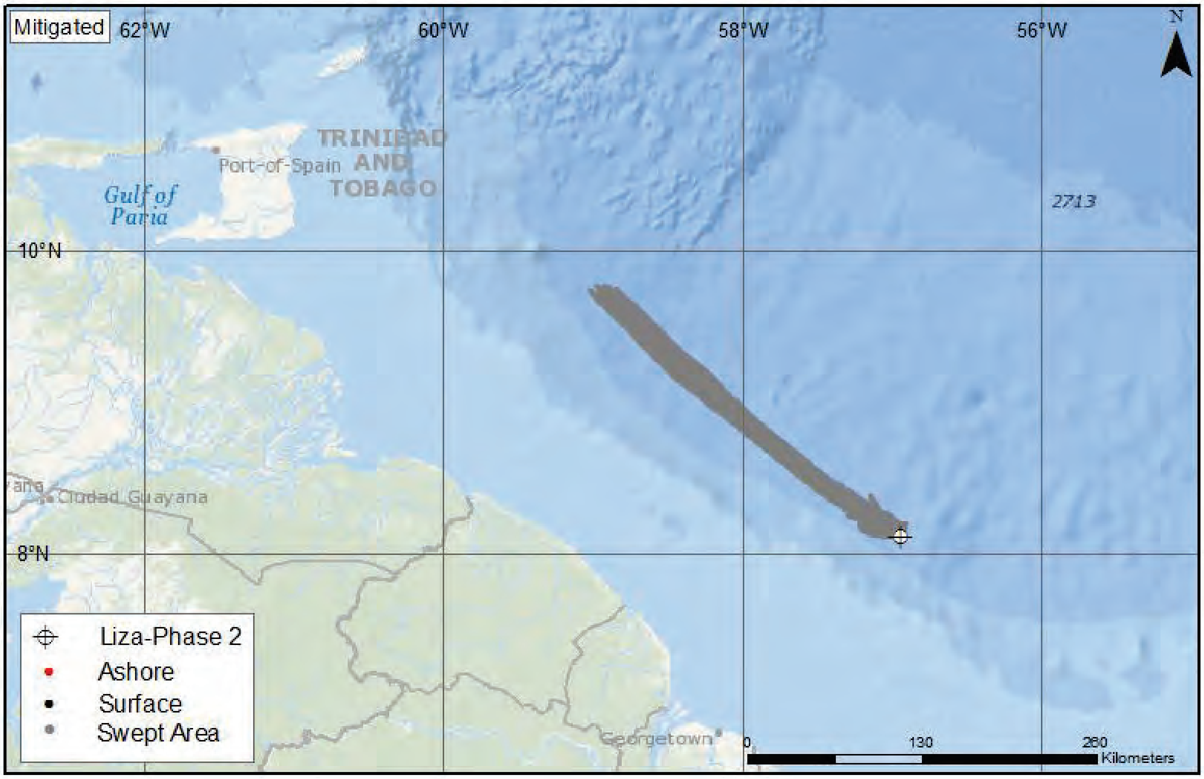


Figure 9.1-13a: Deterministic Map for Scenario 13—Predicted Transport and Fate from a Mitigated 20,000-BPD Subsea Release of Crude Oil After 30 Days—Capped After 21 Days (Summer)

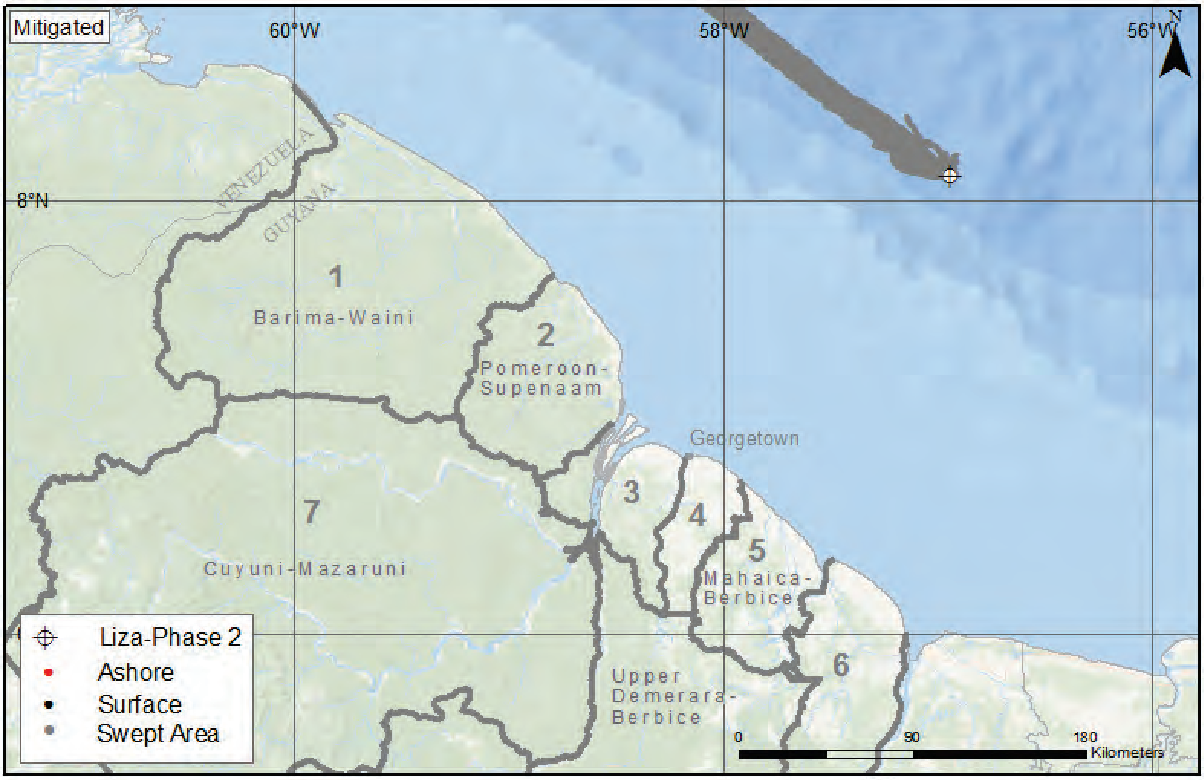


Figure 9.1-13b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport and Fate from a Mitigated 20,000-BPD Subsea Release of Crude Oil After 30 Days—Capped After 21 Days (Summer)

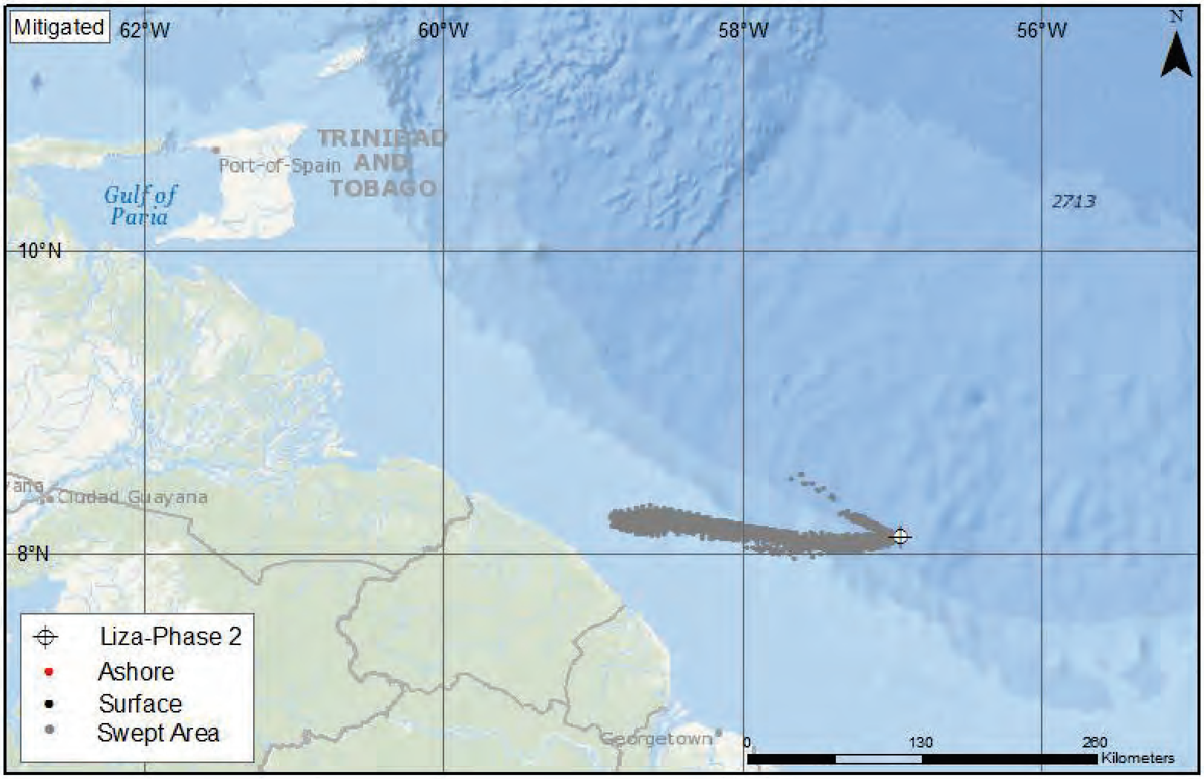


Figure 9.1-14a: Deterministic Map for Scenario 13—Predicted Transport and Fate from a Mitigated 20,000-BPD Subsea Release of Crude Oil After 30 Days—Capped After 21 Days (Winter)

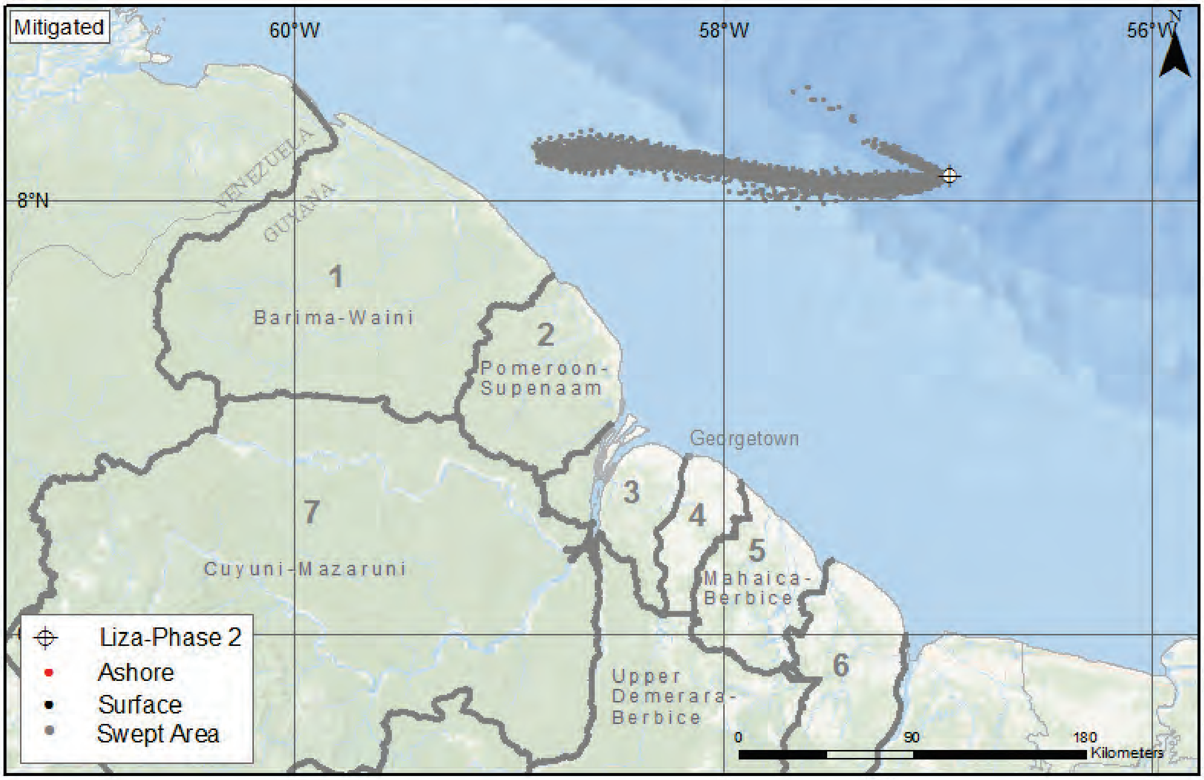


Figure 9.1-14b: (Zoomed In) Deterministic Map for Scenario 13—Predicted Transport and Fate from a Mitigated 20,000-BPD Subsea Release of Crude Oil After 30 Days—Capped After 21 Days (Winter)

9.1.6. Coastal Sensitivity Mapping

Coastal sensitivity mapping was completed for the entire coastal area identified in the oil spill modeling as having the potential to be contacted by hydrocarbons as a result of either of the modeled unmitigated marine oil spill scenarios. The coastal sensitivity mapping consisted of initial desktop-based research, followed by field verification in specific areas (Regions 1–6 in Guyana[1], and Trinidad and Tobago). The mapping included characterization of the following resources:

- Environmental—protected areas, mangroves, shoreline types, seagrass beds, coral reefs, important coastal fish habitats, important coastal bird habitats, and other sensitive habitats; and
- Socioeconomic—coastal and/or indigenous peoples communities (e.g., locations, demographics, and socioeconomic characteristics), ecosystem services (type, beneficiaries, value of services to beneficiaries, habitats, and resources), shoreline- and coastal-dependent commercial and artisanal activities (e.g., fishing, foraging, hunting, agriculture and grazing, and transportation), industrial activities and infrastructure (e.g., water intake facilities, ports), and traditional and cultural practices.

Discussions of the methodologies and results of the coastal sensitivity mapping are included in the relevant resource-specific sections of the EIA. The coastal sensitivity maps are provided in Appendix P.

This information enables EEPGL to prioritize the mobilization of emergency response resources (manpower and equipment) to those areas most sensitive to a spill.

9.1.7. Oil Spill Prevention, Control, and Emergency Response Measures

Regarding spill prevention controls associated with Scenario 13 (loss of well control release), EEPGL's well-control philosophy is focused on spill prevention using safety and risk management systems, management of change procedures, global standards, and trained, experienced personnel. EEPGL has a robust management system (Operations Integrity Management System [OIMS]; see Chapter 2, Description of the Project) that emphasizes attention to safety, well control, and environmental protection. Measures to avoid a loss of well control include:

- Proper preparation for wells (well design, well control equipment inspection and testing);
- Automatic detecting of any excess pressure entering the well during drilling;
- Use of physical barriers including automatic BOPs;

[1] Although oil spill modeling indicates Region 1 is the only Guyana region with the potential to have a coastline impacted by an unmitigated subsea release from a well control event, coastal sensitivity data were collected for Regions 1–6 as part of Liza Phase 1 post permit studies.

- Personnel training and proficiency drills for well control; and
- Use of drilling fluids to control pressures within the well.

Chapter 2 provides additional information related to well control measures.

Regarding spill prevention controls associated with Scenario 12 (FPSO offloading spill), the measures to avoid a spill associated with FPSO offloading include:

- FPSO and tanker collision avoidance controls (as described in Section 9.1.1.4, Offshore Collision between FPSO and Offloading Tanker);
- Use of a certified engineered floating hose system;
- Floating hose damage protection controls;
- Use of emergency disconnect controls on the floating hose system;
- Use of load monitoring systems in the FPSO control room;
- Use of leak detection controls including infrared leak detection;
- Flood lighting for night operations; and
- Volumetric checks during offloading.

Section 2.13, Embedded Controls, provides additional information on spill prevention measures.

A representative list of spill prevention and mitigation measures and associated embedded controls for a typical FPSO development project (based on the Liza Phase 1 Development Project) can also be found in the OSRP.

In addition to the established spill prevention controls, EEPGL also has developed a detailed OSRP, which is included as part of the Project's ESMP, to ensure an effective response to an oil spill, if one were to occur. The OSRP builds on the coastal sensitivity mapping and oil spill modeling described herein and describes the response measures appropriate to the magnitude and complexity of a spill incident.

The OSRP clearly delineates the responsibilities of each entity that would take part in a response and describes how EEPGL and its contractors would mobilize local oil spill response resources, which would be complemented by the regional and international resources provided by its oil spill response contractors. The OSRP describes the EEPGL process for notifying the Government of Guyana with respect to mobilizing its resources. The lead agency for oil spill response in Guyana is the Civil Defense Commission and the drat National Oil Spill Contingency Plan outlines how the Civil Defense Commission will coordinate the responses of other agencies, including MARAD.

Due to the precautionary measures utilized by EEPGL to prevent and control an oil spill, as described above and in Chapter 2, Description of the Project, the likelihood of a Tier II or III oil spill occurring is considered to be **Unlikely**.

9.1.8. Potential Effects on Wildlife and Pros and Cons of Dispersant Use

The decision regarding whether to use chemical dispersants for spill response is based on the characteristics of the spill, the biological and socioeconomic resources that are at risk from exposure to the oil, and the expected net impact of available response options. Protection of different resources is prioritized and the risk to each is established through a process of NEBA, also known as Spill Impact Mitigation Assessment, which considers the relative impacts and performance of different response options.

Modern Type 3 dispersants that would be used in the unlikely event of a spill during the Project consist of a mixture of surfactants (such as those used in detergent products) and solvent. The formulation of dispersant types varies somewhat in order to target specific oil types, water salinities, and temperatures, but the mechanism by which the dispersants work is the same. Dispersants are not typically combined prior to application and the nature of dispersant use is such that in the event that more than one dispersant product is being used during a response, there will be some distance between the sites in most cases. For example, it is possible that two different products could be used for subsea dispersion and surface dispersion; however, the water depths in the PDA mean that these products are unlikely to mix. It is not considered feasible that synergistic toxicity would occur between different types of dispersants if they inadvertently came into contact with each other after application, as the mechanism of action and products are so similar for different Type 3 dispersants and the concentrations involved are very low.

While the dispersant products do have some inherent toxicity, a wide range of scientific ecotoxicity studies, discussed below in more detail, have concluded that dispersed oil toxicity is not driven by dispersant, but rather by the effect of the increased hydrocarbons in the water column and differences in the composition of different hydrocarbon fractions (as discussed in Alexander et al. 2016), and not due to the dispersant product itself. Additionally, it would be in only rare events (e.g., overspray) that exposure to dispersants alone would be expected to occur, as dispersant application is targeted to the oil surface rather than the water surface. In these events, the volume of dispersant will be very small. It is common for dispersants to be sprayed at a rate of approximately 50 liters per hectare (taking account of a typical oil slick thickness of 0.1 millimeter), providing a dispersant thickness of 0.005 millimeter that will immediately begin to rapidly dilute into the water column. Not accounting for horizontal dilution, this results in an initial dispersant concentration of 5 parts per million (ppm) when mixed into the top 1 meter and 0.5 ppm when mixed into the top 10 meters of the water column. The remainder of this discussion therefore focusses on the combination of dispersant and oil as this is the form in which it would be present in the environment.

The reported toxicity of a range of dispersant products indicates that these products mostly fall into the International Maritime Organization (IMO) GESAMP (1996) rank of *slightly toxic* (>10 ppm) or *practically non-toxic* (100 to 1,000 ppm).

The key purposes of surface or subsea dispersant application are to reduce the area of surface oil slicks and to enhance natural biodegradation so that both surface and entrained hydrocarbon concentrations are more rapidly depleted. In marine oil spills in open water, the main concern is generally acute toxicity resulting from a pulsed exposure to the surface slick, or elevated hydrocarbons immediately under the slick, as well as physical oiling of wildlife. Rapid 3-dimensional dilution of the spill in open ocean conditions will generally reduce concentrations of hydrocarbons in the water column to below acute toxicity thresholds such that toxic effects are unlikely (Lee et al. 2013). Furthermore, removing oil slicks from the water surface reduces risks to seabirds, marine mammals, and marine reptiles, which are most at risk from direct contact with surface slicks. Marine mammals and reptiles are also vulnerable to direct exposure to slicks as they surface to breathe, and they may also inhale high concentrations of hydrocarbon vapors from the air directly above a slick. It is generally accepted that the effective use of dispersants will significantly reduce the risk to birds, marine mammals, and marine reptiles.

Reducing the volume of surface oil also typically reduces the volume that strands on shorelines, where shorebirds, nesting turtles, or invertebrate species are vulnerable to direct contact or high concentrations of hydrocarbons. Oil on shorelines is also prone to much lower biodegradation rates and does not have the same potential for rapid toxicity reduction that can occur with open ocean dispersion.

The trade-off of dispersant use is that in-water hydrocarbon concentrations are initially elevated as more of the oil is moved into the water column. As a result, species in the water column, including plankton and fish, are temporarily exposed to higher concentrations of hydrocarbons than would be present at depth under a floating slick. The in-water concentrations then reduce quickly over time and distance from the treatment site as a result of 3-dimensional dilution and biological breakdown of the hydrocarbons. Rapid 3-dimensional dilution of the spill in open ocean conditions will generally reduce concentrations of hydrocarbons in the water column to levels where toxicity is unlikely (Lee et al. 2013).

Table 9.1-5 provides a summary of the potential benefits and risks associated with dispersant use on different environmental receptors. Further discussion on key receptors and effects is provided in the following sections. The assessment of impact severity in Table 9.1-5 considers the likelihood of injury to individual organisms, but also the extent to which populations are able to recover from impact (e.g., planktonic communities have rapid regeneration times, whereas mortality on species such as whales, marine turtles, and mangroves may result in longer-term population effects).

Table 9.1-5: Potential Severity and Mechanism of Impacts for Undispersed vs Dispersed Oil

Receptor	**Potential Impact Severity and Key Mechanisms**			
	Undispersed Oil		**Dispersed Oil [a]**	
Pelagic (Open Water)				
Marine Mammals	Medium/High	• Skin and eye irritation • Inhalation of hydrocarbons above slicks • Toxicity if bulk oil ingested	Low/Medium	• Some toxicity if oil ingested.
Marine Reptiles	Medium/High	• Skin and eye irritation • Inhalation of hydrocarbons above slicks • Toxicity if bulk oil ingested	Low/Medium	• Some toxicity if oil ingested.
Seabirds	High	• Fouling of feathers (hypothermia/drowning) • Skin and eye irritation • Toxicity if bulk oil ingested • Feeding interrupted by lack of visibility	Low	• Prey likely to avoid high concentrations of dispersed oil.
Fish	Low	• Limited toxicity if fish are present near to surface where hydrocarbons are elevated beneath the slick • Fouling of gills if exposed to large oil droplets	Low/Medium	• Probable avoidance of high concentrations of dispersed oil. • Depuration occurs in months.
Plankton (including larval fish and invertebrate species)	Low	• Only impacted if present in surface waters	Medium	• Some toxicity if exposed to dispersed oil in water column.
Commercial Fisheries	Medium	• Fouling of equipment and boats • Reduced value or stock or market restrictions due to fisheries closure or concerns of potential contamination	Medium	• Real or perceived contamination of fish results in reduced value or market restrictions due to fisheries closure.
Benthic (Offshore)				
Invertebrates	Negligible	• Unlikely to be exposed	Low	• Dispersed oil in deep waters during subsea application
Benthic Fish	Negligible	• Unlikely to be exposed	Low	• Dispersed oil in deep waters during subsea application. Active avoidance of high concentrations of dispersed oil.

Receptor	**Potential Impact Severity and Key Mechanisms**			
	Undispersed Oil		**Dispersed Oil [a]**	
Shoreline/Intertidal				
Shorebirds	High	• Fouling of feathers (hypothermia/drowning) • Skin and eye irritation • Toxicity if bulk oil ingested • Feeding interrupted by lack of visibility	Low	• Some toxicity if oil ingested
Invertebrates	Medium	• Smothering of animals or habitat • Toxicity from external contact or ingestion of oil	Low	• Toxicity from dispersed oil ingestion
Marine Algae	Low/Medium	• Mortality • Temporary reduction in photosynthesis and growth	Low	• Temporary reduction in photosynthesis and growth
Intertidal Plants	Medium/High	• Temporary reduction in photosynthesis and growth • Mortality where heavy smothering	Low	• Some mortality • Temporary reduction in photosynthesis and growth

[a] Assumes dispersion has been effective and no surface slicks remain. Assumes that dispersant is not applied in water less than 10-meter depth or closer than 5 kilometers from shore (i.e., high levels of 3-dimensional dilution will occur before dispersed oil reaches shallow water areas).

9.1.8.1. Marine Mammals and Marine Reptiles

Any animal that is directly contacted by hydrocarbons will be vulnerable to irritation of the external tissues, including skin and eyes, nasal, and other body cavities (AMSA 2013b). This type of impact is relevant to marine mammals and marine turtles that may swim through the slick (Fingas 2011; St Aubin and Lounsbury 1990).

Hydrocarbons may be ingested coincidentally with food, or may be inhaled from the air directly above a slick by animals such as marine turtles and marine mammals (Rainer Engelhardt 1983; Fingas 2011; St Aubin and Lounsbury 1990).

Where shoreline oiling occurs, marine turtles and their hatchlings are vulnerable to direct exposure, leading to potential smothering and possible toxic effects.

There are no reports in the literature of experimental exposure of marine mammals or reptiles to chemically dispersed hydrocarbons. Dead dolphins and marine turtles were found during the Macondo spill, in which large amounts of dispersant was applied to the spill. It therefore cannot be discounted that impacts on these animals were related to their exposure to chemically dispersed oil, although there were also extensive surface slicks to which animals were likely exposed and which could be responsible for the observed impacts. However, dispersion of oil will generally reduce risk to marine mammals and marine reptiles by preventing their direct contact with untreated oil or inhalation of high concentrations of hydrocarbon vapors. Both groups have the capacity to process toxins internally and depurate harmful chemicals. The rapid dilution of dispersed oil means that typically only low levels of exposure to toxic compounds would occur.

While there are few reported cases of mortality of marine mammals or reptiles during any documented oil spills, it is generally accepted that effective dispersion will reduce the risk of injury to these species, particularly where dispersion reduces exposure of wildlife to surface slicks and stranded oil.

9.1.8.2. Birds

Direct contact with undispersed oil may cause irritation of sensitive tissues, such as eyes, skin and internal cavities (Fingas 2011; St Aubin and Lounsbury 1990; AMSA 2013b).

Hydrocarbons may be ingested coincidentally with food or during preening (Rainer Engelhardt 1983; Fingas 2011; St Aubin and Lounsbury 1990).

Egg shells are known to be permeable to hydrocarbons that may be transferred from parents or through direct contact such as when an oiled bird returns to the nest from feeding (Finch et al. 2012; Peakall et al. 1987).

The greatest risk to birds from an oil spill is reported to be where their feathers become fouled by oil, subsequently damaging the feather structure, interfering with or inhibiting flying and waterproofing, and rendering the birds vulnerable to hypothermia and drowning. If present in the area, large numbers of seabirds may be impacted or killed where there is heavy surface oiling. They may also avoid or limit hunting in areas where surface slicks limit the visibility of prey;

however, such avoidance may reduce more serious harm than if the bird was to dive through the surface slick.

Effective dispersion of oil will reduce the area of surface slicks and shoreline oiling, avoiding the most significant impacts to birds that result from direct contact with the oil. There is also evidence that dispersed oil is less toxic to developing embryos (where oil is transferred from the parent bird to an egg) than undispersed oil (Albers 1980 cited in Eastin and Rattner 1982).

The use of dispersant will reduce the potential impacts on seabirds and shorebirds relative to potential impacts from an untreated oil spill.

9.1.8.3. Fish and Commercial Fisheries

Toxicity in adult fish has been reported in response to crude oils, heavy fuel oil, and diesel (Holdway 2002; Shigenaka 2011). Fish will generally only be exposed to harmful concentrations of oil from an undispersed slick where they are present in shallow waters beneath a slick or in a location of high concentrations of entrained oil from a subsurface release.

While fish are known to take up hydrocarbons in their tissues, the majority of studies, either from laboratory trials or of fish collected after spill events (including the Hebei Spirit, Macondo, and Sea Empress spills) exhibit evidence of fish tissues returning to normal levels within two months of exposure (Challenger and Mauseth 2011; Davis et al. 2002; Gagnon and Rawson 2011; Gohlke et al. 2011; Jung et al. 2011; Law et al. 1997; Rawson et al. 2011).

The use of dispersant will result in a higher concentration of hydrocarbons in the water column, where fish species may be exposed. The degree of exposure will depend on the water depth and the proximity of the animals to the dispersant application and length of time they remain in the area of the spill. Studies comparing chemically dispersed hydrocarbon mixtures, including crude oil and Corexit 9500, to mechanically dispersed oil on fish species have found similar results (Hemmer et al. 2011; Wetzel and Van Fleet 2001). The National Academy of Sciences (2005) published a workshop consensus describing exposure concentration thresholds of concern (toxicological-relevant concentrations) for dispersed oil on adult fish of 0.5 ppm for a 96 hour exposure, increasing to 100 ppm over 0 to 3 hours (high concern) and 10 ppm over 0 to 3 hours (low concern) (NRC 2005). Rapid dilution of dispersed oil at sea is expected to reduce water column exposure below these thresholds within minutes to hours.

Predatory fish may be exposed to, and accumulate, hydrocarbons from prey species. However, the concentrations of hydrocarbon to which they would be exposed through this route would be small unless very large amounts of contaminated prey were consumed, although short-term elevated hydrocarbons or biomarkers of contamination may be present in the tissues of predatory species exposed in this way.

Fish are at greater risk from dispersed oil than undispersed surface slicks; however, effects from dispersed oil will be limited in area due to high rates of dilution that would rapidly reduce concentrations below harmful levels.

A marine oil spill will typically result in concern regarding contamination of fish stocks. This can result in fisheries closures while fish are assessed for safety, and can affect market value of fish. Additionally, surface oil slicks can foul fishing vessels and equipment. As noted above, there is a slightly higher potential for fish exposure to hydrocarbons in the water column where dispersants are used, but overall impacts on a fishery are not likely to be greater or of longer duration as a result of dispersant use.

9.1.8.4. Benthic Species

Except in shallow waters and intertidal areas where significant hydrocarbon concentrations may occur, surface slicks pose very limited risks to benthic species. Dispersants may somewhat facilitate the likelihood of contamination of sediments by increasing the concentration of hydrocarbons deeper in the water column; although dispersants do not cause oil to sink. However, in deep water, the concentrations that would become entrained in sediments are likely to be very low. Conversely, the reduced viscosity of the hydrocarbon as a result of chemical dispersion may also reduce the subsequent tendency for the product to persist in sediments.

The majority of benthic invertebrates reproduce rapidly and many have broadcast spawning modes of reproduction. As a consequence, localized impacts are unlikely to result in significant population level impacts. The potential risks to benthic species are generally cited as the basis for avoiding dispersant application in shallow or confined waters; however, dispersant use in deep waters with good mixing is considered unlikely to result in additional harm to benthic species relative to undispersed oil.

9.1.8.5. Plankton

Like fish, the exposure of planktonic species (including phytoplankton, zooplankton, and larval invertebrates and fish) to undispersed oil will be determined by their proximity to the water surface. Where plankton exhibiting diurnal cycles rise to the surface, they are vulnerable to becoming entrained in surface oil and mortality would inevitably result.

Where oil has been dispersed, elevated concentrations of entrained and dissolved hydrocarbons in the water column have the potential to result in smothering or toxic effect to planktonic species, which are considered to be highly sensitive to contamination. However, impacts are expected to be localized based on dilution of the dispersed oil, and plankton are abundant and typically have rapid reproductive times.

Dispersed oil is expected to pose a greater threat to planktonic species than undispersed oil; however, other than where protection of large numbers of fish or invertebrate larvae is a priority, impacts on plankton alone would generally not be considered a barrier to dispersant use, particularly if use reduces impacts on more vulnerable environmental or socioeconomic resources.

9.1.8.6. Marine Algae and Marine Plants

Marine algae and marine plants are considered to not be particularly susceptible to impacts from untreated hydrocarbons. Studies of actual spills found no significant differences between oiled and unoiled seagrass meadows following large spills of crude oil (Kenworthy et al. 1993), or of heavy fuel oil contaminated by lighter fuel products (Taylor and Rasheed 2011). Short-term laboratory exposure (up to 10 hours) of seagrasses to various oils likewise did not have a significant impact, although longer exposures did result in reduced growth rates and or photosynthetic activity for some species (Thorhaug and Marcus 1985; Wilson and Ralph 2012). Mortality of intertidal seagrasses have occurred at a site heavily oiled with medium weight crude in Galeta, in which oil became trapped in mangroves and sediments and continued releases occurred over an extended period of many years (Burns et al. 1994).

Smothering of macroalgae may occur if it is exposed on the falling tide; however, the slick would generally be lifted off by the returning tide, particularly in the case of light oils, reducing the period of exposure. Studies identified no significant impacts on algal communities following the *Hebei Spirit* spill of heavy fuel oil (Edgar and Barrett 2000), the *Prestige* crude oil spill (Lobón et al. 2008), or the *World Prodigy* spill of marine diesel (Peckol et al. 1990).

Dispersed oils have been shown to impact growth rates of seagrasses and have increased toxicity to algae compared to those where untreated surface slicks were floating above the plants (Thorhaug and Marcus 1985; Wilson and Ralph 2012). Concentrations in these experiments were typically very high, representative of dispersant application to an oil slick in shallow water.

Except in shallow, confined waters, there is not expected to be any significant benefit to marine algae or plants from either leaving a slick undispersed or dispersing the slick.

9.1.8.7. Intertidal Plants

Hydrocarbons can impact terrestrial plants as a result of smothering of parts of the plant (e.g., mangroves) used for gas exchange or by the loss of leaves due to chemical burning in the less likely event of direct contact of the leaves with the slick (Duke et al. 1999). It is also known that mangroves take up hydrocarbons from contact with leaves, roots, or sediments, and it is suspected that this uptake has the potential to cause defoliation through leaf damage and tree death (Wardrop 1987).

Intertidal sediments can retain hydrocarbons and act as long term reservoirs, where continued releases and fresh slicks can occur for up to 5 years after the initial spill. These sediments can still contain elevated levels of hydrocarbons up to 20 years after a crude oil or diesel spill (Corredor et al. 1990; Teal et al. 1992). This can result in long-term impacts on vegetation, including mangroves and saltmarsh species (Getter et al. 1981; Ward et al. 2003; Sadaba and Barnuevo 2011; DeMicco et al. 2011).

Results from a 25-year study examining the effects of dispersed crude oil versus non-dispersed crude oil on tropical marine ecosystems in Panama indicate that dispersants prevent long-term contamination to mangrove forests and provided the conditions for ecosystem and habitat recovery, as opposed to the site where untreated oil led to chronic exposure to aromatic hydrocarbons and continued to inhibit recovery and repopulation (DeMicco et al. 2011). Experimental field exposures also found that fresh, dispersed crude had significantly less impact on mangroves than untreated oil (Ballou et al. 1987).

Effective dispersion of heavy oil prior to it reaching intertidal areas is also likely to reduce impacts related to smothering of vegetation.

9.1.9. Claims and Livelihood Remediation Processes

In the event of an oil spill causing losses to stakeholders, EEPGL would establish a claims process and, depending on the magnitude of the oil spill, a livelihood remediation program. The purpose of the claims process would be to provide compensation for asset losses and the purpose of a livelihood remediation program would be to restore the welfare and livelihoods of affected persons to conditions no less than pre-impact conditions. Both processes would be transparent, fair, and conducted in a timely manner. EEPGL, in consultation with the Government of Guyana and other jurisdictions (as required) would establish the designated geographic zones associated with the claims and, as applicable, livelihood remediation processes; these would be commensurate with the magnitude of the impacts of the spill. Eligible persons would be compensated based on the magnitude of Project-related impacts they individually experienced, either in regards to human health or as a result of economic loss.

It is anticipated that EEPGL would establish steering committees, working groups, and stakeholder engagement-specific entities to determine eligible stakeholders, standard entitlements, and eligibility criteria for further livelihood compensation and assistance. EEPGL would consider establishing an independent implementation entity as soon as reasonably practicable after the spill to assist in the process of livelihood remediation planning while the initial compensation efforts are ongoing. Depending on the extent of losses, livelihood remediation efforts may potentially range from early support initiatives (within the first year), to transition support (typically from 1 to 2 years after impact), to longer-term support.

9.1.10. Vessel Collision with a Third-Party Vessel, Structure, or Animal (Non-Spill Related Impacts)

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

Section 9.1.1.5, Nearshore Collision between a Project Supply Vessel and Another (Third-Party) Vessel or Structure, or Grounding, and Section 9.1.1.7, Offshore Collision between Project Vessels or between a Project Vessel and Another (Third-Party Vessel), describe potential scenarios in which a Project vessel collision could occur with a third-party vessel or structure, resulting in a spill of hydrocarbons. This section addresses the potential for such a collision, but focuses on the potential non-spill related aspects. This section also addresses the potential for a Project vessel to collide with a marine animal, specifically focusing on marine mammals and marine turtles.

As discussed in Section 9.1.1.5, a variety of Project vessels will supply and support drilling, installation, production operations, and decommissioning activities, and these vessels will transit between the Guyana shorebase(s) and the PDA. There is a potential for collisions between these vessels and other third-party vessels/structures in the Georgetown Harbour/Demerara River area or for the nearshore grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a vessel to steer. Damage to an impacted structure may require repairs, and in extreme cases, temporary closure of the structure; this has occurred before in Guyana (e.g., damage to and temporary closure of the Demerara Harbour

Bridge). In the case of the Project, however, the Georgetown shorebase(s) are downstream of the Demerara Harbour Bridge, which reduces the probability of a Project-related vessel colliding with this structure.

Section 9.1.1.5 includes a summary of the embedded controls that will be in place to reduce the potential for a nearshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels or structures, or causing significant injury, is considered **Unlikely**.

Section 9.1.1.7 includes a summary of the embedded controls that will be in place and the additional mitigation measures that will be employed to reduce the potential for an offshore collision to occur. Based on these controls and measures, the potential for an offshore collision between a Project vessel and another third party vessel is also considered **Unlikely**.

9.1.10.2. Vessel Collision with a Marine Mammal

Collisions with vessels can injure or kill marine mammals. 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. Nevertheless, marine mammals are inherently vulnerable to ship strikes when they surface to breathe or to feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced. Most Project activities will take place in deep ocean 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 shorebase(s), but even at the peak of drilling and installation, the incremental increase in traffic near shorebase(s) will represent a small increase in overall risk to marine mammals. There is very little potential for collisions to occur within the PDA, but the potential remains for individual dolphins or whales to collide with vessels transiting between the PDA and shorebase(s). The greatest potential for collisions to occur will be during drilling and installation, when vessel traffic is at its peak; accordingly, the risk of injury or mortality from vessel collisions will be higher during drilling and installation than during other stages of the Project.

With respect to the potential for injury and mortality from vessels strikes, EEPGL will use the following embedded controls measure for the Project (see Section 2.13, Embedded Controls):

- Provision of awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface; and
- Standing instruction to Project-dedicated vessel masters to avoid marine mammals while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions.

Although the embedded controls noted above are expected to greatly reduce the possibility of a Project vessel striking a marine mammals, it is conservatively assumed that over the duration of the Project life cycle (at least 20 years), such an event is **Possible**.

9.1.10.3. Vessel Collision with a Marine Turtle

Collisions with vessels can also injure or kill marine turtles. Marine turtles tend to spend most of their time at sea at or near the sea surface as verified by the dive profile data described in Section 7.6.2, Existing Conditions—Marine Turtles, 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 ship strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by the higher concentrations of turtles in the shallow nearshore areas. Most Project activities will take place in deep ocean waters, and vessel speeds within the PDA will be low, further reducing the potential for collisions. The only planned nearshore activities will be supply vessels entering/exiting shorebase(s); the anticipated options for shorebase(s) are all located more than 100 kilometers away from the nearest portion of the Shell Beach Protected Area (SBPA), where most marine-turtle nesting in Guyana occurs (and where turtles may aggregate pre- and post-nesting as suggested by tagging data).

There is very little potential for collisions to occur within the PDA, but the potential remains for individual turtles to collide with vessels transiting between the PDA and shorebase(s). The potential for the greatest number of collisions to occur will be during drilling and installation, when vessel traffic is at its peak, so the risk of injury or mortality from vessel collisions will be slightly higher during drilling and installation than during other stages of the Project.

With respect to the potential for injury or mortality from vessels strikes, EEPGL will use the following embedded control measure for the Project (see Section 2.13, Embedded Controls):

- Standing instruction to Project-dedicated vessel masters to avoid marine turtles while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions.

The embedded controls noted above are expected to greatly reduce the possibility of a Project vessel striking a marine turtle; accordingly, it is considered that such an event is **Unlikely**.

9.1.11. Untreated FPSO Wastewater Discharge

The FPSO will be equipped with onboard water treating systems, one of which will treat black water (waste from toilets or urinals) prior to discharge overboard. The FPSO also has a large storage tank with capacity to store up to 7 days of sewage in the event there is an upset to the treatment system. There are also multiple closed valves to prevent accidental release of black water to the ocean. In the unlikely event an upset to this treatment system lasts more than 7 days, this could result in untreated black water being discharged overboard for a short period of time. In summary, the potential for a discharge of untreated black water to occur is considered **Unlikely** for the following reasons:

- The black water treatment system will be subjected to routine inspection and maintenance, providing the opportunity to identify and correct issues requiring attention prior to an upset scenario occurring.

- The black water treatment system will be designed to include capacity for storage of 7 days of untreated wastewater generated on the FPSO in the event there is an upset to the treatment system. This affords time to avoid overboard discharge for a period of time while corrective actions on the treatment system can be implemented, without impacting the ability of the FPSO to continue operating.
- There are multiple closed valves to prevent accidental release of black water to the ocean.

Although such a release is **Unlikely**, computational modeling was conducted for an emergency scenario where there is an upset in the black water treatment system. Under this emergency scenario, it was assumed that untreated black water from accommodations and the clinic would bypass the macerator and the sewage holding tank and be discharged directly overboard through an emergency outfall. Modeling was performed to assess the plume that would result from this scenario. Based on an average sewage generation rate per person and a capacity of 160 persons on board for the FPSO, incorporating a 200 percent contingency factor on this discharge rate, and using conservative estimates of wastewater characteristics (coliform: 10,000,000 colony forming units per 100 milliliters; 5-day Biochemical Oxygen Demand [BOD_5]: 350 milligrams per liter [mg/L]; and total suspended solids [TSS]: 650 mg/L), the modeling results show that the temporary release of untreated wastewater will result in a plume of limited extent. The maximum predicted BOD_5, TSS, and coliform concentrations never exceed the end-of-pipe levels recommended by the IMO’s 2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants. Additional detail regarding the modeling of this scenario is provided in Appendix J, Water Quality Modeling Report.

9.1.12. Onshore Vehicular Accident

The Project will result in a minimal increase in onshore vehicular traffic around the existing shorebase that will be used by the Project. The Georgetown shorebase(s) operations have been designed to minimize road movement of freight. Although the Project-related traffic volume is incrementally insignificant with respect to existing traffic volumes in the vicinity of the shorebase(s) (for example), the potential for a vehicular accident involving a Project-related vehicle is considered **Possible**.

9.1.13. Collisions between Project Vessels/Helicopters and Seabirds

While individual seabirds could be significantly impacted through contact with the FPSO flare structure, its flame, or its radiant heat plume, the likelihood of a seabird being present in the heat zone when temporary, non-routine flaring is occurring is extremely low. Accordingly, this unplanned event is focused on direct mortality and injury related to vessel or helicopter strikes.

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the FPSO. However, rafters are not likely to be present in large aggregations in the PDA because of the metocean conditions offshore Guyana – namely a strong surface current, which is likely to make the surface waters unsuitable for the large aggregations of species that favor more calm and sheltered conditions. The EEPGL seismic surveys conducted in the Stabroek Block in 2015 and 2016 did not document any concentrations of rafting seabirds in the area during their survey period (RPS 2016). On the rare occasions that suitable conditions for rafting occur in the PDA and seabirds are present in high enough concentrations to form rafts, individual seabirds could be susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path.

Helicopters will be used as a form of transit to / from the Guyana shorebase(s) and offshore vessels, and could adversely impact seabirds through helicopter strike of individuals flying near helicopters transiting around or in route to/from the drill ships, FPSO, and installation vessels. Helicopter trips to and from the PDA are not expected to exceed more than a few each day, so the potential for helicopter-bird interactions is expected to be low.

Given the low likelihood of vessels encountering rafting seabirds and EEGPL's embedded control of providing standing instruction to Project dedicated vessel masters to avoid any identified rafting seabirds (that do not move out of the vessel's path on their own) when transiting to and from PDA, where safe and feasible, as well as the limited number of helicopter flights per day between the PDA and shore, the likelihood of a vessel or helicopter interaction with a seabird is considered **Unlikely**.

9.1.14. Summary of Unplanned Events Interactions with Resources/Receptors

Table 9.1-6 indicates which resources/receptors would potentially be impacted by a NADF release (Scenario 14), oil spills (i.e., coastal oil spill [Scenario 3] and marine oil spill [Scenarios 11, 12, and 13], vessel collisions (non-spill related impacts), a discharge of untreated wastewater from the FPSO, or vehicular accidents. The remainder of this chapter evaluates the risk of each of these potential impacts, considering the likelihood of the event and the potential consequence of the event with respect to resultant impacts on the relevant resources/receptors. For simplicity, although NADF is technically a "hydrocarbon" and not an "oil," releases of both NADF and oil are generically referred to as "oil spills" in the remainder of this section.

Table 9.1-6: Resources/Receptors Potentially Impacted by Unplanned Events

Resource/Receptor	Oil Spill			Vessel Collision [a]	Untreated FPSO Wastewater Discharge	Vehicular Accident	Collision between Seabird and Project Vessel or Helicopter
	Marine	Coastal	NADF				
Physical Resources							
Air Quality and Climate	X	X					
Sound (Airborne)							
Marine Geology and Sediments		X	X				
Marine Water Quality	X	X	X		X		
Biological Resources/Receptors							
Protected Areas	X	X			X		
Special Status Species—Fish	X	X			X		

Resource/Receptor	Oil Spill			Vessel Collision [a]	Untreated FPSO Wastewater Discharge	Vehicular Accident	Collision between Seabird and Project Vessel or Helicopter
	Marine	Coastal	NADF				
Special Status Species—Seabirds	X	X			X		X
Coastal Habitats	X	X					
Coastal Wildlife and Shorebirds	X	X					
Seabirds	X	X			X		X
Marine Mammals	X	X		X	X		
Marine Turtles	X			X	X		
Marine Fish	X	X	X		X		
Marine Benthos		X	X				
Ecological Balance and Ecosystems	X	X	X		X		
Socioeconomic Resources/Receptors							
Economic Conditions/ Employment and Livelihoods	X	X		X			
Community Health and Wellbeing	X	X		X		X	
Marine Use and Transportation	X	X		X			
Social Infrastructure and Services	X	X				X	
Waste Management Infrastructure and Capacity	X	X	X				
Cultural Heritage	X	X	-				
Land Use	X	X					
Ecosystem Services	X	X					
Indigenous Peoples	X	X					

[a] This scenario focuses on non-spill related impacts; fuel and crude oil spills from vessel accidents are addressed in the "Oil Spill" columns.

9.2. AIR QUALITY AND CLIMATE

Crude oil is a mixture of hydrocarbons, and is made up of light, medium, and heavy constituents. In the event of an oil spill, the lighter hydrocarbons (including benzene, xylene, and toluene) tend to quickly evaporate into the air. Accordingly, concentrations of these constituents typically drop rapidly during the first 24 hours of a spill. Elevated hydrocarbon concentrations in air are primarily found in the immediate vicinity of a spill and some distance downwind, depending on wind speeds. These constituents would primarily impact oil spill response workers, so air-monitoring equipment would be deployed to monitor levels of air pollutants and appropriate personal protective equipment (PPE) would be provided, as necessary, to those oil spill response workers who are exposed.

In the case of a marine oil spill, the potential for any harmful concentrations of air contaminants to reach the Guyana coastline is considered very low, even for a large spill, considering the distance to shore (approximately 183 kilometers [approximately 114 miles]). Further, any air quality impacts would be temporary. In the event of a marine oil spill or coastal oil spill reaching shorelines or the nearshore environment, elevated concentrations of air contaminants in areas with potential human receptors would be localized to the nearshore area in which the plume was present or the general onshore area alongside where the oil came ashore. Therefore, the consequence of impacts on air quality from a marine or coastal oil spill would be **Low**. In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the overall risk to air quality from a marine oil spill would be **Minor** (see Table 9.2-1).

With respect to potential climate impacts, there would be an indirect impact associated with additional fossil fuel combustion by response vessels and fuel-fired equipment, with some potential for release of methane to the atmosphere, resulting in increased greenhouse gas (GHG) emissions as compared to that associated with planned activities. However, the scale and duration of these additional GHG emissions would be limited, leading to a consequence rating with respect to impacts on climate of **Low**. In combination with a likelihood rating of **Unlikely** for a marine or coastal oil spill, the overall risk to climate from a marine or coastal oil spill would be **Minor** (see Table 9.2-1).

In the event of a release of NADF caused by an emergency riser disconnect due to DP station-keeping failure for a drill ship, lighter oil fractions would likely rise into the middle of the water column and dissipate laterally as they rise, while the NADF would remain at or near the seafloor and would not reach the atmosphere. Therefore, an NADF release would have no impact on air quality or climate.

Table 9.2-1: Risk Ratings for Unplanned Event Impacts on Air Quality

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill or Coastal Oil Spill	Air Quality	Unlikely	Low	Minor	Implement OSRP and conduct air quality monitoring during response; provide appropriate respiratory protection PPE to response workers	Minor
	Climate	Unlikely	Low	Minor	Implement OSRP	Minor

9.3. MARINE GEOLOGY AND SEDIMENTS

A marine oil spill would not impact marine geology, but in the event of sedimentation (where hydrocarbons adhere to other material and settle) or shoreline stranding of the spill, hydrocarbons may be mixed within marine or intertidal sediments. This would primarily be expected in the vicinity of the offshore spill and in the nearshore wave zone (in a situation where the spill reaches the nearshore environment). Research has indicated that the overall impact of a marine oil spill on the seafloor is low, especially when lighter oils are involved (ITOPF Undated). For heavier oil fractions that may sink to the seafloor, weathering processes would continue—reducing concentrations rapidly. Therefore, the consequence rating of a marine oil spill with respect to impacts on marine sediments is considered **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to marine geology and sediments from an oil spill would be **Minor** (see Table 9.3-1).

With respect to a coastal oil spill, diesel oil would not sink or accumulate on the seafloor unless adsorption occurs with sediment; however, it is possible for diesel oil that is dispersed by wave action to form droplets that are small enough to be kept in suspension and moved by the currents. The oil dispersed in the water column can adhere to fine-grained suspended sediments, which can settle out and deposit on the seafloor. This is less likely to occur in open marine settings, and is not likely to result in measurable sediment contamination for small spills (NOAA 2018). For this reason, the consequence rating of a coastal oil spill with respect to impacts on marine sediments is considered **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall risk to marine geology and sediments from a coastal oil spill would be **Minor** (see Table 9.3-1).

In the event of an emergency disconnect of the drilling riser and release of NADF near the seafloor, cuttings would also be released. Neither the NADF nor the cuttings would have any effect on the underlying marine geology of the PDA. The majority of the base oil in the NADF would separate and rise to the surface, whereas the remaining NADF would remain suspended in the water column and have no effect on sediments. The cuttings would accumulate on the seafloor. Cuttings deposits would tend to be deeper and coarser in the immediate vicinity of the wellhead, and would decrease in thickness and grain size with increasing distance from the wellhead. The strength of the bottom currents in the PDA would likely erode any significant deposits near the wellhead over time, dispersing all but the coarsest cuttings down current. The only lasting effect of such an event would likely be a change in the grain-size distribution of marine sediments within the deposition field, although this effect would diminish over time as benthic infauna and natural sediment deposition would bury the deposited cuttings.

The NADF to be used by EEPGL contains International Oil and Gas Producers (IOGP) Group III non-aqueous base fluid (NABF), with low to negligible aromatic content, reducing the potential that changes in marine sediment chemistry as a result of discharge of the NADF would lead to toxicological impacts on benthic infauna. Given the limited volume of material discharged in this scenario (i.e., limited to the volume of the riser), the short-term nature of such an event, and the low-toxicity NADF to be used, the consequence rating of an NADF release with respect to impacts on marine sediments is considered **Low**. In combination with a likelihood rating of **Unlikely** for such an event, the overall risk to marine sediments from a release of NADF would be **Minor** (see Table 9.3-1).

Table 9.3-1: Risk Ratings for Unplanned Event Impacts on Marine Geology and Sediments

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Sediments	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Marine Sediments	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Sediments	Unlikely	Low	Minor	Implement OSRP	Minor

9.4. Marine Water Quality

As described in Section 9.1.3, Weathering Process, marine oil spills are subject to a range of weathering processes. These processes result in the oil partitioning into different phases (entrained, bubbles, etc.) of the marine environment, while experiencing dilution. Some of the spilled oil is removed from the water column via evaporation and photo-oxidation[2]. Additionally, biodegradation processes gradually reduce hydrocarbon concentrations in the marine environment following a spill. The proportion of the spill that mixes[3] through the water column through wave energy is subject to rapid, high levels of dilution along with this biodegradation. Some oil constituents, especially aromatics, are also soluble in water. The proportion of the spill that mixes through the water can increase hydrocarbon concentrations in the water column and result in localized, but temporary, changes to water quality.

Oil spill monitoring has shown that concentrations of oil and its constituents in the water column rapidly decline after a spill, and are usually confined to an area near the origin of the spill (ITOPF Undated). The oil that would be released from a spill in the PDA would be a light crude oil. Lighter crude oils generally have higher biological availability and are generally associated with higher toxicity concerns, as compared to heavy crude oils. This, however, would be offset to some degree by the comparatively more rapid dissipation of a light crude oil through evaporation and dispersion, which means light crude oils may have less impact on the environment overall, relative to heavier crude oils (as long as sensitive resources are sufficiently distant from the origin of the spill). It is also noted that the mixing energy resulting from a loss of well control event may result in higher levels of entrained and dissolved hydrocarbons than would be associated with a surface spill, as the oil would tend to be fragmented into smaller droplets as a result of the reservoir pressure.

[2] Process of chemical breakdown caused by exposure to sunlight
[3] Mixing is achieved by a combination of entrainment and dissolution.

Accordingly, a marine oil spill is considered to have a **High** consequence rating with respect to impacts on water quality, taking into consideration the higher toxicity of the light oil fractions and the magnitude and extent of the spill scenario, balanced against the limited geographic extent and duration of the toxicity impacts as a result of the relatively rapid loss of lighter fractions. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to marine water quality from a marine oil spill is **Moderate**. Even with implementation of the OSRP, the residual risk rating would remain **Moderate** (see Table 9.4-1).

With respect to the coastal oil spill scenario, a spill of diesel oil would also exhibit higher toxicity light oil fractions, but the smaller magnitude of the spill, limited geographic extent, and shorter duration of toxicity impacts, as compared to the marine oil spill scenario, leads to a consequence rating of **Medium** with respect to impacts on marine water quality. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the overall risk to marine water quality from a coastal oil spill is **Minor**. Even with implementation of the OSRP, the residual risk rating would remain **Minor** (see Table 9.4-1).

In the event of an emergency disconnect of the drilling riser and release of NADF near the seafloor, NADF would start to undergo biological degradation after being released from the drilling riser. This process can result in localized decreases in dissolved oxygen concentrations, although this is more likely to be observed in the pore water between the cuttings grains deposited on the seafloor than in the water column, due to the dissolution of NADF in the water column caused by the strong marine currents in the region. Organic enrichment of sediments speeds the biodegradation process, which tends to accelerate oxygen depletion, and NADF cuttings tend to contain higher concentrations of biodegradable matter than water-based drilling fluids (WBDF). Conditions favoring eutrophication[4] and hypoxia[5] in the near-surface pore water within the deposition zone may exist temporarily following a release of NADF, but the high current velocities in the area would tend to prevent formation of large piles of cuttings where these conditions would tend to be more persistent. Eutrophication and resulting hypoxia at the seafloor or within the pore water could be sufficient to cause effects to marine biota, but these changes would likely be short term. From a toxicological perspective, although the NADF used by EEPGL will contain IOGP Group III NABF, it will have low to negligible aromatic content, reducing the potential that changes in marine water quality as a result of discharge of the NADF would lead to toxicological impacts on marine biota. Therefore, an NADF release is considered to have a **Medium** consequence rating with respect to impacts on water quality. In combination with a likelihood of **Unlikely**, the overall risk to marine water quality from a NADF release would be **Minor**.

[4] Over-enrichment of a waterbody with minerals and nutrients that can induce excessive growth of plants (including phytoplankton) or algae

[5] Deficiency in dissolved oxygen concentrations

Table 9.4-1: Risk Ratings for Unplanned Event Impacts on Marine Water Quality

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Water Quality	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Oil Spill	Water Quality	Unlikely	Medium	Minor	Implement OSRP	Minor
NADF Release	Water Quality	Unlikely	Medium	Minor	Implement OSRP	Minor

9.5. PROTECTED AREAS AND SPECIAL STATUS SPECIES

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on protected areas or special status species would be a marine oil spill, a coastal oil spill, or a discharged of untreated wastewater from the FPSO.

9.5.1. Protected Areas

The SBPA encompasses the entire Region 1 shoreline and adjacent inland areas (see Figure 7.1-2), and provides habitat for numerous coastal wildlife species, most notably more than 200 species of birds and several species of critically endangered/endangered/vulnerable marine turtles. The SBPA would be highly sensitive to a marine oil spill if it were to reach the shoreline. However, as discussed above in Section 9.1.5, Oil Spill Modeling Results, Guyana's oceanic waters are influenced by the Guiana Current and the North Brazil Current, and no oil is predicted to contact the shoreline in Region 1 under a mitigated marine oil spill scenario. However, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1. As shown in Figure 9.1-10b, the portion of Region 1 that could be impacted by a spill in this scenario includes the SBPA. This probability range accounts for the fact that a marine oil spill would need to be large enough to reach the Region 1 shoreline (and thus the SBPA), which is unlikely, as response measures would be likely to prevent this, and the tide would need to be sufficiently high at the time of the spill to carry the oil onto the shoreline. In the event of a marine oil spill, the OSRP would be implemented and resources and equipment would be mobilized to protect Shell Beach as necessary.

Based on the biological sensitivity and importance of the SBPA, the consequence of an oil spill reaching the SBPA would be **High**. The low probability (5 to 20 percent) of oil from a large marine oil spill actually reaching the Guyana shoreline supports a likelihood rating of **Unlikely**. Therefore, the overall (pre-mitigation) risk to the SBPA from a marine oil spill is considered **Moderate**. With the effective implementation of the OSRP, the residual (post-mitigation) risk is considered **Minor**.

A coastal oil spill would not be expected to impact SBPA because it would be limited to the area near the shorebase(s) and onshore support facilities utilized by the Project, which would be distant from SBPA. Accordingly, a coastal oil spill would not have the potential to impact protected areas.

9.5.2. Special Status Species

For the purposes of this assessment, special status species are defined as those that are listed on the International Union for Conservation of Nature (IUCN) Red List as Near Threatened (NT), Vulnerable (VU), Endangered (EN), or Critically Endangered (CR) on the IUCN Red List Version 2017.3 (IUCN 2018) that are known or expected to occur in the Project AOI (see Section 7.1.2, Existing Conditions—Protected Areas and Special Status Species, and Appendix L, IUCN-Listed Species in Guyana).

There are 63 marine and coastal species known or expected to occur in the Project AOI that are IUCN Red List ranked NT or higher, including 51 fish, 3 birds, 4 marine turtles, 1 terrestrial turtle, and 4 mammals (1 marine mammal and 3 coastal/riverine mammal species). The vast majority of these species are fish, including highly migratory species such as tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. As noted in Section 8.1.2, Existing Conditions—Socioeconomic Conditions, many of these fish species are also targeted by the Guyanese commercial fishing industry, which can lead to cumulative effects on these species (see Chapter 10, Cumulative Impact Assessment).

Table 9.5-1 summarizes the IUCN Red List ranking and species type for the 63 marine and coastal species known or expected to occur in the Project AOI that are IUCN Red List ranked NT or higher.

Table 9.5-1: Summary of IUCN Red List Rankings for Special Status Species Known or Expected to Occur in the Project AOI

IUCN Ranking	Number of Species	Taxonomic Groups
Critically Endangered (CR)	5	1 marine turtle 4 fish
Endangered (EN)	9	1 marine turtle 6 fish 1 marine bird 1 coastal/riverine mammal
Vulnerable (VU)	26	2 marine turtles 20 fish 1 marine bird 1 marine mammal 1 coastal/riverine mammal 1 terrestrial turtle
Near Threatened (NT)	23	21 fish 1 coastal bird 1 coastal/riverine mammal

Potential risks to marine mammals and marine turtles are assessed in Section 9.9, Marine Mammals, and Section 9.10, Marine Turtles, on the basis of the special status designation of members of these taxa. Accordingly, these assessments are not repeated in this section, and the section focuses instead on assessment of potential risks to special status species from other taxa.

The consequences of impacts from an oil spill on special status species would be highest for fish species ranked as CR and EN because these species are facing an extremely high or high risk of extinction in the wild due to severe population declines, very small populations, and/or very small geographic areas occupied or highly geographically fragmented subpopulations (IUCN 2001). The loss of even a few individuals in these categories could cause significant population-level impacts on CR and EN fish species. Based on this rationale, the consequence of an oil spill on CR or EN fish species is considered **High**. The physical extent of the spill would need to be large to impact multiple individuals of a given species. Oil spill modeling indicates that a marine or coastal oil spill are **Unlikely**. Therefore, the overall risk of a large marine oil spill or a coastal oil spill to CR and EN fish species is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the extent of an oil spill and the probability of oil reaching the Guyana coast line.

The vast majority of the species listed as VU or NT that could occur in the Project AOI are open water fish and impacts on these species from a marine or coastal oil spill would be expected to be lower than impacts on the other taxonomic groups listed in Table 9.5-1 because fish have no need to surface and can therefore avoid floating oil, and the depths present offshore of Guyana would provide sufficient opportunity to do avoid slicks and sheens. Fish would have the potential to encounter emulsified oil rising through the water column from a loss of well control at the wellhead, but most of the fish species would rapidly vacate areas with harmful concentrations of oil in the water column, so exposure times would be brief. Similar to that described above, effective implementation of the OSRP would reduce the risk (**Minor** residual impact risk rating).

The VU and NT species inhabit a mix of offshore and coastal habitats but most of the species are open water fish that would likely have limited exposure to oil, as described above. Based on this rationale, the consequence of a marine oil spill on VU or NT fish species is considered **Medium**. Therefore, the overall risk of a marine oil spill or coastal oil spill to VU and NT species is considered **Minor**. Although effective implementation of the OSRP would reduce this risk by reducing the ultimate swept area for the oil slick and the probability of oil reaching the Guyana coast line, the risk rating is maintained at **Minor**.

Given their susceptibility and sensitivity, the consequence of a marine oil spill on seabirds as a whole is considered **High**, resulting in a pre-mitigation risk level of **Moderate.** Implementation of the OSRP would reduce the residual risk to **Minor** for seabirds as a whole. In the case of Leach’s Storm-Petrel (*Oceanodroma leucorhoa*), however, surveys conducted as part of the Liza Phase 1 Project post-permit studies indicated the offshore PDA is a migratory corridor for a relatively large number of this species. Accordingly, the residual risk rating for marine oil spills as they relate to Leach’s Storm-Petrel is maintained at **Moderate**. In contrast, Black-capped Petrel (*Pterodroma hasitata*) is not known to be present in the AOI in significant numbers (and was not observed during the marine bird surveys described in Chapter 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources). In consideration of the low likelihood that this species would be present in the AOI in the unlikely event of an oil spill, combined with implementation of the OSRP, the residual risk is reduce to **Minor** for this species.

In the case of a discharge of untreated wastewater from the FPSO, modeling indicates the extent of the area affected by constituent levels of potential concern would be limited to a relatively small area around the FPSO. Further, the elevated constituent levels would be expected to reduce in a short-time period, meaning any effects would be short-term in nature. On this basis, the consequence of such an event on protected species would be **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment; accordingly, such an event is considered **Unlikely**. Therefore, the overall risk of an untreated wastewater discharge on special status species is considered **Minor**.

Should rafting special-status seabirds be present in the PDA, individuals could be susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path. In the unlikely event such an interaction would occur, it would likely be limited to a few individuals; accordingly, the consequence of such an event, from a population perspective, is considered **Low**. Given the low likelihood of vessels encountering rafting seabirds and EEGPL's embedded control of providing standing instruction to Project dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA, where safe and feasible, if the birds do not move out of the vessel's path, and the low density of seabirds in the Project AOI, the likelihood of vessel strikes of seabirds is considered **Unlikely.** Accordingly, the risk to seabirds from potential marine vessel collisions is rated as **Minor.**

Helicopters will be used as a form of transit to/from the Guyana shorebase(s) and offshore vessels, and could adversely impact seabirds through helicopter strikes of individuals flying near helicopters transiting around or in route to/from the drill ships, the FPSO, and major installation vessels. It is estimated that during development drilling and FPSO/SURF installation for the Project, flights peak to a total of approximately 30 to 35 round-trip flights per week (combined for Liza Phase 1 and Liza Phase 2). During FPSO/SURF production operations for the Project, an estimated maximum of 20 to 25 round-trip flights per week (combined for Phase 1 and Phase 2) will be necessary to support production operations and continued development-drilling activities. Considering this estimated quantity of flights, and based on the relatively low seabird density in the Project AOI, the number of helicopter-bird interactions is expected to be very low. In the unlikely event such an interaction would occur, it would likely be limited to a single individual; accordingly, the consequence of such an event, from a population perspective, is considered **Low**. Given the low likelihood of helicopters encountering seabirds when transiting to and from PDA, the likelihood of helicopter strikes of seabirds is considered **Unlikely.** Accordingly, the risk to seabirds from potential helicopter strikes is rated as **Minor.**

Table 9.5-2: Risk Ratings for Unplanned Event Impacts on Protected Areas and Special Status Species

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Protected Areas (SBPA)	Unlikely	High	Moderate	Implement OSRP	Minor
Marine Oil Spill	Special Status Species					
	Critically Endangered Fish Species	Unlikely	High	Moderate	Implement OSRP	Minor
	Vulnerable and Near Threatened Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	Endangered Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	Endangered Black Capped Petrel (*Pterodroma hasitata*)	Unlikely	High	Moderate	Implement OSRP	Minor
	Vulnerable Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Oil Spill	Critically Endangered Fish Species	Unlikely	High	Moderate	Implement OSRP	Minor
	Vulnerable and Near Threatened Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	Endangered Fish Species	Unlikely	Medium	Minor	Implement OSRP	Minor
	Endangered Black Capped Petrel	Unlikely	Medium	Minor	Implement OSRP	Minor
	Vulnerable Leach's Storm-Petrel	Unlikely	Medium	Minor	Implement OSRP	Minor
Untreated Wastewater Discharge from FPSO	Special Status Species	Unlikely	Low	Minor	None	Minor
Air or ship strike	Special Status Seabirds	Unlikely	Low	Minor	None	Minor

9.6. COASTAL HABITATS

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on coastal habitats would be a marine oil spill and a coastal oil spill. Based upon the modeling results of a mitigated marine oil spill, no oil is predicted to contact the Guyana shoreline. However, as described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1, which is largely characterized as mangrove forest of high or exceptional quality (see Section 7.2, Coastal Habitats).

Mangroves, of which the largest remaining stands in Guyana occur in the SBPA in Region 1, are important providers of a number of ecological services upon which fish, wildlife, and humans rely. Mangroves provide valuable habitat for crabs and important nursery areas for fish and shrimp, and provide coastal protection from wave action. Mangroves are typically found along the margins of shorelines at the saltwater interface. Due to this physical location, mangroves are vulnerable to exposure during oil spills. Mangroves are considered to be sensitive to heavy contamination by oil for several reasons (ITOPF undated):

- Mangroves rely on oxygen supplied through small pores (lenticels) on their aerial roots. Smothering of the aerial roots by heavy hydrocarbons can block this important oxygen pathway.
- The toxic component of oil can interfere with mangroves' systems for maintaining salt balance, impacting their ability to tolerate salt water.
- Oil can become trapped in mangrove sediments, where it may remain in a relatively unweathered state and be gradually remobilized over a long period, causing repeated "pulses" of exposure.
- If impacted, mangrove habitats are typically slow to recover from oil exposure, often taking 10 years or longer, especially where the shoreline protection services of the mangroves has been compromised.

For these reasons, the consequence of a marine oil spill on mangroves is considered **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to coastal habitats is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the probability of oil reaching the Guyana shoreline.

In the case of a coastal oil spill that reaches the shoreline, this would likely only happen near the shorebase(s) or near the mouth of the Demerara River. Coastal spills would be quickly controlled and contained because of the relatively small volumes and the ready access to spill control equipment. Although mangrove forests are not extensive near the mouth of the Demerara or the Essequibo rivers, fringe mangroves do exist and would be susceptible to exposure to an oil spill. Other coastal habitats that are particularly susceptible to oil spills (e.g., coral reefs, seagrass beds) are not found in these coastal areas of Guyana. These impacts would generally be temporary, limited in area, and readily mitigated, with rapid habitat recovery expected.

Nevertheless, considering the sensitivity of mangroves to oil spills, the consequence or severity of a coastal oil spill on mangroves is considered **High.** In combination with a likelihood rating of Unlikely for a coastal oil spill, the (pre-mitigation) risk to coastal habitats is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the spread of oil in coastal waters.

Table 9.6-1: Risk Ratings for Unplanned Event Impacts on Coastal Habitats

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Habitats	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Coastal Habitats	Unlikely	High	Moderate	Implement OSRP	Minor

9.7. Coastal Wildlife

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on coastal wildlife include a marine oil spill and a coastal oil spill.

As described in Section 7.3.2, Existing Conditions—Coastal Wildlife, the Guyana coastal habitats support a rich and diverse collection of species. Many of these species are dependent on mangroves and other wetland habitats, which are particularly sensitive to oil spills. In addition, there is the potential for some oil that reaches the Guyana shoreline to move into the tidal portions of rivers and other estuarine areas as a result of tidal action, where it could impact fur-bearing species like the neotropical otter (*Lontra longicaudus*) and giant river otter (*Pteronura brasiliensis*), both special status species. Oil can impact the physical structure of feathers and fur, causing a loss of waterproofing and thermoregulation. In addition, animals can inhale hydrocarbons or ingest oil when they groom themselves or feed, which can damage their lungs, cause ulcers, and result in liver and kidney damage.

The most significant impact on coastal wildlife from either a marine or coastal oil spill would occur if oil reached the shoreline or nearshore waters in areas near a large colonial waterbird nesting site during or immediately after the breeding period. During these periods, hundreds to thousands of colonial waterbirds (e.g., herons, ibis, etc.) congregate to nest and feed in nearshore coastal habitats. Waterbirds feed primarily on fish and other aquatic prey, so they would be susceptible to dermal contact and ingestion of oil. This could injure or kill the impacted individual and oiled adults could transfer oil to their eggs or chicks in the nest, which are highly susceptible to the effects of oil. Such impacts could affect a breeding year for local populations.

For these reasons, the consequences of a marine oil spill on coastal wildlife is considered **High**. However, as stated previously in this chapter, oil spill modeling indicates that a mitigated marine oil spill would not reach Guyana's shoreline and that an unmitigated spill would have a 5 to 20 percent chance of reaching the Guyana shoreline. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to coastal wildlife is considered

Moderate. Effective implementation of the OSRP would reduce this risk to **Minor** by reducing the probability of oil reaching the Guyana coastline.

A coastal oil spill would be more likely to directly impact estuarine wildlife than the small portion of a larger marine oil spill that could reach the coastal portion of Guyana. Emergency response measures should be able to prevent any hydrocarbons from a coastal oil spill from affecting estuarine and upstream fresh water environments. Based on the more limited magnitude of a coastal oil spill and its location in a more controllable setting (i.e., riverine vs. open ocean), the impacts would be limited to those individuals in the limited impacted area, and these impacts would be expected to be temporary, with no impacts at the population level for any species.

Nevertheless, considering the sensitivity of some of these coastal species, the consequence or severity of a coastal oil spill on coastal wildlife is considered **High.** In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the (pre-mitigation) risk to coastal habitats is considered **Moderate**. Effective implementation of the OSRP would further reduce this risk to **Minor** by further reducing the spread of oil in coastal waters.

Table 9.7-1: Risk Ratings for Unplanned Event Impacts on Coastal Wildlife

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Wildlife	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Coastal Wildlife	Unlikely	High	Moderate	Implement OSRP	Minor

9.8. SEABIRDS

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on seabirds include a marine oil spill, a coastal oil spill, (non-routine) flaring on the FPSO, discharge of untreated wastewater from the FPSO, a collision of a Project vessel with rafting seabirds, and a collision of a Project helicopter with seabirds in flight.

During most oil spills, seabirds are harmed and killed in greater numbers than other kinds of creatures (NOAA 2016). An oil spill could pose a risk to seabirds through direct and indirect mechanisms, including the following:

- Loss of insulating and water-repelling properties from oiling of plumage, leading to increased mortality;
- Loss or impairment of flight and buoyancy from oiling of plumage, which can render birds unable to feed at sea, which can quickly lead to dehydration and starvation;
- Toxic impacts from the ingestion of hydrocarbons during preening, ingestion of contaminated prey, inhalation of fumes or absorption of hydrocarbons through skin or eggs, leading to increased mortality;

- Habitat degradation at sea and at island or shoreline breeding sites; and
- Mortality of food resources.

Since most oils float at least initially following a release, seabird species that spend significant time resting or foraging on the water's surface are most at risk from direct exposure. Diving birds and waterfowl are considered to have the highest risk of oiling.

No marine Important Bird Areas (IBAs) (e.g., seabird breeding colonies and surrounding foraging areas, non-breeding concentrations, feeding areas for pelagic species) have been designated in Guyana, but three marine IBAs of global or regional importance to seabirds have been designated in neighboring countries: St. Giles Islands and Little Tobago, both located off the northeastern tip of Tobago, and Isla de Aves in Venezuela (see Section 7.4.2, Existing Conditions—Seabirds). The two IBAs located northeast of Tobago support globally important breeding populations of Red-billed Tropicbird (*Phaethon aethereus*) and Laughing Gull (*Leucophaeus atricilla*) and regionally important breeding populations of Audubon's Shearwater (*Puffinus lherminieri*), Magnificent Frigatebird (*Fregata magnificens*), Brown Booby (*Sula leucogaster)*, Masked Booby (*Sula dactylatra)*, Red-footed Booby (*Sula sula*), and Bridled Tern (*Onychoprion anaethetus*). The Isla de Aves IBA in Venezuela supports the largest known breeding colony of Brown Noddy (*Anous stolidus*) in the Caribbean, as well as the principal breeding colony of Sooty Tern (*Onychoprion fuscatus*) in Venezuela. Based on the predominant current, which is to the northwest, an unmitigated large marine oil spill could reach the shoreline of the two Tobago IBAs.

For colonial nesting seabird species, if a spill occurs during the breeding period and oil reaches a breeding colony or impacts individuals that introduce oil to the colony, the impacts on seabirds would likely be more severe compared with those during the non-breeding season. This is because colonial seabird species typically nest close together on islands or shorelines and forage at higher density in proximity to the nesting sites, making larger numbers of birds and their eggs susceptible to oiling. Reproduction requires a lot of energy and a bird's demand for food resources can double or triple during the breeding season. If an oil spill causes mortality or contamination of the birds' food resources, it can inhibit the birds' ability to successfully mate and produce eggs (Henkel et al. 2012). Eggs and very young birds are particularly sensitive to oil exposure, which typically causes embryonic mortality in eggs or death from exposure in chicks (Finch et al. 2011). Some seabirds lay only one egg at a time, so they have an already low reproductive rate, which makes these species more susceptible to adverse impacts from spills that occur in the breeding season (because they could lose an entire recruitment year) (NOAA 2016). Unlike in temperate environments, where seabird breeding seasons are seasonally restricted and highly predictable, seabird nesting periods in tropical environments are highly variable and aligned closely with food availability.

Given their susceptibility and sensitivity, the consequence of a marine oil spill on seabirds is considered **High**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the (pre-mitigation) risk to seabirds is considered **Moderate**. Effective implementation of the OSRP would (excluding Leach's Storm-Petrel (*Oceanodroma leucorhoa*), which is discussed separately above) reduce this risk to **Minor** by limiting the geographic extent of the oil spill and the number of individual birds potentially impacted.

While individual seabirds could be significantly impacted through contact with the FPSO flare structure, its flame, or its radiant heat plume, the likelihood of a seabird 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 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, on the unlikely basis that such an event occurred, it would likely only impact a single individual. Accordingly, the consequence of such an event, from a population perspective, is considered **Low**.

Rafting seabirds may suffer injury or mortality from collision with vessels transiting to and from the PDA. However, rafters are not likely to be present in large aggregations in the PDA because of the metocean conditions offshore Guyana—namely a strong surface current, which is likely to make the surface waters unsuitable for the large aggregations of species that favor more calm and sheltered conditions. Seabird data collected in the Stabroek Block from 2015 through 2018 did not document any concentrations of rafting seabirds in the area. No more than two individuals were observed at a time in offshore areas beyond 100 kilometers (approximately 62 miles) from shore. Should rafting seabirds be present in the PDA, individuals could be susceptible to vessel strike and related injury or mortality. However, large seabird rafts are easily detectible by oncoming vessels, and these vessels could maneuver to avoid them if the birds do not move out of the vessels' path. In the unlikely event such an interaction would occur, it would likely be limited to a few individuals; accordingly, the consequence of such an event, from a population perspective, is considered **Low**. Given the low likelihood of vessels encountering rafting seabirds and EEGPL's embedded control of providing standing instruction to Project dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from PDA, where safe and feasible, if the birds do not move out of the vessel's path, and the low density of seabirds in the Project AOI, the likelihood of vessel strikes of seabirds is considered **Unlikely.** Accordingly, the risk to seabirds from potential marine vessel collisions is rated as **Minor.**

Helicopters will be used as a form of transit to/from the Guyana shorebase(s) and offshore vessels, and could adversely impact seabirds through helicopter strikes of individuals flying near helicopters transiting around or in route to/from the drill ships, the FPSO, and major installation vessels. It is estimated that during development drilling and FPSO/SURF installation for the Project, flights peak to a total of approximately 30 to 35 round-trip flights per week (combined for Liza Phase 1 and Liza Phase 2). During FPSO/SURF production operations for the Project, an estimated maximum of 20 to 25 round-trip flights per week (combined for Phase 1 and Phase 2) will be necessary to support production operations and continued development-drilling activities. Considering this estimated quantity of flights, and based on the relatively low seabird density in the Project AOI, the number of helicopter-bird interactions is expected to be very low. In the unlikely event such an interaction would occur, it would likely be limited to a single individual; accordingly, the consequence of such an event, from a population perspective, is considered **Low**. Given the low likelihood of helicopters encountering seabirds when transiting to and from PDA, the likelihood of helicopter strikes of seabirds is considered **Unlikely.** Accordingly, the risk to seabirds from potential helicopter strikes is rated as **Minor.**

A discharge of untreated wastewater from the FPSO would have localized impacts on water quality, but conditions that could cause such a release would generally be rectified within a short period of time. The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. For these reasons, the consequence of a discharge of untreated wastewater from the FPSO is considered **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously in order for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. Therefore, the overall risk of this event on seabirds is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Minor**.

Table 9.8-1: Risk Ratings for Unplanned Event Impacts on Seabirds [a]

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Seabirds	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Seabirds	Unlikely	High	Moderate	Implement OSRP	Minor
Flaring	Seabirds	Unlikely	Low	Minor	None	Minor
Discharge of untreated wastewater from the FPSO	Seabirds	Unlikely	Low	Minor	None	Minor
Vessel (air or ship) strike	Seabirds	Unlikely	Low	Minor	None	Minor

[a] Excludes listed seabirds, which are covered in the Special Status species resource category.

9.9. Marine Mammals

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine mammals include a marine oil spill, a coastal oil spill, a collision of a Project vessel with an animal, and a discharge of untreated wastewater from the FPSO.

9.9.1. Marine Oil Spill

In the unlikely event of a marine oil spill, marine mammals (i.e., whales, dolphins, and manatees) may be exposed when they surface to breathe or breach in the area of a fresh slick. Exposure to oil may harm their respiratory tissue and eyes, and increase their susceptibility to infections. Baleen whales may be more susceptible to such impacts than toothed whales because of the potential for oil to foul their baleen plates if the whales filter-feed in the vicinity of the oil spill. Marine mammals may also be impacted by indirect impacts associated with oil spills, including increased exposure to sound and risk of injury from ship strikes by response vessels (see below). Although sperm whales (toothed) are the most commonly seen whales in the Project AOI, Bryde's whales (*Balaenoptera brydei*) and several unidentified baleen whales have been documented in the Project AOI.

Despite the potential impacts described above, serious health impacts or deaths in marine mammals due to oil spills are rare. This is attributed to their smooth, hairless skin, to which oil does not readily adhere, and their ability to avoid areas impacted by spills. Based on the total number of visual and acoustic detections from the Project AOI (see Section 7.5.2, Existing Conditions—Marine Mammals), the risk to all marine mammals would be highest in November and lowest in May. For large spills in summer, dolphins and whales would both be at risk, but the risk to dolphins would be higher than to whales. In winter, the risk would shift almost entirely to dolphins as the swept area would shift to the comparatively shallower continental shelf, where whales have not been detected.

Considering the presence and susceptibility of baleen whales, the consequence of a marine oil spill on marine mammals is considered **High**. This is offset to some extent by the prediction that a marine oil spill (and especially a large spill with more than transitory effects in the immediate vicinity of the FPSO) would be **Unlikely**. Therefore, the overall risk of an oil spill on marine mammals is considered **Moderate**. In the event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios, based on NEBA analysis. Upon acceptance of the OSRP, EEPGL would have pre-approval from the EPA for the potential use of the four primary (i.e., most broadly approved and studied) dispersants: Corexit 9500, Corexit 9527A, Finasol OSR 52, and Dasic Slickgone NS. These dispersants have been found to have low toxicity, are effective across a broad range of oil types and environmental conditions, and are readily available globally. Effective implementation of the OSRP would reduce the geographic extent of the spill, but considering the susceptibility of baleen whales to oil spills, their presence in the Project AOI, and their endangered/threatened status, the risk rating is maintained at **Moderate**.

9.9.2. Coastal Oil Spill

As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, coastal oil spills would be small-volume, short-duration spills that would be expected to be quickly brought under control. A temporary, visible sheen on the water surface may occur and water quality would be temporarily impaired in a localized area, but long-term or ecosystem-level impacts on ecologically important or protected species would not be expected. A few of the species described in Section 7.5.2, Existing Conditions—Marine Mammals, including boto (*Inia geoffrensis*), tucuxi (*Sotalia fluviatilis*), West Indian manatee (*Trichechus manatus*), Guiana dolphin (*Sotalia guianensis*), and common bottlenose dolphin (*Tursiops truncatus*), are known to occur in rivers and could therefore be exposed to a coastal oil spill in or near the Demerara River.

The only coastal marine mammal species that could be affected by a coastal oil spill with a conservation status above Least Concern (LC) is the West Indian manatee, which the IUCN lists as Vulnerable (VU). Most marine mammals that could be affected by a coastal oil spill are considered Data Deficient (DD). As a group, these species are not as sensitive as the baleen whales based on conservation status, but in a confined area like the Demerara River they would not be as able to avoid the effects of a spill as they would in the open ocean; accordingly, the consequence of a coastal oil spill on marine mammals is considered **High**. Like a marine oil spill, this is offset to some extent by the fact that an oil spill in the Demerara River is predicted to be **Unlikely**. Therefore, the overall risk of a coastal oil spill on marine mammals is considered **Moderate**. Effective implementation of the OSRP would reduce the geographic extent of the spill and, depending on the specific response strategies implemented in shallower waters, could reduce the amount of oil at the water's surface, resulting in a residual risk rating of **Minor**.

9.9.3. Vessel Collision

As described in Section 9.1.10.2, Vessel Collision with a Marine Mammal, marine mammals are inherently vulnerable to ship strikes when they surface to breathe or to feed. This vulnerability increases in shallow, nearshore areas, where opportunities to maneuver are reduced. As described in Section 7.5.2, Existing Conditions—Marine Mammals, the largest and least maneuverable marine mammals (i.e., the large whales) are only found in the deep portions of the Project AOI. Vessel speeds will be low within the PDA, so there is a very small portion of the Project AOI where vessels may be operating at higher speeds (up to 15 to 20 knots) and have a reasonable expectation of encountering a large whale. Support vessels will operate at higher speeds when transiting the continental shelf, but the only marine mammals they are likely to encounter on the continental shelf are dolphins, which are agile by comparison and much more likely to avoid a vessel strike than the larger whales.

Although they have not been documented conclusively within the Project AOI, several of the largest marine mammals in the world (e.g., blue whale [*Balaenoptera musculus*], fin whale [*Balaenoptera physalus*], and sei whale [*Balaenoptera borealis*]) could occur in the Project AOI, and all of these species are listed as Endangered (EN) by the IUCN. The loss of even a few mature breeding individuals to vessel strikes over the course of the Project life cycle (at least 20 years) would be significant from a conservation perspective; however, most marine mammals that are known to occur in the Project AOI are listed as either LC or DD by the IUCN. Balancing the conservation status of the more abundant species that are known to be present in the Project AOI with that of the rarer species that could be present, the consequence of a vessel collision with a marine mammal is considered **Medium**.

As embedded controls, the Project will provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface, and will provide standing instruction to Project-dedicated vessel masters to avoid marine mammals while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions. However, given the length of the Project life cycle (at least 20 years), a collision with a marine mammal is considered **Possible**, so the overall (pre-mitigation) risk to marine mammals from a vessel collision is considered **Moderate**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating; accordingly, the residual risk rating is maintained at **Moderate**.

9.9.4. Untreated FPSO Wastewater Discharge

A release of untreated wastewater discharge from the FPSO would have localized impacts on water quality, but the potential for occurrence would be rare and conditions that could cause such a release would generally be rectifiable within a short period of time (on the order of hours or days). The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. For these reasons, the consequence of a discharge of untreated wastewater from the FPSO is considered **Low**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. Therefore, the overall risk of this event on marine mammals is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material; accordingly, the residual risk rating is maintained at **Minor**.

Table 9.9-1: Risk Ratings for Unplanned Impacts on Marine Mammals

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Mammals	Unlikely	High	Moderate	Implement OSRP	Moderate
Coastal Oil Spill	Marine Mammals	Unlikely	High	Moderate	Implement OSRP	Minor
Vessel Collision	Marine Mammals	Possible	Medium	Moderate	None	Moderate
Untreated FPSO Wastewater Discharge	Marine Mammals	Unlikely	Low	Minor	None	Minor

9.10. MARINE TURTLES

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine turtles include a marine oil spill, a collision between a Project vessel and an animal, and a discharge of untreated wastewater from the FPSO.

9.10.1. Marine Oil Spill

In the unlikely event of a marine oil spill, several aspects of marine turtle biology place them at particular risk across all of their life stages. Marine turtles nest on sandy beaches. If such beaches were to become oiled, the laid eggs may be contaminated either from oil entering the nest or adult turtles picking up oil and depositing it in the nest as they cross the beach. The eggs are susceptible to oil through absorption, which can inhibit their development. Newly hatched turtles can become oiled after emerging from their nests and crossing an oiled beach on their way to the water. Oiling of juvenile and adult turtles in the water can adversely impact their eyes, mucous membranes, skin, blood, digestive and immune systems, and salt glands.

Several aspects of marine turtle behavior also compound their biological susceptibility to oil:

- Lack of avoidance behavior—marine turtles are not known to consistently take evasive action away from oil spills;
- Indiscriminate feeding—marine turtles have a habit of ingesting floating objects, including the ingestion of oil-fouled food and floating tar balls they mistake for food; and
- Large pre-dive inhalations—if turtles surface to breathe in a fresh slick, the oil can impact their eyes and damage their airways and/or lungs, especially with their large pre-dive breaths which can introduce airborne toxins deep into their respiratory system.

There are five species of marine turtles found in Guyana waters, four of which are known to nest at Shell Beach. The populations of all of these species are under threat and they are classified as Vulnerable (VU) to Critically Endangered (CR) by the IUCN.

The consequence of a marine oil spill on marine turtles is considered **High**, taking into consideration their susceptibility to oil contamination, the presence of individual turtles, important nesting sites in the Project AOI, and their protected status. As explained previously, a marine oil spill from a well control event is considered **Unlikely**, with oil spill modeling indicating a 5 to 20 percent chance that oil would reach the Guyana shoreline and Shell Beach in an unmitigated loss of well control event. Therefore, considering both consequence and likelihood, the overall (pre-mitigation) risk to marine turtles from a marine oil spill is **Moderate**. In the event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios, based on NEBA analysis. Upon acceptance of the OSRP, EEPGL would have pre-approval from the EPA for the potential use of the four primary (i.e., most broadly approved and studied) dispersants: Corexit 9500, Corexit 9527A, Finasol OSR 52, and Dasic Slickgone NS. These dispersants have been found to have low toxicity, are effective across a broad range of oil types and environmental conditions, and are readily available globally. Effective implementation of the OSRP would reduce the overall risk by reducing the probability of oil reaching the Guyana coast line. However, given the CR and Endangered (EN) IUCN classifications for several of these turtle species, the residual risk rating is maintained at **Moderate**.

9.10.2. Vessel Collision

Similar to marine mammals, marine turtles are vulnerable to ship strikes when they surface to breathe. Marine turtles are inherently more vulnerable to ship strikes in the shallow nearshore areas, where they congregate prior to coming ashore to nest, than they are in the open ocean. This increased vulnerability is caused by the higher concentrations of turtles in the shallow nearshore areas. Vessel speeds will be low within the PDA and higher when transiting the continental shelf, where the water is shallower in proximity to the shoreline, but no planned Project vessel movements will occur on the western portion of Guyana’s continental shelf near the marine turtles’ nesting beaches; therefore, the likelihood of a Project vessel striking a mature turtle with eggs on her way to the nesting beaches, or encountering dense congregations of turtles, is low. Although these factors mitigate the risks that collisions pose to marine turtles, the marine turtles occurring in the Project AOI are listed as CR (one species), EN (one species), or VU (two species) by IUCN, so the significance of a vessel strike with a marine turtle was assessed based on the conservative assumption that a CR or EN species would be affected. On this basis, the consequence of a vessel collision with a marine turtle is considered **High**.

The likelihood of a vessel colliding with a marine turtle is assessed based on the chance that a Project vessel's path would cross that of a turtle when either in the PDA or when transiting between the shorebase(s) and the PDA. During development drilling and FPSO/SURF installation, an average of approximately 12 round-trips per week may be made to the Stabroek Block (combined for Liza Phase 1 and Liza Phase 2) by marine vessels. During production operations, it is estimated that this number will be reduced to approximately seven round-trips per week (combined for Phase 1 and Phase 2). Given the relatively low number of vessel movements, limited number of marine turtles expected to be passing through the PDA or transit corridor, and the tendency of concentrations of inter-nesting turtles to remain generally near the nesting beaches in the far western portion of Guyana's Exclusive Economic Zone (EEZ) (far removed from Project-related vessel traffic) as demonstrated by recent telemetry data, a collision with a marine turtle is considered **Unlikely**; accordingly, the overall risk of a vessel collision with a marine turtle is considered **Moderate**. All of the available measures to minimize the risk of a collision have been included in the Project design as embedded controls and are therefore reflected in the initial risk rating; accordingly, the residual risk rating is maintained at **Moderate**.

9.10.3. Untreated FPSO Wastewater Discharge

A discharge of untreated wastewater from the FPSO would have localized impacts on water quality, but conditions leading up to such a release would generally be rare and rectifiable within a short period of time (on the order of hours or days). The affected area of ocean would be somewhat larger than the mixing zone associated with normal operations, but not so large that the event would be regionally significant. For these reasons, the consequence of an untreated FPSO wastewater discharge for marine turtles is considered **Medium**. Multiple redundancies in the FPSO's wastewater management system would have to fail simultaneously for untreated wastewater to be released to the environment, so such an event is considered **Unlikely**. Therefore, the overall risk of an oil spill on marine turtles is considered **Moderate**. Response actions would focus on identifying and rectifying the condition that caused the release rather than recovery of discharged material, and the residual risk would be **Moderate**.

Table 9.10-1: Risk Ratings for Unplanned Event Impacts on Marine Turtles

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Turtles	Unlikely	High	Moderate	Implement OSRP	Moderate
Vessel Collision	Marine Turtles	Unlikely	High	Moderate	None	Moderate
Untreated FPSO Wastewater Discharge	Marine Turtles	Unlikely	Medium	Moderate	None	Moderate

9.11. MARINE FISH

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine fish include a marine oil spill, a coastal oil spill, a release of NADF, or a discharge of untreated wastewater from the FPSO.

9.11.1. Marine Oil Spill

Potential impacts on marine fish from a marine oil spill are related to both water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily polycyclic aromatic hydrocarbons [PAHs]). Contamination in the water column changes rapidly in space and time, such that exposures are typically brief (i.e., typically measured in hours). Exposure to microscopic oil droplets may also impact aquatic biota either mechanically (especially for filter feeders) or as a conduit for exposure to semi-soluble hydrocarbons (which might be taken up in the gills or digestive tract via dissolution from the micro-droplets).

Fish are generally only slightly impacted by oil spills because of their limited exposure to surface slicks and the dispersed oil being rapidly diluted to very low concentrations in open water environments. Fish may also actively avoid oil, as they can detect hydrocarbons in the water. Juvenile life stages of marine fish tend to be more susceptible to impacts from oil spills than adults for several reasons:

- Oil tends to concentrate at the surface and near-surface, at least initially following a release.
- Most marine fishes spend at least their initial larval stages in the plankton (referred to as ichthyoplankton).
- Although ichthyoplankton are capable of volitional movement over small scales, they tend to concentrate near the surface (SFSC 2014; Martins de Freitas and Meulbert 2004; Cowen et al. 2000).
- In addition to acute ingestion- and dermal-contact-related impacts, early life stages are also exposed to developmental related impacts (which may include deformities in heart, jaw, and eye tissues) that may manifest later in life (NOAA 2015).

Despite the susceptibility of juvenile stages of fish to relatively low concentrations of oil in the water column, high mortality of planktonic life stages of fish would be expected to have minor impacts on the long-term populations of most open-ocean species. Very high natural mortality rates for larval life stages (exceeding 99 percent for most marine fishes) (MBC 2011) suggest that most ichthyoplankton that could be killed during an oil spill event would die naturally from other causes in the absence of a spill. Therefore, localized, high losses of these juvenile life stages rarely equate to any measurable loss of adult life stages in the population.

In the event of a marine oil spill, implementation of the OSRP may include use of dispersants for certain types of spill scenarios, based on NEBA analysis. Upon acceptance of the OSRP, EEPGL would have pre-approval from the EPA for the potential use of the four primary (i.e., most broadly approved and studied) dispersants: Corexit 9500, Corexit 9527A, Finasol OSR 52, and Dasic Slickgone NS. These dispersants have been found to have low toxicity, are effective across a broad range of oil types and environmental conditions, and are readily available globally. For reference, in a 2010 study conducted by the U.S. Environmental Protection Agency (USEPA), Corexit 9500A was found to be practically non-toxic[6] to *Menidia* spp. (which is commonly used as a biological model representing juvenile marine fish) during standard acute toxicity tests (USEPA 2010). Although it is impossible to predict the exact quantity of dispersant that would be required under every foreseeable oil spill scenario, based on previous industry experience, the three scenarios identified in the OSRP for which application of dispersants would be recommended could require the application of an estimated total of between 2 cubic meters (m^3) and 159 m^3 of dispersant, depending on how the dispersant is applied, the volume of oil spilled, the relative speed with which other mitigation measures could be applied and their effectiveness, and sea conditions at the time of the spill, as well as other factors. Further discussion of potential impacts on marine fish from the use of dispersants is included in Section 9.1.8, Potential Effects on Wildlife and Pros and Cons of Dispersant Use.

The same factors that would cause rapid dilution of oil in the open ocean (e.g., marine currents, wind, and wave action) would also act to rapidly dilute a dispersant-oil mixture. Since dilution in the marine environment occurs rapidly (especially in areas with strong current activity such as the PDA), the potential for acute impacts from dispersed oil is limited in duration and space, and chronic exposure is not expected to be a significant factor in the overall risks posed to marine biota during a spill event. Undispersed oil generally has similar toxicity as most dispersant-oil mixtures (even when different dispersant types may mix after application), so the responsible use of dispersants in alignment with NEBA, as described in the OSRP, generally does not represent an additional risk to marine biota.

Considering that adult fish may avoid an area affected by a spill, they are not physiologically required to breathe at the surface where oil would accumulate, and the early life stages of marine fish (which are most susceptible to the effects of a spill) naturally experience very high mortality,

[6] The USEPA classifies substances with LC50 values (concentration that will kill 50 percent of the test animals with a single exposure) of greater than 100 ppm as “practically nontoxic”.

the consequence of a marine oil spill for marine fish populations is rated as **Medium**. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to marine fish is considered **Minor**. Effective implementation of the OSRP would reduce the geographic extent of the spill, and would reduce the amount of oil at the water's surface; however, the residual risk is maintained at **Minor**.

9.11.2. Coastal Oil Spill

Although adult fish tend to be resilient to the impacts of oil spills in the open ocean and even to some extent along the coast, fish at all life stages can be substantially impacted in some circumstances, especially when oil spills occur in shallow or confined waters such as the Demerara River. In exceptional circumstances, depletion of a year class for a particular species has been recorded, but mass fish mortalities as a result of an oil spill are rare. Mass mortalities that have occurred have in some cases been associated with spills in rivers (ITOPF Undated). If a spill were to occur in the Demerara River and penetrate the shallow creeks and lagoons within the mangroves, mortality of adult and subadult life stages could be much higher than for a comparable spill in the open ocean. Adult and subadult fish would have some ability to avoid the area affected by a spill, but this ability would be constrained within the confines of the lower Demerara River and younger life stages (which cannot avoid affected areas as readily as adults) would likely comprise a higher proportion of the community in the river than in the open ocean; accordingly, the consequence of a coastal oil spill for fish is rated as **High**. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a coastal oil spill is considered **Unlikely**, so the overall risk of a coastal oil spill to marine fish is considered **Moderate**. Effective implementation of the OSRP would reduce the geographic extent of the spill and, depending on the specific response strategies implemented in shallower waters, could reduce the amount of oil at the water's surface; accordingly, the residual risk rating is reduced to **Minor**.

9.11.3. Release of NADF

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure for a drill ship, lighter oil fractions would likely rise into the mid water column and dissipate laterally as they rise, while the remaining heavier oil fractions of the NADF would remain at or near the seafloor. Such an event would expose fish in the middle depths within the PDA to low concentrations of dissolved light oils and expose deepwater-adapted fishes and benthos within the PDA to NADF, but an NADF release would be expected to only temporarily affect a small area around the release point. In consideration of these factors, the consequence of an NADF release on marine fish is considered **Low**. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a release of NADF is considered **Unlikely**, so the overall risk of a NADF release on marine fish is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk would be **Minor**.

Table 9.11-1: Risk Rating for Unplanned Event Impacts on Marine Fish

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Fish	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Oil Spill	Marine Fish	Unlikely	High	Moderate	Implement OSRP	Minor
NADF Release	Marine Fish	Unlikely	Low	Minor	Implement OSRP	Minor

9.12. MARINE BENTHOS

As indicated in Table 9.1-6, the only unplanned events with the potential for any measureable impacts on marine benthos would be a marine oil spill and an NADF release.

9.12.1. Marine Oil Spill

Most of the oil released from a marine oil spill would be expected to rapidly surface, but some oil may bind with sediments and settle to the bottom, with the potential to expose benthic organisms to toxic constituents. Results from a study initiated after the Deepwater Horizon oil spill found that areas within about 3 kilometers (1.8 miles) of the wellhead had low taxa richness and high nematode/harpacticoid-copepod ratios, indicative of contamination (Montagna et al. 2013). It should be noted that these impacts are considered to have resulted from attempts to regain well control by injecting drilling fluids into the open wellhead rather than the original loss of well control event. Polychaete worms, the most common benthic species in the PDA, display varied responses to oil pollution. After an initial die-off, some polychaete species may increase in abundance and rapidly colonize damaged habitat, while other species may experience reduced populations (Blackburn et al. 2014).

Considering the depth of water, relatively low species diversity, and likely limited geographic extent of impact, the consequence of a marine oil spill on marine benthos is considered **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the overall risk to marine benthos from a marine oil spill is considered **Minor** (see Table 9.12-1). There is little in the way of mitigation that would further reduce the potential impacts of a marine oil spill on marine benthos in proximity to the well; rather, EEPGL's proposed embedded controls to prevent a spill from occurring represent the most effective approach to minimizing this risk.

9.12.2. Release of NADF

Marine benthos would be the most sensitive of all the marine biological resources/receptors to an unplanned release of NADF from an emergency riser disconnect and loss of DP on a drill ship due to their close proximity to the release point, the tendency of the NADF and cuttings plume to remain at or near the seafloor, and their limited capacity to move away from the impacted area compared to other marine biota. A review of impacts of NADF and cutting deposition on marine benthos documented burial, changes in sediment texture, and hypoxia in sediments as the three primary mechanisms of impact on marine biota from a release such as Scenario 14, as described in Section 9.1.1.10, Summary of Spill Scenarios Considered (IOGP 2016). The smaller and less mobile organisms (including burrowing species, worms, and sessile lifeforms such as sponges, bryozoans, gorgonians, and most mollusks) are usually affected to greater degree by such events, while the larger and more mobile species (e.g., large crustaceans, cephalopods) are affected to a lesser degree and can move away from impacted areas. As described in Sections 9.3, Marine Geology and Sediments, and 9.4, Marine Water Quality, marine currents in the Project AOI would mitigate the potential for burial of benthos and formation of hypoxic zones within the sediment. When such events occur, recovery through natural recruitment from adjacent undisturbed areas is typically well underway within a year of the impact having occurred, but the potential does exist for short-term impacts on marine benthos in the event of a release, and such an event would likely cause at least a temporary decrease in both the abundance and diversity of marine benthos within the deposition zone.

As described above, the discharge of NADF and cuttings can lead to toxicological and respiratory impacts in addition to physical habitat impacts on the marine sediment; however, given the limited volume of material discharged in this scenario (i.e., limited to the volume of the riser), the short-term nature of such an event, and the low-toxicity NADF to be used (containing IOGP Group III NABF, with low to negligible aromatic content), the consequence rating of an NADF release with respect to impacts on marine benthos is considered **Medium**. In combination with a likelihood rating of **Unlikely** for an NADF release, the overall risk to marine benthos from an NADF Release would be **Minor** (see Table 9.12-1).

Table 9.12-1: Risk Ratings for Unplanned Event Impacts on Marine Benthos

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Benthos	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Marine Benthos	Unlikely	Medium	Minor	Implement OSRP	Minor

9.13. Ecological Balance and Ecosystems

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on ecological balance and ecosystems include a marine oil spill, a coastal oil spill, a release of NADF, and a discharge of untreated wastewater from the FPSO.

9.13.1. Marine Oil Spill

9.13.1.1. Impacts on the Marine Nutrient Cycle

Impacts on the marine nutrient cycle from a marine oil spill would be determined by the impact of the spill on phytoplankton. The available literature suggests that toxicological impacts of oil on phytoplankton vary widely according to nutrient content of the water, temperature, type of oil, and exposure. A persistent, heavy surface slick has the potential to reduce gas exchange and light transmission at the water's surface, which generally reduces photosynthetic activity and primary productivity in the impacted area (Ozhan et al. 2014). Reduced cellular activity in the phytoplankton would reduce the uptake of nutrients (nitrogen, phosphorous, and silicates) into the base of the aquatic food web. However, these impacts would be short-lived and localized, and the proportions of the phytoplankton populations impacted would be limited. As the oil weathers, the slick would begin to break apart and light transmission would be restored, and the plankton community would be replenished by plankton carried into the Project AOI by the Guiana Current from unaffected areas to the east. Hydrocarbons in the water column would be rapidly diluted to levels below those expected to cause toxicity to planktonic species. The phytoplankton community would be expected to recover quickly due to the influx of unaffected plankton and the phytoplankton's short generation times relative to those of other marine taxa.

Several studies have documented post-spill shifts in feeding behavior in birds and fish, but studies of spill-related impacts on other marine taxa are generally lacking. Most studies cite short-term adjustments in feeding strategies by birds or fish following a spill, but many cite the need for longer-term study to document the role of spills in these shifts or an inability to identify hydrocarbon contamination as a driving factor due to confounding environmental impacts, or both (GOMRI 2015; Piatt and Anderson 1996). Studies that successfully control for such factors and purport to document a causal relationship between oil spills and trophic shifts typically document a shift back to pre-spill conditions within a few years (Moreno et al. 2013; GOMRI 2015).

A large marine oil spill could have ecosystem-level trophic level impacts if hydrocarbons persist in the food web and have toxic impacts on organisms, or if underlying changes in abundance or distribution of prey cause shifts in feeding behavior or effectiveness in upper trophic levels. Although the assimilation of hydrocarbons into living tissues is well established at multiple trophic levels (Teal and Howarth 1984; Neff 2002; Chanton et al. 2012; GOMRI 2015), there has been no conclusive documentation of biomagnification of hydrocarbons up the food chain following a major oil spill. Research on fish following oil spills has documented residence of PAHs in fatty tissues, but also indicates that fish and other higher vertebrates are able to dispose of the hydrocarbons rapidly through metabolic means, such as the Cytochrome P 450 process (Neff 2002).

9.13.1.2. Impacts on Gene Flow

As described in Section 7.9.3, Impact Assessment—Ecological Balance and Ecosystems, obstacles to efficient gene flow occur when physiochemical barriers to migration, breeding, or dispersal/colonization occur. A marine oil spill could represent a potential short-term physiochemical barrier to migration through the Project AOI, although the significance of this barrier impact would vary across species and seasons. Impacts on gene flow in marine fish would be negligible, because there are no known sensitive spawning aggregations or habitat that would support such aggregations in the PDA or in the vicinity of the Project AOI and because fish traveling through the Project AOI en route to more distant aggregation sites would be expected to take an alternate route to avoid an area impacted by a spill. Marine mammals would also be expected to avoid the impacted area, although in the initial stages of a spill they could be impacted to a greater degree than the fish (e.g., if they inhaled vapors or oil at the surface prior to vacating the area). Marine turtles and seabirds would more sensitive to impacts on gene flow because they do congregate to breed in portions of the Project AOI (see Sections 9.8, Seabirds, and Section 9.10, Marine Turtles).

9.13.1.3. Impacts on Biodiversity

A marine oil spill has the potential to cause a short-term decline in biodiversity. Some species may exhibit avoidance behavior, and sensitive species that remain in the area may experience localized population declines or a reduction in vigor. Small spill events would have little if any long-term impact on biodiversity across the North Brazil Large Marine Ecosystem (LME), because these events would impact relatively localized areas, and although there can be minor local decreases in biodiversity associated with even a small spill, recovery would be expected to occur relatively rapidly. The same factors would impact biodiversity in the unlikely event of a more extensive oil spill, but declines in biodiversity within the Project AOI may occur over a larger area and impact a larger number of ecosystem types, so recovery may occur more slowly.

The consequence of a marine oil spill for ecological balance and ecosystems is rated as **Medium** based on the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a marine oil spill is considered **Unlikely**, so the overall risk of a marine oil spill to ecological balance and ecosystems is considered **Minor**. Effective implementation of the OSRP would reduce the geographic extent of the spill and, would reduce the amount of oil at the water’s surface; however, the residual risk rating is maintained at **Minor**.

9.13.2. Coastal Oil Spill

9.13.2.1. Impacts on the Marine Nutrient Cycle

The impacts of a coastal oil spill on the nutrient cycle would be similar to the impacts of a marine oil spill in the sense that they would be largely controlled by the nature of the spill’s impact on phytoplankton and primary production rates. However the types of phytoplankton and their sensitivity to environmental degradation are expected to be different in the Demerara River than offshore. Effects on light transmission at the water’s surface is expected to be much less significant in regulating primary production in the Demerara River than offshore, because turbid conditions in the river naturally limit light transmission in the river. This would imply a greater phytoplankton resilience to oil spills in the river than offshore. However, to the extent that phytoplankton in the river would be impacted by toxicological effects or reduced gas exchange, they may not be as easily replaced from surrounding populations as they would be in the open ocean. Therefore, oil-spill induced reductions in primary productivity may be lower in the river than in the ocean, but the nutrient cycle in the river may also be slower to recover.

9.13.2.2. Impacts on Gene Flow

Similar to a marine oil spill, a coastal oil spill would represent a potential short-term physiochemical barrier to migration through the Demerara River, and the significance of this barrier impact would vary across species and seasons. The most sensitive groups of organisms to these effects would probably be fish and crustaceans, which use the lower river as nursery habitats on a seasonal basis. Impacts would likely be more severe during and immediately following spawning seasons, when entire year classes of juvenile fish and crustaceans would potentially be subject to the effects of a spill on a localized basis. Impacts would likely be less in non-spawning seasons.

9.13.2.3. Impacts on Biodiversity

Impacts on biodiversity from a marine oil spill and a coastal oil spill in or near the Demerara River would be similar in terms of their mechanisms, but would affect different species. A coastal oil spill would probably affect more species of birds, fewer marine mammals, different species of fish than a marine oil spill, and would have little or no impact on marine turtles. As previously discussed, some species groups such as marine mammals, and to some degree marine fish, may be able to avoid the effects of a spill within the river. Coastal birds and shorebirds that forage in the river and along its shores probably would not be as readily able to avoid a spill's effects because their foraging areas are defined by water depth, tides, and other factors that would not change in response to a spill event.

The consequence of a coastal oil spill for ecological balance and ecosystems is rated as **Medium** based on the range of ecological receptors that could be affected, their different tolerances for spill-related impacts, the numerous interdependencies between the biological and physical elements of the marine ecosystem, and the variety of induced and indirect impacts that those interdependencies create. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a coastal oil spill is considered **Unlikely**, so the overall risk of a coastal oil spill to ecological balance and ecosystems is considered **Minor**. Effective implementation of the OSRP would reduce the geographic extent of the spill and, depending on the specific response strategies implemented in shallower waters, could reduce the amount of oil at the water's surface; however, the residual risk rating is maintained at **Minor**.

9.13.3. Release of NADF

9.13.3.1. Impacts on the Marine Nutrient Cycle

Deepsea foodwebs are highly dependent on inputs from the upper portions of the water column such as marine snow[7] and other larger detrital inputs (e.g., carcasses of larger animals). A release of NADF would have no effect on the rate at which these nutrient inputs reach the deep ocean and would have too short a duration to significantly affect the rate at which they would be consumed, so a release of NADF would have little if any effect on marine nutrient cycling.

[7] Fine biological debris and other organic material that descend from upper portions of the water column to the deep ocean

Release of NADF near the seafloor would enrich the nutrient content of the marine sediment down current of the affected wellhead due to the presence of biodegradable organic material in the fluid, and this enrichment could temporarily shift the food chain as the makeup of the marine benthos changes. It is unlikely that these changes in the benthic community would cause substantial changes in upper trophic levels, however.

9.13.3.2. Impacts on Gene Flow

A release of NADF would mostly affect the benthic biota and deepwater/midwater fishes. Empirical data on the rates of genetic exchange in these communities are scarce. Based on the similarities in the benthic communities within the Stabroek Block as discussed in Section 7.8.2.3, Existing Conditions in the Project Development Area, the area of seafloor that could be affected by an NADF release is unlikely to contain genetically distinct populations of benthos or demersal fish. Therefore, in the event that an NADF release were to temporarily cause localized mortality or reduced reproduction, the area would probably be recolonized by organisms with a similar genetic composition as the affected population.

9.13.3.3. Impacts on Biodiversity

As discussed in previous sections, exposure to the impacts of a release of NADF would largely be limited to benthos and fish, and these impacts would be temporally and spatially limited. Considering that benthos and fish communities would be expected to recover rapidly from the effects of an NADF release, an NADF release would not pose a significant risk to biodiversity.

A release of NADF would have little to no lasting effect on nutrient cycles, gene flow, or biodiversity, so the consequence of such a release on ecological balance and ecosystems is considered **Low**. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a release of NADF is considered **Unlikely**, so the overall risk of a NADF release to ecological balance and ecosystems is considered **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk would be **Minor**.

9.13.4. Untreated FPSO Wastewater Discharge

9.13.4.1. Impacts on the Marine Nutrient Cycle

A release of untreated wastewater from the FPSO would enrich the nutrient content of the marine water column down current of the FPSO due to the presence of biodegradable organic material in the discharge. This would have the effect of temporarily expanding the area of higher concentration adjacent to the FPSO, and if it persisted, could cause localized hypoxia within the expanded mixing zone. This enrichment could temporarily shift the food chain as the composition of the marine plankton community changes. It is unlikely that these changes would cause substantial or longer term changes in upper trophic levels, however.

9.13.4.2. Impacts on Gene Flow

A discharge of untreated wastewater from the FPSO would likely cause the more sensitive organisms in the immediate vicinity of the FPSO to vacate the expanded zone of higher concentration temporarily, but this effect would not last sufficiently long to affect reproductive cycles. Similar to the impacts described above in the discussion of the effects of an NADF release in Section 9.13.3, Coastal Oil Spill, the zone of higher concentration that would form as a result of an untreated wastewater discharge from the FPSO is unlikely to contain genetically distinct populations. Therefore, in the event such a discharge were to temporarily cause localized mortality or reduced reproduction, the area would probably be recolonized by organisms with a similar genetic composition as the affected population.

9.13.4.3. Impacts on Biodiversity

Impacts from a discharge of untreated wastewater from the FPSO would be temporally and spatially limited. Considering that benthos and fish communities would be expected to recover rapidly from the effects of such a release as described in previous sections, this event would not pose a significant risk to biodiversity.

A discharge of untreated wastewater from the FPSO would have little to no lasting effect on nutrient cycles, gene flow, or biodiversity, so the consequence of such a release on ecological balance and ecosystems is considered **Low**. As described in Section 9.1.1.10, Summary of Spill Scenarios Considered, a discharge of untreated wastewater from the FPSO is considered **Unlikely**, so the overall risk of such an event to ecological balance and ecosystems is rated as **Minor**. Response actions would focus on identifying and rectifying the condition that caused the release, and the residual risk rating would be maintained at **Minor**.

Table 9.13-1: Risk Ratings for Unplanned Event Impacts on Ecological Balance and Ecosystems

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Ecological Balance and Ecosystems	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Oil Spill	Ecological Balance and Ecosystems	Unlikely	Medium	Minor	Implement OSRP	Minor
NADF Release	Ecological Balance and Ecosystems	Unlikely	Low	Minor	Implement OSRP	Minor
Untreated FPSO Wastewater Discharge	Ecological Balance and Ecosystems	Unlikely	Low	Minor	None	Minor

9.14. SOCIOECONOMIC CONDITIONS/EMPLOYMENT AND LIVELIHOODS

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on socioeconomic conditions or employment and livelihoods in the Project AOI would be a marine oil spill, a coastal oil spill, and a collision between a Project vessel and a non-Project vessel. Oil spills could result in decreased fishery and/or coastal agricultural yields and could potentially impact the fishery and agriculture sectors that currently account for a large part of the country's gross domestic product (GDP). A vessel collision could result in damage to a vessel used for fishing or other commercial/subsistence purposes, leading to an impact on income or livelihood for the affected individual(s).

The economies in Regions 1, 2, 3, 5, and 6 are highly dependent on fishing and agriculture for employment, income generation, and subsistence. Although the economy in Region 4 is comparatively more diversified, populations in the rural areas also rely on agriculture and fishing, and this region actually has the largest number of fisherfolk in the country. These economies would be sensitive to impacts on fisheries and coastal crop production that could result from an oil spill, if it were to reach near-coastal waters or the coast. Impacts of an oil spill on river and coastal transportation networks that link communities and provide access to markets could also affect economies, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available. These potential impacts are discussed below.

9.14.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil reaching near-coastal waters or contacting the coast (Region 1 is the only portion of the Guyana coast with the potential to be contacted by such a spill). It should be noted that based upon the modeling results of a mitigated marine oil spill, no oil is predicted to contact the shoreline in the region.

Fisheries potentially could be impacted by an unmitigated marine oil spill, especially if the oil reaches near-coastal waters, where most artisanal and commercial fishing occurs. Deep-sea tuna fishing, which occurs at a small scale (less than 11 Guyanese vessels, with only 6 in current operation) in deep sea waters, could also be potentially impacted. Fisheries may be impacted by any reduction in fish populations or closure of active fishing areas to allow for clean-up or to avoid potential public health impacts, or as a result of actual or perceived tainting of commercial fish products. Potential impacts on mangrove habitats could impact fishery nursery grounds and future-year class populations. Adult fish, however, are relatively resilient to oil spills because they are mobile and can quickly relocate away from an oil spill (see Section 9.11, Marine Fish). In the event of an unmitigated marine oil spill, there would be several days advance notice before any oil would possibly reach the Guyana coast, so fisherfolk would have ample time to move their boats to unaffected alternate fishing areas.

While the consequence of a marine oil spill impacting commercial fisheries could be considered **High** given the importance of the fishing industry to the economy of the Guyanese coastal populations, a marine oil spill reaching the Guyana coast is considered **Unlikely**. Therefore the (pre-mitigation) risk to fisherfolk is considered **Moderate**. In the unlikely event of a marine oil spill, EEPGL will deploy emergency response equipment to mitigate the effects of the spill, and to protect sensitive coastal resources such as mangroves, as appropriate. Effective implementation of the OSRP would reduce this risk to **Minor** by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation program (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established at the onset of a marine oil spill of sufficient magnitude to affect livelihoods of fisherfolk or other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted).

As discussed in Section 9.20, Land Use, in the unlikely event of an unmitigated marine oil spill, modeling indicates the potential exists for subsistence farming along the SBPA in Region 1 to be impacted, but there are only a few plots of land used for agricultural purposes along or in close proximity to the coast, specifically Father's Beach and Almond Beach. A marine oil spill would only directly affect these areas if it were sufficiently large enough to reach these areas along the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. In the communities further north such, as Three Brothers, Smith's Creek, and Morowhanna, river water occasionally overflows the empoldered areas created for farming, resulting in salt water intrusion. Similarly, spilled oil that reaches the rivers systems could end up in these farming areas. These effects are considered highly unlikely, as the movement of oil upstream would be limited by tidal action. Further, farmers would have ample notice to close sluice gates, and spill responders would have time to install absorbent booms or other spill control equipment to prevent oil from reaching farmers' crops or drainage inlets.

However, due to the relatively limited diversification of the economy in Region 1, the consequence of a marine oil spill that reaches the Guyana coast on socioeconomic conditions and employment and livelihoods in coastal agricultural communities is considered **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to socioeconomic conditions and employment and livelihood for coastal agriculture individual(s) from this unplanned event is considered **Minor** (see Table 9.14-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a marine oil spill and claims and/or livelihood remediation processes would further reduce this risk by compensating for economic losses, the residual risk rating is maintained at **Minor**.

9.14.2. Coastal Oil Spill

The consequences of an unmitigated coastal oil spill impacting commercial and/or subsistence fisheries would be **High** given the importance of the fishing industry to the national Guyanese economy, the likelihood that a response within the Demerara River would interfere with normal vessel traffic in the river over the short to medium term, and the fact that the most important fishing port in Guyana (Meadowbank) is located in Region 4 on the Demerara River. This port is nationally significant not only because of the amount of fish landed there, but also because of its proximity to the population center of the greater Georgetown area. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the (pre-mitigation) risk to socioeconomic conditions and employment and livelihood for fisherfolk or other economic users of affected coastal waterways is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by reducing the area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation program (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established at the onset of a coastal oil spill of sufficient magnitude to affect livelihoods of fisherfolk as well as other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted).

As described in Section 9.20, Land Use, depending on the location of a coastal oil spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary. There are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock in Region 3. These areas are set back from the coast and protected by either manmade structures (e.g. seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

Rice farming, which makes up the majority of agricultural activity in the coastal area of Regions 2 and 3, would not be directly impacted by a coastal oil spill since rice fields are irrigated from inland water conservancies. However, the islands at the mouth of the Essequibo River, including Leguan and Wakenaam, use freshwater from the river for irrigation of rice crops. It is unlikely that a coastal oil spill in the vicinity of Georgetown Harbour would reach the Essequibo River area.

Depending on tidal conditions and extent of spread of the spill, a coastal oil spill also could prevent the opening up of sluices to allow for drainage of lands along the Demerara River. Closure of sluices could prevent the spill moving inland into canals, but if such closure happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the consequence from a flooding perspective.

Due to the relatively limited diversification of the economy in Region 3, the consequence of a coastal oil spill that reaches the Guyana coast on socioeconomic conditions and employment and livelihoods in coastal agricultural communities is considered **Medium**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the (pre-mitigation) risk to socioeconomic conditions and employment and livelihoods from this unplanned event is considered **Minor** (see Table 9.14-1). In the event of a coastal oil spill, the spill would be quickly controlled and contained because of the smaller volumes and the ready access to spill control equipment. There is the potential for a spill in these coastal areas to impact fisherfolk because of its proximity to nearshore fishing grounds. The affected area would be limited and of short duration, and a relatively rapid environmental recovery would be expected. While effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill; and a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses, the residual risk rating is maintained at **Minor**.

9.14.3. Project Vessel Collision with a Third-Party Vessel

There is a potential for collisions between Project vessels and other non-Project vessels in the Georgetown Harbour/Demerara River area. Such an incident may result from navigation error or a temporary loss of power that affects the ability of a Project vessel to steer. From a socioeconomic conditions and employment and livelihoods perspective, the potential impact of such an event could include loss of the equipment necessary for the affected individual to retain his/her livelihood, or an injury which could result in the same effect. On this basis, the consequence of such an event could potentially be **High**.

Section 9.1.1.5, Nearshore Collision between a Project Supply Vessel and Another (Non-Project) Vessel or Structure, or Grounding, includes a summary of the embedded controls that will be in place to reduce the potential for a nearshore collision to occur. Based on consideration of these controls, the likelihood of Project vessel accidents causing any significant damage to third party vessels, or causing significant injury, is considered **Unlikely**. Similarly, Section 9.1.1.7, Offshore Collision between Project Vessels or between a Project Vessel and Another Third Party Vessel, includes a summary of the embedded controls that will be in place and the additional mitigation measures that will be employed to reduce the potential for an offshore collision to occur. Based on these controls and measures, the potential for an offshore collision between a Project vessel and another third party vessel is also considered **Unlikely**.

In combination with a likelihood rating of **Unlikely** for a vessel collision, the (pre-mitigation) risk to socioeconomic conditions and employment and livelihood from this unplanned event is considered **Moderate** (see Table 9.14-1). However, in the event of a collision between a Project vessel and a non-Project vessel that results in damages attributable to EEPGL, consistent with applicable law, EEPGL would provide appropriate restitution.

. On this basis, the risk rating is reduced to **Minor**.

Table 9.14-1: Risk Ratings for Potential Unplanned Event Impacts on Economic Conditions / Employment and Livelihoods

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Fisherfolk Other economic users of marine waters	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor
	Coastal agricultural communities in Region 1	Unlikely	Medium	Minor		Minor
Coastal Oil Spill	Fisherfolk Other economic users of marine waters	Unlikely	High	Moderate		Minor

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
	Coastal Agricultural Communities	Unlikely	Medium	Minor		Minor
Vessel Collision	Non-Project vessel operators	Unlikely	High	Moderate	None	Minor

9.15. Community Health and Wellbeing

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on community health and wellbeing include a marine oil spill, a coastal oil spill, a vehicular accident involving a Project vehicle, and a collision between a Project vessel and a non-Project vessel.

9.15.1. Marine or Coastal Oil Spill

Guyana is one of the poorest countries in South America, and this is particularly relevant for rural populations. Although Guyana as a nation is considered self-sufficient for food, disparities in food supply and family incomes create challenges in maintaining food security and proper nutrition in some communities, with the result that malnutrition and anemia are among the leading causes of death in Guyanese children.

Rural communities on the Guyanese coast are dependent on fishing and agriculture for subsistence and livelihoods. Fish catches and traditional crops such as vegetables and fruits are consumed or often sold locally at markets or roadside stands in all regions. Crabbing, shrimping, and hunting of coastal game, such as iguanas, deer, agouti, labba, and shorebirds, are also practiced for subsistence in many coastal communities, and are especially critical for indigenous communities in Regions 1 and 2. Adverse impacts on these resources as a result of an oil spill could have direct health impacts through entry of harmful substances into the food chain, or through malnutrition if local food supplies become unavailable. Impacts on these sectors could also have impacts via the social determinants of health: if livelihoods are impacted, increased household poverty can impact economic security, quality of life, access to education, and other health-promoting and health-protective resources. Increased economic hardship can also lead to or exacerbate familial problems and mental health impacts, including increased anxiety and suicide, especially for already vulnerable populations.

It should be noted that based upon the modeling results of a mitigated marine oil spill, no oil is predicted to contact the shoreline in the region. However, the health consequences of an unmitigated marine oil spill impacting food availability in coastal communities is considered **High** based on the following factors: (1) dependence on the coastal environment for subsistence and income and the use of rivers for daily household activities such as washing as well as bathing; (2) the high rate of poverty; and (3) the current health challenges faced by the coastal population in Guyana. As described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil reaching near-coastal waters or contacting the coast, yielding a likelihood rating of

Unlikely. Accordingly, the overall (pre-mitigation) risk to community health and wellbeing from a marine oil spill is considered **Moderate**. Effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses (which would further mitigate potential follow-on community health and wellbeing effects due to loss of sustenance). On this basis, the residual risk rating is reduced to **Minor**.

The potential health effects associated with a coastal oil spill could be similar; however, the consequence of such a spill impacting food availability in coastal communities is considered **Medium** based on the fact that the geographic area affected would be more limited, which would create more potential for subsistence fisherfolk to access alternative areas for fishing. Accordingly, the overall (pre-mitigation) risk to community health and wellbeing from a coastal oil spill is considered **Minor**. While effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill; and a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses (which would further mitigate potential follow-on community health and wellbeing effects due to loss of sustenance), the residual risk rating is maintained at **Minor**.

9.15.2. Vehicular Accident

With regard to the potential impact of onshore traffic accidents on community health and wellbeing, additional vehicular trips generated by the Project would be expected to increase the risk of vehicular accidents. The relatively low traffic speeds in Georgetown due to existing congestion may reduce the likelihood of serious injuries resulting from a vehicular accident, although the risk to bicyclists and pedestrians would not be reduced as much due to low vehicle speeds.

Consistent with international best practice, as an embedded control, EEPGL will develop and implement a Road Safety Management Procedure covering drivers and equipment dedicated to the Project to mitigate these risks. The Plan will include, at a minimum, the following components:

- Definition of required driver training, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, if applicable;
- Designation and enforcement of speed limits, through speed governors, GPS, or other monitoring systems;
- Avoidance of deliveries during typical peak traffic hours as well as scheduled closures of the Demerara Harbour Bridge to road traffic (i.e., when traffic conditions worsen along the East Bank Demerara Road), to the extent reasonably practicable;
- Monitoring and management of driver fatigue;

- Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment;
- Implementation of a community safety program for impacted schools and neighborhoods to improve traffic safety: and
- Community outreach to communicate information relating to major delivery events or periods.

The consequence of such an event would be a function of the nature of the accident. Considering the above-referenced suite of embedded controls (many of which would serve to reduce the severity of a vehicular accident, were it to occur) the range of likely consequences is **Low** to **Medium** depending on the extent of damage and severity of any resultant injuries.

The Project-related increase in traffic is expected to be an insignificant incremental addition to the existing traffic. Based on the results of a traffic survey conducted in the vicinity of the shorebase utilized by the Project along the East Bank Demerara Road (see Section 8.5.2.7, Ground Transportation Infrastructure), the average daily traffic volume along this stretch of road ranges between approximately 28,000 to 35,000 vehicles per day (measured at East Bank Demerara Road at Providence Village) to approximately 48,000 to 57,000 vehicles per day (measured at East Bank Demerara Road at Houston Village). In comparison, the Project is expected to generate approximately 20 additional vehicle-trips per day (an upper-end estimate), representing an approximately 0.04 to 0.07 percent increase. Quantitatively, this level of increase suggests the likelihood of a vehicular accident involving a Project vehicle is **Unlikely**. However, considering the planned life cycle for the Project (at least 20 years), the likelihood of an event is conservatively considered to be **Possible**.

In combination with a consequence ranging from **Low** to **Medium**, this leads to a risk rating for vehicular accidents of **Minor** to **Moderate**.

With the implementation of these measures, the risk rating for vehicular accidents could be reduced to **Minor** to **Moderate** (see Table 9.15-1).

9.15.3. Marine Vessel Collision

Accidents involving Project and non-Project vessels could lead to consequences ranging from minor vessel damage to injury or loss of life. The consequence of such an event would be a function of the nature of the accident, and could range from **Low** to **High** depending on the extent of damage and severity of any resultant injuries.

The Project-related increase in vessel traffic is expected to be an insignificant incremental addition to the existing vessel traffic in Georgetown Harbour (the most likely location where a vessel collision could occur, as compared to the open ocean). Based on the results of a marine vessel traffic survey conducted along the Demerara River in the vicinity of the shorebase(s) that will be used by the Project (see Section 8.4.2.2, Existing Conditions in the Project Area of Influence), the average daily marine vessel traffic in Georgetown Harbour is on the order of 700 to 1,000 vessel movements per week. In comparison, based on current drilling activities and past experience with similar developments, it is estimated that during Liza Phase 2 development well drilling and FPSO/SURF installation, an average of approximately 12 round-trips (24 one-way trips) per week may be made to the Stabroek Block (includes both Liza Phase 1 and Liza Phase 2 activities) by marine vessels. During Phase 2 FPSO/SURF production operations, it is estimated that this number will be reduced to approximately seven round-trips (14 one-way trips) per week (includes both Phase 1 and Phase 2 activities). These additional Project-related marine vessel trips represent an approximately 2 to 4 percent increase (during drilling and installation) and an approximately 1 to 2 percent increase (during production operations). Additionally, as an embedded control measure, Project vessels operating near the coast will adhere to speed restrictions and navigation aids, which should further reduce the likelihood of a collision. Considering these factors, the likelihood of a collision between a Project vessel and a non-Project vessel is considered **Unlikely**.

In combination with a consequence ranging from **Low** to **High**, this leads to a risk rating for vessel collisions of **Minor** to **Moderate**. Beyond the embedded controls described above, no additional mitigation measures are reasonably practicable. Accordingly, the residual risk rating is maintained as **Minor** to **Moderate**.

Table 9.15-1: Risk Ratings for Potential Unplanned Event Impacts on Community Health and Wellbeing

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Community Health and Wellbeing	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Community Health and Wellbeing	Unlikely	Medium	Minor	Implement OSRP	Minor
Vehicular Accident	Community Health and Wellbeing	Possible	Low to Medium	Minor to Moderate	None	Minor to Moderate
Marine Vessel Collision	Community Health and Wellbeing	Unlikely	Low to High	Minor to Moderate	None	Minor to Moderate

9.16. Marine Use and Transportation

As indicated in Table 9.1-6, the unplanned events with the potential for measureable impacts on marine use and transportation would be a marine oil spill, a coastal oil spill, and an oil spill resulting from a collision between a Project vessel and a non-Project vessel.

9.16.1. Marine Oil Spill or Coastal Oil Spill

Depending on the extent of the spill, an oil spill could render offshore or nearshore areas inaccessible until response measures are sufficiently complete to permit use of the affected marine areas. This limitation on accessibility could affect the location of commercial or subsistence fishing. For oil spills that reach near-shore waters, this could also affect river and coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available. Both of these impacts could result in follow-on impacts on livelihoods. The potential impacts are discussed in Section 9.14, Socioeconomic Conditions/Employment and Livelihoods.

A marine or coastal oil spill could also have some impact on marine use and transportation as a result of the additional marine vessels and resources that would be mobilized to support spill response, resulting in increased marine congestion in and around Georgetown Harbour. The consequence of increased congestion with respect to impacts on marine use and transportation in and around Georgetown Harbour would depend on the number of additional vessel movements resulting from response efforts, which would itself depend on the nature and extent of the oil spill. In the case of a response to the Tier III marine oil spill scenario discussed in Section 9.1.5, Oil Spill Modeling Reports, the level of response activity would be moderate to high over the response period. On this basis, in the case of a marine oil spill, the consequence of increased congestion with respect to impacts on marine use and transportation is considered **Medium**. In the case of a coastal oil spill, the extent of the spill would likely be comparatively smaller, resulting in a shorter response period and likely a smaller number of involved response vessels. On this basis, in the case of a coastal oil spill, the consequence of increased congestion with respect to impacts on marine use and transportation is considered **Low**.

In combination with a likelihood rating of **Unlikely** for either a marine oil spill or coastal oil spill, the (pre-mitigation) risk to marine use and transportation is considered **Minor**.

9.16.2. Project Vessel Collision with a Third-Party Vessel

As in the case of an oil spill, a collision between a Project vessel and a third-party vessel could result in follow-on impacts from a livelihood perspective (e.g., if a commercial or subsistence fishing vessel were damaged to the extent that its usability is impacted). These potential follow-on impacts are discussed in Section 9.14, Socioeconomic Conditions/Employment and Livelihoods.

In addition to this type of follow-on impact, marine vessel collisions in Georgetown Harbour or coastal areas could interfere with marine use and transportation if the collision results in one or both of the vessels becoming temporarily immobilized such that it presents an obstruction to other marine traffic. However, even if a collision is of sufficient magnitude to result in this outcome, it is likely the affected vessel could be relocated relatively quickly. Furthermore, Georgetown Harbour is sufficiently wide to allow vessels to pass around a potential obstruction until such time as the obstruction is cleared. On this basis, the consequence of a vessel collision with respect to potential impacts on marine use and transportation is considered **Low**.

As discussed in Chapter 13, Recommendations, Project vessels will be operated in accordance with standard international and local navigation procedures, which will reduce the likelihood (as well as the potential consequence) of a vessel collision. On this basis, the likelihood of a collision between a Project vessel and a third-party vessel in or around Georgetown Harbour is considered **Unlikely**.

Accordingly, the (pre-mitigation) risk to marine use and transportation as a result of a vessel collision is considered **Minor**. While prompt response and removal of any grounded or damaged vessel would serve to further reduce the consequence of such an impact, the residual risk rating is maintained at **Minor**.

Table 9.16-1: Risk Rating for Unplanned Events/Vessel Collisions on Marine Use and Transportation

Unplanned Event	Resource	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Use and Transportation	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Oil Spill	Marine Use and Transportation	Unlikely	Low	Minor	Implement OSRP	Minor
Vessel Collision	Marine Use and Transportation	Unlikely	Low	Minor	Prompt removal of damaged vessel	Minor

9.17. Social Infrastructure and Services

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on social infrastructure and services include a marine oil spill, a coastal oil spill, and a vehicular accident.

9.17.1. Marine Oil Spill or Coastal Oil Spill

A marine oil spill could impact social infrastructure and services primarily as a result of spill response efforts. Depending on the extent of the required response, response teams could temporarily increase the burden on housing, medical, harbor pilots, or other infrastructure and services. These infrastructure and service demands would only be temporary (for the duration of required clean-up, likely on the order of a few weeks to months, depending on the extent of the spill and whether any oil reaches the Guyana coast). If the spill remains offshore, most of these infrastructure and service demands would likely be concentrated in Georgetown, where most response vessels would likely be based, but also where infrastructure and services capacities are greater. If oil were to reach the Guyana shoreline, land-based response efforts would be required, and the duration of response efforts would be greater. It should be noted that based upon the modeling results of a mitigated marine oil spill, no oil is predicted to contact the shoreline. However, as described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1. Little infrastructure or service capacity exists in Region 1, so the consequence of a potential impact on social infrastructure and services as a result of a marine oil spill reaching the coast is considered **Medium**.

In the case of a coastal oil spill that reaches the shoreline, this would likely only happen near the shorebase(s) or near the mouth of the Demerara River. The available capacity of social infrastructure and services in Regions 3 and 4 is comparatively larger than in Region 1. Accordingly, the consequence of a potential impact on social infrastructure and services as a result of a coastal oil spill reaching the coast is considered **Low**.

In combination with a likelihood rating of **Unlikely** for either a marine oil spill or a coastal oil spill, the (pre-mitigation) risk to social infrastructure and services is considered **Minor** (see Table 9.17-1). While the mitigation measure of OSRP implementation would serve to reduce the likelihood or extent of a shore impact, the residual risk rating is maintained at **Minor**.

9.17.2. Vehicular Accident

A vehicular accident could have a potential impact on social infrastructure and services as a result of temporary increases in road congestion (i.e., until an accident is cleared) or burdening of healthcare infrastructure in the case of an accident requiring medical services. In the case of potential road congestion, an accident would be expected to be cleared from the roadway relatively quickly. In the case of potential health infrastructure needs, the burden from a given accident—even a more serious one—would not be expected to overwhelm the existing capacity in Georgetown. Accordingly, the consequence of a vessel collision's potential impact on social infrastructure and services is considered **Low**.

The Project-related increase in traffic is expected to be an insignificant incremental addition to the existing traffic. As discussed in Section 9.15, Community Health and Wellbeing, the Project is expected to generate an approximately 0.04 to 0.07 percent increase in the number of vehicles along the stretch of road adjacent to the shorebase planned to be used for the Project. Quantitatively, this level of increase suggests the likelihood of a vehicular accident involving a Project vehicle is **Unlikely**. However, based on the planned life cycle for the Project (at least 20 years), the likelihood of such an event is conservatively considered to be **Possible**.

Accordingly, the (pre-mitigation) risk to social infrastructure and services as a result of a vehicular accident is considered **Minor**. While prompt response and removal of any damaged vehicle would serve to further reduce the consequence of such an impact, the residual risk rating is maintained at **Minor**.

While EEPGL will develop and implement a Road Safety Management Procedure, as summarized in Section 9.15, Community Health and Wellbeing, to further reduce the likelihood (and consequence) of a vehicular accident, the residual risk rating is maintained at **Minor**.

Table 9.17-1: Risk Rating for Unplanned Events and Vehicular Accident Risks to Social Infrastructure and Services

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Social Infrastructure and Services	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Oil Spill	Social Infrastructure and Services	Unlikely	Low	Minor	Implement OSRP	Minor
Vehicular Accident	Social Infrastructure and Services	Possible	Low	Minor	None	Minor

9.18. WASTE MANAGEMENT

As indicated in Table 9.1-6, the unplanned events with the potential to result in measureable impacts on waste management would be a marine oil spill, a coastal oil spill, or an NADF release. This section considers the risk to waste management as a result of these potential unplanned events.

In the event of a hydrocarbon spill, the following wastes could be generated:

- Recovered oil
- Oily water mixed with recovered oil
- Sorbent materials
- Oiled containment boom
- Oiled PPE
- Oiled sediment
- Oiled vegetation
- Oiled debris
- Deceased wildlife

All waste generated as a result of oil spill cleanup activities would be managed in accordance with the Waste Management Plan (WMP), OSRP, and Guyana laws and local regulations. The typical waste streams associated with a cleanup could include recovered product not able to be reintroduced into the system, oily water, absorbent materials, decontamination materials, contaminated trash and debris, general trash and debris, and affected vegetation/foliage, among others. Should a significant oil spill occur, an incident-specific WMP (to complement the EEPGL country-wide WMP in the ESMP) may be developed as part of the response. Further, the WMP may be adapted as required if a spill is likely to produce more waste than can be handled by EEPGL’s regular waste contractor.

The onshore waste facility in Georgetown is licensed and has capacity to treat all of the anticipated Project-generated wastes appropriate for treatment at this facility (which includes the bulk of the wastes that would be generated in a spill response). The vertical infrared thermal

(VIR) unit is modular and can be expanded with additional boxes. The contractor's permit is not volume-limited and the operation can thus be expanded as needed. The Haags Bosch landfill is a large facility with ample capacity for the disposal of the treated residues and other non-hazardous wastes that would be expected to be generated during a spill response. On the basis that EEPGL has a robust plan for managing waste (i.e., through a combination of the OSRP and WMP, as well as provisions for adapting these plans as needed based on the nature of the response effort), the consequence of a marine or coastal oil spill or NADF release on waste management is considered **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, a coastal oil spill, and an NADF release, the pre-mitigation risk to waste management from any of these events is considered **Minor** (see Table 9.18-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the extent of an oil spill and thus the quantity of waste that would be generated in the course of responding to the oil spill, the residual risk rating is maintained at **Minor**.

Table 9.18-1: Risk Ratings for Unplanned Event Impacts on Waste Management

Unplanned Event	Resource	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor

9.19. CULTURAL HERITAGE

As indicated in Table 9.1-6, the only unplanned events with the potential to result in measureable impacts on cultural heritage would be a marine oil spill, a coastal oil spill or an NADF release. This section considers the risk to coastal cultural heritage and underwater cultural heritage as a result of these potential unplanned events.

9.19.1. Coastal Cultural Heritage

As noted in Section 8.7.2.2, Coastal Cultural Heritage, desktop research has identified two known ceramic/pottery sites near the coastline, as well as additional archaeological sites, including shell mounds, further inland. Additionally, Section 8.9.2, Existing Conditions—Ecosystem Services, describes cultural heritage sites identified by local community members during the late 2017 and early 2018 ecosystem services field verification work. In Region 1, these include shell mounds near Haimacobra Village, Warimuri Village, and Assakata Village, as well as a sacred site (a 200-year-old church) near Santa Rosa Village. In Region 2, a historic landmark (a Dutch chimney) in the Supenaam area was identified. In Region 3, identified historical sites included a monument and an eighteenth-century Dutch koker, both located near Best Klien/Pouderoyen (ERM/EMC 2018).

Based on the ubiquity of past human occupations (and thus archaeological sites), especially along coastlines, it is possible that there are additional unidentified archaeological resources along Guyana's coastline. Based upon the modeling results for a mitigated marine oil spill, no oil is predicted to contact the shoreline in the region. Modeling of an unmitigated marine oil spill from a subsea release of crude oil due to a well control event, indicates a spill has a 5 to 20 percent probability of contacting the coast in Region 1. If this were to occur, the spill would generally only impact the intertidal zone, unless the spill coincides with a significant storm surge. Additionally, while archaeological sites are common along coastlines, sites in the intertidal zone tend to lack stratigraphic integrity due to the dynamic interface between the ocean and the land, especially along beaches. Effective implementation of the OSRP would further reduce the risk of an oil spill reaching the coast by limiting the geographic extent the oil could travel. Accordingly, the consequence of a marine oil spill on coastal cultural resources is considered **Low**.

A coastal oil spill, if it were to occur, would likely happen near the shorebase(s) or near the mouth of the Demerara River. The coastline in this area is highly developed, significantly reducing the likelihood that coastal cultural resources would be present at any locations where a coastal oil spill resulted in an impact to the shoreline (no such resources were identified in the ecosystems services field verification work described above). Accordingly, the consequence of a coastal oil spill on coastal cultural resources is considered **Low**.

A release of NADF is not expected to reach the coast under any conditions. Accordingly, the consequence of a NADF release with respect to potential impacts on coastal cultural heritage is considered **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, a coastal oil spill, and an NADF release, the pre-mitigation risk to coastal cultural resources from any of these events is considered **Minor** (see Table 9.19-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact to coastal cultural heritage from an oil spill, the residual risk rating is maintained at **Minor**.

Table 9.19-1: Risk Ratings for Unplanned Event Impacts on Coastal Cultural Heritage

Unplanned Event	Resource	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Coastal Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor

9.19.2. Underwater Cultural Heritage

With respect to potential impacts on underwater cultural heritage, in the unlikely event of a spill, some oil would be expected to settle to the seafloor and could damage submerged cultural heritage (e.g., shipwrecks), but the highest probability for this to occur would be in proximity to the spill source. Based on geophysical surveys conducted in the PDA and surrounding vicinity, no shipwrecks or associated artifact scatters were identified within the PDA or vicinity (see Section 8.7.2.1, Underwater Cultural Heritage). Based on these factors, the consequence of a marine oil spill with respect to impacts on underwater cultural heritage is therefore considered **Low**. The same factors would apply to a release of NADF, so the consequence of an NADF release with respect to potential impacts on underwater cultural heritage is also considered **Low**.

As described above, a coastal oil spill, if it were to occur, would likely happen near the shorebase(s) or near the mouth of the Demerara River. Much of the Demerara Harbour is subjected to routine dredging, and it is unlikely that intact cultural resources are present where dredging occurs. Further, the type of oil spilled in a coastal oil spill would be marine diesel, which is less likely than crude oil to settle to the seafloor. Based on these factors, the consequence of a coastal oil spill with respect to potential impacts on underwater cultural heritage is considered **Low**.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, a coastal oil spill, and an NADF release, the risk to underwater cultural heritage from any of these events is considered **Minor** (see Table 9.19-2). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact to underwater cultural heritage from an oil spill, the residual risk rating is maintained at **Minor**.

Table 9.19-2: Risk Ratings for Unplanned Event Impacts on Cultural Heritage

Unplanned Event	Resource	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
NADF Release	Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor

9.20. LAND USE

As indicated in Table 9.1-6, the only unplanned events with the potential to result in measureable impacts on land use would be a marine oil spill or a coastal oil spill. The principal concerns with respect to potential land use impacts from a marine or coastal oil spill relate to the scenario where an oil spill would affect a portion of the shoreline being used for agriculture purposes (e.g., subsistence farming or livestock) or where an oil spill could indirectly result in adverse impacts on land drainage (i.e., through sluice closures). Accordingly, the assessment of potential impacts on land use from unplanned events is focused on these scenarios.

As described in Section 9.1.10, Vessel Collision with a Third-Party Vessel or Structure (Non-Spill Related Impacts), if a coastal oil spill were to occur at the shorebase(s) or as a result of the nearshore grounding of a vessel or a vessel collision, marine diesel could enter the Georgetown Harbour/Demerara River estuary. As shown in Figure 9.20-1, there are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock. As shown in the figure, these areas are set back from the coast and protected by either manmade structures (e.g. seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

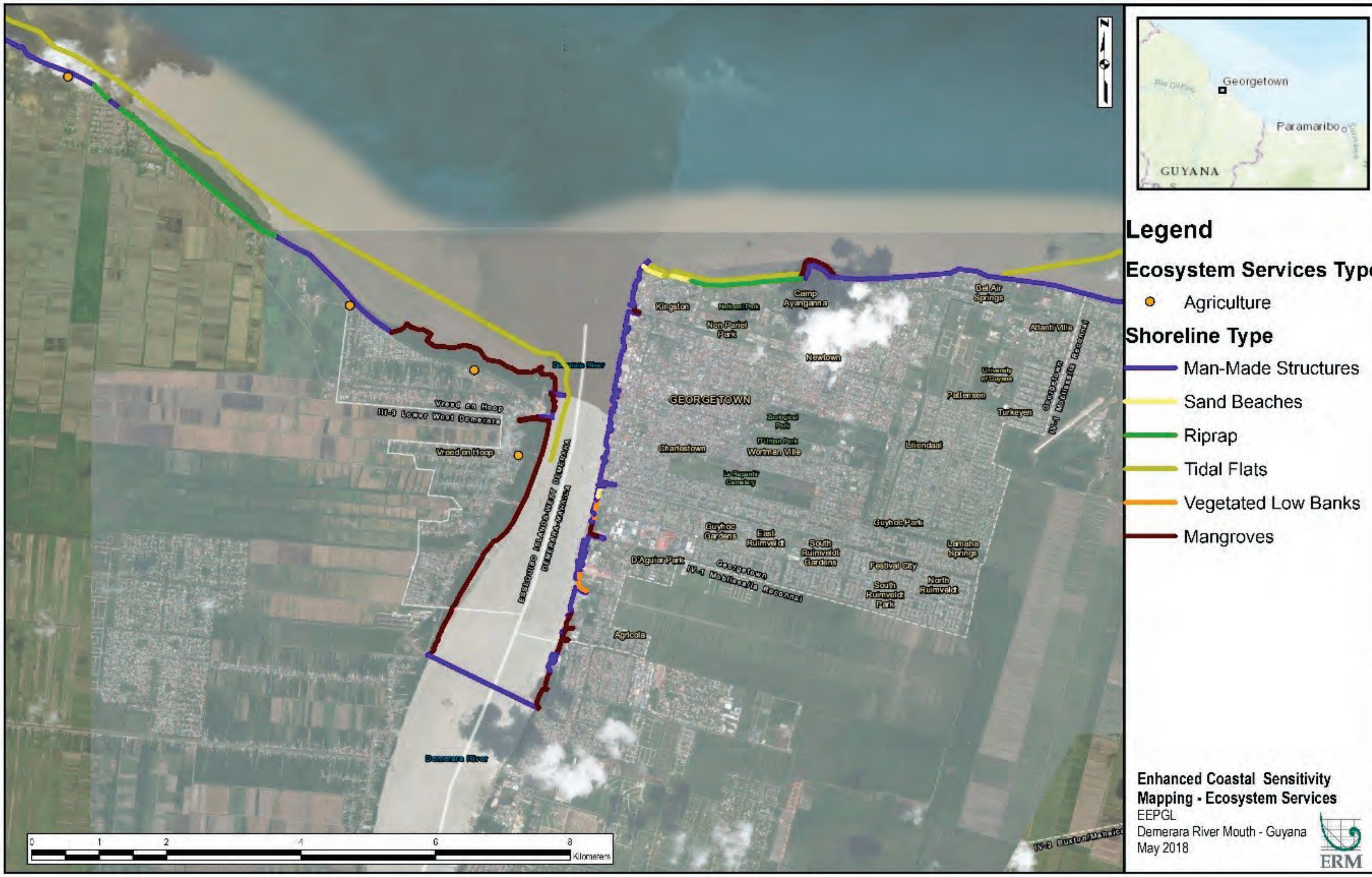


Figure 9.20-1: Agricultural Areas along Coast in Georgetown / Demerara River Vicinity

Depending on tidal conditions and extent of spread of the spill, a coastal oil spill also could prevent the opening up of sluices to allow for drainage of lands along the Demerara River. Closure of sluices could prevent the spill moving inland into canals, but if such closure happens in the rainy season, it could affect area drainage and lead to water accumulation on lands and flooding as a result. However, if this were to occur, the limitation on opening sluices would be expected to be short-term in nature, reducing the consequence from a flooding perspective.

Based on the factors above, the overall consequence of a coastal oil spill with respect to potential impacts on land use for agricultural purpose is considered to be **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the risk to land use from this unplanned event is considered **Minor** (see Table 9.20-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact to land use from a coastal oil spill, the residual risk rating is maintained at **Minor**.

Based on modeling of a mitigated marine oil spill, no oil is predicted to contact the shoreline. However, as described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1. As shown in Figure 9.1-10b, the area of potential effect in this scenario includes the SBPA, where only a few plots of land are used for agricultural purposes along or in close proximity to the coast, specifically at Father's Beach and Almond Beach (see Figure 9.20-2). As with a potential coastal spill, a marine oil spill would only affect these areas if it were sufficiently large to reach these areas along the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. Accordingly, the consequence of a marine oil spill with respect to potential impacts on land use for agricultural purpose is considered to be **Low**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to land use from this unplanned event is considered **Minor** (see Table 9.20-1). While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of an impact to land use from a marine oil spill, the residual risk rating is maintained at **Minor**.

Table 9.20-1: Risk Ratings for Unplanned Event Impacts on Land Use

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Land Use	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil Spill	Land Use	Unlikely	Low	Minor	Implement OSRP	Minor

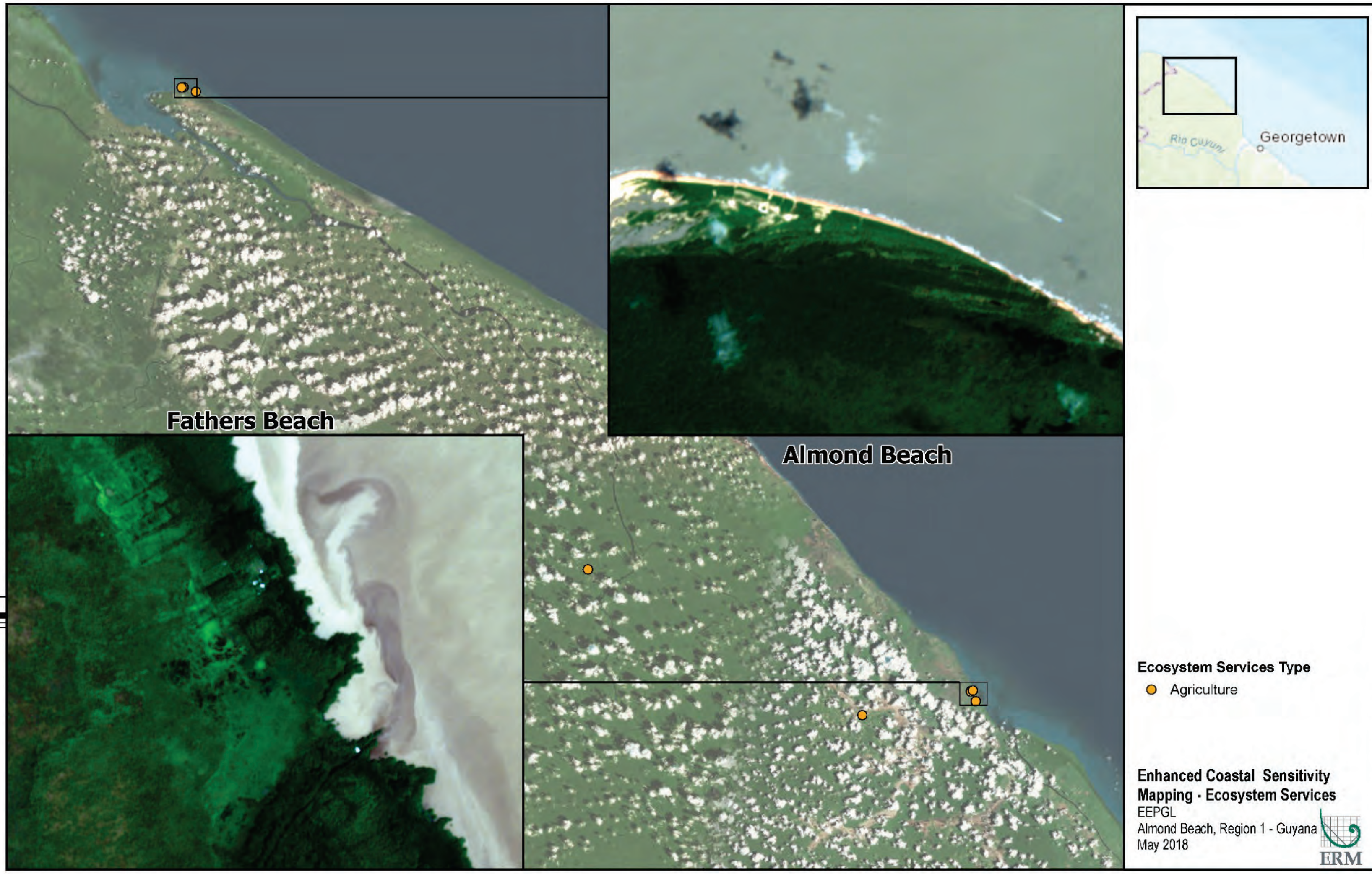


Figure 9.20-2: Agricultural Areas along Coast in Region 1

9.21. ECOSYSTEM SERVICES

As indicated in Table 9.1-6, the only unplanned event with the potential for any measureable impacts on ecosystem services would be a marine oil spill and a coastal oil spill. As described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil reaching near-coastal waters or contacting the coast, with Region 1 being the only portion of the Guyana coast with the potential to be contacted by such a spill (based upon the modeling results of a mitigated marine oil spill, no oil is predicted to contact the shoreline in the region). As described in Section 9.20, Land Use, depending on the location of a coastal oil spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary, potentially affecting coastal ecosystem services in Regions 3, 4, or (depending on the magnitude of the spill) possibly Region 2. For these reasons, the discussion of potential impacts on ecosystem services are focused on Region 1 (in the case of a marine oil spill) and Regions 2 to 4 (in the case of a coastal oil spill).

Guyana is a country that is rich in natural resources, and these are still relied upon by a large proportion of the population for livelihoods and subsistence. Fisheries and agriculture are still among the top contributors to the country's GDP, and these activities occur primarily in the coastal areas. The Region 2 and 3 economies derive a large share of their income from farming, with rice being predominant in Region 2 and rice and sugarcane being predominant in Region 3. Populations in these regions also grow many non-traditional crops for local sale and consumption. In Region 1, agriculture occurs at a relatively small scale—for subsistence use mainly—but a number of other natural resource-based activities take place, particularly by indigenous communities. Along the coast and at the river mouths, these activities include fishing, crabbing, hunting, and trapping. Some communities also hunt shorebirds, wild animals, and marine turtles, and collect marine turtle eggs and medicinal plants from the Shell Beach area. While the Region 4 economy is more diversified relative to the other coastal regions, there is still a large fishing sector and considerable agricultural activity in the rural parts of the region, as is the same with Regions 5 and 6.

Other provisioning services that could be potentially impacted by an unmitigated marine oil spill include the coastal transportation networks that link communities and provide access to markets, especially in Region 1 and between Regions 2 and 3, where aquatic transportation is the only method of transportation available.

In addition to provisioning services, the marine and coastal ecosystems in Guyana provide a range of other important services that offer protection and are necessary for the functioning and support of ecosystems and both human and non-human life. These include regulating services such as the coastal flood protection offered by mangrove forests and wildlife habitat provided by mangrove forests, mud banks, and coastal swamps.

In terms of cultural services, areas along the coast in Regions 2 to 4 are important for religious and traditional ceremonies for ethnic groups in Guyana. Many members of the Hindu community conduct funeral ceremonies on the seashore, with disposal of ashes in the ocean. Throughout the year and during holy festivals, Hindus also perform cleansing ceremonies on the seashore. African cultural organizations perform traditional emancipation ceremonies at a specific seawall location in the Georgetown area once a year. Furthermore, the seawalls, beaches and coastal parks are important to locals for tourism, recreation, and leisure.

Table 9.21-1 provides a summary of the potential ecosystem services impacts that could result from a marine oil spill or a coastal oil spill.

Table 9.21-1: Potential Ecosystem Services Receptors and Impacts from a Marine Oil Spill or Coastal Oil Spill

Receptor(s)	Key Potential Impacts
Coastal population in Regions 2, 3, 4	• Impacts on commercial fisheries and subsistence fishing • Impacts on coastal agriculture (subsistence farming and non-traditional crops, e.g. coconut, palm hearts) and grazing of animals • Impacts on aquatic transportation systems and trade • Impacts on shoreline protection provided by mangroves • Impacts on recreation, leisure and tourism
Hindu population in Regions 2, 3, 4	• Disruption of religious ceremonies (funeral and cleansing ceremonies)
Coastal population in Region 1, predominately Indigenous Peoples	• Impacts on agriculture, fishing, crabbing, hunting, trapping • Impacts on shoreline protection provided by river mangroves with occasional impact on mangroves on Shell Beach • Aquatic transportation systems and trade

9.21.1. Marine Oil Spill

As described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil reaching near-coastal waters or contacting the coast (Region 1 is the only portion of the Guyana coast with the potential to be contacted by such a spill). It should be noted that based upon the modeling results of a mitigated marine oil spill, no oil is predicted to contact the shoreline in the region.

As described in Section 9.22, Indigenous Peoples, indigenous communities in remote areas of Region 1 rely on coastal habitats for subsistence and livelihoods and have fewer alternative food sources and livelihood opportunities. In the event of a marine oil spill reaching the coast, provisioning ecosystem resources in Region 1 could potentially be adversely impacted. In the event that mangrove forests and swamps along the coast are impacted by an oil slick, species such as fish, crabs, birds, and wild animals (iguanas, deer, wild hog, agouti, labba, etc.), which are depended upon by indigenous communities as a source of protein, would potentially be impacted.

Therefore, with respect to provisioning ecosystem services, the key concerns would be potential impacts on fishing and crabbing from an unmitigated marine oil spill, especially if the oil reaches near-coastal waters (where most artisanal and commercial fishing occurs) and potential impacts on trapping, hunting, and coastal agriculture.

Consistent with the discussion in Section 9.14, Socioeconomic Conditions/Employment and Livelihoods, the (pre-mitigation) risk to fisheries resources and aquatic transportation networks is considered **Moderate**. In the unlikely event of a marine oil spill, EEPGL will deploy emergency response equipment to mitigate the effects of the spill and to protect sensitive coastal resources such as mangroves, as appropriate. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating for livelihoods affected as a result of effects to fisheries-related ecosystem services or effects to other near-shore provisioning services (e.g., should mobility of transport and access to markets via aquatic networks be impacted). On this basis, the residual risk rating is reduced to **Minor**.

With respect to potential impacts on coastal agriculture in Region 1, in the unlikely event of an unmitigated marine oil spill, modeling indicates the potential exists for subsistence farming along the SBPA in Region 1 to be impacted, but there are only a few plots of land used for agricultural purposes along or in close proximity to the coast, specifically Father's Beach and Almond Beach. Furthermore, there are only a few coastal areas where hunting and trapping occur. A marine oil spill would only directly affect these areas if it were sufficiently large enough to reach these areas along the shoreline and the tide was sufficiently high at the time of the spill to carry the spill onto the sites in question. In the communities further north, such as Three Brothers, Smith's Creek, and Morowhanna, river water occasionally overflows the empoldered areas created for farming, resulting in salt water intrusion. Similarly, spilled oil that reaches the river systems could potentially end up in these farming areas. These effects are considered highly unlikely, as the movement of oil upstream would be limited by tidal action. Further, farmers would have ample notice to close sluice gates, and spill responders would have time to install absorbent booms or other spill control equipment to prevent oil from reaching farmer's crops or drainage inlets.

Consistent with the discussion in Section 9.14, the risk to coastal agriculture from a marine oil spill is considered **Minor**. While effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast; and a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating economic losses related to loss of these provisioning services, the residual risk rating is maintained at **Minor**.

With respect to regulating ecosystem services, specifically shoreline protection, in the unlikely event of a marine oil spill reaching the coast, important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. These provide a range of ecosystem services to coastal populations in Region1. If oiling is severe enough to cause the loss of some mangrove forests, this would weaken a critical component of the country's sea defense system and expose the coastal population to increased coastal flooding hazard, especially in Region 1, where agricultural areas are not protected from flooding by the same system of sea defense as in Regions 2 to 6. On this basis, the consequence of a marine oil spill with respect to potential impacts on shoreline protection in Region 1 is considered **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to shoreline protection-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a marine oil spill, the residual risk rating is maintained at **Minor**.

9.21.2. Coastal Oil Spill

Consistent with the discussion in Section 9.14, Socioeconomic Conditions/Employment and Livelihoods, the (pre-mitigation) risk to provisioning ecosystem services related to fishing or other economic uses of affected coastal waterways is considered **Moderate**. Effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating affected fisherfolk for loss of harvest due to regional fisheries closures attributed to the oil spill, as well as other affected stakeholders (e.g., should mobility of transport and access to markets via aquatic networks be impacted). On this basis, the residual risk rating is reduced to **Minor**.

Consistent with the discussion in Section 9.14, depending on the location of a coastal oil spill, marine diesel could enter the Georgetown Harbour/Demerara River estuary. There are only a few areas along the shore zone or coastal areas near Georgetown and on the western bank of the Demerara River bank that are used for agricultural purposes—specifically, subsistence farming and/or grazing of livestock in Region 3. These areas are set back from the coast and protected by either manmade structures (e.g. seawall) or mangroves. A potential coastal spill would only affect land use in these areas if it occurred in proximity to one of the sites, were sufficiently large to reach the shoreline, and the tide was sufficiently high at the time of the spill to carry the spill over the bank and onto the sites in question.

Rice farming, which makes up the majority of agricultural activity in the coastal area of Regions 2 and 3, would not be directly impacted by a coastal oil spill since rice fields are irrigated from inland water conservancies. However, the islands at the mouth of the Essequibo River, including Leguan and Wakenaam, use freshwater from the river for irrigation of rice crops. It is unlikely that a coastal oil spill in the vicinity of Georgetown Harbour would reach the Essequibo River area.

Consistent with the discussion in Section 9.14, the (pre-mitigation) risk of a coastal oil spill that reaches the Guyana coast on coastal agricultural-related ecosystem services communities is considered **Minor**. In the event of a coastal oil spill, the spill would be quickly controlled and contained because of the smaller volumes and the ready access to spill control equipment. There is the potential for a spill in these coastal areas to impact fisherfolk because of its proximity to nearshore fishing grounds. The affected area would be limited and of short duration, and a relatively rapid environmental recovery would be expected. While effective implementation of the OSRP would reduce this risk by reducing the area affected by such a spill; and a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and

Livelihood Remediation Processes) would be established to further reduce this risk by compensating for economic losses, the residual risk rating is maintained at **Minor**.

With respect to shoreline protection, in the unlikely event of a coastal oil spill, important habitats such as mangrove forests, mud flats, swamps, and beaches could be impacted. However, agricultural areas in Regions 2 to 4 are better protected by manmade sea defense than in Region 1. On this basis, the consequence of a coastal oil spill with respect to potential impacts on shoreline protection in Region 2 to 4 is considered **Low**. In combination with a likelihood rating of **Unlikely** for a coastal oil spill, the risk to shoreline protection-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal oil spill, the residual risk rating is maintained at **Minor**.

With respect to potential impacts on recreation and tourism, in the unlikely event of a coastal oil spill reaching the coast, recreational uses of coastline areas could be impacted. Based on the high prevalence of use of most of the coastline for recreation and local tourism on a consistent basis, the consequence of such an impact is considered **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to local tourism and recreation-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal oil spill, the residual risk rating is maintained at **Minor**.

With respect to potential impacts on traditional use and religious ceremonies, in the unlikely event of a coastal oil spill reaching the coast, use of coastline areas for religious purposes could be impacted. Based on the use of the coastline for traditional and religious services, and the large Hindu population in the potentially affected coastal regions, the consequence of such an impact is considered **Medium**. In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to religious use-related ecosystem services from this unplanned event is considered **Minor**. While the mitigation measure of OSRP implementation would serve to considerably reduce the risk of such an impact from a coastal oil spill, the residual risk rating is maintained at **Minor**.

Table 9.21-2: Risk Ratings for Potential Unplanned Event Impacts on Ecosystem Services

Unplanned Event	Ecosystem Service	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill (Region 1)	Fishing and aquatic transport	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor
	Coastal agriculture, trapping hunting	Unlikely	Medium	Minor		Minor

Unplanned Event	Ecosystem Service	Likelihood of Event	Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
	Shoreline protection	Unlikely	Medium	Minor	Implement OSRP	Minor
Coastal Oil Spill (Region 2, 3, or 4)	Fishing and aquatic transport	Unlikely	High	Moderate	Implement OSRP	Minor
	Coastal agriculture	Unlikely	Medium	Minor	Implement claims and or livelihood remediation processes for affected individuals	Minor
	Shoreline protection	Unlikely	Low	Minor	Implement OSRP	Minor
	Recreation	Unlikely	Medium	Minor		Minor
	Religious ceremonies	Unlikely	Medium	Minor		Minor

9.22. INDIGENOUS PEOPLES

As indicated in Table 9.1-6, the only unplanned event with the potential to result in measureable impacts on indigenous peoples would be a marine oil spill. A coastal oil spill, if it were to occur, would likely happen near the shorebase(s) or near the mouth of the Demerara River. Significant indigenous populations are not present in this area; accordingly, potential risk to indigenous peoples from a coastal oil spill is not discussed further herein.

As discussed in Section 8.9.3, Impact Assessment—Ecosystem Services, indigenous populations in the more remote coastal areas of Regions 1 and 2 make use of a range of coastal resources for subsistence and livelihoods. Communities that are directly adjacent to the coast include Three Brothers, Almond Beach, and Father's Beach. Indigenous villages located 5 to 10 kilometers (approximately 3 to 6 miles) inland from the coast in Regions 1 and 2 include Santa Rosa, Waramuri, Manawarin, Assakata, and Wakapau. These communities engage in a number of natural resource-based activities including small-scale agriculture (coconuts in particular), fishing, crabbing, hunting, trapping, heart of palm harvesting, and natural-medicine harvesting on the coast. Most of the indigenous communities from Region 1, and a few communities from Region 2 that are located inland from the coast, venture to the Shell Beach coastline (within the SBPA) to engage in these activities (ERM/EMC 2018). The communities depend on the waterways for potable and domestic water supply and, in most cases, the waterways are the only form of transportation available.

In the SBPA, fishing and crabbing are common activities at the westernmost end of Shell Beach (at the mouth of the Waini River) and easternmost end (at the mouth of the Moruca River). An area along Shell Beach referred to as "Iron Punt," which can be accessed from the ocean and from Luri Creek, is also a common fishing and crabbing area. Aside from serving as a transit route, Luri Creek also provides communities with opportunities for fishing, crabbing, and bird hunting, particularly in the dry season, and some hunting (labba, deer, land turtles, ducks) in the wet season.

Indigenous communities in remote areas of Region 1, and to a much lesser extent in Region 2, rely on the coastal habitats for subsistence and livelihoods and fewer alternative food sources and livelihood opportunities. In the event of an oil spill reaching the coast, provisioning resources used by indigenous communities could potentially be adversely impacted. In the event that mangrove forests and swamps along the coast are impacted by oil, species such as fish, crabs, birds, and wild animals (iguanas, deer, wild hog, agouti, labba, etc.), which are depended upon by indigenous communities as a source of protein, would potentially be impacted.

For these reasons, the consequence of a marine oil spill on coastal indigenous communities is considered to be potentially **High**. As described in Section 9.1.5, Oil Spill Modeling Results, modeling of an unmitigated marine oil spill from a well-control event indicates a 5 to 20 percent probability of the oil contacting the coast in Region 1. It is noted that modeling of a mitigated marine oil spill, predicts no oil would contact the shoreline in the region.

In combination with a likelihood rating of **Unlikely** for a marine oil spill, the risk to indigenous peoples from this unplanned event is considered **Moderate** (Table 9.22-1). The Project will establish an OSRP that will be implemented in the unlikely event of a spill. Effective implementation of the OSRP would reduce this risk by reducing the probability of oil reaching near-coastal waters or the Guyana coast. Additionally, a claims process and, as appropriate, a livelihood remediation process (see Section 9.1.9, Claims and Livelihood Remediation Processes) would be established to further reduce this risk by compensating affected individuals (including indigenous peoples, if affected) for effects to livelihood as a result of an oil spill. On this basis, the residual risk rating is reduced to **Minor**.

Table 9.22-1: Risk Rating for Potential Unplanned Event Impacts on Indigenous Peoples

Unplanned Event	Resource/ Receptor	Likelihood of Event	Consequence	Pre-Mitigation Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Indigenous Peoples	Unlikely	High	Moderate	Implement OSRP Implement claims and/or livelihood remediation processes for affected individuals	Minor

9.23. TRANSBOUNDARY IMPACTS

The planned Project activities are not predicted to have any measureable "transboundary impacts" (i.e., impacts outside the Guyana EEZ). All predicted impacts from planned activities will occur within the Guyana EEZ. However, there is the potential for transboundary impacts to result from unplanned events that may occur, such as oil spills. As the oil spill modeling indicates, transboundary impacts could potentially occur under Scenarios #12 (2,500 bbl offloading spill) and #13 (20,000 BOPD release from a well-control event over 30 days) as defined in Section 9.1.1.10, Summary of Spill Scenarios Considered. The unmitigated modeling results for both of these scenarios indicate there is the potential for oil to reach portions of Venezuela, Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, and St. Lucia (see Figures 9.1-5a, 9.1-6a, 9.1-11a, and 9.1-12a), although this would be unlikely - as response measures would be implemented.

Modeling of an unmitigated spill predicts that surface oil would travel towards the northwest in all scenarios during both the summer (June to November) and winter (December to May) seasons. Differences in seasonal wind speed and direction result in a range of shoreline length predicted to be oiled. Stronger easterly winds would result in the potential for more significant shoreline oiling, particularly in Venezuela and Trinidad and Tobago, while lower wind speeds allow the surface plume to be transported to the north of Trinidad and Tobago and into a portion of the Caribbean Sea.

Impacts on resources and receptors in these other countries would be similar to those discussed in this chapter for Guyana. Although the likelihood of a marine oil spill remains **Unlikely**, there would be the potential to impact the same resources and receptors discussed in the chapter for Guyana. Further, there are some additional resources that could potentially be affected (e.g., coral reefs), which recent marine surveys have documented are sparsely distributed across the middle and outer continental shelf and continental slope (ERM 2018a and ERM 2018b). The coastal sensitivity mapping conducted for the transboundary area potentially affected by a spill, as described in Section 9.1.6, Coastal Sensitivity Mapping, included the coastal regions of the countries that could potentially be impacted by an unmitigated marine oil spill such as Scenario 13, and included these other potentially affected resources. A general overview of potential effects on these countries is provided below.

9.23.1. Potential Effects on Trinidad and Tobago

The probability of shoreline oiling tends to be highest on the coast of Trinidad and Tobago because of the predominant current flow through the Stabroek Block and into the Caribbean Sea. The unmitigated oil spill modeling indicates that the probability of oil from a large subsea release of crude oil (i.e., Scenario 13 from Section 9.1.6, Coastal Sensitivity Mapping) reaching the Trinidad and Tobago coastline ranges up to approximately 90 percent, with the time of first arrival ranging from 5 to 10 days for a spill depending on whether the spill is modeled during winter or summer seasons. The mitigated scenarios show oil travelling in generally the same direction. However, effective application of multiple response strategies described in the OSRP prevents oil from reaching any coastline, including Trinidad and Tobago, as indicated in Figures 9.1-13a and 9.1-14a.

The coastal sensitivity mapping indicates that Trinidad and Tobago have several marine resources that could be potentially impacted by an oil spill. While Trinidad lacks coral reefs, Tobago has several reefs. Most are on the west side of the island and would therefore be sheltered from oil carried westward toward the island, but a few are located on the northern and southern ends of the island (including the island's largest reef, Buccoo Reef, located at Tobago's southern end) that could be exposed to oiling in the unlikely event that oil reached the island. Trinidad's seagrass communities are mostly located along the northwest coast near Chaguaramas and should be sheltered from an oil spill. Tobago's seagrass communities are mostly clustered near the southern end of the island and would be more exposed to oiling if a spill reached Tobago's shoreline.

Four species of marine turtles (hawksbill [*Eretmochelys imbricata*], leatherback [*Dermochelys coriacea*], green [*Chelonia mydas*], and olive ridley [*Lepidochelys olivacea*]) nest on Trinidad, and all of these except olive ridley nest on Tobago. Significant numbers of both islands' nesting beaches would be exposed to oiling by an unmitigated slick approaching from the east; however, slightly more than half of Tobago's nesting beaches would be protected along the west coast. Nearly all of Trinidad's nesting beaches are located along the northern and eastern coasts and would be at risk of oiling if an unmitigated spill reached Trinidad. The most sensitive coastal species to an oil spill reaching Trinidad and Tobago is probably the West Indian manatee (*Trichechus manatus*). Its known habitat in the country is exclusively located on the east coast of Trinidad in an area that would have up to a 90 percent probability of being oiled in the unlikely event of an unmitigated large subsea release of crude oil from a well control event.

Several marine IBAs (e.g., seabird breeding colonies and surrounding foraging areas, non-breeding concentrations, feeding areas for pelagic species) of global or regional importance to seabirds have been designated in Trinidad and Tobago.

Numerous fishing areas are located east of Trinidad and could be impacted by a large unmitigated subsea release of crude oil. The largest and most concentrated coastal/nearshore fishing activities in this part of Trinidad's EEZ are located along the southeastern coast from Cocos Bay in the north to Guayaguayare Bay in the south. These areas extend from the coast to approximately 20 kilometers (12 miles) offshore. Further north in the vicinity of Salybia, Sena, and Saline Bays, fishing is concentrated slightly further offshore, approximately 15 to 30 kilometers (9 to 18 miles) from the coast. All of these areas would have a high probability of being impacted by a large unmitigated subsea release of crude oil from a well control event.

9.23.2. Potential Effects on Venezuela

The probability of shoreline oiling from an unmitigated marine oil spill is high for the coast of Venezuela because of the predominant westerly current flow through the Stabroek Block. Several marine IBAs of global or regional importance to seabirds have been designated in Venezuela. The most important areas in Venezuela that could be impacted by a large unmitigated subsea release of crude oil would be the Gulf of Paria and the Orinoco River Delta. The Orinoco

River Delta is located south of Trinidad in eastern Venezuela. The Orinoco River Delta and the Gulf of Paria support numerous biological resources of regional and global significance, including extensive mangroves, diverse shorebird and estuarine fish communities, threatened and endangered marine turtles and marine mammals, and artisanal and commercial fisheries (Miloslavich et al. 2011).

The Gulf of Paria in Venezuela is located west of Trinidad and would be mostly protected from the impacts of an unmitigated spill approaching from the east; however, southern portions of the gulf could be impacted by a large unmitigated subsea release of crude oil if it passed west of Trinidad. In such a scenario, the probability of oiling would vary widely depending on the season. The southern and eastern portions of the gulf would have a high probability of being oiled (up to 70 percent depending on location and season) while areas slightly north and west would have a much lower probability of being oiled. The northern portion of the Orinoco River Delta would have a 5 to 10 percent probability of being oiled during the summer season, and both that probability and the possible extent of oiling in the delta would increase to approximately 40 percent if a large unmitigated subsea crude oil release were to occur in the winter. The unmitigated oil spill modeling indicates that the time of first arrival in the delta would be about 15 to 20 days for a spill occurring during the summer season and approximately 5 to 10 days during the winter season.

9.23.3. Potential Effects on Other Islands/Countries

The probability of shoreline oiling from an unmitigated spill is less for the other potentially affected countries (i.e., Barbados, Grenada, St. Vincent and the Grenadines, St. Lucia, Martinique, Curacao, Aruba, Haiti, Dominican Republic, Colombia) and would be less than for Trinidad and Tobago and Venezuela, ranging from 5 to 70 percent, with the time of first arrival ranging from 5 to 45 days, depending on the country and the time of year. The benefit of the longer time for first arrival of oil is that more time is available to implement the OSRP and provide measures to protect sensitive habitats. Many of the islands are important tourist destinations and support valuable coral reefs, seagrass beds, and other habitats and species sensitive to oil.

9.23.4. Summary

It should be noted that the unmitigated oil spill modeling did not take into consideration any emergency response actions. Implementation of the OSRP would help to significantly minimize potential transboundary impacts just as it would minimize impacts within the Guyana EEZ, as demonstrated by oil spill modeling, which considers OSRP implementation. 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.

10. CUMULATIVE IMPACT ASSESSMENT

10.1. INTRODUCTION

The Project Development Area (PDA) is located approximately 183 kilometers (approximately 114 miles) offshore, so there are few opportunities for the Project to cumulatively impact resources that would be impacted by other activities with the exception of: other EEPGL activities (e.g., Liza Phase 1 Project development and ongoing exploration drilling); potential future offshore Guyana oil and gas exploration by other developers; and other non-oil and gas projects (e.g., Guyana mariculture project, replacement of Demerara Harbour Bridge). These Project and non-Project activities together could cumulatively impact some resources such as special status species and marine mammals (e.g., via risks from potential vessel strikes or exposure to underwater sound), community health and wellbeing (e.g., via increased demand on limited medical infrastructure capacity), and marine use and transportation (e.g., via marine traffic congestion, especially near Georgetown Harbour), among others analyzed and discussed in this chapter.

This section discusses a cumulative impact assessment (CIA) conducted to evaluate the potential contribution of the Project toward the cumulative impacts on the resources identified as Valued Environmental Components (VECs) by stakeholders.

Following good international industry practice, this section follows the International Finance Corporation's (IFC's) *Good Practice Handbook—Cumulative Impact Assessment and Management: Guidance for Private Sector in Emerging Markets* ("the Handbook") (IFC 2013). The Handbook provides a methodology for identifying the most significant cumulative impacts; the methodology includes a desktop review of publicly available information and consultation with key stakeholders. This methodology focuses on environmental and social components referred to in the handbook as VECs, which are: (1) rated as "critical" by potential Project-Affected Communities (PACs)[1] and/or the scientific community; and (2) cumulatively impacted by the Project under evaluation, by other projects, and/or by natural environmental and social external drivers (IFC 2013). Although the Project is not subject to the IFC Performance Standards (PS), the methodology applied herein is generally consistent with the relevant IFC PS, especially PS 1—Assessment and Management of Environmental and Social Risks and Impacts (IFC 2012a), and PS 6—Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC 2012b).

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

10.2. OBJECTIVES AND SCOPE

The overall objective of this CIA is to identify and assess the contribution by the Project to cumulative impacts. It is based on information included throughout prior sections of this EIA, information generated for the Liza Phase 1 Development Project EIA Post-Permit Studies (ERM/EMC, 2018), information provided by EEPGL, and information available in the public domain. The specific objectives are:

- Identify VECs that could be impacted cumulatively in the onshore and offshore areas potentially affected by the Project, considering input from stakeholders and potential PACs through the consultation process;
- Identify other existing and planned projects and external environmental and social drivers that could cumulatively impact VECs;
- Undertake a high-level assessment of potential cumulative impacts on VECs, considering the Project and the other identified existing and planned projects and external drivers in the area;
- Recommend a management framework for the integrated management of potential cumulative impacts.

10.3. METHODOLOGY

10.3.1. Definitions of Key Terminology for the CIA

The following are definitions for key terminology used in the CIA.

Cumulative Impact: Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to other existing, planned, and/or reasonably anticipated actions, projects, or activities. For practical reasons, the identification, assessment, and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concern and/or concerns of Affected Communities.

CIA: Process to identify and evaluate cumulative impacts.

Other Projects: Existing, planned, or reasonably expected future developments, projects and/or activities potentially affecting VECs.

External Drivers: Sources or conditions that could affect or cause physical, biological, or social stress on VECs, such as natural environmental and social drivers, human activities, and external stressors. These can include climate change, population influx, natural disasters or deforestation, among others. These are typically less defined and planned than Other Projects.

VEC: Environmental and social components considered as important by the scientific community and/or Potentially Affected Communities. VECs may include:

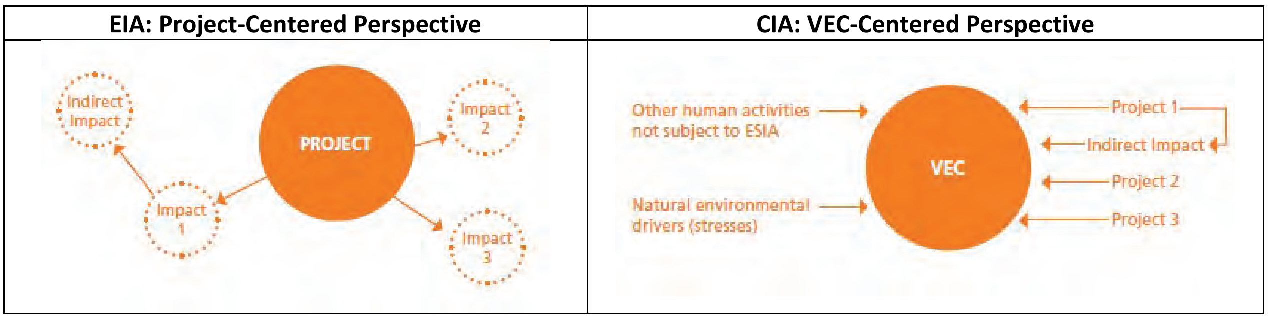
- Physical features, habitats, wildlife populations (e.g., biodiversity, water supply);
- Ecosystem services (e.g., protection from natural hazards, provision of food);
- Natural processes (e.g., water and nutrient cycles, microclimate);

- Social conditions (e.g., community health, economic conditions); and
- Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites).

VECs reflect the public and scientific community's "concern" or special interest about environmental, social, cultural, economic, or aesthetic values (IFC 2013). According to the IFC's methodology, VECs are considered the ultimate recipients of cumulative impacts because they tend to be at the ends of ecological pathways.

10.3.2. Overall CIA Approach

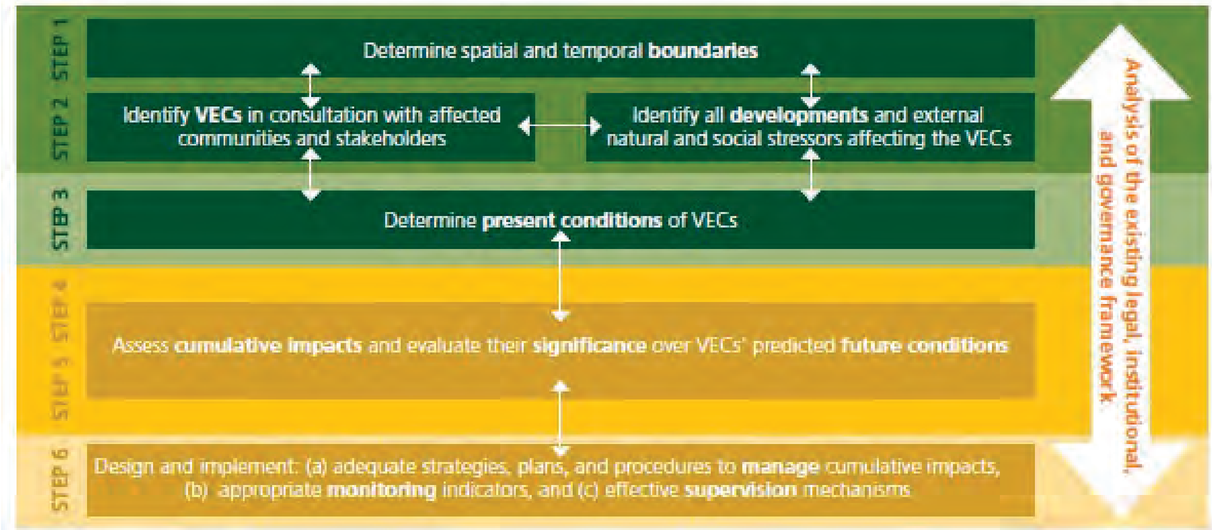
Unlike an EIA, which focuses on a project as a generator of impacts on various environmental and social receptors, a CIA focuses on VECs as the receptors of impacts from different projects and activities (see Figure 10.3-1). In a CIA, the overall resulting condition of the VEC and its related viability are assessed.



Source: IFC 2013

Figure 10.3-1: Comparing ESIA and CIA

As previously described, the CIA is derived from desktop reviews of publicly available information, information obtained during the EIA process for the Liza Phase 1 Development Project Post-permit studies, Liza Phase 2-focused studies, ongoing exploration activities, and information provided by EEPGL. The assessment follows the six steps for a CIA (see Figure 10.3-2). The process is iterative and flexible, with some steps having to be revisited in response to the results of others. For example, the VEC selection step usually needs to be adjusted after the potential impacts of the Project are identified. The steps are described in detail below.



Source: IFC 2013

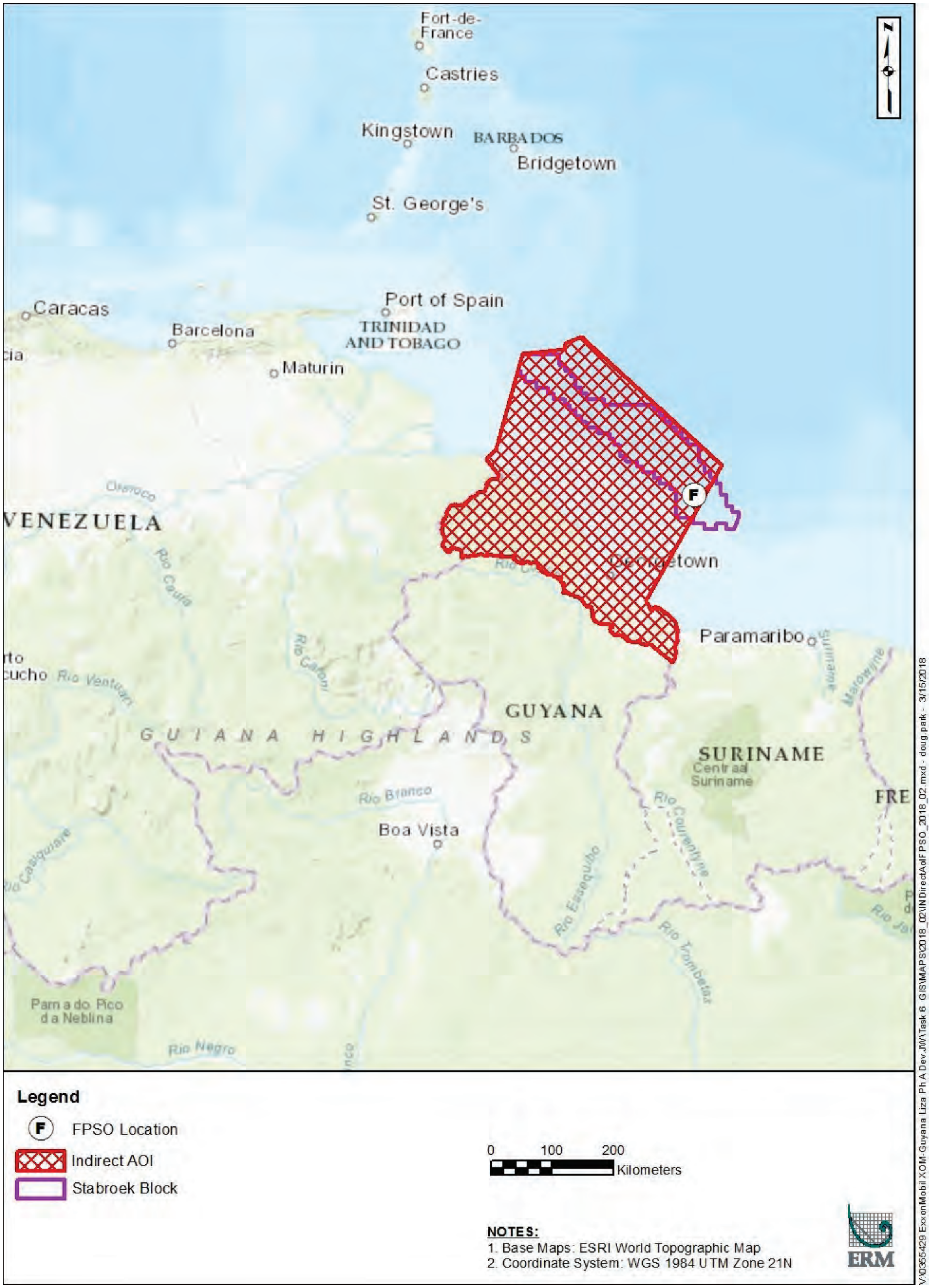
Figure 10.3-2: Summary of IFC's Cumulative Impact Assessment Methodology

10.3.3. Limitations

The Handbook takes into consideration the limitations that a private developer may face carrying out a CIA as part of an EIA, and the Guyana Environmental Protection Act requires preparers of EIAs to identify any limitations on availability of information to support the EIA, or difficulties encountered in compiling such information. The limitations applicable to this CIA, include: (1) incomplete information about other projects and activities (e.g., the information is not available in the public domain); (2) uncertainty with respect to the implementation of future projects; and (3) difficulty in establishing thresholds or limits of acceptable change for VECs, and therefore the significance of cumulative impacts.

10.3.4. Determination of Spatial and Temporal Boundaries

The geographic scope of the EIA was defined as the direct and indirect Project Area of Influence (AOI) (see Chapter 5, Scope of the Environmental Impact Assessment). Based on an assessment of the VECs for the CIA, it was determined that the Indirect AOI is sufficient to serve as the spatial boundary of the CIA, in that it covers: (1) the extent of the selected VECs, and (2) the extent of the potential impacts from the Project, other projects, and external drivers. Figure 10.3-3 shows the spatial boundary of the CIA.



Note: Map does not represent a depiction of the maritime boundary lines of Guyana

Figure 10.3-3: Spatial Boundary of the CIA

Temporal delimitation for a CIA is frequently a challenge due to the uncertainty inherent to potential future projects. For this reason, good international industry practice suggests consideration of a 3-year temporal boundary when conducting a CIA. The current assessment, however, uses a five-year temporal boundary, based on the expected timeline of the Project and the other potentially planned EEPGL projects (see Figure 10.3-4). As discussed further in Section 10.4.1, Other EEPGL Projects, the other planned EEPGL projects considered in the CIA include: (1) Liza Phase 1 Development Project; (2) continued exploration drilling; (3) a future development project referred to as the Payara Development Project; and a project to transport associated gas from the Liza Phase 1 PDA to shore for creation of natural gas liquids (NGLs) and natural gas power production, referred to as the Gas to Shore Project. As described in Section 2.2, Project Schedule, the Project's drilling and installation stages are expected to cover approximately 3.5 years (2020 to 2023) and the production operations stage is expected to start mid-way through drilling and last at least 20 years (2022 to at least 2041). The timelines of the Payara Development Project, the Gas to Shore Project, and future exploration activities are represented conceptually for the purposes of the CIA; these timelines are very preliminary in nature and would be refined as needed in the future based on evolving EEPGL plans in Guyana.

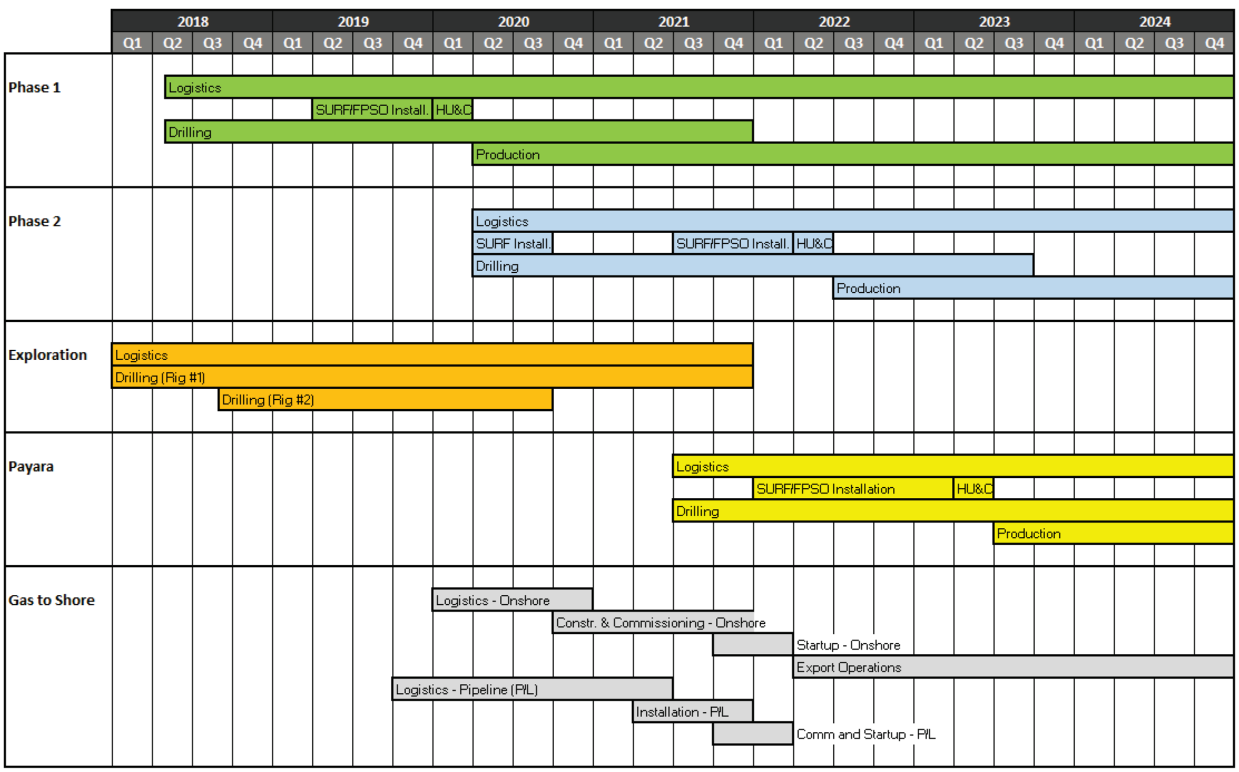


Figure 10.3-4: Temporal Boundary of the CIA for EEPGL's Projected Offshore Activities (Conceptual for CIA Purposes)

10.3.5. Identification of VECs, Other Projects, and External Drivers

10.3.5.1. *VECs*

To be included in a CIA, a VEC must first be confirmed to be valued by some identifiable stakeholder group and/or the scientific community. Second, the VEC must be reasonably expected to be affected by ***both*** the project under evaluation (i.e., the Liza Phase 2 Development Project) and some combination of other projects and external drivers.

Throughout the scoping and consultation process for the Project EIA (see Chapter 5, Scope of the Environmental Impact Assessment) and the Liza Phase 1 Development Project post permit Ecosystem Services (ESS) studies for Guyana's coastal regions (ERM/EMC 2018), the Consultants conducted or participated in various disclosure meetings, one-on-one key informant interviews, focus groups, and other general meetings. These engagements with key stakeholders included local and national government agencies, non-governmental organizations (NGOs), academia, local communities, civil society, and local industries. These engagements allowed the Consultants to develop a list of preliminary VECs and to establish the value or importance of receptors to the stakeholders. In total, the Consultants directly interviewed, engaged with, or received comments from over 600 local community leaders and residents in the six coastal regions. Table 10.3-1 presents the stakeholder groups engaged by the Consultants; information from these engagements was considered in the selection of VECs.

Table 10.3-1: Key Stakeholder Groups Interviewed

Stakeholder	Region	Stakeholder Engagement Activity	Date
Local Government			
RDC and general public	1	Scoping Consultation Meeting for Liza Phase 2 Development Project in Mabaruma	2 February 2018
RDC and general public	2	Scoping Consultation Meeting for Liza Phase 2 Development Project in Anna Regina	24 January 2018
RDC and general public	2	Scoping Consultation Meeting for Liza Phase 2 Development Project in Charity	25 January 2018
RDC and general public	3	Scoping Consultation Meeting for Liza Phase 2 Development Project in Leonora	26 January 2018
RDC and general public	4	Scoping Consultation Meeting for Liza Phase 2 Development Project in Georgetown	5 February 2018

Stakeholder	Region	Stakeholder Engagement Activity	Date
RDC and general public	5	Scoping Consultation Meeting for Liza Phase 2 Development Project in Hopetown	17 January 2018
RDC and general public	6	Scoping Consultation Meeting for Liza Phase 2 Development Project in No. 66 Village	18 January 2018
National Government			
Ministry of Communities	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	Jan, Feb 2018
Ministry of Sports	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	Jan, Feb 2018
Ministry of Agriculture, Fisheries Department	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	April 2018
Regulatory			
EPA	NA	General consultation and coordination for Phase 2	Various dates throughout 2017 and 2018
Sector Agencies	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	16 January 2018
National Agriculture Research & Extension Institute—Mangrove Restoration and Management Department	NA	ESS discussions and field participation	January–April 2018
Academia			
University of Guyana	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	Jan. 2018
NGOs			
Conservation International	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	February 2018/May 2018
World Wildlife Fund	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	February 2018/May 2018
Guyana Marine Conservation Society	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project	February 2018/April 2018
Associations/Civil Society			
Fishing Industry and Fisherfolk Community, including cooperatives and businesses	Regions 2, 4, 5, and 6	Scoping Consultation Meeting for Liza Phase 2 Development Project/Liza 1 Development Drilling Updates	February 2018/April 2018

Stakeholder	Region	Stakeholder Engagement Activity	Date
Guyana Association of Trawler Owners and Seafood Processors	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project/Liza 1 Development Drilling Updates	February 2018/April 2018
Artisanal Fishing Association	NA	Scoping Consultation Meeting for Liza Phase 2 Development Project/Liza Phase 1 Development Drilling Updates	February 2018/April 2018
Communities			
CDC—Father's Beach	1	ESS stakeholder meetings	4 April 2018
CDC—Manawarin	1	ESS stakeholder meetings	5 April 2018
CDC—Haimacobra	1	ESS stakeholder meetings	5 April 2018
CDC—Waramuri	1	ESS stakeholder meetings	6 April 2018
CDC—Santa Rosa	1	ESS stakeholder meetings	6 April 2018
CDC—Assakata	1	ESS stakeholder meetings	7 April 2018
CDC—Warapoka	1	ESS stakeholder meetings	7 April 2018
CDC—Three Brothers	1	ESS stakeholder meetings	9 April 2018
CDC—Mabaruma	1	ESS stakeholder meetings	10 April 2018
CDC—Aruka Mouth	1	ESS stakeholder meetings	10 April 2018
CDC—Morawhanna	1	ESS stakeholder meetings	11 April 2018
CDC—Smith's Creek	1	ESS stakeholder meetings	11 April 2018
CDC—Imabataro	1	ESS stakeholder meetings	11 April 2018
CDC—Almond Beach	1	ESS stakeholder meetings	12 April 2018
NDC—Charity/Urasara	2	ESS stakeholder meetings	15 November 2017
NDC—Evergreen/Paradise	2	ESS stakeholder meetings	16 November 2017
NDC—Aberdeen/Zorg-en-Vlygt	2	ESS stakeholder meetings	16 November 2017
NDC—Anna Regina Town Council	2	ESS stakeholder meetings	17 November 2017
NDC—Annandale/Riverside	2	ESS stakeholder meetings	17 November 2017
NDC—Good Hope/Pomona	2	ESS stakeholder meetings	17 November 2017
NDC—Wakenaam	3	ESS stakeholder meetings	20 November 2017
NDC—Leguan	3	ESS stakeholder meetings	21 November 2017
NDC—Mora/Parika	3	ESS stakeholder meetings	22 November 2017
NDC—Hydronie/Good Hope	3	ESS stakeholder meetings	22 November 2017
NDC—Greenwich Park/Vergenoegen	3	ESS stakeholder meetings	23 November 2017
NDC—Tuschen/Uitvlugt	3	ESS stakeholder meetings	23 November 2017
NDC—Stewartville/Comelia Ida	3	ESS stakeholder meetings	24 November 2017
NDC—Hague/Blankenburg	3	ESS stakeholder meetings	24 November 2017
NDC—La Jalousie/Nouvelle Flanders	3	ESS stakeholder meetings	27 November 2017
NDC—Best/Klien/Pouderoyen	3	ESS stakeholder meetings	27 November 2017
NDC—Georgetown City	4	ESS stakeholder meetings	5 December 2017
NDC—Industry/Plaisance	4	ESS stakeholder meetings	28 November 2017

Stakeholder	Region	Stakeholder Engagement Activity	Date
NDC—Better Hope/LBI	4	ESS stakeholder meetings	28 November 2017
NDC—Beterverwagting/ Triumph	4	ESS stakeholder meetings	29 November 2017
NDC—Mon Repos/La Reconnaissance	4	ESS stakeholder meetings	29 November 2017
NDC—Buxton/Foulis	4	ESS stakeholder meetings	30 November 2017
NDC—Unity/Vereeniging	4	ESS stakeholder meetings	30 November 2017
NDC—Haslington/Grove	4	ESS stakeholder meetings	4 December 2017
NDC—Enmore/Hope	4	ESS stakeholder meetings	4 December 2017
NDC—Woodlands/Farm	5	ESS stakeholder meetings	17 January 2018
NDC—Hamlet/Chance	5	ESS stakeholder meetings	17 January 2018
NDC—Profit/Rising Sun	5	ESS stakeholder meetings	17 January 2018
NDC—Mahaicon/Abary	5	ESS stakeholder meetings	18 January 2018
NDC—Union/Naarstigheid	5	ESS stakeholder meetings	18 January 2018
NDC—Seafield/Tempie	5	ESS stakeholder meetings	19 January 2018
NDC—Bath/Woodley Park	5	ESS stakeholder meetings	22 January 2018
NDC—Woodlands/Bel Air	5	ESS stakeholder meetings	22 January 2018
NDC—Zeelugt/Rosignol	5	ESS stakeholder meetings	23 January 2018
NDC—Ordinance/Fort Lands	6	ESS stakeholder meetings	24 January 2018
NDC—Kintyre/No. 37	6	ESS stakeholder meetings	25 January 2018
NDC—Gibraltar/Fyrish	6	ESS stakeholder meetings	25 January 2018
NDC—Kilcoy/Hampshite	6	ESS stakeholder meetings	26 January 2018
NDC—Rose Hall Town Council	6	ESS stakeholder meetings	26 January 2018
NDC—Port Mourant/John	6	ESS stakeholder meetings	29 January 2018
NDC—Bloomfield/Whim	6	ESS stakeholder meetings	29 January 2018
NDC—Lancaster/Hogstye	6	ESS stakeholder meetings	30 January 2018
NDC—Black Bush Polder	6	ESS stakeholder meetings	30 January 2018
NDC—Good Hope/No. 51	6	ESS stakeholder meetings	31 January 2018
NDC—Macedonia/Joppa	6	ESS stakeholder meetings	31 January 2018
NDC—Bushlot/Adventure	6	ESS stakeholder meetings	1 February 2018
NDC—Maida/Tarlogie	6	ESS stakeholder meetings	1 February 2018
NDC—No. 52/No. 74	6	ESS stakeholder meetings	2 February 2018
NDC—Corriverton Town Council	6	ESS stakeholder meetings	2 February 2018

NA = not applicable; CDC = Community Democratic Council; NDC = Neighborhood Democratic Council; RDC = Regional Democratic Council

10.3.5.2. *Other Projects*

Through a thorough review of publicly available information and interviews with EEPGL, government authorities, and proponents of other potential planned projects, the Consultants identified existing, and future planned projects located within the spatial and temporal boundaries of the CIA, having the potential to result in cumulative impacts on identified VECs. Section 10.4.1, Other EEPGL Projects, and Section 10.4.2, Other Non-EEPGL Projects, describe the other projects.

10.3.5.3. *External Drivers*

Regionally present external drivers and stressors were identified by the Consultants through EIA-generated information and publicly available information. Section 10.4.3, External Drivers, describes these identified external drivers.

10.3.6. Description of VEC Conditions

Based on publicly available information and the data presented in the existing conditions sections of the EIA, the baseline conditions of the selected VECs were briefly described (see Section 10.5.2, VEC Description). The VEC baselines provide information on the VECs' anticipated resilience against external stressors and their potential impacts (cumulative impacts and sources of stress) and thus provide an indication of their viability and sustainability.

10.3.7. Assessment of Cumulative Impacts on VECs

CIAs are future-oriented and project contributions are assessed as the difference between the expected future condition of the VEC in the context of all possible known stressors plus the project or projects under evaluation. This step of the CIA assesses the future conditions of the VECs, considering the Project, other projects, and external drivers. If the residual impact on a VEC was rated as **Minor** or higher for at least one potential impact associated with planned Project activities (refer to Chapters 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources, for residual impact significance ratings) the VEC was identified as potentially eligible for the CIA. Additionally, if the residual risk rating for any VEC was rated as **Moderate** or higher for at least one unplanned event, the VEC was identified as potentially eligible for the CIA.

The results of the CIA are presented in tabular format in Section 10.6, Assessment of Cumulative Impacts on VECs, and each potential cumulative impact is prioritized based on the following definitions:

- **High Priority:** The VEC is expected to be adversely impacted by Other Projects and/or External Drivers and the future addition of the Project could incrementally contribute to the potential adverse impact. Actions should be implemented in the short term to mitigate potential adverse cumulative impacts on the VEC.
- **Medium Priority:** The VEC could potentially be impacted by Other Projects and/or External Drivers, and the Project could potentially incrementally contribute to the adverse impact. Actions should be implemented in the medium term to mitigate potential adverse cumulative impacts on the VEC.
- **Low Priority:** The VEC could potentially be impacted by Other Projects and/or External Drivers, but the Project would not be expected to contribute to the adverse impact or its contribution would be expected to be negligible. No actions are required to mitigate potential adverse cumulative impacts on the VEC.

10.3.8. Cumulative Impact Management Framework

Internationally recognized good practices for managing cumulative impacts include:

- "Effective application of the mitigation hierarchy (avoid, reduce, and remedy) in the environmental and social management of the specific contributions of a project to expected cumulative impacts; and
- Undertaking best efforts to engage, leverage, and/or contribute in multi-stakeholder collaborative initiatives or discussion groups to implement management measures that are beyond the capacity and responsibility of any individual project developer." (IFC 2013)

The embedded controls and management measures included in the EIA provide a means to mitigate the specific contributions of the Project to effects on VECs, following the mitigation hierarchy (refer to mitigation measures in Chapters 6, Assessment and Mitigation of Potential Impacts from Planned Activities—Physical Resources; 7, Assessment and Mitigation of Potential Impacts from Planned Activities—Biological Resources; and 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources; management framework in Chapter 11, Environmental and Social Management Plan Framework; and a summary of embedded controls and mitigation measures in Chapter 13, Recommendations). Supplementing these controls and management measures, the CIA provides recommendations for EEGPL to apply in the context of the Project (as well as in its other projects) to manage potential cumulative impacts on these VECs.

10.4. OTHER PROJECTS AND EXTERNAL DRIVERS

Given the exploration success within the Stabroek Block to date and growing international interest, there is reasonable likelihood that oil and gas exploration and/or development offshore Guyana will continue for the foreseeable future. For example, in addition to the original Liza discovery, EEPGL has made several additional discoveries since 2016, and preliminary evaluation of a potential Payara Development Project is currently underway. There is also potential for oil and gas activities by other operators in the region. Other than for periodic vessel transit across the Stabroek Block, such operations would take place outside of the block. Therefore, the closest that another operators' activities could be expected to approach the Project would be approximately 20 kilometers (approximately 12.4 miles), which is the shortest distance from the Phase 2 PDA to the boundary with a non-EEPGL license block)[2].

Six other (non-Project) activities have been identified as potentially relevant with respect to the potential for their impacts to interact with Project impacts on a given VEC. These are described below, organized as other EEPGL projects (Section 10.4.1) and other non-EEPGL projects (Section 10.4.2).

10.4.1. Other EEPGL Projects

After consulting with EEPGL, the Consultants identified the following Other EEPGL Projects to be included in the CIA: (1) Liza Phase 1 Development Project; (2) Continued Exploration Drilling; (3) Payara Development Project; and (4) Gas to Shore Project. Summaries of these projects are presented below. Figure 10.4-1 shows the locations of the Liza Phase 1 Floating Production, Storage, and Offloading (FPSO) vessel, the Liza Phase 2 FPSO, and a nominal area in which the Payara PDA is expected to be located. Continued exploration drilling could occur throughout the Stabroek Block or possibly into adjacent blocks (this is not shown on the figure due to commercial sensitivities and lack of definition of exploration program outlook). The Gas to Shore pipeline will originate from the vicinity of the Liza Phase 1 FPSO. The pipeline route and landing location for the Gas to Shore Project are not yet finalized, so these are also not shown on the figure.

[2] Other operators could request permission from EEPGL to conduct geophysical or geotechnical survey operations within the Stabroek Block. However, for safety reasons any such activities would not be allowed to overlap with EEPGL operations in space and time. Therefore, the potential impacts associated with such operations (e.g., marine discharges, traffic, sound) would not significantly contribute to cumulative impacts.

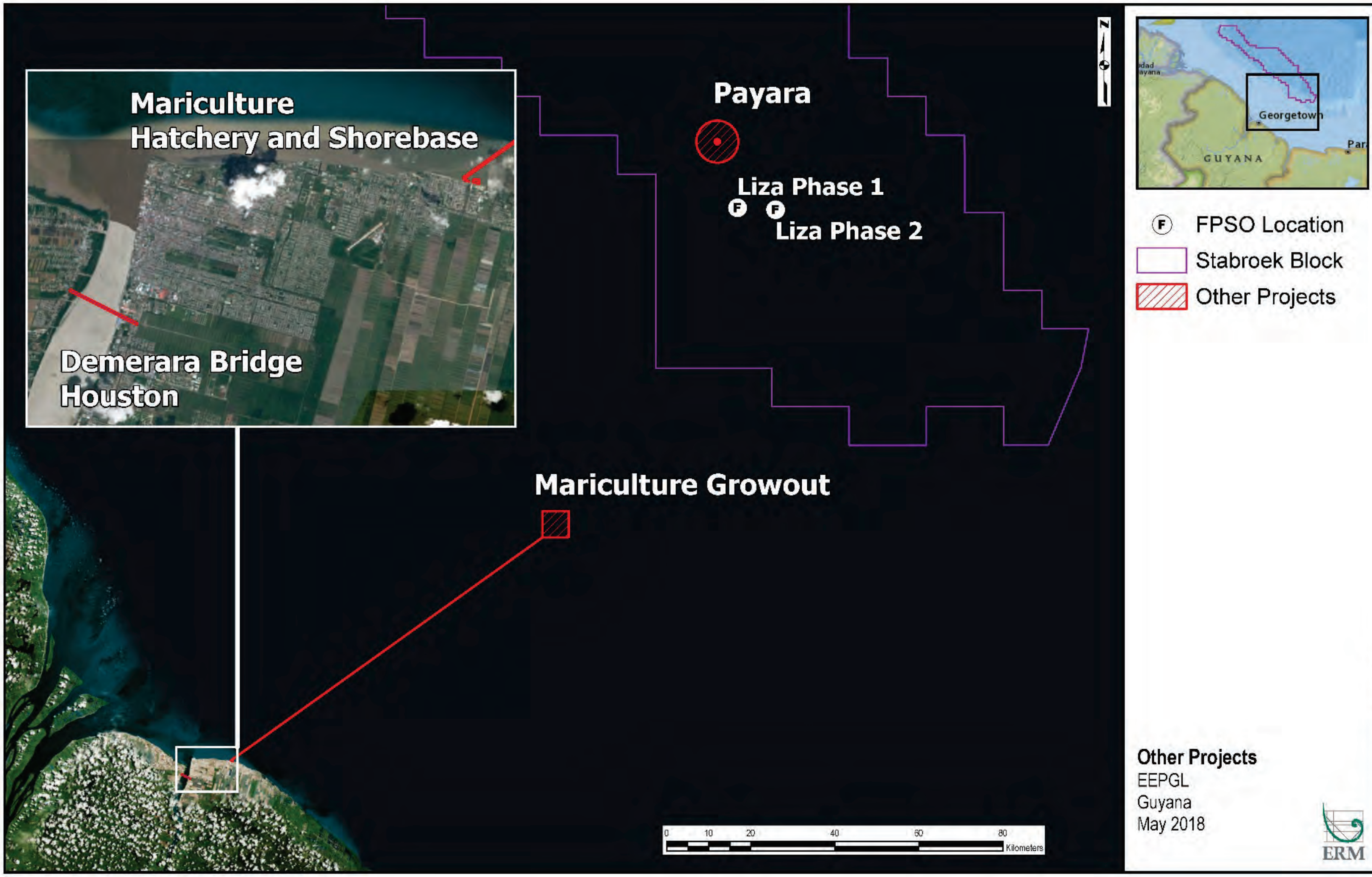


Figure 10.4-1: Conceptual Locations of Other Projects

10.4.1.1. *Liza Phase 1 Development Project*

Project Summary

The Liza Phase 1 Development Project (Liza Phase1) has been permitted to develop the offshore resource by drilling approximately 17 subsea development wells and using an FPSO to process, store, and offload the recovered oil. The FPSO will be connected to the wells via associated Subsea, Umbilicals, Risers, and Flowlines (SURF), which will transmit produced fluids (i.e., oil, gas, produced water) from production wells to the FPSO, as well as treated gas and water from the FPSO to injection wells. The Liza Phase 1 PDA, where the drilling and production operations activities will collectively occur, is a 50 square kilometers (km^2) area located approximately 190 kilometers (approximately 120 miles) offshore. The Liza Phase 1 Project will consist of three stages: (1) Drilling and Installation, (2) Production Operations, and (3) Decommissioning.

Shorebases, laydown areas, warehouses, fuel supply, and waste management facilities will support the Liza Phase 1 Project across project stages. Marine support will include various supply vessels with an average of 12 trips per week during drilling and installation and about 7 trips per week during production operations. These vessels are planned to originate from shorebases in Guyana and/or Trinidad. Aviation support is expected to average about 30 to 35 flights per week during drilling and installation and about 20 to 25 flights during production operations.

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 is planning on re-injecting the remaining gas back into the Liza reservoir, which will assist in optimizing management of the reservoir.

Project Schedule and Distance from Liza Phase 2 Development Project

During the Liza Phase 2 Development Project, it is anticipated that a minimum of one drilling rig will be working in the Stabroek Block to drill the Liza Phase 1 development wells; drilling was initiated in May 2018 and is expected to continue for 3.5 years (i.e., projected completion by year end 2021). Installation is expected to start in the second quarter of 2019 and extend through the end of 2019, followed by initiation of the production operations phase. The distance from the Liza Phase 2 FPSO to the Liza Phase 1 FPSO is approximately 8.5 kilometers (approximately 5.3 miles; Figure 10.4-1).

Potential Impacts

The Liza Phase 1 Project EIA assessed potential environmental and socioeconomic impacts of the Project resulting from planned activities and potential unplanned events (specifically an oil spill), as well as (based on best available information at the time) the Liza Phase 1 Project's contributions to cumulative impacts on resources and receptors.

The Liza Phase 1 Project is not expected to disturb natural onshore habitats. There may be a minor increase in traffic congestion in or near the onshore shorebases, and a Road Safety Management Procedure should mitigate those impacts. The only resources with the potential to incur any meaningful adverse impacts from planned Liza Phase 1 Project activities would be offshore air quality and marine-oriented resources (i.e., marine sediments, marine water quality, and biological resources such as fish, mammals, and turtles). The Liza Phase 1 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.

There would be a minor (approximately 0.3 km^2) permanent loss of benthic habitat 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 re-colonization of the impacted areas.

Even though a large marine oil spill is unlikely, and the probability of such a spill impacting the coastal resources of Guyana is very low, a large marine oil spill would likely have adverse impacts on marine resources in the area impacted by the spill. Those resources most at risk would be water quality, seabirds, marine mammals, and marine turtles. Effective implementation of an Oil Spill Response Plan (OSRP) would help mitigate this risk by further reducing the ocean surface area impacted by a spill and by reducing the potential for oil exposure to these species. Even in the unlikely event of an oil spill, little irreversible damage would be expected, although it could take a decade or more for any impacted resources to fully recover, depending on the volume and duration of the release as well as the time of year in which the release occurred.

10.4.1.2. *Continued Exploration Drilling*

Project Summary

Exploration drilling by EEPGL is planned to continue to take place in the Stabroek Block, and possibly in adjacent blocks, over the next few years, subject to continued exploration success (i.e., discoveries). There is currently one exploration drilling rig working in the Stabroek Block. In addition, a second exploration rig is envisioned to start within 50 kilometers (approximately 31 miles) of the Liza Phase 2 PDA by the third quarter of 2018. While continued exploratory drilling is contingent on the results of exploration, the EEPGL exploration program is nominally envisioned to consist of eight additional wells (environmental authorization is in place); an additional 8 to 12-well program is being contemplated (environmental authorization pending).

Project Schedule and Distance from Liza Phase 2 Development Project

One drill ship is actively drilling exploration wells in the Stabroek Block and is expected to continue through the end of 2021; the second exploration drill ship is anticipated to start in third quarter of 2018 and continue for approximately two years (until end of third quarter of 2020; Figure 10.3-4). The duration and extent of the exploration drilling, however, is entirely dependent on continued successful results. For the purpose of this CIA, it is conservatively assumed that all exploration drilling activity would occur inside the Stabroek Block, within 50 kilometers (approximately 31 miles) of the Liza Phase 2 PDA.

Potential Impacts

Because the exploration drilling program involves activities similar in nature to the development drilling stages of both the Liza Phase 1 and Liza Phase 2 Development Project, the same potential environmental and socioeconomic impacts for these stages would generally be relevant for ongoing and future exploration drilling.

10.4.1.3. *Payara Development Project*

Project Summary

The planned Payara Development Project is expected to be a design concept similar to those of the Liza Phase 1 and Liza Phase 2 Development Projects (i.e., an FPSO with a subsea tieback system). Although the sizing and capacity of the Payara Development Project facilities are not currently defined, for the purposes of this CIA it is assumed that the Payara Development Project FPSO size/capacity will be between those of the Liza Phase 1 and Liza Phase 2 Development Projects, with 15 to 30 wells envisioned. For the purposes of this CIA, the preliminary area within which the Payara FPSO and subsea infrastructure are expected to be located (northwest of the Liza Phase 1 FPSO) is shown on Figure 10.4-1.

Project Schedule and Distance from Liza Phase 2 Development Project

For the purpose of this CIA, the estimated timeline for the Payara Development Project follows approximately one year behind the Liza Phase 2 Development Project. The Payara Development Project therefore envisions filing an Application for Environmental Authorisation in early 2019, with an assumed 2.5-year period from Application submittal to start of development drilling (assuming an Environmental Permit is issued). On this same assumed basis, SURF installation would start approximately three years after Application submittal (January 2022), and production would start four years after Application submittal (third quarter of 2023; Figure 10.3-4). For the purposes of this CIA, the distance from the Liza Phase 2 FPSO to the assumed Payara FPSO location is on the order of approximately 20 kilometers (approximately 12.4 miles; Figure 10.4-1).

Potential Impacts

Because the Payara Development Project would be similar in nature to both the Liza Phase 1 and the Liza Phase 2 Development Projects, the same potential environmental and socioeconomic impacts for these stages would generally be relevant for the Payara Development Project.

10.4.1.4. *Gas to Shore Project*

Project Summary

For gas disposition, EEPGL is currently advancing preliminary planning work for a potential Gas to Shore Project. The Gas to Shore Project is expected to transport associated gas from the Liza Phase 1 PDA to shore for creation of NGLs and natural gas power production. Purposes of the potential project include beneficial use of associated natural gas, reducing Guyana’s reliance on imported heavy fuel oil, lowering national greenhouse gas (GHG) emissions through cleaner burning natural gas, and bridging to a greener energy economy for Guyana. It is estimated that the Gas to Shore Project scope would include new facilities including a pipeline from the Liza Phase 1 PDA to shore, a new NGL facility, and associated onshore facilities. The Gas to Shore Project may include or be developed concurrently with a new onshore power plant and power distribution system. The NGL facility would likely include truck loading for wholesale distribution to domestic Guyana, NGL bottling, or other processing facilities.

Project Schedule and Distance from Liza Phase 2 Development Project

For the purposes of this CIA, the estimated timeline for the Gas to Shore Project envisions filing an Application for Environmental Authorisation in the second half of 2018, with start of onshore facilities construction in late 2020 and start of offshore pipeline construction in early 2021. For the purposes of this CIA, the distance from the Liza Phase 2 FPSO to the seaward end of the assumed subsea gas pipeline location is on the order of approximately 8.5 kilometers (approximately 5 miles). Onshore facilities would be on the order of approximately 180 kilometers (approximately 112 miles) from the Liza Phase 2 FPSO location.

Potential Impacts

Potential impacts from the Gas to Shore Project would be assessed in accordance with Guyana requirements for environmental authorization of the proposed project. It is estimated that potential environmental and socioeconomic impacts from offshore pipeline development would be similar to those associated with subsea infrastructure components of the Liza Phase 1 and Liza Phase 2 Development Projects (e.g., temporary disturbance to the marine environment during pipeline construction activities, potential interference with fishing and other marine use activities during pipeline construction activities, changes to water quality as a result of permitting discharges from pipeline construction-related vessels).

10.4.2. Other Non-EEPGL Projects

10.4.2.1. *Replacement of Demerara Harbour Bridge*

Project Summary

The Demerara Harbour Bridge in Georgetown has been in operation for approximately 40 years and is no longer able to efficiently service either the present or estimated future traffic demands. The Government of Guyana is currently considering replacement of the heavily used bridge as a means of relieving congestion of both vehicular road and river-based vessel traffic induced by the opening and closing of the retractor spans that allow large vessels to pass. In 2013, a pre-feasibility study identified three alternative locations for the new bridge: Houston, Peters Hall (the existing location), and New Hope. In November 2015, the Ministry of Public Infrastructure sought Expressions of Interest to complete a feasibility study and design for a new bridge across the Demerara River (Kaieteur News Online 2015). The Government of Guyana commissioned LievenseCSO to execute the feasibility and design study and a final study was submitted in August 2017 (LievenseCSO 2017).

The design proposed by LievenseCSO consists of a low bridge with three lanes and a movable section to transit seagoing vessels. The bridge would be designed with a minimum clearance of 17.5 meters above chart datum to allow uninterrupted passing of trawlers, tugs and barges and smaller coastal and service vessels. The feasibility study found this to be the preferred solution, and concluded the preferred location would be at Houston–Versailles. The study also points out that traffic is estimated to continue to grow at 5 percent per year, and that new linking roads would be required to fully use the new bridge capacity.

At the time of this CIA, it is unclear when or if the replacement bridge project will proceed. However, it is being included in the CIA as a reasonably foreseeable project.

Project Schedule and Distance from Liza Phase 2 Development Project

The new bridge is proposed to be located in close proximity to the shorebase that EEPGL is planning to use to support the Liza Phase 2 Development Project (Figure 10.4-1). If construction of a new bridge moves forward within the next 20 years, the construction-related activities for the bridge might occur at the same time as some stages of the Liza Phase 2 Development Project.

Potential Impacts

The proposed Houston–Versailles bridge location was found by the feasibility study author to be the alternative with the least urban and environmental impacts. However, the author concluded there are some potential impacts that would need to be mitigated by others, such as resettlement of houses, potential impacts on the Muneshwers terminal, and potential impacts on the PSI Fishing terminal adjacent to the bridge.

In addition, the author identified potential impacts on the west bank of the Demerara River as including damage or modification to mangroves, the current drainage channel, and a timber company. Other potential impacts identified in the feasibility report for the relocation project are impacts on the harbor and on river navigation. Procedures for river navigation would have to be reconsidered and new lead lines developed. The study concludes that all these potential impacts and challenges are manageable.

To evaluate traffic-related impacts, the feasibility study predicted traffic growth and the results were used to assess impacts environmental components such as noise, air quality, safety, nuisance and health. To mitigate potential traffic-related impacts, the study suggests construction of bypasses on the west and east sides of the bridge.

Potential biodiversity impacts from construction of the new bridge are anticipated by the feasibility study author to include impacts on mangroves on both banks of the Demerara River. According to the study, mangroves on the east bank are already impacted by anthropogenic activities, and the mangrove fringe on the east bank is also characterized as being considerably smaller than the mangrove fringe on the west bank. The study suggests technical solutions could be proposed to ensure low impact on biodiversity.

The feasibility study concludes that the overall social impact of the bridge replacement project would be positive, especially if links and bypasses are constructed simultaneously with bridge construction. Shorter traffic time and economic development would benefit the communities. Nevertheless, the study also points out that some residents may suffer impacts from noise emissions and air quality emissions during construction, and by being exposed to heightened road safety risk (these impacts would be expected to be worse during construction). In addition, the proposed Houston–Versailles location would require resettlement of a number of households adjacent to the selected alignment.

10.4.2.2. *Guyana Mariculture Project*

Project Summary

A mariculture project (Caribbean Mariculture Inc.) has been proposed for development offshore Guyana. In December 2017, an updated project summary was submitted to the EPA (Geer 2017). According to the project summary document, the project is designed to grow marine species currently caught by the capture fisheries in Guyana. The project asserts that by growing selected species of fish, marine resources can be spared, resulting in an improved reliability[3] of fish production.

The project would have three main components: (1) hatchery; (2) shorebase area; and (3) growout area. The hatchery operation would be land-based, at Le Ressouvenir, East Coast Demerara. The proposed hatchery area is bordered by mangroves to the east and west, the Atlantic Ocean to the north, and by residential areas and drainage structures to the south. The proposed shorebase operations would also be land-based, at Le Ressouvenir, East Coast Demerara. The proposed shorebase is located next to the hatchery, and similarly, it is bordered by mangroves to the east and west, the Atlantic Ocean to the north, and by residential areas and drainage structures to the south. The proposed growout operations would be located in the open ocean. The proposed growout area is indicated in the report as being located within an area approximately 39 km^2 (15 square miles [mi^2]) in size, approximately 120 kilometers (approximately 75 miles) from an area north of Devonshire Castle, and approximately 160 kilometers (approximately 99 miles) from an area north of the boundary between Administrative Regions 1 and 2. Figure 10.4-1 shows the proposed location of the project components, as determined from the publicly available project summary document and subsequent correspondence with the project proponent by the Consultants. Further correspondence with the project proponent indicates the potential for the growout area to be 65 km^2. The project proponent considers the growout area location to be preliminary, and indicates it will be further refined following consultations with government agencies to determine suitability for the proposed activities. If agreed upon by the various government agencies, the project proponent intends to make the approved final location publicly available.

[3] Seasonal volatility in catches of marine fish has been validated by the Liza Phase 1 post permit studies.

The following species would be grown: southern red snapper (*Lutjanus purpureus*); Atlantic grouper (*Epinephelus itajara*); cobia (*Rachycentron canadum*); grey snapper (*Cynoscion acoupa*); and gillbacker (*Sciades parkeri*).

The summary document briefly describes the mariculture operation. Broodstock of the various species would be captured alive from the wild, and transported to the hatchery. This broodstock would be placed in eight concrete tanks, each with a capacity of 28 cubic meters. The broodstock would then be induced utilizing environmental manipulation, so as to facilitate spawning. This would involve manipulation of photoperiod, water quality and nutrition. Chlorine bleach would be used for cleaning the tanks, and the hatchery in general. No additives would be used.

In the hatchery, the broodstock would be spawned, producing eggs, which would then hatch into fry (very small fish). These fry would be grown to fingerlings (slightly larger fish). Lastly, the fingerlings would be transported to the growout area, where they would be stocked and grown to market-sized fish.

In the growout area, the project would use cages with a mesh size of 35 to 45 millimeters (knot to knot), or a 70 to 90 millimeters stretch measure. This size would accommodate the size of fingerlings to be stocked from the hatchery operations, prevent the entry of predators, and facilitate adequate water exchange. In order to secure the cages, the project would use 1.0- to 2.5-metric tonne drag embedment anchors. The growout operation would be serviced by feeding, holding and harvesting support infrastructure, as well as logistics support, so as to be able to get inputs onto, and products off of, the facility. The growout operation would also have accommodations for staff, who would be required to supervise operations and conduct required tasks on a 24-hour basis.

The capital investment for the project is estimated at $17.5 million U.S. dollars (USD) ($3.6 billion Guyanese dollars [GYD]) over a 3-year period. Production capacity is projected to be 100,000 pounds of fish per month.

Project Schedule and Distance from Liza Phase 2 Development Project

The project summary report indicates that construction would take approximately three years, and that the project lifespan is expected to be 20 years. Based on the coordinates provided in the project summary report, the onshore components of the mariculture project would be located approximately 10 kilometers (approximately 6 miles) southeast of the mouth of the Demerara River. The offshore component (growout area) would be located somewhere within a 39 km^2 (15 mi^2) area, with its closest boundary approximately 87 kilometers (approximately 54 miles) south-southwest from the Liza Phase 2 FPSO (Figure 10.4-1).

Potential Impacts

The project summary report includes a list of potential environmental effects for the proposed project, and their corresponding mitigation measures, as follows:

- Eutrophication of Surrounding Area: The main negative environmental effects in aquaculture are associated with discharge of effluent, containing fish waste products, from farms into the environment, and potentially result in water eutrophication.
- Predation of Fingerlings of Wild Fish Species: It is probable that fingerlings of various species of wild fish will enter the cages, which are used as growing structures for the fish. Once in the cages, it is likely that these fingerlings will be subject to predation. Four of the five species that would be grown are predaceous, and one is omnivorous.
- Water Quality Changes: Due to the activities associated with the proposed culture of a significant biomass of fish, there could be changes in the baseline water parameters around the culture site. It is likely that in the immediate vicinity of the growout or culture area, there could be an increase of certain compounds, such as ammonia and nitrates, resulting from protein metabolism by the cultured species.
- Noise Pollution: The operation of diesel generators would generate noise. These generators are expected to be operational between eight to twelve hours per day, depending on the power requirements.
- Spills and Leakages: There is the possibility of spills and leakages of fuel, which could cause localized pollution of the surrounding environment until it is cleaned up.
- Sewerage: Both the onshore and offshore operations will generate sewerage, which represents a potential source of pollution.

10.4.3. External Drivers

10.4.3.1. *Natural Hazards and Climate Change*

In general, Guyana does not suffer from many natural hazards. The primary natural hazards faced by the population are floods. The low-lying coastal plains in the northern areas of Regions 1 to 6 face severe risk of flooding. In the recent past, floods have produced significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Floods can also potentially increase the transmission of water-borne diseases, such as typhoid fever, cholera, leptospirosis and hepatitis A; and vector-borne diseases, such as malaria, dengue and dengue hemorrhagic fever, yellow fever, and West Nile Fever (WHO 2018).

The World Bank estimates that Guyana is one of the most vulnerable countries to global climate change due to its low-lying coastal areas, many below mean sea-level, and a high percentage of the population and critical infrastructure located along the coast (World Bank 2016). In addition, increases in the global mean temperatures could have a significant impact, especially on the coastal plain and on activities such as the dominant agriculture sector in Guyana (UNPD 2018).

Changes in rainfall patterns and a predicted sea-level rise associated with climate change pose threats to the Guyanese coastal population and its livelihoods. As such, the country invests continuously in the construction and maintenance of sea and river defense infrastructure. In addition, significant efforts are being made to protect and enhance natural sea defense mechanisms, in particular mangrove ecosystems.

10.4.3.2. *Commercial Fishing*

Marine fisheries and subsistence fishing occur throughout Guyana's coastal waters, from the shore to the edge of the continental shelf, approximately 150 kilometers (approximately 93 miles) from shore, although most fishing activity occurs well inshore from the edge of the continental shelf. There are four main types of marine fisheries in Guyana (see Chapter 8, Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources), as differentiated by the species targeted, gear types used, and the depth of water where the fishery takes place:

- Industrial fisheries use trawls to target seabob, shrimp, and prawns, at depths of 13 to 16 meters primarily, but can also occur shallower or deeper depending on seasonal movements of the resource on the continental shelf.
- Semi-industrial fisheries use fish traps and lines to target red snapper and vermilion snapper, at the edge of the continental shelf.
- Artisanal fisheries use gillnets, seines, and other gear to target shrimp and a mix of fish species, at depths of 0 to 18 meters.
- Shark fisheries use trawls, gillnets, and hook and line to target a sharks throughout the continental shelf waters, although these fisheries capture a number of species as bycatch.

Guyana's marine fishing activities are directed at exploiting its shrimp resources using trawlers, and its ground-fisheries (with the exception of the deepwater semi-industrial trap-based fishery) are based on wooden vessels and employ a variety of gear by artisanal fisherfolk. Interviews with fisherfolk conducted as part of the Liza Phase 1 post permit studies indicated that gillnets are the most productive type of gear in the smaller-scale fisheries that operate closer to the coast, although gillnets are among the most susceptible gear types to fouling by *Sargassum*, which presents a seasonal challenge to fisherfolk. There is limited exploitation of pelagic resources over the outer continental shelf and towards the continental slope.

The large-scale commercial trawl fishery mainly targets seabob, a short-lived shallow water shrimp (*Xiphopenaeus kroyeri*), and various finfish species (MacDonald et al. 2015). The fishing industry is one of the most important direct and indirect economic drivers in Guyana (see Section 8.1.2, Existing Conditions—Socioeconomic Conditions). However, unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles (Stiles et al. 2010). The Liza Phase 1 post permit studies documented some remnant coral growth in some areas on the continental shelf, and indicated the trawl fishery as a probable factor preventing recovery of Guyana's corals and other shallow benthic communities (ERM 2018).

10.5. VEC Selection and Description

10.5.1. Selection of VECs

All the potentially eligible VECs were analyzed against the following criteria: (1) confirmed to be valued by an identifiable stakeholder group; (2) reasonably expected to be potentially significantly impacted by the Project (i.e., at least one potential impact significance rating of **Minor** or above for a planned Project activity or at least one risk rating of **Moderate** or above for an unplanned event); ***and*** (3) reasonably expected to be potentially impacted by some combination of other projects and external drivers. Table 10.5-1 summarizes the VECs considered in this CIA.

Table 10.5-1: Selected VECs for Inclusion in CIA

VEC	Valued by Stakeholders	Potentially Affected by Liza Phase 2 Development Project [a]	Potentially Affected by One or More Other Projects	Potentially Affected by One or More External Drivers
Special Status Species	Yes	Yes	Yes	Yes
Marine Mammals	Yes	Yes	Yes	Yes
Marine Turtles	Yes	Yes	Yes	Yes
Marine Fish	Yes	Yes	Yes	Yes
Community Health and Wellbeing	Yes	Yes	Yes	Yes
Marine Use and Transportation	Yes	Yes	Yes	Yes
Social Infrastructure and Services	Yes	Yes	Yes	Yes
Marine Water Quality	Yes	Yes	Yes	No
Ecological Balance and Ecosystems	Yes	Yes	Yes	Yes
Employment and Livelihoods	Yes	Yes	Yes	Yes

[a] At least one potential impact significance rating of **Minor** or above for a planned Project activity or at least one risk rating of **Moderate** or above for an unplanned event.

Several environmental and social receptors or components were not selected as potentially eligible for the CIA, in all cases because they were not reasonably expected to be significantly impacted by the Liza Phase 2 Development Project (i.e., at least one potential impact significance rating of **Minor** or above for a planned Project activity or at least one risk rating of **Moderate** or above for an unplanned event)—and in some cases were also not reasonably expected to be potentially impacted by some combination of Other Projects and External Drivers. Table 10.5-2 presents the components that were not selected as VECs for the CIA.

Table 10.5-2: VECs Not Selected for Inclusion in CIA

Potential VEC	Valued by Stakeholders	Potentially Affected by Liza Phase 2 Development Project [a]	Potentially Affected by One or More Other Projects	Potentially Affected By One or More External Drivers
Sound (Airborne)	Yes	No	No	No
Air Quality	Yes	No	No	No
Marine Geology/Sediments	Yes	No	No	Yes
Protected Areas	Yes	No	No	Yes
Coastal Wildlife	Yes	No	No	Yes
Coastal Habitats	Yes	No	No	Yes
Marine Benthos	Yes	No	No	Yes
Economic Conditions	Yes	No (positive)	Yes (positive)	Yes
Waste Management	Yes	No	No	No
Cultural Heritage	Yes	No	No	No
Land Use	Yes	No	No	Yes
Ecosystem Services	Yes	No	No	Yes
Indigenous People	Yes	No	No	Yes

[a] At least one potential impact significance rating of **Minor** or above for a planned Project activity or at least one risk rating of **Moderate** or above for an unplanned event.

10.5.1.1. *Air Quality*

Although stakeholders expressed interest in the potential effects and cumulative impacts of the Project on air quality, this VEC was not included in the CIA because the Project´s potential impact on it was determined to be of **Negligible** significance (see Section 6.1, Air Quality). Air dispersion modeling was carried out to assess air quality impacts for onshore human receptors. Additionally, in the Air Quality Modeling Report (Appendix E), the cumulative impacts from both the Liza Phase 1 and Phase 2 Development Projects were assessed for their combined impact on onshore air quality, and the resulting cumulative impact significance was also found to be **Negligible**. Specifically, for all modeled pollutants, the maximum onshore concentrations predicted to result from planned Project activities are less than 1.5 percent of the respective WHO ambient air quality guidelines (WHO 2005), and the maximum onshore concentrations predicted to result from the Project and the Liza Phase 1 Project both operating at the same time and Phase 2 are less than or equal to 2.5 percent of the WHO ambient AQS.

10.5.1.2. *Coastal Habitats*

Although highly valued by stakeholders, this component was not selected as potentially eligible for the CIA, as the EIA (see Section 7.2, Coastal Habitats) establishes that the planned Project activities and associated air emissions, effluent discharges, and sound generation, which will occur approximately 183 kilometers (approximately 114 miles) offshore, will not impact any coastal habitats. In addition, the operation of the existing Guyana shorebase(s) on the east side of the Demerara River is expected to have negligible or no impact on coastal habitat.

10.5.2. VEC Description

10.5.2.1. *Special Status Species*

Section 7.1, Protected Areas and Special Status Species, provides a detailed description of existing conditions for protected areas and special status species. Special status species are defined as those listed on the International Union for Conservation of Nature (IUCN) Red List as Critically Endangered (CR), Endangered (EN), Vulnerable (VU), and Not Threatened (NT); and are considered to be potentially present in the Project AOI. The following is a brief summary focused on coastal and marine species meeting this description.

There are 296 species known to occur in the coastal and marine habitats in Guyana on the IUCN Red List. Sixty-three of these marine and coastal species have been ranked NT or higher. According to the IUCN's classification scheme, these species currently face a credible threat of extinction. Of the 63 species, five are strictly coastal species, so they would not be impacted by planned Project activities; the remaining (non-coastal) special status species are known or expected to occur within the Project's AOI and could experience potential impacts from planned Project activities. During EEPGL-commissioned survey and monitoring activities, 15 of the non-coastal special status species have been observed in the Stabroek Block, along the Guyana coast, or between the coast and the Stabroek Block. The 15 sightings included two marine mammal species, four marine turtle species, four fish species, four bird species, and one coastal/freshwater mammal species.

Most of the threatened (CR, EN or VU) or NT species that could potentially be impacted by planned activities of the Project are marine fish. They include highly migratory species such as species of tunas and sharks, bentho-pelagic species including certain groupers, and demersal species including species of skates and rays. Many of these fish species are also targeted by the Guyanese commercial fishing industry.

10.5.2.2. *Marine Mammals*

Section 7.5, Marine Mammals, provides a detailed description of existing conditions for marine mammals in the Project AOI. The following is a brief summary focused on species recorded in the region.

The existing composition and distribution of the marine mammal community in the vicinity of the PDA was assessed through literature review, marine mammal observer (MMO) data collected during EEPGL's exploration activities from 2014 to 2018 (see Appendix M, Protected Species Observer Summary), and incidental reports associated with strandings and bycatch (Project GLOBAL 2007). The equatorial waters of Guyana are located within sub-region VI of the WCR, which includes Guyana, Suriname, and French Guiana (Ward and Moscrop, 1999). Many cetacean species are known to occur either seasonally or year-round in these waters, but there are minimal data concerning the life history and behavior of the majority of these species. Two pinniped groups (seals and sea lions) are considered to be locally extinct or extremely rare, and would not be expected to be encountered in coastal waters adjacent to the Project PDA (Ward et al. 2001).

Data on marine mammals have been collected in the Stabroek Block since 2015, during various survey activities related to oil and gas exploration activities. Data collection was based on visual and auditory detections. Over the approximately 3-year study period, there have been a total of 575 marine mammal detections recorded. To date, 12 species of cetacean have been confirmed in the Stabroek Block on the basis of these detections, with conservation statuses[4] of Least Concern (LC) or Data Deficient (DD), except for the sperm whale (*Physeter microcephalus*) which is has a conservation status of VU (see Section 7.5, Marine Mammals, for a detailed list of species). Although whales accounted for only 16 percent of the total detections, sperm whales were the most commonly identified species of whale or dolphin during the entire study period. Results indicate there may be a seasonal component to dolphin abundance offshore Guyana, whereas whale data does not show such a trend.

Overall, toothed whales (sperm, melon headed [*Peponocephala electra*], and pilot whales) and dolphins (pantropical and bottlenose) are considered to be the most likely marine mammal species that could be encountered in the Project PDA. Bryde's whales (*Balaenoptera brydei*) and other unidentified baleen whales have also been observed in offshore waters in the PDA. Nearshore, other dolphins such as common, spotted, and spinner dolphins may be encountered. Nearshore Project activities in or near the Demerara River could encounter West Indian manatees (*Trichechus manatus*), which are sparsely distributed in coastal and riverine waters of the region. Currently, the West Indian manatee is generally threatened by loss of habitat, poaching, entanglement with fishing gear, and increased boating activity.

10.5.2.3. *Marine Turtles*

Section 7.6, Marine Turtles, provides a detailed description of existing conditions for marine turtles in the Project AOI. The following is a brief summary focused on species recorded in the region.

Five marine turtle species are found in the region, all of which occur in Guyanese waters. Four of these species: green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*), hawksbill turtle (*Eretmochelys imbricata*), and olive ridley turtle (*Lepidochelys olivacea*) nest on Guyana's beaches. Loggerhead turtles (*Caretta caretta*) also occur offshore Guyana, but rarely come ashore. In addition to using sandy beaches for egg-laying, as a group, marine turtles require healthy coral reef, seagrass, and hard-bottom habitats for food and refuge, although the relative importance of these habitats varies by species. Based on each species' known habitat requirements, some green turtles likely remain in Guyana waters as juveniles to feed in the sargassum mats, while the other species typically move to clearer waters and coral reefs to the north after hatching (Piniak and Eckert 2011).

All five species have IUCN Red List conservation statuses: green turtles are listed as EN; leatherbacks are listed as VU; hawksbill turtles are listed as CR; loggerhead turtles are listed as EN with high risk of extinction; and olive ridley turtles are listed as VU.

[4] Conservation status was based on the IUCN Red List of Threatened Species (IUCN 2018).

Leatherback turtles are the most common marine turtle species on Guyana's nesting beaches, while nesting olive ridley and hawksbill turtles are less common. Leatherbacks make extensive seasonal migrations between different feeding areas and nest at the same location every year (NOAA Fisheries undated). According to the Protected Areas Commission, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) occurs at night from March to August (PAC 2014). The primary nesting site for all these species in Guyana is Shell Beach, located on the northwestern coast of Guyana. The exact locations of secondary nesting sites change due to coastal erosion, which creates and destroys nesting areas continuously, but they are generally distributed along the northwest coast between the Pomeroon River and the Waini River estuaries.

The primary threats to marine turtles are poaching of eggs and adults, intentional and accidental fishing, and habitat disturbance and degradation due to marine pollution, coastal zone development, shore erosion, lighting, and debris. Population monitoring and conservation activities are limited, primarily due to the logistical challenges associated with the remoteness of primary nesting sites.

Observations conducted during seismic surveys between July 2015 and April 2018 detected 13 marine turtles: two green turtles, two loggerhead turtles, two olive ridley turtles, two hawksbill, and five unidentified turtles. Based on these recent sightings and data compilations, it is possible that any of the five above-referenced marine turtle species could be encountered in the Project PDA. In March 2018, four green turtles were fitted with satellite tags during nesting activities at Almond Beach. Based on data collected in the first month of tracking, the green turtles in this study appear to be exhibiting typical inter-nesting intervals for their species, characterized by laying four or five nests spaced apart by approximately two-week intervals. Available data from the tagged turtles suggests the waters extending out to the 10 m bathymetric contour are important habitat for nesting green turtles at Almond Beach during the nesting season. During this preliminary assessment of the inter-nesting period, turtles exhibited variable ranges in dispersal (12 to 192 kilometers [approximately 7.5 to 119 miles]), primarily occupied the upper water column (less than10-meter depth), and spent limited time at the surface (25 to 50 percent) while at sea. Although marine turtles clearly use the middle and outer continental shelf during the non-nesting period, the telemetry study generally suggests that at least green turtles remain close to shore during the nesting period.

10.5.2.4. *Marine Fish*

Section 7.7, Marine Fish, provides a detailed description of existing conditions for marine fish in the Project AOI. The following is a brief summary of this description.

Guyana's marine fish community exemplifies the ecological connectivity among the mangroves, estuaries, and offshore zones, because many fish species are dependent on different habitats at specific life stages or occur in more than one habitat type. Several species that occur in the nearshore and offshore zones as adults are dependent on coastal mangroves as juveniles, particularly drums, croakers, and snappers. Catfishes occur in the mangroves, estuaries, and oceanic waters as adults (MOA 2013). The nearshore fish community is dominated by drums, croakers, and marine catfishes, and includes other species such as snooks (*Centropomus undecimalis*) and tarpon (*Megalops atlanticus*). Further offshore, the fish community is more complex, consisting of pelagic, highly migratory species such as tunas, jacks, and mackerels in the upper water column and snappers and groupers in the demersal zone (lowest section of the water column, near the seafloor) (MOA 2013). Sharks are found nearshore and offshore.

Scientific data on marine fish in the Project PDA are sparse. Much of what is known about marine fishes offshore Guyana is known from study of commercial landings. The most complete historical data on marine fish in Guyana's territorial waters come from a two-year trawl survey conducted in 1958 and 1959 (Lowe-McConnell 1962). The study was designed as a trawl survey and was therefore more oriented toward demersal species. Based on comparisons with species lists from nearby countries, McConnell determined that about 50 percent of Guyana's marine fish species were widely distributed coastal species.

Supplementing these historical data, information on fish species in the PDA is available from observations made during EEPGL's various activities in the southeastern half of the Stabroek Block since 2015. In addition, between September and October 2017 and between March 2018 and April 2018, the Consultants conducted fish studies which included characterizing the fish community in areas near the Stabroek Block and the continental shelf by deepwater fish sampling, continental shelf fish sampling, nearshore fish sampling, coastal and estuarine sampling, and an assessment of commercial and artisanal fish landings. A total of 114 species of fish were captured during the study. Compared to the shallower environments sampled during this assessment, the deepwater environment exhibited less species diversity than other environments. Trawls on the continental shelf produced the most diverse species assemblage, accounting for 102 species (nearly 90 percent of the entire fish diversity documented in the study). A total of eight species were only captured using longline sampling on the continental shelf. The portion of the continental shelf offshore the Shell Beach Protected Area (SBPA) produced the highest number of fish species of any of the continental shelf transects. Based on the catch data from this transect, the remoteness of this area from commercial fishing harbors and its proximity to the SBPA are likely playing a role in conserving the fishery resource on the far northwestern Guyanese continental shelf. A total of 42 species were captured at the nearshore stations, many of which were also captured on the continental shelf. Ten species were captured in the estuaries. There was a seasonal aspect to the nearshore and shallow continental shelf data, as estuarine and anadromous species appeared in the dataset in the rainy season, increasing the diversity of these communities in response to seasonal freshwater inputs from major rivers.

In addition to producing the most diverse fish assemblage, the trawl sampling on the continental shelf also produced a variety of benthic incidental take. Although benthic resources were not targeted during this study, the benthic incidental take provided noteworthy insights into the continental shelf benthos and deepwater benthic macrofauna that had not been documented by prior studies. Perhaps most significant was the presence of living hard corals (*Madrepora oculata* and *Solenosmilia variabilis*) that were recovered from trawl samples.

Thirty marine and coastal fishes in Guyana have been ranked by the IUCN as threatened (CR, EN, or VU) with another 21 ranked as NT. An additional 17 are considered DD and cannot be objectively assessed with the currently available data. These species are listed in Appendix L, IUCN-Listed Species in Guyana. They include highly migratory species (e.g., some tunas and sharks), bentho-pelagic species (e.g., some groupers), and demersal species (e.g., some skates and rays). As noted in Section 7.7, Marine Fish, many of these fish species are also targeted by the Guyanese commercial fishing industry.

All of the CR species are coastal or estuarine species and would not be expected to occur in the vicinity of the PDA. Several of the EN species, including Atlantic bluefin tuna, whale shark, squat-headed hammerhead shark, and scalloped hammerhead shark, are open water pelagic species and could occur in the PDA intermittently, but would not be expected to be residents in the area. The two remaining EN species (golden tilefish and Nassau grouper) are bottom-dwelling species and do not move large distances as adults, but they are most often associated with uneven bottoms containing rocky outcrops, shipwrecks, or other structural habitats. The continental slope in the vicinity of the PDA lacks any known structure that would be expected to attract or aggregate these species.

10.5.2.5. *Community Health and Wellbeing*

Section 8.3, Community Health and Wellbeing, provides a detailed description of existing conditions related to community health and wellbeing in the Project AOI. The following is a brief summary of that description.

According to the Ministry of Public Health, health outcomes in Guyana continue to improve steadily, with an increase in life expectancy at birth, improvements in maternal and child health, and a notable decrease in suicide rate. However, there is still work to be done in maternal and child health to meet the Millennium Development Goal targets for mortality rates, as well as in mental health, to continue to tackle underlying issues like the stigma associated with mental illness and the shortage of mental health workers.

The most common non-communicable diseases in 2013 were diabetes, cardiovascular diseases, heart diseases, hypertension, cancers, chronic lung diseases, gastroenteritis and liver disease, accidents, violence related injuries, and mental illnesses. Communicable diseases also continue to impact productivity, quality of life, and wellbeing in Guyana, particularly in the hinterland regions. In 2012, the most common communicable diseases were malaria, tuberculosis, and human immunodeficiency virus (HIV) (Ministry of Public Health 2013). Malaria is found in much of Guyana and is most prevalent in Regions 1, 7, 8, and 9. Dengue fever, chikungunya, lymphatic filariasis, and zika are also locally transmitted in Guyana. Unlike malaria, transmission of these diseases tends to be more common in populated and urbanized areas.

Government health spending compares favorably with other Latin American and Caribbean countries, and has averaged about 3 percent of gross domestic product (GDP) in recent years. However, the system continues to have a number of challenges related to human resources capacity and infrastructure capacity, which are especially acute in remote areas such as Region 1. Health facilities that can be found in the coastal regions are regional hospitals, district hospitals, diagnostic centers, health centers, and health posts. The last two are the most widespread health facilities within these regions.

Regarding quality of life, as it relates to access to basic services such as water and sanitation, electricity and telecommunications, there is a positive trend, but there are still challenges and opportunities for improvement. While access to improved water sources has increased over the years, wastewater and sanitation coverage and infrastructure in the country are limited, thus hampering efforts to improve health conditions. The quality of water supply services is hindered by decaying distribution networks (World Bank 2016). An estimated 91.2 percent of the coastal population and 56.2 percent of the interior population have access to electricity. Mobile telephone coverage is comparable among coastal regions, and an average of 88.6 percent of households in the country has at least one member with a mobile phone. Region 1 shows lower levels of access to computers, television, and radio, relative to other regions.

10.5.2.6. *Marine Use and Transportation*

Section 8.4, Marine Use and Transportation, provides a detailed description of Guyana's existing marine and coastal transportation infrastructure. The following is a brief summary of the existing conditions for this VEC, including a discussion of waterways, coastal shipping channels, ports, and offshore shipping lanes.

Guyana has approximately 1,000 kilometers (approximately 620 miles) of navigable rivers, which provide water access to most population and economic centers. Subsea telecommunications cables, which are part of the SGSCS run through the Stabroek Block, but are located outside the Project PDA.

The Port of Georgetown contains more than 40 separate wharves, including six primary cargo wharves, as well as four tanker berths (NGIA 2014). Other privately owned docks and portside facilities near Georgetown and the mouth of the Demerara River have staging areas or storage yards. A shipping channel is maintained on the lower Demerara River for the use of private, commercial, and military vessels. The Demerara River channel has a dredged depth of 5.9 meters (approximately 19 feet), and is dredged weekly to maintain this depth (Stabroek Harbour Master 2018).

In April 2018, the Consultants undertook a study to record marine vessel traffic in Georgetown Harbour between the mouth of the harbor and the existing shorebase at Muneshwers Houston Terminal that is planned to be used by the Project. Fishing vessels accounted for most of the marine traffic. At the observation location near the mouth of the harbour, 76 percent of recorded vessel movements were either fishing boats or trawlers. At the observation location closer to the shorebase used by the Project, fishing boats and trawlers accounted for 71 percent of the traffic, while passenger boats and "other" vessels (primarily small, private boats) made up 11 percent of the traffic. Marine traffic activity was nearly continuous throughout each day. Day-to-day variations, particularly in fishing vessel movements, resulted from tides and weather.

The Transport and Harbours Department is responsible for the management of the national ferry service. The department has four ferry vessels, three of which operate in the Essequibo River and one in the Berbice River. The ferries on the Essequibo River serve several ports (also known as "Stellings") on either side of the Essequibo River and on Leguan and Wakenaam Islands.

In addition to the national ferry service, many smaller vessels (also known as "speedboats") provide transportation between Regions 2 and 3 across the Essequibo River, as well as across the Demerara River, between the Stabroek Market stelling in Georgetown (Region 4) and Vreed-en-Hoop stelling (Region 3) on the west bank of the river. They operate at the same ports as the national ferry service, and may also call at smaller informal landings as client demand and conditions warrant.

10.5.2.7. *Social Infrastructure/Services*

Section 8.5, Social Infrastructure and Services, provides a detailed description of existing conditions related to social infrastructure and services in the Project AOI. The following is a brief summary of this VEC, which includes Guyana's housing, water and sanitation, power, telecommunication, educational and security infrastructure; as well as ground and air transportation infrastructure.

Regions 3, 4, and 6 represent the largest proportion of the population and, as expected, recorded the highest number of dwelling units in both the 2002 and 2012 census years. The results of the 2002 census indicate that detached houses are the most common type of housing in all regions, and a majority of homes in the coastal area are owned by their occupants. However, the census data report that Regions 3 and 4 have a higher proportion of rented and squatted homes, which is consistent with data obtained during the late 2017 and early 2018 ecosystem services field work completed by the Consultants (ERM/EMC 2018). Housing stock in some regions is aging and in need of upgrade (IDB 2016a). According to the 2002 census, more than 30 percent of the housing stock in Regions 3, 4, 5, and 6 was built before 1970.

Potable water is primarily obtained from the deeper aquifers that underlie Georgetown and the coastal plain. Water is distributed by Guyana Water Inc. (GWI). There are three major water treatment plants in the country, located in Georgetown, New Amsterdam, and Guymine (FAO 2015). In rural areas not served by GWI, domestic water is obtained from a mix of ground, surface, and rainwater sources. In Regions 2, 3, 4, 5, and 6, irrigation is by gravity from surface water resources trapped by shallow earthen dams known as "conservancies."

Most of the electricity in the coastal plain of Guyana is generated, transmitted and distributed by the state-owned utility Guyana Power & Light Inc. However, electrical supply is not very reliable. Coastal areas that are not serviced by Guyana Power & Light are the Region 2 area west of Charity, and Region 1. Currently, 83 percent of Guyana's installed generation capacity is thermal, relying on expensive imported liquid fuels and making average electricity prices among the highest in Latin America and the Caribbean. The high cost of electricity is a major challenge for business.

The majority of households in the coastal regions have access to mobile phone service. In 2016, the first 4G network in the country was installed. Fiber optic cable is also a pressing need to improve reliability and accessibility (PSC 2015) of mobile phone services.

Schools are located all along the coast of Regions 3, 4 and 6, which are also the most populated regions. Region 1 and Region 2 areas west of Charity have very few schools. The majority of post-secondary institutions (technical schools, colleges and universities) are found in Georgetown.

The Guyana Defense Force is the military service of Guyana and has land, sea, and air units responsible for defending the territorial integrity of Guyana.

Guyana has an approximately 3,990-kilometer (approximately 2,480-mile) road network that is used by the approximately 100,000 vehicles in the country. There are six main national paved roads that each have two lanes, except for four-lane segments along the East Bank and East Coast Demerara. The road network is dependent on a system of bridges and culverts that provide crossings over a dense system of canals, drains, and sluices throughout the coastal lowlands. Georgetown has a compact, grid-based street network. Road conditions vary widely and can be poor in some locations. The port area is linked to central Georgetown via the East Bank Demerara Road. Most intersections are not signal-controlled; where signals do exist, they are frequently out of service.

Traffic congestion is a chronic problem in and around Georgetown. Many different types of vehicles, including cars, large commercial vehicles, mini-buses, horse-drawn carts, bicycles, mopeds, scooters, and motorcycles, all share the same travel lanes. Traffic congestion occurs frequently, in particular just before and just after school hours.

In March 2018, a survey of existing traffic conditions along the East Bank Demerara Road was completed by the Consultants in the general vicinity of the existing shorebase facility that will be used by the Project. The survey concluded that East Bank Demerara Road is particularly susceptible to congestion due to backups at the Demerara Harbour Bridge, the only road crossing of the Demerara River. Daily retraction of the bridge for a period of about 1 hour causes severe traffic congestion at both ends of the bridge. When the bridge's retractable section is open (i.e., when vehicles cannot cross), several movements at the intersection of the Demerara Harbour Bridge with the East Bank Demerara Road operate at a Level of Service (LOS)[5] rating of "F", indicating significant delays and near-gridlock conditions. When the retractable section is closed (i.e., when vehicles can cross), the entire East Bank Demerara Road system operates at an LOS rating of "C" or better, typically considered acceptable conditions for urban traffic.

The limited number of bridge openings causes delays and inconvenience to ocean going vessels. The Government of Guyana has investigated replacing the existing bridge with a new bridge (with an elevated central span that would reduce or eliminate the need for drawbridge openings) further downstream. The proposed new bridge would be located further north than the existing bridge and would connect Houston on the East Bank with Versailles on the West Bank.

[5] LOS is a standard numerical measure of the delay expected to be experienced at an intersection, compared to expected norms; it is expressed as a letter grade between A (least delay) and F (most delay, gridlock).

Guyana's air transportation infrastructure comprises two international airports: the Cheddi Jagan International Airport and the Eugene F. Correira International Airport (commonly referred to as Ogle Airport). In addition, nearly 100 aerodromes serve smaller towns and villages, principally in the hinterland region (IDB 2016b).

10.5.2.8. *Marine Water Quality*

Section 6.4.2 provides a detailed description of existing conditions for marine water quality in the Project AOI. The following is a brief summary of this description.

Guyana's marine environment, particularly hydrographic and isohaline conditions, is bounded, and heavily influenced, by the Orinoco and Amazon rivers in Venezuela and Brazil, respectively. During the rainy season, Guyana's coastal marine waters receive large volumes of freshwater discharges from these major rivers, as well as from Guyana's own Essequibo, Demerara, and Berbice rivers (FAO 2005). Of these, the Amazon River is the one that influences marine water quality the most in the region.

EEPGL has collected water quality samples from the Stabroek Block as part of three surveys in 2014, 2016, and 2017. Samples were analyzed for a range of constituents, including total organic carbon (TOC), total suspended solids (TSS), total hydrocarbons (THC), polycyclic aromatic hydrocarbons (PAHs), and metals. Additionally, the water column was profiled at each station with a conductivity-temperature-depth (CTD)[6], augmented with additional sensors for dissolved oxygen, pH, and turbidity.

Results from the surveys are fairly consistent throughout the three years and across sampling stations, with samples showing a stratified water column in terms of temperature, salinity, and dissolved oxygen. The THC and PAH concentrations were generally at low levels across the survey area, with little variation between samples. All levels were below the U.S. Environmental Protection Agency (USEPA) water quality guidelines. In all three years, the reported metal concentrations were low in all water samples and did not vary substantially between stations or with depth. Concentrations of all metals were below their respective USEPA Saltwater Quality Standards thresholds (USEPA 2016), where these are available.

10.5.2.9. *Ecological Balance and Ecosystems*

Section 7.9, Ecological Balance and Ecosystems, provides a detailed description of existing conditions for ecological balance and ecosystems in the Project AOI. The following is a brief summary focused on three key ecological functions of the marine ecosystem in the Project AOI: the marine nutrient cycle, gene flow, and maintenance of biodiversity.

The NOAA uses the Large Marine Ecosystem (LME) concept as a model to assess and manage ecological functions at the regional scale. LMEs are defined as relatively large areas of ocean space of approximately 200,000 km^2 (20,000,000 hectares or approximately 80,000 mi^2) or greater, adjacent to the continents in coastal waters where primary productivity is generally

[6] A CTD is an oceanography instrument used to measure the conductivity, temperature, and pressure of seawater (the D stands for "depth," which is closely related to pressure).

higher than in open ocean areas. The PDA is located in the northwestern portion of the North Brazil Shelf LME, which is in the “Highly Productive” category, owing to large nutrient inputs from the Amazon Basin as well as complimentary inputs from smaller rivers that drain the Guiana Shield (Heileman 2009). Primary productivity has been found to be highest in the transition zone between nutrient-rich coastal waters, with low sunlight transmission and clearer offshore waters where light is transmitted more readily but nutrients are comparatively scarce (Heileman 2009).

Marine environments (particularly open-ocean environments such as the Stabroek Block) are often considered homogenous across large geographical distances. A number of studies of marine biota have been conducted within or in the vicinity of the PDA in recent years and none have detected the presence of endemic species. In 2016, environmental DNA was collected from sediment and seawater samples during a baseline survey of the Liza-1 Field. No regionally endemic species were reported. These results are consistent with the concept that genetic isolation is much rarer in the open ocean than on land (CEGA 2016).

10.5.2.10. *Employment and Livelihoods*

Section 8.2, Employment and Livelihoods, provides a detailed description of existing conditions associated with employment and livelihoods. The following is a brief summary focused on the main industry groups for Guyana’s coastal regions.

According to the most recent national census conducted by the Guyana Bureau of Statistics (BSG 2012), 87.5 percent of the labor force was employed and 12.5 percent was unemployed. Region 1 unemployment rate was the highest in the country (19.3 percent). Region 2 had the lowest unemployment rate (10.6 percent).

Many of the residents in the coastal NDCs in Regions 1 through 6 are directly employed by or linked to the fishing industry due to their proximity to the coast. Statistics from the 2012 census indicate that the agriculture, forestry, and fishing industry group employs the largest number of workers in Regions 2 and 3, while, in Region 1, this group was second to mining and quarrying. Similarly, fishing supporting services include boat building, ship repairs, fuel services, entertainment, and household products needed by sailors and fisherfolk—and provide numerous employment opportunities to residents.

Guyana has recently seen the emergence of its oil sector. Oil production operations would likely generate a larger number of indirect jobs than direct employment (Oil Now Guyana 2017). Internal statistics collected by EEPGL indicate that in addition to employment of Guyanese nationals for a limited number of positions, EEPGL’s local procurement has included a diverse range of goods and services such as transportation, catering, office supplies, accommodations, security, engineering, and housekeeping, which will have had positive impacts on employment - particularly in the tertiary sector.

Some challenges faced by artisanal fisherfolk are illegal fishing, piracy, and operating costs. The dynamic accretion and erosion of the Guyanese coastline as a result of natural forces can also pose challenges for fisherfolk by preventing them from landing their boats in some areas. Saltwater intrusion also occurs up the Moruca and other smaller rivers in Region 1 in dry season. It was noted as having impacts on fishing livelihoods in several villages in Region 1 (ERM/EMC 2018).

Agriculture is a major livelihood activity in Region 2, where rice farming dominates agricultural production. Most households also raise livestock, such as cattle, hogs, poultry, and small ruminants. Climate change is perceived as a challenge for some agricultural producers. For example, changes in sunshine and rain patterns are thought to influence crop yields. Sea-level rise potentially associated with climate change is also considered a threat for coastal farmers, given that the coastal plains, where the majority of the country's agricultural activity occurs, lie below sea level (ECLAC 2011).

10.6. Assessment of Cumulative Impacts on VECs

For the CIA, the potential impacts from the four Other EEPGL Projects (Liza Phase 1, exploration drilling, Payara Development Project, and Gas to Shore Project) being planned or contemplated by EEPGL are discussed together, and are assumed to be similar to those associated with the Liza Phase 2 Development Project (for the planned activities shared with the Liza Phase 2 Development Project). The potential impacts from Other Non-EEPGL Projects are discussed separately.

In addition to the air quality modeling conducted for the cumulative emissions from the Liza Phase 1 and Liza Phase 2 Development Projects (Section 10.5.1.1), quantitative analyses of cumulative effects were also conducted for potential water quality impacts resulting from simultaneous production operations discharges from the Liza Phase 1 and Liza Phase 2 FPSOs, and for potential traffic congestion impacts (an aspect of social infrastructure and services) resulting from simultaneous use of the shorebase by the Liza Phase 1, Liza Phase 2, and Payara projects, as well as continued exploration drilling.

10.6.1. Water Quality Modeling for Simultaneous Operations

Although the two FPSOs are approximately 8.5 kilometers apart, modeling was conducted to assess whether there is a potential for cumulative impacts on water quality due to offshore discharges from the respective developments. The modeling included the major operational discharges and assessed the potential for plumes from the two FPSOs to overlap and result in cumulative impacts. None of the plumes constituents that were included in the assessment (see Table 3-4) showed overlaps. The only constituent with a reference standard (less than 3 degrees Celsius (ºC) above ambient beyond 100 meters) is temperature rise. With both FPSOs operating, and each FPSO discharging both produced water and cooling water (both of which add a thermal load), there was no overlap in plumes, even when the "plume" from each FPSO was defined as a temperature rise as low as 0.05 ºC. Based on the results of the detailed modeling of all discharges, the significance of cumulative impacts on water quality from simultaneous operation of the Phase 1 and Phase 2 FPSOs is considered **Negligible**. A detailed discussion of the methodology and results is presented in Appendix J, Water Quality Modeling Report.

10.6.2. Traffic Impact Modeling for Simultaneous Operations

In March 2018, a survey of existing traffic conditions was completed along the East Bank Demerara Road, in the general vicinity of the existing shorebase facility that is planned to be used by the Project. Using the data from this survey, a traffic analysis model was used to complete an assessment of the LOS for each of the study intersections, for the various movements (through, right turn, left turn, U-turn) completed at each intersection. LOS is a standard numerical measure of the delay expected to be experienced at an intersection, compared to expected norms; it is expressed as a letter grade between A (least delay) and F (most delay, gridlock). Modeling was completed for morning peak hours, afternoon peak hours and afternoon peak hours when the Demerara Harbour Bridge was closed.

In addition to modeling LOS ratings for existing conditions along the East Bank Demerara Road, the Caribbean Transportation Consultancy Services Company Limited (CARITRANS) traffic study (see Section 8.5.2.7, Ground Transportation Infrastructure) modeled LOS ratings for the following scenarios:

- Existing conditions under current road network, with the inclusion of additional Project traffic (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions under current road network in 2023 - with assumed non-Project traffic growth (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions under current road network in 2023 - with assumed non-Project traffic growth—with the inclusion of additional Project traffic (a.m. peak, p.m. peak, and Bridge Closed);
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth (a.m. peak, p.m. peak, Bridge Closed);
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth—with the inclusion of additional Project traffic (a.m. peak, p.m. peak, Bridge Closed);
- Existing conditions under current road network, with the inclusion of additional Project traffic from Liza Phase 1, Liza Phase 2, exploration drilling, and Payara ("the Cumulative Project traffic");
- Conditions under current road network in 2023 - with assumed non-Project traffic growth, with the inclusion of additional Cumulative Project traffic (a.m. peak, p.m. peak, and Bridge Closed;
- Conditions with the proposed New Demerara Harbour Bridge and bypass lanes in 2023—with assumed non-Project traffic growth—with the inclusion of additional Cumulative Project traffic (a.m. peak, p.m. peak, Bridge Closed).

The LOS ratings are summarized in the Traffic Impact Assessment Report provided as Appendix O.

The LOS modeling for the various projected scenarios confirms that the additional Project-related traffic scenarios, including the Cumulative Project traffic scenario, will not meaningfully change LOS ratings along the East Bank Demerara Road; therefore, it is expected that cumulative additions to traffic from the Other EEPGL Projects will not measurably change existing traffic congestion in Georgetown. This holds true for existing traffic conditions, either currently or in 2023, as well as the scenario that envisions construction of a new Demerara Harbour Bridge, which is itself expected to improve traffic congestion along the East Bank Demerara Road.

10.6.3. Summary of Cumulative Impact Assessment

Table 10.6-1 summarizes the CIA for the VECs identified as eligible for the CIA.

Table 10.6-1: Summary of Cumulative Impact Assessment

VEC	Potential Impacts from Liza Phase 2 Development Project	Potential Impacts from Other EEPGL Projects: Liza 1, Payara, Gas to Shore, and Exploration Drilling	Potential Impacts from Other Projects: New Demerara Harbour Bridge	Potential Impacts from Other Projects: Mariculture	Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
Special Status Species[7]	As discussed in more detail in the resource-specific impact assessment sections for marine fish (Section 7.7) and seabirds (Section 7.4), planned Project activities could result in a number of potential impacts, including: auditory impacts from vessel activity or pile driving, distribution and habitat changes from altered bottom habitats or water quality, exposure to permitted discharges, entrainment in water intakes; and the attractive potential of lighting from the FPSO, drill ships, and major installation vessels. Based on the ranges of magnitudes for potential impacts and the receptor sensitivity ratings applicable for the various IUCN listing levels, the significance ratings for potential residual impacts on special status species are: marine fish—CR (**Negligible**); marine fish—EN (**Negligible**); marine fish—VU (**Negligible** to **Minor**); seabirds—EN (**Negligible** to **Minor**); and seabirds—VU (**Negligible** to **Minor**).	Due to similarity in nature and magnitude, similar impacts to those of Liza Phase 2 (for planned activities shared with Liza Phase 2) are expected: marine fish—CR (**Negligible**); marine fish—EN (**Negligible**); marine fish—VU (**Negligible** to **Minor**); seabirds—EN (**Negligible** to **Minor**); and seabirds—VU (**Negligible** to **Minor**).	Based on the information available, the Consultants do not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants foresee potential impacts from the Mariculture Project on special status marine fish. This is in consideration of a potential impact related to the predation of fingerlings of various species of wild fish, as they can enter the cages, which are used as growing structures in mariculture. Once in the cages, it is likely that these fingerlings will be subject to predation. Four of the five species that would be grown are predaceous, and one is omnivorous.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles. Rising temperatures associated with longer-term global climate change could potentially affect some special status species' ranges.	The Project and other projects could have potential negative impacts on marine fish and seabird special status species. The Project embedded controls would mitigate their impacts to an acceptable level (**Minor** or **Negligible**). External drivers such as commercial trawl fishing and longer-term global climate change could also potentially negatively affect this VEC. However, it is not expected that the Project would have an incremental contribution to the negative effects.	**Low**
Marine Mammals	During all Project stages, a key potential impacts on marine mammals is exposure to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**). During drilling and installation, the key potential impacts are injury from sound exposure (**Negligible**); and underwater sound disturbance leading to deviation from area (**Moderate**). A potential **Positive** impact comes from offshore lighting; it is considered to be an attractant for fishes, and therefore as a secondary attractant for some marine mammals. Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine mammals.	Due to similarity in nature and magnitude, the offshore and nearshore impacts for Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, a key potential impacts on marine mammals is exposure to permitted discharges, potentially leading to toxicological impacts (**Negligible**). • During drilling and installation, the key potential impacts are injury from sound exposure (**Negligible**); and underwater sound disturbance leading to deviation from area (**Moderate**). • A potential **Positive** impact comes from offshore lighting; it is considered to be an attractant for fishes, and therefore as a secondary attractant for some marine mammals.	Based on the information available, the Consultants estimate that the West Indian Manatee (*Trichechus manatus*) (VU) could potentially be negatively impacted by bridge construction activities in or near the Demerara River; however, the level of significance of the potential impact cannot be assessed without further information on the nature of the planned project development.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	Rising temperatures (including sea temperatures) associated with longer-term global climate change could potentially affect some fish species distribution and, in consequence, alter the distribution of marine mammals that prey on them.	Balancing the conservation status of the more abundant marine mammal species that are known to be present in the Project AOI with that of the rarer species that could be present, the consequence of a vessel collision with a marine mammal is considered to be **Moderate**. This is an expected risk from the Project as well as Other EEPGL Projects, which will also entail marine vessel movements within the Stabroek Block; therefore, the Project could incrementally contribute to adverse cumulative impacts from potential vessel strikes.	**Medium**

[7] Excludes listed marine mammals and marine turtles, which are covered in the Marine Mammals and Marine Turtles resource categories.

VEC	Potential Impacts from Liza Phase 2 Development Project	Potential Impacts from Other EEPGL Projects: Liza 1, Payara, Gas to Shore, and Exploration Drilling	Potential Impacts from Other Projects: New Demerara Harbour Bridge	Potential Impacts from Other Projects: Mariculture	Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
		• Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine mammals.					
Marine Turtles	During all Project stages, the key potential impacts on marine turtles are: disturbance from artificial lighting (**Negligible**); displacement from habitat to avoid disturbance from vessel activity (**Negligible**); acoustic injury from sound exposure (**Negligible**); and exposures to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**). Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine turtles.	Due to similarity in nature and magnitude, the offshore and nearshore impacts of Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, the key potential impacts on marine turtles are: disturbance from artificial lighting (**Negligible**); displacement from habitat to avoid disturbance from vessel activity (**Negligible**); acoustic injury from sound exposure (**Negligible**); and exposures to permitted discharges, potentially leading to toxicological or metabolic impacts (**Negligible**). • Vessel strikes (an unplanned event) are assessed as a risk (**Moderate**) to marine turtles.	Based on the information available, the Consultants do not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles.	All five species of marine turtles found in the region have IUCN Red List categories ranging from VU to CR. The Project and other projects are expected to have negligible adverse impacts on marine turtles. Commercial trawl fisheries could cause harm to these species. However, it is not expected that the Project would have an incremental contribution to the negative effect due to the negligible significance of its impacts.	**Low**
Marine Fish	During all Project stages, the key potential impacts are auditory impacts on fish (pelagic species) from vessel activity **(Negligible)**; disturbance from or attraction to offshore lighting that would affect pelagic species **(Negligible**). During drilling and installation, the key potential impacts are auditory impacts on demersal species from pile driving and VSP **(Negligible);** exposure to permitted discharges, potentially leading to toxicological impacts **(Negligible)**; and distribution and habitat changes for demersal species from altered bottom habitats and presence of Project infrastructure **(Minor)**. During production operations, the key potential impacts are pelagic species entrainment via water withdrawals **(Negligible**); pelagic species attraction to artificial light (**Negligible);** and distribution changes due to altered water quality for pelagic species **(Negligible).**	Due to similarity in nature and magnitude, the offshore impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, the key potential impacts are auditory impacts on fish (pelagic species) from vessel activity **(Negligible)**; disturbance from or attraction to offshore lighting that would affect pelagic species **(Negligible**). • During drilling and installation, the key potential impacts are auditory disturbance on demersal species from pile driving and VSP **(Negligible);** exposure to permitted discharges, potentially leading to toxicological or metabolic impacts **(Negligible)**; and distribution and habitat changes for demersal species from altered bottom habitats and presence of Project infrastructure **(Minor)**. • During production operations, the key potential impacts (**Negative**) are pelagic species entrainment via water withdrawals **(Negligible**); pelagic	Based on the information available, the Consultants do not foresee impacts from the New Demerara Harbour Bridge Project on this VEC, or they would be considered **Negligible**.	A potential adverse impact is the predation of fingerlings of various species of wild fish, as they can enter the cages, which are used as growing structures for the fish. Once in the cages, it is likely that these fingerlings will be subject to predation. Four of the five species that would be grown are predaceous, and one is omnivorous.	The large-scale commercial trawl fishery mainly targets seabob, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish and turtles, damaging the seafloor, and leading to overfishing. Bottom trawl nets can also harm coral reefs, sharks, and marine turtles. Rising temperatures associated with longer-term global climate change could potentially affect some marine fish species distribution ranges.	The Project and other projects could have potential negative impacts on marine fish species. The Project embedded controls would mitigate their impacts to an acceptable level (**Minor** or **Negligible**). External drivers such as commercial trawl fishing and longer-term global climate change would also potentially negatively affect this VEC. However, it is not expected that the Project would have an incremental contribution to the negative effects.	**Low**

VEC	Potential Impacts from Liza Phase 2 Development Project	Potential Impacts from Other EEPGL Projects: Liza 1, Payara, Gas to Shore, and Exploration Drilling	Potential Impacts from Other Projects: New Demerara Harbour Bridge	Potential Impacts from Other Projects: Mariculture	Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
		species attraction to artificial light (**Negligible**); and distribution changes due to altered water quality for pelagic species (**Negligible**).					
Community Health and Wellbeing	During all Project stages, there will be increased worker presence and Project use of medical and health resources in the Georgetown area. Therefore, the key potential impacts could be increased risk of communicable disease transmission (**Negligible**); impacts on public safety (**Negligible**); public anxiety over oil and gas sector risks (**Minor**); and reduced access to emergency and health services (**Minor**). Vehicular traffic accidents and marine vessel collisions involving Project vehicles/vessels and non-Project vehicles/vessels (unplanned events), resulting in potential injuries, are assessed as a risk (**Minor** to **Moderate**, depending on severity of the incident) to community health and wellbeing.	Due to similarity in nature and magnitude, the impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, there will be increased worker presence and increased Project use of medical and health resources in the Georgetown area. Therefore, the key potential impacts could be increased risk of communicable disease transmission (**Negligible**); impacts on public safety (**Negligible**); public anxiety over oil and gas sector risks (**Minor**); and overburdening of medical and health services (**Minor**). • Vehicular traffic accidents and marine vessel collisions involving Project vehicles/vessels and non-Project vehicles/vessels (unplanned events), resulting in potential injuries, are assessed as a risk (**Minor** to **Moderate**, depending on severity of the incident) to community health and wellbeing.	As a result of the project, the feasibility study predicts some level of traffic growth, which would affect environmental components such as noise, air quality, public safety, nuisance and health. To mitigate potential traffic-related impacts, the study suggests construction of bypasses on the west and east sides of the bridge. The feasibility study concludes that the overall social impact of the Project will be positive, especially if links and bypasses are constructed simultaneously with bridge construction. Shorter traffic time and economic development would benefit the communities.	A key negative potential impact would be noise pollution from the operation of diesel generators. These generators are expected to be operational between eight to twelve hours per day, depending on the power requirements. This could have the potential to result in noise-related effects to community health and wellbeing.	Changes in rainfall patterns and a predicted sea-level rise associated with longer-term global climate change pose threats to the Guyanese population and its livelihoods. In the recent past, floods have produced negative and significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. In addition, floods can potentially increase the transmission of communicable diseases, such as water-borne diseases (e.g., typhoid fever, cholera). Also, receding flood waters and pooling water from heavy rainfall can provide perfect conditions for mosquito breeding increasing the incidence of mosquito-borne diseases (e.g., malaria, dengue).	The Project, Other EEPGL Projects and external drivers could contribute to the same types of negative impacts on this VEC: increase risk of communicable disease transmission, public safety, public anxiety, and reduced access to emergency and health services. The mitigation measures proposed for the Project would appropriately mitigate its negative impacts and contribution (**Minor** or **Negligible**). The potential adverse impacts identified for the Harbour Bridge replacement project could include public safety impacts associated with the construction phase. The Project is not expected to have an incremental contribution to the negative effect.	**Low**
Marine Use and Transportation	During all Project stages, the key potential impacts caused by maritime transport of Project materials, supplies, and personnel are: increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, along transit routes leading to Georgetown; and reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tankers, drill ships, and workover vessels. The potential impacts will have an effect on commercial cargo and commercial fishing vessels **(Negligible)**; and on subsistence fishing vessels **(Minor)**. A marine vessel collision involving Project vessels and non-Project vessels (unplanned events), potentially resulting in a temporary obstruction to a marine navigation way, is	Due to similarity in nature and magnitude, the offshore and nearshore impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, the key potential impacts (**Negative**) caused by maritime transport of Project materials, supplies, and personnel are: increased vessel traffic in Georgetown Harbour, coastal waters between Georgetown and the PDA, along transit routes leading to Georgetown; and reduced availability of ocean surface areas for non-Project activities due to marine safety exclusion zones around the FPSO, tankers, drill ships, and workover vessels. The	During the construction stage of the Project, some of the key adverse potential impacts could include impacts on the harbor and on river navigation. Procedures for river navigation would have to be reconsidered and new lead lines developed.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	To the extent the frequency or intensity of severe storms and flooding could be influenced by climate change, these could potentially damage some harbors and bridges during the Project life cycle (at least 20 years). Commercial fishing vessels contribute significantly to local marine traffic in the region.	The Project, Other EEPGL Projects, the Harbor Bridge replacement project, and external drivers could contribute to the potential negative impacts on this VEC: increased vessel traffic and reduced availability of ocean surface areas. The most vulnerable to these effects would likely be the subsistence fishing vessels with nearshore navigation. However, the mitigation measures proposed would appropriately mitigate the negative impacts and contribution (**Minor** or **Negligible**). The Project is not expected to have an incremental contribution to the negative effect.	**Low**

VEC	Potential Impacts from Liza Phase 2 Development Project	Potential Impacts from Other EEPGL Projects: Liza 1, Payara, Gas to Shore, and Exploration Drilling	Potential Impacts from Other Projects: New Demerara Harbour Bridge	Potential Impacts from Other Projects: Mariculture	Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
	assessed as a risk (**Minor**) to marine use and transportation.	potential impacts will have an effect on commercial cargo and commercial fishing vessels **(Negligible)**; and on subsistence fishing vessels **(Minor)**. • A marine vessel collision involving Project vessels and non-Project vessels (unplanned events), potentially resulting in a temporary obstruction to a marine navigation way, is assessed as a risk (**Minor**) to marine use and transportation.					
Social Infrastructure and Services	During all Project stages, a key potential impact from Project workers and influx of job seekers to Georgetown area would be an increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost for the general population of Georgetown and vicinity (drilling and installation—**Minor**, and production operations/decommissioning—**Negligible**). During all Project stages, a key potential impact from Project-related vehicle movements would be an increase in traffic congestion (**Negligible**). Vehicular traffic accidents collisions involving Project vehicles and non-Project vehicles (unplanned events), resulting in potential temporary contributors to traffic congestion, are assessed as a risk (**Minor**) to social infrastructure and services.	Due to similarity in nature and magnitude, the onshore impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, a key potential impact from Project workers and influx of job seekers to Georgetown area would be an increased demand or use of housing and utilities and infrastructure, leading to reduced availability and/or increased cost for the general population of Georgetown and vicinity (drilling and installation—M**inor**, and production operations/decommissioning—**Negligible**) • Vehicular traffic accidents collisions involving Project vehicles and non-Project vehicles (unplanned events), resulting in potential temporary contributors to traffic congestion, are assessed as a risk (**Minor**) to social infrastructure and services.	During the construction stage of the project, some of the key adverse potential impacts in the West Bank could include damage or modification of the current drainage channel and a timber company. Other potential impacts identified for the bridge relocation project are impacts on the harbor and on river navigation. Procedures for river navigation would have to be reconsidered and new lead lines developed.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or it would be considered **Negligible**.	Changes in rainfall patterns and a predicted sea-level rise associated with longer term global climate change pose threats to the Guyanese population and its livelihoods. In the recent past, floods have produced negative and significant health impacts, direct economic losses for agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Guyana is one of the most vulnerable countries to longer term global climate change due to the low-lying coastal areas, many below mean sea-level and with a high percentage of the population and critical infrastructure located along the coast.	The Project, Other EEPGL Projects, the Harbour Bridge project, and external drivers could contribute to the potential negative impacts on this VEC: increased demand or use of housing, utilities and infrastructure. However, the Project is not expected to contribute to the negative effect or its contribution would be **Negligible**.	**Low**
Marine Water Quality	During all Project stages, key potential impacts caused by liquid effluent discharges from drill ships and marine support vessels could be changes in water quality and temperature, potentially contributing to health impacts on or avoidance of marine life (**Negligible**). During drilling/installation and decommissioning, key potential impacts caused by discharge of drill cuttings could be increased TSS concentrations in water column, potentially contributing to health impacts on marine life (**Negligible**).	Due to similarity in nature and magnitude, the offshore impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, key potential impacts caused by liquid effluent discharges from drill ships and marine support vessels could be changes in water quality and temperature, potentially contributing to health impacts on or avoidance of marine life (**Negligible**).	Based on the information available, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	The main adverse potential impact in aquaculture are associated with the discharge of effluents, containing fish waste products, from farms into the environment, and potentially result in eutrophication. Due to the activities associated with the proposed culture of a significant biomass of fish, there could be changes in the baseline water parameters around the culture	After severe flooding events, the rivers might carry debris from inland areas, including agricultural fields, which could temporarily affect marine water quality in coastal areas.	The Project, Other EEPGL Projects, the mariculture project and external drivers could contribute to the potential negative impacts on this VEC, including changes in water quality. However, the suite of embedded controls related to water quality management included in the Project's design, would appropriately mitigate the negative impacts and contribution. The Project is not expected to have an incremental contribution to the adverse effect.	**Low**

VEC	Potential Impacts from Liza Phase 2 Development Project	Potential Impacts from Other EEPGL Projects: Liza 1, Payara, Gas to Shore, and Exploration Drilling	Potential Impacts from Other Projects: New Demerara Harbour Bridge	Potential Impacts from Other Projects: Mariculture	Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
	During production operations, key potential impacts could include elevated temperature from cooling water discharge, and changes in water quality from routine effluent discharges (**Negligible**).	• During drilling and installation, key potential impacts caused by discharge of drill cuttings could be increased TSS concentrations in water column, potentially contributing to health impacts on marine fauna (**Negligible**). • During production operations, key potential impacts could include elevated temperature from cooling water discharge, and changes in water quality from routine effluent discharges (**Negligible**).		site. It is likely that in the immediate vicinity of the grow-out or culture area there be an increase of certain compounds, such as ammonia and nitrates, resulting from protein metabolism by the cultured species.			
Ecological Balance and Ecosystems	During all Project stages, the key potential impacts are changes in the marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution (**Negligible**); and impacts on gene flow (**Negligible**). During production operations, the key potential impact is introduction of invasive species via ballast water (**Minor**).	Due to similarity in nature and magnitude, the offshore and nearshore impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, the key potential impacts are changes in marine nutrient cycle, resulting in localized and temporary changes in phytoplankton species distribution (**Negligible**); and impacts on gene flow (**Negligible**). • During production operations, the key potential impact is introduction of invasive species via ballast water (**Minor**).	Based on the information available, the Consultants do not foresee impacts from the project on this VEC, or they would be considered **Negligible**.	Based on the information available, the Consultants anticipate localized changes in the marine nutrient cycle, and foresees the possibility of genetic changes over time in native species depending on the source of fingerlings and rates of escape from the facility, as well as introduction of non-native species. However, the Consultants predict the size of the North Brazil LME, the strong currents in the vicinity, and the assimilative capacity of the ocean will prevent impacts from the Mariculture Project on this VEC from exceeding **Negligible**.	Unselective fishing gear such as bottom trawls can cause harm to other fisheries and to the marine environment by catching juvenile fish or turtles, and damaging the seafloor. These impacts would have a negative effect on the ecological balance of the coastal-marine ecosystem. Longer-term global climate change driven increases in the global mean temperatures could have a significant impact on ecosystems and ecological balance. Some ecosystems may become more vulnerable to invasive species.	The Project, Other EEPGL Projects and external drivers would contribute to the potential negative impacts on this VEC: changes in nutrient cycle, gene flow and introduction of invasive species. However, the mitigation measures proposed would appropriately mitigate the adverse impacts. The Project is not expected to have an incremental contribution to the adverse effect.	**Low**
Employment/Livelihoods	During all Project stages, a potential impact (**Positive**) is related to increased employment, local business activity and household income for the population of Georgetown and vicinity. During all Project stages, key potential adverse impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations) are identified for industrial fisherfolk (**Negligible**); and artisanal fisherfolk (**Minor**).	Due to similarity in nature and magnitude, the offshore and nearshore impacts from Other EEPGL Projects would be similar to those of the Liza Phase 2 Development Project (for planned activities shared with Liza Phase 2): • During all Project stages, a potential impact (**Positive**) is related to increased employment, local business activity and household income for the population of Georgetown and vicinity. • During all Project stages, key potential adverse impacts on fishing livelihoods (marine safety exclusion zones within the PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations) are identified for industrial fisherfolk	Some potential adverse impacts from the construction of the new bridge could be resettlement of some houses; potential impacts on the Muneshwers Terminal; and potential impacts on the PSI Fishing terminal adjacent to the bridge.	Based on the information available, the Consultants do not foresee impacts from the Mariculture Project on this VEC, or they would be considered **Negligible**.	The fishing industry is one of the most important direct and indirect economic drivers in Guyana, yet unselective fishing gear such as bottom trawls can cause harm to other fisheries. Changes in rainfall patterns and a predicted sea-level rise associated with longer term global climate change pose threats to the Guyanese population and its livelihoods during the Project life cycle (at least 20 years). In the recent past, floods have produced negative and significant health impacts, direct economic losses for	The Project, Other EEPGL Projects and external drivers would contribute to the potential negative impacts on this VEC: impacts on fishing livelihoods. The most vulnerable to these effects would be the artisanal fisherfolk. However, the embedded controls in the Project's design would appropriately mitigate the negative impacts. The Project is not expected to have an incremental contribution to the adverse effect.	**Low**

VEC	Potential Impacts from Liza Phase 2 Development Project	Potential Impacts from Other EEPGL Projects: Liza 1, Payara, Gas to Shore, and Exploration Drilling	Potential Impacts from Other Projects: New Demerara Harbour Bridge	Potential Impacts from Other Projects: Mariculture	Potential Impacts from External Drivers	Cumulative Impact	Priority Ranking
		(**Negligible**); and artisanal fisherfolk (**Minor**).			agriculture, livestock, fisheries, and forestry industries, and significant damage to roads and other infrastructure. Longer-term global climate change driven increases in the global mean temperatures could have a significant impact on the coastal plain and on activities including the dominant agriculture sector in Guyana.		

10.7. CUMULATIVE IMPACTS MANAGEMENT FRAMEWORK

In the following sections, recommendations are provided at the Project level, the EEPGL level (as EEPGL is the operator for several of the Other Projects assessed in the CIA), and the regional level.

10.7.1. Project Level

Effective application of the mitigation hierarchy (avoid, reduce, remedy) to manage individual contributions of cumulative impacts is recommended as best practice. EEPGL has incorporated a number of embedded controls (see Section 2.13, Embedded Controls, for a detailed list and description), which are physical or procedural controls that are planned as part of the Project design. These are considered from the very start of the impact assessment process as part of the Project, and are factored into the pre-mitigation impact significance ratings. In addition, a number of mitigation measures (see Sections 6, 7, 8, and 13) have been proposed to address potential impacts from the Project. The EIA also includes an Environmental and Social Management Plan, which summarizes the embedded controls and mitigation and monitoring measures by VEC.

At the Project level, the above measures are considered sufficient to address the contributions of the Project to cumulative impacts.

10.7.2. EEPGL Level

One medium priority cumulative impact on a VEC (i.e., for marine mammals) was identified, suggesting that additional consideration should be given in the medium term to address potential cumulative impacts on this VEC. The medium priority ranking derives primarily from the potential cumulative impacts that could arise from additional vessel movements from simultaneous oil exploration and production operations (leading to the potential for an increased risk from vessel strikes). EEPGL is the operator for the other oil exploration and production projects/activities considered in the CIA. Accordingly, it is recommended that EEPGL, when designing and undertaking additional projects/activities, ensure that the same level of potential impact management (i.e., as in Phase 2) be implemented (e.g., embedded controls associated with minimization of the risk of marine mammal vessel strikes). 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—in order 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 to cumulative impacts.

10.7.3. Regional Level

The CIA did not identify any high priority cumulative impacts on VECs. Therefore, the Consultants do not deem necessary the development and implementation of a multi-stakeholder collaborative management framework. However, as cumulative impacts could vary in the future, with the addition of other projects or external drivers, it is recommended that EEPGL consider participation, to the extent feasible and practicable, in working groups and/or industry organizations aimed at addressing management of potential impacts on regional resources to which EEPGL's projects could incrementally contribute with respect to cumulative impacts.

11. ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN FRAMEWORK

11.1. INTRODUCTION

This chapter provides a framework for the Project Environmental and Socioeconomic Management Plan (ESMP). The ESMP is the document that describes the measures EEPGL will implement to manage the Project's potential environmental and socioeconomic risks and reduce impacts on the environment and communities. The scope of this chapter includes the following:

- An overview of the policy framework underpinning the ESMP;
- Description of the ESMP structure;
- Description of the general ESMP guiding principles;
- Description of the general content of the management plans comprising the ESMP; and
- Description of how updates to the ESMP will be managed.

The Terms of Reference (ToR) for this EIA require an ESMP, consisting of several affiliate-level, environmental media-specific or contingency-focused management plans, to be submitted concurrently with the EIA. The individual management plans that comprise the ESMP have been prepared consistent with the framework described herein. EEPGL will update the ESMP and its constituent plans to address the final conditions from the Environmental Authorisation, upon approval of the Project by the EPA.

11.2. REGULATORY AND POLICY FRAMEWORK

The Project is subject to various regulatory requirements as described in Chapter 3, Administrative Framework, the resource-specific laws and commitments described in each resource-specific discussion, the conditions established by the EPA upon issuance of the Environmental Authorisation, the conditions of the Petroleum Production Licence, and approval of the Project Development Plan by the Guyana Geology and Mines Commission (GGMC). Other government agencies also have regulatory authority over aspects of the Project, including, but not limited to, the Fisheries Department of the Ministry of Agriculture, Guyana Revenue Authority, Civil Defense Commission, and Maritime Administration Department (MARAD).

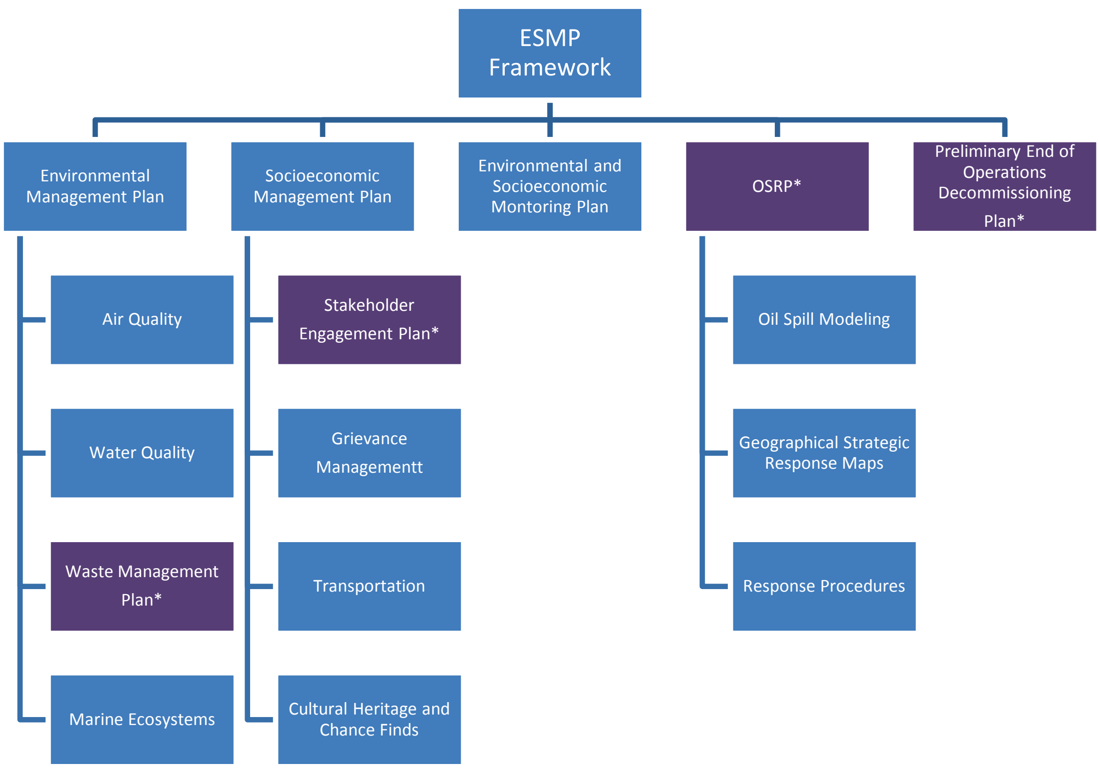
EEPGL is committed to ensuring its compliance with the laws and regulations of Guyana, and conducting business in a manner that is compatible with the environmental and economic needs of the communities in which it operates, and protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (OIMS), which is further described in Section 3.5, EEPGL's Operations Integrity Management System.

11.3. ESMP Structure

Figure 11.3-1 depicts the overall structure of the Project ESMP. The specific management plans included in this ESMP are organized into five categories:

- Environmental Management
- Socioeconomic Management
- Environmental and Socioeconomic Monitoring
- Oil Spill Response
- Preliminary End of Operations Decommissioning[1]

Each of these categories includes one or more specific management plans, which are included within the ESMP unless otherwise noted, as shown in Figure 11.3-1.



** Due to the size and/or complexity of these documents, these are stand-alone plans, and are provided as an appendix to the ESMP or as a separate volume to the regulatory submittal for the Liza Phase 2 Development Project (i.e., Oil Spill Response Plan [OSRP]).*

Figure 11.3-1: ESMP Structure

[1] In alignment with the EPA's Initial Closure and Reclamation Plan

11.4. GENERAL ESMP GUIDING PRINCIPLES

EEPGL developed the overall ESMP, and each of the specific management plans it contains, consistent with the following guiding principles:

- Covers all Project stages (i.e., there are not separate management plans for each Project stage), except for a Preliminary End of Operations Decommissioning Plan;
- Contains a level of detail that is fit for purpose and varies among the individual management plans;
- Represents a "living document" that will be revised or amended as the Project progresses in response to changing circumstances, lessons learned, or other appropriate reasons;
- Develops some of the management plans as country-wide plans (e.g., Oil Spill Response Plan [OSRP], Waste Management Plan [WMP], Stakeholder Engagement Plan [SEP]), with asset-level details contained in an attachment as required, with the rest of the management plans (at this time) remaining asset-specific; and
- Reflects all regulatory commitments and obligations, including those from the EIA, supporting plans, and environmental authorizations.

11.5. MANAGEMENT PLAN CONTENTS

The ESMP Framework contains an introduction and scope as well as a summary of the applicable regulations, standards, and guidelines. As indicated above, each management plan is fit for purpose, and therefore varies to some extent in content, but contains specific management measures for each component that include proposed mitigation measures developed from the impact assessment as well as embedded controls (see Chapter 13). The plans also include the following information for each measure:

- The source of potential impact;
- The likely affected receptor;
- The specific Project component(s) for which the control/measure will be implemented (e.g., FPSO, support vessels, shorebase(s), etc.) and/or the specific stage or stages of the Project during which each measure will be implemented (e.g., drilling, installation, production operations);
- A description of the management measure; and
- Monitoring requirements, where applicable.

11.6. MANAGEMENT OF CHANGE

During Project implementation, changes may be required to address unanticipated conditions or situations. Managing change is an integral part of OIMS. Risk assessments, audits, inspections, and/or observations may identify the need for amendments to the ESMP. In these cases, the ESMP will be updated to reflect change. In addition, the ESMP will be updated when applicable environmental laws, regulations, standards, and/or company processes, systems, and/or technologies that are being applied to the Project change. EEPGL will notify the EPA of any significant updates to the ESMP and will provide an updated version of the document for their records and use. The ESMP is also envisioned to be a living document that will be updated to reflect continuous learning and improvements, and will be shared with the Government of Guyana.

12. CONCLUSIONS AND SUMMARY OF IMPACTS

This section summarizes the potential environmental and socioeconomic impacts of the Project resulting from planned Project activities and potential unplanned events, as well the Project's potential contributions to cumulative impacts on resources and receptors.

12.1. PLANNED PROJECT ACTIVITIES

The planned Project activities are predicted to have **Negligible** impacts on physical resources (i.e., air quality, marine geology and sediments, marine water quality), no impacts on coastal biological resources, **Negligible** to **Moderate** impacts on marine biological resources, and **Negligible** to **Minor** 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 183 kilometers (approximately114 miles) offshore; and the Project will capture and re-inject recovered natural gas (the portion which is not used as fuel on the Floating Production, Storage, and Offloading [FPSO] vessel) back into the Liza reservoirs, treat all required wastewater streams prior to discharge to the sea, have a very small physical footprint (e.g., installation of infrastructure will only physically disturb about 0.8 square kilometers (km^2) of benthic habitat), and use Marine Mammal Observers (MMOs) and "soft starts" during VSP and pile driving operations to reduce the potential for auditory injury or disturbance to marine mammals. 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.

12.2. UNPLANNED EVENTS

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 possible spill trajectories and rates of travel. The location of the Project 183 kilometers (approximately 114 miles) offshore, prevailing northwest currents, the light nature of the Liza 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 a 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, a subsea release of crude oil from a well control event at a Liza field 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 [Project Development Area] PDA). 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 the exposure of these resources to oil.

Additional unplanned events, also considered unlikely to occur because of the extensive preventative measures employed by EEPGL, could include collisions between Project vessels and non-Project vessels; Project vessel strikes of marine mammals, marine turtles, or rafting seabirds; and collisions between Project vehicles and non-Project vehicles. 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 and marine turtles; adherence to international and local marine navigation procedures; adherence to Road Safety Management Procedure) will also serve to reduce the likely extent of impact, were such an event to occur.

12.3. 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 Project (approximately 8.5 kilometers [approximately 5.3 miles] to the west of Liza Phase 2 PDA), continued exploration drilling, a future planned development project approximately 20 kilometers (approximately 12.4 miles) north of the Liza Phase 2 PDA, and the Gas to Shore Project, which is expected to transport associated gas from the Liza Phase 1 Project Development Area to shore for creation of natural gas liquids and natural gas power production. Additionally, there are 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.

The Project activities, other planned EEPGL activities, and non-EEPGL activities together could cumulatively impact some resources such as marine mammals (via vessel strikes or potential acoustic injury or disturbance from underwater sound), marine turtles (via vessel strikes), marine fish (via degraded water quality and entrainment of fish from cooling and ballast water intakes), community health and wellbeing (via increased demand on limited medical treatment capacity), marine use and transportation (via additional marine congestion, especially near Georgetown Harbour), and social infrastructure and services (via increased demand for limited housing, utilities, and services; or via increased traffic congestion). Many of the above potential impacts that require offshore interaction between the Project and others 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 to 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 in Phase 2) be implemented. In addition, with the intention of minimizing the potential interactions between effects of multiple projects, EEPGL can actively manage, where feasible and practicable, the spatial and temporal overlap of their additional projects activities. This approach would be expected to be sufficient to address contributions of the Project and other EEPGL projects to cumulative impacts.

12.4. 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^2) 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.

12.5. Project Benefits

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 (PA) 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 PA and the Liza Development Local Content Plan approved by the Ministry of Natural Resources on 6 April 2018.
- By hiring Guyanese nationals in alignment with the PA and the Liza Development Local Content Plan.

In addition to direct revenue sharing, expenditures, and employment, the Project will also likely generate induced economic benefits. These induced benefits 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.

12.6. SUMMARY

Table 12.6-1 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/Subsea, Umbilicals, Risers, and Flowlines [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 12.6-1: Summary of Residual Impact Significance Ratings, Residual Risk Ratings and Cumulative Impact Priority Ratings

Resource	Highest Residual Impact Significance Rating (Planned Project Activities)			Highest Residual Risk Rating (Unplanned Events)	Cumulative Impact Priority Rating
	Drilling and Installation	Production Operations	Decommissioning		
Air Quality and Climate	Negligible	Negligible	Negligible	Minor	NA
Sound [a]	None	None	None	None	None
Marine Geology and Sediments	Negligible	None	None	Minor	NA
Marine Water Quality	Negligible	Negligible	Negligible	Moderate	Low
Protected Areas	None	None	None	Minor	NA
Special Status Species: [b]					
• Critically Endangered and Terrestrial Species	Negligible	Negligible	Negligible	Minor	Low
• Vulnerable/Near Threatened Fish Species	Minor	Minor	Minor	Minor	Low
• Endangered Fish and Endangered Black-Capped Petrel (*Pterodroma hasitata*)	Negligible	Minor [d]	Negligible	Minor	Low
• Vulnerable Leach's Storm-Petrel (*Oceanodroma leucorhoa*)	Negligible	Minor [d]	Negligible	Moderate [e]	Low
Coastal Habitats	None	None	None	Minor	NA
Coastal Wildlife	None	None	None	Minor	NA
Seabirds [c]	Negligible	Negligible	Negligible	Minor	NA
Marine Mammals	Moderate	Negligible	Negligible	Moderate	Medium
Marine Turtles	Negligible	Negligible	Negligible	Moderate	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**		
Marine Fish	Minor	Negligible	Negligible	Minor	Low
Marine Benthos	Negligible	Positive	Positive	Minor	NA
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:					
• Housing and utilities	Minor	Negligible	Negligible	Minor	Low
• Ground and air transportation	Negligible	Negligible	Negligible	Minor	Low
Waste Management	Negligible	Negligible	Negligible	Minor	NA
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 Chapter 10)
[a] Potential underwater sound-related impacts on marine mammals, marine turtles and marine fish are assessed in the resource-specific sections for those resources.
[b] Excludes listed marine turtles, which are covered in the Marine Turtles resource category.
[c] Excludes listed seabirds, which are covered in the Special Status species resource category.
[d] 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.
[e] The residual risk rating for Leach's Storm-Petrel is considered Moderate based on the results of marine bird surveys in 2017 and 2018, which documented the importance of the offshore zone as a migratory corridor for this special status marine bird.

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13. RECOMMENDATIONS

The Consultants recommend the following measures be considered by the EPA, Guyana Geology and Mines Commission (GGMC), and the Environmental Assessment Board (EAB) as conditions of issuance of an Environmental Authorisation for the Project:

- Embedded Controls—incorporate all of the proposed embedded controls (see Table 13-1).
- Mitigation Measures—adopt the recommended mitigation measures (see Table 13-2).
- Management Plans—implement the proposed Environmental and Socioeconomic Management Plan (ESMP) to manage and mitigate the potential impacts identified in the EIA. The ESMP includes the following:
  - Environmental and Socioeconomic Management Plan Framework (Chapter 11)
  - Environmental Management Plan, including:
    - Air Quality Management
    - Water Quality Management
    - Waste Management
    - Marine Ecosystems Management
  - Socioeconomic Management Plan, including:
    - Stakeholder Engagement
    - Grievance Management
    - Transportation Management
    - Cultural Heritage Management, including Chance Finds
  - Oil Spill Response Plan, including oil spill modeling, Net Environmental Benefit Analysis (NEBA), emergency preparedness and response procedures, Wildlife Response Plan, and geographic strategic response maps.
  - Preliminary End of Operations Decommissioning Plan
  - Environmental and Socioeconomic Monitoring Plan
- Oil Spill Preparedness—EEPGL has proactively embedded many controls into the Project design to prevent a spill from occurring, and we agree that a large spill that affects the Guyana coastline 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 [SBPA]; 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 Floating Production, Storage, and Offloading (FPSO) vessel, 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 Liza Phase 2 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.

Table 13-1: List of Proposed Embedded Controls

Embedded Controls	Resources/Receptors Benefited
Development Well Drilling and Subsea, Umbilicals, Risers, and Flowlines (SURF)/FPSO Installation and Commissioning	
Utilize water-based drilling fluids (WBDF) to the extent reasonably practicable (upper sections of the wells) and in other cases use low-toxicity International Oil and Gas Producers (IOGP) Group III non-aqueous base fluid (NABF).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
When non-aqueous drilling fluid (NADF) is used, utilize a solids control and cuttings dryer system to treat drill cuttings prior to discharge, such that the content of NADF on discharged cuttings, averaged over all well sections drilled using NADF does not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Avoid visible oil sheens on receiving water as a result of any commissioning-related discharges or FPSO cooling water discharge.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, seabirds, marine benthos
Initiate Vertical Seismic Profile (VSP) activities during daylight hours after a suitable pre-watch by Marine Mammal Observers is performed and begin with soft-start procedures, which incrementally increase source sound levels to allow sensitive marine organisms time to move away from the activity before full sound source energy is utilized, in accordance with Joint Nature Conservation Committee guidelines.	Marine mammals, marine fish, marine turtles
With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: • Change liquid hydrocarbon transfer hoses periodically; • Utilize dry-break connections on liquid hydrocarbon bulk transfer hoses; • Utilize a liquid hydrocarbon checklist before every bulk transfer • Perform required inspections and testing of all equipment prior to deployment/installation; • Utilize certified blowout preventer (BOP) equipment; • Regularly test certified BOP equipment and other spill prevention equipment; • Utilize overbalanced drilling fluids to control wells while drilling; • Perform operational training certification (including well control training) for drill ship supervisors and engineers; • Regularly audit field operations on the drill ships to ensure application of designed safeguards; and • Utilize controls for mitigating a failure of the dynamic positioning system on the drill ships and maintaining station keeping, which include: – Use of a Class 3 Dynamic Positioning (DP) system, which includes numerous redundancies; – Rigorous personnel qualifications and training; – Sea trials and acceptance criteria;	Air quality, marine geology and sediments, marine water quality, protected areas and special status species, coastal habitats, coastal wildlife and shorebirds, marine mammals, marine turtles, marine fish, marine benthos, ecological balance and ecosystems

Embedded Controls	Resources/Receptors Benefited
– Continuous DP proving trials; – System Failure Mode and Effects Analysis; – Continuous DP failure consequence analysis; and – Establishment of well-specific operations guidelines.	
During pile-driving activities, gradually increase the intensity of hammer energy to allow sensitive marine organisms to vacate the area before injury occurs (i.e., soft starts).	Marine mammals, marine turtles, marine fish
Maintain marine safety exclusion zones to be issued through the Maritime Administration Department (MARAD) with a 500 meter (approximately 1,640 foot) radius around drill ships and major installation vessels, and a 2 nautical mile (approximately 12,150 foot) radius around FPSO during offloading operations - to prevent unauthorized vessels from entering areas with an elevated risk of collision.	Marine use and transportation
Ensure all vessel wastewater discharges (e.g., storage displacement water, ballast water, bilge water, deck drainage) comply with International Maritime Organization (IMO)/International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL 73/78) requirements.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Utilize leak detection controls during installation and operation of SURF equipment (e.g., pigging and pressure testing of lines, periodic remotely operated vehicle surveys of subsea trees, manifolds, flowlines, and risers).	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Production Operations	
Re-inject produced gas that is not used as fuel gas on the FPSO to avoid routine flaring. With respect to non-routine flaring, the following measures will be implemented: • Monitor flare performance to maximize efficiency of flaring operation; • Ensure flare equipment is appropriately inspected and function-tested prior to production operations; and • Ensure flare equipment is appropriately maintained and monitored during production operations.	Air quality
Notify regulator when process upset events or unplanned maintenance occur, resulting in a flaring event sustaining at least 10 million standard cubic feet per day and lasting 5 days or longer.	Air quality
Avoid routine venting (excludes tank flashing emissions, standing/working/breathing losses) except during safety and emergency conditions.	Air quality
Avoid use of chlorofluorocarbons and polychlorinated biphenyls.	Air quality
Treat produced water on the FPSO to limit oil and grease content to 29 milligrams per liter (mg/L) monthly average and 42 mg/L daily maximum.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems
Design produced water and cooling water discharges from FPSO to avoid increases in ambient water temperature of more than 3˚C at 100 meters (approximately 328 feet) from discharge point.	Marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds, ecological balance and ecosystems

Embedded Controls	Resources/Receptors Benefited
Utilize a Mooring Master from the FPSO located onboard the offloading tanker to support safe tanker approach/departure and offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a hawser with a quick release mechanism to moor the FPSO to the tanker at a safe separation distance during offloading operations.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Ensure FPSO offloading to tankers occurs within an environmental operating limit that is established to ensure safe operations. In the event that adverse weather occurs during offloading operations that is beyond the environmental operating limit, the tanker will cease offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine use and transportation, marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a certified marine-bonded, double-carcass floating hose system that complies with the recommendations of Oil Companies International Marine Forum (OCIMF) Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM) 2009 Edition or later.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize a load monitoring system in the FPSO control room to support FPSO offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize leak detection controls during FPSO offloading that include: • Leak detection for breach of the floating hose that complies with the recommendations of OCIMF GMPHOM 2009 Edition or later; and • Utilization of instrumentation/procedures to perform volumetric checks during offloading.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Utilize low-sulfur fuels for major vessels, where available and commercially viable.	Air quality
Utilize dust suppression measures at the shorebase(s) to reduce impacts on air quality.	Air quality
Provide trained medical personnel on board the FPSO and major installation vessels and provide an EEPGL-dedicated ambulance service to minimize reliance on medical infrastructure and facilities in Guyana.	Community health and wellbeing
Ensure Project vessels conduct ballasting operations in accordance with IMO/MARPOL requirements.	Ecological balance and ecosystems
General Measures	
Maintain equipment, marine vessels, and helicopters in good working order and operate in accordance with manufacturers' specifications to reduce atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality, sound, marine water quality, marine mammals, marine turtles
Equip project vessels with radar systems and communication mechanisms to communicate with third party mariners.	Marine use and transportation

Embedded Controls	Resources/Receptors Benefited
Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and to reduce air emissions to the extent practicable.	Air quality, marine water quality
Shut down (or throttle down) sources of combustion equipment in intermittent use where reasonably practicable in order to reduce air emissions.	Air quality
Utilize secondary containment for bulk fuel storage, drilling fluids, and hazardous materials, where practicable.	Marine water quality
Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Marine water quality
Perform regular audits of field operations on the drill ships, FPSO, and shorebase(s) to ensure application of designed safeguards.	Air quality, marine water quality
Treat sewage to applicable standards under MARPOL 73/78.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
For those wastes that cannot be reused, treated, or discharged/disposed on the drill ships or FPSO, ensure they are manifested and safely transferred to appropriate onshore facilities for management. Waste management contractors will be vetted prior to utilization. If deficiencies in contractors' operations are noted, an action plan to address the identified deficiencies will be established.	Waste management
Utilize oil/water separators to limit oil in water content in bilge water to less than 15 parts per million per MARPOL 73/78.	Marine geology and sediments, marine water quality, marine mammals, marine turtles, marine fish, marine benthos, seabirds
Provide awareness training to Project-dedicated marine personnel to recognize signs of marine mammals at the sea surface. Provide standing instruction to Project-dedicated vessel masters to avoid marine mammals and marine turtles while underway and reduce speed or deviate from course, as needed, to reduce probability of collisions.	Marine mammals, marine turtles
Provide standing instruction to Project-dedicated vessel masters to avoid any identified rafting seabirds when transiting to and from Project Development Area (PDA).	Seabirds
Observe standard international and local navigation procedures in and around the Georgetown Harbour and Demerara River, as well as best ship-keeping and navigation practices while at sea.	Marine use and transportation
Ensure Project workers are subjected to health screening procedures to minimize risks of transmitting communicable diseases.	Community health and wellbeing
Employ Guyanese citizens having the appropriate qualifications and experience where reasonably practicable. Partner with select local institutions and agencies to support workforce development programs and proactively message Project-related employment opportunities.	Socioeconomic conditions, employment and livelihoods
Procure Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.	Socioeconomic conditions, employment and livelihoods
Utilize a Worker Code of Conduct that includes requirements for interaction with local communities while on shore-leave.	Community health and wellbeing
Implement a transparent, accessible, and consistent Community Grievance Mechanism (CGM) early on, prior to onset of Project activities. Ensure CGM is well publicized and understood by the public.	Community health and wellbeing

Embedded Controls	Resources/Receptors Benefited
Monitor grievances received and resolved by the CGM; adjust CGM and other management measures, as appropriate	Community health and wellbeing
Implement a community safety program for potentially impacted schools and neighborhoods to increase awareness and minimize potential for community impacts due to vehicle incidents.	Social infrastructure and services, community health and wellbeing
Develop and implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related ground transportation activities. The procedure will include, at a minimum, the following components: • Definition of typical, primary travel routes for ground transportation in Georgetown area; • Development of an onshore logistics/journey management plan to reduce potential conflicts with local road traffic when transporting goods to/from onshore support facilities • Definition of required driver training for Project dedicated drivers, including (but not limited to) defensive driving, loading/unloading procedures, and safe transport of passengers, as applicable; • Designation and enforcement of speed limits, through speed governors, global positioning system, or other monitoring systems for Project-dedicated vehicles; • Avoidance of deliveries during typical peak traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; • Monitoring and management of driver fatigue; • Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment for Project-dedicated vehicles; and • Community outreach to communicate information relating to major delivery events or periods.	Social Infrastructure and Services, Community Health and Wellbeing
Coordinate with relevant aviation authorities and stakeholders to understand peak Project-related utilization rates.	Social infrastructure and services
Utilize an established SSHE program to which all Project workers and contractors will be required to adhere to mitigate against risk of occupational hazards. Ensure all workers and contractors receive training on implementation of these principles and are required to adhere to them in the daily execution of their duties.	Occupational health and safety
Maintain an Oil Spill Response Plan (OSRP) to ensure an effective response to an oil spill, including maintaining the equipment and other resources specified in the OSRP and conducting periodic training and drills.	All resources and receptors potentially impacted by an oil spill
Where practicable, direct lighting on FPSO and major vessels to required operational areas rather than at the sea surface or skyward.	Seabirds, marine turtles
Provide screening on FPSO and drill ships for seawater intakes to minimize the entrainment of aquatic life, where practical.	Marine fish

Table 13-2: List of Proposed Mitigation Measures

Proposed Mitigation Measure	**Resources/Receptors Benefited**
Report direct greenhouse gas (GHG) emissions from the facilities owned or controlled by the Project to the EPA on an annual basis in accordance with internationally recognized methodologies and good practice.	Air Quality and Climate
Issue Notices to Mariners via MARAD, the Trawler's Association, and fishing co-ops for movements of major marine vessels (including the FPSO, drill ship, and installation vessels) to aid them in avoiding areas with concentrations of Project vessels and/or where marine safety exclusion zones are active.	Employment and Livelihoods, Marine Use and Transportation
Augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners and, where possible, communicate regarding major vessel movements and marine safety exclusion zones.	Employment and Livelihoods, Marine Use and Transportation
Promptly remove damaged vessels (associated with any vessel incidents) to minimize impacts on marine use, transportation, and safety.	Marine Use and Transportation
Proactively communicate the Project's limited staffing requirements as a measure to reduce the magnitude of potential population influx to Georgetown from job-seekers.	Social Infrastructure and Services
Adopt and implement as needed a Chance Find Procedure that describes the requirements in the event of a potential chance find of heritage or cultural resources.	Cultural Heritage
Require Project workers to adhere to a Worker Code of Conduct, which will address shore-leave considerations.	Community Health and Wellbeing
Utilize a dedicated medical provider to complement the services of the local private medical clinic utilized by the Project, and procure a dedicated ambulance to avoid overwhelming the local medical infrastructure.	Community Health and Wellbeing
Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Requiring use of appropriate PPE by response workers; and • Implementing a Wildlife Oil Response Program, as needed.	All resources
Implement a claims process and, as applicable, a livelihood remediation program to address economic losses or impacts on livelihood as a result of an oil spill.	Socioeconomic Conditions, Employment and Livelihoods, Indigenous Peoples, Ecosystem Services

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14. PROJECT TEAM

Member	Company and Position	Education (Highest Degree)	Years of Experience
David Blaha	ERM: Program Lead	MS Environmental Management	35
Todd Hall	ERM: Partner-in-Charge	ME Civil (Environmental) Engineering	22
Jason Willey	ERM: Project Manager, Biological Resource Specialist	MS Environmental Science and Policy	15
Matt Erbe	ERM: Project Controls Lead	MS Hydrogeology	19
Kris Hiatt	ERM: Document Production Manager	BA English	15
Noam Raffel	ERM: Senior GIS Analyst	MS Geographic Information Sciences	5
Karin Nunan	ERM: Socioeconomic and Stakeholder Engagement Lead; Ecosystems Services Specialist	MS International Relations and Conflict Resolution	20
Julia Tims	ERM: Biological Environment Lead, Avian and Terrestrial Wildlife Specialist	MS Natural Resources Management/Ecology	22
Rick Osa	ERM: Air Quality Monitoring Lead	ME Engineering Management	30
Greg Lockard	ERM: Cultural Heritage Assessment Lead	PhD Anthropology	21
Benjamin Sussman	ERM: Transportation Assessment Lead	MCRP (City and Regional Planning)	17
Mark Garrison	ERM: Air Emission Dispersion Modeling Lead	MS Environmental Science	28
Shwet Prakash	ERM: Water Quality Assessment Lead	MS Civil Engineering	13
Mike Fichera	ERM: Senior Water Quality Specialist	MS Environmental Engineering	23
Melinda Todorov	ERM: Senior Marine Scientist	MS Aquatic Ecology	9
Peyun Kok	ERM: Socioeconomic and Community Health Specialist	MES Urban and Regional Planning	7
Dusty Insley	ERM: Geological Resource Specialist	BS Geology	10
Jon Connelly	ERM: Biological Resource Specialist	BA Environmental Studies	12
Michael Fraser	ERM: Acoustics Specialist	BSc Electroacoustics	20
Vanessa Cottle	ERM: Cumulative Impact Assessment Lead	MS Water Resources Management	13
Rowena Cerro	ERM: Cumulative Impact Assessment	MA Biological Sciences	10
Charles Ceres	Ground Structures Engineering Consulting: Project Director	MS Geotechnical Engineering	39
Hance Thompson	Ground Structures Engineering Consulting: Senior Specialist	M.Sc, Environmental and Earth Resources Management	13
Raeburn Jones	Ground Structures Engineering Consulting: Biological Resource Specialist	BSc Forestry	23
Patrick Williams	Ground Structures Engineering Consulting: GIS Analyst	High school diploma	9
Shyam Nokta	Environmental Management Consultants: Principal and Environmental Management Specialist	MS Environmental Assessment and Management	15

Member	Company and Position	Education (Highest Degree)	Years of Experience
Khalid Alladin	Environmental Management Consultants: Project Manager	BA Geology	17
Richard Persaud	Environmental Management Consultants: Community Resources Specialist	BA Geography/Economics	20
Romeo De Freitas	Environmental Management Consultants: Biological Resource Specialist	High school diploma	30

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Section 6.1 Air Quality

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Chapter 8 Assessment and Mitigation of Potential Impacts from Planned Activities—Socioeconomic Resources

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Chapter 9 Assessment and Mitigation of Potential Impacts from Unplanned Events

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