Environmental Impact Assessment

Liza Phase 1 Development Project

Esso Exploration and Production Guyana, Limited

May 2017

www.erm.com

David W. Blaha

ERM Partner

The business of sustainability

ERM

-Page Intentionally Left Blank-

TABLE OF CONTENTS

VOLUME I-ENVIRONMENTAL IMPACT ASSESSMENT

List of Tables

List of Figures

VOLUME II-TECHNICAL APPENDICES

VOLUME III-ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN

VOLUME IV-OIL SPILL RESPONSE PLAN

List of Acronyms

% .... percent
%BFROC .... percentage of base fluid retained on cuttings
°C .... degrees Celsius
µg/m3 .... micrograms per cubic meter
µPa .... micro pascal
AASM .... Airgun Array Source Model
AMS .... Alarm Management System
AOI .... Area of Influence
AQS .... air quality standards
AUV .... Automated Underwater Vehicle
bbl .... barrel(s)
BOEM .... U.S. Bureau of Ocean Energy Management
BOP .... blowout preventer
BOPD .... barrels of oil per day
CARICOM .... Caribbean Community
CBP .... chlorinated by-products
CCC .... criterion continuous concentrations
CCR .... central control room
CFC .... chlorofluorocarbon
CITES .... Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMC .... criterion maximum concentrations
CO .... carbon monoxide
COLREG .... Convention on the International Regulations for Preventing Collisions at Sea
CPACC .... Caribbean Planning for Adaptation to Climate Change
CPI .... Carbon preference index
CR .... Critically Endangered
CREE .... Center for Rural Empowerment and the Environment
CSC .... International Convention for Safe Containers
CTD .... conductivity, temperature, and depth
dB .... decibel
DC .... drill center
DDIA .... Declared Drainage and Irrigation Areas
DP .... Dynamic Positioning
EBS .... environmental baseline surveys
EEA .... European Environment Agency
EEPGL .... Esso Exploration and Production Guyana Limited
EIA .... Environmental Impact Assessment
EITI .... Extractive Industries Transparency Initiative
EMT .... emergency medical technician
EN .... Endangered
EPA .... Guyanese Environmental Protection Agency
ESMP .... Environmental and Socioeconomic Management Plan
EUNIS .... European Nature Information System

EX ....Extinct
EZZ..............................Exclusive Economic Zone
F&G ....Fire and Gas
FAL..............................Convention on Facilitation of International Maritime Traffic
FEED ....Front-End Engineering and Design
FGSI.............................Fugro GeoServices Incorporated
FLET ....flowline end termination
FPSO............................Floating Production, Storage, and Offloading
FSO ....Floating Storage and Offloading
FSV ....Fast Supply Vessel
ft...................................Feet/Foot
Fugro ....Fugro Marine Geoservices, Inc.
Fugro EMU ....Fugro EMU Limited
FWRAM......................Full Waveform Range-dependent Acoustic Model
GDP ....Gross Domestic Product
GEA ....Guyana Energy Agency
GEMSS-GIFT..............Generalized Integrated Fate and Transport
GGMC.........................Guyana Geology and Mines Commission
GHG ....greenhouse gas
GINA...........................Government Information Agency
GLSC ....Guyana Lands and Surveys Commission
GMPHOM..................Guide to Manufacturing and Purchasing Hoses for Offshore Moorings
GPHC..........................Georgetown Public Hospital Corporation
GRA.............................Guyana Revenue Authority
GT&T ....Guyana Telephone & Telegraph
GuySuCo ....Guyana Sugar Corporation
GWI ....Guyana Water Inc.
GYD.............................Guyanese dollar
H_2S ....hydrogen sulfide
ha ....hectares
HFC ....High-frequency cetaceans
HVAC ....Heating, Ventilation, and Air Conditioning
IBA...............................Important Bird Area
ICSS ....Control and Safety System
ICZM ....Integrated Coastal Zone Management
IDB...............................Inter-American Development Bank
IFC ....International Finance Corporation
ILO...............................International Labor Organization
IMF ....International Monetary Fund
IMO ....International Maritime Organization
IOGP............................International Oil and Gas Producers
ITCZ ....Inter-Tropical Convergence Zone
IUCN...........................International Union for Conservation of Nature
IUU ....Illegal, Unreported, and Unregulated
IWC ....International Whaling Commission
JNCC ....Joint Nature Conservation Committee
kbd...............................thousands of barrels per day

kHz............................kilohertz
km..............................kilometers
LADCP........................Lowered Acoustic Doppler Current Profiler
LC ....Least Concern
LCDS..........................Low Carbon Development Strategy
LFC.............................Low-frequency cetaceans
LME............................Large Marine Ecosystem
MA..............................Millennium Ecosystem Assessment
MACT ....Maximum Acceptable Toxicant Concentration
MARAD......................Maritime Administration
MARPOL 73/78..........International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
MBES..........................multi-beam echo sounder
MDG...........................Millennium Development Goal
MFC............................Mid-frequency cetaceans
mg/L...........................milligrams per liter
mi................................miles
MICS ....Multiple Indicator Cluster Survey
MMO..........................marine mammal observation/observer
MOC...........................North Atlantic Meridional Overturning Circulation
MONM ....Marine Operations Noise Model
MoNRE.......................Ministry of Natural Resources and Environment
MPV ....Multi-Purpose Vessel
MSC ....Marine Sustainability Council
mscfd..........................million standard cubic feet per day
MW.............................megawatt
M-weighted................Auditory weighting functions for marine mammals
N/A............................not applicable
NABF ....non-aqueous base fluid
NADF.........................non-aqueous drilling fluid
NBC............................North Brazil Current
NBSAP.......................National Biodiversity Strategy and Action Plan
NDC ....Neighbourhood Democratic Councils
NDIA..........................National Drainage and Irrigation Authority
NDS............................National Development Strategy
NTD............................Neglected Tropical Diseases
NEAP ....National Environmental Action Plan
NGO...........................non-governmental organization
nm...............................nautical mile
NO_2.............................nitrogen dioxide
NOAA........................U.S. National Oceanic and Atmospheric Administration
NOM ....naturally occurring organic matter
NT...............................Near Threatened
O&G ....oil and grease
OAS ....Organization of American States
OCIMF ....Oil Companies International Marine Forum

OI..................................Operations Integrity
OIMS............................Operations Integrity Management System
OSH..............................Occupational Safety and Health
OSR..............................Oil Spill Response
OSRP............................Oil Spill Response Plan
P&A..............................plugged and abandoned
PA/GA........................public address and general alarm system
PAH..............................Polycyclic aromatic hydrocarbons
PC.................................Project Contribution
PCS...............................Process Control System
PDA..............................Project Development Area
PEC...............................Predicted Environmental Concentration
PM_{10} particulate matter with aerodynamic diameter of less than 10 micrometers
$PM_{2.5}$.............................particulate matter with aerodynamic diameter of less than 2.5 micrometers
POB..............................personnel on board
POP..............................Persistent Organic Pollutant
ppb...............................parts per billion
PPE...............................personal protective equipment
ppm..............................parts per million
ppt................................parts per thousand
Pr/Ph Ratio.................Ratio of pristane to phytane
Project..........................Liza Phase 1 Development Project
PSC...............................Private Sector Commission
PSV...............................Platform Supply Vessel
PTS...............................Permanent Threshold Shift
RMS..............................root mean square
RO.................................reverse osmosis
ROV..............................remotely operated vehicle
SBP................................sub-bottom profiler
SBPA............................Shell Beach Protected Area
SC..................................Scientific Committee
SCAT............................Shoreline Clean-up Assessment Technique
SDU..............................Subsea Distribution Unit
SEA...............................Strategic Environmental Assessment
SEL...............................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
SPAW...........................Specially Protected Areas and Wildlife
SPL................................sound pressure level
SRU...............................Sulfate Removal Unit
SSHE............................Safety, Security, Health, and Environment

STCW .... International Convention on Standards of Training, Certification and Watchkeeping
SURF .... Subsea, Umbilicals, Risers, and Flowlines
TB.................................. Tuberculosis
THC.............................. total hydrocarbons
TIP .... Technical Information Paper
TOC .... total organic carbon
ToR .... Terms of Reference
TSS................................ total suspended solids
TV .... Tug Vessel
UCM............................. Unresolved complex mixture
UNAIDS .... Joint United Nations Program on HIV/AIDS
UNESCO...................... United Nations Educational, Scientific and Cultural Organization
UNFCC .... United Nations Framework Convention on Climate Change
UPS............................... uninterruptible power supply
USD .... U.S. Dollars
USEPA .... U.S. Environmental Protection Agency
VLCC .... Very Large Crude Carrier
VOC.............................. volatile organic compounds
VSP .... Vertical Seismic Profile
VU .... Vulnerable
WBDF........................... water-based drilling fluids
WHO .... World Health Organization
WRC .... Wider Caribbean Region
WRF.............................. Weather Research and Forecasting

-Page Intentionally Left Blank-

Glossary

Term	Definition
Anthropogenic	Made by humans, or attributable to human activity.
Barrel	The basic unit for measuring oil. 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 persistant substance, usually a pollutant or toxin, in the tissues of organisms at successively higher levels in a food chain
Borehole (or wellbore)	A deep, narrow 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.
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 ship	A self-propelled floating offshore drilling unit that is a ship constructed to permit 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 which 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.
Equivalent barrels (or barrel of oil equivalent [BOE])	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 barrels of oil equivalent (BOE). The energy content of six thousand cubic feet of gas (6 MCF) is roughly equivalent to one barrel of oil.

Term	Definition
Exploration	The search for oil and gas. Exploration operations include aerial surveys, geophysical surveys, geological studies, core testing and the drilling of test (wildcat) wells.
Exploratory well	A well drilled to 1) find oil or gas in an undiscovered or unproven area (wildcat), or 2) extend the limits or depths of a known area.
Flare (or Flaring)	In the oil industry: A system of piping and burners used to dispose (by burning) of surplus gas or vapors produced with the oil.
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 or transported via pipeline. 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 surface pipe through which oil travels from a well to processing equipment or to storage.
Hydrostatic test	A way in which pressure vessels such as pipelines, plumbing, gas cylinders, boilers 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 to the specified test point. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss.
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	Type of gridless atmospheric 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 field.
Laydown area	An area that has been cleared for the temporary 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 of vehicles.
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 utilized 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.

Term	Definition
Oil field	The surface area covering one or more reservoirs containing oil. The oil field also usually includes the reservoir, the wells, and the production equipment, etc.
Overboard water	Another name for produced water or brine produced from oil and gas wells.
Platform	An immobile structure used in offshore drilling on which the drilling rig, crew quarters, and other related items are located.
Plugging of well	The sealing off of the fluids in the stratum penetrated by a well so that the fluid from one stratum will not escape into another or to the surface.
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.
Refinery	The facility where the characteristics of petroleum or petroleum products are changed.
Reservoir	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 connect subsea equipment to a surface facility such as an FPSO.
Shorebase	The land based facility that provides logistical and material support for offshore activities and facilities.
Spread mooring anchor 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 to help support the wellhead installed on the conductor casing.

Term	Definition
Tree	The assembly of valves, pipes and fittings used to control the flow of oil and gas from the casing head.
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.

ENVIRONMENTAL IMPACT STATEMENT

EIS Executive Summary

Esso Exploration and Production Guyana Limited (EEPGL) proposes the "Liza Phase 1 Development Project" (Project) to develop the Liza field located in the Stabroek Block offshore Guyana. EEPGL obtained an offshore 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 190 km (~120 mi) offshore from Georgetown in waters approximately 1,500 to 1,900 meters (m) deep. Subsequent surveys and exploratory drilling have identified a reservoir of oil in a sandstone formation approximately 3,600 m below the seabed (approximately 5,400 m below sea level). This reservoir is estimated to have a recoverable resource of 0.8 to 1.4 billion oil-equivalent barrels.

EEPGL (45%), together with Hess Guyana Exploration Limited (30%) and CNOOC Nexen Petroleum Guyana Limited (25%), are parties to a Petroleum Agreement with the Government of Guyana. Under this agreement, and in light of the Liza field discovery, EEPGL has applied for a Petroleum Production Licence and submitted a Project Development Plan to the Minister Responsible for Petroleum.

A key permit required for EEPGL to develop the Liza field is the Environmental Authorisation from the Guyana Environmental Protection Agency (EPA) in accordance with the Guyana Environmental Protection Act of 1996 (EP Act Cap. 20:05). As part of its regulatory role, the EPA, considering recommendations from the Environmental Advisory Board (EAB) and Guyana Geology and Mines Commission (GGMC), 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 July 5, 2016. Based on an initial assessment of the Project, the EPA determined that an Environmental Impact Assessment (EIA) was required. The purpose of the EIA is to provide the factual and technical basis required by EPA, EAB, and the GGMC to make an informed decision on EEPGL's Application. EEPGL has 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.

EEPGL proposes to drill approximately 17 subsea development wells and use 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 separate production (oil, gas, and produced water), gas injection, and water injection flowlines and risers, and associated subsea equipment. The Project will also involve shorebase facilities and marine/aviation services to support development drilling, FPSO and subsea equipment installation, production operations, and ultimately decommissioning. EEPGL will utilize proven and industry accepted standards and has incorporated many embedded controls into the overall Project design to minimize environmental and socioeconomic impacts. It could take up to four years to drill the wells, with drilling planned to begin as early as 2018. The initial production is expected to begin by mid-2020, with operations continuing for at least 20 years. The Project is expected to employ up to

600 persons during 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 minor impacts on physical resources (i.e., air quality, marine sediments, and water quality), no impacts on coastal biological resources, minor impacts on marine biological resources, and largely positive impacts on socioeconomics. These predictions are based on the fact that the bulk of the Project activity will occur approximately 190 km (~120 miles) offshore, and the Project will capture and re-inject produced natural gas, which is not used as fuel on the FPSO, back into the Liza reservoir; treat required wastewater streams prior to discharge to the sea; have a very small physical footprint (e.g., infrastructure construction disturbs only about 0.3 km^2 of benthic habitat); and use Marine Mammal Observers (MMO) during selected activities to minimize the potential impacts to marine mammals due to auditory injury and ships strikes.

Unplanned events, such as a large oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL. Nevertheless, an oil spill is considered possible, and EEPGL has conducted oil spill modeling to evaluate the range of likely spill trajectories and rates of travel. The location of the Project 190 km (~120 mi) offshore, prevailing northwest currents, the light nature of the Liza field crude oil, and the region's warm waters would all help minimize the severity of a spill. Accounting for these factors, the modeling indicates only a 5 to 10 percent probability of any 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 spill at a Liza well would likely impact marine resources found near the well, such as sea turtles and certain marine mammals that may transit or inhabit the area impacted by a spill. Air quality, water quality, seabirds, and marine fish 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 fishermen if commercial fish and shrimp were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year the release were to occur (e.g., whether a spill would coincide with the time of year when these species are more common). Effective implementation of the Oil Spill Response Plan (OSRP) would help mitigate this risk by further reducing the ocean surface area impacted by a spill and thereby reduce oil exposure to these species.

As described above, although a large 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 sea 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 training exercises, 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 embedded controls, recommended mitigation measures, and appropriate Environmental and Socioeconomic Management Plans, including an OSRP, be adopted. With the implementation of such controls, mitigation measures, and management plans, the Liza Phase 1 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.

EIS 1.0 INTRODUCTION

This Environmental Impact Statement (EIS) has been prepared for the Liza Phase 1 Development Project (Project) in accordance with the Guyana Environmental Protection Agency (EPA) Environmental Impact Assessment Guidelines (November 2000) and the Project Final Terms of Reference (February 2017).

This EIS was prepared by Environmental Resources Management (ERM), which is an international environmental and social consulting firm with extensive experience in the preparation of Environmental Impact Assessments (EIA) for offshore oil and gas development projects. ERM is also a Guyana EPA registered consultant. EIA Appendix B provides the Curriculum Vitae of the key members of the EIA team.

ERM did not encounter any specific difficulties in preparing the EIA. The information provided on the Project and the resources found in the Project Development Area (PDA) were adequate for ERM to prepare a robust impact assessment.

EIS 1.1 Project Sponsor

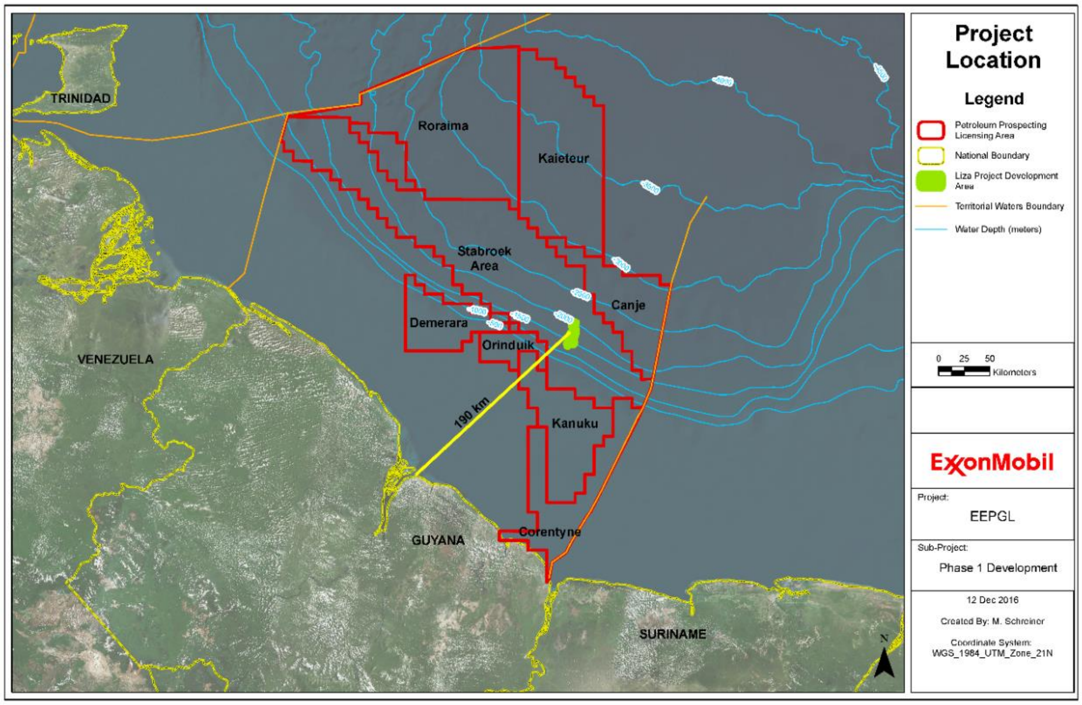
The Project Sponsor is a joint venture among Esso Exploration and Production Guyana Limited (EEPGL), Hess Guyana Exploration Limited (Hess), and CNOOC Nexen Petroleum Guyana Limited (Nexen). EEPGL will be the operator of the Project, and is used in this EIA to represent the joint venture. EEPGL, which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

EIS 1.2 Project Context

EEPGL obtained 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 190 kilometers (~120 miles) offshore from Georgetown in waters approximately 1,500 to 1,900 meters (m) deep (Figure EIS-1). Subsequent surveys and exploratory drilling have identified a reservoir of oil in a sandstone formation approximately 3,600 m below the seabed (approximately 5,400 m below sea level). This reservoir is estimated to have a recoverable resource of 0.8 to 1.4 billion oil-equivalent barrels.

EEPGL, together with Hess and Nexen, are parties to a Petroleum Agreement with the Government of Guyana. Under this agreement, and in light of the Liza field discovery, EEPGL has applied for a Petroleum Production Licence and submitted a Project Development Plan to the Minister Responsible for Petroleum.

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



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

EIS 1.3 Purpose of the Project

The purpose of the Project is to achieve safe and efficient production of hydrocarbons from the Liza field. A confidential 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 would begin receiving oil revenues when oil is produced.

EIS 1.4 Regulatory Framework and Purpose of this EIA

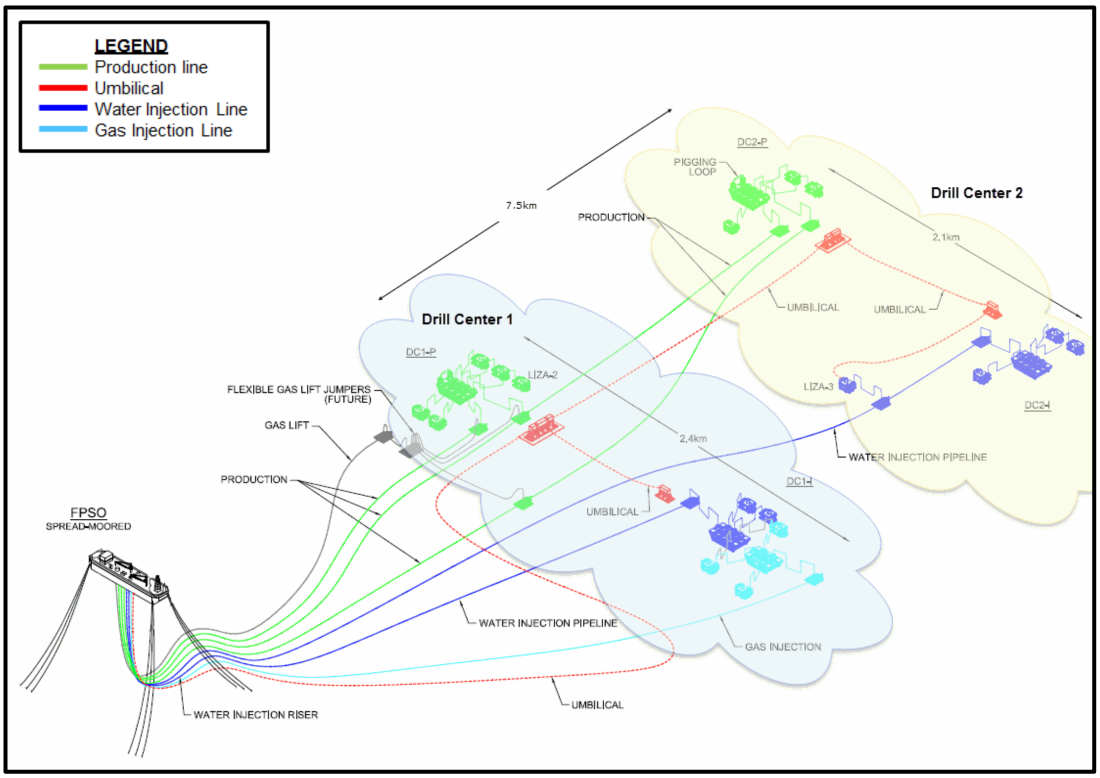
In order to develop the Liza field, EEPGL needs to obtain approval of an Application for Environmental Authorisation (Application) from the Guyana EPA in accordance with the Guyana EP Act (Cap. 20:05). Toward that end, EEPGL filed its Application with the EPA on July 5, 2016. As part of its regulatory role, the EPA, taking into consideration recommendations from the Environmental Advisory Board (EAB) and GGMC, is responsible for deciding whether and under what conditions to grant EEPGL's Application. Based on an initial assessment of the Project, the EPA determined that an EIA was required. The purpose of this EIA is to provide the factual and technical basis required by EPA, EAB, and the GGMC to make an informed decision on EEPGL's Application. If approved, the EPA would issue an Environmental Permit[1] with the terms and conditions necessary to effectively protect the environment.

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

EIS 2.0 PROJECT DESCRIPTION

The Project proposes to develop the offshore resource by drilling approximately 17 subsea development 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 Project drilling and production operations activities will collectively occur in what is referred to as the Project Development Area (PDA), which is an approximately 50 km² area located approximately 190 km (~120 mi) offshore (Figure EIS-2). The Project will also involve use of onshore shorebase facilities and marine/aviation services to support development drilling, SURF and FPSO installation, production operations, and ultimately decommissioning.

Figure EIS-2 Preliminary Liza Phase 1 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 would be addressed in a separate environmental authorization.

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

EIS 2.1 Drilling and SURF/FPSO Installation

Figure EIS-3 Typical Drill Ship

EEPGL will use one or two drill ships (Figure EIS-3), to drill the development wells. The approximately 17 development wells are currently planned to include eight production wells (for recovering the oil), six water wells (to inject water into the Liza reservoir to maintain pressure), and three gas wells (to re-inject recovered gas not used on the FPSO into the reservoir). The wells will be clustered around two drill centers. For safety reasons, a 500 m 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 (WBDF), 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 are then discharged to the sea.

Once each well is drilled, a wellhead and tree are installed and the well is connected to a manifold, which is 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.

Figure EIS-4 FPSO

The FPSO (Figure EIS-4) will be a converted double hull tanker with the capacity to store 1.6 million barrels of stabilized crude oil. The FPSO will be secured to the seafloor by a 16- to 20-point spread mooring anchor system. The FPSO and the mooring system are designed to remain in place for at least 20 years and to sustain extreme (100-year return period) environmental conditions. The FPSO will also provide living quarters and associated utilities for approximately 140 personnel. For safety reasons, the FPSO will have a two nautical mile exclusion zone to avoid interactions with unauthorized vessels.

EIS 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 reservoir, although some of the gas will be used as fuel on the FPSO, and some gas may be occasionally flared on a non-routine, 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*
Oil Production	100,000 barrels per day (bpd) (designed to safely operate at sustained peaks of 120,000 bpd)
Produced Water	100,000 bpd
Total Liquids	150,000 bpd
Produced Gas	180,000,000 standard cubic feet per day
Gas Injection	160,000,000 standard cubic feet per day (assumes some produced gas will be used as fuel gas for the FPSO)
Water Injection	190,000 bpd

* Project facilities will have the potential to safely operate at sustained peaks above the design rate. For purposes of this EIA, potential impacts generated by the Project (e.g., air emissions) were based on a potential peak production volume of 144,000 bpd to be conservative in the analysis.

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 m (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 an offloading tanker using a floating hose at a rate of approximately one million barrels of oil in about 28 hours.

Figure EIS-5 Typical FPSO Offloading to a Conventional Tanker

EIS 2.3 Decommissioning

Prior to the end of operations (estimated at approximately 20 years), EEPGL will initiate detailed planning for facility decommissioning, including filing a Notice of Intent for Decommissioning to the GGMC and EPA. All development wells will be permanently plugged and abandoned. It is expected that the SURF equipment and the FPSO mooring lines will be abandoned in place on the seafloor in accordance with standard industry practice (subject to the decommissioning plan). The FPSO will be disconnected from its mooring system and towed to a shipyard for decommissioning.

EIS 2.4 Onshore, Marine, and Aviation Support

Shorebases, laydown areas, warehouses, fuel supply, and waste management facilities will support the Project across the Project stages as described above. EEPGL is planning to utilize shorebases in Guyana and Trinidad to support the Project. 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.

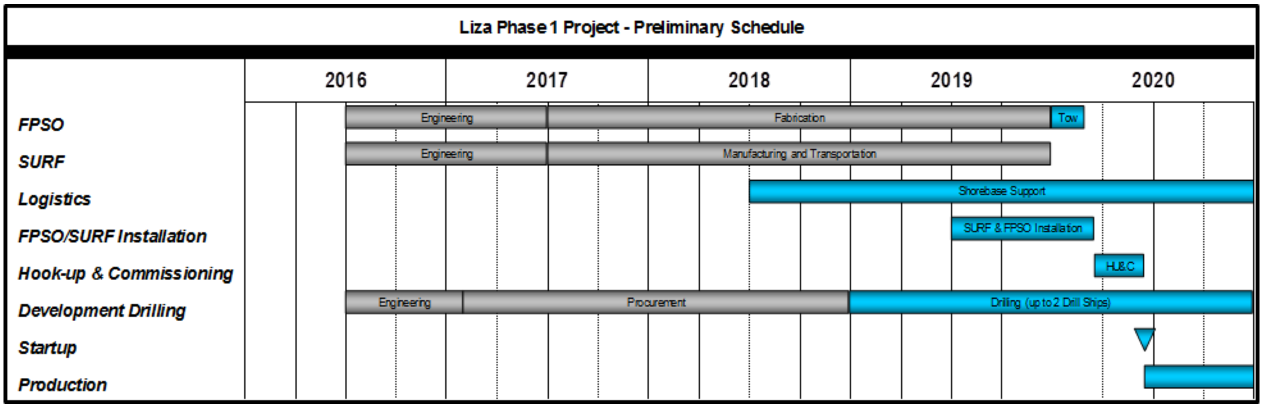
EIS 2.5 Project Workforce

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.

EIS 2.6 Project Schedule

It could take up to four years to drill the approximately 17 wells, with drilling planned to begin in 2018 or 2019. Installation of the SURF and FPSO are likely to be initiated in 2019 to be ready for initial production by mid-2020, with operations continuing for at least 20 years (Figure EIS-6).

Figure EIS-6 Preliminary Project Schedule



EIS 2.7 Public Consultation

EEPGL has conducted a robust public consultation program to both inform the public about the Project and to understand stakeholder concerns so this feedback could be incorporated into the EIA, as applicable. EEPGL has held various workshops with the government and others regarding offshore oil and gas development. EEPGL and/or ERM have held meetings with over 30 Guyana government agencies/commissions, many elected officials and Regional Administrators, over 15 professional or business associations, various international and domestic non-governmental organizations, several universities and research institutes, various religious and ethnic organizations, and the media. EEPGL and ERM participated in two sector agency scoping meetings, with over 150 attendees of which approximately 100 were members of the general public. These were followed by six public scoping meetings in Regions 1 through 6, which had over 300 attendees, of which over 200 were public participants.

EIS 2.8 Alternatives

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

- Location Alternatives - The location of the Project, and the development wells in particular, is driven by the location of the resource to be recovered. There are no meaningful differences in location alternatives for the FPSO, SURF equipment, and drill centers within the PDA, as the nature of the seafloor and the water surface are not expected to vary appreciably across the area; thus, no environmental or social benefits would be achieved by minor location modifications.

- Development Concept Alternatives –
    - Facility Type: Given the water depth and distance to shore of the Liza field, the development alternatives 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, which would increase environmental impacts. The FPSO was chosen because it is a more efficient, stand-alone solution for deepwater oil processing and storage, and is also the environmentally preferred alternative.
    - Gas Disposition: Three primary alternatives were considered for addressing associated gas produced during Phase 1 operations: gas re-injection, gas export, and continuous flaring. Gas re-injection was determined to be feasible for Phase 1, and it also provides benefits in reservoir management. As such, 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 continue to be evaluated, particularly given challenges related to commercialization of associated gas. The FPSO has been designed to allow for future gas export should an export alternative be identified.
- Technology Alternatives – EEPGL is using the most appropriate industry-proven technology 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 the Project in Guyana.
- No-go Alternative – Under this alternative the Project would not be executed and the existing conditions in the PDA would remain unaffected by the Project, and the potential positive and negative impacts assessed 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 also selection of the environmentally preferred action alternative.

EIS 3.0 PROJECT IMPACTS

This section summarizes the predicted environmental and socioeconomic impacts of the Project resulting from planned activities and potential unplanned events (specifically an oil spill), as well the Project's contributions to cumulative impacts on important 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 the Section 6 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	Economic Conditions
Sound	Coastal Habitats	Employment and Livelihoods
Marine Geology and Sediments	Coastal Wildlife and Shorebirds	Community Health & Wellbeing
Marine Water Quality	Seabirds	Marine Use and Transportation
	Marine Mammals	Social Infrastructure and Services
	Marine Turtles	Cultural Heritage
	Marine Fish	Land Use
	Marine Benthos	Ecosystem Services
	Ecological Balance and Ecosystems	Indigenous Peoples

EIS 3.1 Planned Activities

The Project is an offshore oil development and all drilling, installation, production operation, and decommissioning activities will occur over 190 km (~120 miles) off the coast of Guyana. The Project should not disturb any natural onshore habitats. There may be a minor increase in traffic congestion near the onshore shorebases, and a Road Safety Management Procedure should mitigate those impacts. 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 would be air quality and marine-oriented resources (i.e., marine sediments, water quality, and biological resources), which are discussed briefly below.

EIS 3.1.1 Air Quality

Emissions generated by the Project generally emanate from three source categories: (a) specific point sources such as the power generating units and diesel engines on drill ships and on the FPSO, (b) non-routine flaring used to combust produced gas when not consumed as fuel gas on FPSO or re-injected, and (c) general area sources such as support vessels, construction vessels, tug boats, 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 being less than or equal to 1 percent of the WHO guideline).

The Project will also emit greenhouse gases (GHGs) throughout its predicted lifecycle, with peak emissions during steady-state production operations stage estimated to be approximately 980 kilotonnes of CO_2-equivalents per year. There are no applicable regulatory criteria against which these GHG emissions can be compared, but these emissions are 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 (which is not used as fuel on the FPSO) back into the Liza reservoir, which represents a significant reduction in potential GHG emissions versus that which would result from routine gas flaring.

EIS 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.

During well drilling as each well is started, the Project will release a small volume of WBDF and cuttings at the seafloor. Low toxicity NADF will be used for the remainder of the well drilling, but will be captured, recovered to the extent practicable, and reused. EEPGL would treat the drill cuttings to reduce the drilling fluids retained on the cuttings prior to discharging overboard. Modeling indicates that the residual NADF on the cuttings may have a localized, minor impact on water quality.

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.

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 within approximately 100 meters of the discharge point.

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, Chlorine	≤ 700,000 bpd	Discharge will meet internationally recognized standards limiting increases in ambient water temperature.
Produced Water	Water separated from reservoir fluids	Oil & grease, Temperature, Residual production and water treatment chemicals	≤ 100,000 bpd	Will be treated to meet internationally recognized limits on oil & grease content.
Sulfate Removal and Potable Water Processing Brines	Removal of sulfates from seawater prior to injection; potable water processing	Biocide, Chlorine, Oxygen scavenger, Scale inhibitor	≤ 100,000 bpd	Discharge meets applicable standards without treatment.
Domestic & Sanitary Wastewater	Personnel black and gray water, food wastes	Nutrients, chlorine, bacteria	9,000 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	≤ 1,100,000 barrels during each loading	Discharge will be conducted in accordance with internationally recognized standards.

EIS 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 0.3 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 ship 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 the localized accumulation of cuttings on the seafloor, primarily around the well 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 polychaete worms, occur at low densities. Modeling indicates that smothering effects from drill cuttings would be limited to a very small area around the well (approximately 43 m diameter area).

EIS 3.1.4 Marine Biological Resources

Marine resources (i.e., seabirds, fish, mammals, and turtles) have the potential to be impacted by the Project, but it was determined that the significance of these impacts range from minor to negligible for the reasons explained below.

The Project could impact seabirds by interfering with their migration (i.e., lights serving as attraction), and potential exposure to the radiant heat from the flare. The Project lighting will be downcast to minimize its attraction potential and flaring will be non-routine and temporary (i.e., during select maintenance activities), so the overall Project impact on seabirds was determined to be negligible.

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 m 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.

Marine mammals may be impacted by two types of sound: continuous sound from vessels and machinery operating in the PDA, and by comparatively louder, shorter duration impulse sound from Vertical Seismic Profiling (VSP) and driven piles. 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 approximately 10 m horizontal distance from the vessels, approximately 100 m from the VSP, and approximately 1300 m from the driven piles (at depths > 1000m). Many of the larger baleen whales and dolphins would naturally avoid the area of potential effect (especially around Drill Center 2) because it would be deeper than their typical maximum dive depths. Others, such as sperm whales, dive deep enough that they could potentially be exposed to injurious sound levels throughout the PDA, however it would not be expected that they would be exposed for continuous time periods predicted to be necessary to result in injury. Vessel strikes would likely pose more of an immediate threat than auditory injury. Marine observers will be used to monitor for mammals present prior to or approaching during the VSP, and soft start procedures will be used to allow any mammals in the immediate vicinity of the VSP and pile driving to vacate the area before sound levels reach potentially injurious levels in accordance with JNCC guidelines. Vessel crews will also lookout for marine mammals to minimize the potential for vessel strikes.

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. The most significant potential Project-related impacts on marine turtles would be from marine vessel strikes and the same measures employed to manage risks of strikes on mammals would help manage risks of strikes on turtles. Numbers of vessel trips are modest in relation to existing vessel activity in Guyana waters; thus, impacts to marine turtles are not anticipated to result in a significant impact.

EIS 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, three types of unplanned events were identified and considered – hydrocarbon spill, vessel collision, and onshore vehicular accident. While a vessel collision and a vehicular accident could result in injuries, significant injuries or fatalities would be expected to be rare occurrences considering likely vessel and vehicle speeds in areas where risk of collisions is highest. Thus, vessel collisions and vehicular accidents are considered to have small, temporary, and localized impacts. The remainder of this section focuses on the potential impacts from an 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 nine spill scenarios, including spills of different types of hydrocarbons (e.g., crude oil, marine diesel, fuel oil, lubricating oil, NADF), with several being applicable for spills at the shorebases and on vessels in the Demerara River estuary (e.g., from supply vessel) or in the Atlantic Ocean (e.g., from a well, drill ship, 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 expected to be 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 190 km (~120 mi) 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 sensitive coastal resources 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 to 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. The oil spill model indicates that even in the unlikely event of an oil spill, there is only a 5 to 10 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 10 percent.

It is highly unlikely oil spilled in the Liza field would reach the Guyana shoreline in the case of an actual spill. In addition to the low probability of oil reaching the Guyana shoreline 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 and furbearers), as well as coastal communities and indigenous peoples dependent on fishing in the ocean and other ecosystem services (Table EIS-4). However, 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 these resources being considered minor.

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 Wildlife	Mangroves and wetlands are common habitats along the Guyana coastline (and support many species) and are considered 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. 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.

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
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

EIS 3.3 Cumulative Impacts

The Project is located approximately 190 km (~120 mi) offshore, so there are few opportunities for the Project to cumulatively impact resources that would be impacted by other activities. There is the potential for other future offshore Guyana oil and gas exploration and possibly development. If such non-Project activities were to occur, the Project and non-Project activities together could cumulatively impact some resources such as Marine Mammals (via vessel strikes or sound), Marine Turtles (vessel strikes), Marine Fish (degraded water quality and seawater entrainment), Community Health and Wellbeing (increased demand on limited medical treatment capacity), Marine Use and Transportation (marine congestion especially near

Georgetown harbor), and Social Infrastructure and Services (increased demand for limited housing, utilities, and services). Many of the above potential impacts that require offshore interaction between the Project and others have a limited chance of co-occurring, given the size of the Stabroek Block. Thus, potential cumulative impacts were considered to be of Minor significance.

EIS 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 0.3 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 recolonization of the impacted areas. Even in the unlikely event of an 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 on the volume and duration of the release as well as the time of year the release were to occur.

EIS 3.5 Environmental and Socioeconomic 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
  - Waste Management Plan
  - Marine Ecosystems Management
- Socioeconomic Management Plan, including:
  - Stakeholder Engagement Plan
  - Grievance Management
  - Transportation and Road Safety Management
  - Cultural Heritage Management and Chance Finds
- Environmental and Socioeconomic Monitoring Plan
- Oil Spill Response Plan, including
  - Oil Spill Modeling
  - Coastal Sensitivity Mapping
  - Emergency Preparedness and Response Procedures
- Preliminary End of Operations Decommissioning Plan

EIS 4.0 CONCLUSIONS AND RECOMMENDATIONS

EIS 4.1 Conclusions

The planned Project is predicted to have minor impacts on physical resources (i.e., air quality, marine sediments, and water quality), no impacts on coastal biological resources, minor impacts on marine biological resources, and largely positive impacts on socioeconomics. These predictions are based on the fact that the bulk of the Project will occur approximately 190 km (~120 miles) offshore, and the Project will capture and re-inject produced natural gas; treat all significant wastewater streams prior to discharge to the sea; have a very small footprint (e.g., only physically disturb about 0.3 km^2 of benthic habitat); and use MMOs during VSP operations to minimize the potential for auditory damage and injury from ship strikes 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, and oil spill modeling has been conducted to evaluate the range of likely spill trajectories and rates of travel. The location of the Project 190 km (~120 miles) offshore, prevailing northwest currents, the light nature of the Liza field crude oil, and the region's warm waters would all help minimize the severity of a spill. Accounting for these factors, the modeling indicates only a 5 to 10 percent probability of oil reaching the Guyana coast, without taking into consideration the effectiveness of any oil spill response.

Although the probability of an oil spill reaching the Guyana coast is very small, a well control spill at a Liza well would likely impact marine resources found near the well, such as sea turtles and certain marine mammals (especially baleen whales) that may transit or inhabit the area impacted by a spill. Air quality, water quality, seabirds, and marine fish 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 fishermen if commercial fish and shrimp were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year the release were to occur (e.g., whether a spill would coincide with the time of year [May to September] when these species are more common in the PDA). Effective implementation of the OSRP would reduce this risk by further reducing the ocean surface area impacted by a spill and oil exposure to these species.

Table EIS-6 provides a summary of the predicted residual (taking into consideration proposed mitigation measures) impact significance ratings for impacts to each of the resources/receptors that may result from each of the Project stages (i.e., well drilling, SURF/FPSO installation, production operations, and decommissioning), unplanned event (i.e., oil spill), and cumulative impacts.

Table EIS-6 Summary of Residual Impact Ratings

Resource	Drilling and Installation	Production Operations	Decommissioning	Oil Spill*	Cumulative Impacts
Air Quality and Climate	Negligible	Negligible	Negligible	Minor	Negligible
Sound[2]	None	None	None	Minor	None
Marine Geology/Sediments	Negligible	None	None	Minor	Negligible
Marine Water Quality	Minor	Minor	Minor	Moderate	Minor
Protected Areas	None	None	None	Minor	None
Special Status Species:**					
• Critically Endangered and Terrestrial Species	Negligible	Negligible	Negligible	Minor	Minor
• Vulnerable/Near Threatened Species (sharks & bony fish)	Minor	Minor	Minor	Minor	Minor
• Endangered Fish and Black Capped Petrel	Negligible	Negligible	Negligible	Minor	Minor
Coastal Habitats	None	None	None	Minor	None
Coastal Wildlife/Shorebirds	None	None	None	Minor	None
Seabirds	Negligible	Negligible	Negligible	Minor	Negligible
Marine Mammals	Moderate	Negligible	Negligible	Moderate	Minor
Marine Turtles	Minor	Negligible	Negligible	Moderate	Minor
Marine Fish	Minor	Negligible	Negligible	Minor	Minor
Marine Benthos	Negligible	Negligible	Negligible	Minor	Negligible
Ecological Balance & Ecosystems	Negligible	Minor	Negligible	Minor	Negligible
Economic Conditions	Positive	Positive	Positive	Minor	Negligible
Employment/Livelihoods	Positive	Positive	Positive	Minor	Negligible
Community Health & Wellbeing	Minor	Minor	Minor	Minor	Minor
Marine Use/Transportation					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Minor
• Commercial fishing	Minor	Minor	Minor	Minor	Minor
• Subsistence fishing	Minor	Minor	Minor	Minor	Minor
Social Infrastructure /Services	Negligible	Negligible	Negligible	Minor	Minor
Cultural Heritage	Negligible	Negligible	Negligible	Minor	Negligible
Land Use	Negligible	Negligible	Negligible	None	Negligible
Ecosystem Services	None	None	None	Minor	None
Indigenous Peoples	None	None	None	Minor	None

*Based on oil spill modeling of an unmitigated well control event in the PDA that indicates oil reaching Guyana shoreline is highly unlikely (5-to 10 percent probability).
** Excludes listed sea turtles, which are covered in the Marine Turtles resource category.

[2] Sound-related impacts on Marine Mammals are factored into the Marine Mammal impact assessment.

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

- Through revenue sharing with the Government of Guyana, although the details of this revenue sharing is confidential. 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 and outside the scope of the EIA;

- By procuring select Project goods and services from Guyanese businesses to the extent reasonably practicable; and

- By hiring Guyanese nationals where reasonably practicable, although the potential magnitude of hiring will be limited.

In addition to direct revenue sharing, expenditures, and employment, the Project would also likely generate induced economic benefits as other non-Project related businesses benefiting from direct Project purchases or worker spending will re-invest locally or expand spending in the area, thereby also generating more local value-added tax. These beneficial "multiplier" impacts will occur throughout the Project life.

EIS 4.2 Recommendations

ERM recommends the following measures be considered by EPA, GGMC, and the EAB as conditions of any approval of the Project:

- Embedded Controls – incorporate all of the proposed embedded controls (see EIA Chapter 11).
- Mitigation Measures – adopt the recommended mitigation measures (see EIA Chapter 11).
- Management Plans – implement the proposed Environmental and Socioeconomic Management Plan.
- Oil Spill Response –EEPGL has proactively embedded many controls into the Project design to prevent a spill from occurring, and we agree that a spill is unlikely. But given the sensitivity of many of the resources that could be impacted by a spill (e.g., Shell Beach Protected Area, marine mammals, critically endangered and endangered sea turtles, Amerindian 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, document the availability of appropriate response equipment on board the FPSO, and demonstrate that offsite equipment could be mobilized for a timely response.

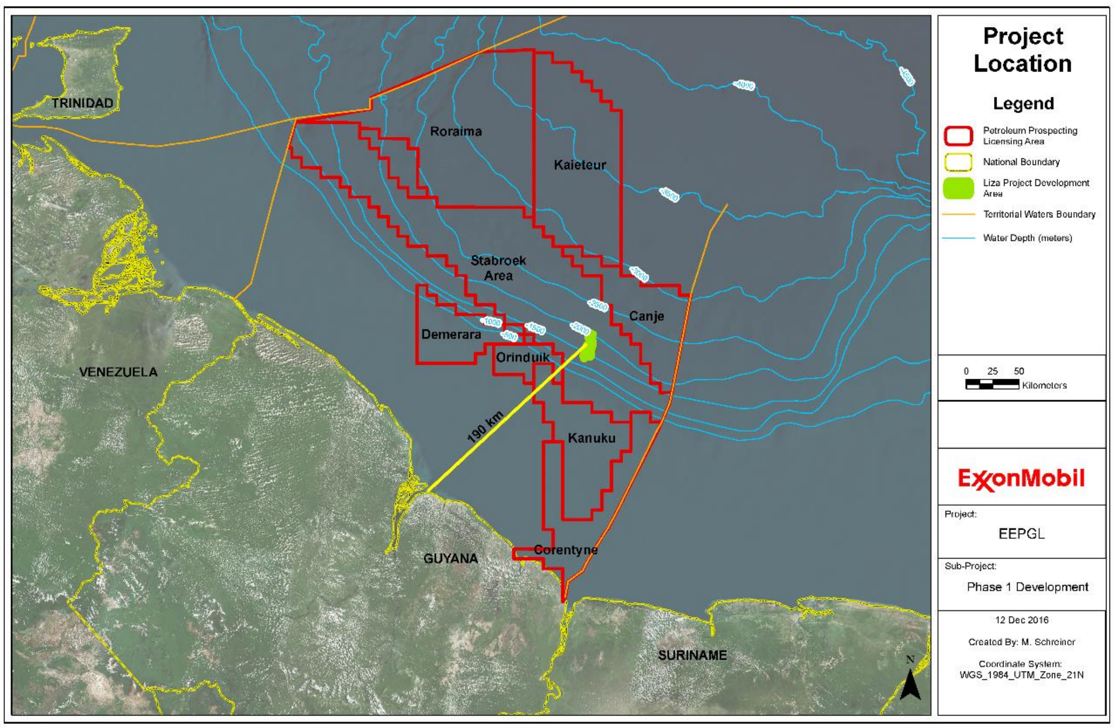
With the adoption of such embedded controls, mitigation measures, and management plans, and requirements for emergency response preparedness, the Liza Phase 1 Development Project is expected to pose only minor risks to the environmental and socioeconomic resources of Guyana, while potentially offering significant economic benefits to the residents of Guyana.

ENVIRONMENTAL IMPACT ASSESSMENT

1.0 INTRODUCTION

Esso Exploration and Production Guyana Limited (EEPGL)[3], together with its joint venture partners Hess Guyana Exploration Limited and CNOOC Nexen Petroleum Guyana Limited, is seeking an environmental authorization for the first phase of oil field development of the Liza prospect in the eastern half of the Stabroek Block (hereafter referred to as the Liza Phase 1 Development Project, or the Project), which is located approximately 190 km (~120 mi) offshore from Georgetown (Figure 1-1). Based on exploration and assessment activities in the Stabroek Block, including three exploration wells (Liza-1, Liza-2, and Liza-3, respectively), EEPGL believes these reservoirs potentially contain a recoverable resource of between 0.8 and 1.4 billion oil equivalent barrels.

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



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

3 EEPGL will be the operator of the Project, and is used in this EIA to represent the joint venture.

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 July 5, 2016. 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 for Environmental Authorisation[4] to permit the Project. After submission and review of this EIA, the EPA takes into account recommendations from the Environmental Advisory Board (EAB) and the Guyana Geology and Mines Commission (GGMC), the public's comments, and EPA's own review, including support from technical experts within other ministries, in deciding whether and under what conditions to grant EEPGL's Application.

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. GGMC oversees EEPGL's Prospecting Licence, under which offshore exploration and drilling activities (e.g., Liza 1, 2, and 3 wells) were conducted, and has received EEPGL's application for a Petroleum Production Licence and associated Development Plan for the first phase of the Liza field development. GGMC will also provide technical input into the review of the EIA, as discussed above, and will consider the findings of the EIA as part of its evaluation of EEPGL's application for Petroleum Production Licence for the Liza Phase 1 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 and whether the environmental authorization should be granted, and if so, under what terms and conditions.

This EIA was prepared by Environmental Resources Management (ERM), which is an international environmental and social consulting firm with extensive experience in the preparation of EIAs for offshore oil and gas development projects. In the Project's Final Terms of Reference (ToR), EPA approved ERM as the independent consultant to undertake the EIA. This EIA has been prepared in compliance with the Guyana Environmental Protection Act (EP Act, Cap.20:05), the Environmental Protection (Authorisation) Regulations (2000), the Environmental Impact Assessment Guidelines – Volume 1, Version 5 (2004), the Environmental Impact Assessment Guidelines – Volume 2, Version 4 (2000), other applicable Guyana

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

regulations, international good practice, EEPGL's corporate standards, and in accordance with ERM's standard practice.

1.2 EEPGL Exploration Well Drilling History

EEPGL has drilled five exploration wells within the Stabroek Block offshore Guyana, with a sixth well planned in 2017, as indicated in Table 1-1 below. 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.

Tab1e 1-1 EEPGL Stabroek Exploration Well Drilling History

Well Name	Year Drilled	Result
Liza-1	2015	Successful (oil found)
Liza-2	2016	Successful
Liza-3	2016	Successful
Skipjack	2016	Dry well (no oil found)
Payara	2016	Successful
Snoek	Planned for 2017	Not available

1.3 Goals and Objectives of the EIA

The goals of the EIA are to:

- Provide the factual and analytical basis required by EPA and the GGMC to make an informed decision on EEPGL's Application for Environmental Authorisation to permit the Project; and
- Provide a basis for EEPGL to understand and appropriately avoid or manage the risks imposed by the Project via design or other management measures.

In support of those goals and in accordance with the EIA Final ToR, which were approved by the EPA on February 17, 2017, the underlying objectives of the EIA are to:

- Describe the Project, including its various components and activities and full life cycle through to decommissioning;
- Describe the existing conditions within the Project's Area of Influence (AOI);
- Identify and assess the potential direct and indirect environmental and socioeconomic impacts that could credibly result from the Project using a risk-based assessment process;
- Evaluate the potential for cumulative impacts;
- Describe a strategy to manage the identified significant adverse impacts of the Project;
- Characterize potential positive benefits of the Project; and
- Recommend monitoring to assess the effectiveness of the management strategy.

1.4 Components of the EIA

As required by the Guyana EP Act (Cap. 20:05) and further described in the Guyana Environmental Impact Assessment Guidelines, this EIA includes the required components of an EIA:

- Project Description – see Chapter 2 of the EIA;
- Environmental Baseline Studies – see Chapter 6 of the EIA;
- Environmental Assessment – see Chapters 7, 8, and 10 of the EIA;
- Environmental Impact Statement – provided at the beginning of the EIA; and
- Environmental and Socioeconomic Management Plan – the Environmental and Social Management Plan (ESMP) Framework is provided as Chapter 9 of the EIA.

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* (November 2004) includes as Appendix 2 an EIA Review Checklist. Provided below in Table 1-2 is an EIA "roadmap" that shows where all of the Checklist "Items Evaluated" can be found in this EIA.

Table 1-2 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 ToR confirmed
2. Multidisciplinary Team *The accuracy of the EIA depends on the qualifications of the multidisciplinary team not only regarding the EIA process and methods but also regarding their knowledge of the several stages of the specific type of project. Therefore, individual CVs should be submitted as part of the EIA Annexes. Signatures of each member of the team must be affixed.*	• Chapter 12 lists all team members and references, Appendix A provides signatures, and Appendix B includes all CVs.
3. Inter-disciplinary Achievement *An EIA must present information regarding the interactions and integration between the physical, biological and socio-economic aspects of the environment in that particular area of the study.*	• Chapter 7 includes assessment of all three categories of resources

EIA Review Checklist Items	Corresponding EIA Reference
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 EIS
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?* *5.02 Are all phases identified (e.g. planning, construction, operation and decommissioning)?* *5.03 Is the geographical area for each phase identified?* *5.04 Are the land use requirements for each phase identified?* *5.05 Is there an inventory of the nature and quantity of materials used in the production process?* *5.06 Are there inventories of the type and quantity of products, by-products and effluents expected to be produced by the project?* *5.07 Is there an inventory of the type and quantity of residues?* *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?* *5.09 Is information on employment provided?*	• 5.01 – see Chapter 2 • 5.02 – see Section 2.3 (Drilling), 2.6 (Installation, Hookup, and Commissioning), 2.7 (Production Operations), and 2.9 (Decommissioning) • 5.03 – see Section 2.1, all stages occur within this same area • 5.04 – see Section 2.8, only onshore supply and support has any land requirements • 5.05 – see Section 2.10 • 5.06 – see Section 2.10 • 5.07 – see Section 2.10 • 5.08 – Noise impacts are quantified in Section 7.2.5; thermal and liquid discharges are quantified in Section 7.1.4; and air (gaseous) emissions are quantified in Section 7.1.1 • 5.09 – see Section 2.12

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.* *6.01 Did the developer consider alternatives?* *6.02 Was the "no-project" scenario considered?* *6.03 Were the environmental factors adequately presented for each alternative?* *6.04 Is the final choice adequate?*	• 6.01 – see Section 2.16 • 6.02 – see Section 2.16 • 6.03 – see Section 2.16 • 6.04 – see Sections 2.16 and 10
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.*	• See Section 5.1
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.*	• See Sections 3.1 through 3.3
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.* *9.01 Has the compatibility between the proposal and the identified existing activities been analysed?* *9.02 Are the activities compatible?* *9.03 Does the inventory of existing activities match what is observed?*	• See Chapter 8, which discusses other activities in the AOI, as part of the Cumulative Impact Assessment • 9.01 – see Section 8.1.2 • 9.02 – see Section 8.1.2 • 9.03 – see Section 8.1.2

EIA Review Checklist Items	Corresponding EIA Reference
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.* *10.01 Is the information presented specific and relevant?* *10.02 Were difficulties in attaining information (if any) documented?* *10.03 Have the impact indicators identified been adequately covered (see Section 13)*	• See Chapter 6 • 10.01 – see Chapter 6 • 10.02 – see Chapter 6 • 10.03 – see Chapter 6
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.*	• See Chapter 4 for a description of the EIA methodology • See Chapter 7, which includes description of analytical approach for each resource
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?*	• See Section 7.1, which addresses impacts to physical resources
12.2. Biological Impacts *- Have all the identified impacts on flora, fauna, rare / endangered species, sensitive ecosystems, species habitats and ecological balance been checked against the relevant impacts in the ToR.*	• See Section 7.2, which addresses impacts to biological resources

EIA Review Checklist Items	Corresponding EIA Reference
- 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?*	
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?*	• See Section 7.3, which addresses impacts to 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?*	• See Section 7.3.7, which addresses cultural heritage resources

EIA Review Checklist Items	Corresponding EIA Reference
- Have the social implications of the impacts been assessed? *- Have cause/effect relations been properly identified?*	
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?*	• See Section 7.3, which addresses economic resources (combined with other 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?*	• Other potentially impacted resources not specifically listed above have been included, such as marine sediments, marine use and transportation, and indigenous peoples.

EIA Review Checklist Items	Corresponding EIA Reference
- Has the social distribution of the impacts been identified? *- Have cause/effect relations been properly identified?*	
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.* *13.01 Have cumulative impacts been adequately identified and characterized?* *13.02 Have the magnitudes been estimated?* *13.03 Have the impacts been assigned a significance?* *13.04 Has the social distribution of the impacts been identified?* *13.05 Have cause/effect relations been properly identified?*	• 13.01 - see Chapter 8 • 13.02 – see Section 8.2 • 13.03 – see Section 8.2 • 13.04 – see Section 8.2 • 13.05 – see Section 8.2
14. Impact Indicators *Impact indicators are the parameters used to estimate the magnitude of the impacts.* *14.01 Were the impact indicators used adequate for all the impacts identified?*	• See Chapter 4, which outlines approach for characterizing magnitude of impacts • See Chapter 7, which assesses magnitude for impacts
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.* *15.01 Have the impact prediction techniques used been described?* *15.02 Are they adequate?*	• 15.01 – see Chapter 4, which describes the impact assessment methodology used; Chapter 7 describes methodology and results of analytical approaches for each resource/receptor • 15.02 – see Chapter 4
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*	• See Chapter 4, which describes the approach for characterizing magnitude of impacts • Chapter 7 assesses magnitude for impacts for each resource/receptor

EIA Review Checklist Items	Corresponding EIA Reference
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)?	
17.0 Importance/Significance of Impacts *Usual methods involve objective criteria regarding the ecological and social relevance of the project* *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?* *17.02 Is the significance based on objective criteria in order to minimize subjectivity of judgments?*	• 17.01 – see Chapter 4, which describes the approach for characterizing the importance and significance of impacts • 17.02 – see Chapter 7, which describes the methodology and results of analytical approaches for each resource/receptor
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.*	• See Chapter 7.3, which addresses impacts to socioeconomic resources (specifies affected groups)
19 Stakeholder Participation *19.01 Are the results of stakeholder participation, such as the results of interviews, hearings etc. clearly documented?* *19.02 Have questionnaires used been included?* *19.03 Are the extent and method of stakeholder participation adequate?* *19.04 Are the conclusions drawn valid, based on available data?*	• 19.01 – see Section 4.5 • 19.02 – No specific questionnaires were used, but numerous Key Informant Interviews, informal meetings, capacity building workshops as well as two Agency/Sector scoping meetings and six public scoping meetings from Regions 1-6 were held. • 19.03 – see Section 4.5 • 19.04 – see Section 4.5
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.*	• See Section 2.16 and Chapter 10
21 Environmental Management Plan (EMP)	• See Chapter 9 and the ESMP

EIA Review Checklist Items	Corresponding EIA Reference
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*	
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?*	• See Section 9.6 and the 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.*	• See Chapter 9 and the ESMP

2.0 PROJECT DESCRIPTION

Previous seismic testing and exploratory drilling have determined the presence of a high porosity sandstone reservoir of crude oil with an estimated recoverable resource of 0.8 to 1.4 billion oil-equivalent barrels in an area referred to as the Liza field, located within the eastern half of the Stabroek Block.

The purpose of this Project is to develop the Liza field and produce the oil in what is referred to as the Liza Project Development Area (PDA). Phase 1 of the Project will consist of the drilling of approximately 17 development wells, the installation and operation of Subsea Umbilicals, Risers, and Flowlines (SURF) equipment, the installation and operation of a Floating Production, Storage, and Offloading (FPSO) facility, and ultimately Project decommissioning. The Project will also involve onshore facilities and marine/aviation services to support development drilling, installation, production operations, and decommissioning.

This section discusses the following information related to the Project:

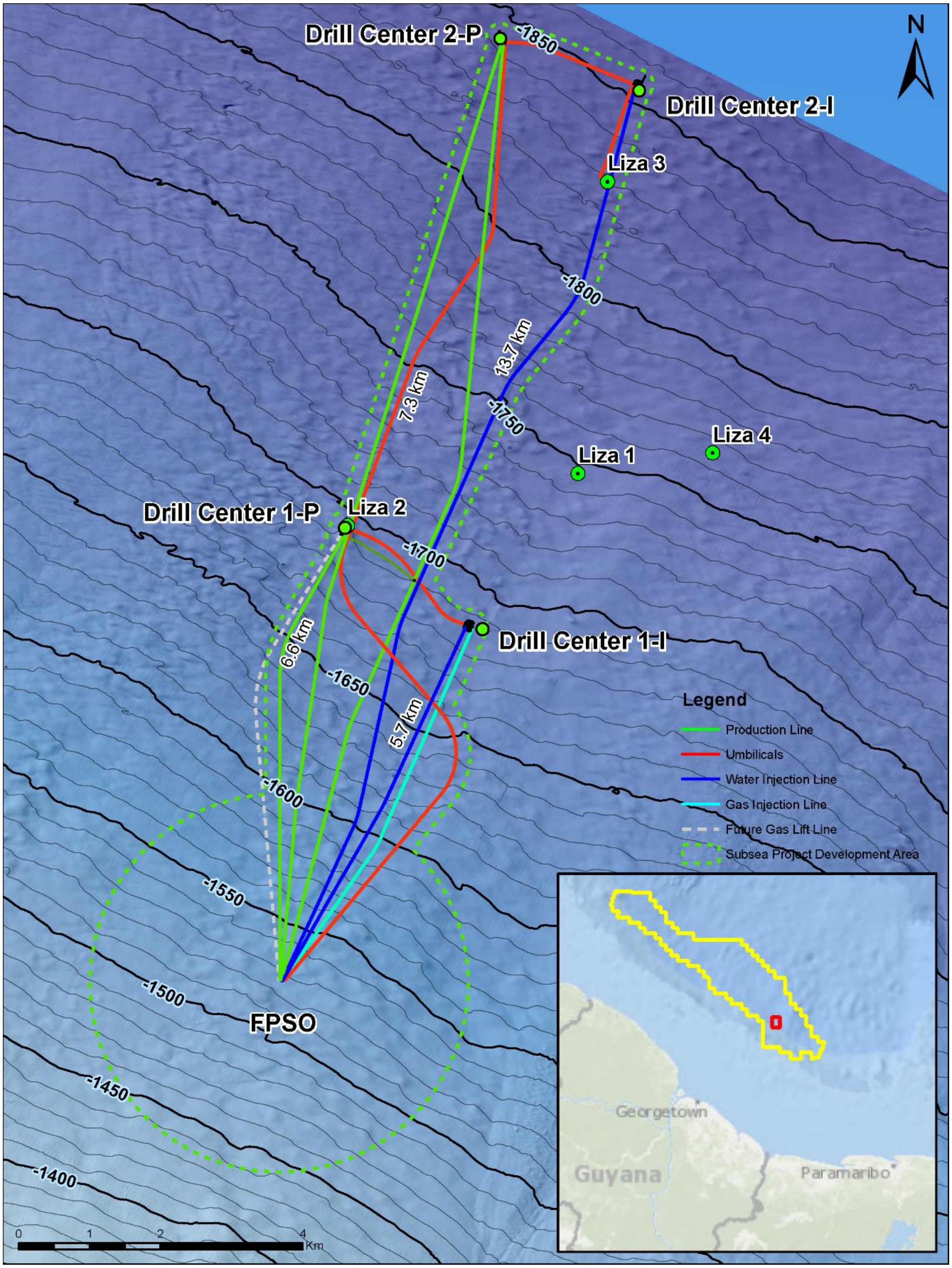
- Project location;
- Overview of development concept;
- Drilling and well design;
- SURF;
- FPSO vessel, including topsides facilities and the vessel mooring system;
- Installation, hook-up, and commissioning activities;
- Production operations, including offloading by conventional tankers;
- Onshore, marine, and aviation support;
- End of operations (decommissioning);
- Materials, emissions, discharges, and wastes;
- Embedded controls;
- Project workforce;
- Worker health and safety;
- Project schedule; and
- Project alternatives.

2.1 Project Location

The Stabroek Block, which covers an area of approximately 26,800 km^2, is oriented roughly parallel to the Guyana coastline, extending across the entire width (northwest to southeast) of Guyana territorial waters. Figure 1-1 illustrates the location of the Liza PDA, which is located approximately 190 km (~120 mi) from the coastline northeast of Georgetown, within the Stabroek Block.

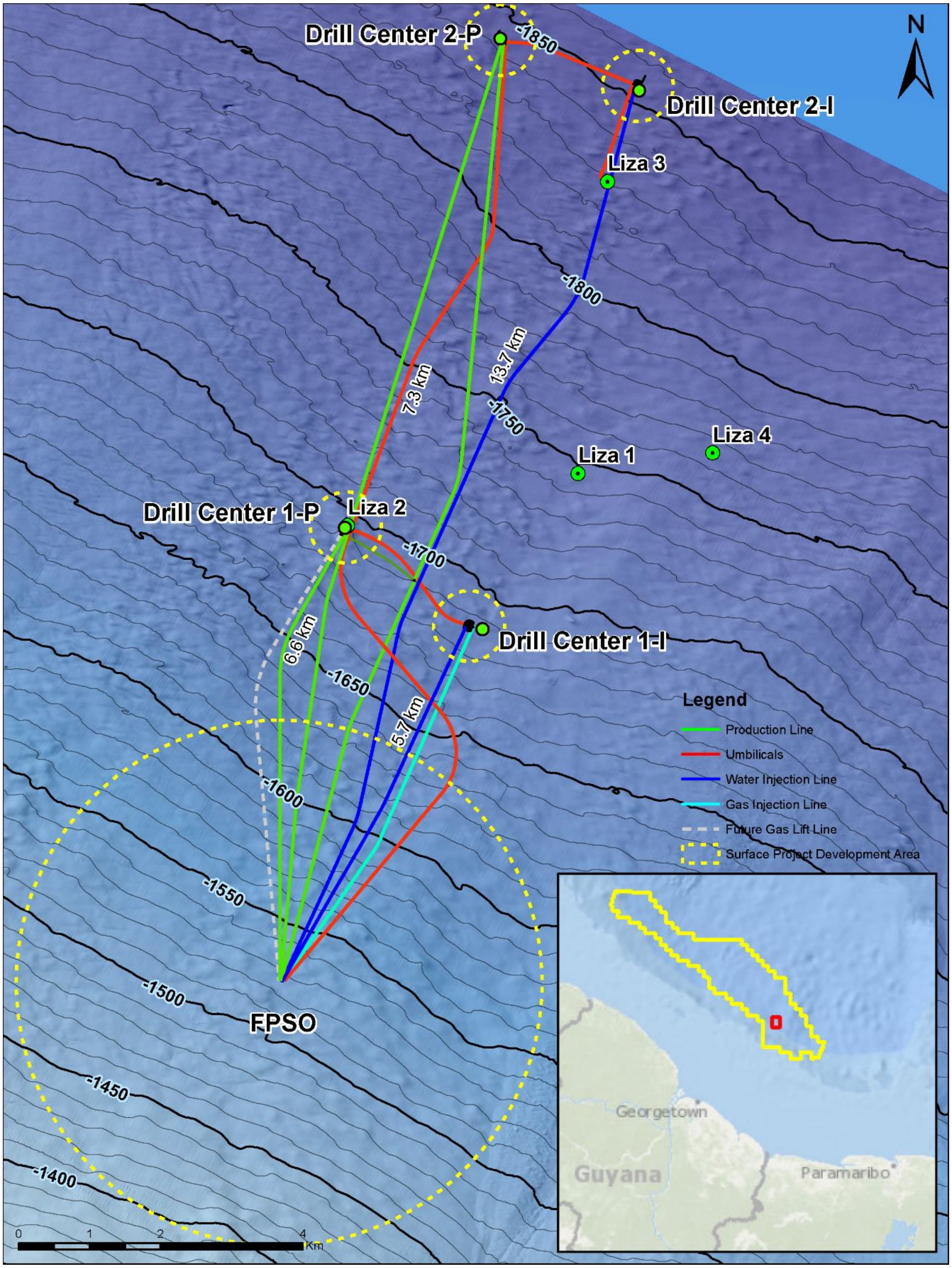
Figures 2-1 and 2-2 illustrate the preliminary conceptual layout of the FPSO, SURF equipment, and drill centers within the Stabroek Block; their proximity to the Liza-1, Liza-2 and Liza-3 exploration wells; and the subsea and surface extents of the PDA, respectively.

Figure 2-1 ***Subsea Project Development Area for FPSO Installation, SURF, and Drill Centers within Stabroek Block***



Note: Locations on figure subject to change.

Figure 2-2 Surface Project Development Area for FPSO and Drill Centers within Stabroek Block



Note: Locations on figure subject to change.

The locations of the future development wells will be finalized before Project implementation; however, the decision has been made that the wells will be drilled from two main drill centers[5].

During the development drilling, installation of the FPSO/SURF facilities, and production operations stages, work may be performed in the area denoted on Figure 2-1 as the Subsea PDA, covering an estimated 4,500-5,000 hectares (ha). Most of this subsea area will not be physically disturbed; the estimated subsea area to be disturbed during installation of SURF equipment and the FPSO mooring system (see Figure 2-1) is approximately 400,000 m^2 (30 ha) (incorporating a 50 percent contingency factor).

During the development drilling and FPSO production operations stages, work may be performed on the surface of the ocean within the area denoted on Figure 2-2 as the Surface PDA, also covering an estimated 4,500-5,000 ha. As further described in subsequent sections and represented on Figure 2-2, some of the ocean surface would have operational constraints that would restrict unauthorized vessels from entering a defined safety exclusion zone during drilling, installation, and production operations. Note, however, that while Figure 2-3 shows four potential exclusion zones around the drilling locations, a maximum of only two drill ships will be operating at any one time. The safety exclusion zones for the large installation vessels are not specifically denoted on Figure 2-2; however, exclusion zones similar to those for the drill ships will be maintained for these vessels while working in the PDA.

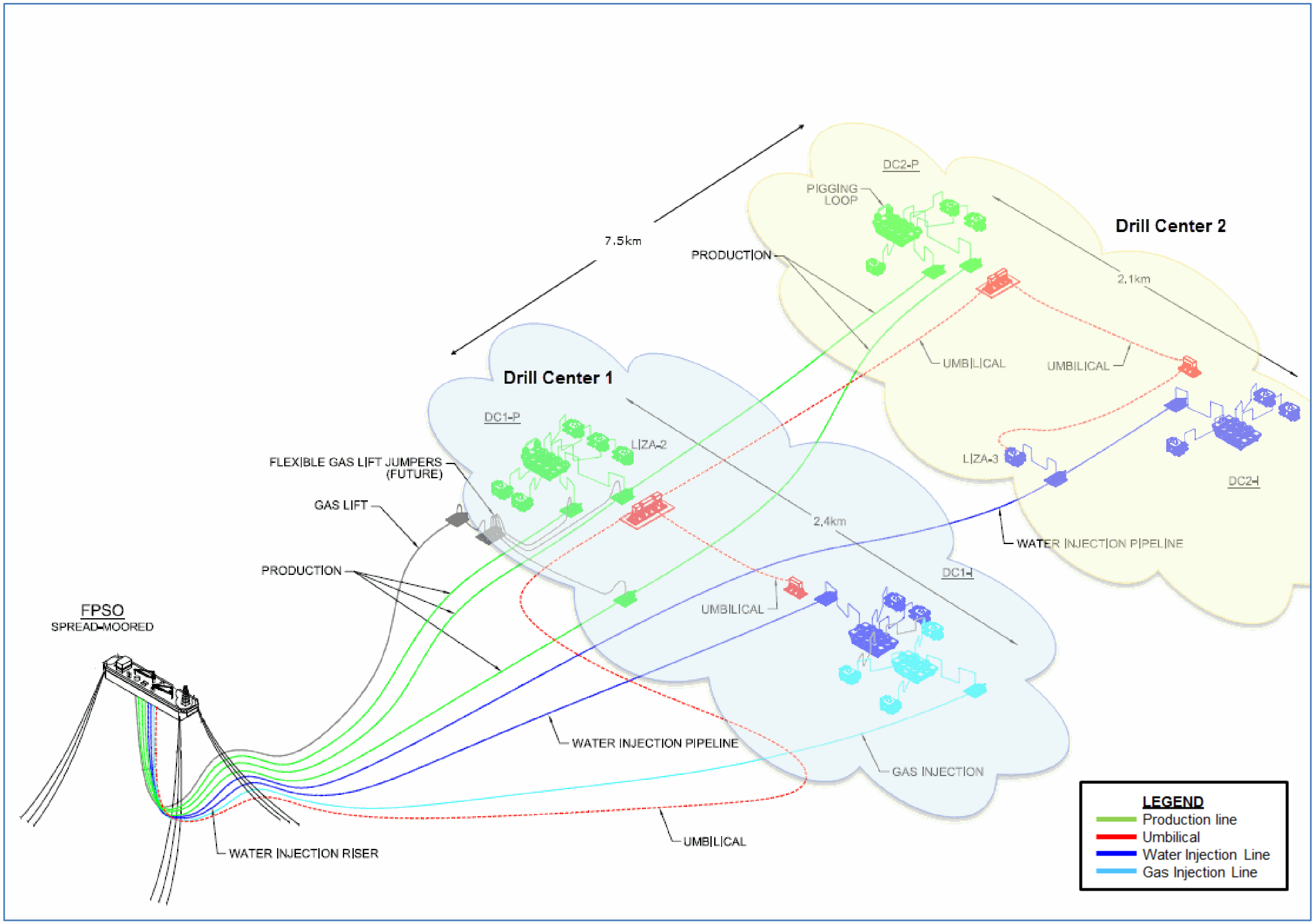
2.2 Overview of the Development Concept

2.2.1 Development Concept

The Liza field will be developed during Phase 1 with approximately 17 development wells drilled from two drill centers, each with separate production, gas, and water injection manifolds. Figure 2-3 illustrates the preliminary field layout of the proposed Liza field development, which includes 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 shown on Figure 2-3 are further described in the relevant Drilling, SURF, and FPSO sections in this chapter.

[5] A drill center is defined as a group of wells (including production, water injection, and/or gas 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 1 will be separated into 1-P (production) and 1-I (injection) components.

Figure 2-3 Preliminary Liza Phase 1 Field Layout



The development wells consist of production wells, water injection wells, and gas injection wells. A portion of the associated gas (i.e., gas entrained in the wellstream) produced from the reservoir will be used onboard the FPSO as fuel gas, and the remaining balance will be re-injected back into the reservoir via the gas injection wells. Alternative uses of gas for future phases are being studied and would be addressed in a separate or amended EIA. Water injection will be used as needed to maintain reservoir pressure for optimal production over the life cycle of the Project.

The Liza field will be developed using a spread-moored FPSO (see Section 2.5). The FPSO will be a converted double hull Very Large Crude Carrier (VLCC) that will support the topsides facilities, process the produced wellstream from the production wells, and store the processed crude oil. Offloading of the processed crude oil for export will occur directly to conventional tankers in a tandem configuration. Subsea production, gas, and water injection wells and manifolds will be tied back to the FPSO via flowlines and risers (see Section 2.4).

2.2.2 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, as well as the EEPGL Operations Integrity Management System (OIMS)[6] and the EEPGL Safety, Security, Health, and Environment (SSHE) policies[7]. EEPGL and its contractors will have structured management systems to verify the ongoing application of all necessary codes, standards, procedures, and SSHE management systems. An overview of the EEPGL OIMS Framework is included in Section 3.

2.3 Drilling and Well Design

2.3.1 Drilling Program

The Project proponent is considering the use of up to two drill ships, similar to the drill ship shown on Figure 2-4, to drill the development wells during Phase 1. Both drill ships may be operated simultaneously. Drilling operations may occur prior to, during, and after the installation of the FPSO and SURF components.

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

[7] The SSHE 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 Typical Drill Ship

During the drilling process, drill ships will require various tubulars, instruments, and devices (collectively referred to as the drill string) to conduct the well construction process, which will be as follows: drilling the borehole, running and cementing casings, and installing the completion and production tubing. The drilling program will employ high-angle and extended reach drilling technologies. These technologies allow wells to reach targets up to approximately 4 km (~2.5 mi) from the drilling seabed location. The wells will be clustered around two drill centers rather than distributed over the producing reservoir. This approach reduces the number of drilling locations, thereby reducing the area potentially impacted by drilling operations including discharged drill cuttings[8]. The planned development drilling program and its cuttings management approach is consistent with industry practices, considered protective of the environment, and has been the basis for the Liza-1, Liza-2 and Liza-3 exploration wells.

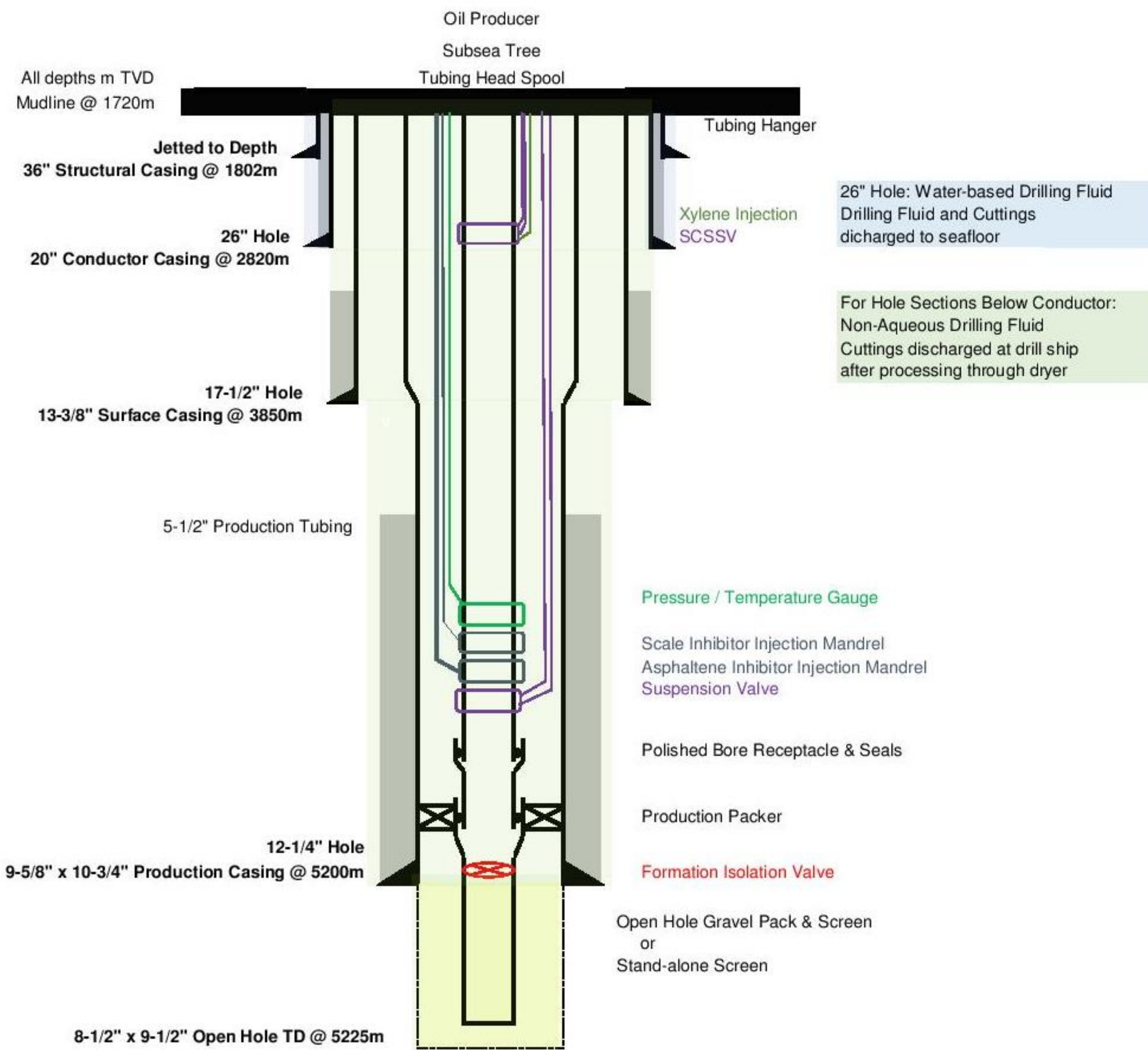
2.3.2 Typical Well Design

Once the borehole is started for a well, pipe (also known as casing) must be inserted into the borehole and cemented in place (to keep the well from collapsing and to seal the casing to the formation). As shown on Figure 2-5, various sized casings will be progressively set as the wells are drilled deeper. The size and strength of the casings to be used in the design of the well takes into account the peak reservoir temperature and pressure conditions that may be encountered during drilling and during production operations when the wells are flowing reservoir fluids. After each casing string cement job is completed, pressure testing will be performed to confirm

[8] Drill cuttings are the broken bits of solid material produced as the drill bit advances through the borehole in the rock or soil. The cuttings are usually carried to the surface by drilling fluid circulating up from the drill bit.

integrity according to standard industry practices. A provisional well program and design, including casing types and sizes, setting depths, drilling fluid types, and discharge locations for the development drilling program is shown on Figure 2-5.

Figure 2-5 Provisional Casing Program for Development Drilling Program



The first (i.e., most shallow) section of each well, also known as the structural casing section, will be jetted or drilled with seawater. Drill fluids and cuttings from this section will be discharged to the sea at the mudline without treatment per standard industry practice. For each subsequent section of the well to be drilled, the drill string will be removed and the casing will be lowered into the hole to prevent its collapse. Wet cement will then be pumped down the casing and forced into the annular space between the hole and the outside of the casing, as well as into the annular space between the present and previously set casing.

The conductor casing, which is designed to hold back seabed surface soils and support the weight of the entire well, is then set and cemented back to the seabed. Drilling fluids and cuttings from this section will be discharged to the sea at the mudline per standard industry practice.

A drilling riser will be deployed to connect the conductor casing and the drill ship, and the blowout preventer[9] (BOP) will be installed. Marine drilling risers with buoyant joints and tension will be used to connect the wells via the BOP to the drill ship. BOPs will be periodically tested during the well construction process.

After this point, all returns of drilling fluids and cuttings will be directed to the drill ship for treatment (i.e., solids control and centrifugal cuttings dryer system) to reduce solids in the fluids as well as the fluids retained on cuttings. After treatment, the cuttings will be discharged to the sea from the drill ship. Based on prior analysis from the Liza-1 exploration program, cuttings disperse in the ocean current as they descend through the water column, which typically prevents significant accumulations of cuttings in any particular location on the seafloor.

The surface casing will then be set and cemented in competent rock at a depth below the mudline to allow drilling to the top of reservoir. The production casing will be set and cemented at the top of reservoir, and it is the casing string in which the production tubing is run.

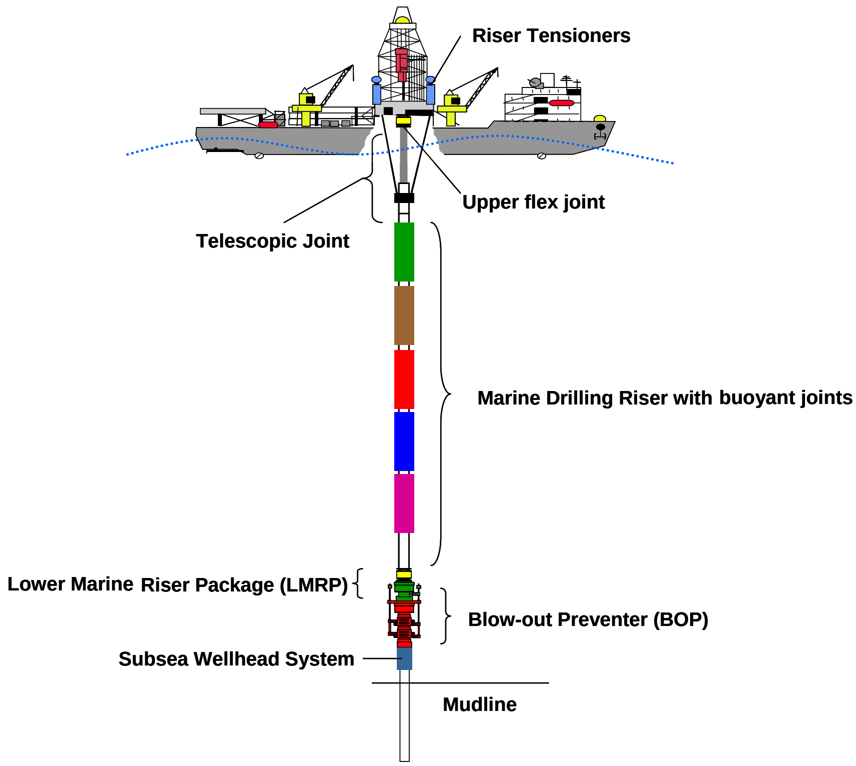
The production tubing carries the reservoir fluids from the production zone to the wellhead when the wells are flowing. The production tubing includes the subsurface safety valve (SSSV), which is designed to mitigate the uncontrolled release of fluids from the reservoir during the production process. The production tubing also protects the production casing from corrosion and deposition of by-products, such as sand, paraffins, and asphaltenes.

After the production tubing is run, the well will be suspended (i.e., flow prevented) by installing barriers to flow; the riser and BOPs will be removed; and the subsea tree will be installed and tested. At that point, the well is ready for future connection to the SURF components.

Figure 2-6 shows the various components of a typical subsea drilling system.

[9] Blowout preventers are secondary safety devices that are installed at the top of a well, which may be closed in order to prevent the uncontrolled flow of liquids and gases in the event of a loss of well control during drilling operations.

Figure 2-6 Typical Subsea Drilling System



2.3.3 Drilling Fluids

Two categories of drilling fluids will be used: water-based drilling fluids (WBDF) and low-toxicity non-aqueous drilling fluids (NADF) in which the continuous phase is an International Oil and Gas Producers Association (IOGP) Group III non-aqueous base fluid (NABF) with low to negligible aromatic content. WBDF will be used when drilling the upper sections of the well. To avoid formation of hydrates (ice-like crystals) due to the cold water temperature and high pressure, salt or organic inhibitors may be added to the WBDF.

Based on wellbore stability analysis and experience gained from Liza-1 and Liza-2 drilling, NADF will be required to maintain borehole stability while drilling all well sections below the conductor casing.

Cuttings treatment equipment will be installed on the drill ships to allow recovery of NADF 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 cuttings dryers on other similar projects has significantly reduced the %BFROC.

During completion activities, a solids-free weighted brine composed of a fresh water base with water–soluble salts will be utilized. Viscosified brine-based fluid will be utilized during displacement and gravel packing operations. The brine will be filtered through diatomaceous earth and cartridge filters. Brine, gravel pack fluids, proppant, diatomaceous earth (fossilized skeletal remains of marine diatoms), and filtered solids will be discharged to the sea in accordance with standard industry practice.

Any unused or used and recovered drilling fluids and products will be re-used, recycled or disposed of in accordance with applicable regulations and best practices. A preliminary list of the types of drilling, completion and treatment fluids that may be utilized can be found in Section 2.10.

2.3.4 Well Cleanup and Ancillary Processes

To facilitate well cleanup, development wells will be drilled, completed, and tied-back to the FPSO. Completion and treatment fluids and solids left in the wellbore will be flowed back to the FPSO, where they will either be treated and discharged or collected for onshore disposal. The wells will not be cleaned up to the drill ship using temporary well test equipment; but, rather, all wells will be cleaned up through the subsea tree/flowlines/production equipment on the FPSO. Such small quantities of fluids will be incorporated with the crude product from other wells. Resulting gas and water will be processed along with fluids from other wells. No well tests of the Phase 1 development wells are planned.

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 provides further time/depth information to improve knowledge and understanding of the structure and stratigraphy of the reservoir.

A VSP survey, which can be conducted from a drill ship or other support vessel, requires a sound source (commonly compressed air) and a receiver. Data is acquired by the receiver, which is installed within the wellbore. The source may be located with zero offset from the well (directly above the wellbore), at a fixed offset (a defined lateral distance from the well), walk away (at a range of offsets), or walk above (at zero offset to the down hole well location). The final scope of the VSP survey and specific geophysical tools to be used is still under review.

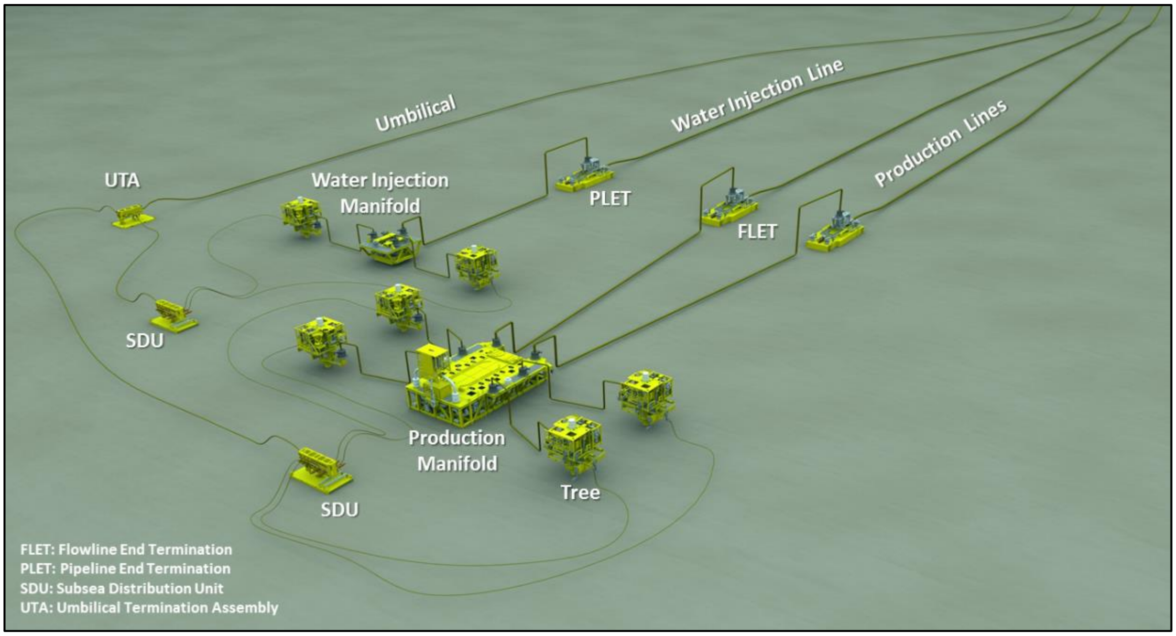
2.4 Subsea, Umbilicals, Risers, and Flowlines

The SURF facilities concept for the Project is comprised of subsea production trees, and gas/water injection trees clustered around subsea manifolds in two subsea drill centers. The risers, flowlines, and umbilicals[10] will connect the subsea facilities on the seafloor to the FPSO. The production manifolds will consolidate the production fluid from the individual production wells to the flowlines, and the injection manifolds will distribute injection gas/water to the individual gas/water injection wells. The subsea production control system on the FPSO will monitor and control the subsea facilities through an umbilical and subsea control distribution system that supplies power, communication, hydraulic fluid, and chemicals. The hydraulic fluid for operating the subsea hydraulic valves 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

[10] An umbilical is 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.

highest required injection pressures. Overpressure protection will be provided on the FPSO, in accordance with industry standards, to protect the subsea systems. Figure 2-7 shows an illustration of a representative SURF system similar to what is currently being designed for the Project.

Figure 2-7 Representative SURF System



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

The production drill centers will be connected to the FPSO with round-trip piggable production flowlines. A pig is a specially designed device that is placed in the riser/flowline at a launcher at one end and pushed by pressure until it reaches the receiving trap or catcher at the other end. Pigging is performed to aid and assist in the maintenance, operations, cleaning, and inspection of flowlines. Figure 2-8 shows an example of a pig.

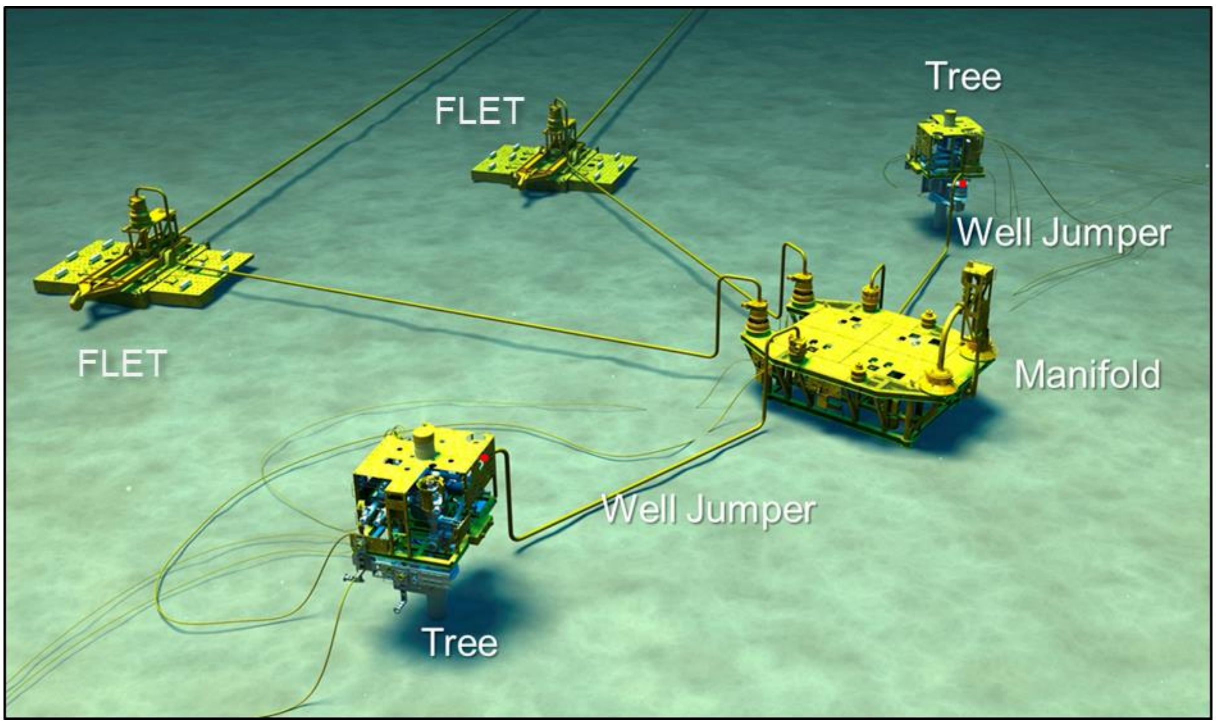
Figure 2-8 Example of Wire Brush Cleaning Pig

2.4.1 Well Flow Connections

Well flow connections between the subsea wells and the FPSO include several components. Each subsea development well is capped by a subsea tree, which include several isolation valves and a choke valve to control production and water and gas injection. For a given set of wells tied to the same manifold, the subsea trees are connected by well jumpers to the subsea manifold, which is then connected by flowline jumpers to flowline end terminations (FLETs) located towards the drill center end of the flowline.

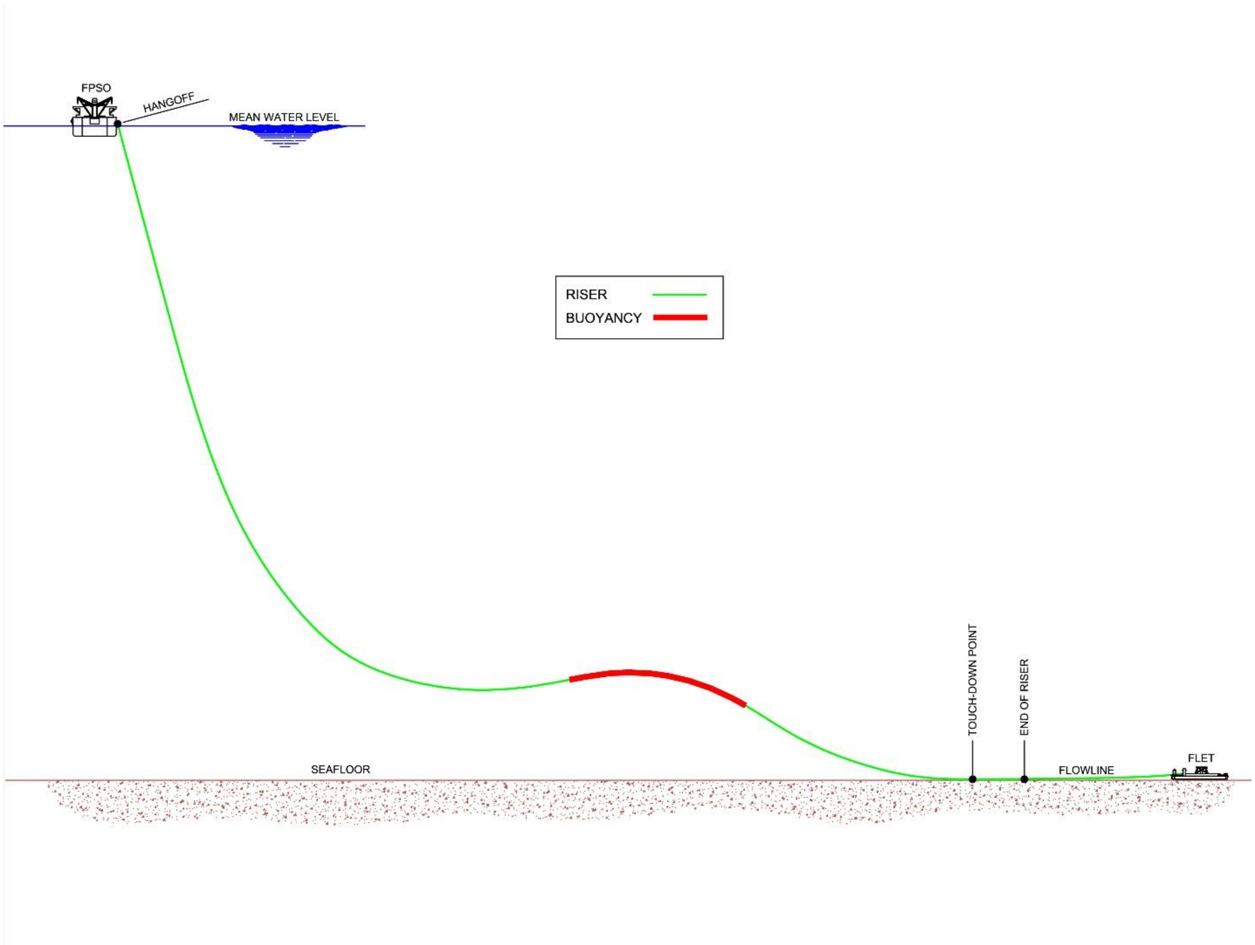
A typical configuration of the subsea trees, FLETs, flowlines, and manifolds expected at a drill center for the Project is indicated on Figure 2-9.

Figure 2-9 Representative Subsea Trees, FLETs, Jumpers, and Manifold



From the drill center, the rigid flowlines travel on the seabed to the vicinity of the FPSO and transition to vertical risers, where they connect to the FPSO at the surface. The risers carry fluids up to the FPSO at the surface, as shown on Figure 2-10. In the case of injection streams (i.e., for gas and water injection), the same configuration is used, but flow is from the FPSO downward through the risers to the water or gas injection manifolds.

Figure 2-10 Representation of Riser Connected to FPSO



2.4.2 FPSO Topside Subsea Control System

The FPSO will provide power, utilities, cabling, and tubing tie-ins to subsea control equipment installed on its topsides to control the subsea equipment. The FPSO will be configured with back-up power, in the event primary power is lost.

The subsea trees and manifolds will be monitored and controlled through the subsea control system on the FPSO via a dynamic and static steel tube umbilical. Subsea control system will accommodate typical monitoring requirements such as pressure and temperature measurement.

2.4.3 Risers, Flowlines, Umbilicals, and Manifolds

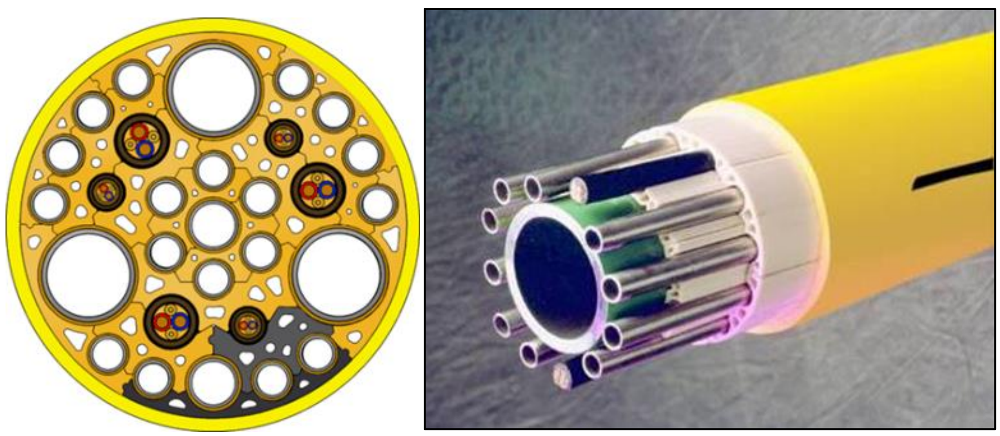
2.4.3.1 Risers and Flowlines

The Project will incorporate production, water, and gas injection flowlines and risers, as shown on Figure 2-3. Flowline and umbilical lengths will range from approximately 3.2 to 6.4 km (~2 mi to 4 mi), excluding risers, in water depths of approximately 1500 to 1900 m. The current design lengths are based on preliminary shallow hazard surveys and current field layout, which may be adjusted during detailed design.

2.4.3.2 Umbilical

The umbilical (Figure 2-11) will be designed as an integrated bundle of tubes and cables to transport hydraulic fluid, injection chemicals, and electrical power/communication. A single dynamic umbilical, which will be connected to the FPSO at the surface and end at production Drill Center 1 (DC1-P), will service the Liza field during Phase 1. In-field umbilicals will be used to further distribute these services to the other subsea equipment.

Figure 2-11 Representative Integrated Dynamic Umbilical Cross Section



2.4.3.3 Manifolds

Manifolds are gathering points, or central connections made up of valves, hubs, piping, sensors, and control modules. Manifolds include a protective structural framework that rests on a seabed foundation where multiple trees, jumpers, and flowlines gather to consolidate flows before they are either transported to the FPSO on the surface as part of production or back down for injection of water and gas into the reservoir (Figure 2-12).

Figure 2-12 Representative Subsea Manifold

2.4.3.4 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 it will be installed at some time during the Project production operations stage based on the production characteristics of the Liza reservoirs. This system will include a riser and flowline to DC-1P with connections to the production flowlines.

2.5 Floating Production, Storage, and Offloading Vessel

2.5.1 General Description

The FPSO vessel to be utilized for the Project will be a VLCC tanker, which utilizes 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 100,000 barrels of oil per day (BOPD), with potential to safely operate at sustained peaks of up to approximately 120,000 BOPD. For the purposes of this EIA, potential impacts generated by the Project will be based on the highest potential oil production volume, which is conservatively based on 144,000 BOPD[11]. The FPSO hull will be capable of storing a minimum of 1.6 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.

[11] 144,000 BOPD is 20% over the sustained peak volume of 120,000 BOPD.

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 injection into the reservoir, and to treat produced water for disposal overboard into the sea. Living quarters and associated utilities will be provided in order to support the operations on the FPSO.

Table 2-1 provides an estimate of the design rates for the FPSO facility. Although the Project nameplate oil production capacity is 100,000 barrels per day (bpd), the Project facilities will have the potential to safely operate at sustained peaks above the design rate. For purposes of this EIA, potential impacts generated by the Project (e.g., air emissions) were based on a potential peak production volume of 144,000 bpd to be conservative in the analysis.

Table 2-1 FPSO Key Design Rates

Service	Design Rate[1] [2]
Oil Production (bpd)	100,000
Produced Water (bpd)	100,000
Total Liquids (bpd)	150,000
Produced Gas (Mscfd)	180
Gas Injection (Mscfd)	160 (assumes 20 Mscfd of produced gas will be used as fuel gas for the FPSO)
Water Injection (bpd)	190,000

Notes:
bpd = barrels per day
Mscfd = million standard cubic feet per day
[1] All design rates are presented as the peak annual average.
[2] The facilities will have the potential to safely operate at sustained peaks of oil production up to approximately 120,000 bpd. For the purposes of the EIA, 144,000 bpd has been used as the basis to analyze potential impacts from the Project.

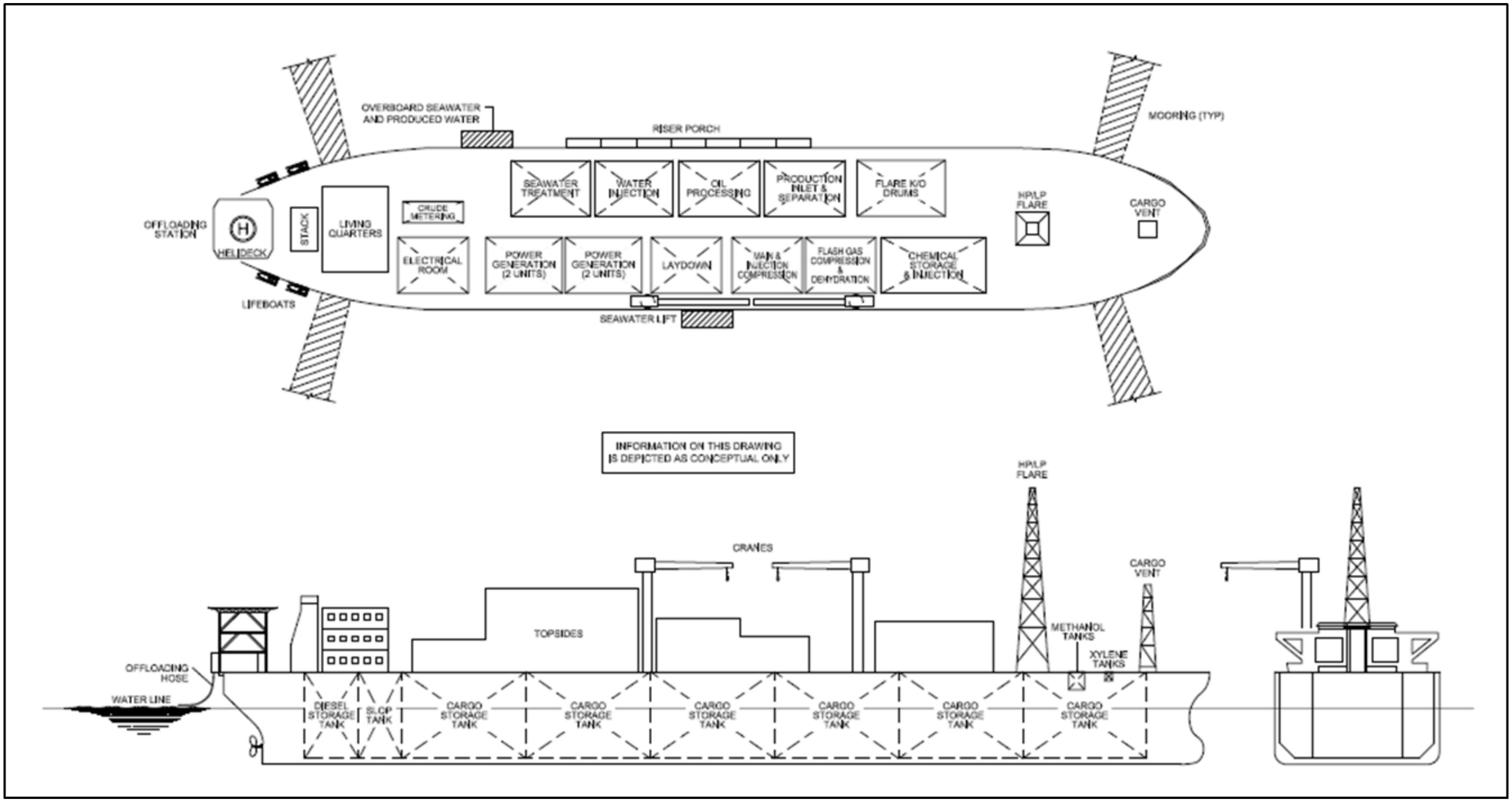
Key FPSO design features include the following:

- 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 the produced gas back into the reservoir, except during times of injection system unavailability, which will require temporary, non-routine flaring.

A computer simulated picture of the planned FPSO and a general schematic of a converted FPSO topsides and hull are provided on Figures 2-13 and 2-14, respectively.

Figure 2-13 Computer Simulated Picture of Planned Liza Phase 1 FPSO

Figure 2-14 General Schematic of a Converted FPSO Topsides and Hull



2.5.2 FPSO Topsides

The FPSO's topsides design employs 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, pre-assembled and most facilities, modules, components and systems pre-tested.

The principal functions of the topsides process facilities will be:

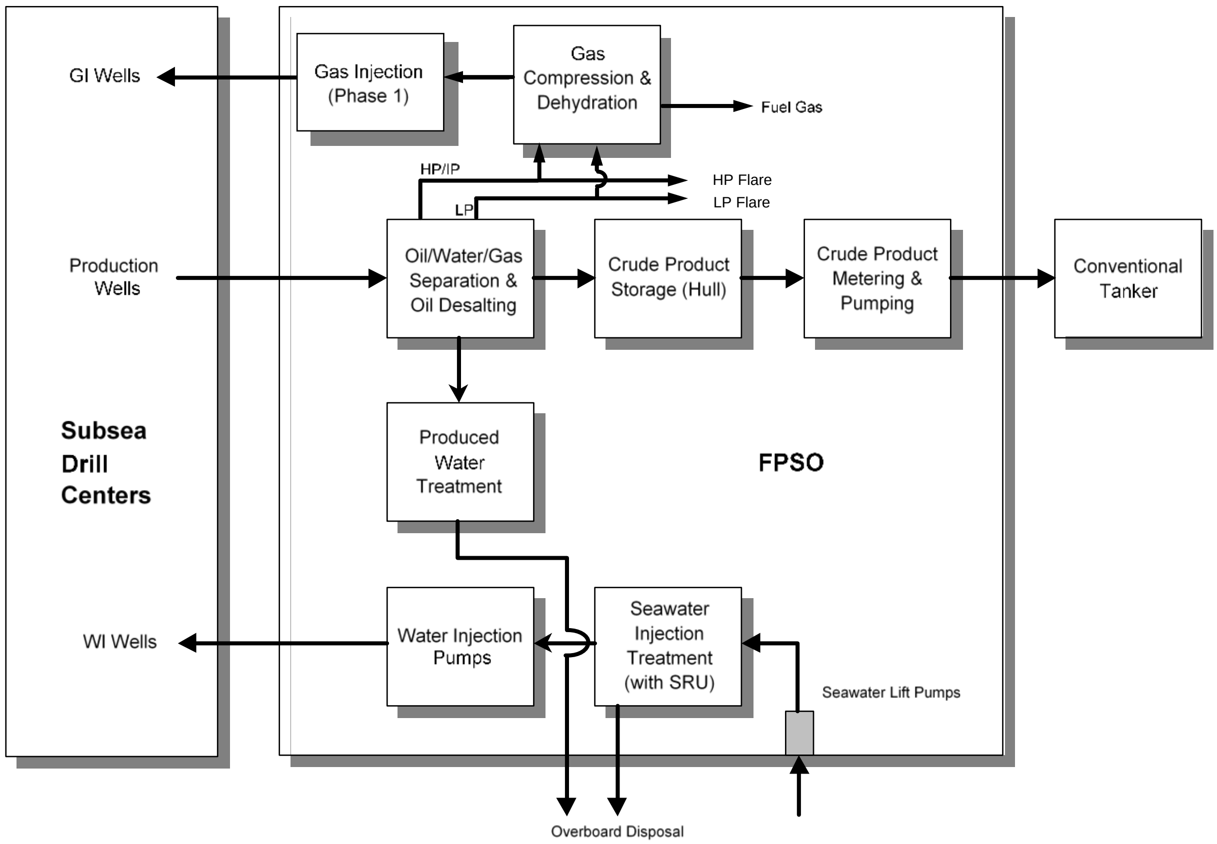
- To receive, separate, and process the produced reservoir fluids to provide:
    - a crude oil product for offloading onto conventional tankers,
    - produced water from the reservoir to be of sufficient quality for environmentally acceptable discharge to the sea, and
    - produced gas to meet requirements for FPSO turbine generator fuel gas and for re-injection into the reservoir;
- To treat seawater to provide a suitable supply of injection water to support the reservoir depletion plans; and
- To provide support systems for the safe accommodation of approximately 80-120 personnel involved in the operation of the production facilities and, on occasion, personnel 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 up to approximately 140 personnel.

2.5.3 FPSO Process Systems

The process facilities on the FPSO topsides are shown schematically on Figure 2-15 and are described in the subsequent sections.

Figure 2-15 Process Flow Diagram



Notes:
GI = Gas re-injection
WI = Water injection
HP = High pressure
IP = Intermediate pressure
LP = Low pressure
SRU = Sulfate Removal Unit

2.5.3.1 Oil / Water / Gas Separation and Oil Desalting

An inlet manifold will receive full wellstream fluids (consisting of oil, gas, and water) from the production flowlines and will route the fluids to the FPSO processing facilities. The wellstream fluids will be separated into oil, water, and gas phases in a single train of separation. The separation train consists of three stages (high, intermediate, and low pressure) of flash separation to produce a stabilized crude product. Fresh water will then be added to the stabilized crude product to remove dissolved salts as part of oil desalting. The final crude oil product from the flash separation / stabilization process will be treated to meet the specifications for sale prior to being sent to the crude product 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.

2.5.3.2 *Gas Processing*

For Phase 1, the Project will re-inject produced gas (that will not be consumed as fuel gas on the FPSO) back into the reservoir. The purpose of the FPSO gas processing system is to condition the associated produced gas (which is not consumed as FPSO fuel gas) to the appropriate specification prior to re-injection into the reservoir. It comprises systems to compress gas, dehydrate gas, and direct gas to be re-injected.

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 High Pressure (HP) or Low Pressure (LP) Flare Systems. Flaring will be temporary and non-routine. Flaring is discussed in more detail in Section 2.5.4.3 below.

2.5.3.3 *Produced Water Treatment*

The produced water treating system will be designed to collect produced water from the FPSO processing facilities and treat the water for discharge overboard per standard industry practice. The system will consist of primary and secondary treatment. Primary treatment will consist of either a skim vessel or hydrocyclones for removal of large oil droplets from the produced water. Secondary treatment will consist of a gas flotation for removal of small oil droplets in order to meet the discharge specification. Produced water that does not meet the overboard discharge specification will be routed to an appropriate tank in the hull for further treatment.

2.5.3.4 *Seawater Treatment and Water Injection System*

Water injection will be used for reservoir pressure maintenance to enhance oil production. Seawater used for injection water will be treated prior to injection into the producing reservoirs, per standard industry practice. The seawater treatment system will include sea lift pumping, filtration, deaeration, and sulfate removal. Seawater lift pumps on the FPSO will be used to pump seawater from depths up to 100 meters below the surface in order to access colder seawater than what is available from the ocean surface. The filtration system will consist of both coarse filtration (strainers) and fine filtration (multi-media filtration) for removal of particulate from the incoming seawater. Following filtration, seawater will be vacuum deaerated for removal of oxygen. The deaerated seawater will then be pumped through a membrane system for removal of sulfate ions from the seawater as the final treatment step. The treated seawater will then be pumped to the necessary pressure for injection into the producing reservoir.

A portion of the treated seawater will be further treated through a reverse osmosis system to make fresh water. Fresh water is required for removal of salt from the crude product as part of oil desalting, as described in Section 2.5.3.1.

2.5.4 FPSO Utility Systems

This section discusses the utility system requirements for the FPSO. For the most part, the utility systems designed to support the process facilities will be located above deck. Marine utility systems may be used to support topside systems where appropriate.

2.5.4.1 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, the compression systems, and miscellaneous utility systems.

The seawater lifting system described in Section 2.5.3.4 will also supply the required seawater for cooling. Process hydrocarbon fluids do not come into contact with this seawater. Treated seawater will be disposed of overboard at a suitable temperature so as not to significantly impact marine life.

2.5.4.2 Process Heating

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

2.5.4.3 Flaring System

EEPGL intends to re-inject all operationally produced gas under routine conditions, except that which will be utilized for FPSO operations (e.g., fuel gas). 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 depressure the facilities in a controlled manner as a result of emergency shutdown events. In addition, temporary, non-routine flaring will occur during equipment maintenance, process upsets, and start-up. The flare system will include both an HP and LP flare sharing a common flare tower, as shown on Figure 2-15. The flare tower has elevated flare tips for both high and low pressure 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.

2.5.4.4 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. These chemicals are further described in Section 2.10. Table 2-6 provides a summary of the key effluent characteristics for planned discharges to water.

2.5.4.5 *Air*

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

2.5.4.6 *Nitrogen*

Instrument air will feed the nitrogen generation system. Nitrogen will be provided as required for purging (i.e., removing residual amounts of products), inerting (i.e., introducing non-flammable gas to prevent ignition), blanketing (i.e., filling vapor space in tanks with non-flammable gas to prevent ignition), and as required for miscellaneous utilities.

2.5.4.7 *Drains*

The FPSO topsides shall be equipped with the following drain systems:

- Non-hydrocarbon open drain. Used to collect drain fluids (e.g., rainwater) from non-hydrocarbon areas and to route them to the slop tank in the FPSO hull or direct overboard.
- Hydrocarbon open drain. Used to collect drain fluids (e.g., oil contaminated water) from hydrocarbon areas and to route them to the slop tank in the FPSO hull.

2.5.4.8 *Other*

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, medical facility, and storage facility for supplies and spare parts will also be provided. Heating, Ventilation, and Air Conditioning (HVAC) systems will be provided for buildings and enclosures.

2.5.5 Power Generation System

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

- 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) capable to allow for restoring power to the facility (i.e., black start).
- 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).

Additionally, for back-up power during emergency situations, the uninterruptible power supply (UPS) system will be provided to power equipment such as the Integrated Control and Safety System (ICSS) and subsea controls, among others.

2.5.6 Integrated Control and Safety System (ICSS)

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 to a public address and general alarm system (PA/GA) to provide distinct audible and visual alarm notification.

The ICSS includes the Process Control System (PCS), Safety Instrumented System (SIS), the Fire and Gas (F&G) system, the Alarm Management System (AMS), the Operator graphics / consoles; and the third-party interfaces to packaged systems (such as compressors, subsea, and marine, among others).

2.5.7 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, support vessels, helicopters, and tankers as well as communication on the FPSO.

2.5.8 Additional Vessel Systems

2.5.8.1 FPSO Cargo Systems

The main purpose of the FPSO cargo system will be:

- To receive, distribute, and store on-specification crude oil from the process facilities into the 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 non-hazardous and hazardous drain system. The oil and water 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 specification.

The FPSO cargo tanks will be blanketed with inert gas. As depicted on Figure 2-15, a tank vent system will be provided to release vapor and inert gas from the cargo tanks to a safe location, toward the bow of the FPSO, to prevent an overpressure event in the tanks.

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.

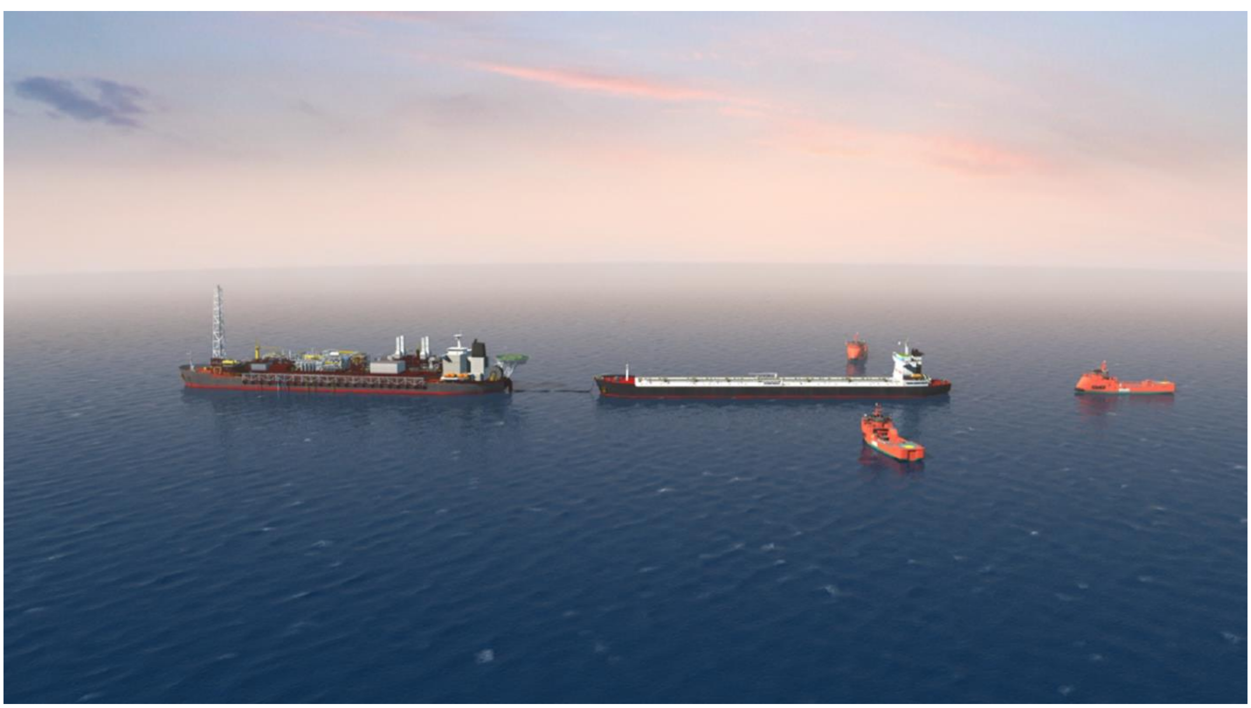
2.5.8.2 *Custody Transfer Meter*

For offloading, crude will be pumped from the FPSO hull storage tanks through a custody transfer metering package on the topsides and into the offloading system at a rate sufficient to achieve transfer of approximately 1 million barrels of oil in up to 28 hours up to a VLCC class tanker size.

2.5.8.3 *Crude Oil Offloading*

Export of the crude oil from the FPSO will be via a floating hose to the midship manifold of a conventional tanker. The FPSO will be configured for tandem offloading to a conventional tanker which will be owned/operated by others. The separation distance between the stern of the FPSO and the conventional tanker will be approximately 120 m (390 ft). The maximum conventional tanker size envisioned is a VLCC class. During offloading operations, the conventional tanker will maneuver and hold station relative to the FPSO with the aid of up to three assistance tugs, as shown on Figure 2-16. Crude will be transported to buyers' final location by the conventional tankers after each offloading operation.

Figure 2-16 General Offloading Configuration



2.5.8.4 *Ballast System*

Ballast water will be required during the transit from the shipyard to the site. Once on site, the unneeded ballast water from the FPSO may be discharged overboard.

2.5.8.5 *Spread Mooring System*

The FPSO will be permanently moored by fixed, spread mooring with up to a 20 point mooring line system each connected to their respective 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 a 100-year environmental condition.

2.5.9 Safety and Personnel Protection Systems

FPSO safety systems will include:

- Firewater System – The firewater system will have one pump each located at the fore and aft ends of the FPSO, with one pump serving as a redundant backup.
- 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 (CCR), 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 Generation – To prevent fires, the cargo tanks will be operated with an inert gas blanket at all times except during tank entry. The inert gas for cargo tanks will be supplied by an inert gas system utilizing flue gas from the marine boilers. To provide gas blanketing for other spaces, including the methanol and xylene tanks, inert 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 (POB). A fast rescue boat will also be provided, complete with a davit launching and retrieving system.

2.6 Installation, Hook-up, and Commissioning

The sequence and duration of each FPSO and SURF installation, hook-up, and commissioning activity will be further defined as part of ongoing Project planning and development. The final sequence and durations of activities will depend on a number of factors, including, but not limited to, final Project design, marine vessel and equipment availability, mobilization times, and weather, among other factors. Key installation, hook-up, and commissioning activities will include:

- 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 injection flowlines and risers. These components will be cleaned and tested to verify and ensure integrity after installation, and then staged on the seafloor until arrival of 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 Installation – Installation of the manifolds, manifold foundation piles, jumpers, Subsea Distribution Units, and flying leads at the drill centers followed by integrity testing and verification.
- Umbilical Installation – Installation of the umbilical and umbilical termination unit.
- 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 de-watering / displacing flowlines and umbilicals with commissioning fluids, which are further discussed in Section 2.10, and testing SURF control and shutdown systems. Some of these commissioning fluids may be discharged to the sea per standard industry practice, as shown in Section 2.10.2, Table 2-6. Any unused or used and recovered commissioning fluids and products will be re-used, recycled, or disposed of in accordance with applicable regulations and best practices.

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

During the FPSO/SURF installation stage, a remotely operated vehicle (ROV) may be periodically utilized to support the above mentioned activities (e.g., underwater observations, connections, and sampling, among others).

2.7 Production Operations

The Project will include a leased FPSO, owned and operated by the FPSO contractor, and a subsea development, owned by EEPGL and operated by the FPSO contractor under the direction of EEPGL. Throughout production operations, EEPGL's personnel will perform oversight and monitoring of the FPSO contractor to ensure that management systems pertinent to safety, the environment, and operations integrity are properly implemented. To accomplish this, EEPGL plans to utilize an onboard representative (OBR) supported by operational and technical specialists to monitor, and direct as necessary, operation of the FPSO and SURF facilities.

Operating processes will include flowing the hydrocarbon well stream from the reservoir to the FPSO, where further fluid separation, stabilization, storage, and management will occur prior to offloading the crude oil to the conventional tankers. General maintenance of the FPSO and SURF components will also be performed offshore during production operations. Some industry standard chemicals will be required as part of the processing and handling of the oil and associated gas on the FPSO, as well as treating produced water prior to discharge. Both the FPSO and SURF facilities will also require the use of industry standard additives to provide flow assurance and prevent corrosion, scale, hydrate, and asphaltene formation as previously noted in Section 2.5.4.4 and described in Section 2.7.1. These subsea and topsides chemicals will separate into the oil, water or gas phases of the process stream, depending on their solubilities and applications. Therefore, residual quantities of these chemicals may be contained in the processed crude oil, discharged with produced water, or emitted to the atmosphere with vented and fugitive gases.

The final chemical requirements and quantities will be determined as part of the ongoing FPSO and SURF facilities design work, and a preliminary list is provided in Table 2-2. Any unused or used and re-captured production chemicals will be re-used, recycled, or disposed of in accordance with applicable regulations and best practices.

The objective of the following sections is to provide a general overview of the flow assurance challenges and strategies.

2.7.1 Common Flow Assurance Additives

2.7.1.1 Hydrates

Ambient seafloor temperatures in the Liza area are sufficiently cold that hydrates could form in the FPSO and SURF equipment. To prevent the formation of hydrates, a combination of inhibitor (methanol), thermal insulation, and operating practices will be utilized.

2.7.1.2 Paraffin and Asphaltenes

The insulation needed for hydrate mitigation is sufficient to prevent Paraffin (wax) deposition in the subsea production system. Paraffin inhibitor can be injected along with downhole asphaltene inhibitor downhole if needed. Asphaltene precipitation and/or deposition are expected at near wellbore and in production wells. Asphaltene deposition will be mitigated with continuous asphaltene inhibitor downhole. In case asphaltene deposition cannot be mitigated by asphaltene inhibitors, production wells will be soaked with xylene as remediation. Pigging operations with or without xylene may also be used for remediating any asphaltene deposition in the production flowline and riser.

2.7.1.3 Scale Control

Scale formation will be managed using scale inhibitor downhole and by sulfate reduction with Sulfate Removal Unit (SRU) at topsides.

2.7.1.4 Corrosion Control

Internal corrosion of the subsea facilities shall be managed by a combination of material selection and injection of inhibitor. Components in the production path upstream of the flowlines will be fabricated from corrosion-resistant alloys suitable for the intended service. The carbon steel flowlines and risers will be protected by the injection of corrosion inhibitor at the subsea production manifold headers.

2.7.2 Hydrogen Sulfide (H_2S) Management

The concentration of H_2S will be extremely low for the initial stage (i.e., 5-10 years) of FPSO/SURF production operations. There may be potential for the reservoir to sour 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, response planning, and equipment for leak detection and alarms).

2.7.3 Marine Safety

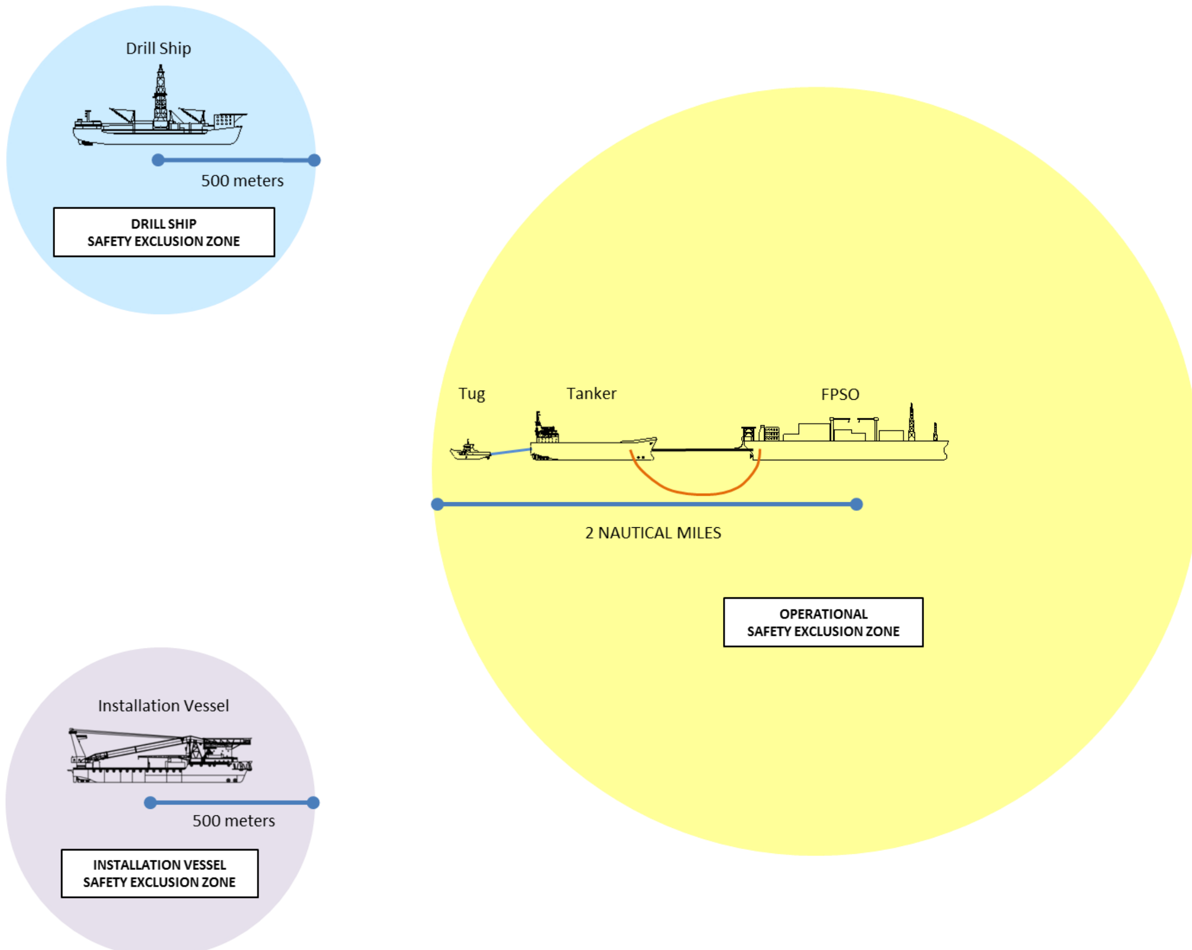
The Maritime Administration (MARAD) of the Ministry of Public Infrastructure is responsible for issuing notices to mariners concerning safety at sea.

MARAD will be advised of the location of drill ships during the drilling of the development wells and the performance of well workovers in the PDA, and of the location of installation vessels during major installation activities so that mariners are aware of these activities. Safety exclusion zones with a 500 m (~ 1640 ft) 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, as represented on Figure 2-17.

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 employed during the FPSO/SURF installation, hook-up, and commissioning stage. The Project will also communicate major vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators 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.

As also shown on Figure 2-17, during the production operations stage, the FPSO will have a 2 nautical mile (nm) radius encircling the vessel where marine support and tanker off-loading will occur. No unauthorized vessels will be allowed to enter this approximately 4,000 ha operational marine safety exclusion zone. EEPGL will use radar and visual surveillance of the marine safety exclusion zones to monitor vessel traffic. Any vessels that may inadvertently enter the marine safety exclusion zone without authorization will be contacted via radio and instructed to leave the area. If EEPGL is unable to contact the vessel by radio, a Project supply vessel will approach the encroaching vessel and notify them that they have entered a marine safety exclusion zone. If the encroaching vessel ignores these instructions, EEPGL will contact the Guyana Coast Guard for support.

Figure 2-17 Preliminary Safety Exclusion Zones during Drilling, Installation, and Offloading Operations



2.7.4 Offloading Tankers

Conventional tankers supporting offloading operations typically arrive anywhere from one day to several hours ahead of the scheduled loading time, as a function of weather and ocean conditions. When the conventional tanker is ready to approach, a Mooring Master will board the vessel approximately 2 km (~1 mi) from the FPSO, in order to guide it to the FPSO for offloading. The conventional tankers will export the crude oil to the buyer's final location after offloading operations have been completed.

2.8 Onshore, Marine, and Aviation Support

2.8.1 Onshore Supply and Support Activities

Shorebase(s), laydown areas, pipe yards, warehouses, fuel supply, heliport, and waste management facilities in Guyana will be utilized to support development drilling, FPSO/SURF installation, production operations, and ultimately decommissioning. These onshore facilities will be owned/operated by others and will not be dedicated to the Project. The specific shorebase(s) and onshore support facilities (e.g., warehouses, laydown yards) to be utilized in Guyana have not yet been identified by EEPGL. A preliminary footprint estimate for onshore staging and storage in Guyana is approximately 30,000-50,000 m^2. However, the final area required will be determined as the Project development plan progresses. Accordingly, ERM has performed the impact assessment on the basis that the Project will utilize existing shorebase(s) located in Georgetown that meet this minimum requirement. Should any new or expanded shorebase(s) or onshore support facilities be utilized, 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 the EIA.

A typical shorebase quay is shown in Figure 2-18, and a typical laydown yard is shown in Figure 2-19. Where existing Guyana shorebase(s) do not have the technical and/or capacity requirements to support Project activities, EEPGL will potentially consider the use of other onshore support facilities and services in Guyana, as identified and deemed necessary. Additional logistical support may be provided by other regional suppliers outside of Guyana, as informed by inputs from EEPGL contractors after contract award, to address Project needs (e.g., deepwater port access in Trinidad).

Onshore support facilities will include pier/port/quayside space with sufficient draft for receipt of cargo vessels bringing materials to and from the shorebase(s). Marine support vessels will 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:

- 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;
- Potential operation of a cement and drilling and completion fluids plant to support offshore drilling operations; and
- Secure handling and storage of wastes pending final recycling, treatment, or disposal.

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

Figure 2-18 Typical Shorebase Quay

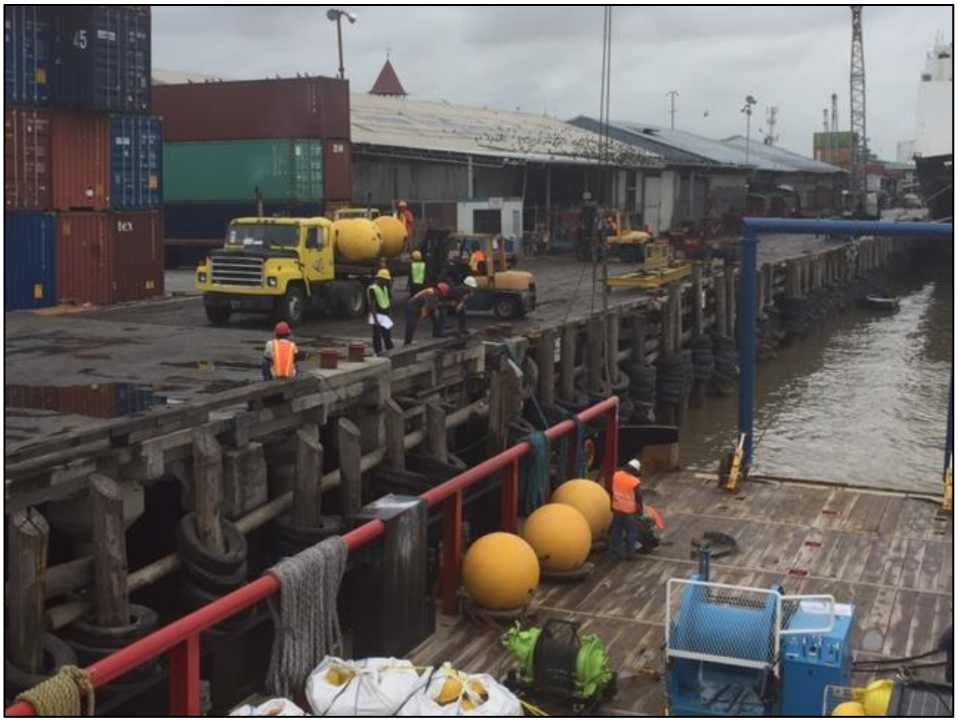


Figure 2-19 Typical Laydown Yard

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 owner/operator(s), with any required permitting being the responsibility of the shorebase owners/operators.

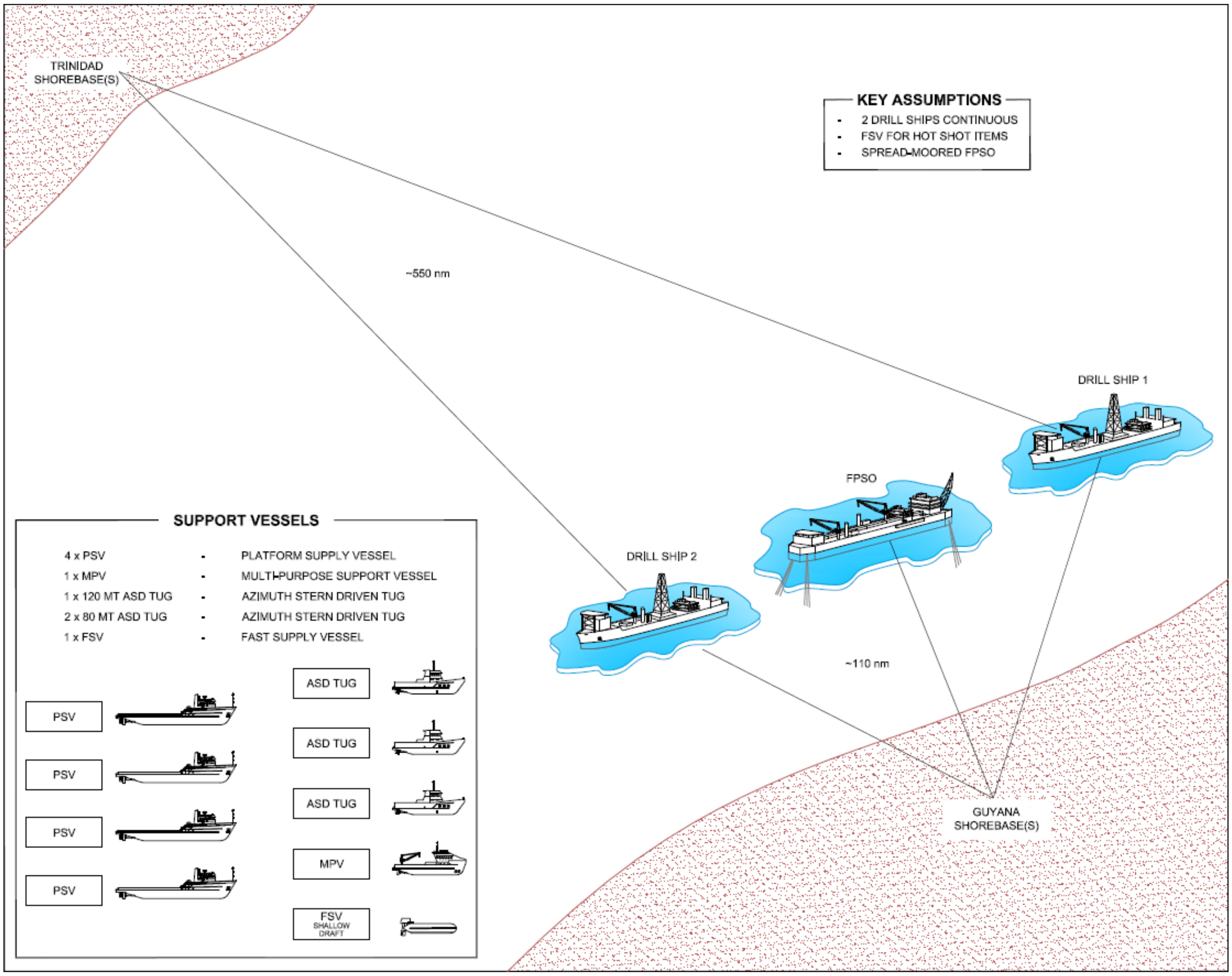
2.8.2 Logistical Support

An average of 10 round-trip helicopter flights is currently being made per week to support ongoing exploration drilling activities. It is estimated that during development drilling and FPSO/SURF installation, an incremental 20 to 25 helicopter flights per week will be added, for a total of 30 to 35 round-trip flights per week. During FPSO/SURF production operations, an estimated 20 to 25 round-trip helicopter flights per week will be necessary to support FPSO/SURF production operations and development drilling activities.

There will be a variety of marine and aviation support equipment supporting the FPSO, installation vessels, and drill ships, as shown on Figure 2-20. The support vessels will consist of Platform Supply Vessels (PSVs) conducting re-supply trips to the FPSO and drill ships, Tug Vessels (TVs) supporting tanker offloading activities, and Multi-Purpose Vessels (MPVs) supporting subsea installation and maintenance activities. Based on current drilling activities and past experience with similar developments, it is estimated that during development drilling and FPSO/SURF installation, an average of 12 vessel trips per week may be made to the PDA. During FPSO/SURF production operations, it is estimated that this number will be reduced to approximately 7 vessel trips per week. The vessels are planned to be loaded and offloaded at shorebase facilities in Guyana and/or Trinidad. Figure 2-21 depicts a conceptual diagram and estimated number and types of logistical support equipment that will be utilized to support the Project.

Figure 2-20 Typical Logistics Support Vessels

Figure 2-21 Potential Drilling and Operations Stage Peak Fleet Profile



2.9 End of Operations (Decommissioning)

In advance of the completion of the Phase 1 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 most appropriate technology available at that time. The decommissioning plan and strategy will be based on a notice of the 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 EP Act (Cap. 20:05).

EEPGL will perform inspections, surveys, and testing to assess, and report to the EPA the conditions that will provide the basis and required information to prepare a plan for decommissioning. All risers, pipelines, umbilicals, subsea equipment, and topside 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 work with the EPA and the GGMC to select the final decommissioning strategy based on a comparative assessment, which is designed to evaluate the potential safety, environmental, technical, and economic impacts and associated mitigation measures in order to finalize the decommissioning plan.

Wells will be permanently plugged and abandoned (P&A) by restoring suitable cap rock to prevent escape of hydrocarbons to the environment. P&A barriers will be installed in the wellbore, 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 non-hazardous wastes, will be managed and disposed of 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 management and disposal.

2.10 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 exposure to NORM or radiography. 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 Personal Protection Equipment (PPE) to its Project workforce as described in Section 7.1.2. Underwater sound is discussed as part of the Marine Mammal impact evaluation (see Section 7.2.5). The Project generates 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 Section 7.1.4). The Project generates light, which is discussed as part of the Seabird and Marine Turtle impact evaluations (see Sections 7.2.4 and 7.2.6, respectively).

2.10.1 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, 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 2-2 below provides preliminary inventories of the primary chemicals that would be used as part of the Project's drilling, installation/commissioning and production operation stages, respectively. 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 ship or FPSO, in appropriate storage containers with either secondary containment or appropriate drainage control.

Table 2-2 Project Materials and Chemicals

<table>
<tr><th>Project Phase</th><th colspan="2">Primary Chemical Materials / Products</th></tr>
<tr><td rowspan="2">Drilling</td><td>Water-based drilling fluid (WBDF)
Water, seawater, or inorganic salts
Barite
Clays
Water-soluble biopolymers and modified biopolymers
Thinners
Shale Inhibitors
Calcium Carbonate
Lost circulation material
Caustic Soda
Soda Ash</td><td>Non-aqueous drilling fluid (NADF)
Base Oil (IOGP Group III)
Barite
Calcium chloride brine
Organophilic clay
Emulsifier
Wetting Agent
Viscosity modifiers
Fluid loss modifiers
Lime
Calcium Carbonate</td></tr>
<tr><td>Completion & Treatment Fluids
Brines
Barite
Water Soluble Polymers
Inorganic and Organic Acids
Calcium Carbonate
Caustic Soda
Surfactants
Hydrate Inhibitor
Oxygen Scavenger
Corrosion Inhibitor</td><td>Cement
Cement class “G”
Extender
Accelerator
Defoamer
Retarder
Surfactant
Dye</td></tr>
<tr><td>SURF Equipment Commissioning</td><td>Low-toxicity, water soluble hydraulic fluid
Nitrogen
Hydrate inhibitor (e.g., methanol, ethylene glycol)</td><td>Marine gas oil
Biocide
Oxygen scavenger
Corrosion inhibitor</td></tr>
<tr><td>Production Operations</td><td>Corrosion inhibitor
Scale inhibitor
Asphaltene inhibitor
Xylene
Methanol
Deumulsifier
Defoamer</td><td>Polyelectrolyte
Triethylene glycol
Hydrogen sulfide scavenger
Oxygen scavenger
Biocide
Clarifier/coagulant
Hydraulic fluid</td></tr>
</table>

2.10.2 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 non-routine 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 – dominated by FPSO product storage tanks, but also including other tank storage);
- 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), and potential unplanned CFC releases from the HVAC and refrigeration systems.

Table 2-3 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:

- 2018 – 2019: Drilling, SURF installation and commissioning, and operation of related support vessels
- 2020 – 2021: Drilling, FPSO startup and associated temporary, non-routine flaring, beginning of production operations, tanker loading
- 2022 – 2040: Production operations following cessation of drilling, including temporary non-routine flaring, operation of related support vessels, and tanker loading.

Table 2-3 Annual Air Emissions Summary

Pollutant	Source Category	Annual Emissions (Tonnes unless otherwise specified)		
		2018-2019	2020-2021	2022-2040
Nitrogen Oxides (NO_x)				
	FPSO	0	1,635	1,545
	FPSO Flaring (temporary, non-routine)	0	375	175
	Tanker Loading	0	135	140
	Area Sources[12]	2,385	1,125	1,125
	Drill ship	1,255	1,670	0
	Total	3,640	4,945	2,975
Sulfur Dioxide (SO_2)				
	FPSO	0	45	50
	FPSO Flaring (temporary, non-routine)	0	0	5
	Tanker Loading	0	110	115
	Area Sources	85	40	40
	Drill Ship	45	60	0
	Total	130	250	205
Particulate Matter (PM)				
	FPSO	0	45	35
	FPSO Flaring (temporary, non-routine)	0	15	5
	Tanker Loading	0	10	10
	Area Sources	170	80	80
	Drill Ship	90	120	0
	Total	260	210	130
Carbon Monoxide (CO)				
	FPSO	0	425	405
	FPSO Flaring (temporary, non-routine)	0	2,030	940
	Tanker Loading	0	30	30
	Area Sources	500	235	235
	Drill ship	265	350	0
	Total	765	3,070	1,610
Other Pollutants				
Hydrogen Sulfide (H_2S)	FPSO Flaring (temporary, non-routine)	n/a	< 1	< 1
Volatile Organic Compounds (VOCs)	All Sources	95	10,250	10,720
Greenhouse Gases (GHGs [kilotonnes CO_2-equivalents])	All Sources	195	1,510	980

Note: The annual estimated totals currently reflect the preliminary Project schedule, which could change.

[12] 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.

2.10.3 Discharges

The Project will have several planned discharges to water related to the operations and maintenance of the drill ships, FPSO, installation and commissioning activities. These planned discharges, based on the preliminary design information, are listed in Table 2-4. Potential discharges include drill cuttings and fluids, well completion and treatment fluids, produced water, cooling water, sulfate removal and potable water processing brines, topsides drainage, hydrostatic test water, ballast water, BOP testing fluids, and sanitary and domestic wastewater, as described below. All Project vessels will be equipped to comply with the water pollution control standards required by 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).

Drill Cuttings and Fluids: WBDF, as listed in Table 2-2, and associated cuttings will be discharged to the sea without treatment per standard industry practice. The process for treating and discharging cuttings with residual NABF, as listed in Table 2-2, is described in Section 2.3.3.

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 2.5.3.3.

Cooling Water: Seawater is used to dissipate heat generated by the oil and water treating systems, the compression systems, and miscellaneous utility systems. Process hydrocarbon fluids do 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 & 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 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.

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 ~97 percent water with ~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 2-4 summarizes drilling-related discharges and Table 2-5 summarizes commissioning and production-related discharges.

Table 2-4 Summary of Drilling and Completion-Related Discharges

Fluid Type	Estimated Discharge Per Well (bbl) [a]
Drill Cuttings Discharges	6,000
Water-Based Drilling Fluid (WBDF) Discharges	13,000
Non-Aqueous Base Fluid (NABF) retained on cuttings	400
Cement Returns	3,800
Completion and Treatment Fluids	6,000

[a] Values based on deepest well

Table 2-5 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)	≤ 500,000 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	25,000 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)	400 bbl total	None	N/A
Production Discharges			
Produced Water • Oil & Grease • Residual production and water treatment chemicals	≤ 100,000 bpd	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 m from discharge	Yes
Cooling Water • Hypochlorite: ≤ 5 ppm	≤ 700,000 bpd	No visible oil sheen on receiving water Temperature rise <3°C at 100 m 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	≤ 100,000 bpd	None	N/A
Subsea Hydraulic Fluid Discharge • Water soluble, low-toxicity	≤ 5 bpd	None	N/A

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate	Discharge Criteria	Treatment Required to Meet Criteria?
FPSO Bilge Water	1,800 bpd	Oil in water content: <15 mg/L	Yes
Inert Gas Generator Cooling Water	Negligible	None	N/A
FPSO Slop Tank Water	Negligible	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	N/A
Tanker Ballast Water	1,100,000 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	N/A
Rain Water/Deck Drainage/Wash Down Water	Rainfall dependent	No visible oil sheen on receiving water	N/A
Gray Water	5,000 bpd	None	N/A
Black Water (sewage)	4,000 bpd	Total residual chlorine as low as practical but not less than 1 ppm	Yes
Food Preparation Wastes	<30 bpd	Macerated to <25 mm diameter	Yes

Notes:
bbl = barrels
bpd = barrels per day

2.10.4 Waste Management

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 2-6 indicates, waste will begin to be generated when drilling commences, as early as 2018 per the current project schedule. Waste volumes generated will increase as drilling activity increases in 2019 and 2020. Additional waste will be generated from SURF installation and FPSO commissioning and hookup activities in the 2019-2020 timeframe. Waste volumes will then begin to decrease as drilling activity declines in 2021 and significantly decrease during the production operations stage once drilling activity is complete (2022 to 2039). When production operations cease, some waste will be generated from decommissioning activities.

Table 2-6 Summary of Estimated Annual Project Waste Generation and Management Methods

	Representative Waste Streams	Estimated Annual Waste Generation (metric tonnes)(1)					
		2018	2019	2020	2021	2022-2039	2040
Totals by Classification							
Non-hazardous wastes(2)	Plastic, glass, paper, scrap metal	1850	4220	5870	2480	400	330
Hazardous wastes	Used oil, paint waste, oil-contaminated cement	1770	4050	5470	2170	190	210
Totals by Management Method							
Offshore Incineration	Wood, paper, cardboard	250	600	830	360	80	110
Onshore Treatment / Incineration	Used NADF, oil sludge, unused chemicals	1670	3820	5140	2014	140	140
Onshore Landfill (all non-hazardous)(2)	General trash, incinerator ash,	1610	3630	5030	2080	280	230
Recycle into Process	Used oil, oily water	0	0	20	30	30	20
Recycle (all non-hazardous)	Plastic, glass, scrap metal	90	220	320	170	70	60

(1) The annual totals reflect the current preliminary Project schedule (see Section 2.14), which could change.

(2) 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 2-4 under FPSO source) 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 who is operating an existing onshore waste treatment/incineration facility at a local shorebase in Georgetown, Guyana (see Figures 2-22 and 2-23). The Project is planning to utilize similar facilities in Guyana or the region during the development drilling, FPSO/SURF production operations, and decommissioning stages. To the extent that solid wastes are being disposed of by a Guyanese licensed onshore disposal facility (i.e., 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 Environmental and Socioeconomic Management Plan (ESMP).

Figure 2-22 Typical Waste Management Facilities at a Local Shorebase

Figure 2-23 Vertical Infrared Unit with Wet Scrubber and Oxidizer at Typical Waste Management Facilities

2.11 Embedded Controls

EEPGL has incorporated the embedded controls[13] provided in Table 2-7 into the Project:

Table 2-7 List of Embedded Controls

Embedded Control Measures	Resources/Receptors Benefitted
Drilling and SURF/FPSO Installation and Commissioning	
• Utilize WBDF to the extent reasonably practicable and in other cases use low-toxicity IOGP Group III NABF.	Marine sediments, water quality, mammals, turtles, fish, and benthos
• When NADF is used, utilize a solids control and cuttings dryer system to treat drill cuttings prior to discharge such that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous fluids shall not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine sediments, water quality, mammals, turtles, fish, and benthos
• For VSP activities, commence such operations during daylight hours after a suitable pre-watch by Marine Mammal Observers (MMOs) is performed and begin with soft start procedures, which incrementally increase source sound levels in order to allow marine mammals and turtles time to move away from the activity before full sound source energy is utilized, in accordance with JNCC guidelines.	Marine mammals, marine turtles
• With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: o Change liquid hydrocarbon transfer hoses periodically o Utilize dry-break connections on liquid hydrocarbon bulk transfer hoses o Utilize a liquid hydrocarbon checklist before every bulk transfer o Perform required inspections and testing of all equipment prior to deployment/installation; o Utilize certified Blowout Prevention (BOP) equipment; o Regularly test certified BOP equipment and other spill prevention equipment; o Utilize overbalanced drilling fluids to control wells while drilling; o Perform operational training certification (including well control training) for drill ship supervisors and engineers; o Regularly audit field operations on the drill ships, FPSO, and shorebase(s) to ensure application of designed safeguards; and o Controls for mitigating a failure of the dynamic positioning system on the drill ships and maintain station keeping, which include:	Air quality, marine sediments, marine water quality, protected areas, sensitive species, coastal habitats, coastal wildlife and shorebirds, marine mammals, turtles, fish, benthos, ecology and ecosystems

[13] Embedded controls are engineering specifications, components, and/or operational procedures that are planned as part of the Project.

Embedded Control Measures	**Resources/Receptors Benefitted**
▪ Use of a Class 3 Dynamic Positioning (DP) system, which includes numerous redundancies; ▪ Rigorous personnel qualifications and training; ▪ Seatrials 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.	
• During pile driving activities, gradually increase the intensity of hammer energy to allow sensitive species to vacate the area before injury occurs (i.e., soft starts).	Marine mammals
• Maintain marine safety exclusion zones with a 500 m (~1,640 ft) radius around drill ships and major installation vessels to prevent unauthorized vessels from entering potentially hazardous areas.	Marine use and transportation safety
Production Operations	
• Re-inject produced gas which is not utilized as fuel gas on the FPSO to avoid routine flaring. With respect to non-routine flaring, the following measures will be implemented: o Monitor flare performance to maximize efficiency of flaring operation; o Ensure flare equipment is appropriately inspected and function tested prior to production operations; and o Ensure flare equipment is appropriately maintained and monitored during production operations.	Air quality
• Treat produced water on the FPSO to limit oil and grease (O&G) content to 29 mg/L monthly average and 42 mg/L daily maximum.	Marine water quality, mammals, turtles, fish, and benthos, seabirds, ecology and ecosystems
• Design produced water and cooling water processes to avoid increases in ambient water temperature of more than 3˚C at 100m (~328 ft) from the FPSO when discharging.	Marine water quality, mammals, turtles, fish, and benthos, seabirds, ecology and ecosystems
• Perform onboard waste incineration for certain categories of waste.	Land use
• 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 safety
• Utilize support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation safety
• 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 safety
• FPSO offloading to tankers will occur 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	Marine sediments, water quality, mammals, turtles, fish, benthos, and

Embedded Control Measures	Resources/Receptors Benefitted
the environmental operating limit the tanker will cease the offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	seabirds
• Utilize a marine bonded, double-carcass floating hose system certified by Class or other certifying agency that complies with the recommendations of OCIMF Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM) 2009 Edition or later.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Utilize breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Utilize a load monitoring system in the FPSO control room to support FPSO offloading.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Utilize leak detection controls during FPSO offloading which include: ○ Leak detection for breach of the floating hose that complies with the recommendations of OCIMF GMPHOM 2009 Edition or later; ○ Utilization of instrumentation/procedures to perform volumetric checks during offloading.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Provide trained medical personnel on board the FPSO and major installation vessels to minimize reliance on medical infrastructure and facilities in Guyana.	Community health and wellbeing
• Utilize marine safety exclusion zone of 2 nautical miles around the FPSO to prevent unauthorized vessels from entering potentially hazardous areas.	Marine use and transportation safety
• Project vessels will conduct ballasting operations in accordance with IMO regulations.	Ecological Balance and Ecosystems
General Measures	
• Maintain equipment, marine vessels, and helicopters in good working order and operate in accordance with manufacturer's specifications in order to reduce atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality, water quality, marine mammals, marine turtles
• Regularly inspect and service shorebase cranes and construction equipment in order to mitigate the potential for spills and to maintain air emissions at optimal levels.	Air 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 practical.	Water quality
• Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Water quality
• Perform regular audits of field operations on the drill ship, FPSO, and shorebase to ensure application of designed safeguards.	Air quality, water quality

Embedded Control Measures	Resources/Receptors Benefitted
• Treat sewage to applicable standards under MARPOL 73/78.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• For those wastes that cannot be reused, treated, or discharged/disposed on the drill ship or FPSO they will be 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.	Land use
• Utilize oil/water separators to limit oil in water content in bilge water to <15 parts per million (ppm; per MARPOL).	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Provide standing instruction to Project dedicated vessel masters to avoid marine mammals and 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 safety
• Project workers will be subject to health screening procedures to minimize risks of communicable diseases.	Community health and wellbeing
• Utilize an established SSHE program to which all Project workers and contractors will be required to mitigate against risk of injury/illness to workers. • All workers and contractors will receive training on implementation and will be required to adhere to its principles.	Occupational and community health, safety, and wellbeing
• Maintain an 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
• Where practicable, direct lighting on FPSO and major vessels to required operational areas rather than at the sea surface or skyward.	Seabirds and marine turtles
• Provide screening on FPSO and drill ships for seawater intakes to minimize the entrainment of aquatic life, where practical.	Marine fish

2.12 Project Workforce

Preliminary workforce estimates are provided in Table 2-8. These estimates have been slightly revised since submittal of the Application for Environmental Authorisation.

Table 2-8 Workforce Estimates

Project Stage	Estimated Workforce
Development Drilling	Approximately 600 persons offshore at peak, when utilizing up to two drill ships concurrently (Dependent upon final drill ships and support vessels selected)
Installation, including FPSO and SURF Mobilization, and Hook-up/Commissioning	Approximately 600 persons offshore at peak (Dependent upon final installation and support vessels selected)
Production Operations, including FPSO and conventional tanker	Approximately 100 to 140 persons offshore at peak (an additional 25 to 30 persons would be onboard the tanker) (Dependent upon conventional tanker schedule)
Decommissioning	Approximately 60 persons offshore at peak

In addition to the offshore components, there will also be personnel providing shorebase and marine logistical support onshore (approximately 100-150 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 installation stage until reaching a peak during the development drilling campaign and FPSO/SURF installation activities, and then will diminish during FPSO/SURF production operations. The logistical support onshore staff level is expected to increase again briefly during decommissioning.

2.13 Worker Health and Safety

EEPGL and its parent company, ExxonMobil, are committed to protecting the safety, security, and health of its employees, contractors, and the public, with a goal of *Nobody Gets Hurt*. It has a robust and effective management system to protect its Project workforce. EEPGL will implement its Operations Integrity Management System (OIMS) (see Section 2.2) during each Project stage. This program is designed to manage occupational risks to Project workers and, therefore, occupational health and safety are not discussed further in this EIA.

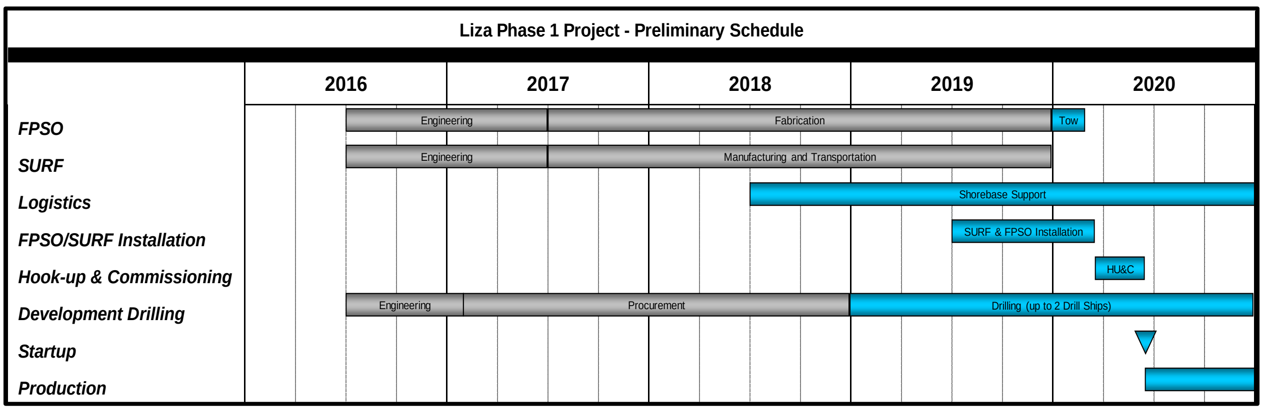
2.14 Project Schedule

At this time, the proposed Project schedule is still being refined. The Project life cycle will include development drilling, installation, production operations, and decommissioning, as well as associated logistics and onshore support. The engineering stage will precede FPSO and SURF installation and development drilling operations, and will include front-end engineering and design (FEED) and detailed engineering. The execution stage will include procurement, fabrication and construction, drilling, installation, hook-up, commissioning, and start-up. Operations and maintenance will follow start-up and will be the longest stage of the Project.

Figure 2-24 provides a preliminary schedule for the major Project components and activities. As depicted on Figure 2-24, oil production and export from the Project is planned for approximately mid-2020. To support this goal, development well drilling from up to two drill ships is planned to start in early 2019, with the potential for mobilization in 2018. The installation of the SURF components and the FPSO are planned to commence in 2019. Production will continue for at least 20 years. The milestones are still being refined and are subject to change.

This schedule provides for simultaneous development drilling and FPSO/SURF production operations, which will involve bringing the initial production wells online as subsequent development wells are being drilled.

Figure 2-24 Preliminary Project Schedule



2.15 Project Benefits

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

- Through revenue sharing with the Government of Guyana, although the details of this revenue sharing is confidential. 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 and outside the scope of the EIA;
- By procuring select Project goods and services from Guyanese businesses to the extent reasonably practicable; and
- By hiring Guyanese nationals where reasonably practicable, although the potential magnitude of hiring will be limited.

In addition to direct revenue sharing, expenditures, and employment, the Project would also likely generate induced economic benefits as other non-Project related businesses benefiting from direct Project purchases or worker spending will re-invest locally or expand spending in the area, thereby also generating more local value-added tax. These beneficial "multiplier" impacts will occur throughout the Project life.

2.16 Alternatives

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

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

2.16.1 Location Alternatives

The location of the Project, and the development wells in particular, is driven by the location of resource to be recovered. There are no meaningful location alternatives for the FPSO, SURF equipment, and drill centers within the PDA.

2.16.2 Development Concept Alternatives

Given the water depth and distance to shore of the Liza field, the development alternatives for Phase 1 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 in order to enable export of the oil to buyers. The use of an FSO would significantly increase the Project offshore infrastructure, which would increase Project impacts on air quality (e.g., increased air emissions), marine water quality (e.g., additional wastewater discharges), marine benthos (e.g., increased disturbance of the seafloor FSO for mooring system), marine use and transportation (e.g., expanded exclusion zones for other marine vessels). Therefore, the FPSO was chosen as the preferred concept for Phase 1 because it is a more efficient, stand-alone solution for deepwater oil processing and storage, and it also provides for fewer environmental impacts.

Three primary alternatives were considered for addressing associated gas produced during Phase 1 operations: gas re-injection, gas export, and continuous flaring. Gas re-injection was determined to be feasible for Phase 1, and it also provides benefits in reservoir management and reduced air emissions. As such, 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, particularly given challenges related to commercialization of associated gas. The FPSO has been designed to allow for future gas export should an export alternative be identified.

2.16.3 Technology Alternatives

EEPGL is using the most appropriate industry-proven technology 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 the Project in Guyana.

2.16.4 No-go Alternative

The no-go alternative means that the proposed Project would not be executed. If this alternative is applied, the existing conditions described in Chapter 6 would remain unaffected by the Project and the potential positive and negative impacts assessed in Chapter 7 would not be realized. Therefore, evaluating the no-go alternative means evaluating the tradeoff between positive and negative impacts.

2.16.5 Summary of Alternatives

EEPGL considered a reasonable range of alternatives to the Project and their environmental impacts, and has selected the best action alternative, which is also the environmentally preferred alternative, for use during Phase 1. The FPSO and SURF production system is a proven development concept for deepwater oil developments and would leverage both operator and industry proven technologies and experiences.

-Page Intentionally Left Blank-

3.0 ADMINISTRATIVE FRAMEWORK

The Project must comply with applicable policies, guidelines, and legislation in Guyana (see Section 1.1, *Purpose of the EIA*). This chapter reviews the relevant legislations and policies in Guyana that are applicable to the Project and is divided into three sections:

- Section 3.1 describes Guyana's national legal framework, focusing on laws that apply to environmental issues in a general context such as the Constitution of Guyana, as well as specific national laws and regulations that focus on environmental issues such as the EP Act (Cap. 20:05) and the Environmental Protection (Authorisation) Regulations of 2000, and petroleum development issues. It also identifies several resource-specific environmental laws that are more narrowly focused and are directly or indirectly relevant to the Project.
- Section 3.2 describes the elements of the national policy framework that apply to the Project. These strategies and policies articulate the government's goals with respect to various environmental issues.
- Section 3.3 describes the various international and regional conventions and protocols to which Guyana is a signatory that are applicable to the Project.

In addition to these Guyana regulations, Section 3.4 discusses EEPGL's Operations Integrity Management System (OIMS), which establishes common expectations to address risks inherent in its business.

3.1 National Legal Framework

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

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.

3.1.2 The Environmental Protection Act

In 1996, the EP Act (Cap. 20:05) was ratified to implement the environmental provisions of the Constitution. The EP Act (Cap. 20:05) 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 EP Act (Cap. 20:05) authorized the formation of the EPA, and establishes the EPA as the lead agency on environmental matters in Guyana (FAO, 2013). The EPA is one of the agencies included within the Ministry of Natural Resources. The EP Act (Cap. 20:05) further mandates the EPA to oversee the effective management, conservation, protection, and improvement of the environment (EPA, 2012). 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 the sustainable use of natural resources.

The EPA has issued an official guidance document entitled "Environmental Impact Assessment Guidelines" which describes the general components and content of a typical EIA. This EIA has been prepared consistent with the recommendations in this document (see Table 1-2).

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 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.

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. 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 Governance (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 and announced pending revisions to the Petroleum Act. These revisions were due for consideration by Guyana's National Assembly before the end of 2016 (Kaieteur News, 2016) but had not been presented for approval as of February 2017. In late January 2017, Guyana's Government Information Agency (GINA) announced the Ministry of Natural Resources' plan to conduct a national outreach program to provide information to the public and answer questions on the emerging oil and gas sector (GINA, 2017).

3.1.5 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 are also indirectly related to the environment. Several of Guyana's environmental statutes were enacted prior to the 1980 Constitution and were subsequently incorporated into the newly formed national legal framework, but most were enacted after 1980. Table 3-1 identifies these laws and summarizes their relevance to the Project.

Table 3-1 Resource-Specific Environmental and Social Laws

Title	Objective	Relevance to the Project
Biological Resources		
Fisheries Act, 2002	Regulates fishing and related activities in Guyana territorial waters.	The Fisheries Act authorizes the prohibition and/or regulation of deposition or discharge of substances harmful to fish. Would primarily affect the contents of routine discharges from Project vessels and the FPSO.
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, 2016)	Provides for the establishment of a Management Authority and the management of the country's flora and fauna.	Provides a supportive mechanism cognizant of the national goals for wildlife protection, conservation, management and sustainable use.

Physical Resources		
Environmental Protection Water Quality Regulations, 2000	Focused on setting effluent standards, reporting requirements, penalties for violations of standards, and permitting requirements for discharges.	Regulates discharges of listed substances, which could include substances used during the Project. Would affect the concentrations of certain constituents (primarily metals, but including others such as nitrogenous compounds, fluoride, and sulfate) that could be discharged in the routine discharges from the Project.
Environmental Protection Air Quality Regulations, 2000	Sets ambient air quality standards, reporting requirements, penalties for violations of standards, and permitting requirements for stationary and mobile sources.	Regulates discharges that could be emitted during the Project, including smoke, particulates, and carbon monoxide (CO).
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 produced by the Project.
Toxic Chemicals Control Act No. 13 of 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 this Project, but small amounts of chemicals may be used. The Act would regulate the importation, registration, and use of these chemicals.
Environmental Protection Noise Management Regulations, 2000	Establishes general provisions for noise avoidance and restrictions from multiple commercial and industrial sources including sound making devices, night clubs, equipment, tools, and construction activities.	Tools and equipment includes pile drivers, steam shovels, pneumatic hammers, pumps, vent or valve devices and any other similar equipment. A regulated facility includes any offshore installation and any other installation, whether floating or resting on the seabed.

Draft Guyana Standard, Requirements for Industrial Effluent Discharge into the Environment, 2015	Compulsory standard used for monitoring of effluents into freshwater, estuarine, and marine water resources.	Sets limits for key parameters in discharges of industrial effluent. Would affect the concentrations of many of the same constituents in routine discharges that would be regulated under the Environmental Protection Water Quality Regulations 2000. Would also dictate the general water chemistry parameters (e.g., temperature, biological oxygen demand, pH) of these discharges.
Public Health		
Occupational Safety and Health Act, 1997	Legally defines the responsibilities of workers and management with respect to keeping workplaces safe.	Would generally apply to workers and Project-related activities on the Project site(s).
Food & Drug Regulations (Food and Drug Act)	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.
Social / Cultural Resources		
National Trust Act	Stewardship of historic resources and places of cultural significance.	Governs the management of any building, structure, object, or other man-made 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.

Most recently, the Minister of Natural Resources, who functions as the sponsoring Minister for the Oil and Gas industry, announced plans in September 2015 to upgrade the country's upstream oil and gas policy, which was originally crafted in 2012 and finalized in 2014, indicating an evolving policy and regulatory framework surrounding the oil and gas industry in Guyana.

To date, there are 16 laws concerning oil and gas in Guyana. The majority of these laws are housed with the EPA, National Advisory Council on Occupational Safety and Health, Guyana Revenue Authority (GRA), GGMC, or Guyana National Bureau of Standards.

3.2 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 policies applicable to the Project.

3.2.1 National Development Strategy

The National Development Strategy (NDS) recommends priorities for Guyana's economic and social development policies for the next decade. The draft document 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. Relevant features to this Project covered under Volume 3 include the coastal zone, fisheries, waste management, pollution control, and environmental impacts of private-sector activities (NDS, 1997).

Volume 5 of the NDS 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 development and regulation of the sector into the future (NDS, 1997).

3.2.2 National Environmental Action Plan

Guyana's National Environmental Action Plan (NEAP) articulates the national 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 is directly relevant to the Project in several ways. It identifies the coastal zone, which will support Project activities, as an area in need of focused management due to the concentrated human population along the coast and the susceptibility of the coastal environment to both natural and human-induced degradation. 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.

3.2.3 Integrated Coastal Zone Management Action Plan

Guyana's Integrated Coastal Zone Management (ICZM) process is an ongoing initiative to: promote the wise use, development, and protection of coastal and marine resources; enhance collaboration among sectorial agencies; and promote economic development. In 2000, after 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 (GLSC, 2006). 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.

3.2.4 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 established 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.

3.2.5 Guyana's National Biodiversity Strategy and Action Plan (NBSAP)

Guyana's current National Biodiversity Strategy and Action Plan 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 socio-economic 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. It also simultaneously recognized the importance of the mining industry to the national economy and the potential for conflicts between the mining industry and ecotourism if land degradation is associated with mining activity is not appropriately managed. The NBSAP set 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.

3.2.6 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 (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”.

3.2.7 Guyana Energy Agency’s Strategic Plan

The Guyana Energy Agency (GEA) was established by the Guyana Energy Agency Act of 1997 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 (GEA, undated). The GEA’s Strategic Plan for 2014-2018 specifically charges the Agency with monitoring “the production, importation, distribution, and utilization of petroleum and petroleum products.”

3.3 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 relevant to the Project to which Guyana has acceded or is a signatory are listed in Table 3-2.

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 which 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 would govern certain specific aspects of the Project as they relate to labor.

The IMO is a similar organization whose member states have agreed to one or more conventions related to maritime activities. These include three "key" conventions (the International Convention for the Safety of Life at Sea, the International Convention for the Prevention of Pollution from Ships, 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. Guyana's Maritime Administration manages compliance with the requirements of the agreements Guyana is signatory to under the IMO, with technical assistance from the IMO's Regional Maritime Advisory Office in Port of Spain, Trinidad.

The agreements to which Guyana is party through its membership in the ILO and IMO are identified in bold in Table 3.2.

Table 3-2 International Agreements Relevant to Environmental and Socioeconomic Issues in Guyana

Agreement/ Convention	Objective	Status	Relevance to Project
Climate Change/Air Quality			
United Nations Framework Convention on Climate Change	Promote international cooperation to limit average temperature increases and resulting changes in climate. Promote international cooperation to adapt to these impacts.	Acceded and Ratified in 1994	Provides for controls on greenhouse gas emissions within Guyana's territory (maritime and land), and establishes national policy regarding adaptation to climate change.
Kyoto Protocol	Extends the UNFCCC and commits countries to reduce greenhouse gas emissions.	Acceded in 2003	Establishes national emission reduction targets.
Vienna Convention on the Protection of the Ozone Layer	Provides a framework for the protection of the ozone layer.	Acceded in 1993	Establishes measures for protecting the ozone layer.
Montreal Protocol on Substances that Deplete the Ozone Layer	Is a protocol to the Vienna Convention and is designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion.	Acceded in 1993	Prohibits the use of several groups of halogenated hydrocarbons that may deplete the ozone layer.

Pollution Prevention			
International Convention for the Prevention of Pollution from Ships	Regulates various forms of marine pollution, including oil and fuel, noxious liquid, hazardous substances, sewage, garbage, air emissions, and ballast water.	Acceded in 1997	Impacts the handling and disposition of controlled substances from the drill ships, FPSO, and support vessels.
International Convention for Safe Containers	Promote the safe transport and handling of containers through generally acceptable test procedures and related strength requirements, and facilitate the international transport of containers by providing uniform international safety regulations, equally applicable to all modes of surface transport.	Acceded in 1997	Regulates the manufacture, use, and integrity of containers used on board the drill ships, FPSO, and support vessels.
International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties	Confirms the right of coastal member states to take specific actions when necessary to prevent pollution from oil following a maritime casualty	Acceded in 1997	Would protect Guyana's rights to respond to an oil spill if such an event were to occur.
International Convention on Civil Liability for Oil Pollution Damage	Establishes vessel owners' liability for damages caused by pollution from oil spills and provides for compensation would be available where oil pollution damage was caused by maritime casualties involving oil tankers	Acceded in 1997	Would not apply directly to EEPGL's activities, but would apply to potential spills from tankers that had received oil from the FPSO.
Basel Convention on the Transboundary Movement of Hazardous Wastes and Their Disposal	Reduce and control the movements of hazardous waste between nations and discourage transfer of hazardous waste from developed to less developed countries.	Acceded in 2001	Would apply to the Project only if hazardous waste generated in Guyana were disposed outside Guyana, or if hazardous waste was brought into Guyana from a foreign state for disposal during execution of the Project.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	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.	Acceded in 2007	Would apply to the Project only if chemicals and/or pesticides listed under the convention were shipped into or out of Guyana.

Stockholm Convention on Persistent Organic Pollutants (POPs), as amended	Requires party nations to take measures to eliminate or reduce the release of persistent organic pollutants.	Acceded in 2007	Would apply to the Project only if POPs were released to the environment during the course of Project-related activities in Guyana.
International Convention on Oil Pollution Preparedness, Response and Cooperation	Establishes measures for dealing with marine oil pollution incidents	Ratified in 1997	Requires ships to have a shipboard oil pollution emergency plan.
Ecological/Environmental Quality/Cultural Heritage			
The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region	Provide framework for international protection and development of the marine environment across the Caribbean region.	Acceded and Ratified in 2010	Sets general goals for protection for the marine environment, especially from pollution.
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.	Acceded and Ratified in 2010	Elaborates on the wildlife goals established in the Cartagena Convention and Convention on Biological Diversity.
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.	Signed in 1992, Ratified in 1994	Discourages activities that would negatively impact biodiversity.

United Nations Convention on the Law of the Seas	Defines nations' rights and responsibilities in terms of their use of oceans and provides guidance on environmental and natural resource management.	Concluded in 1982 and ratified in 1994	Defines legal status of subsea mineral resources as the "common heritage of humankind," encourages resource development to be done in a way that supports healthy global economic growth and trade balance, and mandates that states take measures to prevent, control, and reduce pollution of the oceans.
Convention on International Trade in Endangered Species of Wild Flora and Fauna	Protects endangered plants and animals from international trade.	Acceded in 1977	Restricts collection and trade of endangered species.
UNESCO Convention on the Protection of the Underwater Cultural Heritage	Protects "all traces of human existence having a cultural, historical, or archaeological character" that have been under water for over 100 years.	Ratified in 2014	Applies to shipwrecks.
Labor/Health/Safety			
International Convention for the Safety of Life at Sea	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.	Acceded in 1997	Affects construction, operation, and equipment on board the drill ships, FPSO, installation vessels, and support vessels.
Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation	Promotes safety at sea by criminalizing actions that would endanger a vessel or its cargo, or contributing to activities that would do so.	Acceded in 2003	Would apply to any activity intended to endanger vessels while at sea conducting permitted activities related the Project.
Dock Work Convention	Regulates activities associated with the loading and unloading of cargo onto/from oceangoing vessels when at port.	Acceded 1983	Would apply to loading and offloading activities at the shorebase.

Repatriation of Seafarers Convention (Revised)	Requires vessel owners/operators to repatriate (at the operator's expense) seafarers that have successfully concluded a minimum period of service onboard a vessel (minimum time to qualify for this benefit to be determined by the member state but not to exceed 12 months)	Acceded 1996	Would apply to workers onboard both EEPGL owned/operated vessels, their contractors, and tankers receiving oil from the FPSO.
Seafarer's Identify Documents Convention	Requires signatory states to issue identity cards to seafarers and for other signatory states to allow holders of these cards entry to their territories for the purposes of shore leave, joining a crew, or repatriation after completing a voyage.	Acceded 1966	Would apply to seafarers entering or egressing Guyana prior to or following employment on vessels operated by EEPGL or its contractors, and to seafarers on shore leave while employed by EEPGL or its contractors.
Convention on the International Regulations for Preventing Collisions at Sea	Officially recognizes the importance of traffic separation in the marine environment and codifies basic measures to accommodate traffic separation, including safe speed, signaling conventions, and general vessel conduct.	Acceded in 1997	Governs operation of drill ships, FPSO, installation vessels, and support vessels.
International Convention on Standards of Training, Certification and Watchkeeping	Obligates crews operating vessels flagged in signatory states to adhere to minimum standards relating to training, certification and watch keeping. Requires signatory states to submit detailed information to the International Maritime Organization concerning administrative measures taken to ensure compliance with the convention.	Acceded in 1997	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.
Convention on Facilitation of International Maritime Traffic	Prevent unnecessary delays in maritime traffic arising from burdensome documentation requirements, and establish uniform formalities and other procedures to permit transboundary maritime commerce and travel.	Acceded in 1998	Facilitates entry of drill ships, FPSO, installation vessels, and support vessels into Guyana.

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

To highlight Guyana's 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, and in September 2015, the country recommitted its support to the ILO.

3.4 EEPGL's Operations Integrity Management System

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

EEPGL's OIMS Framework[14] establishes common expectations used by Company affiliates worldwide for addressing risks inherent in its business. The term Operations Integrity (OI) 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 Company 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 will be consistent with the risks associated with the business activities being planned and performed. Figure 3-1 provides a high level description of the OIMS Framework and its 11 essential Elements.

[14] http://corporate.exxonmobil.com/company/about-us/safety-and-health/operations-integrity-management-system[15] The European Nature Information System (EUNIS) is a habitat classification system developed by the European Environment Agency (EEA) in collaboration with international experts. The EUNIS includes all types of natural and artificial habitats, both aquatic and terrestrial.

Figure 3-1 Operations Integrity Management System

4.0 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 undertaken in a manner consistent with the Guyana Environmental Impact Assessment Guidelines – Volumes 1 and 2 (2000 and 2004, respectively).

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 intended to share 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.

This 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 that EEPGL will take to avoid, reduce, and remedy adverse 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. The EP Act (Cap. 20:05) defines an "adverse" impact as meaning one or more of the following:

- Impairment of the quality of the natural environment or any use that can be made of it;
- Injury or damage to property or to plant or animal life;
- Harm or material discomfort to any person;
- An adverse effect on the health of any person;
- Impairment of the safety of any person;
- Rendering any property or plant or animal life unfit for use by human or unfit for its role in the ecosystem;
- Loss of enjoyment of normal use of property; and
- Interference with the normal conduct of business.

Information on potential impacts, including potential cumulative impacts related to the Project, was obtained by ERM from various primary and secondary sources, including: consultation and key informant interviews with the EPA, GGMC, and other stakeholders; environmental impact assessments for other similar projects worldwide; and scientific research and literature.

The key stages for this 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;
- Mitigation, Management, and Monitoring; and
- Disclosure and Reporting.

The methodologies for the key stages are described in the subsequent 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 for Environmental Authorisation (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 may determine that the information included in the application is sufficient to support a permitting decision, or it may require a Strategic Environmental Assessment, Environmental Management Plan, and/or an Environmental Impact Assessment. The EPA determined that the Project could result in potentially significant impacts, and, in accordance with the EP Act (Cap. 20:05), indicated on July 29, 2016 that the Project requires an Environmental Impact Assessment to inform a decision to approve or reject the Project.

4.2 Scoping and Terms of Reference

The key objectives of scoping are to:

- Identify key sensitivities and those 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 ensure that the process and output are focused on the key issues. The ToR describes the scope, technical approach, and issues of importance to be considered in the EIA.

EPA issued a draft ToR for the Project on September 8, 2016, and its availability was advertised in the newspaper on September 9, 2016. Sector Agency Scoping Meetings were held on October 5 and 6, 2016, to receive government agency comments on the draft ToR. Public Scoping Meetings were held in each of the six coastal regions as follows to receive public comments on the draft ToR:

- Region 1: November 14, 2016
- Region 2: October 26, 2016
- Region 3: October 24, 2016
- Region 4: December 3, 2016
- Region 5: December 2, 2016
- Region 6: November 8, 2016.

Following the public scoping meetings, the EPA required the submittal of an updated Project Summary, which EEPGL submitted on January 13, 2017. The EPA issued a public notice for the updated Project Summary with an additional 28-day public comment period. EPA approved the Final ToR on February 17, 2017. The Final ToR was developed to guide the preparation of the EIA and outline the requirements of the same. The Final ToR incorporated the concerns, issues, and suggestions garnered during the 28-day Public Notification Period and the public and sector agency meetings described above.

4.3 Assessing Existing Conditions

The description of existing physical, environmental, and socioeconomic conditions provides information on resources/receptors identified during scoping that have 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 areas potentially impacted by the Project;
- 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 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.

4.4 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 would 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 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 has been conducted to support the development of the EIA and associated ESMP. The objectives of the Project's stakeholder engagement activities are to:

- Promote the development of respectful and open relationships between stakeholders and EEPGL during the Project life cycle;
- 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;

- 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 and EEPGL expectations for stakeholder engagement; and
- Record feedback and resolve 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, and their frequency 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 the stakeholder identification and mapping analysis, 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 the consultation is to ensure that EEPGL has identified key stakeholder issues and concerns.

EEPGL may disseminate information through print and online publications, 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 the Project 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). 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 can be addressed.

4.5.3 Stakeholder Engagement Process

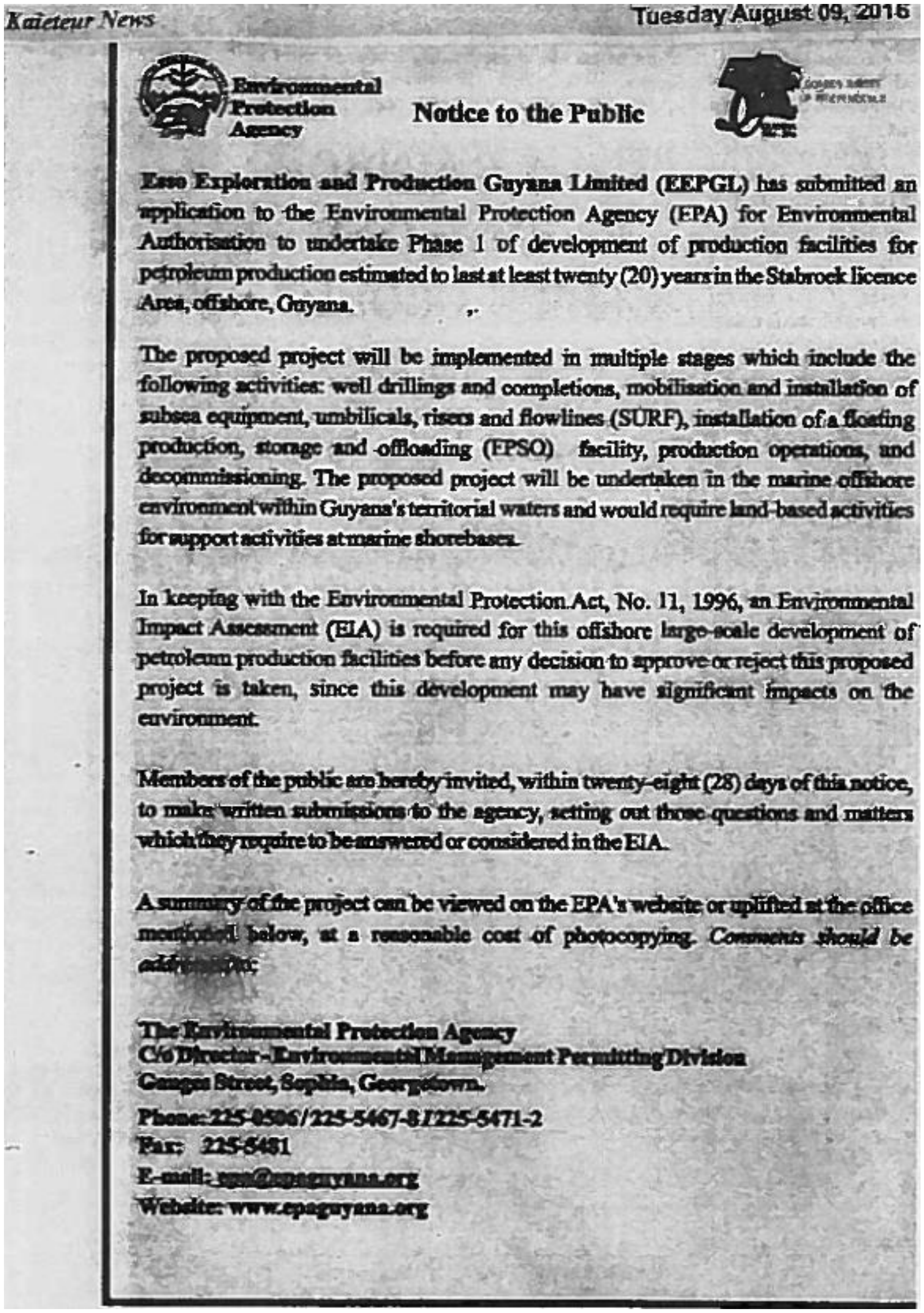
Stakeholder engagement activities are an integral part of the Project lifecycle: from the initial notification when the Project is proposed, to the scoping of potential impacts, to the EIA, and throughout the life of the Project.

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 and/or planned specific to the EIA stage are summarized below.

- EEPGL has held many meetings and various workshops with the government and others on offshore oil and gas exploration and development.
- The submission of the Application was posted in the local newspaper on August 9, 2016, by EPA (Figure 4-1) and was subject to a 28-day public comment period. There were no comments received from the public in regards to the Application.
- EEPGL and/or ERM have held meetings or key informant interviews with over 30 Guyana government agencies/commissions, many elected officials and Regional Administrators, over 15 professional or business associations, international and domestic non-governmental organizations, several universities and research institutes, various religious and ethnic organizations, and the media to inform stakeholders about the Project and to collect information needed for the EIA. Although questionnaires were not used, these meetings are documented in the SEP and inputs from these engagements were incorporated into the existing conditions and impact assessment components of the EIA (Chapters 6 and 7, respectively).
- The Draft ToR was developed and published by the EPA on their website on September 8, 2016.
- Sector Agency Scoping Meetings were held with EEPGL, the EPA, and other government agencies on October 5 and 6, 2016, with over 150 attendees of which approximately 100 were members of the general public, to discuss the Draft ToR, scope potential impacts, and capture agency-level stakeholder feedback on the Draft ToR.
- Public Scoping Meetings for the purpose of scoping potential impacts and capturing stakeholder opinions from the general public on the Draft ToR were held in Regions 1 through 6 during October, November, and December 2016 with over 300 attendees, of which over 200 were public participants (Figure 4-2).

- Following the public scoping meetings, the EPA required the submittal of an updated Project Summary, which EEPGL submitted on January 13, 2017, that was followed by an additional 28-day public comment period.
- The EPA approved the TOR for the Project on Feburary 17, 2017.
- Several select stakeholders were consulted following acceptance of the TOR, including:
  - 50 business community stakeholders at the Marriott hotel in Georgetown on February 20, 2017;
  - the Guyana Oil and Gas Association on February 21, 2017; and
- Once the EIA was submitted to the EPA on February 27, 2017, the EPA administered a 60-day public comment period, during which the public was invited to submit comments to the EPA on the EIA.
- During the 60-day public comment period, EEPGL held a number of small group and individual meetings with various stakeholders including government agencies/commissions and NGOs, Regional Administrators, and academic and ethnic/religious institutions. The purpose of these meetings was to provide an overview of the EIA results and answer questions relating to the EIA process and results.
- During the 60-day public comment period, EEPGL also held public meetings in Regions 1 and 6. The meetings included an overview presentation of the EIA results, and provided the public the opportunity to pose questions about the EIA and the Project.

Figure 4-1 Environmental Application Invitation for Public Comment



Kaieteur News Tuesday August 09, 2016

Environmental Protection Agency

Notice to the Public

Esso Exploration and Production Guyana Limited (EEPGL) has submitted an application to the Environmental Protection Agency (EPA) for Environmental Authorisation to undertake Phase 1 of development of production facilities for petroleum production estimated to last at least twenty (20) years in the Stabroek licence Area, offshore, Guyana.

The proposed project will be implemented in multiple stages which include the following activities: well drillings and completions, mobilisation 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 marine offshore environment within Guyana's territorial waters and would require land-based activities for support activities at marine shorebases.

In keeping with the Environmental Protection Act, No. 11, 1996, an Environmental Impact Assessment (EIA) is required for this offshore large-scale development of petroleum production facilities before any decision to approve or reject this proposed project is taken, since this development may have significant impacts on the environment.

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

A summary of the project can be viewed on the EPA's website or uplifted at the office mentioned below, at a reasonable cost of photocopying. *Comments should be addressed to:*

The Environmental Protection Agency
C/o Director - Environmental Management Permitting Division
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 4-2 Sample Draft Terms of Reference Invitation for Public Comment - Regions 2 and 3

Environmental Protection Agency

Notice to the Public

Invitation to Public Scoping Meetings

The Public is hereby notified that there will be Public Scoping Meetings in Regions 2 and 3, for the **Esso Exploration and Production Guyana Limited Phase 1 of Development of Production Facilities** for Petroleum Production estimated to last at least twenty (20) years in the Stabroek License Area, Offshore, Guyana (please see Project Summary for map showing location of the proposed operation).

The proposed project will be implemented in multiple stages which include the following activities: well drillings and completions, 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 marine offshore environment within Guyana's territorial waters and would require support of land-based activities.

The purpose of these meetings is to allow members of the Public to express issues/ concerns / recommendations that should be covered by the Environmental and Social Impact Assessment (ESIA) for this project.

Members of the Public, including sectoral agencies and relevant Authorities, are invited to these meetings to be held on:

Region 2
Date: October 26, 2016
Location: Anna Regina
Venue: Anna Regina Multilateral Secondary School
Time: 4:00 p.m.

Region 3
Date: October 24,2016
Location: Leonora
Venue: Synthetic Track
Time: 4:00 p.m.

A summary of the project, as well as the draft Terms of Reference for the ESIA study, can be viewed on the EPA's website (www.epaguyana.org) or uplifted at the Office mentioned below:

Environmental Protection Agency
Environmental Management Permitting Division
Ganges Street, Sophia, Georgetown
Phone: 225-0506 / 225-2062 / 225-1218 / 225-6917
Fax: 225-5481
Email: epa@epaguyana.org
Website: www.epaguyana.org

Once the EIA process is complete, and assuming EEPGL obtains environmental authorization and other approvals from EPA, GGMC, and EAB, the Project will, subject to a final investment decision, transition into execution. 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 well drilling) and will respond to any grievances (e.g., 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.

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 (Table 4-1).

During the Project's EIA scoping phase, the EPA led a series of eight scoping meetings (two meetings attended by agency representatives, and one public meeting each in Regions 1-6). These meetings served to inform stakeholders about, and receive feedback on, the EIA Terms of Reference (ToR) which were also made available on the EPA website throughout the scoping phase. The public was also made aware that comments could be submitted directly to the EPA during the 28-day public comment period of the scoping phase.

A total of 163 comments were received from public stakeholders over the course of the scoping phase. Some were raised in person at the scoping meetings, while others were submitted via comment boxes at the meetings, or by letter to the EPA. The largest number of comments (58) pertained to the EIA approach, process and/or methodology, including questions about the EIA timeline, the company conducting the EIA, delineation of the Area of Influence (AOI), data collected for the EIA, stakeholder engagement efforts over the course of the EIA process, and content of the ESMP. There were also numerous questions and comments (37) about potential impacts of the Project, including impacts to marine life and other biological resources, fishing livelihoods, air quality, indigenous lands, and potential for accidents. A total of 40 comments pertained to the Project Description, including the project location, life of the project, processes for waste management, use of produced gas, and measures to prevent and address oil spills. A total of 19 comments were received about possible socioeconomic benefits of the Project, including employment, government revenues, and local content. Seven comments were received regarding the EPA's role and capacity in the EIA process, and three questions were received about the administrative framework regulating oil and gas development in Guyana. Table 4-1 below summarizes key themes raised by stakeholders during the EIA scoping phase, and indicates how these have been considered in the EIA.

Table 4-1 Themes in Scoping Comments Received and Consideration in EIA

Key Theme	Consideration in EIA
Differences between Phase 1 and Phase 2, types of SURF and FPSO equipment and methods, gas re-injection	Phase 2 has not been defined. Any future phases would be addressed through a separate permitting process. A Project Description is provided in Chapter 2.
EIA methodology, hierarchy, data collection techniques, types of surveys and studies, limitations, predictive analysis, and considerations for mitigation	The methodology for the EIA including existing condition data collection, assessment, and mitigation analysis is discussed in Chapter 4.
Oil spill response (OSR) capabilities, protection measures, vessel information, response capacity (e.g., trained responders, equipment), notifications, liability	OSR planning is discussed in Chapter 7. Potential impacts as a result of an unplanned event, such as an oil spill, are assessed in Section 7.4. A separate Oil Spill Response Plan for the Project is being developed.
Area of Influence (AOI) determinations	The AOI for the Project is described in Chapter 5.
Timing for public comment period, cut-off dates, and how comments are incorporated into the EIA	Details related to the EIA process and the administrative frameworks are discussed in Chapter 3. Details related to the public comment period and how stakeholder feedback is incorporated into the EIA are discussed here in Section 4.5.
Credentials and experience of the company developing the EIA.	A brief description of ERM and its experience conducting EIAs for offshore oil and gas projects is presented in Section 1.0 of the EIA. Curriculum vitae for the key EIA team members are provided in Appendix B of the EIA.
Subcontractor management and monitoring, logistical support requirements, and onshore shorebases	Details related to subcontractors and logistical support are described in Chapter 2.
Decommissioning	Decommissioning information is presented in Chapter 2.
Alternatives analysis, particularly as it pertains to Air Quality	An alternatives analysis is included in Section 2. Further details pertaining to Air Quality, Climate Change, and the impact on receptors is discussed in Chapter 7.
Strategic Environmental Assessment (SEA) details, current and previous stakeholder engagement information	The SEA that was submitted to EPA in March 2014 and includes previous stakeholder information can be found on the EPA website.
Role of Marine Mammal Observers	Information pertaining to marine mammal data collection can be found in Chapter 6.
Potential socioeconomic benefits of the Project including employment and government revenue.	Socioeconomic benefits of the Project are discussed generally in Section 7.3.2 and Section 7.3.3 of the EIA. Opportunities for local employment and procurement are currently under study; details will be elaborated in a Project-specific local content plan.
Potential adverse impacts on livelihoods and economy, including fishing livelihoods.	Potential adverse impacts to employment, livelihoods and economy are discussed in Section 7.3.2, Section 7.3.3. and Section 7.4.4.

Key Theme	Consideration in EIA
Management and use of produced gas	A description of the gas production rate, and its management and use by the Project are described in Section 2.5 of the EIA.
Use and disposal of hazardous substances	A list of chemicals that the Project intends to use is provided in Section 2.10.1 of the EIA. Management of wastes including hazardous waste is provided in Section 2.10.4.
Emissions and their impacts	An estimated annual emissions summary is provided in Section 2.10.2 of the EIA, while assessments of Project emissions on ambient air quality and climate are provided in Section 7.1.1.
Waste streams and their management and discharge	Descriptions of the Project vessels' discharges, and management/disposal systems and practices are provided in Sections 2.10.3 and 2.10.4.
Possible effects on coastal resources including mangroves and artisanal fisheries	Assessment of impacts to coastal resources is provided in Section 7.2.1, Section 7.2.2, Section 7.2.3, Section 7.4.3 and Section 7.4.4 of the EIA.
Possible effects on marine life	An assessment of impacts to biological receptors, including marine wildlife, can be found in Section 7.2 and Section 7.4.3 of the EIA.
Possible effects on fishing livelihoods	Assessment of impacts to fishing livelihoods can be found in Section 7.3.3 and Section 7.4.4.
Impacts to indigenous people, lands and resources	A discussion of indigenous people and resources and their potential to be affected by the Project is provided in Section 7.3.10 and Section 7.4.4.8.
Oil spill potential impacts and impacted locations	Oil spill modeling results, and assessment of potential impacts of an oil spill are discussed in Section 7.4 of the EIA.
Potential for social changes such as trafficking, prostitution, drug trade etc.	Potential impacts to community safety are assessed in Section 7.3.4 of the EIA.
Principles and content of the Environmental and Social Management Plan (ESMP)	The guiding principles and an overview of general structure and content of the ESMP are discussed in Chapter 9 of the EIA.
Type of anchor mooring on offshore vessels	The type of anchor mooring or other positioning mechanism to be utilized by Project vessels is discussed in Section 2.

Some questions were raised during the scoping meetings that were outside the scope of an EIA (e.g., the potential for an oil refinery in Guyana) and/or are confidential, such as the details of EEPGL's agreement with the Government of Guyana, and are therefore not discussed in Table 4-1.

During the Project's 60-day public comment period, EEPGL conducted a series of individual and small group meetings, as well as two public consultations (one in in Region 1 and one in Region 6). The stakeholders that were engaged during this period include:

- Environmental Protection Agency
- Ministry of Natural Resources
- Maritime Administration Department
- Civil Defense Commission
- Ministry of Agriculture, Department of Fisheries
- Guyana Geology and Mines Commission
- Ministry of Health
- Region 2 Administration
- Ministry of Communities
- Ministry of Indigenous Peoples' Affairs
- National Trust of Guyana
- Conservation International Guyana
- World Wildlife Fund Guyana
- Guyana Marine Conservation Society
- University of Guyana
- Guyana Hindu Dharmic Sabha
- Region 1 (public consultation)
- Region 6 (public consultation)

Stakeholder comments were documented over the course of these engagement events. Comments and questions related to a range of topics including potential impacts on fishing livelihoods, potential impacts to marine biodiversity, potential impacts on air emissions and how these were assessed, financial responsibility in the event of an oil spill, application of the mitigation hierarchy, Project employment opportunities and other socioeconomic benefits, and the Project's stakeholder engagement process. EEPGL compiled comments received over the course of the 60-day public comment period that could necessitate changes to the EIA and ESMP. In addition, the EPA received written comments from stakeholders during the public comment period which were forwarded to EEPGL. Upon conclusion of the public comment period, EEPGL thoroughly considered all comments received and updated the EIA and ESMP as relevant and appropriate.

4.6 Assessment of Impacts and Identification of Mitigation

The primary purpose of an EIA is to predict the potential impacts resulting from a proposed Project and to identify and evaluate the efficacy of measures to avoid, reduce, or remedy these impacts. ERM uses a standard impact assessment methodology for evaluating the impacts and significance of projects around the world – the ERM Impact Assessment Standard. This methodology takes into consideration both the magnitude of an impact and the sensitivity/vulnerability/importance of the resource/receptor to determine the significance of the impact (see Table 4-2), which is described in more detail below.

Table 4-2 Evaluation of Impact Significance

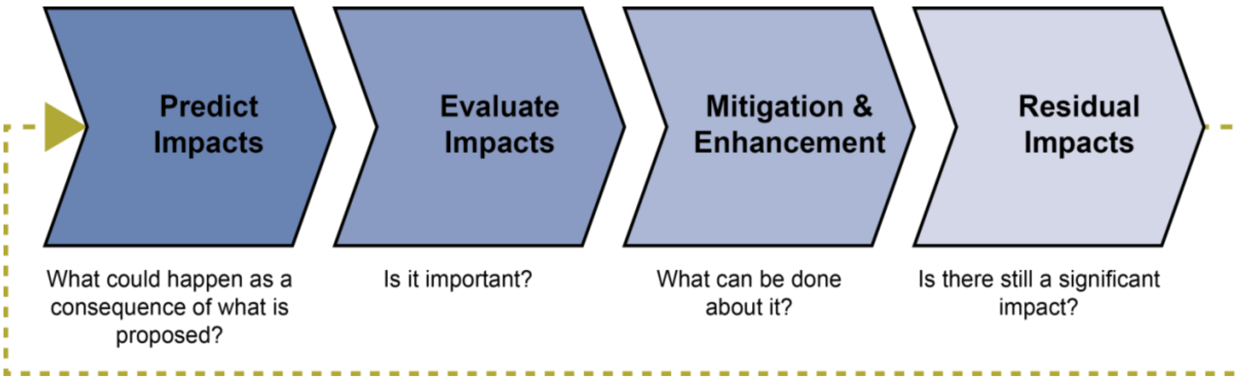
Impact Significance Matrix		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	**Medium**	**High**
Negative Impacts				
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major
Positive Impacts				
Magnitude of Impact	NA	Positive	Positive	Positive

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

- **Direct** – Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., disturbance of a benthic community habitat on the seafloor);
- **Indirect** – Impacts that follow indirectly from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., impacts to marine fish who feed off a directly impacted benthic community); and
- **Induced** – Impacts that result from other activities (that are not part of the Project) that happen as a consequence of the Project (e.g., influx of job seekers).

The assessment of impacts proceeded through an iterative four-step process, as illustrated in Figure 4-3.

Figure 4-3 Impact Prediction and Evaluation Process



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.

"Magnitude" is a function of the following impact characteristics:

- Type of impact (i.e., direct, indirect, induced; avoidable or unavoidable)
- Nature of the change (what is impacted and how; positive or negative);
- Size, scale, or intensity;
- Geographical extent and distribution (e.g., local, regional, national, international);
- Duration and/or frequency (e.g., temporary, short term, long term, permanent); and
- Reversibility (reversible or irreversible).

Magnitude therefore describes the change that is predicted to occur in the resource / receptor (e.g., the area and duration over which air or groundwater may become polluted, the level of increase in concentration, the degree and probability of impact on the health or livelihood of a local community). The magnitude of impacts are predicted and evaluated using a variety of different methods appropriate to the resources/receptors potentially impacted by the Project. For example, models are used to evaluate potential impacts on physical resources (e.g., water quality, oil spill, air dispersion, and underwater sound models). Table 5-1 provides additional information on the analytical methods used in assessing impacts for resources/receptors.

The magnitude of an impact takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum (in the case of adverse impacts) including *Negligible, Small, Medium,* and *Large*. Some impacts can result in changes to the environment that may be immeasurable, undetectable, or within the range of normal natural variation. Such changes can be regarded as essentially having little or no impact, and are thus characterized as having a *Negligible* magnitude. Other impacts may result in changes that are substantial and/or extremely widespread, and these are characterized as having a *Large* magnitude. In the case of positive impacts, this EIA does not attempt to characterize magnitude. In determining the magnitude of impacts on resources / receptors, embedded controls are taken into consideration. For example, the assessed magnitude of impacts on seawater quality from proposed produced water discharge considers the efficacy of produced water treatment measures that are part of the Project design.

The "sensitivity/vulnerability/importance" of the impacted resource/receptor is characterized by considering the nature of the resource/receptor as well as other factors including legal protection, government policy, stakeholder views, and economic value. The definitions for *Low*, *Medium*, and *High* sensitivity/vulnerability/importance designations will vary on a resource/receptor basis.

Step 2: Evaluate Impacts

For routine aspects of the Project, the significance for each impact was assigned based on the evaluations of the magnitude of the impact and the sensitivity/vulnerability/importance of the resource/receptor using the matrix shown in Table 4-2 above. This matrix applies to all resources/receptors. The assignment of a significance rating enables decision-makers and stakeholders to understand key potential Project impacts.

The following considerations are provided to clarify what the various significance designations represent.

- An impact of *Negligible* significance is one where a resource/receptor will not be impacted by a particular activity, or the predicted impact is deemed to be imperceptible or is indistinguishable from natural background variations, or small magnitude impacts are predicted only to low sensitivity receptors.
- An impact of *Minor* significance is one where a resource/receptor will experience a noticeable impact, but the impact magnitude is *Small* or *Medium* and/or the resource/receptor is, *respectively,* of *Medium* or *Low* sensitivity/vulnerability/ importance.
- An impact of *Moderate* significance has an impact magnitude that falls somewhere in the range from a threshold above which the impact is *Minor*, up to a level that might be just short of being considered *Major*.
- An impact of *Major* significance is one where the impact magnitude is *Medium* or *Large* for a resource/receptor of *High* sensitivity/vulnerability/importance (or *Large* magnitude for a *Medium* sensitivity/vulnerability/importance resource/receptor).
- An impact of *Positive* significance is one that has been identified as having a positive impact on the receptor/resource. This EIA does not attempt to characterize magnitude for positive impacts.

The specific criteria used to evaluate significance of impacts for each resource/receptor are presented in Chapter 7.

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 these types of events, understanding the significance of the risk requires understanding of the:

- Consequence (potential) of the event if it were to occur; and
- Likelihood of the event occurring.

As such, for these unplanned events, a Risk Table (Table 4-3) based on event consequence and likelihood is used to assess the significance of impacts associated with the events.

Table 4-3 Evaluation of Risk

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

"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 an event could occur;
- **Possible**—the event has a reasonable chance to occur at some time during normal operating conditions; and
- **Likely**—the event is expected to occur during the life of the facility.

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 impact significance assignment process.

Step 3: Mitigation and Enhancement

The next step in the process for this EIA 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 preference is always given to avoid the impact before considering other types of mitigation. The preferred hierarchy of measures followed in this EIA is:

- **Avoid**—remove the source of the impact by employing alternative designs or operations to avoid risks related to environmental and socioeconomic impacts;
- **Reduce**—lessen the probability and/or consequence of impacts that cannot be avoided (e.g., reduce the size of the project footprint); and
- **Remedy**—if significant impacts cannot be avoided or reduced, then "repair" the consequences of the impact after it has occurred through rehabilitation, reclamation, restoration, compensation, and/or offsets.

Management measures are generally not developed for potential adverse impacts that are assessed as *Negligible*. Practicable measures, as available, are adopted for higher levels of impact significance.

Step 4: Determine and Manage Residual Impacts

The final step in the iterative impact evaluation process for this EIA is the determination 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 pursuing elements of Step 1 and Step 2 to re-evaluate the magnitude and then the significance of the potential impact now considering the implementation of proposed mitigation measures. If significant residual impacts remain, efforts aligned with Step 3 are made to identify additional or alternative cost-effective and practicable mitigation measures.

- The management emphasis for *Moderate* and *Major* impacts is on reducing the impact to a level that is as low as reasonably practicable. This does not necessarily mean, for example, that impacts of *Moderate* significance have to be reduced to *Minor*, but rather that impacts are being managed effectively and efficiently.
- Although a goal of an impact assessment is to eliminate *Major* residual impacts through impact avoidance or other measures, for some resources/receptors, there may be *Major* residual impacts after all practicable mitigation options have been exhausted. Decision-makers must weigh such negative factors against the positive ones, such as employment, in reaching a decision on the Project.

4.7 Mitigation, Management, and Monitoring

In support of the EIA process, ERM and EEPGL developed a Project ESMP (as summarized in Chapter 9) that includes:

- Management measures identified in the impact assessment;
- Summary of how the measures will be implemented; and
- Monitoring strategy to evaluate the effectiveness of the management measures.

The management strategy uses an adaptive approach during the Project life cycle to ensure that recommended management measures are implemented as planned and produce the desired outcomes. This adaptive approach provides the Project, in consultation with the EPA and other stakeholders, the opportunity to:

- Address unanticipated adverse impacts that are encountered through the addition of new management measures (following the avoid/reduce/remedy hierarchy);
- Adjust or replace existing management measures when appropriate during the Project life cycle to address evolving impacts; and
- Retire existing management measures when no longer demonstrating value.

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 possibility of non-routine, unplanned events.

-Page Intentionally Left Blank-

5.0 SCOPE OF THE ENVIRONMENTAL IMPACT ASSESSMENT

The scope of the EIA includes all Phase 1 Project stages (i.e., development drilling, installation, hook-up/commissioning, production operations, and decommissioning) as described in Chapter 2 and planned activities listed in Section 5.2. The EIA also addresses non-routine, unplanned events (e.g., spills and releases). This EIA builds on the previous Strategic Environmental Assessment prepared for EEPGL's original Exploration Drilling in the Stabroek Petroleum Prospecting License Area (March 2014), and the Environmental Management Plan prepared for EEPGL's Liza Field Multiwell Exploration Program (February 2016). The collection of additional data and completion of further analyses, however, were required to evaluate the potential environmental and socioeconomic impacts of all stages of the Project, which are addressed in this EIA.

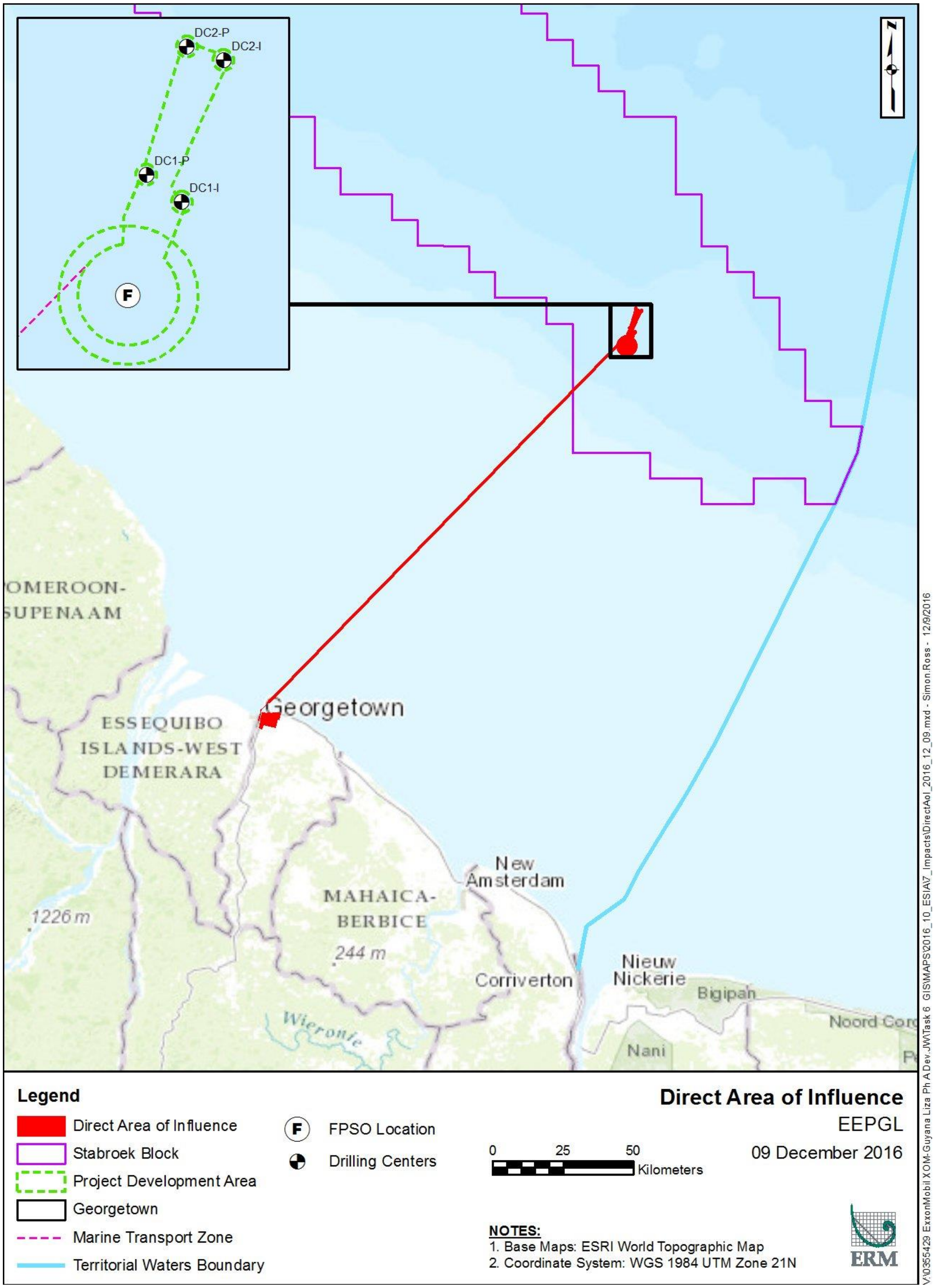
5.1 The Area of Influence

The area potentially impacted by a project is referred to as its Area of Influence (AOI). For purposes of this impact assessment, the Project AOI was divided into a direct and an indirect AOI, as described below:

- Direct AOI, within which the Project is expected to have direct impacts (Figure 5-1). This area includes: (1) the PDA (i.e., the Liza Phase 1 area including the subsea wells, SURF equipment, and the FPSO); (2) the marine transit corridors between the PDA and shore-based activity centers in Guyana and Trinidad; and (3) the city of Georgetown; and
- Indirect AOI, within which the Project is expected to have indirect impacts (Figure 5-2). This area includes: (1) 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 Section 7.4 for more details on oil spill modeling) and (2) coastal Regions 1 to 6 who could be impacted to a greater extent by the Project than the other regions because of their subsistence and commercial marine fisheries (e.g., potential impacts on fish and marine transport) and increased exposure to Project socioeconomic impacts. 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 EEPGL's activities as assessed in this EIA.

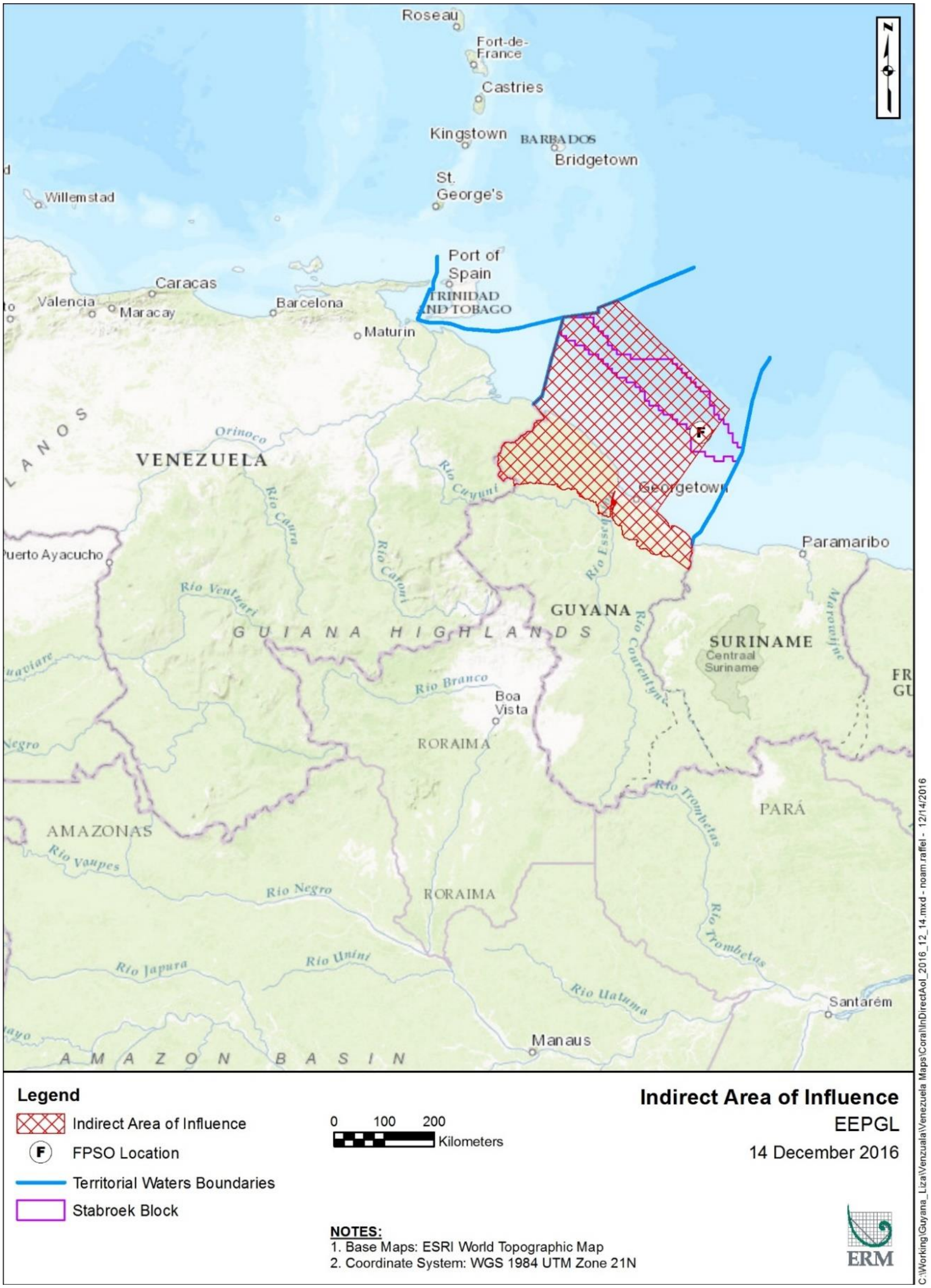
As described in Section 8, cumulative impacts on environmental and socioeconomic resources could potentially result from incremental impacts of the Project, when combined with other past, present, and reasonably foreseeable future projects/developments within the AOI. The geographic area of concern for the cumulative impacts analysis is generally consistent with the Project AOI.

Figure 5-1 Direct Area of Influence



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

Figure 5-2 Indirect Area of Influence



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

5.2 Project Interactions with Environmental and Socioeconomic Receptors

In order 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 AOI. These interactions are the mechanisms that could trigger Project-related impacts on resources/receptors.

Each of the Project activities and potential unplanned events listed below has the potential to interact with existing resources/receptors in the AOI, which could potentially create environmental or socioeconomic impacts.

- <u>Development Drilling Stage:</u>
    - Drill ship and drilling operations
        - Power generation
        - Drill cuttings discharges
        - Drilling fluids discharges
        - Wastewater discharges
        - Offshore waste treatment and disposal including incineration
    - VSP
    - ROV operations
    - Onshore waste management, recycling, treatment, and disposal

- <u>Installation of FPSO/SURF Components Stage:</u>
    - Marine installation vessels and FPSO
        - Power generation
        - Install mooring system (e.g., driven or suction piles for FPSO and select SURF equipment)
        - Discharge of hydrostatic test water, hydrate inhibitor, ballast water
        - Wastewater discharges
        - Limited waste incineration
    - ROV operations and installation of SURF equipment
    - Hook-up and commissioning of FPSO and SURF equipment
    - Onshore waste management, recycling, treatment, and disposal

- <u>Production Operations Stage:</u>
    - FPSO Vessel Operations
        - Power and heat generation
        - Non-routine, temporary flaring
        - Produced water discharges
        - Brine discharges from sulfate removal and potable water processing
        - Sanitary wastewater discharges
        - Ballast water discharge (one time at mobilization)
        - Non-hydrocarbon contact cooling water discharges
        - Gas re-injection into reservoir
        - Seawater intake

    - 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 domestic wastewater discharge
  - Offshore waste treatment and disposal including waste incineration
  - Onshore waste management, recycling, treatment, and disposal

- Decommissioning Stage:
  - Marine decommissioning vessels and FPSO
    - Power generation
    - Disconnection of mooring system and SURF equipment
    - Wastewater discharges
    - Limited 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 shorebases, 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

5.3 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 5-1 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 lists those resources/receptors that have been identified as unlikely to have the potential to be impacted by the Project and the rationale for this determination. These resources/receptors are excluded from further consideration in the EIA.

Table 5-1 Summary of Resources/Receptors Retained for Further Consideration in EIA and Corresponding Potential Impacts, Primary Sources of Potential Impacts, and Analytical Approach

Resource or Receptor	Potential Impacts	Primary Sources of Potential Impacts	Analytical 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. Potential impact of greenhouse gas emissions from the Project on climate change.	• Power generation • Other combustion sources • Non-routine, temporary flaring • Fugitive emissions from storage and loading • Waste incineration • Helicopter and aviation emissions	To describe actual air quality conditions in the vicinity of the Project, ambient air quality data were collected at the proposed Project site approximately 190 km (120 mi) offshore of Guyana, including measurements of particulate matter (PM_{10}), carbon monoxide (CO), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), and volatile organic compounds (VOC). Measurements were taken onboard a research vessel. Air emission inventories were prepared for these pollutants and a screening level analysis was conducted to identify potential air quality impacts associated with Project activities. Dispersion modeling was conducted to assess potential impacts to ambient air quality. Potential impacts were described. Estimated greenhouse gas (GHG) emissions for the Project were calculated.
Sound	Auditory impacts on Project workers.	• Equipment/machinery operating onboard the FPSO or drill ships •	Managing occupational-related risks through appropriate PPE.
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 non-aqueous base fluid (NABF) on drill cuttings discharges.	• Drilling of development wells • Installation of FPSO and SURF components	A fate and transport model (GIFT) was used to evaluate cuttings and drilling fluid deposition surrounding the development wells. The physical differences between the native seafloor and the accumulated drill cuttings, as well as the distribution of residual NABF on drill cuttings, were described based on the results of the modeling analysis.
Marine Water Quality	The Project could have localized impacts to marine water quality in the PDA from discharge of drill cuttings and from routine operational and hydrotesting discharges. The Project could potentially impact marine water quality in the Project AOI as a result of non-routine, unplanned events.	• Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Installation of FPSO and SURF components • Wastewater discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned event (e.g., spill or release)	A fate and transport model (GIFT) was used to evaluate total suspended solids (TSS) concentrations resulting from discharge of drilling fluid and cuttings based on global ocean currents data. USEPA's CORMIX model was 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 was used to estimate concentrations of dissolved hydrocarbons that might result from different unplanned event scenarios
Biological Resources			
Protected Areas and Special Status Species	The Project is not expected to impact Protected Areas during routine, planned operations and activities in the Project AOI. The Project could potentially impact Protected Areas in the Project AOI as a result of non-routine, unplanned events. The Project could potentially impact some special status species (e.g., endangered or listed species) in a localized manner in the PDA as a result of underwater sound, light, seawater withdrawal, and 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.	• Non-routine, unplanned event (e.g., spill or release) • Underwater sound generated by marine component operations and activities • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Vessel movements	Oil spill modeling was used to simulate the trajectory of an oil spill and assess the 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 was reviewed for information on the impacts of planned offshore activities on special status species, including marine turtles, fish, and marine mammals. Oil spill modeling was used to assess potential spill-related impacts. Underwater sound was modeled to assess potential auditory impacts associated with marine activities. USEPA's CORMIX model was 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 operational discharges and one-time hydrotesting discharges. The GIFT model was used to evaluate TSS concentrations resulting from discharge of drilling fluid and cuttings based on global ocean currents.

Resource or Receptor	Potential Impacts	Primary Sources of Potential Impacts	Analytical Approach
Coastal Habitats	The Project is not expected to impact beaches, mangroves, or wetlands in the Project AOI during routine, planned operations and activities. The Project could potentially impact beaches, mangroves, and wetland habitats in the Project AOI as a result of non-routine, unplanned events.	• Non-routine, unplanned event (e.g., spill or release)	Oil spill modeling was used to simulate the trajectory of an oil spill and assess the risk of oiling beaches, mangroves, or wetlands.
Coastal Wildlife and Shorebirds	The Project is not expected to impact coastal wildlife or shorebirds during routine, planned operations and activities in the Project AOI. The Project could potentially impact coastal wildlife and shorebirds in the Project AOI as a result of non-routine, unplanned events.	• Non-routine, unplanned event (e.g., spill or release)	Oil spill modeling was used to simulate the trajectory of an oil spill and assess the risk of impacting coastal wildlife and shorebirds.
Seabirds	The Project could potentially impact seabirds in a localized manner in the PDA as a result of light (i.e., disorientation). The Project could potentially impact seabirds in the Project AOI as a result of non-routine, unplanned events.	• Drill ship, FPSO, and support vessel operations • Lighting on offshore facilities (e.g., FPSO, drill ships) • Non-routine, temporary flaring • Waste incineration • Non-routine, unplanned event (e.g., spill or release)	The scientific literature was reviewed for information on the impacts of lighting from planned offshore activities on seabirds. Oil spill modeling was used to assess potential spill-related impacts on seabirds.
Marine Mammals	The Project could potentially impact some marine mammals in a localized manner in the Project AOI as a result of underwater sound and ship strikes. The Project could potentially impact marine mammals in the Project AOI as a result of non-routine, unplanned events.	• Underwater sound generated by marine component operations and activities • Ship strikes • Changes in forage availability • Lighting on offshore facilities (e.g., FPSO, drill ships) • Seawater intake by FPSO • Wastewater discharges • Drilling of development wells (cuttings and fluid discharge) • Cooling water discharges • Produced water discharges • Hydrotesting discharges • Non-routine, unplanned event (e.g., spill or release)	The scientific literature was reviewed for information on the impacts of planned offshore activities on marine mammals, turtles and fish. Analyses were performed based on expected marine mammal and turtle presence and Project vessel transits to assess likelihood of vessel strikes. Oil spill modeling was used to assess potential spill-related impacts. Underwater sound was modeled to assess potential auditory impacts associated with marine activities. USEPA's CORMIX model was 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 operational discharges and one-time hydrotesting discharges. A fate and transport model (GIFT) was used to evaluate total suspended solids (TSS) concentrations resulting from discharge of drilling fluid and cuttings based on global ocean currents. Oil spill modeling will be used to assess potential spill-related impacts on marine mammals, turtles, and fish.
Marine Turtles	The Project could potentially impact some marine turtles in a localized manner in the Project AOI as a result of underwater sound, ship strikes, and light. The Project could potentially impact marine turtles in the Project AOI as a result of non-routine, unplanned events.		
Marine Fish	The Project could potentially impact some 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.		
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 • Non-routine, unplanned event (e.g., spill or release)	Fate and transport model (GIFT) was used to predict the extent and thickness of cuttings discharged on the seafloor surrounding the development wells. The physical differences between the native seafloor and the accumulated drill cuttings, as well as the distribution of NABF containing cuttings and potential for toxicity impacts, were described based on the results of the modeling analysis. Impacts from planned activities were evaluated in terms of the percentage of benthic habitat impacted by disturbance.

Resource or Receptor	Potential Impacts	Primary Sources of Potential Impacts	Analytical Approach
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 component operations and activities • 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 discharges • Ballast water discharges • Waste incineration • Non-routine, unplanned event (e.g., spill or release)	The scientific literature was reviewed to determine the ecological relationships between major marine taxonomic groups. Oil spill modeling was used to assess potential spill-related impacts on marine organisms.
Socioeconomic Resources			
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 to income from agriculture and fisheries could also occur as a result of non-routine, unplanned events.	• 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 were reviewed and key informant interviews were conducted to identify key economic drivers in the national, regional, and local economies and determine the likely Project-related impacts on these economic factors. A particular emphasis was placed on industrial sectors 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 (beneficial impact). There is also the potential for limited adverse impacts to fishing activities as a result of marine safety exclusion zones or marine traffic, and non-routine, unplanned events.	• Local employment for:
		  o Drill ships
		  o Installation vessels
		  o FPSO topside equipment and operations
		  o Marine support and supply vessels
		  o Tankers
		  o Tugs and support vessels
		  o 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 were assessed against data obtained through key informant interviews on the existing service industry within Guyana. The potential for adverse impacts to fishing activities was 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. Potential occupational hazards to Project workforce working onshore and offshore were assessed.

Community Health and Wellbeing	Most Project activities will be located offshore in the PDA and would have no direct impacts on communities in Guyana. Introduction of limited levels of foreign labor could potentially have health and socioeconomic impacts. The Project could potentially impact community health and wellbeing in the Project AOI due to onshore traffic, social interaction, or as a result of non-routine, unplanned events.	• Increased traffic as a result of Project activities at the Guyana shorebase locations • Social interaction between Project workers and residents • Pressure on wages from introduction of foreign workers and increased competition for skilled labor • Noise and light near shore by Project marine and aviation operations • Non-routine, unplanned event (e.g., spill or release)	Potential risks to safety and health of local communities posed by shorebase operations were assessed. Key informant interviews were conducted to characterize existing road, marine, and air traffic safety conditions, as well as coastal agriculture, aquaculture, and offshore/coastal fishing activities. Oil spill modeling was used to simulate the trajectory of an oil spill and to assess potential spill-related impacts on community health and wellbeing.
Marine Use and Transportation	The Project may 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 were conducted to characterize communities dependent on marine transportation for livelihoods (e.g., speedboat operators and fisherpersons), and to characterize existing marine vessel and safety conditions in the Project's AOI.

Resource or Receptor	Potential Impacts	Primary Sources of Potential Impacts	Analytical Approach
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 may 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 overburden existing capacity and supply • Shorebase operations • Ground transportation operations	Key informant interviews and review of government reports were conducted to assess existing demand on public infrastructure, transportation networks, vehicular traffic, and public services and to determine the impact (access and safety) that any additional demand on these resources would have on impacted communities.
Cultural Heritage	The Project has the potential to adversely impact cultural heritage through localized disturbance of archaeological or historical sites related to Project development. These resources have conservation, cultural, and other values to stakeholders. The Project could potentially impact cultural heritage in the Project AOI as a result of non-routine, unplanned events.	• Drilling of development wells • Installation of FPSO and SURF components • Non-routine, unplanned event (e.g., spill or release)	AUV and other geophysical surveys were conducted to map seabed objects in the PDA. Oil spill modeling was used to simulate the trajectory of an oil spill and to assess the potential for a release from an unplanned event to contact terrestrial archaeological sites.
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 transfer facilities • Onshore waste recycling, treatment and disposal facilities	Land use in the area surrounding onshore facilities planned for Project use was reviewed and assessed with respect to the potential for significance of land use changes 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 AOI.	• Direct or indirect impacts derived from one or more of the impacts on physical, biological, or socioeconomic resources described above	The use of natural resources by local communities, including indigenous communities, was examined to identify specific dependencies on resources that could be impacted by the Project. Where dependencies on natural resources that would be impacted were identified, the direct and indirect impacts of Project activities on local communities' access to and use of impacted resources was assessed.
Indigenous Peoples	The Project is not expected to directly cause any changes to population and demographics in indigenous communities. The Project could potentially impact indigenous peoples in the Project AOI as a result of non-routine, unplanned events.	• Non-routine, unplanned event (e.g., spill or release)	Coastal communities, including indigenous communities, in the Project AOI were mapped. Key informant interviews were conducted to characterize socioeconomic conditions in communities, and their reliance on natural resources. Oil spill modeling was used to simulate the trajectory of an oil spill and to assess the potential for oil to contact lands and natural resources of coastal communities.

Table 5-2 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 topography or landscapes.
Groundwater quality	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	
Natural hazards	The Project is not located within an area that is known to have a high level of seismic activity or susceptibility to other natural hazard with the potential to affect Project facilities.
Vibration and radiation	The Project will not generate any vibration or radiation that would be expected to impact resources/receptors. See Section 2.10

-Page Intentionally Left Blank-

6.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

6.1 Physical Resources

6.1.1 Air Quality and Climate

This section describes the existing air quality conditions and climate in the Project 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 ppm, parts per billion (ppb), or micrograms per cubic meter ($\mu g/m^3$), averaged over various periods of time.

6.1.1.1 Methodology

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.

To develop more specific 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 in the area to support design development. 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.

Air Quality: Since the PDA is located approximately 190 km (~120 miles) offshore in the Atlantic Ocean and far removed from any anthropogenic sources of emissions other than intermittent marine traffic, ambient air quality is determined primarily by regional influences rather than by local emission sources or topographic influences. ERM has conducted offshore air monitoring, including the collection of air samples, to analyze existing ambient concentrations of relevant air quality pollutants in the PDA; the samples were collected from onboard a research vessel within the Stabroek Block and PDA. The pollutants collected include 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 (VOC).

6.1.1.1 Regional or National Setting/Context

Climate: Guyana has a wet tropical climate characterized by two pronounced wet seasons and year-round warm temperatures.

The bimodal wet/dry regime is caused by the annual migration of the Inter-Tropical Convergence Zone (ITCZ), which changes latitude based on the Earth's position and angle in relation to the sun. Northward movement of the ITCZ occurs as energy from the sun is strongest in the Northern Hemisphere during the Northern Hemisphere's summer, thereby increasing solar heating in that hemisphere. The relative changes in solar heating slightly shift the atmosphere primary circulation cells, which cause 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 annual rainfall totals range between 70 inches and 110 inches (~180 cm to ~280 cm, Hydromet, 2014). 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 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.

Air Quality: For purposes of this EIA, relevant literature was used to identify appropriate ranges of concentrations to represent existing conditions. Based on the estimated Project emissions profile, the principal relevant air pollutants of interest are $PM_{2.5}$ and NO_2. Yale University (2016) published a report that ranked Guyana 6th (from the best) out of 180 countries in air quality. As part of this study, Yale University (2015) published an online mapping tool, which estimates that the average concentration of $PM_{2.5}$ in onshore Guyana is 2.5 µg/m^3. No values were found in the literature for onshore air quality existing conditions for NO_2.

6.1.1.2 *Existing Conditions in Area of Influence*

Climate: In general, climate conditions within the Project AOI should be similar to those described above for Guyana. The results of the ERM's offshore monitoring effort to further characterize climate conditions within the PDA have been incorporated into Appendix L of the EIA.

Air Quality: The PDA is well offshore and far removed from any existing stationary anthropogenic sources of airborne pollution. In addition, the prevalent wind direction is from the northeast (open ocean); therefore, ambient air quality within the PDA is expected to be good. This assumption was confirmed by the results of a 20-day ambient air quality measurement program conducted aboard the Research Vessel Proteus. Those measurements found that air pollutant levels were generally below detection levels, with the exception of PM_{10}. Chemical analysis of particulate matter samples found that the most of the collected mass was composed of sodium chloride—the most likely source of which is sea salt.

6.1.2 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 description of the modeling study used to predict underwater sound levels associated with Project activities in the PDA is discussed in Section 7.2.5, Marine Mammals.

This analysis is limited to underwater sound because the Project is located approximately 190 km (~120 mi) offshore from Georgetown, so airborne sound and ground-borne vibration from offshore Project activities will not impact onshore community or public receptors in Guyana. Offshore, the principal airborne sound receptors of potential concern will be the Project 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 will not measurably impact any airborne sound or ground-borne vibration at the onshore shorebase, pipe yards, and warehouse locations. Therefore, airborne sound and ground-borne vibration are not discussed further in this section.

6.1.2.1 *Underwater Acoustic Metrics*

Underwater sound amplitude is measured in decibels (dB) relative to a fixed reference pressure (p_0 = 1 micro Pascal (μPa)) or reference energy level (1 $\mu Pa^2 \cdot s$). Three common descriptors are the:

- 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 $\mu Pa^2 \cdot s$).

The peak SPL metric is the maximum instantaneous SPL in a stated frequency band attained by an acoustic event. The peak metric is commonly quoted for impulsive sounds, but does not account for the duration or bandwidth of the sound. At higher intensities, the peak SPL can be a valid criterion for assessing whether a sound is potentially injurious or may cause behavioral implications to 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). This level is the root mean square pressure level of the pulse.

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 energy dose over a specific event or time. The SEL metric measures the sound energy to which an organism at that location would be exposed.

Sound loudness is a subjective term describing the strength of the ear's perception of a sound. It is a complex interaction between the sound pressure level and the hearing ability of an individual receptor for that sound (how well the sound can be detected). Because the loudness of impulsive sound is not generally proportional to the instantaneous acoustic pressure, the peak SPL is a poor indicator of perceived loudness. As such, several other sound level metrics such as RMS SPL and SEL are commonly used to evaluate the loudness of impulsive sound and its impacts on marine life.

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 (JASCO, 2016).

6.1.2.2 Methodology

Ambient underwater sound levels were based on literature values for coastal Guyana. Research has indicated that with the exception of localized or short term events that may cause acute exposure (e.g., passage of a single ship, intense rain events, or whale vocalizations) underwater sound levels do not vary much in the open ocean. Human activities are minimal in the PDA (principally related to commercial fishing and other ocean going vessels). Therefore, the use of literature values from coastal Guyana should be a reasonable representation of underwater sound conditions in the PDA.

6.1.2.3 Regional or National Setting/Context

Ambient underwater sound levels can serve as existing conditions from which to measure potential disturbance impacts associated with Project activities. Sound in the ocean is the result of both natural and anthropogenic sources. Examples of notable sound levels produced by natural sources include snapping shrimp (peak SPL of individual snaps vary from 183 to 189 dB re 1 μPa at 1 m, with a typical peak spectrum between 2 and 5 kHz and energy extending to 200 kHz), waves breaking at 50 Hz due to sea surface agitation (61 to 76 dB re 1 $\mu Pa/\sqrt{Hz}$ depending on the sea state), and waves breaking at 25 kHz due to sea surface agitation (32 to 47 dB re 1 $\mu Pa/\sqrt{Hz}$ depending on the sea state) (Hildebrand 2009). Examples of notable sound levels produced by human or mechanical sources include cargo vessels at 16 knots (173 m length; 192 dB RMS re 1 μPa at 1 m with typical spectrum between 40 and 100 Hz), small boat outboard engine at 20 knots (160 dB RMS re 1 μPa at 1 m with typical spectrum between 1000 and 5000 Hz), seismic array (260 dB RMS re 1 μPa at 1 m with typical spectrum between 5 and 300 Hz), and sub-bottom profiler (230 dB RMS re 1 μPa at 1 m with typical spectrum between 3000 and 7000 Hz) (Hildebrand 2009).

6.1.2.4 *Existing Conditions in Project Development Area*

Guyana's entire continental shelf and slope, including the Stabroek Block, are influenced by the Guiana Current, which transports warm, turbid water north from the mouth of the Amazon River across the coast of northern South America. There are currently no notable sources of mechanical or human-generated background sound in the PDA, other than sporadic instances of commercial vessels and other ocean going vessels. Considering the natural sources such as the Guiana Current and other features of the PDA (e.g., depth, distance from shoreline), existing underwater sounds in the PDA are not expected to exceed 120 dB_{rms}.

6.1.3 Marine Geology and Sediments

6.1.3.1 *Coastal Geology*

Guyana's continental shelf occupies an area of 18,790 mi^2. The average width of the continental shelf is approximately 113 km (~70 mi) (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 km (~268 mi) 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.

6.1.3.2 *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 6-1 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 6-1 Major Geologic Formations of the Guyana Basin

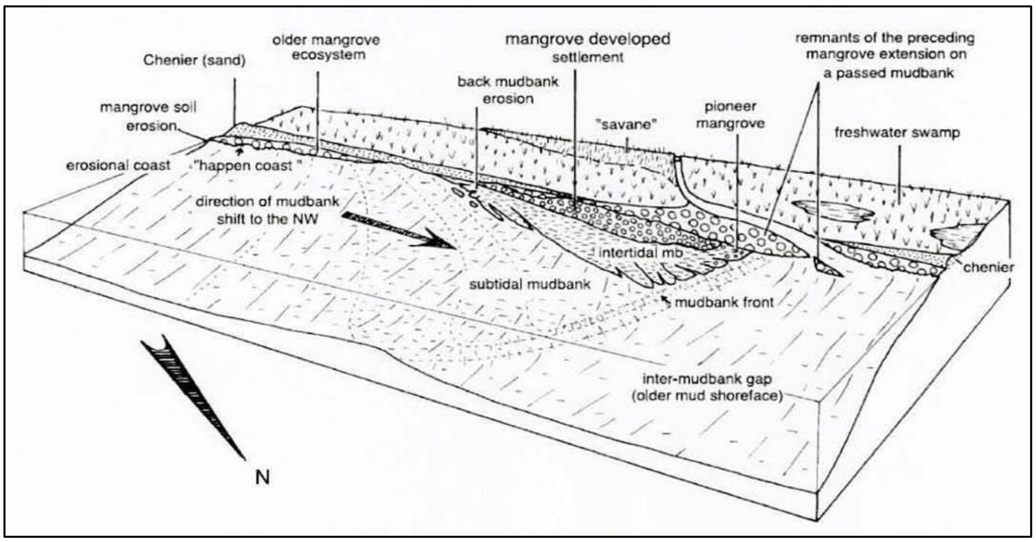
Formation	Age	Composition
Corentyne	Pleistocene-Pliocene	Sandstone and shale
Pomeroon	Miocene-Eocene	Carbonate sandstone and shale
Georgetown	Maastrichtian	Sandstone, shale and carbonate
New Amsterdam	Lower Tertiary to Maastrichtian	Sandstone and shale
Canje	Santonian to Turonian	Organic shale, non-organic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

Formation	Age	Composition
Precambrian Basement	Proterozoic-Hadean	Metamorphic rock

6.1.3.3 Marine Sedimentology

Fine clay and mud sediment are transported from the mouth of the Amazon River and are deposited approximately 21 to 60 km (13 to 37 mi) offshore to an average thickness of approximately 20 m (~65 ft) along Guyana's continental shelf (CGX Resources, 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 km (13 to 37 mi) offshore (Figure 6-1).

Figure 6-1 Typical Distribution of Mudbanks and Mangroves on Guyana's Coast



Source: Institutional Capacity Building Activities on Guyana Sea Defenses, 2005.

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 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 (MTC) 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 m (~ 15 ft) to 41 m (135 ft). 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).

6.1.3.4 Sediment Quality

Sediment samples were collected from the Stabroek Block offshore Guyana as part of two environmental baseline surveys (EBS). The surveys were conducted prior to EEPGL exploration drilling activities in April and May of 2014 (Maxon Consulting, Inc. and TDI Brooks International, Inc., 2014) and during later EEPGL exploration drilling activities in March of 2016 (FUGRO EMU Limited, 2016). Sediment samples were collected from 10 sampling stations as part of the 2014 survey and from 25 sampling stations as part of the 2016 survey (these locations are collective referred to as the Study Area in this section); the stations include locations within the PDA as well as locations outside the PDA, but within the southeastern portion of the Stabroek Block. A discussion of the results from both surveys is provided below. Summaries of the results for metals and hydrocarbon concentrations in the sampled sediments are presented in Table 6-2 and Table 6-3, respectively.

Table 6-2 Summary Results for Sediment Metals, Reported in µg g^{-1} dry weight

Parameter	Mean	Minimum	Maximum	Mean Background[1]	Effects Range Low[2]	Effects Range Median[3]
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

Parameter	Mean	Minimum	Maximum	Mean Background[1]	Effects Range Low[2]	Effects Range Median[3]
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

N/A – Not applicable (background level not available)
Note: One half of the detection limit was used for non-detect results in all statistical calculations
1 Mean concentration in upper continental crust (Wedepohl, 1995).
2 NOAA Effects Range Low (Ecotox, 1996)
3 NOAA Effects Range Median (Ecotox, 1996)

Table 6-3 Summary Results for Sediment Hydrocarbons

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

PAH - Polycyclic aromatic hydrocarbons; NPD – Naphthalene, phenanthrene, anthracene, and dibenzothiophene (2-ring and 3-ring PAHs); SHC - Saturated and aliphatic hydrocarbons; THC - Total hydrocarbons; UCM - Unresolved complex mixture; CPI - Carbon preference index (the ratio of odd number carbon chain n-alkanes to even numbered chain n-alkanes); Pr/Ph - Ratio of pristane to phytane

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

nC12-20 – Alkanes ranging from carbon numbers 12 to 20

nC21-36 – Alkanes ranging from carbon numbers 21 to 36

nC12-36 – Alkanes ranging from carbon numbers 12 to 36

N/A – Not applicable (background level not available)

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

6.1.3.5 2014 EBS Results (TDI Brooks International, Inc., 2014)

During the 2014 EBS, 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 measured to assess general patterns of distribution across the Study Area, which was defined as the Liza Area of Interest for the purpose of the study, and what is now considered the PDA. 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; 2 metals (i.e., 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 µg g^{-1} compared to an upper continental crust mean background concentration of 2 µg g^{-1}). However, all average concentrations were at or below the 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 polycyclic aromatic hydrocarbons (PAHs).

Aliphatic Compounds: 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 saturated hydrocarbons that encompass light and heavy fractions of petroleum (i.e., alkanes nC_9-nC_{40}) and selected isoprenoids (branched chain unsaturated hydrocarbons), including pristine and phytane. Concentrations of total SHC ranged from 8 µg g^{-1} to 14 µg 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 µg g^{-1} to 12 µg g^{-1}, with an average of 7.0 µg g^{-1}, which makes up approximately 66 percent of the average 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 (nC16)/(Pentadecane [nC15] + Heptadecane [nC17]) ratio: At "background" levels, hydrocarbons nC15 and nC17 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 (nC16) is rarely found in biolipids (Thompson and Eglinton 1978); paraffins of nC15, nC17, or nC19 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-carbon-number over even-carbon-number n-alkanes, with an average CPI value of approximately 2, indicating 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, 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 indicates relatively higher concentrations of plankton-related hydrocarbons, as compared to hydrocarbons from anthropogenic sources.

PAHs: 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) ranged from 0.02458 µg g^{-1} to 0.05336 µg 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 sediment hydrocarbon results indicate that biogenic or natural materials are the primary source of the low-level hydrocarbons measured in the survey area. Biogenic hydrocarbon sources most likely consist of terrestrial plant and humic material transported to the survey area via river inputs.

6.1.3.6 2016 EBS Results (Fugro, 2016)

During the 2016 EBS, 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 (i.e., Stabroek Block). 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 investigation compared to the 2014 investigation. Average concentrations of anthropogenic-indicator metals arsenic and nickel exceeded the 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}. Levels 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. The values of CPI 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-carbon-number over even-carbon-number n-alkanes, 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 sediments, indicating the primary source of the hydrocarbons is likely biological.

PAHs, a subset of total hydrocarbons, were analyzed. Concentrations of total PAHs ranged from 0.016 µg g^{-1} to 0.239 µg g^{-1}. The sample distribution of individual PAHs provided information for a range of hydrocarbon sources. A distribution ratio is listed below as well as a general discussion of its relevance in determining the source of the hydrocarbons.

- Naphthalene, Phenanthrene, Anthracene, and Dibenzothiophene (NPD)/4 to 6 Ring Ratio – The ratio of the sum of naphthalene, phenanthrene, anthracene, and dibenzothiophene (petrogenic indicators) divided by the sum of 4 to 6-ring PAHs (pyrogenic indicators). This ratio is useful to determine the relative contributions of pyrogenic and petrogenic hydrocarbons in differentiating sources. 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 sediment hydrocarbon 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.

6.1.4 Oceanographic Conditions/Marine Water Quality

6.1.4.1 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 6-2 illustrates the proximity of the Guiana Current, NBC, and North Equatorial Counter Current 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. These eddies can travel northwest along the South American coast. The current magnitude within these eddies can vary with depths significantly. These eddies may range from approximately 145 km to 400 km (~90 to 250 mi) in diameter.

During springtime, 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 in April to May, while minimum speeds commonly occur in September (Gyory et al., 2013).

The Guiana Current primarily travels near the water surface while the deeper portion of the water column in the Stabroek Block is strongly influenced by the North Atlantic Deep Western Boundary Current, which is the southward limb of the North Atlantic MOC which returns colder, denser water from polar regions to the subtropics at intermediate and deep levels.

In May 2014, EEPGL commissioned a Lowered Acoustic Doppler Current Profiler (LADCP) survey of four stations along a transect located in the central portion of the Stabroek Block to support design development. The profilers were placed at depths ranging from approximately 970 m to 1100 m. The survey indicated the presence of both the Guiana Current and the Deep Western Boundary Current. Figure 6-3 shows vector stick plots from the four stations along the LADCP transect. Figure 6-4 shows the locations of these LADCPs relative to the planned FPSO location and the southern boundary of the Stabroek Block. The three deepest 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 due to the Deep Western Boundary

Current). The shallowest station (Station 4) showed a similar layered structure, but the speed of the north-westward surface current, however, was significantly greater at this station than at the others (TDI-Brooks International, Inc., 2014).

Figure 6-2 Marine Currents in the Vicinity of the Project Development Area

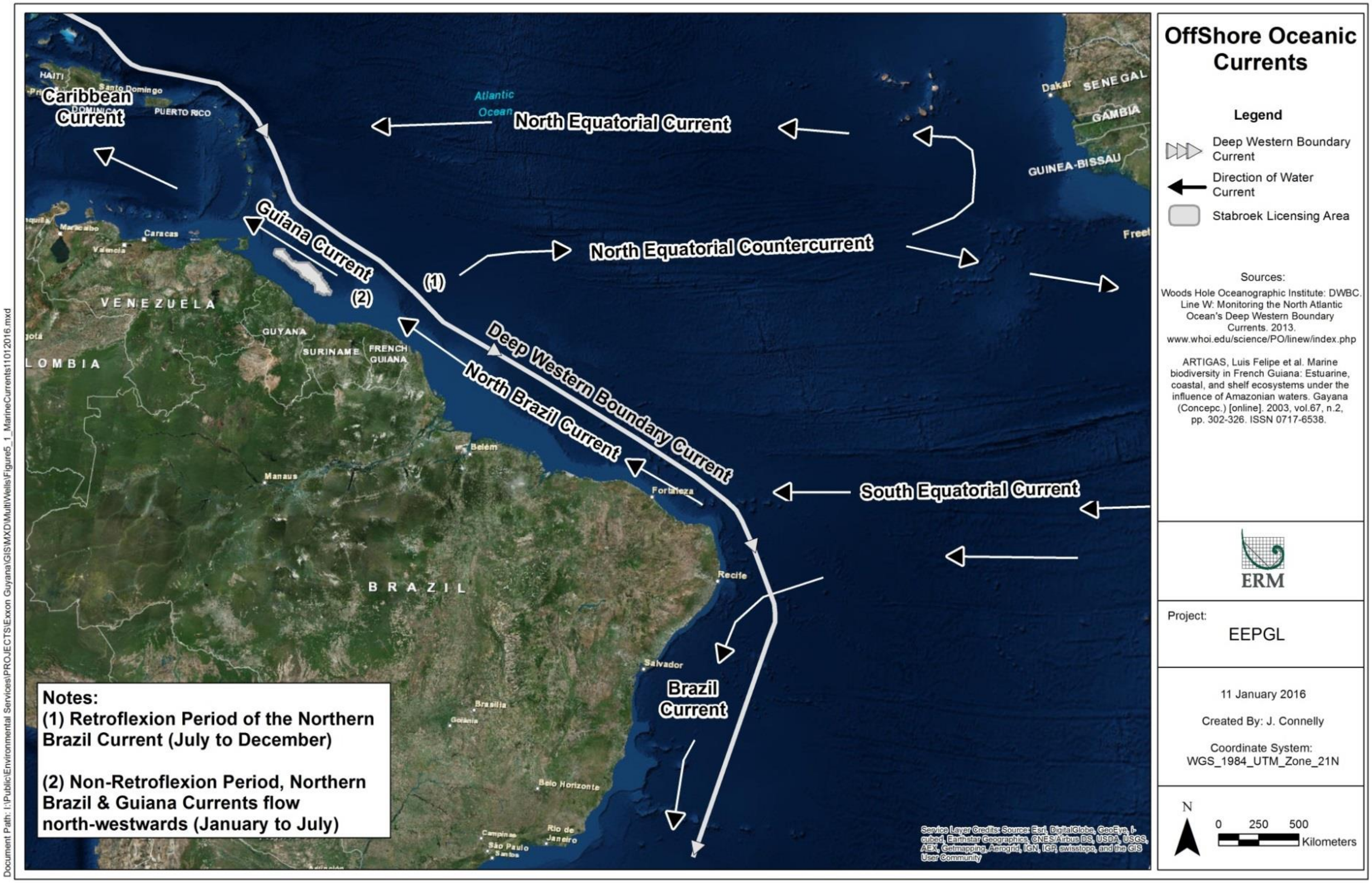
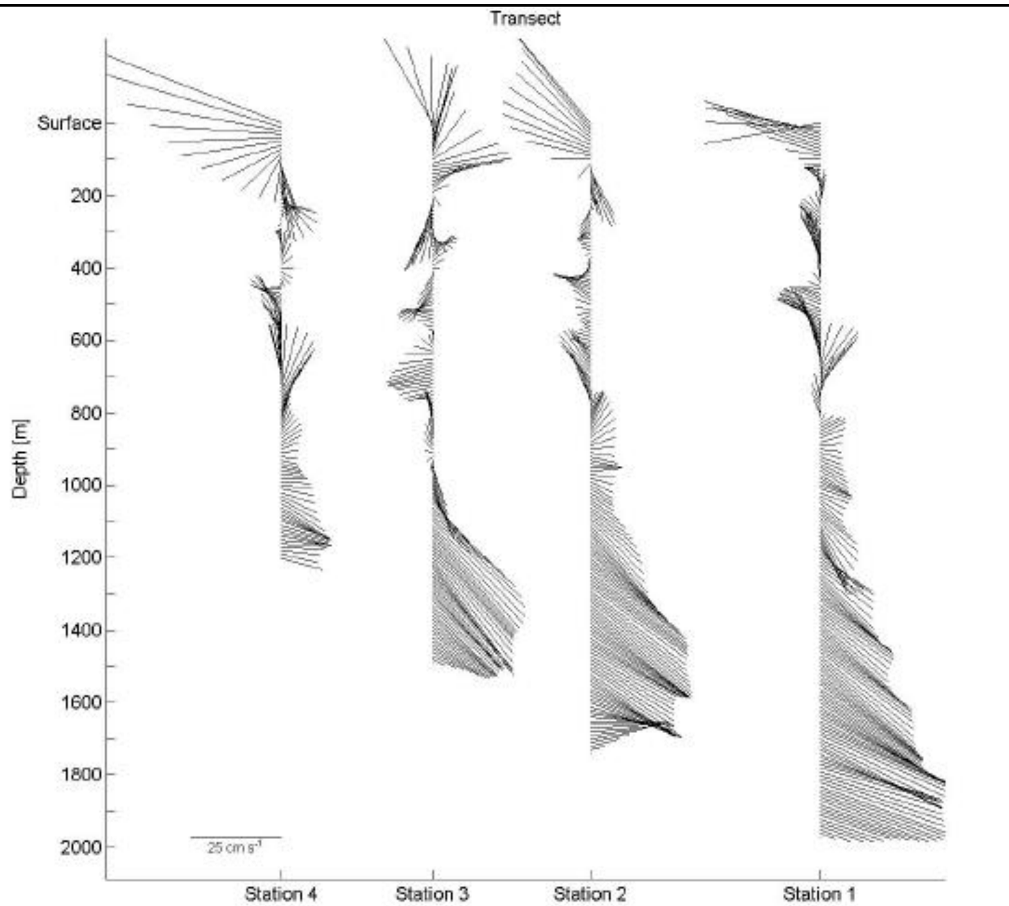


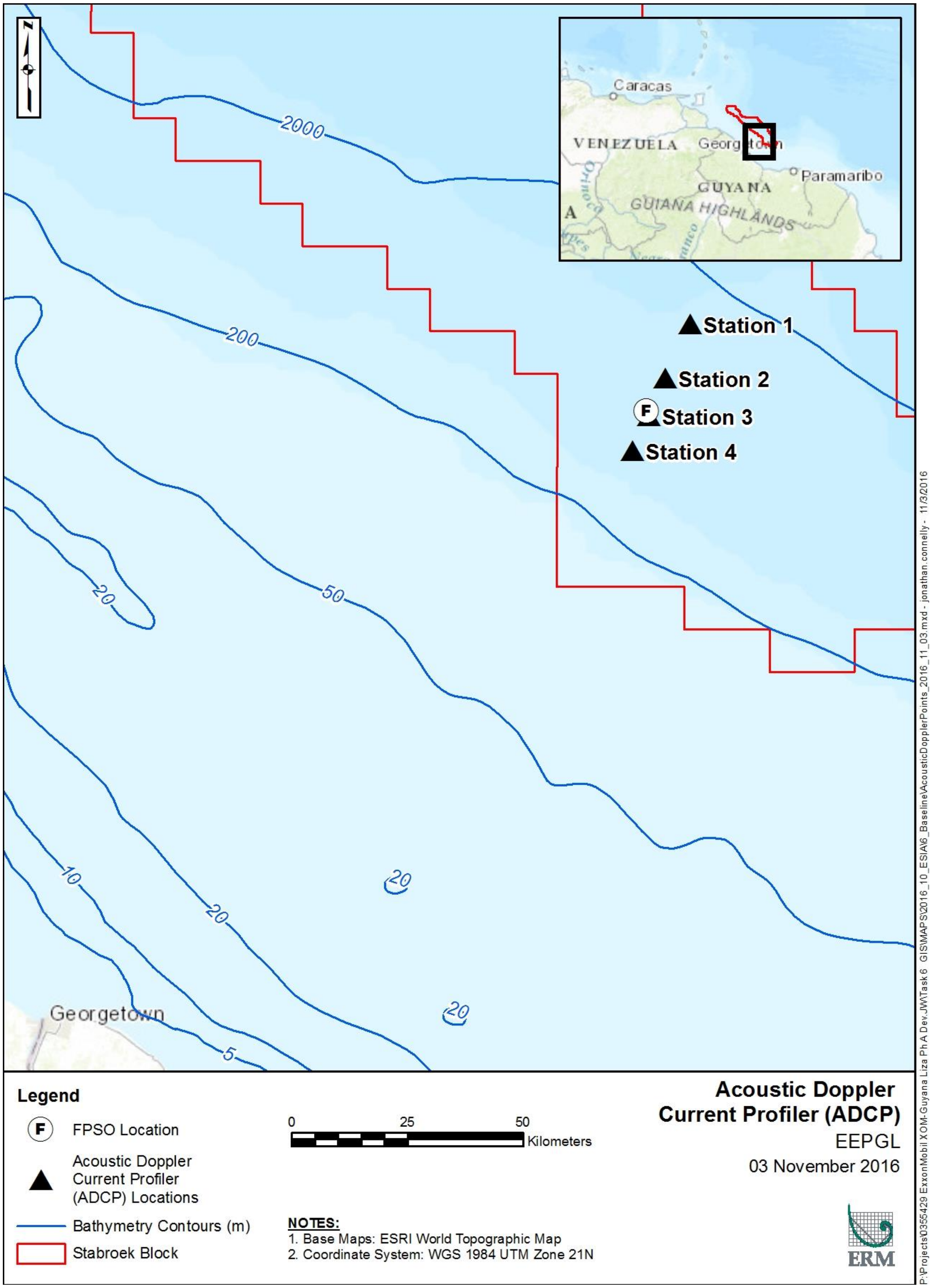
Figure 6-3 Vector Stick Plot for Stations on the Stabroek LADCP Transect



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.

Source: TDI-Brooks, 2014

Figure 6-4 LADCP Locations



6.1.4.2 Marine Water Quality

The hydrographic and isohaline conditions in Guyana's coastal marine waters are greatly impacted by the outflow of the coastal rivers in the region, as described in Section 6.1.4.1. The large amount of freshwater discharge impacts ocean salinity and temperature. Oceanic water is relatively heavy, cold, and saline compared to the lighter, warm, and fresher water of the Amazon and Orinoco plumes, which converge offshore of Guyana. These convergences form oceanic fronts offshore of Guyana. Freshwater lenses 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 impact the marine environment offshore Guyana, the Amazon River, with its average discharge of 180,000 m^3/sec (Nittrouer and De Master, 1987), is the most prominent factor in marine water quality in the region. Analysis of the Amazonian plume has shown there is little seasonal variation in the plume's nutrient content (e.g., silicates of 144 $\mu mol.kg^{-1}$, phosphates of 0.7 $\mu mol.kg^{-1}$, and nitrates of 16 $\mu mol.kg^{-1}$) (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 the Guyanas.

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, but since the mid-1990s the LME has consistently warmed (Sherman and Hempel, 2009). Although the ocean temperature has alternately warmed and cooled in recent decades, 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).

Water quality samples were collected from the Stabroek Block offshore Guyana as part of two environmental survey efforts in 2014 and 2016. The 2014 samples were collected in April and May of 2014 prior to exploration drilling activities (Maxon Consulting, Inc. and TDI Brooks International, Inc., 2014).

The 2016 survey provided an additional detailed integrated site investigation covering 247 mi^2 (~64,000 ha) of the offshore PDA (FUGRO EMU, 2016). This study enables ERM to have a multi-year database of water quality in the Stabroek Block, as well as the ability to analyze a greater number of locations to further characterize the block. Sampling locations were chosen based on current and future exploration and potential development activities.

In the 2016 study, water quality samples were collected at top, middle, and bottom depths and analyses of the collected samples covered a range of physicochemical parameters. In addition, conductivity, temperature, and depth (CTD) profiles (including dissolved oxygen, pH, and turbidity measurements) were acquired and assessed through in situ monitoring of water column profiles at 15 locations.

Results from the 2016 vertical profiles show a stratified water column in terms of temperature, salinity, and dissolved oxygen. The depths of the thermocline, halocline, and oxygen boundary layer were observed to increase with the total depth of water. Dissolved oxygen concentrations reach near saturation levels near the surface, but decrease with depth. The mean sea surface temperature was 27.8 ºC, while bottom temperatures ranged between 2.7 ºC (deepest station) and 11.2 ºC (shallowest station). Salinity ranged between 37.05 parts per thousand (ppt) to 36.60 ppt near the surface. In depths below the halocline, the salinity ranged between 33.63 ppt and 35.50 ppt. Mean pH values ranged between 8.18 and 8.47, increasing slightly with depth. Low turbidity was measured throughout the water column, with values less than or equal to 2.9 formazine turbidity units (FTU).

The presence of organic carbon content in the water column was analyzed by measuring TOC in discrete water samples. TOC decreased slightly with depth. TOC ranged between 0.9 mg/l and 3.9 mg/l at the surface and between 0.9 mg/l and 2.4 mg/l in the bottom depths.

Total suspended solids (TSS) concentrations were generally higher near the surface than at depth. In the 2016 survey, values ranged from 2.4 mg/l to 18.3 mg/l near the surface and from below the detection limit to 7.7 mg/l at the bottom depths.

In the 2014 survey, measured hydrocarbon concentrations were mostly below detection limits (total SHC less than 13 µg/l to less than 13.5 µg/l). In the 2016 survey, whose protocols allowed for lower detection limits, THC were detected at concentrations ranging from 8.3 µg/l to 35.9 µg/l in the bottom depths and 10.0 µg/l to 33.1 µg/l near the surface. Individual n-aliphatics were also measured, from 12 carbons (n-dodecane) to 36 carbons (n-hexatriacontane). The sum of all measured aliphatics in the 2016 survey ranged from 0.55 µg/l to 4.22 µg/l at the surface and from 0.37 µg/l to 16.3 µg/l in the bottom depths.

In the 2014 survey, PAHs were reported to be below detection limits with the exception of naphthalene as well as the C1 and C2 alkylated homologues of naphthalene, fluorene, and phenanthrene, all of which are ubiquitous trace-level laboratory contaminants. In the 2016 survey, the sum of the PAHs with two to six benzene rings ranged from 0.051 µg/l to 0.109 µg/l at the surface and 0.059 µg/l to 0.133 µg/l at the bottom depths. The sum of the 16 PAHs from U.S. Environmental Protection Agency's (USEPA's) priority pollutant list ranged from 0.006 µg/l to 0.021 µg/l.

Pristane to phytane ratios, indicative of the possible origin of hydrocarbons present, were close to 1.0, suggesting an oxidizing depositional environment with the compounds likely derived from chlorophyll (Moustafa and Morsi, 2012). Ratios below 1.0 would suggest the presence of petroleum-based hydrocarbons.

In both the 2014 and 2016 surveys, measured metal concentrations in the collected water samples were below USEPA Saltwater Quality Standards (USEPA, 2015). Table 6-4 provides the minimum, mean, and maximum values for metals measured in 2014 and 2016, along with USEPA's criterion maximum concentrations (CMCs) and criterion continuous concentrations (CCCs) for comparison. The CMCs and CCCs are the USEPA's recommended highest concentrations in saltwater that are not expected to pose a significant risk for acute and chronic impacts, respectively, to the majority of species in a given environment (USEPA, 2016). All samples had concentrations within the natural range of the ocean water (Morel et al., 2006), well below the CMCs and CCCs.

Table 6-4 EBS Water Column Heavy Metals Concentrations

	Heavy Metals Concentrations (µg/l)							
	Arsenic	**Barium**	**Cadmium**	**Chromium**	**Copper**	**Lead**	**Mercury**	**Zinc**
Min	1.02	6.4	0.03	0.523	0.211	0.041	<0.0002	<4
Mean	1.43	7.5	0.043	0.656	0.385 - 1.68	0.144	0.000104	2.44 - 6.42
Max	1.77	9.2	0.064	0.778	3.68	0.625	0.000254	26.4
USEPA CMC	40	40	4.8	210	90	1.8	1.8	69
USEPA CCC	8.8	8.8	3.1	8.1	81	0.94	0.94	36

Source: Maxon Consulting, Inc. and TDI Brooks International, Inc., 2014; Fugro, 2016
Note: One half of the detection limit was used for non-detect results in all statistical calculations.

6.2 Biological Resources

6.2.1 Protected Areas and Special Status Species

Formerly, the EPA was Guyana's focal point for the Convention of Biological Diversity, and the agency coordinated the National Protected Areas System (EPA, Undated), which included five protected areas.

In 2011, Guyana enacted Protected Areas legislation that 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 archeological finds or sites; and mining. If any prohibited activities occur, fines range from $50,000 to $500,000 (Guyanese dollars [GYD]) (Protected Areas Act, 2011). Guyana's National Biodiversity Strategy and Action Plan (2015) states 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.* (GNBSAAP, 2015)

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 nine percent of Guyana's land area, as summarized in Table 6-5. Figure 6-5 illustrates the locations of Guyana's Protected Areas. There are currently no designated marine Protected Areas in Guyana.

Table 6-5 Protected Areas in Guyana

Protected Area	Km^2
Kaieteur National Park	630
Iwokrama Forest	3,710
Kanashen (Community Owned Conservation Area)	6,250
Kanuku Mountains	6,110
Shell Beach Nature Reserve	2,000
Moraballi Forest Reserve	110
Mabura Hill Forest Reserve	20

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 so it is most pertinent to the impacts analysis of the Project. The 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 6-6 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 km (~87 mi) between the Waini, Baramani, and Moruka rivers, and the Atlantic Ocean. The PDA is located approximately 300 km (187 mi) 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 mainly pulverized shells from crustaceans (RBAPSBPA, 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 (<30 percent) and sandy beaches (<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 Protected Area 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.

Figure 6-5 Protected Areas of Guyana

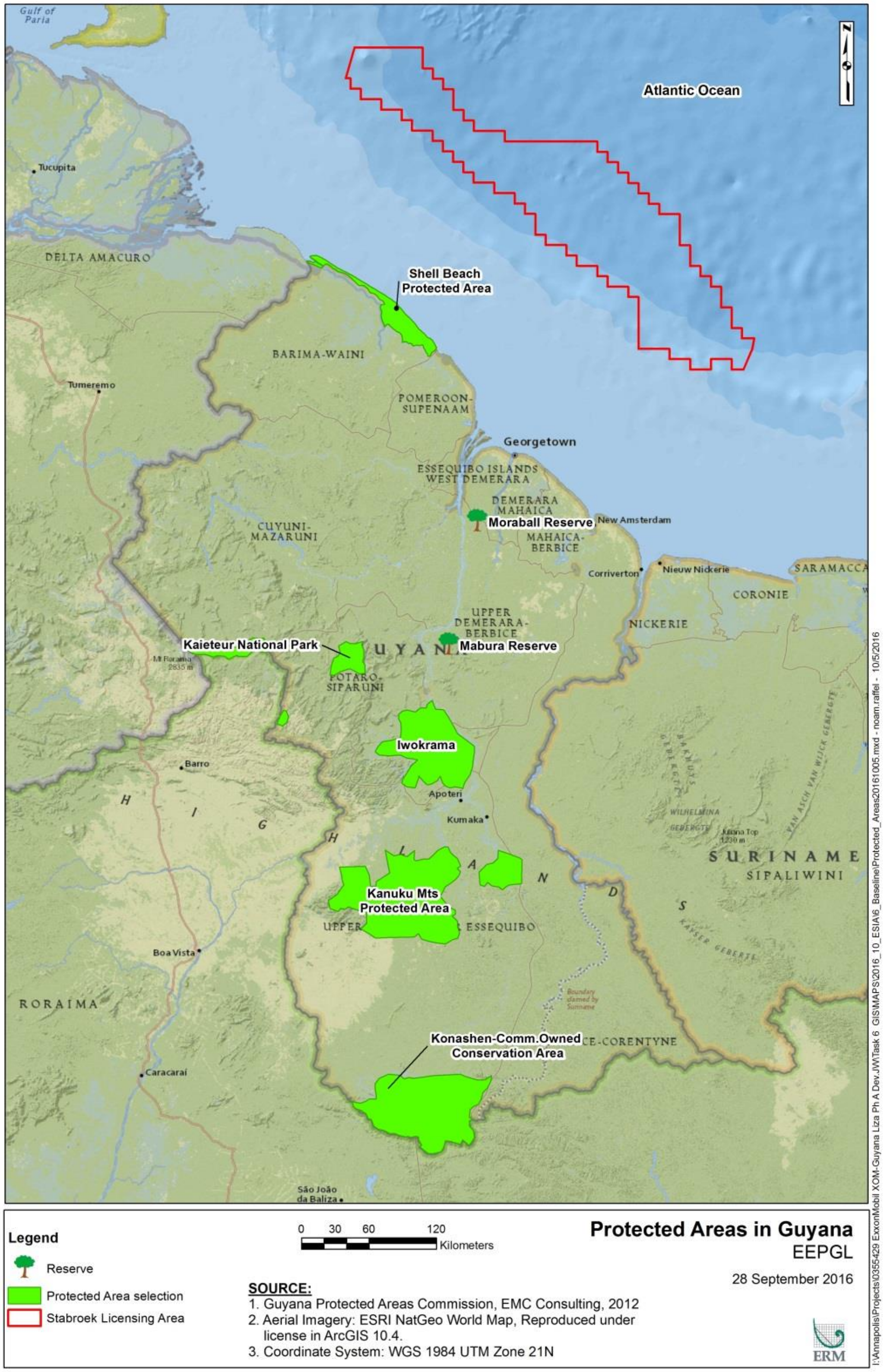
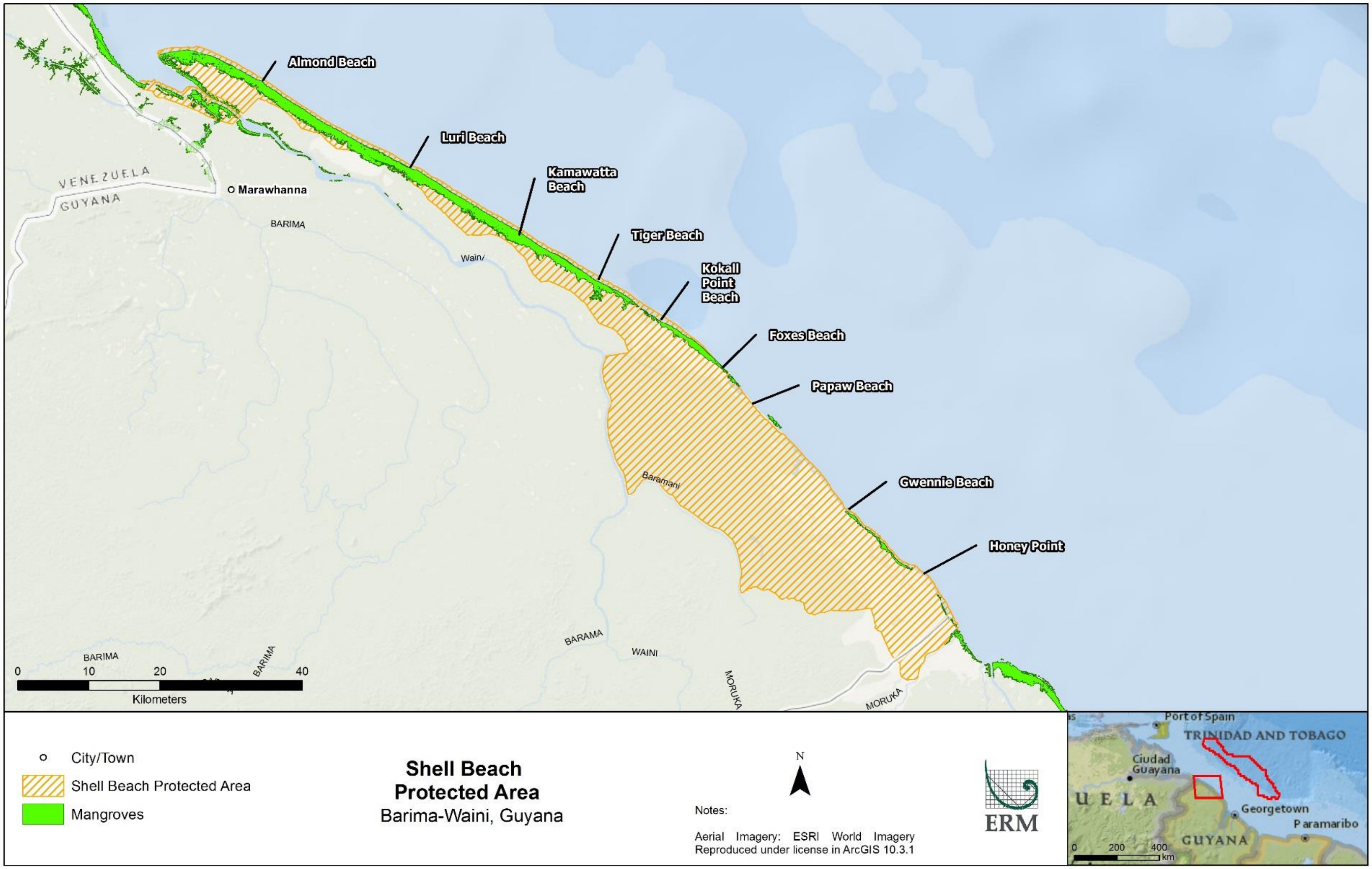


Figure 6-6 Shell Beach Protected Area



Shell Beach is best known as a sea 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 sea turtles. Most nesting beaches in Guyana are used by only one or two species of sea turtles, but four species of sea turtles (Leatherback, Hawksbill, Olive Ridley, and Green Turtle) nest at Shell Beach (Pritchard, 2001). In addition to sea turtles, there are also at least four other species of turtles present within the Protected Area, including yellow-foot tortoise (*Geochelone denticulate*), scorpion mud turtle (*Kinosternon scorpioides*), giant river turtle (*Podocnemis expansa*), and mata mata (*Chelus fimbriata*).

The SPBA also supports rich bird, herpetofauna (reptiles and amphibians), and mammal communities. The 2004 Rapid Biodiversity Assessment 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 (*Bufo Marinus*), paradoxical frog (*Pseudis paradoxa*), and numerous tree frogs (*Hyla* spp.) (RBAPSBPA, 2004).

Twenty species of mammals, including howler monkeys (*Alouatta* spp.), jaguars (*Panthera* spp.), and manatees (*Trichechus* sp.), are known to inhabit the Shell Beach area and surrounding coastal region (Prince et al., 2004; Kalamandeen et al., 2005). Appendix G – Flora and Fauna Diversity of Shell Beach, provides an extensive list of species within the area.

Resources within Protected Areas are a key factor in supporting local communities (see Chapter 7 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 Protected Area. Other communities included within the boundary of the Protected Area, as delineated in 2011, include Father's Beach and Assakata. The remainder of the Protected Area 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 utilized by the locals include blue sheriga (*Callinectes bocourti*), sheriga (*Portunas spinimamus*), bunderi (*Cardiosoma guanhumi*), and buck-crab (*Ucides cordatus*) (RBAPSBPA, 2004). They have also historically engaged in sea turtle trapping and harvesting of sea turtle eggs. 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).

6.2.1.1 Special Status Species

The International Union for Conservation of Nature (IUCN) maintains a Red List, which provides taxonomic, conservation status, and distribution information on plants and animals that have been globally evaluated to determine their relative risk of extinction (IUCN, 2014). The IUCN categorizes species according to their risk at six status levels ranging from "Extinct" to "Least Concern," as defined in Table 6-7.

Table 6-7 Definitions of IUCN Red List Threatened Categories

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	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

Species categorized as CR, EN, and VU are collectively considered to be internationally "threatened," while NT species are close to qualifying as "threatened" and LC species are considered internationally widespread and abundant. There are 296 species known to occur in the coastal and marine habitats in Guyana on the IUCN Red List. Sixty-two of these marine and coastal species have been ranked NT or higher. These species are listed in Appendix H. According to the IUCN's classification scheme, these species currently face a credible threat of extinction.

Most of the threatened (CR, EN or VU) or NT species that could be impacted by the Project are 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. As noted in Section 6.3.3.2, many of these fish species are also targeted by the Guyanese commercial fishing industry. The remaining threatened or NT marine and coastal species in Appendix H include sea turtles, marine mammals, and crustaceans.

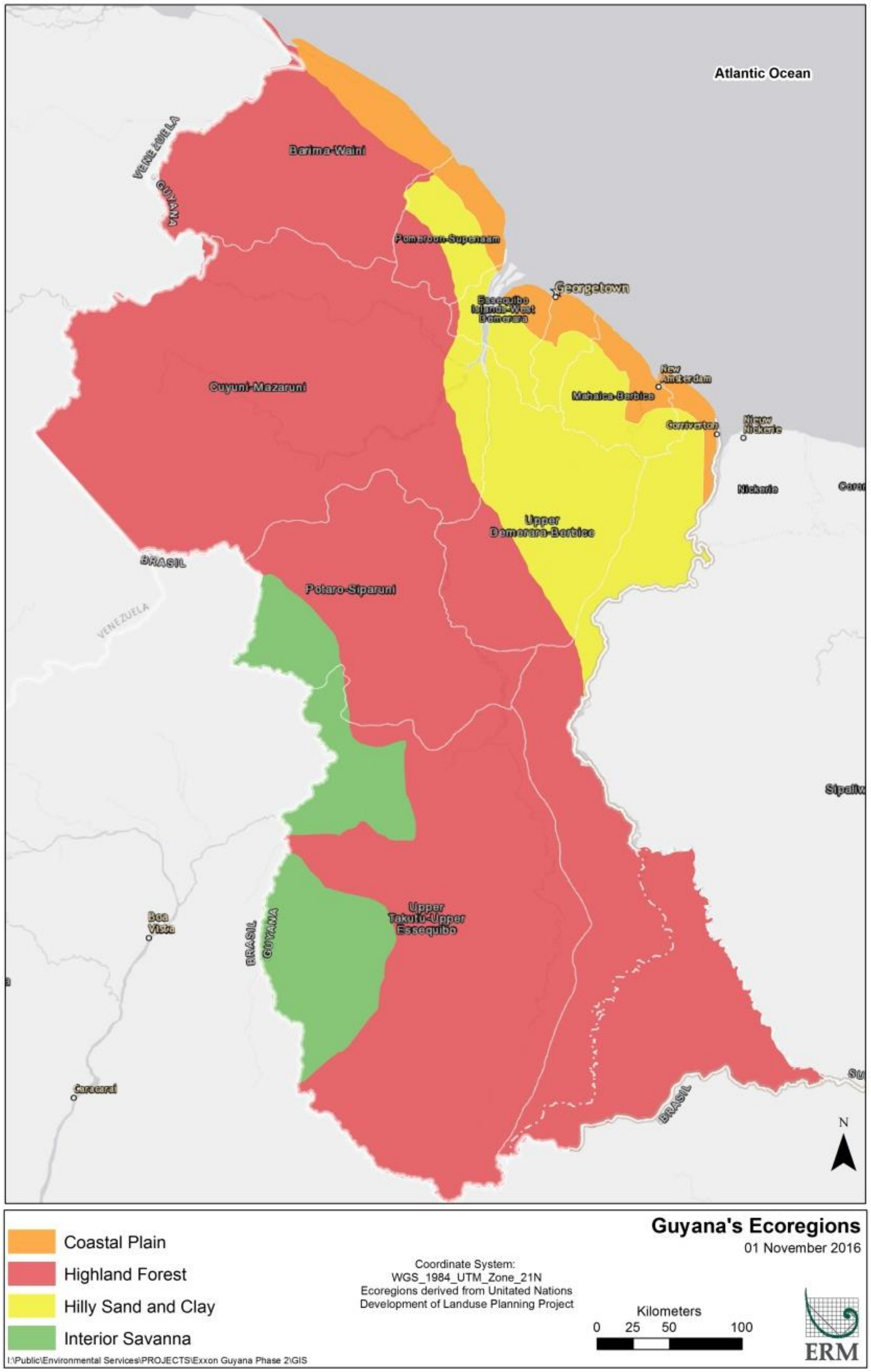
6.2.2 Coastal Habitats

There are four ecoregions in Guyana (Figure 6-7): coastal plain, interior savannas, hilly sand and clay, and forested highlands (GNBSAAP, 2015). The Project will have no impact on the interior savannas, hilly sand and clay, and forested highlands, so 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., oil spill]).

Guyana's coastal plain occupies approximately 7 percent of the country's total area and extends along the entire approximately 400 km (~250 mi) of the Atlantic coast, varying in width from approximately 16 km to 64 km (10 mi to 40 mi) (Kalamandeen and Da Silva, 2002) and in elevation from sea level to approximately 3 m (~10 ft) (GNBSAAP, 2015). The coastal plain is a narrow belt of sediments with riverine and marine clays and silts stretching along Guyana's coastline. The coastal zone is a highly productive and sensitive environment that is subjected to marine and terrestrial influences. Guyana's coastal ecoregion is a network of plains and low hills, including mangroves, salt to brackish lagoons, brackish herbaceous swamps, swamp woods, and swamp forests. The coastal zone 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, 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.

Figure 6-7 Guyana's Ecoregions



6.2.2.1 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 6.1.3). Figure 6-8 shows the general distribution of mangrove resources along coastal Guyana; Figure 6-9 provides photographs of mangroves in Guyana. It is difficult to ascertain the exact location and extent of mangrove forests in the country because the mangroves are subject to erosion and other factors that can lead to rapid and dramatic changes in distribution.

A 2008 Smithsonian report stated that mangroves occupied over 81,000 hectares of Guyana's coast in six of Guyana's 10 geopolitical regions (Smithsonian, 2008). The Guyana Mangrove Restoration Project estimates 75 percent of the country's mangroves are concentrated in Regions 1 and 2 (GMRP Fact Sheet, 2010), which are located along the northwestern coast and include SBPA.

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). In 2014, ERM conducted a coastal zone sensitivity analysis as part of the Oil Spill Response (OSR) planning for the Liza-1 drilling program. The analysis included detailed mapping of mangroves along Guyana's coast from Georgetown west to the Venezuelan border. Figure 6-8 is a composite of 10 individual map tiles showing the identified distribution of mangroves (red-shading) across this portion of Guyana's coastline as of 2013.

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. RGME (2014) noted that in Guyana black mangroves typically colonize the coastal shorelines, and red mangroves establish themselves 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. 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, Krul and Moraes, 2007). 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).

Figure 6-8 Guyana's Mangrove Distribution (Georgetown west to Venezuelan Border)

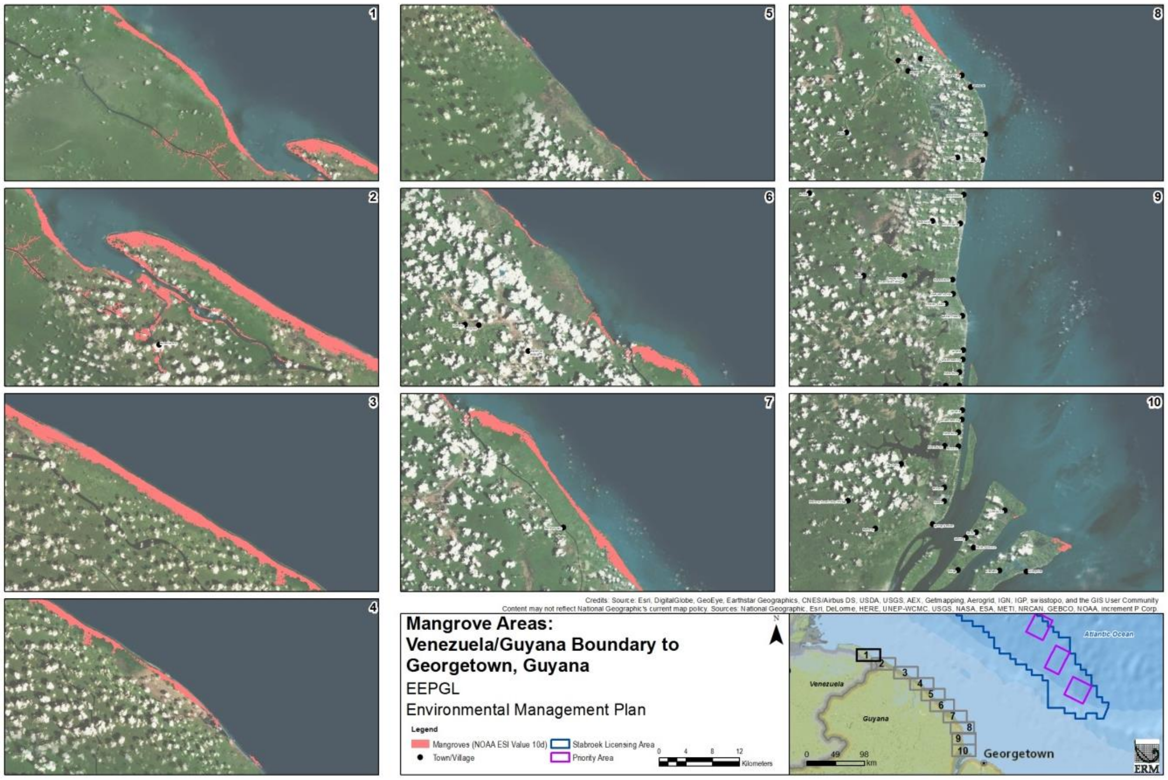


Figure 6-9 Mangrove Photographs

Coastal Mangroves

Red Mangrove Forest

Source: ERM, 2016; Rapid Biodiversity Assessment of Shell Beach, 2004

6.2.2.2 Beaches

Guyana has relatively few beaches, but the beaches that do occur are critically important nesting habitats for sea turtles and providing habitat used by a variety of avian, herpetofauna, and mammalian species (see Figure 6-6, for the locations of beaches in the SBPA).

6.2.2.3 Mudbanks

See Section 6.1.3 for the description of the physical attributes and location of Guyana's mudbanks, which generally refer to the submerged mud features below the low tide line (as distinct from the intertidal mud "flats". There has been no targeted biological surveys of Guyana' mud banks conducted to date, but coastal mud 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).

6.2.3 Coastal Wildlife and Shorebirds

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% of the country's human population, Guyana's coastal region supports a diverse fauna. This section briefly describes bird, mammal, reptile, and amphibian species that are representative of Guyana's coastal region.

6.2.3.1 Coastal Wildlife

Numerous mammal, reptile, and amphibian species occur in Guyana's mangroves, agricultural areas, and coastal forests. There are over 50 species of mammals present including opossums; bats; primates such as capuchin monkeys (*Cebus apell*a), squirrel monkeys (Saimira sciureus), howler monkey (*Alouatta seniculus*) and Guianan saki (*Pithecia pithecia*); giant ant-eater (*Myrmecophaga triactyla*); several species of cats including pumas (*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.); and the giant river otter (*Pteronura brasiliensis*), which is a freshwater species, and the neotropical otter (*Lontra longicaudi*s), which is found in both freshwater and estuarine habitats (WWF, undated). Other reptiles that frequent this ecoregion are the green iguana (*Iguana iguana*), spectacled caiman (*Caiman crocodilus)* and anaconda (*Eunectes murinus*). Amphibians are generally less common along the coast than in the interior especially due to saline influence in the mangroves, but two species that are found along the coast are the paradoxal frog (*Pseudis paradoxa*) and the pipa frog (*Pipa pipa*).

6.2.3.2 Shorebirds

Guyana has a high species richness and diversity of flora and fauna. The coastal bird community is rich in Guyana, with over 200 species of coastal birds recorded, including a variety of parrots and macaws, numerous waterbirds and shorebirds, and raptors including the rare Harpy Eagle (*Harpia harpyja*) (GNBSAAP, 2015). A 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 Snowy Egret (*Egretta thula*) and Cattle Egret (*Bulbulcis ibis*) were also abundant. In 2007, 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 and mudflats and the checklist includes 47 species within 18 families for the mangroves and 38 species within 8 families for the mudflat habitats (Braun et al., 2007) (Appendix I). 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 Rufous Crab-hawk (*Buteogallus aequinoctialis*), Great Egret (*Ardea alba*), Greater Kiskadee (*Pitangus sulphuratus*), Scarlet Ibis (*Eudocimus ruber*) and the Pied Water Tyrant (*Fluvicola pica*) (Appendix I).

As discussed in Section 6.2.2, Shell Beach is the only coastal Protected Area in Guyana. Two biodiversity surveys have been undertaken within and around Shell Beach over roughly the past decade (Mendonca et al. 2006; GEPA et al.; 2004). Each of these surveys documented over 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats 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 Laughing Gull (*Larus atricilla*), Scarlet Ibis (*Eudocimus ruber*), Yellow-billed Tern (*Sterna superciliaris*), Least Tern (*Sterna antillarum*), Spotted Sandpiper (*Actitis macularia*), *Lesser* Yellowlegs (*Tringa flavipes*), and Blackbellied Whistling-duck (*Dendrocyna autumnalis*) (Mendonca et al. 2006; GEPA et al.: 2004).

BirdLife International (2016a) 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.

6.2.4 Seabirds

Seabirds are birds that spend their 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, and terns. Twenty-two species of seabirds breed in the Caribbean and dozens more occur as migrants through the region. Seabird data that is specific to Guyana is almost non-existent and no comprehensive survey of seabirds has ever been conducted in Guyana (BirdLife International, 2016).

Birdlife International lists 21 species of seabirds for Guyana (BirdLife International, 2016). Other current data sources, such as eBird, and seabird observations recorded in the Stabroek Block during the EEPGL seismic surveys conducted in 2015 and 2016, increase the total number of documented seabird species in Guyana to 30 (eBird, 2016; RPS, 2016). 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 Venezuela, respectively (BirdLife International, 2016). Table 6-8 lists the seabird species documented in Guyana based on the BirdLife data, eBird records, and EEPGL observations. Any of these species could occur in the PDA at some time during the year (specific timing of occurrence is dependent on the species and environmental conditions). All of the 30 species of seabirds known to occur in Guyana are currently listed on the IUCN Red List as LC, which means that the population status of the species does not meet the IUCN criteria for a threatened or NT designation (IUCN, 2016).

Of the species observed in the Stabroek Block during the EEPGL seismic surveys, the most commonly observed species (in descending order of number of sightings (i.e.; frequency of occurrence) were the Masked Booby (*Sula dactylatra*), Magnificent Frigatebird (*Fregata magnificens*), and Brown Booby *(Sula leucogaster*) (RPS, 2016).

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, are 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 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. No slower moving or circular currents or areas of upwelling that could concentrate marine biota are known to occur in the PDA. 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, 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.

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 6-10 depicts the location of these IBAs relative to the Stabroek Block.

Table 6-8 Seabird Species Known to Occur in Guyana

Common Name [a, b, c]	Scientific Name
Magnificent Frigatebird [a, b, c]	*Fregata magnificens*
Brown Booby [a, b, c]	*Sula leucogaster*
Masked Booby [a, b]	*Sula dactylatra*
Red-footed Booby [b]	*Sula sula*
White-tailed Tropicbird [a, b]	*Phaethon lepturus*
Leach's Storm-petrel [a, c]	*Oceanodroma leucorhoa*
Audubon's Shearwater [a, b, c]	*Puffinus lherminieri*
Wilson’s Storm-petrel [b, c]	*Oceanites oceanicus*
Cory's Shearwater [a, b]	*Calonectris diomedea*
Barolo Shearwater [b]	*Puffinus baroli*
Great Shearwater [a, c]	*Ardenna gravis*
Arctic Jaeger [c]	*Stercorarius parasiticus*
Pomarine Jaeger [a, b, c]	*Stercorarius pomarinus*
Parasitic Jaeger [b]	*Stercorarius parasiticus*
South Polar Skua [b]	*Stercorarius maccormicki*
Great Skua [c]	*Catharacta skua*
Least Tern [b, c]	*Sternula antillarum*
Royal Tern [b, c]	*Sterna maxima*
Black Tern [b, c]	*Chlidonias niger*
Common Tern [a, b, c]	*Sterna hirundo*
Bridled Tern [b, c]	*Onychoprion anaethetus*
Sooty Tern [c]	*Onychoprion fuscatus*
Sandwich Tern [b, c]	*Thalasseus sandvicensis*
Roseate Tern [b]	*Sterna dougalli*
Brown Noddy [b, c]	*Anous stolidus*
Gull Billed-tern [b, c]	*Gelochelidon nilotica*
Northern Gannet [b]	*Morus bassanus*
Laughing Gull [b, c]	*Larus atricilla*
Brown Pelican [b, c]	*Pelecanus occidentalis*
Neotropic Cormorant [b, c]	*Phalacrocorax brasilianus*

[a] Species observed in in the Stabroek Block during the EEPGL seismic surveys conducted in 2015 and 2016 (RPS, 2016)
[b] eBird record (eBird Caribbean, 2016)
[c] BirdLife International record (BirdLife International, 2016)

St. Giles Islands IBA includes one main island and several surrounding rock outcrops that support globally important numbers of breeding Red-billed Tropicbird (*Phaethon aethereus*) and regionally important numbers of breeding Audubon's Shearwater (*Puffinus lherminieri*), Magnificent Frigatebird (*Fregata magnificens*), Masked Booby (*Sula dactylatra*), and Red-footed Booby (*S. sula*). Other seabirds such as Brown Booby (*S. leucogaster*) 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 (*Larus 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, 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 (*Sterna fuscata*) in Venezuela (12,182 pairs) (Lentino and Esclasans, 2009).

Figure 6-10 Location of IBAs with Importance to Seabirds Relative to Stabroek Block

6.2.5 Marine Mammals

Although there have been no comprehensive studies in the PDA, 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, 2001; Ward and Moscrop, 1999), marine mammal observation (MMO) data collected during EEPGL exploration activities from 2014 to 2016 (RPS PSO database), studies on cetaceans in offshore waters of neighboring countries such as Suriname and Venezuela (de Boer, 2015; IWC/SC 2006), 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, and two pinniped groups (seals and sea lions), have been documented in the region, but are either now considered to be locally extinct or extremely rare and would not be expected to be encountered in coastal waters adjacent to the PDA (Ward, 2001). However, the manatee may be encountered in nearshore and riverine settings.

6.2.5.1 <u>Regional Setting</u>

The equatorial waters of Guyana are located within sub-region VI of the Wider Caribbean Region (WCR). 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 WCR, 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).

6.2.5.2 <u>Marine Mammal Data from the Project Development Area</u>

The 2007 Global Bycatch Assessment of Long-lived Species (Project GloBAL) Country Profile of Guyana 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 6-9.

Table 6-9 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*	Data Deficient	Bryde's whales are moderately sized and closely resemble their relative, the sei whale.

Common Name	Scientific Name	IUCN Status	Notes
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.
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 dolphin species, such as pilot whales.
Long beaked common dolphin	*Delphinus capensis*	Data Deficient	The range of this dolphin is more restricted than that of the short beaked common dolphin. It has a varied diet. One of the main threats to this dolphin is fisheries.
Minke whale	*Balaenoptera acutorostrata*	LC	Minke whales are the second smallest baleen whale.
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*	Data Deficient	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*	Data Deficient	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 m deep or more, and spend great lengths of time at depth. A pod may spread out up to 800 m (~2,640 ft) 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*	Data Deficient	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*	Data Deficient	The dwarf sperm whale is the smallest species commonly known as a whale. Dwarf sperm whales feed mainly on squid and crab. Its preferred habitat appears to be just off the continental shelf.

Common Name	Scientific Name	IUCN Status	Notes
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 1000 in number.
Humpback whale	*Megaptera novaeangliae*	LC	Found in oceans and seas around the world, humpback whales typically migrate up to 25,000 km 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*	Data Deficient	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*	Data Deficient	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.
True's beaked whale	*Mesoplodon mirus*	Data Deficient	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 four to twenty 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 m (984 to 2,625 ft) to forage.
False killer whale	*Pseudorca crassidens*	Data Deficient	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.

Common Name	Scientific Name	IUCN Status	Notes
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 benefitted the species and it is now one of the most abundant dolphin species in the world.
Clymene dolphin	*Stenella clymene*	Data Deficient	Clymene dolphins spend most of their lives in waters over 100 m (330 ft) 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*	Data Deficient	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: Global, 2007; De Boer, 2015; IUCN 3.1; Minasian et al., 1984

A recent peer-reviewed study was conducted in Suriname and adjacent waters in 2012 (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, effort-related surveys. These are shown in bold in Table 5-A of de Boer (2015). 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 be occurring.

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 and sei whales). 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 and melon-headed whale. Spinner and pantropical spotted dolphins 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 m to 3,350 m [3,900 ft to 11,000 ft] 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 (IWC) Scientific Committee's (SC's) Draft Report on Small Cetaceans of the Wider Caribbean (IWC/SC, 2006) cites information from French Guiana and Venezuela and provides secondary information on Guyana's marine mammals. 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).

Marine mammal observations during recent seismic surveys conducted between December 2015 and March 2016 (RPS, 2016) noted that dolphins were detected (either visually or acoustically) on 20 occasions and included four species: pantropical and bottlenose dolphins, short-finned pilot whales, and melon headed whales. Two sperm whale detections and two Bryde's whale detections were also recorded, along with one unidentified baleen whale. Visual monitoring was conducted over a period of about 85 days for a total of 1007.5 hours. Data from this winter study were combined with other observations in the Stabroek and Canje Blocks to develop the list of confirmed species sighted depicted in Table 6-10.

Table 6-10 Marine Mammal Species Visually Observed during EEPGL Activities Since 2014

Common Name	Scientific Name
Bryde's whale	*Balaenoptera brydei*
Fraser's dolphin	*Lagenodelphis hosei*
Melon headed whale	*Peponocephala electra*
Pantropical spotted dolphin	*Stenella attenuate*
Risso's dolphin	*Grampus griseus*
Short-finned pilot whale	*Globicephala macrorhynchus*
Sperm whale	*Physeter microcephalus*
Spinner dolphin	*Stenella longirostris*

Source: RPS, 2016

Table 6-11 summarizes the data for acoustic and visual observations of marine mammals in the vicinity of the PDA, month-by-month, over the period June 1, 2014 to September 1, 2016. The locations of whales sighted or identified from acoustic observations during this period are depicted on Figure 6-11.

Table 6-11 Data Compiled from PSO Observations June 2014 to September 2016

	Number of Observations											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Sperm Whale	3	2	2	1	0	1	4	6	2	4	0	0
Dolphin	56	28	3	8	6	7	14	34	52	42	52	42
Baleen Whale	7	3	6	4	0	2	3	0	0	0	1	3
Beaked Whale	0	0	0	0	1	0	1	0	0	0	0	0

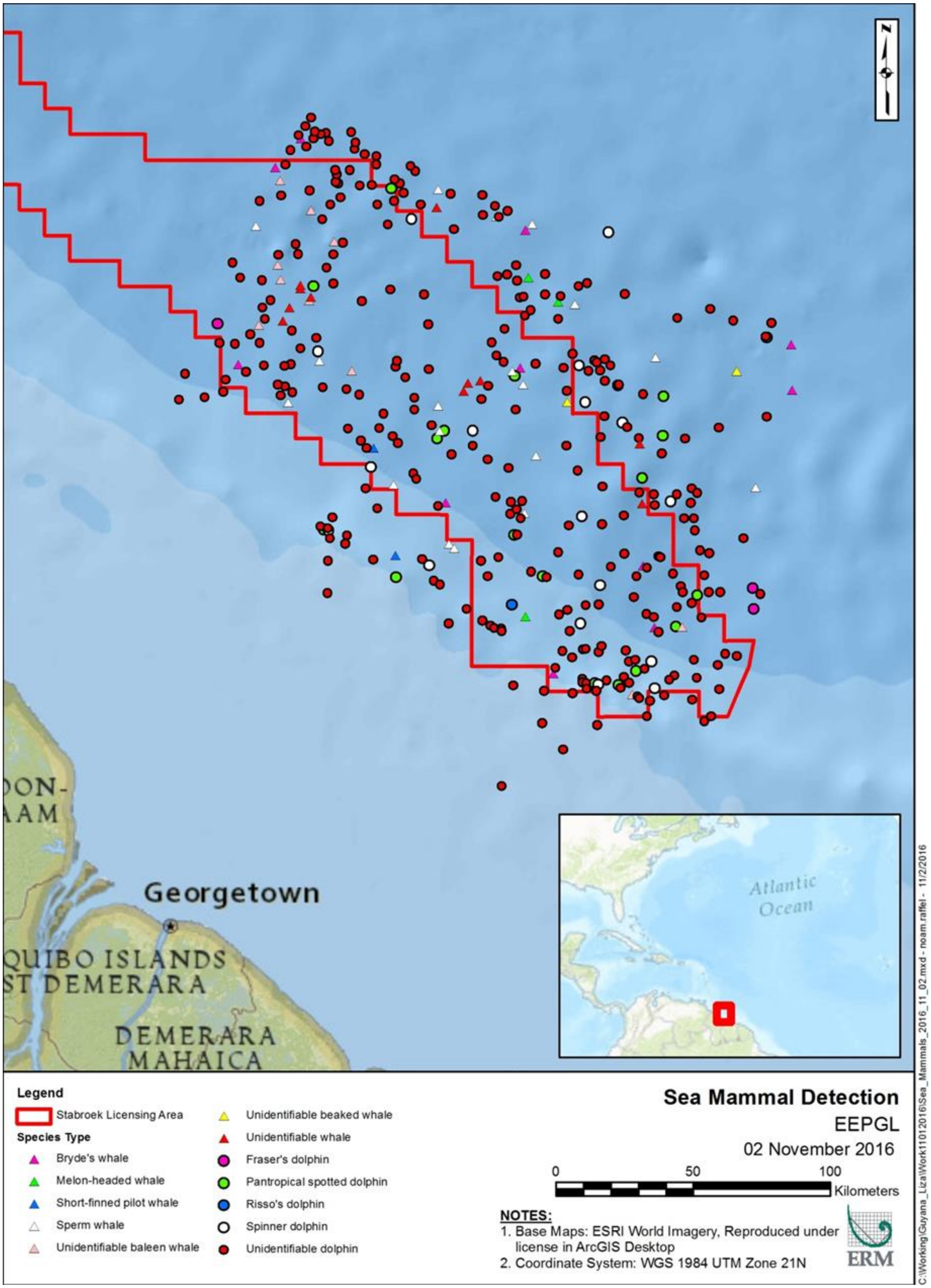
Source: RPS PSOMAP database search from June 1, 2014, to Sept 1, 2016. Includes visual and acoustic detections. Data indicates number of detections rather than abundance.

These observations off of Guyana correspond with those documented by De Boer (2015) off of Suriname. Based on these recent sightings and data compilations, toothed whales (including dolphins) are detected most frequently in the PDA, but baleen whales may also be encountered.

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*), spotted dolphin (*Stenella spp*.), longmouth or common dolphin (*Delphinus delphi*), tucuxi (*Sotalia fluviatilis*), spinner dolphin (*Stenella longirostrus*), and bottlenose dolphin (*Tursiops truncatus*). Individuals of these species may be encountered by marine support vessel operations and tankers in these waters.

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 6-11 Locations of Marine Mammal Sightings Relative to the Stabroek Block



6.2.6 Marine Turtles

According to the *Regional Sea Turtle Conservation Program and Action Plan for the Guianas* (2003), sea 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. Data from this action plan along with more recent compilations from Project Global (2007), The Center for Rural Empowerment and the Environment ([CREE], 2014), and observations collected during exploration activities from 2014 to 2016 represent the main sources of data for turtles in the Project Area. In addition, information on the interaction between sea turtles and trawl fisheries on the Guianas shelf since the 1970s was reviewed (Pritchard 1973, 1991).

6.2.6.1 Regional Setting and Species Descriptions

Five sea 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 sea 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 sea 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 (National Marine Fisheries Service & U.S. Fish and Wildlife Service, 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 et al., 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 et al., 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., 2005b).

Leatherback turtles are the largest of all sea turtle species and do not have a hard shell like other sea 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 (DOE, 2014); however, they are also known to forage along coastlines. Leatherbacks make extensive seasonal migrations between different feeding areas and nest at the same location every year (NWF, 2014b). 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 (Eckert and Grobois 2001). A moderate number of nests can also be found in Guyana, Venezuela, Trinidad, and Colombia. This species is listed by the IUCN as Vulnerable.

The hawksbill turtle is a small- to medium-sized sea turtle that has an elongated head that tapers to a point with a beaklike mouth, giving its name (NOAA, 2014e). 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, 2014e). These types of habitats are generally found northwest of the PDA in the Caribbean Sea. This species is listed as Critically Endangered by the IUCN.

The loggerhead turtle is an oceanic turtle distributed throughout the world. The loggerhead turtle 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 sea turtle has a low reproductive rate; females lay an average of four egg clutches and then become quiescent, producing no eggs for two to three 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 with high risk of extinction.

The olive ridley turtle is a small circumtropical sea turtle that is classified as vulnerable by the IUCN. While olive ridley turtle populations have declined in prior decades, their populations have remained stable 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, 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, 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 CREE, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) occurs at night from March to August (CREE, 2014).

The primary threats to sea 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 sea 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).

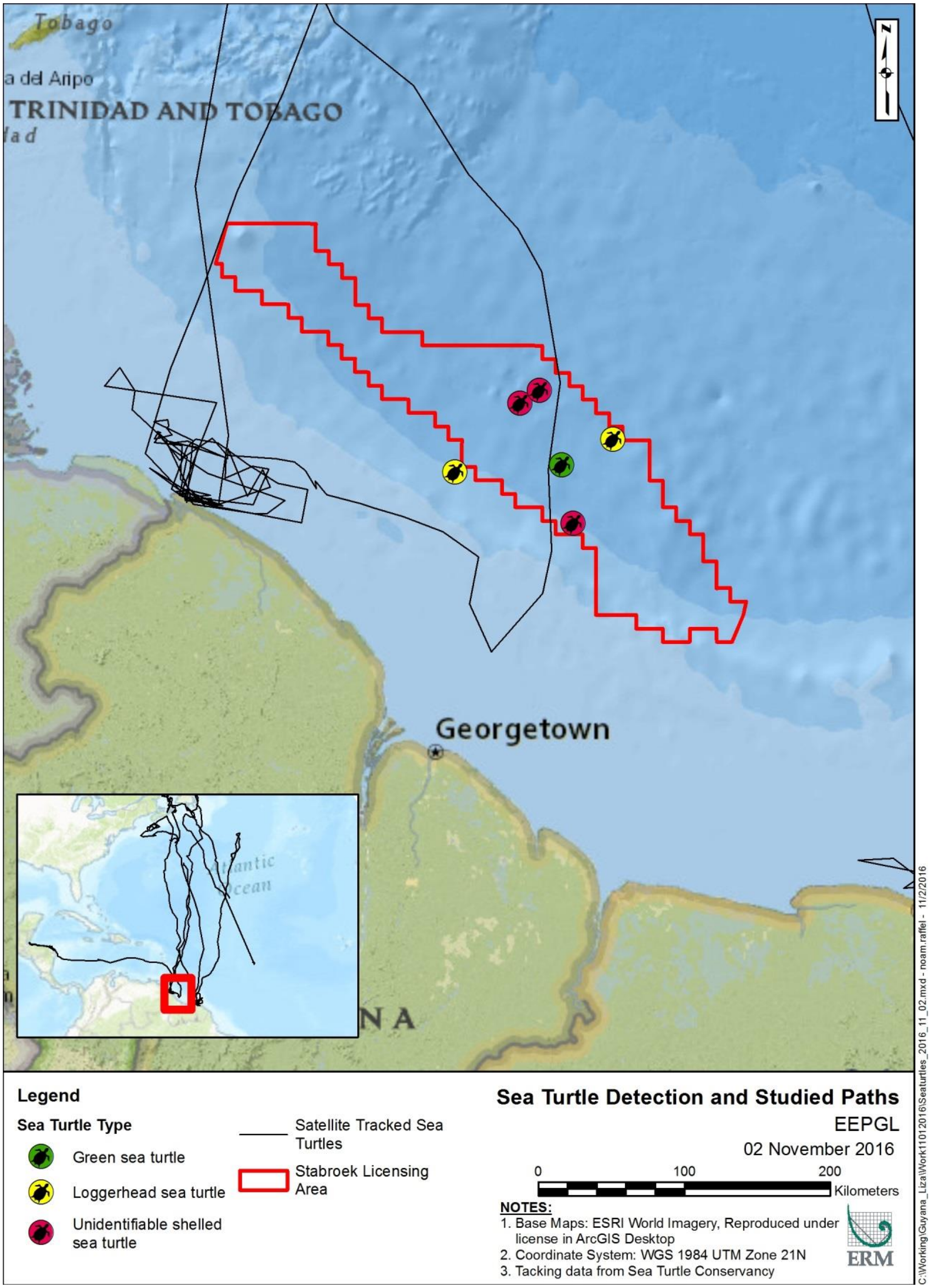
6.2.6.2 Marine Turtle Data for the Project Development Area

MMO observations conducting during seismic surveys between July 2015 and August 2016 detected six sea turtles: one green turtle, two loggerhead turtles and three unidentified turtles. The locations of the sightings are indicated on Figure 6-11.

Based on these recent sightings and data compilations, it is possible that any of the five above-referenced sea turtle species could be encountered in the PDA.

The Sea Turtle Conservation Society actively maps sea turtle movements, by placing satellite transmitter tags on individual turtles after they finish nesting (see www.conserveturtles.org). Starting on May 21, 2012, the Society mapped movements of three leatherback turtles from their nesting place at Shell Beach (Figure 6.-12). 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 Piniak and Eckert's (2011) assertion that most species of marine turtles likely move out of Guyanese waters as juveniles.

Figure 6-12 Location of Sea Turtle Sightings and Satellite Tracks Relative to the Stabroek Block



6.2.7 Marine Fish

Scientific data on marine fish in the PDA are sparse. Much of what is known about marine fishes offshore Guyana is known from study of commercial landings. The inshore fish community is dominated by drums, croakers, and marine catfishes, and includes other species such as snooks and tarpon. 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 inshore and offshore.

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 as juveniles, particularly drums, croakers, and snappers. Catfishes occur in the mangroves, estuaries, and oceanic waters as adults. Some other species, including snooks and tarpon, may occur occasionally in the ocean, but are specifically adapted to completing their entire life cycles in mangrove-lined estuaries (MOA, 2013).

6.2.7.1 Historical Data on Demersal Coastal Species

The most complete data on marine fish in Guyana's territorial waters come from a two-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 (McConnell, 1962). Although the study report does not contain a map of the individual stations, the map of the study area indicates that they extended seaward to the edge of the continental shelf. Although the study did capture some pelagic species, it was designed as a trawl survey and was therefore more oriented toward demersal species. The study documented the presence of 213 species of fish, comprised primarily of drums, croakers, catfishes, jacks, grunts, and snappers. McConnell noted a spatial pattern in the distribution of fishes across the shelf, and separated the shelf into four biogeographic zones:

- Zone 1: described as the "brown fish" zone, water depths from 0 to 10 fathoms (0-18 m). The fish community in this zone was dominated by drums, catfishes, rays, and various toadfishes (Batrachoididae).
- Zone 2: described as the "golden fish" zone, water depths from 10 up to 30 fathoms (18-55 m). The fish community in this zone was dominated by catfishes, jacks, and grunts.
- Zone 3: described as the "silver fish" zone. This zone was associated with less turbid oceanic waters and the location of this zone was more dependent on water quality than depth, but the fish typical of this zone were particularly abundant in water 20 to 40 fathoms (37-75 m).
- Zone 4: described as the "red fish" zone, ranging from water depths of about 20 fathoms near Suriname and 30 to 40 fathoms (55-75m) closer to Georgetown seaward to the edge of the continental shelf. Snappers and various demersal species comprised the bulk of the catch in this zone.

Approximately 80 species of fish occurred in Zone 4 in the McConnell study. These species are listed in Appendix K. Although the PDA is located slightly north of the seaward limit of McConnell's study area (and in deeper water), the catches from Zone 4 contain species that are also found at much deeper depths, and are therefore considered indicative of the types of fish that are likely to occur in the PDA, especially near the seafloor.

The data from Zone 4 in the McConnell study include several species that are commonly associated with coral reefs, including butterflyfishes, angelfishes, wrasses, and parrotfishes (MConnell, 1962). McConnell notes that coral fragments appeared in the trawl, but that the coral retrieved in the net was dead. It seems likely that the coral-associated fishes in the McConnell study were likely present on scattered fragments of dead coral or possibly small dead patches of coral rather than on living reefs.

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, 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. 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 likely explains the presence of so many widespread species in the dataset.

The Guyana Fisheries Department (a division of the Guyana Ministry of Agriculture) does not monitor non-commercial marine fisheries, but bycatch data from the nearshore shrimp trawl fishery provided by the Guyana Fisheries Department (summarized in Table 6-12) are consistent with the McConnell study with respect to marketable species in McConnell's "brown" fish zones. Recent bycatch data collected since 2012 from shrimp trawlers identify seven species of fish. Four of these species (Bangamary, Bashaw, Croaker, Sea Trout) are in the family Scianidae, which McConnell identified as characteristic of Zone 1 (McConnell et al., 1962); Bangamary, Bashaw, and Sea Trout represent 65-75 percent of the total bycatch by weight each year from 2012 to 2015.

Table 6-12 Fish Bycatch from the Nearshore Shrimp Trawling Fishery 2012-2015 (mt)

Species	2012	2013	2014	2015
Bangamary	757	921	1,380	1,151
Butterfish	559	665	6622	485
Bashaw	111	189	1799	168
Croaker	0	0	0	0
Sea Trout	303	292	4711	303
Grey Snapper	3	2	22	0.1
Snook	0	0	0	42
Total	**1,733**	**2,069**	**2,692**	**2,148**

Source: ERM Personal Communication 16

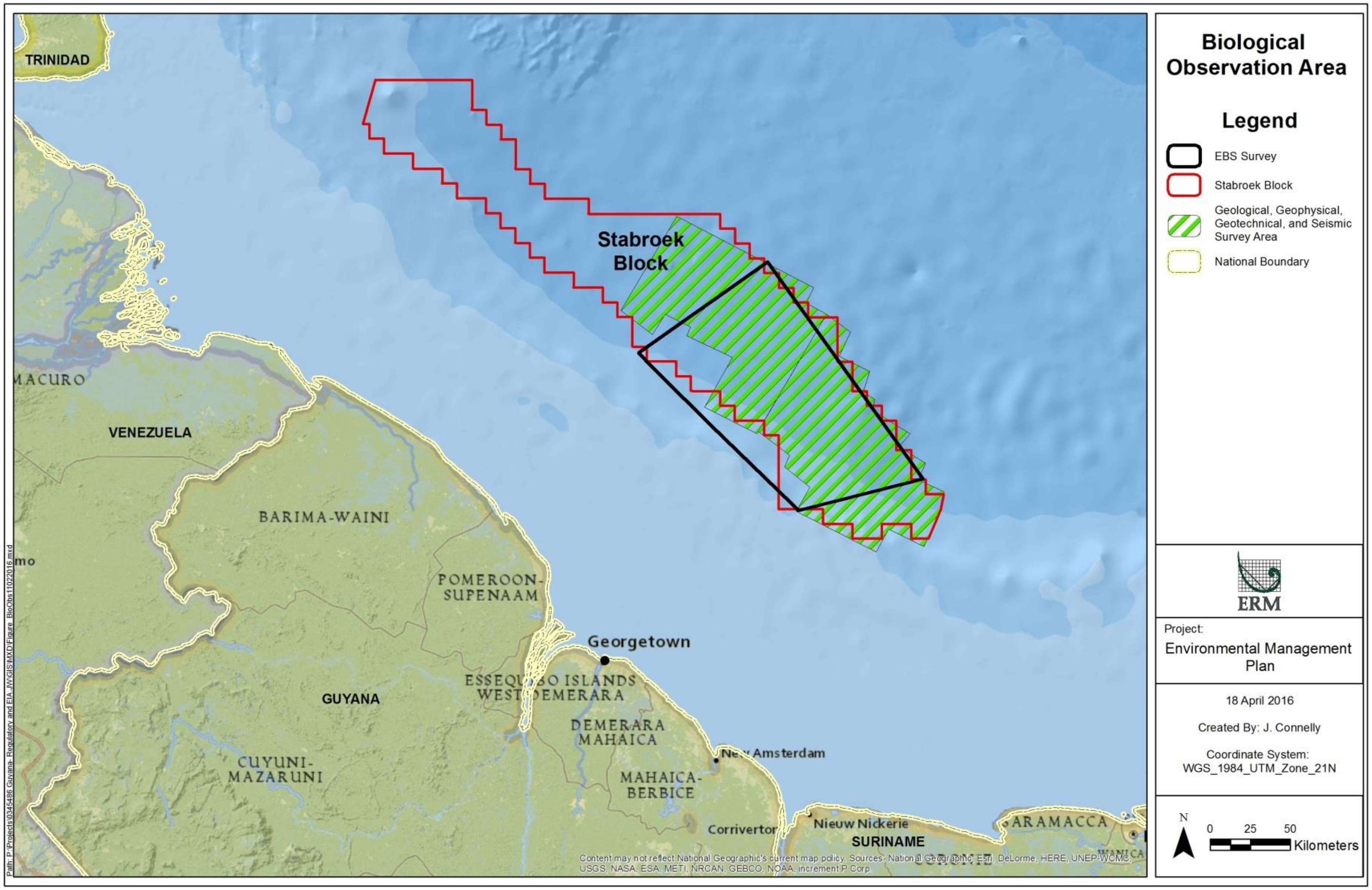
6.2.7.2 *Observations from EEPGL's Offshore Activities*

Project-specific information on fish species from the PDA is available from observations made during EEPGL's various activities in the southeastern half of the Stabroek Block since 2014 (Figure 6-13). Fish observed in this area (Figure 6-13) include 17 species, as listed in Table 6-13. None of these species were documented in the McConnell study, but the data from EEPGL's activities were acquired from surface observations and are comprised of species that are characteristic of the upper water column, so would not be expected in McConnell's trawl survey.

Table 6-13 Fish Species Observed in the Stabroek Block during EEPGL Activities Since 2014

Common Name	Scientific Name
Mahi-mahi	*Coryphaena hippurus*
Jack	*Seriola sp.*
Atlantic tripletail	*Lobotes surinamensis*
Atlantic flying fish	*Chellopogon melanurus*
Little tunny	*Euthynnus alletteratus*
Manta ray	*Manta sp.*
Ocean sunfish	*Mola mola*
Planehead filefish	*Stephanolepis hispidus*
Sailfish	*Istiophrous albicans*
Skipjack tuna	*Katsuwonus pelamis*
Blackfin tuna	*Thunnus atlanticus*
Yellowfin tuna	*Thunnus albacares*
Clearwing flying fish	*Cypselurus comatus*
Blue marlin	*Makaira nigricans*
Bar jack	*Caranx ruber*
Crevalle jack	*Caranx hippos*
Rainbow runner	*Elagatis bipinnulata*

Figure 6-13 Approximate Locations of Biological Observations Made Since 2014



In the summer of 2011, several islands in the eastern Caribbean (e.g., Anguilla, Antigua & 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. Quantities were sufficiently large in the block to clog intake hoses for vessel propulsion systems and foul acquisition equipment being used to collect seismic data in the block at the time. 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*).

6.2.7.3 Special Status Fish Species

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. According to the IUCN's classification scheme, these species currently face a credible threat of extinction, and are expected to face such risks soon. An additional 17 are considered Data Deficient and cannot be objectively assessed with the currently available data. Most of the threatened or NT species that could be impacted by the Project are fish. These species are listed in Appendix H. 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 6.3.3.2, many of these fish species are also targeted by the Guyanese commercial fishing industry.

All of the CR species are coastal 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.

The VU, NT, and Data Deficient categories all contain a mix of pelagic species (e.g., sharks and tunas) and demersal marine species (such as grouper, skate, and ray species), and in some cases species that are important targets of fishery activities (e.g., gillbacker).

6.2.8 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.

6.2.8.1 Methodology

This section draws on information provided in the scientific literature, maps, Automated Underwater Vehicle (AUV) photographs, as well as field data collected by box coring and sediment profile imaging during the 2014 and 2016 environmental surveys.

6.2.8.2 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 characteristic of coastal tropical Atlantic environments elsewhere. This is due to the highly turbid conditions offshore of Guyana, which do not permit the growth of warm water corals, since they 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 m and *S. variabilis* from approximately 219 m to 2,165 m. The locations and the extent of deepwater corals offshore of Guyana have not been published (Freiwald et al., 2004). 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 species living within or on reefs that were originally constructed by more robust species such as *S. variabilis*.

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 (USEPA, 2010). While these species are free swimming, they are often found at or near the bottom.

In addition to shrimp, there are other species of crustaceans found in the deepwater areas of the Caribbean Sea. These include several species of isopods (such as *Leptanthura guianae* and *Malacanthura truncata*) (Poore and Schotte, 2009 and 2015) and amphipods (including *Ampelisca mississippiana*, and *Thaumastasoma* species). 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).

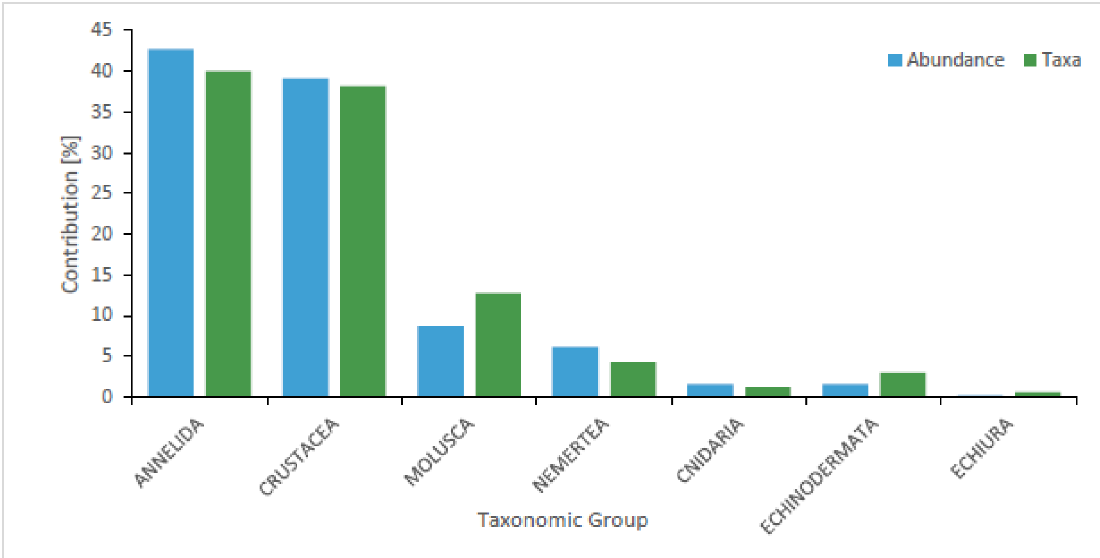
6.2.8.3 Existing Conditions in the Project Development Area

Results of the 2014 environmental survey revealed that the total abundance of benthic infauna in the PDA was low, averaging 116 organisms per 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 (avg. 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 deep-water 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. No deepwater coral growth was detected in either the 2014 or 2016 environmental surveys or the AUV surveys of the seafloor in the vicinity of the Liza-1 well (Maxon Consulting, Inc. and TDI Brooks International, Inc., 2014; FUGRO EMU Limited, 2016).

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 environmental study showed an overall prevalence of annelids (including polychaetes), crustaceans, and mollusks typical for marine sediments as well as low macrofaunal densities. The 2016 samples averaged 20 organisms per 0.1 m^2, which can be extrapolated to 200 organisms per 1 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 in 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 6-14).

Figure 6-14 Abundance of Major Taxonomic Groups Identified in 2016 EBS



Source: FUGRO EMU Limited, 2016

Table 6-14 identifies the common macrofauna families identified in the 2014 and 2016 studies. As the 2014 survey did not categorize the macrofauna organisms beyond the family level, the commonalities between the 2014 and 2016 surveys were identified based on equivalent families. Both 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 is 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.

Table 6-14 List of Common Macrofauna Families between the 2014 and 2016 Environmental Survey Reports

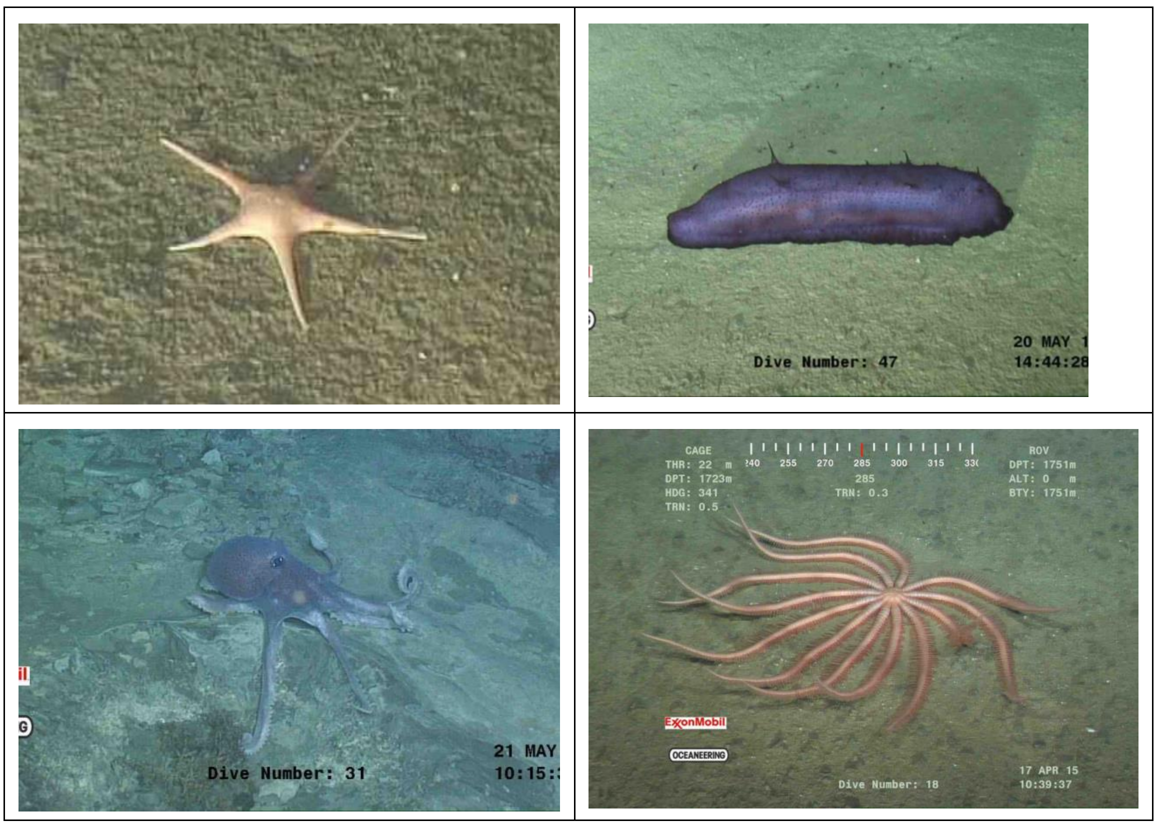
Phylum	Class	Order	Family
Annelida	Polychaeta	Sabellida	Oweniidae
Annelida	Polychaeta	Spionida	Spionidae
Annelida	Polychaeta	Spionida	Magelonidae
Annelida	Polychaeta	Terebellida	Cirratulidae
Annelida	Polychaeta	Terebellida	Ampharetidae
Annelida	Polychaeta	Not assigned	Orbiniidae
Annelida	Polychaeta	Not assigned	Paraonidae
Annelida	Polychaeta	Not assigned	Capitellidae
Annelida	Polychaeta	Not assigned	Maldanidae
Annelida	Polychaeta	Not assigned	Opheliidae
Annelida	Polychaeta	Phyllodocida	Phyllodocidae
Annelida	Polychaeta	Not assigned	Orbiniidae

Phylum	Class	Order	Family
Annelida	Polychaeta	Eunicida	Lumbrineridae
Annelida	Polychaeta	Eunicida	Onuphidae
Arthropoda	Malacostraca	Cumacea	Unidentified
Arthropoda	Malacostraca	Tanaidacea	Apseudidae
Mollusca	Scaphopoda	Dentaliida	Dentaliidae
Nematoda	Unidentified	Unidentified	Unidentified
Sipuncula	Sipunculidea	Golfingiiformes	Unidentified
Sipuncula	Sipunculidea	Golfingiiformes	Golfingiidae
Sipuncula	Sipunculidea	Golfingiiformes	Phascolionidae

Notes: The term "not assigned" references that the scientific community has not specifically classified the organism to a given categorization. The term "unidentified" refers to the surveyor's inability to further identity the categorization of an organism.

Figure 6-15 depicts some of the benthic fauna detected during the 2014 environmental survey.

Figure 6-15 Benthos Photographed in the Vicinity of the Liza-1 Well



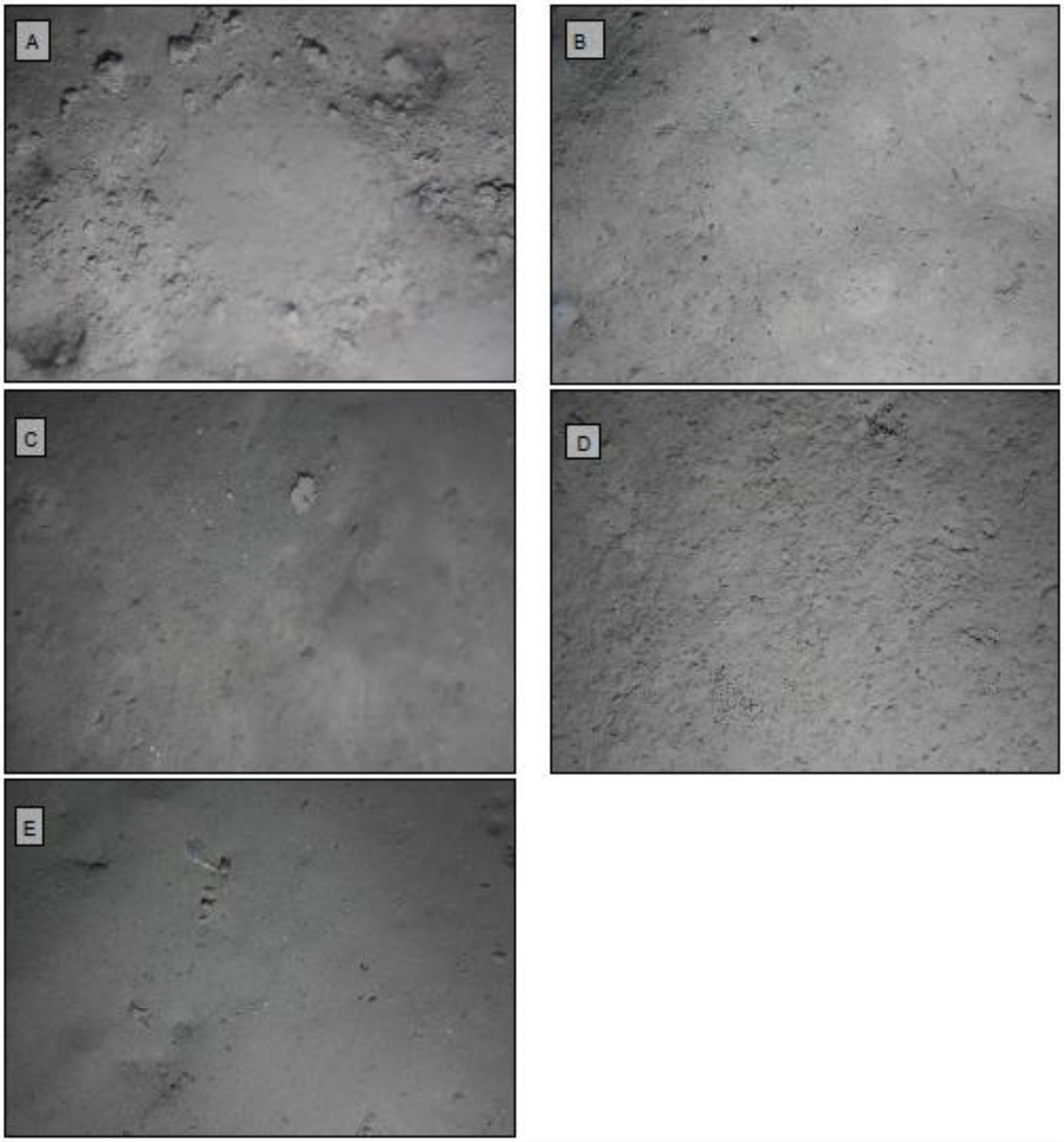
Source: Maxon Consulting, Inc. and TDI Brooks International, Inc., 2014

Both surveys reported that there was not a strong correlation between macrofaunal communities or number of species and any single parameter such as sediment characteristics or water depth.

The results of the seabed photography sediment and faunal data review showed the survey area primarily consists of one broad benthic habitat type: sublittoral sediment (EUNIS[15] code A5). This marine benthic habitat can encompass a wide range of sediments from boulders and cobbles, through pebbles and shingles, coarse sands, sands, fine sands, muds, and mixed sediments (Davies et al., 2004). 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. Figure 6-16 provides representative photographs of the circa-littoral sandy mud biotope taken from five of the 2016 sample stations. Epifauna were sparse in the photographs taken, 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.

[15] The European Nature Information System (EUNIS) is a habitat classification system developed by the European Environment Agency (EEA) in collaboration with international experts. The EUNIS includes all types of natural and artificial habitats, both aquatic and terrestrial.

Figure 6-16 Representative Photographs of the Circa-Littoral Sandy Mud Biotope Photographed in the Vicinity of the Liza-1 Well



Source: FUGRO EMU Limited, 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

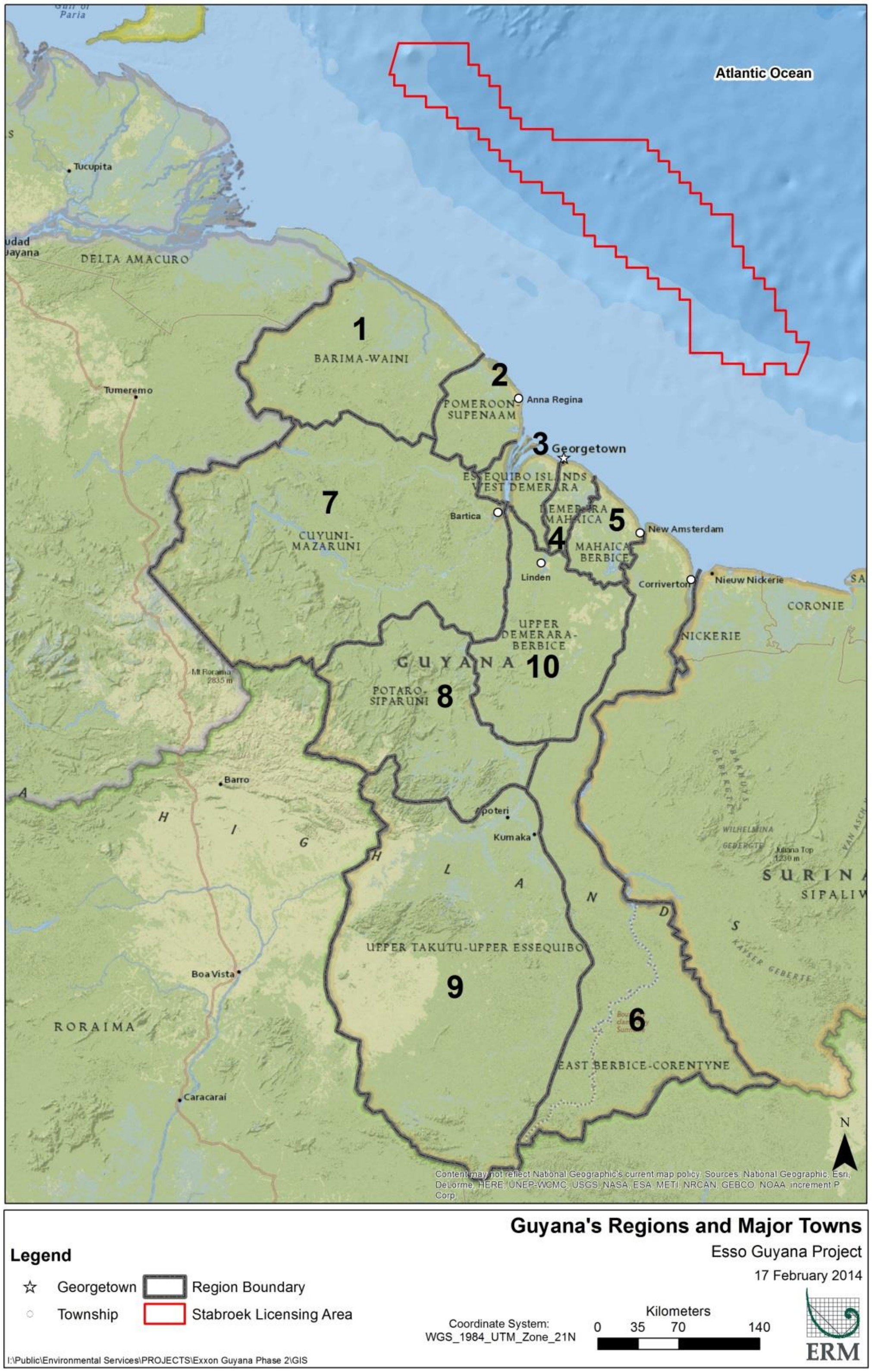
6.3 Socioeconomic Resources

This section describes the existing socioeconomic characteristics of the Project AOI. It was developed based on secondary information contained in Project-related materials; socio-economic 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.

6.3.1 Administrative Divisions in Guyana

Guyana is divided administratively into 10 regions, pictured on Figure 6-17. These regions are further subdivided into Neighborhood Democratic Councils (NDCs), of which there are 65 in total. Within the NDCs are villages, the smallest administrative unit. In addition, there is one city that serves as the capital (Georgetown) and nine townships. Four of these townships were designated as new townships by the Ministry of Communities in 2015 as part of an administrative decentralization effort. Each of the nine townships has its own mayor and council, and is intended to serve as an administrative hub for government services, such as passports and driver's licenses, as well as providing utilities and public services, such as water and sanitation, as well as other services such as banking.

Figure 6-17 Guyana's Administrative Regions and Townships



6.3.2 Population Distribution

Most of Guyana's population is located in the six coastal regions, and, according to the 2012 national census, nearly half of the country's population lives in Region 4 (Demerara-Mahaica), which includes the capital city of Georgetown. Table 6-15 summarizes the distribution of population within the 10 regions in 2012, the last year for which complete census data are available.

Table 6-15 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%

Source: Bureau of Statistics Guyana, 2012; Bureau of Statistics Guyana, 2002.

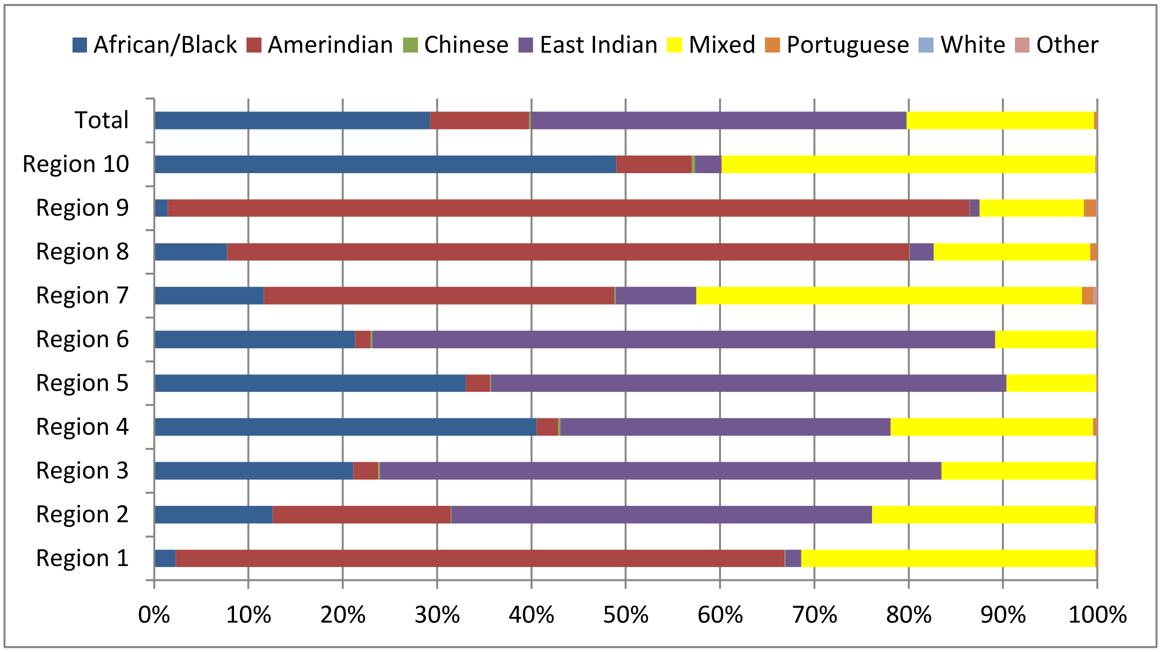
Note: Each region's change in population should be weighted based on that region's percent of the total population, so the sum of population changes in each region do not add up to the total national population change.

6.3.2.1 Ethnic Composition

Data from the 2012 census indicate that the majority of the country's population are representatives of two ethnic groups, those of East Indian descent (39.8 percent) and those of African descent (29.3 percent). These are followed by populations of mixed ethnicity (19.9 percent) and indigenous peoples who, in Guyana, 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 6-18 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. However, the majority of population residing in the more remote and rural Regions 1, 8, and 9 is of Amerindian ethnicity.

Figure 6-18 Regional Distribution of Ethnicity, 2012



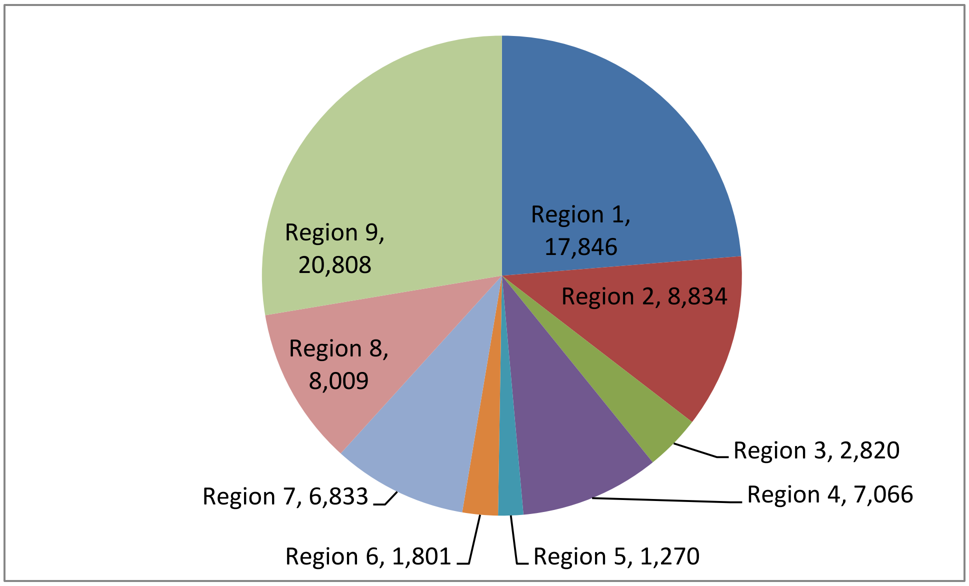
Source: Bureau of Statistics Guyana, 2012

6.3.2.2 Indigenous Peoples

Amerindians in Guyana 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.

According to Minority Rights Group International (2008), there are nine main Amerindian groups in Guyana, of which three are coastal: the Carib, Warao, and Arawak tribes. Other groups tend to inhabit the country's hinterland regions. Many of the Amerindians in Guyana, particularly in the coastal area, have undergone cultural integration with the general population and share much of the same culture as the Afro- and Indo-Guyanese population. However, as a whole, the standard of living for the Amerindian population in Guyana is lower than for the general population, particularly for those in remote areas where provision of infrastructure and services is a challenge. The distribution of Amerindian population among the regions is shown on Figure 6-19.

Figure 6-19 Amerindian Population by Region, 2012



Source: Bureau of Statistics Guyana, 2012

The coastal plain of Region 1 and part of Region 2 are not accessible by road and therefore 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. Communities that are directly adjacent to the coast are the titled community of Three Brothers along the Waini River, directly inland from Shell Beach, and the non-titled communities within the SBPA (Almond Beach, Father's Beach and Unity Grant). Titled indigenous communities located 5-10 km inland from the coast in Regions 1 and 2 are Santa Rosa, Waramuri, Manawurin, Assakata and Wakapau. In the SBPA, fishing and crabbing activity is particularly active at the westernmost end of Shell Beach, at the mouth of the Waini River. At the eastern end of Shell Beach in the community of 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 (Protected Areas Commission, 2015).

In Regions 3 and 4, titled indigenous communities are located inland and not within the coastal plain.

6.3.3 Education

The education system in Guyana is similar to that of other Caribbean countries, with school being compulsory from ages of 5 to 16 through pre-primary, primary, and secondary schools. The federal Ministry of Education controls education budgets, policies, and standards and administers these by region. In 2012, the government spent 3.2 percent of GDP on the education sector (CIA World Factbook, 2016). Between the years of 2008 and 2012, the youth (15-24 years) literacy rate was 93.7 percent and 92.4 percent for females and males, respectively. Pre-primary and primary school gross enrollment averaged from 83.7 percent to 88.7 percent depending upon grade and gender, with male youth averaging a few percentage points lower than female youth. Secondary school net enrollment was 80.6 percent and 71.2 percent for female and male youth, respectively (UNICEF, 2016).

At the time of writing, the 2012 census compendium on social indicators had yet to be released. Therefore, the only reliable data on educational attainment at the regional level are from the 2002 census compendium, which shows that Region 1 had the highest percentages of male youth (10.9 percent) and female youth (15.3 percent) with either no schooling or Kindergarten level only, with Regions 8 and 9 only a few percentage points higher. In Regions 2 and 3, the percentage of all youth with either no schooling or Kindergarten level only ranged between 2 percent and 4 percent. Region 4 and Region 10 had the highest level of enrollment across all levels (Guyana Bureau of Statistics, 2002).

The levels of primary education for the indigenous population are typically lower than non-indigenous groups of the population. In the Amerindian communities, the attendance rate at primary schools has been reported to be 50 percent lower than average. This is partly attributable to a shortage of teachers, and standardized teaching methods and curriculum which limits 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).

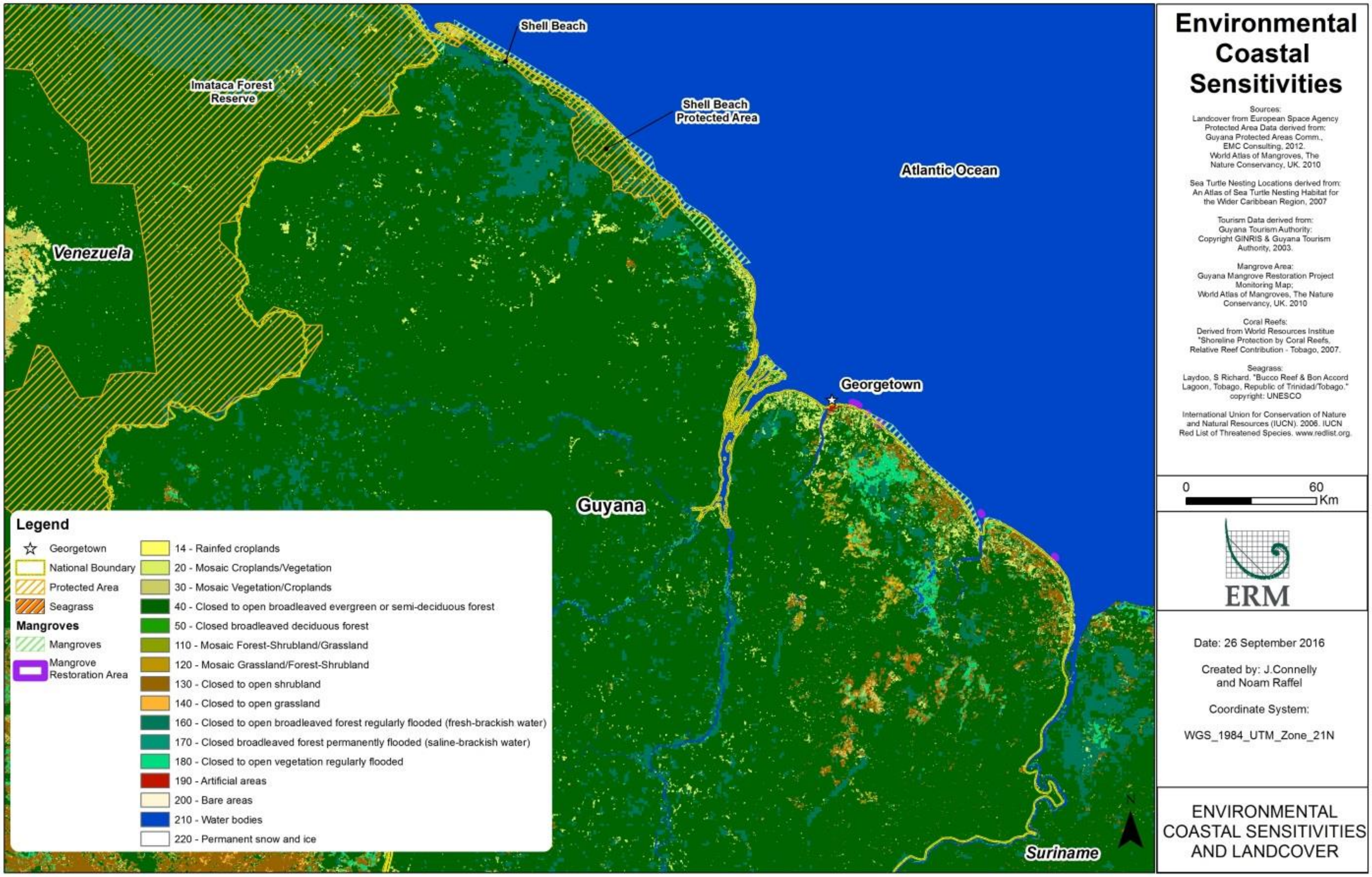
6.3.4 Land Use

Guyana is divided into the following three main geographic zones:

- The low-lying coastal plain occupying about 5 percent of the country's land area, which ranges from approximately 5 km to 6.5 km (~3 to 4 mi) wide along the coast;
- The "white sand belt", a largely vegetated zone dominated by white sandy soils lying inland from the coastal zone, ranging from approximately 150 km to 250 km (~93 mi to 155 mi) wide and containing most of the country's mineral deposits; and
- The interior highlands that extend from the white sand belt to the country's southern borders and makes up the largest land area in the country.

As described above, Guyana is a sparsely populated country, with the majority of the population concentrated in the coastal plain region. In 2012, the cultivated area in Guyana was estimated at 1,107,000 acres. Cultivated land is also concentrated in the coastal plain, where the majority of the population resides (FAO, 2015). Figure 6-20 shows land cover in the coastal and white sand belt areas. In the coastal plain areas, cultivated areas are evident in Regions 2, 3, and 4 (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 non-traditional crops and livestock.

Figure 6-20 Land Cover in Coastal Guyana



Source: ERM, 2014 and CCI, 2012

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 6.2.2.

6.3.4.1 Land Ownership

The pattern of land ownership in Guyana today is approximately 85% government-owned, approximately 14 percent Amerindian-owned, and one to two 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 and these tend to be small properties of 5-15 acres each (Government of Guyana, 1997). Leases of government-owned lands are issued by the Guyana Lands and Surveys Commission (GLSC).

According to a study of the land registration system in Guyana conducted by the Inter-American Development Bank (IDB), the country's dual property registration system (title registration and deed registration) has regulations that overlap and conflict, and is 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).

6.3.5 Economy

Guyana's nominal GDP in 2015 was $653.8 billion GYD, or approximately $3.2 billion U.S. dollars (USD). The per capita GDP in 2015 was $761,000 GYD, or approximately $3,700 USD (BSG, 2016), and it was reclassified by the World Bank from a lower middle income to an upper middle income country in 2016 (World Bank, 2016). Guyana's main sectors by contribution to GDP are summarized in Table 6-16.

Table 6-16 Economic Sectors and Contribution to GDP, 2015

Sector	Percent of GDP
Agriculture, Fishing and Forestry	19.2%
Wholesale and Retail Trade	12.3%
Transportation and Storage	11.2%
Mining and Quarrying	10.9%
Construction	9.8%
Manufacturing	7.4%
Public Administration	7.2%
Information and Communication	7.0%
Financial and Insurance Activities	5.0%
Education	4.5%
Other Services	3.9%
Health and Social Services	2.0%
Real Estate	1.2%

Source: PSC, 2015

Note: Percentages add to more than 100 due to rounding.

Guyana relies heavily on trade, with exports totaling $238.3 billion GYD ($1.15 billion USD) in 2015, up from $183.3 billion GYD ($884.9 million USD) in 2010 (Guyana Bureau of Statistics, 2015). The main export products for the country are sugar, rice, bauxite, gold, forest products, and fish (FAO, 2015). Sectors that are uniquely tied to the coastal environment in Guyana, as well as the mining sector, are described in further detail below.

6.3.5.1 *Agriculture*

According to the Private Sector Commission, Guyana has a relatively strong agricultural sector and is the only net exporter of food in the Caribbean. In 2015, agriculture, fishing and forestry accounted for 19.2 percent of the country's GDP, or $73.9 billion GYD (approximately $356.7 million USD).

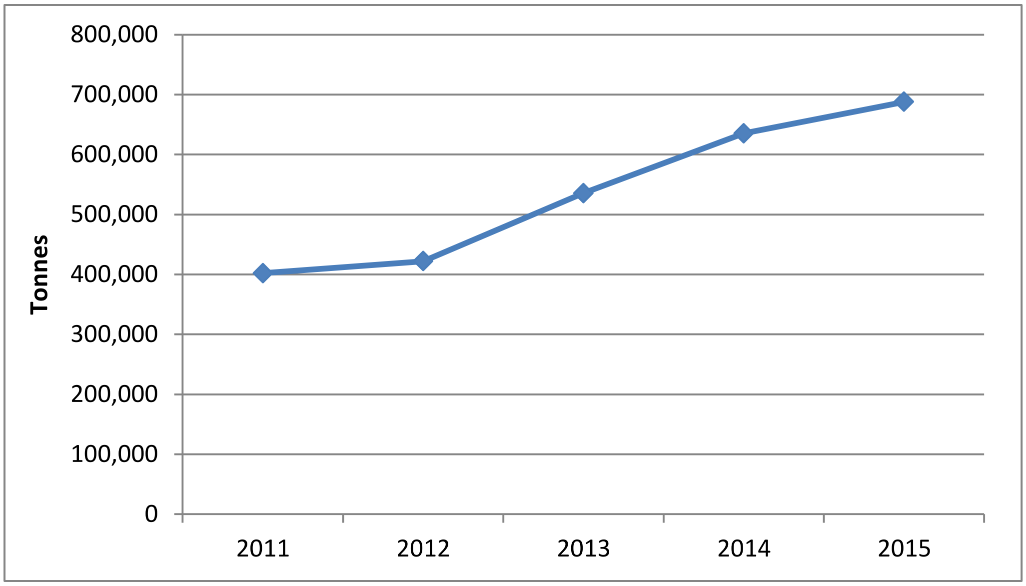
Rice

Rice farming is the predominant agricultural activity in the coastal areas of Regions 2 and 3, 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 6-21).

Figure 6-21 Rice Field in Region 2 Pomeroon-Supenaam

The rice sector yield grew by 8.3 percent in 2015 (see Figure 6-22). However, the first half of 2016 has seen a decline in yields attributed to El Niño-related dry weather, as well as an early arrival of the rainy season (Ministry of Finance, 2016).

Figure 6-22 Annual Rice Production, 2011-2015



Source: Private Sector Commission 2015

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 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 that were 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 6-23). The drainage canals are generally constructed at or very near sea level to achieve the gradient necessary for drainage of the surrounding landscape and can therefore be tidally influenced, but 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).

Figure 6-23 Sluice Gate (Koker) in Charity (Region 2) at High Tide

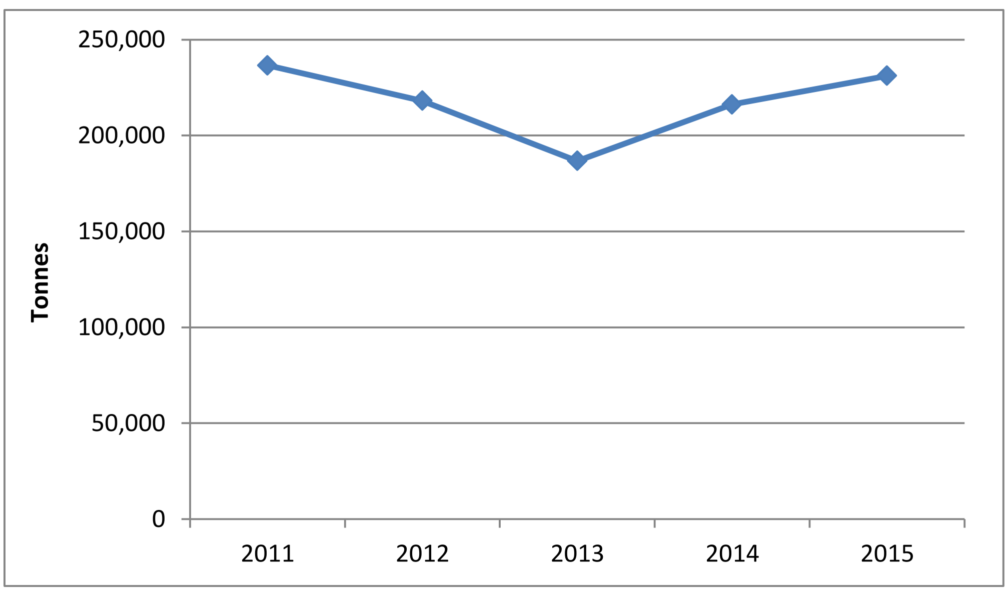
Note: Seawater seeping into drainage canal from ocean through closed gate.

Sugar

Figure 6-24 shows an aerial view of sugar plantations in Region 2. Sugar production increased in 2014 and 2015 after being in decline in previous years (Figure 6-25). According to Guyana Sugar Corporation (GuySuCo), the national sugar company, sugar production employs 18,000 people in Guyana and accounts for 40 percent of the country's agricultural production. GuySuCo's Demerara sugar is exported to markets in the European Union, the U.S., and CARICOM countries.

Figure 6-24 Aerial View of Sugar Plantations in Region 2

Figure 6-25 Annual Sugar Production, 2011-2015

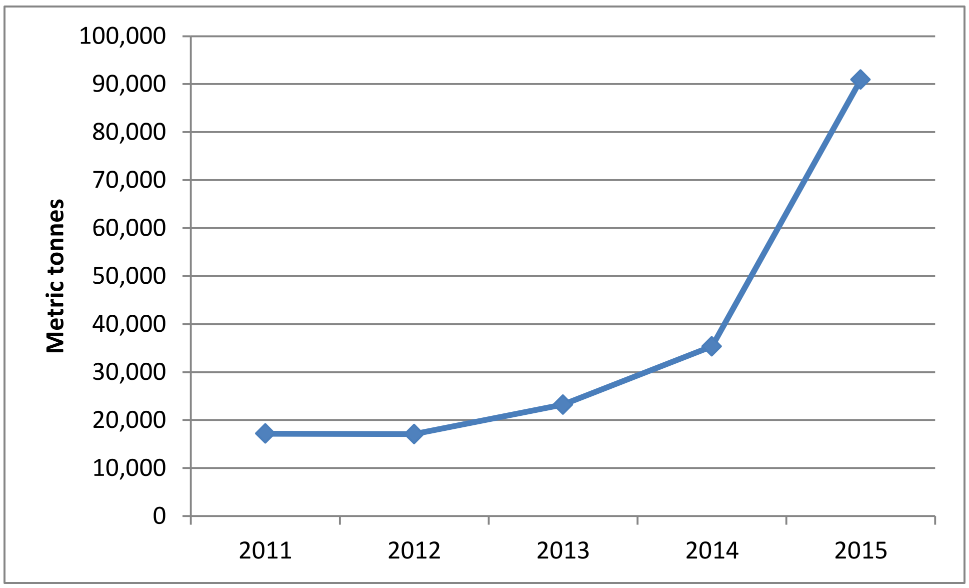


Source: Private Sector Commission 2015

Coconut

The coconut industry in Guyana has grown in recent years (Figure 6-26) 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 recent news media articles, the amount of land in the Pomeroon area being converted to coconut cultivation is increasing (Guyana Chronicle, 2016; Stabroek News, 2016).

Figure 6-26 Annual Coconut Production, 2011-2015



Source: Ministry of Agriculture, 2016a

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.

Value-added Agricultural Products

According to various interviewed stakeholders, establishment of 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). A number of 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 Private Sector Commission 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, and obtaining financing for start-up costs.

6.3.5.2 Fisheries and Aquaculture

Marine Fisheries

There are four main types of marine fisheries in Guyana (MOA, 2013) that can be defined by the species targeted, gear types used, and the depth of water where the fishery takes place. Table 6-17 summarizes the characteristics of these fisheries.

Table 6-17 Primary Characteristics of Marine Fisheries in Guyana

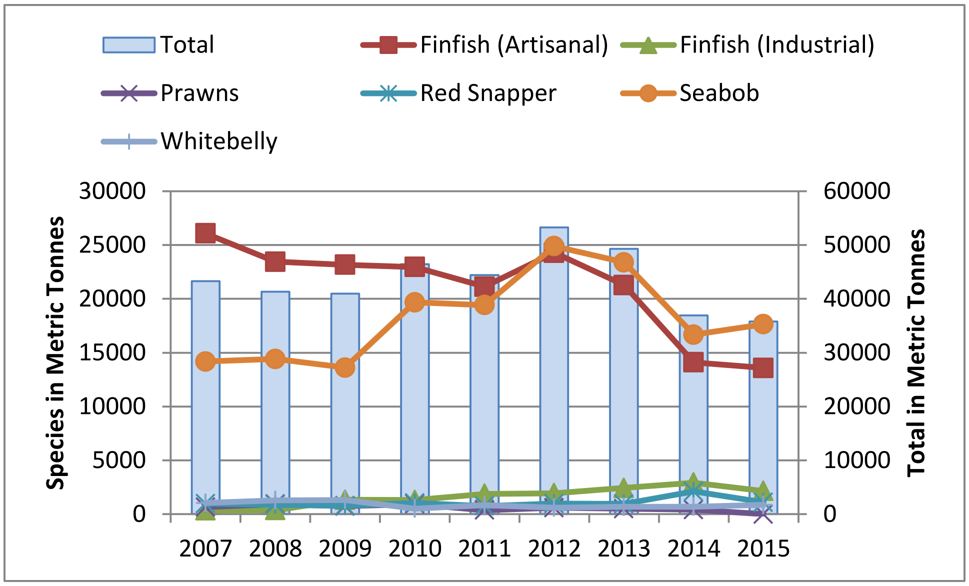
Type of Fishery	**Species**	**Gear**	**Depth**
Industrial	Seabob, shrimps, and prawns	Trawls	Primarily between 13-16 m, but can occur from 0-75 m
Semi-industrial	Red snapper and vermillion snapper	Fish traps and lines	Edge of continental shelf
Artisanal	Mixed fish and shrimp	Gillnets, seines, and others	0–18 m
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

Note: “Whitebelly” identified in Figure 6-27 is a species of shrimp and is included in the artisanal shrimp fishery.

According to data from the Private Sector Commission (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). 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 6-27. 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 2014. 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).

Figure 6-27 Commercial Fisheries Catch Volumes, 2007-2015



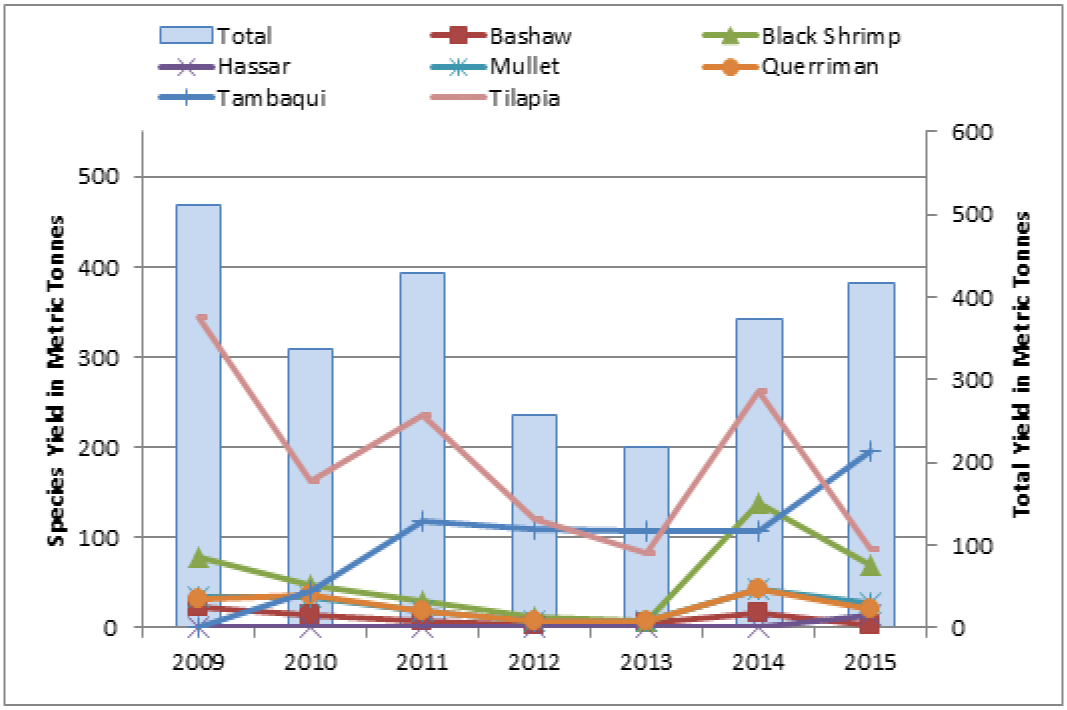
Source: Ministry of Agriculture, 2016a

The industrial seabob shrimp sector continues to be an important commercial fishery for Guyana, and industry leaders are currently in the process of applying for Marine Sustainability Council (MSC) 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 seven-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).

Aquaculture

According to data from the Ministry of Agriculture, the main species produced in aquaculture establishments are the fish 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 for which data are available (Figure 6-28).

Figure 6-28   Fish Yields from Aquaculture, 2009-2015



Source: Ministry of Agriculture, 2016a

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).

6.3.5.3 Mining and Quarrying

The mining sector is an important sector for Guyana and contributed to over half of exports in 2015 (Guyana Bureau of Statistics, 2015). Most notably, raw gold, bauxite and diamonds equated to 43.5 percent, 9.1 percent, and 1.5 percent, respectively, of export totals in 2015. The Guyana Geology and Mines Commission estimated that in 2010, mining and quarrying accounted for 9 percent of GDP, and employed over 11,000 persons directly and almost 14,000 indirectly (GGMC, 2010). 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 3.0 percent in 2015, as global commodity prices collapsed for Guyana's major mining exports (World Bank, 2016).

6.3.5.4 Manufacturing

Manufacturing contributed 7.4 percent of GDP in 2015 and grew by 5.3 percent from 2014 to 2015. The most important 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 (UNDP, 2005).

6.3.5.5 Tourism

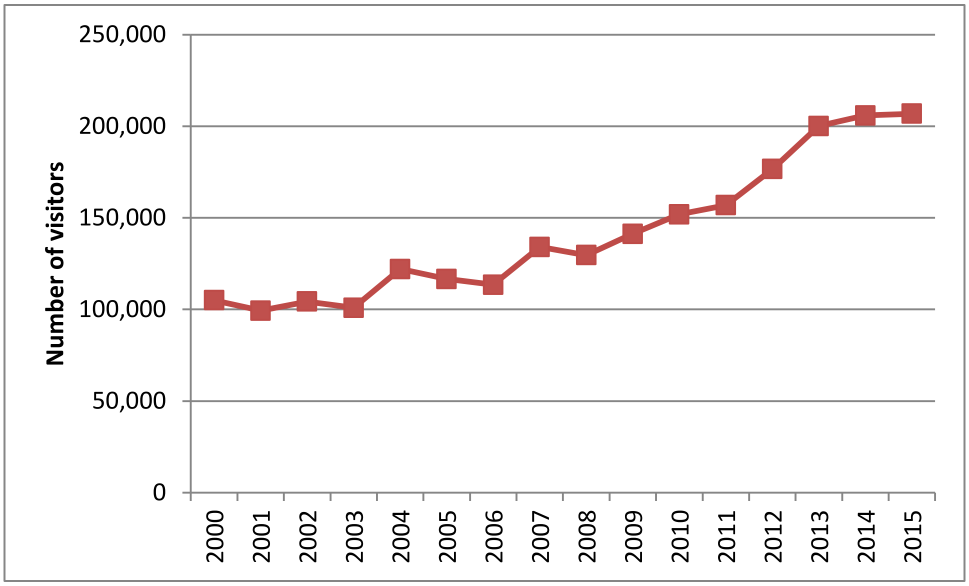
According to the World Travel and Tourism Council, tourism contributed 3.3 percent to the country's GDP in 2015. Although most tourism infrastructure (e.g., hotels) is located in the most populated townships such as Georgetown, Linden, and Berbice, many of Guyana's tourist attractions are located in the country's hinterland. These attractions offer nature, culture, and adventure-based experiences such as trips to waterfalls and Amerindian villages, which 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).

Deposition of sediment 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 with clearer water in the region. Some tourism occurs at the SBPA during the sea turtle nesting season, but because infrastructure and systems have not yet been established to facilitate travel or provide convenient accommodations, this number is limited. In general, however, Guyana is thought to have considerable ecotourism potential, and development of tourism infrastructure at the country's Protected Areas is considered a key part of the Protected Areas Commission's current strategic plan (PAC, 2016).

Data from the Department of Tourism indicate that the number of international visitors to Guyana has doubled since the early 2000s (see Figure 6-29), 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 hosting of regional sporting tournaments, particularly cricket events, in the Georgetown area. This has brought many international visitors, particularly those from the Caribbean. During major events such as the Cricket World Cup, traffic congestion beyond the norm was observed in the Georgetown area (ERM Personal Communication 3).

Figure 6-29 Annual International Visitors to Guyana, 2000-2015



Source: Department of Tourism, 2016

Most of the major tourist attractions in Guyana, such as museums, the zoo, parks, public gardens, and the Stabroek Market, are located in Georgetown. 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, 2009). Guided tours of Georgetown's historic buildings and sites are available, as are guided tours of attractions such as the Essequibo River, the El Dorado Rum Factory, and the Georgetown City Centre.

6.3.6 Employment and Livelihoods

Results of the most recent national census indicate that 87.5 percent of the labor force was employed and 12.5 percent was unemployed at this time (2012). Data from the previous census in 2002 indicate that the unemployment rate did not change in this 10-year period (BSG 2012; BSG 2002).

In 2012, the unemployment rate in Region 1 was the highest in the country at 19.3 percent of the labor force. Region 2 had the lowest rate of unemployment in the country at this time, 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 23.0 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 in 2012 (BSG, 2016). This was the industry group employing the largest number of workers in Regions 2 and 3, while, 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 of people in Region 2 (14.9 percent), while in Region 3, Construction employed the second largest number of workers (12.1 percent). It should be noted that the Agriculture, Forestry, and Fishing industry group, and the primary sector[16] in general, is dominated by male workers, with female workers making up less than ten percent of the workers employed in this industry group 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 67.0 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 21.0 percent and 12.0 percent of employment in Region 4.

The issues facing indigenous groups of Guyana are typically related to lack of empowerment and inclusion into the mainstream economy. The standard of living for the indigenous minority of Guyana continues to be lower than that of 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 the lack of formal employment opportunities as a significant contributing factor. Income generation 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 Region 1 and 2 indigenous communities also work in mining and logging camps in the hinterland (IDB, 2007).

6.3.6.1 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 6-30). 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). Farther west in Region 2 at Lima, larger scale fishing is practiced about 8 km (~5 mi) offshore. Small artisanal boats are still used because the coastal mudflats in this area do not allow for the use of larger boats. Fisherfolk go out for 10-12 days at a time and fish for snapper, snook, trout, wrasse, patwa, 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 6-31). There are no landing areas for commercial fishing vessels in Region 1; small scale fishing activity occurs along the Region 1 coast and is primarily for subsistence. 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.

[16] According to the BSG, 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.

Figure 6-30 Salted Fish Drying Outside a Fisherperson's Home in Region 2

Source: ERM, 2016

Figure 6-31 Fresh Fish Being Sold at Stabroek Market in Georgetown

Source: ERM, 2016

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, a fisherman 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 6.3.3, annual yields in the fishery sector have declined in the last four years for fish, and three of the last four 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 (IUU)[17] fishing in Guyana, its role in threatening 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 ERM 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 implicated the recent establishment of a Coast Guard Station at the mouth of the Pomeroon River as having influenced the decrease in piracy. Of those who have encountered pirates, they were typically unsure of their assailants' nationality, but speculated that they could be Venezuelan, Guyanese, Surinamese, or a mixed group from different countries.

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, ERM personnel 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 6-32).

[17] IUU 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 6-32 Fishing Boat Landed on a Coastal Mudflat in Region 2, September 2016

Source: ERM, 2016

6.3.6.2 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 in Region 2 as well. Most households also raise livestock, such as cattle, hogs, poultry, and small ruminants. The Amerindian community of Mainstay, located approximately 6 km (~3.5 mi) 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 (Protected Areas Commission, 2014).

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, lies 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.

6.3.6.3 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, though 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 6-33). 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 6.3.8

Figure 6-33 Speedboats Docked in Parika, Region 3

Source: ERM, 2016

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 ERM Personal Communication 6).

6.3.7 Community Health and Wellbeing

According to the Ministry of Health, health outcomes in Guyana continue to improve steadily, with life expectancy at birth increasing from 63 years in 1998 to 67 years in 2010 (Ministry of Health, 2013).

6.3.7.1 Health Status

Causes of Death

The leading causes of mortality in 2010 were chronic diseases, including cardiovascular and cerebrovascular diseases, cancers, diabetes, and hypertension (Ministry of Health, 2013b).

According to the World Health Organization, Guyana had the highest rate of suicide of any country in the world in 2015, at 44.2 deaths per 100,000 people, versus the global average of 16 (WHO, 2014). 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).

Burden of Disease

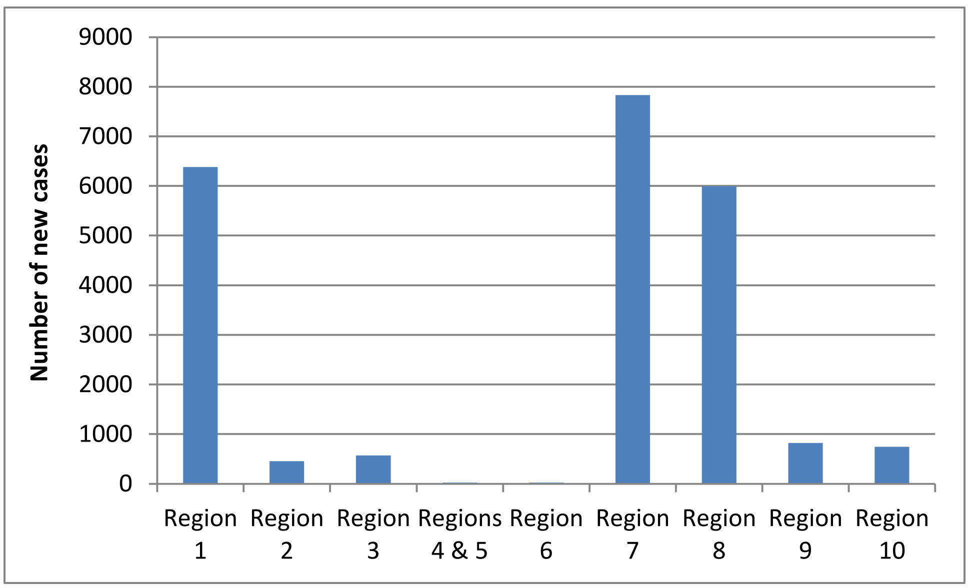
As with many other developing countries, Guyana is undergoing an epidemiological transition by which non-communicable diseases are beginning to replace communicable diseases as the leading causes of illness and mortality. This shift is largely due to trends toward more sedentary occupations and lifestyles, as well as unhealthy diets and habits such as tobacco and alcohol use. 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 things, to integrate agricultural practices with improved food security and nutrition (Ministry of Health, 2013a).

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.

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[18], 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 (Ministry of Public Health, 2014).

Figure 6-34 shows the number of reported new malaria cases for each region in 2010, the most recent year for which data are available.

Figure 6-34 Malaria Incidence by Region, 2010



Source: Ministry of Public Health, 2013b

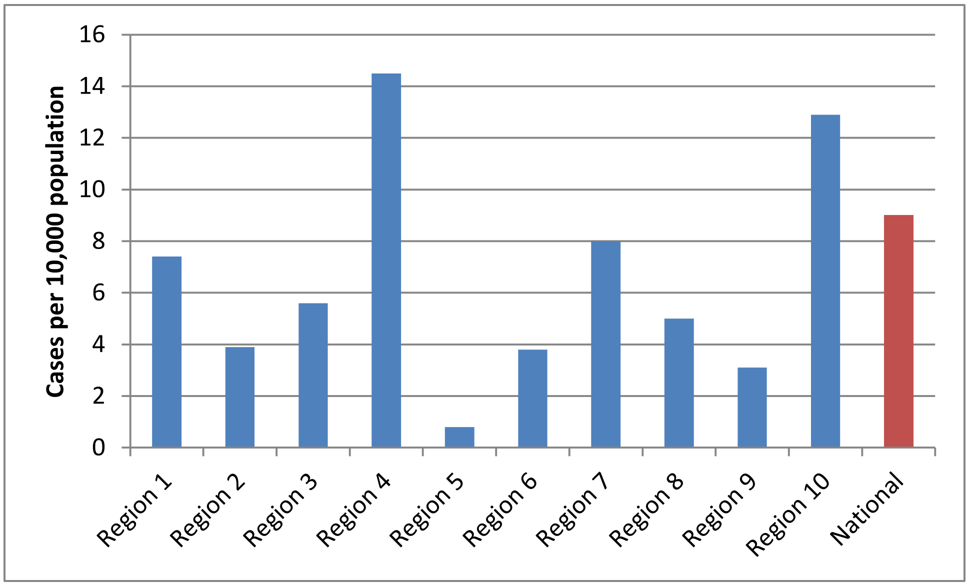
Dengue fever, chikungunya, lymphatic filariasis, and Zika are also locally transmitted in Guyana. Unlike malaria, transmission of these diseases tends to be common in populated and urbanized areas.

Tuberculosis (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/AIDS epidemic. In 2010, the national average for TB incidence was nine cases per 10,000 people. Regional distribution of cases in 2010 is shown on Figure 6-35.

---

[18] 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). Source: Centers for Disease Control and Prevention, 2012.

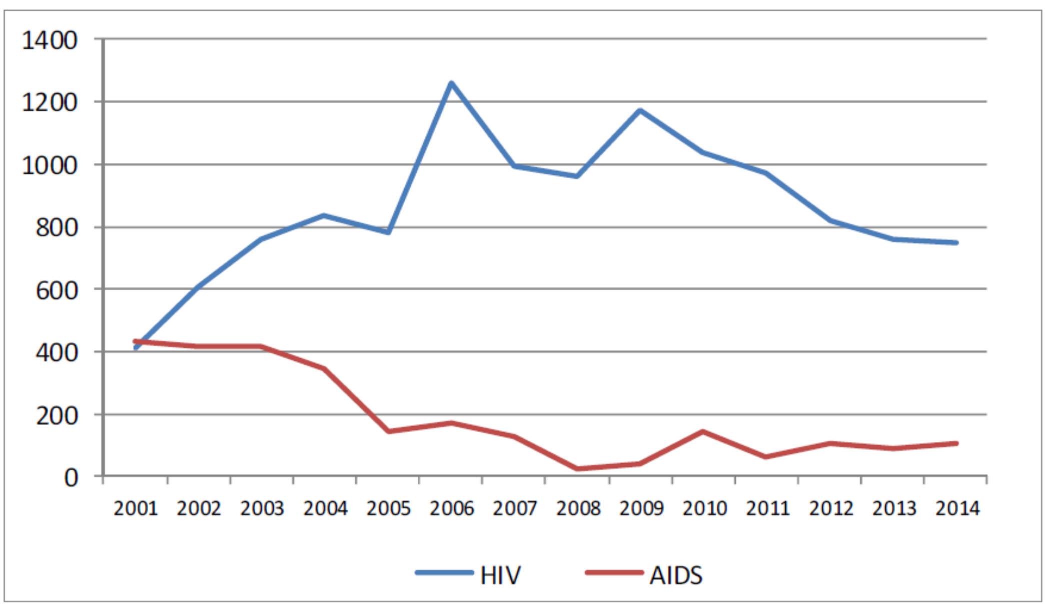
Figure 6-35 TB Incidence Rate by Region, 2010



Source: Ministry of Public Health, 2013b

In 2015, the number of people living with HIV in Guyana was estimated at 7,800, and the prevalence rate in the population aged 15 to 49 was 1.5 percent. According to the Joint United Nations Program on HIV/AIDS (UNAIDS), 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 6-36) and AIDS-related deaths.

Figure 6-36 Annual Number of HIV and AIDS Cases, 2001-2014



Source: UNAIDS, 2015

The Neglected Tropical Diseases (NTDs) 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 (MDG) targets of reducing child mortality rates by two thirds, and maternal mortality ratio by three quarters between 1990 and 2015. Furthermore, 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 (UNICEF, 2014).

6.3.7.2 Health Care System

Government health spending compares favorably with other Latin American and Caribbean countries, and has averaged about 3 percent of GDP in recent years, equivalent to $11.5 billion GYD annually ($57.5 million USD) (Ministry of Public Health, 2013b). The healthcare system in the country is highly decentralized, with Regional Democratic Councils and Regional Health Authorities managing, financing, and providing health services. The system experiences a number of challenges related to human resources capacity and infrastructure capacity.

Health Facilities

Health facilities in the coastal regions are summarized in Table 6-18 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 6-18 Health 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, some of the biggest health system shortfalls are 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 crash 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).

Health Human Resources

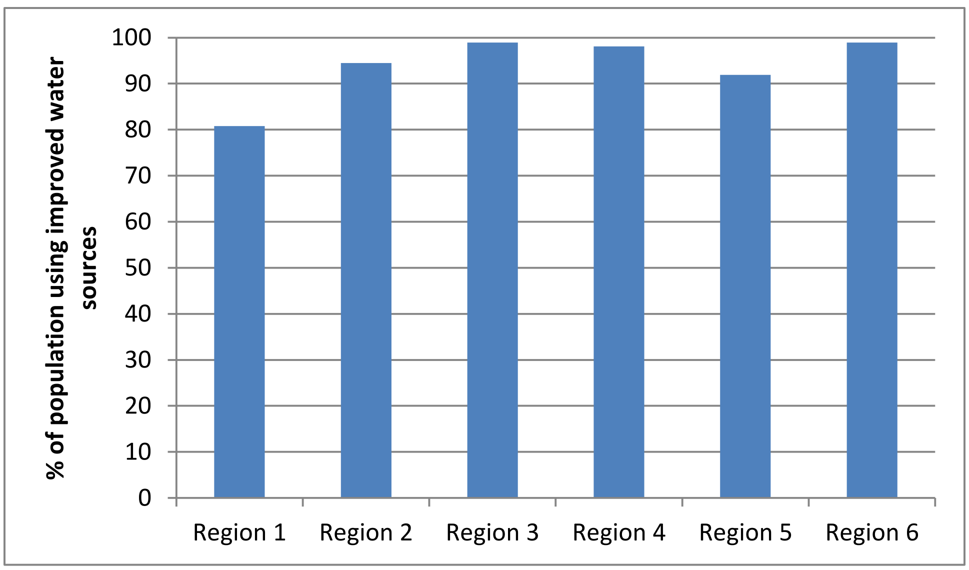
Retention of health care professionals in Guyana is a challenge, as in many other developing countries that see emigration of skilled workers to developed countries. The most recent available statistics from the Ministry of Public Health indicate that there were 6.8 physicians and 13.3 nurses per 10,000 people in the country in 2010 (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.

6.3.7.3 *Quality of Life*

Water and Sanitation

According to the most recent Guyana Multiple Indicator Cluster Survey (MICS)[19], 94 percent of Guyana's population had sustainable access to improved drinking water sources[20] as of 2014, and 95.4 percent used an improved sanitation facility[21] (UNICEF, 2014). Figure 6-37 shows the percentage of the population with access to improved sources of drinking water, by region.

Figure 6-37 Percent of Population with Access to Improved Water Sources by Region, 2014



Source: UNICEF, 2014

[19] The MICS program was developed by UNICEF 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.

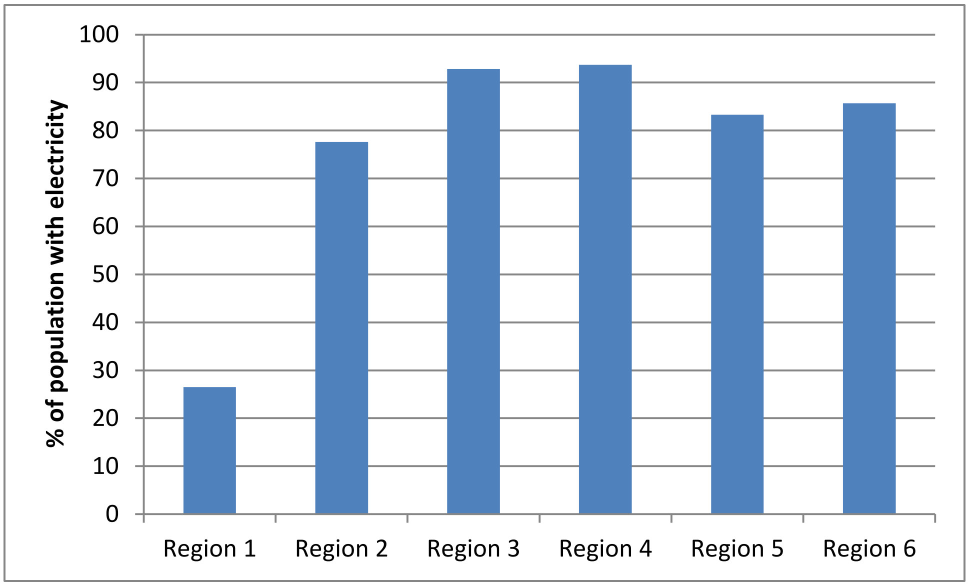
[20] Improved water sources refer to any of the following types of supply: piped water into dwelling, compound, yard, to neighbor, or to public tap/standpipe; tube well/borehole; protected well; protected spring; and rainwater collection. Bottled water is considered as an improved water source only if the household is using an improved water source for handwashing and cooking.

[21] 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 6-38 shows the percent of the population with electricity in each of the coastal regions.

Figure 6-38 Percent of Population with Electricity by Region, 2014

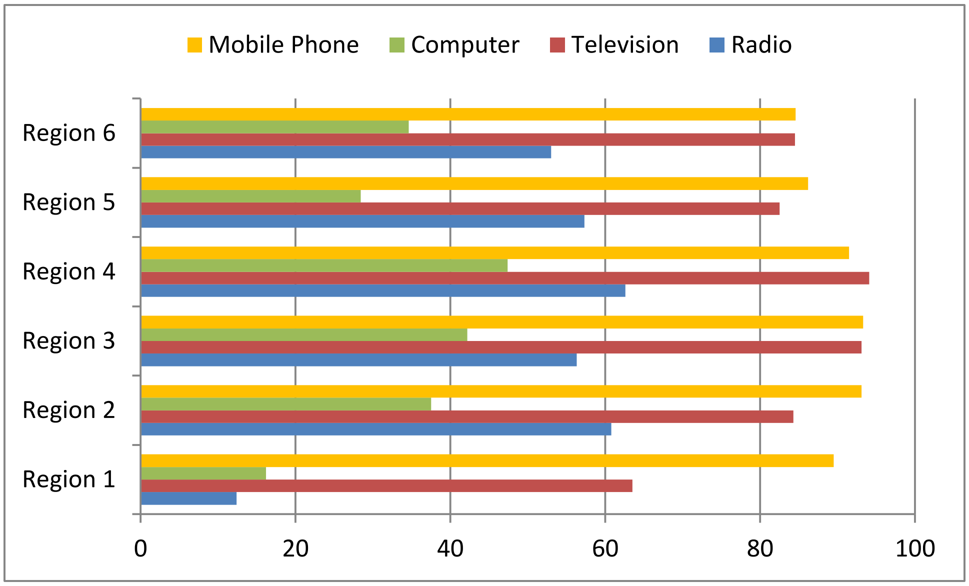


Source: UNICEF, 2014

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 6-39).

Figure 6-39 Household Access to Telecommunications, 2014



Source: UNICEF, 2014

6.3.7.4 Natural Hazards

Guyana is not threatened by many natural hazards, but due to its low-lying coastal plain it faces severe risk of flooding. 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, and conservancy dams to protect agriculture in the vulnerable coastal areas.

In 2005, torrential rains caused many rivers and water conservancies in the coastal plain to overflow, causing flooding in Regions 1, 2, 3, 5, and 6. The floods resulted in the direct or indirect deaths of 19 people, either from 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 (~$50 million USD) (UNDP, 2005).

6.3.8 Marine Use and Transportation

6.3.8.1 Introduction and Methodology

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 primarily obtained from Project-specific documents, including the Project's Final Multi-well Environmental Management Plan (February 2016) and Strategic Environmental Assessment (March 2014). Other sources of information include key informant interviews, reports, studies, and other publicly available information.

6.3.8.2 Regional Setting

The EP Act requires EIAs to assess impacts on material assets. Nearly all the Project-related activities will occur at designated shorebases on the coast, coastal marine waters, or offshore. Therefore, for the purposes of this EIA "material assets" were determined to include the marine infrastructure within the AOI which consists of waterways, coastal shipping channels, ports, and offshore shipping lanes. Guyana has approximately 1000 km (~620 mi) of navigable rivers, which provide water access to most population and economic centers. Subsea telecommunications cables are also present in or near the PDA.

6.3.8.3 Existing Conditions in the Project Development Area

The Minister of Public Infrastructure's MARAD is responsible for ensuring the safe and efficient operation of shipping activities in Guyana territorial waters. MARAD operates in accordance with the IMO and is a party to a number of IMO Conventions, including conventions on: Safety of Life at Sea (SOLAS); Standards of Training, Certification, and Watchkeeping (STCW); and Prevention of Pollution from Ships. Jamaican and Trinidadian shipping lanes may cross the Stabroek Block (Figure 6-40).

As described in Section 6.3.2, 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 km (~93 mi) from shore although most fishing activity occurs well inshore from the shelf edge. Figure 6-41 depicts the primary fishing zones offshore Guyana by fishery type and the primary fishing ports or landing sites in Regions 2 and 3. There are no formal landing sites in Region 1.

The Port of Georgetown contains more than 40 separate wharves, including six primary cargo wharves ranging from approximately 130 m to 247 m (~427 ft to 810 ft) in length, 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, although these facilities are congested and space is limited. 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 Stabroek Harbour Master. As of 2014, the Superintendent of Surveys of the Harbour Master Department indicated that ship draft in the channel was approximately 4.5 m (~15 ft) at low water, but that dredging work was ongoing to reach a target depth of approximately 5.5 m (~18 ft).

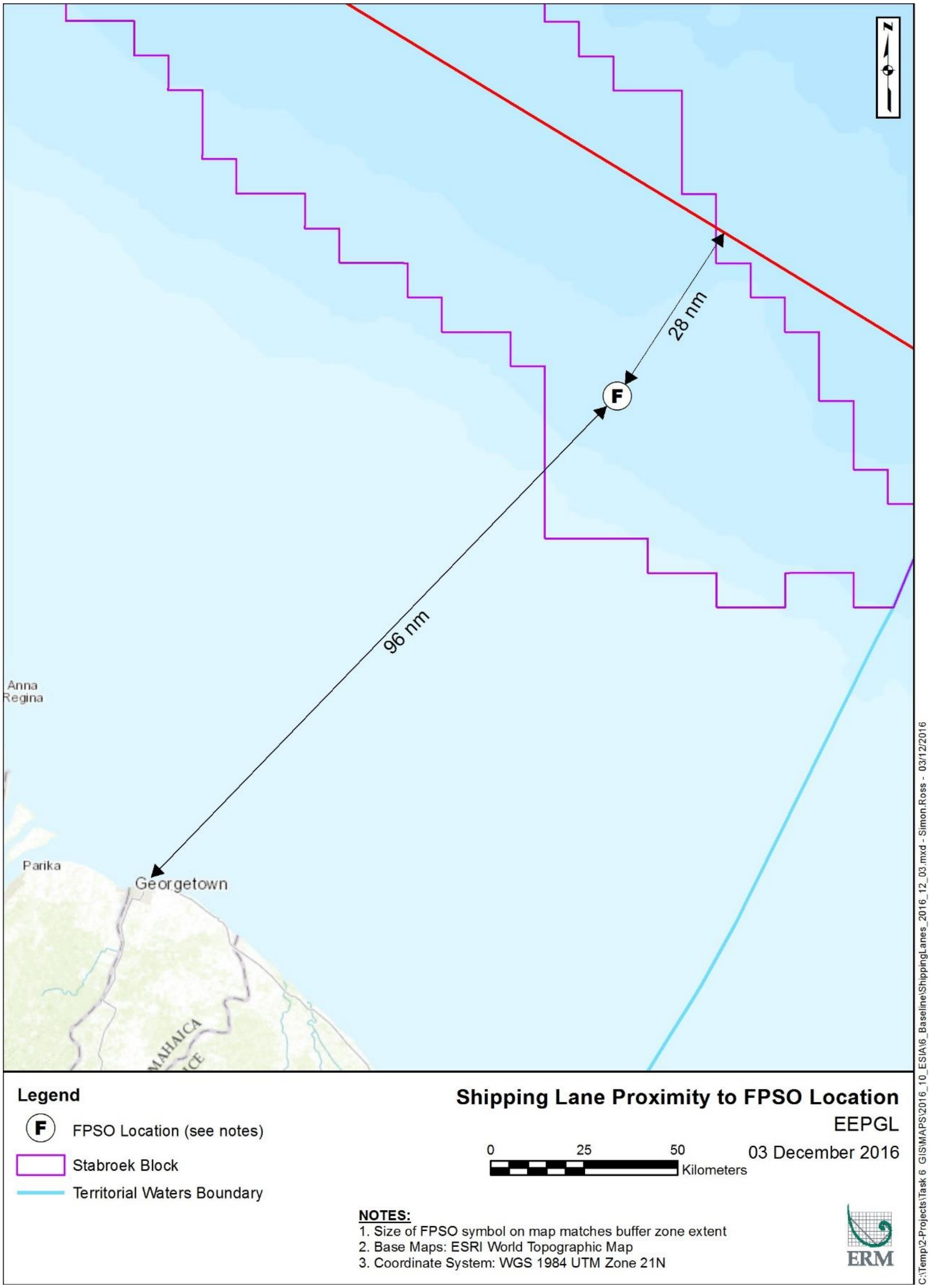
The Transport and Harbours Department is responsible for the management of the national ferry service. The department has four ferry vessels, three of which operate in the Essequibo River and one in the Berbice River. The ferries on the Essequibo River serve several ports (also known as "Stellings") on either side of the Essequibo River and on Leguan and Wakenaam Islands, as shown on Figure 6-42.

In addition to the national ferry service, many smaller vessels provide transportation between Regions 2 and 3 across the Essequibo River. These smaller vessels are collectively and informally known as "speedboats" because they typically travel faster than the ferries (Figure 6-33). These speedboats vary in size, power, and capacity, but can typically carry from 5 to 15 passengers. 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.

Telecommunications

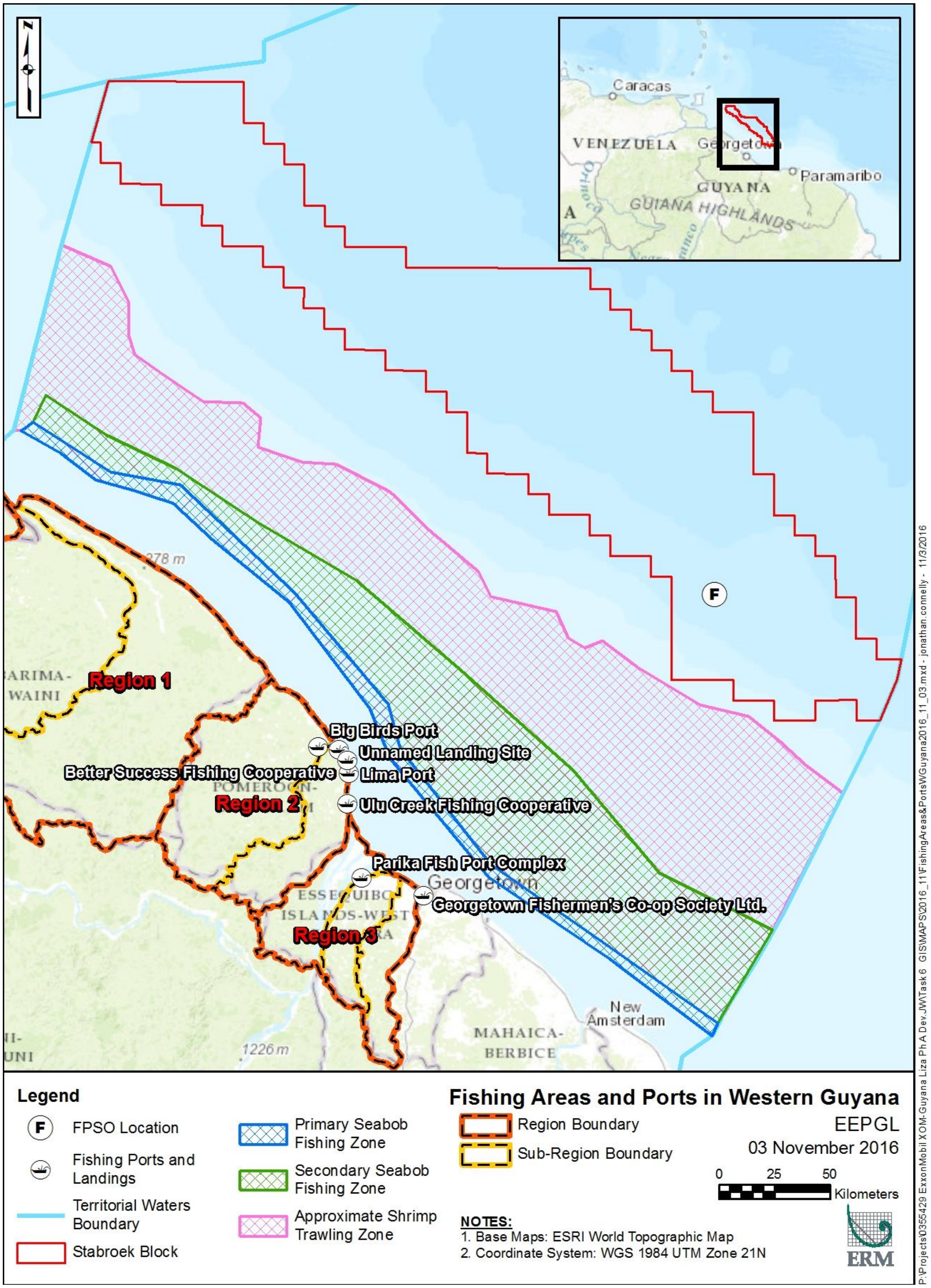
A publically mapped Guyana Telephone & Telegraph (GT&T) subsea telecommunications cable which is part of the Suriname Guyana Submarine Cable System (SGSCS) runs through the Stabroek Block, but is outside the PDA.. Since the SGSCS is outside the area of direct impact, and the Project would not have any indirect impacts on it, the SGSCS is not discussed further in this EIA.

Figure 6-40 Offshore Shipping Lanes



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

Figure 6-41 Fishing Zones and Ports



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

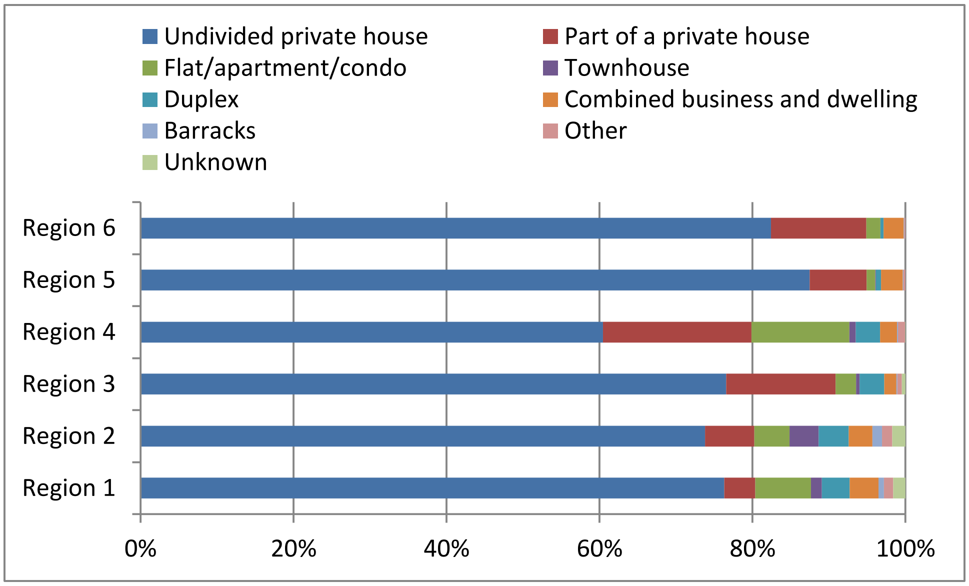
Figure 6-42 Maritime Transportation Facilities

6.3.9 Social Infrastructure and Services

6.3.9.1 Housing

Figure 6-43 shows the breakdown of housing types in the coastal regions as of the 2002 census (housing data from the 2012 census are not yet available) and indicates that detached houses are the most common type of housing in all regions.

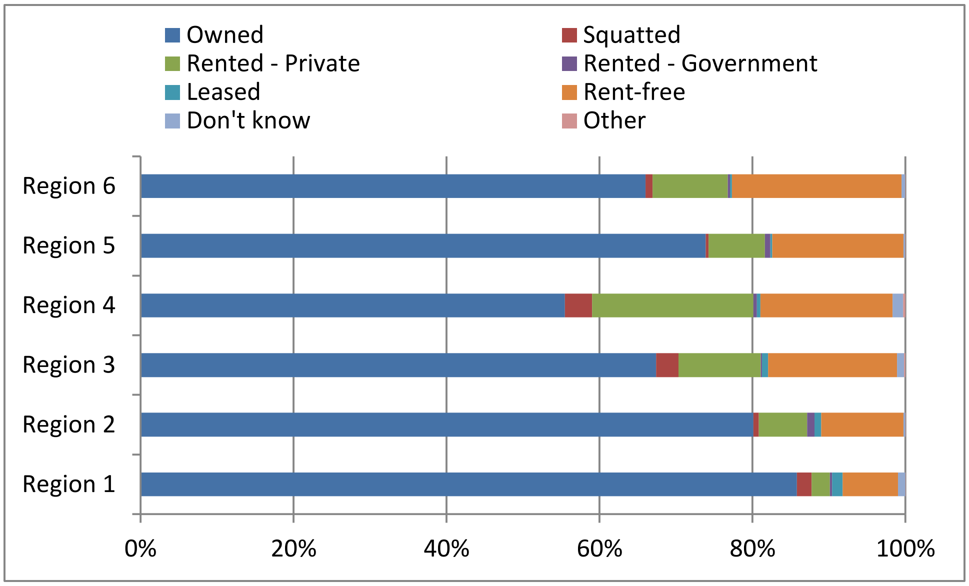
Figure 6-43 Proportion of Housing Types by Region



Source: Bureau of Statistics, 2002

Figure 6-44 shows the breakdown of home ownership types by region and shows that the majority of homes in the coastal area are owned by their occupants. However, Regions 3 and 4 have a higher proportion of rented and squatted homes. 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, 2008, 2016). There are currently 216 squatting areas in the country, of which 154 have been brought under the regularization program.

Figure 6-44 Proportion of Home Ownership Types by Coastal Region



Source: Bureau of Statistics, 2002

Data from the 2014 MICS 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.

6.3.9.2 Ground Transportation Infrastructure

Guyana has an approximately 3990 km (~2,480 mi) road network that is used by the approximately 80,000 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. Most streets are no more than two lanes wide, with approximately 7 m to 8m (~23 ft to 26 ft) of paved width (Google Earth, 2016). The port area is linked to central Georgetown via 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, including just before and just after school hours.

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 6-45). Daily retraction of the bridge for a period of about one hour causes severe traffic congestion at both ends of the bridge. 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 (Kaieteur News 2015).

Figure 6-45 Demerara Harbour Bridge

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 (OSAC 2016).

At the time of writing, the Ministry of Public Infrastructure was working with the IDB to develop a Sustainable Urban Transport Plan for Georgetown. This will focus more on management of current traffic than addition of significant new infrastructure; for example, separation of slower-moving traffic from vehicular traffic in designated lanes (ERM Personal Communication 9).

6.3.9.3 Water and Sanitation

According to the Food and Agriculture Organization (FAO), 95 percent of water usage in Guyana in 2010 was for irrigation and livestock, with four (4) percent used by municipalities and one (1) percent by industry (FAO, 2015).

Potable Water

Most potable water is obtained from the deeper aquifers that underlie Georgetown and the coastal plain. Water is distributed by Guyana Water Inc. (GWI), a commercial public enterprise that has five service areas along the coast, and a separate program to serve communities in the hinterland. 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. Rainwater is often used for potable household use, while river water is typically used for cleaning and other non-potable uses.

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 Water

Areas with fully developed drainage and irrigation systems are called Declared Drainage and Irrigation Areas (DDIAs) and are found in Regions 2, 3, 4, 5, and 6. In these regions, irrigation is by gravity 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 the surrounding fields. The Tapakuma conservancy is a large human-made conservancy. It serves Region 2 and has been designed to provide irrigation to about 120 square kilometers (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 (NDIA) has responsibility for the maintenance and delivery of the irrigation water supply throughout the country.

6.3.9.4 Power

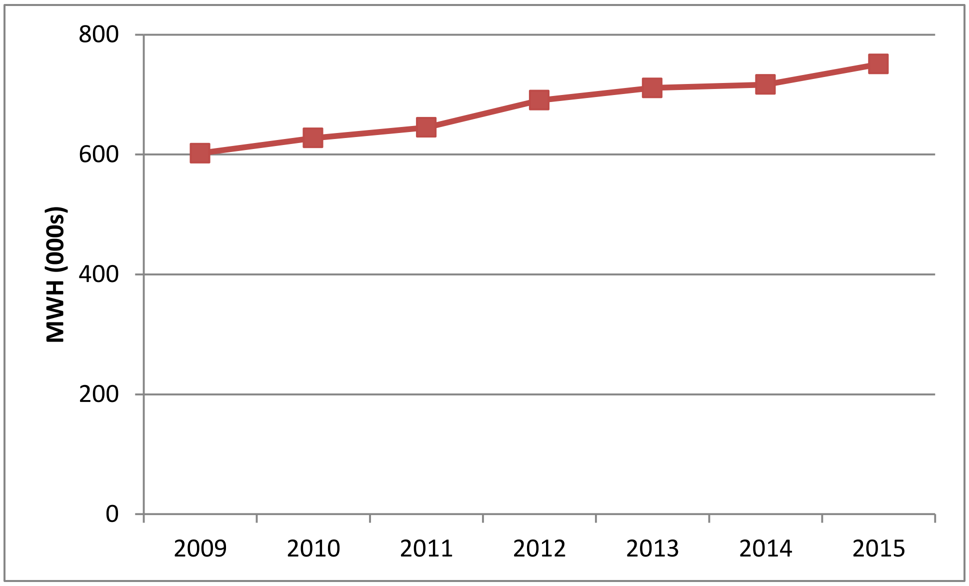
Most of the electricity in the coastal plain of Guyana is generated, transmitted and distributed by the state-owned utility Guyana Power & Light Inc (GPL). However, due to poor reliability of the electrical supply, many users also have their own diesel generators. Coastal areas that are not serviced by GPL are the Region 2 area west of Charity, and Region 1. Most areas of the hinterland do not have electricity service, and the government has implemented a number of hinterland energy development projects in recent years which have included installation of solar systems, and feasibility studies for hydropower and wind projects (GPL, 2016).

The PSC has noted that the high cost of electricity in Guyana is a major challenge for business. This was also raised as an issue by representatives of agricultural processing associations (ERM Personal Communications 1, 5, and 10).

According to the PSC, development of hydroelectricity should be a major priority for the country. The plan for the 165 megawatt (MW) Amaila Falls hydroelectric plant was cancelled in 2015 due to delays and the potential for cost overruns (ERM Personal Communication 10).

Total electricity generation output in Guyana in thousands of MW-hours for the period 2009 through 2015 is presented on Figure 6-46.

Figure 6-46 Electricity Generation in Guyana, 2009-2015



Source: Ministry of Finance, 2015

Although Guyana has significant potential for hydroelectric and biomass-fueled electricity generation, at this time, 83 percent of its 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 remaining 17 percent of installed capacity is biomass-based, using bagasse (sugarcane fibers remaining after cane juice is extracted) as fuel to self-generate power at GuySuco's sugarcane factories. There are plans to enhance the generation capacity of the GuySuco factories such that excess power is available and can be exported to the National electrical grid, and the government continues to explore options for a hydroelectric power project (GEA, 2015; ClimateScope, 2015).

6.3.9.5 Telecommunications Infrastructure

As described in Section 6.3.7, 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.

6.3.9.6 Educational Facilities

Table 6-19 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.

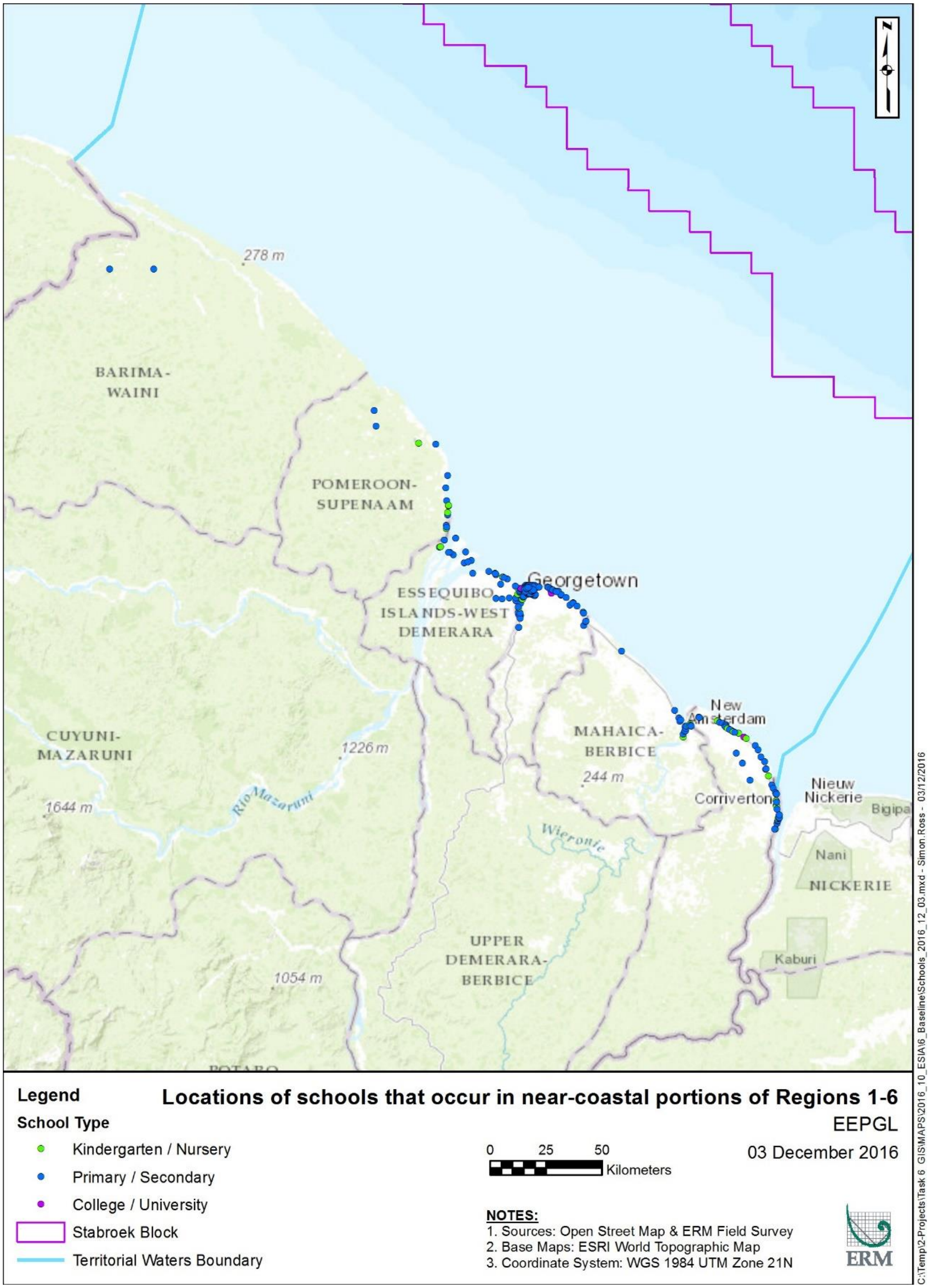
Table 6-19 Number of Educational Facilities in Guyana's Coastal Regions

	Nursery	Primary	Secondary	Technical/ Vocational	College/ University
Region 1	17	42	3	0	0
Region 2	49	37	8	1	0
Region 3	59	59	13	0	0
Region 4	65	54	15	4	7
Region 5	34	32	7	0	0
Region 6	67	54	17	1	2

Source: Guyana Ministry of Education 2013

Table 6-19 includes the full list of schools in the coastal regions as reported by the Guyana Ministry of Education, but Figure 6-47 only shows schools occurring near the coast. In general, this distribution reflects population trends along the coast. Schools are found all along the coast of Regions 3, 4 and 6, which are also the most populated regions. In Region 2, schools are found along the coast until the coastal road ends, and are much fewer in the Region 2 areas west of Charity and in Region 1.

Figure 6-47 Locations of Schools that Occur in Near-coastal Portions of Regions 1-6



* NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.

6.3.9.7 Security Facilities

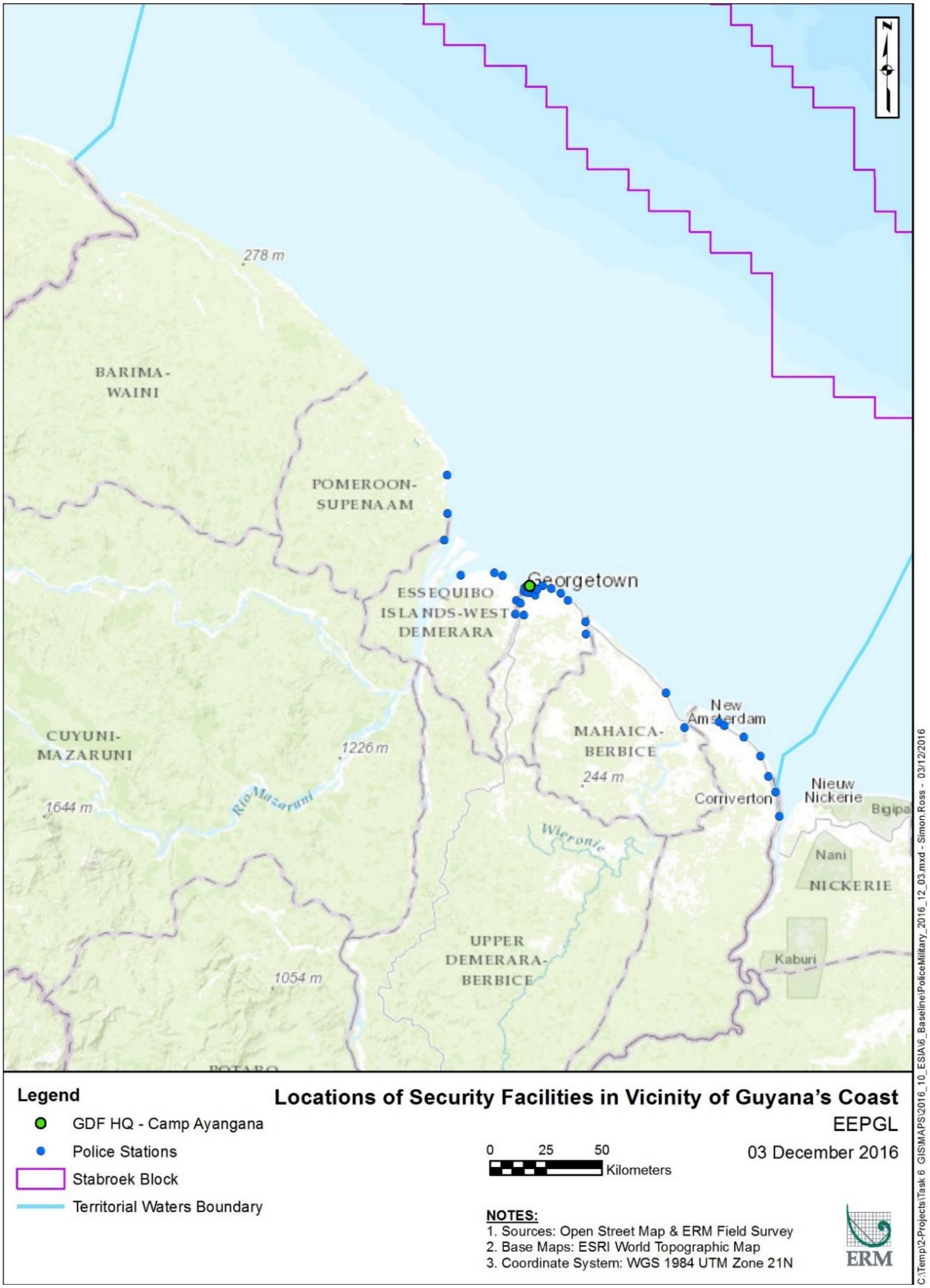
The Guyana Defense Force (GDF) is the military service of Guyana and has land, sea (Coast Guard) and air (Air Corps) units responsible for defending the territorial integrity of Guyana. In terms of internal security, the Guyana Police Force (GPF) operates as a semiautonomous agency under the Ministry of Home Affairs. The GPF has seven geographic policing divisions each with their own headquarters, stations and outposts as summarized in Table 6-20.

Table 6-20 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 Kwakani.	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.	Leonora, West Coast Demerara	6	1
E&F	Upper Demerara including the area surrounding the bauxite holdings of Linden, Ituni and Kwakani 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 6-48 shows the locations of 35 (approximately 50 percent) of the total reported police stations in Guyana enumerated in the table above (locational data were not available for the interior outpost locations).

Figure 6-48 Locations of Security Facilities in Immediate Vicinity of Guyana's Coast



** NOTE: Map does not represent a depiction of the maritime boundary lines of Guyana.*

6.3.10 Cultural Heritage

6.3.10.1 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. EEPGL retained Fugro Marine Geoservices, Inc. (Fugro) to conduct a geophysical and remote sensing survey of the seafloor within the PDA to identify the occurrence of any potential cultural resources that may impact, or be impacted by, the design and placement of planned subsea equipment for the Project. Remote sensing surveys employ various instruments that use high and/or low frequency sound waves to collect information from the seafloor. This survey used several of these including:

- Multi-beam echo sounders (MBES), 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 AUV and hull mounted 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); and
- Sub-bottom profilers (SBP), 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 and hull mounted used).

Submerged archaeological sites are not expected in waters deeper than approximately 125 m (~410 ft), 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 would be deeper than approximately 125 m (~410 ft), the only potential cultural resources in the Project area are man-made objects that have sunk, most notably shipwrecks.

Fugro's Offshore survey operations employed AUV mounted, high-resolution, multi-beam echo sounder (MBES), side-scan sonar (SSS), chirp sub-bottom profiler (SBP), and digital camera, as well as hull mounted MBES and SBP units. The remote sensing instruments utilized and the settings employed for each instrument are provided in Table 6-21. The survey was divided into three areas: the Liza Field Development (Main AUV Survey) Area; the Upper Slope and Outer Shelf Reconnaissance (USOS Survey) Area; and the Skipjack Survey Area.

Table 6-21 Remote Sensing Instruments and Survey Settings

Type of Instrument	Model	Survey Settings	Hull or AUV Mounted	Survey Areas in which Equipment was Used
MBES	Kongsberg EM2040 bathymetric system	Frequency of 200kHz swath coverage of 150 degrees	AUV Mounted	Main AUV Survey Area/Where Possible in USOS Survey Area/ Skipjack Area
	Kongsberg EM302 bathymetric system	Frequency of 30kHz	Hull Mounted	USOS Survey Area
SSS	EdgeTech model 2200 full-spectrum system	Dual Frequencies of 105kHz and 410kHz	AUV Mounted	Main AUV Survey Area/Where Possible in USOS Survey Area/Skipjack Area
SBP	EdgeTech model DW-106 full spectrum system	Frequency Range of 1kHz to 10kHz	AUV Mounted	Main AUV Survey Area/Where Possible in USOS Survey Area/ Skipjack Area
	EdgeTech 3300 full spectrum system	Frequency Range of 1kHz to 10kHz	Hull Mounted	USOS Survey Area
Underwater Digital Camera	Prosilica Allied Vision GE4000	35 millimeter digital imagery, ~8 m (~26 ft) above seafloor	AUV Mounted	As Needed for Ground Truthing in all Survey Areas

ERM 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. ERM 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 anticipated impact, as the methodology and quality of data produced met the guidelines and requirements for near and offshore remote sensing cultural surveys as defined by the U.S. Bureau of Ocean Energy Management (BOEM) and the English Heritage, whose, guidelines together help frame "internationally recognized practices" for remote sensing surveys designed to locate and assess cultural heritage.

The survey was divided into three areas: the Liza Field Development (Main AUV Survey) Area; the Upper Slope and Outer Shelf Reconnaissance (USOS Survey) Area; and the Skipjack Survey Area. The main AUV Survey identified 73 Side Scan Sonar Targets (UD01- UD073), which were assessed for their potential as marine hazards and/or cultural resources. The targets ranged from approximately 0.5 m to 10.5 m wide, and from approximately 2 m to 27 m long. Only three targets, UD03, UD06, and UD070 possessed recordable height, measuring approximately 0.75 m, 1 m, and 0.5 m tall, respectively. However, none of these three targets possess shapes or other characteristics that might suggest they are culturally sensitive objects (e.g., shipwrecks), and upon closer inspection all three targets are thought to be either pieces of debris or geological formations. Based on an analysis of the geophysical and remote sensing data, Fugro concluded that:

- One of the targets (SC17) 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, target SC17 could not be relocated, though the seafloor at its previously recorded location showed signs of the object having moved downslope (drag scars). 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) (Figure 6-50);
- Another of the targets (SC110) was initially thought to be a potential vessel, but upon second inspection was identified as likely being a fishing net (Figure 6-51); and
- The remaining 71 targets in the main AUV Survey area were judged to be modern debris (e.g., debris associated with previous well development projects, cable laying efforts) or geological features (e.g., rock clusters or formations) of no significant cultural value. As examples of modern debris, three of the targets, UD08, UD011, and UD021 (Figure 6-49), were interpreted as discarded chain or cable coils.

In summary, upon review of the SSS imagery and data collected, ERM concluded that these 73 SSS targets are likely modern debris, fishing nets, chain or cable coils, or geological features of no significant cultural value.

Figure 6-49 SSS Targets UD08, UD011, and UD021 Found within the Main AUV Survey Area

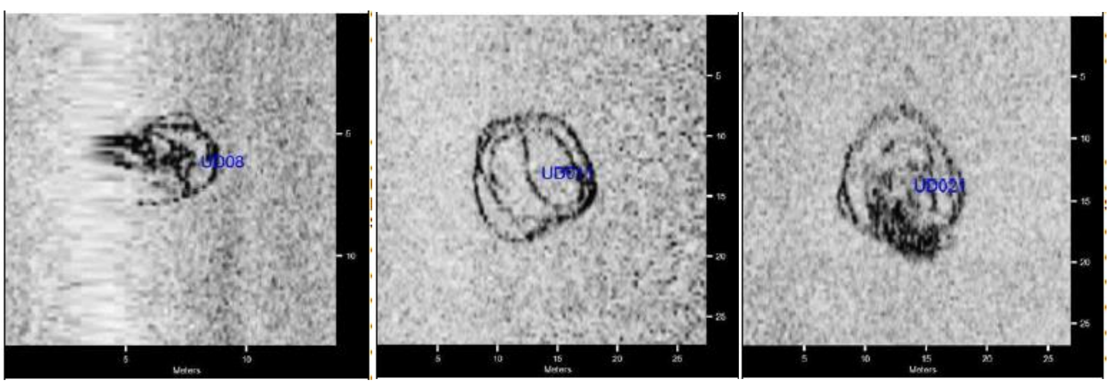


Figure 6-50 SSS Target SC17 in the Main AUV Survey Area

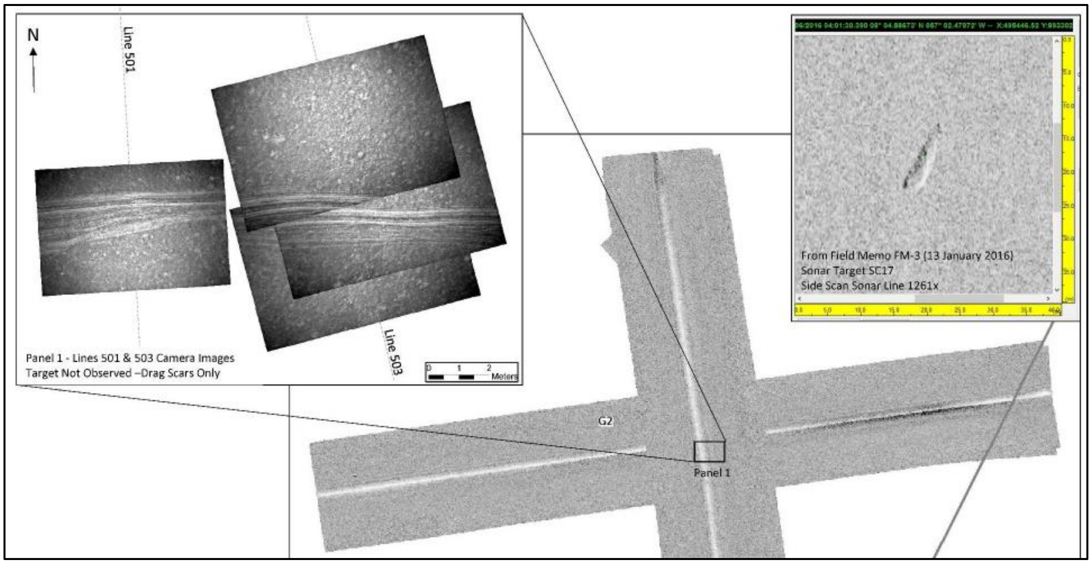
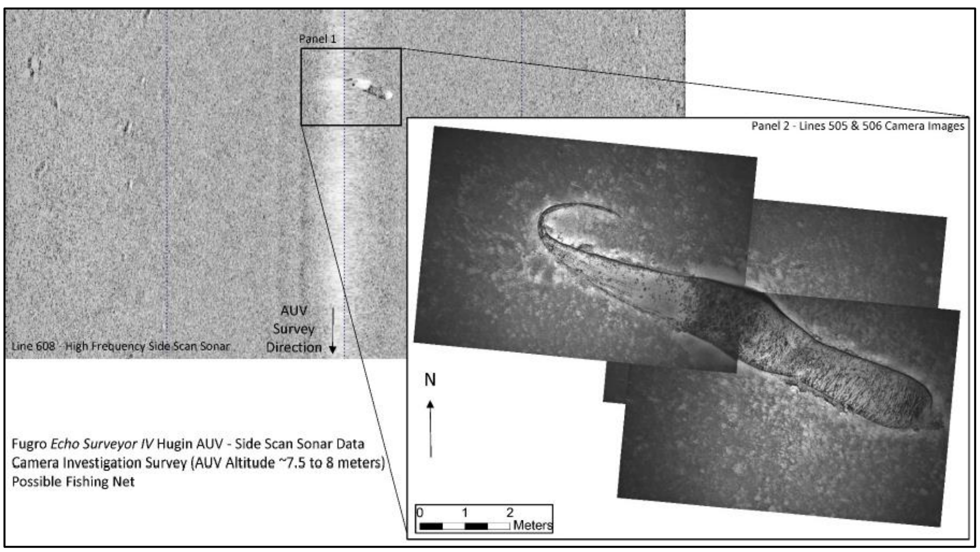


Figure 6-51 SSS Target SC110 in the Main AUV Survey Area

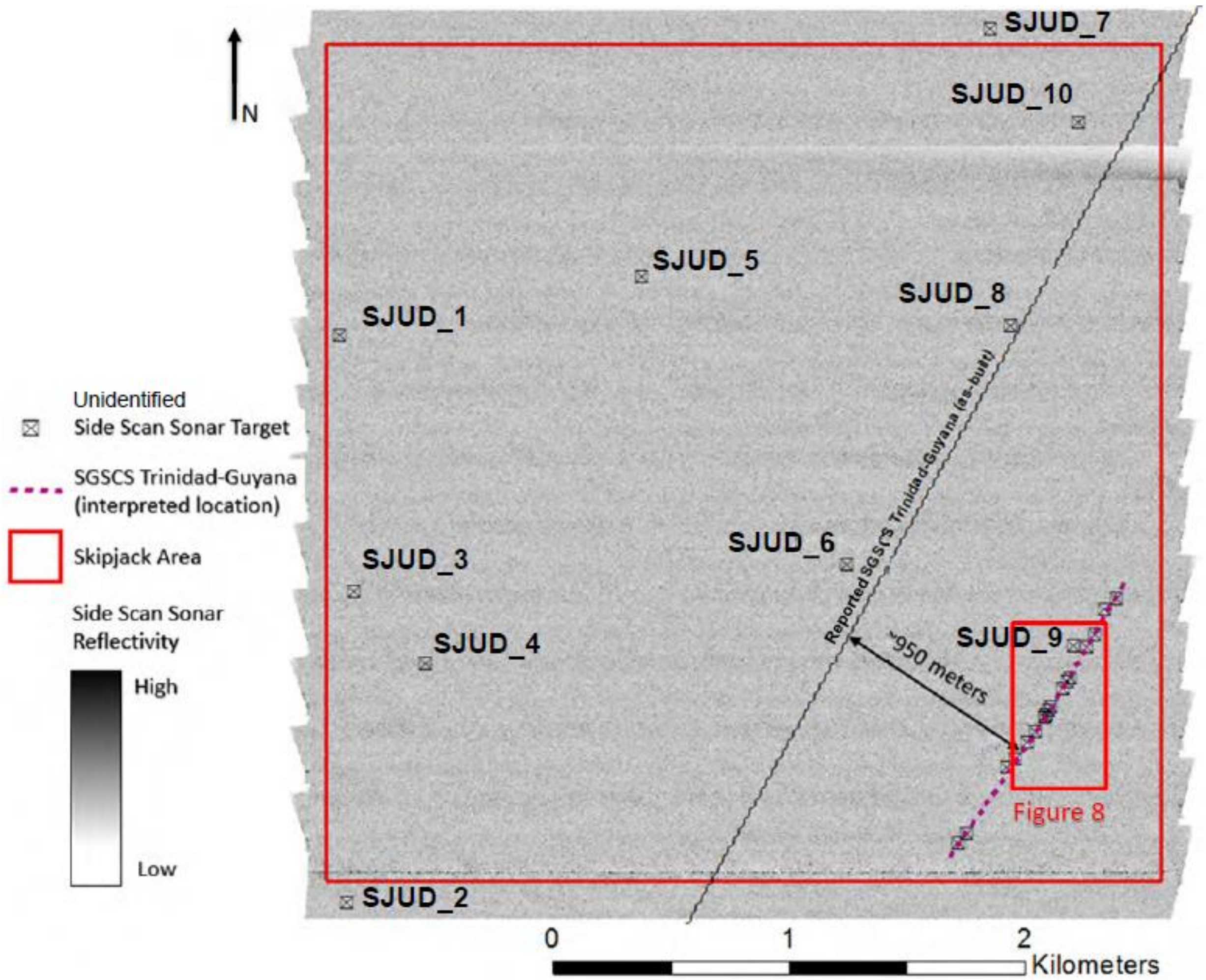


Remote sensing efforts in the USOS Survey Area revealed no discernable objects, either geological or man-made in origin, and thus it was concluded that there are no cultural concerns for the USOS Survey Area.

Ten SSS targets were identified in the SkipJack Survey Area, each of which appeared linear in shape, with lengths ranging from approximately 4 m to 78 m (~13 ft to 256 ft), widths ranging from approximately 1 m to 5.5 m (~3 ft to 18 ft), and no measureable heights (Figure 6-52). None of these targets were concluded to represent culturally significant objects, and are likely to be either geological formations or modern debris. In addition, a series of subtle reflections in the SSS data located in the southeast portion of the Skipjack Survey Area are understood to represent the Suriname-Guyana Submarine Cable System (SGSCS) Trinidad-Guyana cable.

These reflections run approximately 950 m (~3,116 ft) to the southeast and parallel to the reported as-built position of the SGSCS Trinidad-Guyana cable. The presence of this cable accounts for the presence of discarded cable or chain remains located within the main AUV survey area.

Figure 6-52 SSS Mosaic Showing SSS Targets, Including the Potential SGSCS Trinidad-Guyana Cable, in the Skipjack Survey Area



6.3.10.2 Coastal Cultural Heritage

Maps obtained from the Guyana National Trust also show the presence of several shell mounds, seashell deposits, quarries, and ceramic/pottery sites (i.e., scatters) along the Atlantic coast of Guyana, including archaeological sites found near Moruka, Uitvlugt, Stewartville, and Leonora. These sites are of significant cultural value to both the people of Guyana as well as researchers from other parts of the world, 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.

6.3.11 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. Each of these is defined below (Millennium Ecosystem Assessment [MA], 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.
- Supporting services: Natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Review of information indicates 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 below.

6.3.11.1 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 addition to cultivated agriculture, 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 coconuts, manicole (heart of palm), mangrove bark, timber, tuli palm used for roof thatch, and crabwood seeds that are processed to make crabwood oil. Fishing, crabbing, and shrimping also occur on a small scale in the mangroves. There is also potential for apiculture in the mangroves. There are currently five apiaries with a total of 100 beehives in Region 1, and seven apiaries with a total of 120 beehives in Region 2. However, it is not clear whether any of these are located in mangrove forests. In Regions 4, 5, and 6, apiculture does occur in mangroves (Ministry of Agriculture, 2016). Despite their protected status, sea turtles and their eggs are sometimes poached in the coastal area (ERM Personal Communication 11).

6.3.11.2 Regulating Services

One of the most important regulating services provided by coastal ecosystems is shoreline and flood protection. 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.

6.3.11.3 *Cultural Services*

Throughout Guyana's populated coastal regions, the seashore is often utilized 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 round, but especially during the holy festival of Kartik Snan, which occurs in October or November each year (ERM Personal Communication 12).

Some members of African ethnic organizations also make use of the seashore to commemorate African Holocaust day at the Kingston Seawall in Georgetown, as well as other spiritual and religious events (ERM Personal Communication 13).

Although infrastructure in the area is not well developed and tourism activity is limited, the SBPA has high aesthetic and educational value and potential for ecotourism due to its importance as a sea turtle nesting area.

6.3.11.4 *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).

-Page Intentionally Left Blank-

7.0 ASSESSMENT OF POTENTIAL IMPACTS

This chapter of the EIA discusses direct, indirect, and induced impacts that could occur as a result of the Project. Sections 7.1 through 7.3 discuss impacts that are expected to occur due to planned Project activities. Section 7.4 discusses impacts that are not expected to occur, but could potentially occur due to unplanned events.

As described in Chapter 4, this impact assessment was performed using the methodology of the ERM Impact Assessment Standard. This methodology takes into consideration both the magnitude of an impact and the sensitivity/vulnerability/importance of the impacted resource/receptor to determine the significance of the impact (see Figure 7-1); the methodology is described in more detail in Chapter 4.

In Chapter 7, the potential impacts to resources/receptors are described. For each potential impact, the impact magnitude and resource/receptor sensitivity/vulnerability/importance are characterized and assigned ratings as noted in Figure 7-1. Once these ratings are assigned, the matrix is used to determine the impact significance.

Figure 7-1 is annotated to show an example of a potential impact (considering embedded controls that are part of the Project design, but not yet considering any proposed mitigation measures) that is assigned a magnitude of **Small** and for which the resource has been characterized as having a **Medium** sensitivity. The resulting impact significance (which is termed the "pre-mitigation significance" is therefore determined to be **Minor** (as shown by the dashed circle). If a mitigation measure were to be proposed such that it reduced the impact magnitude to **Negligible**, for example, the impact significance would be reduced to **Negligible** (as shown by the solid circle). As described in Chapter 4, positive impacts (i.e., benefits) are not assigned magnitude ratings and the impact significance is simply expressed as **Positive**.

Figure 7-1 Evaluation of Impact Significance

Impact Significance Matrix		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	**Medium**	**High**
Negative Impacts				
Magnitude of Impact	Negligible	Negligible	Negligible	Negligible
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	Major
	Large	Moderate	Major	Major
Positive Impacts				
Magnitude of Impact	NA	Positive	Positive	Positive

The impact assessment covers the Project stages described in Chapter 2 (i.e., drilling and installation, hook-up and commissioning, production operations, and decommissioning). The nature of activities comprising the hook-up and commissioning stage are such that all potential impacts associated with this stage are also associated with at least one other Project stage. Accordingly, this impact assessment focuses on potential impacts associated with the other three stages (drilling and installation, production operations, and decommissioning), and this effectively also addresses impacts associated with the hook-up and commissioning stage.

It is also noted that not all resources/receptors have potential impacts associated with every one of these three Project stages. Accordingly, there are instances where a particular Project stage is not discussed with respect to a resource/receptor.

7.1 Physical Resources

For the purposes of this EIA, "physical resources" are intended to include non-biological natural resources.

7.1.1 Air Quality and Climate

7.1.1.1 *Introduction*

This section addresses potential impacts on air quality due to emissions resulting from 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 the Project, and GHG emissions from these same sources.

7.1.1.2 *Relevant Project Activities and Potential Impacts*

Emissions generated by the Project generally emanate from two source categories: a) specific *point sources* such as the power generating units and diesel engines on drill ships and on the FPSO, flares used (non-routinely) to combust produced gas when not consumed as fuel gas on the FPSO or injected back into the Liza reservoir, vents and onboard incineration of wastes; and b) general *area sources* such as support vessels, installation vessels, tug boats, 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 receptors onshore in Guyana, the increases may have the potential to contribute to health impacts. Because air quality for Project workers will be addressed through standard occupational exposure guidelines, the air quality impact assessment was limited in consideration to these potential onshore 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 and, therefore, is not addressed in this EIA.

Table 7-1 summarizes potential Project impacts on air quality and climate.

Table 7-1 Project Activities and Potential Impacts – Air Quality and Climate

Stage	Project Activity	Resource	Key Potential Impacts
Drilling and 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 in onshore receptors.
		Climate	• Increased emissions of GHGs, potentially contributing to climate impacts* (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 in onshore receptors.
		Climate	• Increased emissions of GHGs, potentially contributing to climate impacts* (more of a global concern).

**Please see discussion in Section 7.1.1.2*

7.1.1.3 Characterization of Impacts – Air Quality

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 USEPA in the publication *AP-42: Compilation of Air Pollutant Emission* Factors (AP-42). 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 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 7-2 provides a summary of expected annual emissions from various Project activities for three time periods: 2018-2019 (development drilling, SURF installation and commissioning, and operation of related support vessels); 2020-2021 (drilling, FPSO startup and associated temporary, non-routine flaring, beginning of production operations, tanker loading); and 2022-2040 (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 2019, the annual emissions summarized in Table 7-2 represent the maximum anticipated for any one year during that 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 7-2 Annual Air Emissions Summary

Pollutant	**Source Category**	**Annual Emissions (Tonnes unless otherwise specified)**		
		2018-2019	**2020-2021**	**2022-2040**
Nitrogen oxides (NO_x)				
	FPSO	0	1,635	1,545
	FPSO Flaring (temporary, non-routine)	0	375	175
	Tanker Loading	0	135	140
	Area Sources	2,385	1,125	1,125
	Drill ship	1,255	1,670	0
	Total	3,640	4,945	2,975
Sulfur dioxide (SO_2)				
	FPSO	0	45	50
	FPSO Flaring (temporary, non-routine)	0	0	5
	Tanker Loading	0	110	115
	Area Sources	85	40	40
	Drill Ship	45	60	0
	Total	130	250	205
Particulate matter (PM)				
	FPSO	0	45	35
	FPSO Flaring (temporary, non-routine)	0	15	5
	Tanker Loading	0	10	10
	Area Sources	170	80	80
	Drill Ship	90	120	0
	Total	260	210	130
Carbon monoxide (CO)				
	FPSO	0	425	405
	FPSO Flaring (temporary, non-routine)	0	2,030	940
	Tanker Loading	0	30	30
	Area Sources	500	235	235
	Drill ship	265	350	0
	Total	765	3,070	1,610

Pollutant	**Source Category**	**Annual Emissions (Tonnes unless otherwise specified)**		
		2018-2019	**2020-2021**	**2022-2040**
Other Pollutants				
Hydrogen Sulfide (H_2S)	FPSO Flaring (temporary, non-routine)	n/a	<1	<1
Volatile Organic Compounds (VOCs)	All Sources	95	10,250	10,720
Greenhouse Gases (GHGs [kilotonnes CO_2-equivalents])	All Sources	195	1,510	980

Notes:
1. The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.14), which could change.
2. 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.
3. PM emissions represent total PM; for the purpose of the impact assessment, the total PM values were used for modeling of both PM_{10} and $PM_{2.5}$ emissions (producing conservatively high modeling results).
4. 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.

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 (AQSs); therefore, the guidelines used for reference in this assessment were those established by the World Health Organization (WHO). The WHO guidelines are summarized in Table 7-3. These guidelines were published in *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide - Global Update 2005* (WHO, 2005) except for CO and H_2S, which were published in WHO *Air Quality* Guidelines *for Europe, 2nd edition, 2000* (WHO, 2000).

Existing air quality is discussed in Section 6.1.1. A concentration value of 2.5 $\mu g/m^3$ for $PM_{2.5}$ (from a Yale University 2015 study) was identified for air quality onshore Guyana. No values were found in the literature for existing onshore air quality for the other substances modeled. However, Yale University (2016) published a report that ranked Guyana 6th (from the best) out of 180 countries in air quality. Accordingly, it was concluded that onshore Guyana is an *undegraded airshed* for the purpose of impact assessment process (see below).

Table 7-3 WHO Ambient Air Quality Guidelines

Pollutant	Averaging Period	Guideline Concentration (µg/m3)
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

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 intent of this grid was to identify maximum predicted pollutant concentrations generated by the Project across the onshore portion of the Project AOI. The methodology utilized was to predict maximum concentrations at all of the onshore grid points using the dispersion model, and then to compare these maximum values 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 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 (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 the shore at 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 7-2 displays the modeling domain used in this analysis, showing the locations of the main Project point sources (the FPSO and the drill centers), and of 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.

*Model Selection: T*he CALPUFF model (a non-steady-state model used in the U.S. 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 long distance between the principal Project-related sources and the receptors. As shown on Figure 7-2, the distance from the PDA to the closest shoreline is greater than 190 kilometers. At this distance, emission plumes released from Project point sources would travel for 10 hours, assuming an average wind speed of 5 meters/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.

Figure 7-2 Air Quality Modeling Domain

Meteorological Data: The Weather Research and Forecasting (WRF) model was used to develop hourly meteorology inputs for CALPUFF for one year – calendar year 2014. WRF 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 km, so that a two-dimensional profile of hourly winds and temperature was developed every 12 km within the domain shown on Figure 7-2. The profiles were used by CALPUFF to simulate the transport and dispersion of emission plumes from Project sources, allowing the model to calculate ambient 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 7-3). Results are summarized in Table 7-4.

Table 7-4 Modeling Results Summary at Potential Onshore Receptor Locations

Pollutant	Averaging Period	Guideline Concentration (µg/m3)	Maximum Predicted Concentration (µg/m3)			Percent of WHO Guideline		
			2018-2019	2020-2021	2022-2040	2018-2019	2020-2021	2022-2040
NO_2	1-hour	200	1.3	2.1	1.5	0.6%	1.0%	0.7%
	Annual	40	0.1	0.2	0.1	0.3%	0.4%	0.2%
SO_2	10-minute	500	0.1	0.7	0.6	0.0%	0.1%	0.1%
	24-hour	20	0.0	0.2	0.2	0.1%	0.9%	0.9%
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%	0.1%	0.0%
$PM_{2.5}$	24-hour	25	0.0	0.1	0.0	0.2%	0.2%	0.1%
	Annual	10	0.0	0.0	0.0	0.1%	0.1%	0.0%
CO	1-hour	30,000	0.3	2.6	2.6	0.0%	0.0%	0.0%
	8-hour	10,000	0.3	1.5	1.4	0.0%	0.0%	0.0%
H_2S	30-minute	7	n/a	n/a	0.00002	n/a	n/a	0.0002%

The magnitude rating for air quality 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 most commonly used is based upon guidance from the International Finance Corporation (IFC). This approach is set out below on Figure 7-3.

As shown in Table 7-4, for all the modeled constituents, the maximum onshore concentrations predicted to result from Project activities are negligible relative to WHO guidelines (all less than or equal to 1 percent of the AQS). Accordingly, a magnitude rating of **Negligible** was assigned for impacts on air quality.

Figure 7-3 Definitions for Magnitude Ratings for Potential Impacts on Air Quality

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

Undegraded airshed = environmental conditions where no existing concentrations exceed a specific air quality guideline (coastal Guyana is considered an *undegraded airshed* based on the existing concentrations presented above).

Sensitivity of Resource – Air Quality

The standard approach taken assumes that the sensitivity for human health 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 the 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 airshed at all potential onshore receptor locations would be either a **Medium** or a **High** sensitivity rating.

Impact Significance and Mitigation Measures – Air Quality

Based on the magnitude of impact and receptor sensitivity ratings, the significance of impacts on air quality for all receptors is **Negligible**. Based on this rating, no mitigation is recommended.

7.1.1.4 *Characterization of Impacts – Climate*

Table 7-5 summarizes the estimated annual GHG emissions for the Project throughout the projected Project lifecycle.

Table 7-5 Estimated Annual Project GHG Emissions

	Estimated Annual GHG Emissions in kilotonnes CO_2-equivalents		
	2018-2019	**2020-2021**	**2022-2040**
All Project Activities	195	1,510	980

Notes:
1. The annual estimated totals generally reflect the current preliminary Project schedule (see Section 2.14), which could change.

As potential climate impacts are more of a global concern from cumulative worldwide GHG emissions, as opposed to concern for a local airshed, modeling of GHG emissions is typically not performed as part of an EIA for a proposed 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 utilized within the Project AOI. Quantification of GHG emissions will be conducted annually in accordance with internationally recognized methodologies and good practice.

7.1.1.5 *Summary of Impact Significance Ratings*

Table 7-6 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on air quality and climate, and the impact significance rating resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-6 Air Quality and Climate - Pre-Mitigation and Residual Impact Significance Ratings

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 in onshore human receptors	Negligible	Medium or High (assumed)	Negligible	None	Negligible
All Project stages	Climate – increased GHG concentrations, potentially contributing to climate impacts	NR	NR	NR	(a)	NR

NR = not rated
(a) EEPGL will quantify and report GHG emissions to the EPA consistent with international guidelines.

7.1.2 Sound

As indicated in Section 6.1.2, the Project would not be expected to result in significant airborne sound impacts or ground-borne vibration impacts due to the distance between Project sound sources and onshore communities and receptors (the Stabroek Block is approximately 190 km offshore). The only airborne sound receptors will be workers onboard the FPSO, drill ships, and other Project-associated vessels. With respect to worker protection, EEPGL will utilize industry standard engineering and administrative controls for sound mitigation, and will monitor sound levels and provide appropriate hearing protection PPE for workers as needed. Therefore, the Project's potential impacts from airborne sound and ground-borne vibration were not assessed. Potential impacts from Project-related underwater sound are discussed with respect to potential marine life receptors (in Sections 7.2.5 and 7.2.7).

7.1.3 Marine Geology and Sediments

7.1.3.1 *Introduction*

This section describes the assessment of potential impacts on marine geology and sediments. 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 would be some localized disturbance of sediments in a limited area; however, this impact would be negligible with respect to the seafloor morphology. Additional discussion regarding potential impacts on marine benthos from these activities is provided in Section 7.2.8, Marine Benthos. No impacts on marine geology and sediments would be expected as a result of activities associated with production operations or decommissioning.

7.1.3.2 *Relevant Project Activities and Potential Impacts*

The process of drilling the wells will produce drill cuttings that are discharged either directly to the seafloor (in open hole sections drilled riserless and with seawater) or from the drill ship into the ocean (in hole sections drilled with a riser) after treatment (i.e., solids control and centrifugal cuttings dryer system). The planned development drilling program and its cuttings management approach is consistent with industry practices and protective of the environment. For each well, approximately 2,600 bbl of cuttings for the open hole sections will be discharged to the sea without treatment per standard industry practice, as these sections are drilled using WBDF instead of NADF. For sections drilled with a riser, approximately 3,300 bbl of cuttings (per well) discharged from the drill ship into the ocean would first be treated to remove associated drilling fluids to acceptable discharge thresholds. EEPGL will utilize a cuttings dryer that incorporates a high-speed centrifuge to achieve high liquids/solids separation, reducing waste volumes. Planned discharges of drill cuttings and fluids will locally impact the marine sediment layer as a result of accumulation of cuttings on the seafloor. Cuttings will accumulate on the seafloor around the well locations, with the distribution of deposition determined by oceanographic conditions.

Table 7-7 summarizes potential Project impacts on marine geology and sediments.

Table 7-7 Project Activities and Potential Impacts – Marine Geology and Sediments

Stage	Project Activity	Key Potential Impacts
Drilling and 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
Production Operations Decommissioning	No planned Project activities associated with Production Operations or Decommissioning are expected to result in impacts to Marine Geology and Sediments	• None anticipated

7.1.3.3 *Characterization of Impacts*

Drill Cuttings Deposition Modeling

Modeling of the deposition of cuttings and fluids was performed using the Generalized Integrated Fate and Transport (GEMSS-GIFT) model. This three-dimensional, particle-based model uses Lagrangian 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.

Four scenarios were modeled, considering the drill centers with the shallowest and deepest water depths (DC1-I and DC2-I, respectively), 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 models. 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 seafloor (as noted above, these cuttings may alternatively be discharged from the drill ship prior to treatment).

Table 7-8 summarizes the results of the modeling for the four drill cuttings discharge scenarios. Releases deeper in the water column at DC2-I traveled less distance and therefore resulted in a smaller depositional footprint since the currents near the seafloor were slower than currents near the seafloor at DC1-I. Higher current velocities near the surface at DC1-I also contributed to a larger overall footprint size.

Table 7-8 Summary of Modeling Results for Drill Cuttings Discharge Scenarios

Scenario	Total Area (m^2) with Thickness >1 cm	Total Area (m^2) with Thickness > 5 cm
1a DC1-I (shallowest water depth); Min Currents	23,928	4,575
1b DC1-I; Max Currents	14,725	5,815
2a DC2-I (deepest water depth); Min Currents	3,801	1,442
2b DC2-I; Max Currents	4,056	1,590

Magnitude of Impact – Sediment Morphology

Modeling of cuttings discharge and deposition indicates the maximum depositional thickness of cuttings on the seafloor is predicted to be between 19 cm and 75 cm, depending on currents and well 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 of 5 cm 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 7.2.8). 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 modeled area predicted to be approximately 43 m in diameter. Deposition thicknesses decrease rapidly with increasing distance from the well. Although the 1 cm thickness does not represent an impact threshold, Table 7-8, also shows the predicted areal coverage of deposition above this level for each scenario.

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 cm 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, it is likely there will be some pauses and delays during the drilling of a well, meaning the actual drilling duration likely will be greater than 21 days. Under the assumption that a subsequent well at a given drill center would not be started any sooner than 30 days after the start of the previous well at that drill center, the total depositional thicknesses therefore represent a conservatively high estimate of the average depositional rate across a full month.

In terms of a magnitude rating, the 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. Assuming no more than two drill ships could be drilling at any one time, the conservative approach is therefore to double the highest *total area* results from Table 7-8, to reflect the largest area predicted to be subjected to a cuttings deposition rate greater than 5 cm per month at any one time. This results in a predicted area of approximately 11,600 m^2 (~124,860 ft^2), which represents approximately 0.00004 percent of the area of the Stabroek Block. Further, as described above, 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 impact relative to the overall sediment resource of the Stabroek Block, the magnitude of impact on sediment morphology from drill cutting deposition was rated as **Negligible**.

Sensitivity of Resource – Sediment Morphology

The sensitivity of the overall marine sediment resource to morphology impacts from drill cuttings deposition is considered **Low**, as unlike the mud banks offshore Guyana 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 impacted by the drill cuttings discharge do not support high densities of marine species and are not unique.

A separate consideration was made for the mud banks offshore Guyana; they are of critical ecological importance as feeding zones for birds, nursery areas for fish, and habitat for a variety of invertebrates. Thus, they were assigned a sensitivity rating of **High**.

Impact Significance and Mitigation Measures – Sediment Morphology

Based on the magnitude of impact and receptor sensitivity ratings, the significance of impacts on sediment morphology is **Negligible**. Based on this rating, no mitigation is recommended.

With respect to the mud banks, as discussed in Section 6.1.3, these features exist within 40 km (approximately 25 mi) from the shore (i.e., on the order of approximately 160 km (~100 mi) from the drilling locations). Based on the results of modeling, the cuttings would not reach the mud banks; hence, the impact magnitude rating (specifically for the mud banks) is **Negligible**. Thus, despite the **High** sensitivity rating for the mud banks, the **Negligible** impact magnitude leads to a significance rating of **Negligible** for potential morphological impacts on the mud banks. Based on this rating, no mitigation is recommended.

Magnitude of Impact – Sediment Quality

The embedded controls in the Project design to reduce the impact of drilling discharges on sediment quality include: use of WBDF to the extent reasonably practicable (for drilling of initial open hole well sections), and use of IOGP Group III NABF in all other cases. WBDF contains no hydrocarbons and is less harmful to marine organisms; 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 6.9 percent (wet weight).

The NABF to be used in the NADF by EEPGL 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 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 Stabroek Block impacted by drill cuttings deposition. For this reason, and considering the low-toxicity nature of the NADF, the magnitude of impact is considered **Negligible**.

Sensitivity of Resource – Sediment Quality

As in the case of impacts on sediment morphology 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 mud banks offshore Guyana 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 impacted by the drill cuttings discharge do not support high densities of marine species and are not unique.

Impact Significance and Mitigation Measures – Sediment Quality

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for sediment quality impacts. Based on this rating, no mitigation is recommended.

Summary of Impact Significance Ratings

Table 7-9 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on marine geology and sediments, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-9 Marine Geology and Sediments - Pre-Mitigation and Residual Impact Significance Ratings

Stage	Resource Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation	Sediment morphology - from accumulated drill cuttings	Negligible	Low (drill centers) High (mud banks)	Negligible	None	Negligible
	Sediment quality - from residual NABF on deposited drill cuttings	Negligible	Low (drill centers) High (mud banks)	Negligible	None	Negligible

Stage	Resource Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Production Operations Decommissioning	None anticipated	---	---	---	None	---

7.1.4 Marine Water Quality

7.1.4.1 *Introduction*

This section describes the assessment of potential impacts on marine water quality. 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 sub-sections describe the various discharges for which marine water quality impacts were assessed, the application of computational models for impact magnitude quantification, and a discussion of the impact assessment.

7.1.4.2 *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 during jetting and drilling of the initial sections of the well will increase TSS concentrations around the well near the seafloor. Cuttings discharged from the drill ship 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 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 7-10 summarizes potential Project impacts on marine water quality.

Table 7-10 Project Activities and Potential Impacts – Marine Water Quality

Resource/Receptor	Stage	Project Activity	Key Potential Impacts
Marine water quality (marine fauna as receptors)	Drilling and Installation	Discharge of drill cuttings, resulting in increased TSS concentrations in water column Liquid effluent discharges 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	Liquid effluent discharges 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	Liquid effluent discharges from marine support vessels (chemical substances)	• Increased chemical concentrations in water column, potentially contributing to health impacts on marine fauna

7.1.4.3 Characterization of Impacts – Increased TSS from Drill Cuttings Discharge

Magnitude of Impact – Increased TSS from Drill Cuttings Discharge

Modeling of the deposition of cuttings and fluids was performed using the Generalized Integrated Fate and Transport (GEMSS-GIFT) 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 TSS concentrations resulting from the planned discharges.

Four scenarios were modeled, considering the shallowest and deepest water depths of the four drill centers (DC1-I and DC2-I, respectively), each under two current conditions: 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 7.1.3), modeling of increases in 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 seafloor discharge (see results discussion below).

Modeling of cuttings discharge and deposition predicts the maximum TSS concentrations at the seafloor occurring during drilling of the initial sections of the well would be between approximately 4,323 micrograms per liter (mg/L) and 9,737 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 would be between approximately 1.6 mg/L and 5.3 mg/L, depending on currents and well location. These concentrations are much lower because drill cuttings and fluids from the subsequent well sections are treated on the drill ship to remove a substantial amount of the drilling fluid prior to discharge at the surface. Additionally, the 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, recommended by MARPOL (IMO, 2006), was used to assess the extent of the area with the potential to impact photosynthesis via a reduction in light penetration (an indirect impact resulting from increased TSS concentrations in the water column). Table 7-11 summarizes the results of the modeling for the four drill cuttings discharge scenarios.

Table 7-11 Summary of TSS Modeling Results for Drill Cuttings Discharge Scenarios

Scenario	Maximum TSS (mg/L) Surface/Seafloor	Area (km²) with TSS > 35 mg/L Threshold Surface/Seafloor
1a DC1-I (shallowest water depth), Min Currents	2.1 / 4,323	0 / 0.094
1b DC1-I, Max Currents	2.9 / 5,517	0 / 0.168
2a DC2-I (deepest water depth), Min Currents	1.6 / 5,260	0 / 0.091
2b DC2-I, Max Currents	5.3 / 9,737	0 / 0.088

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

Even at the seafloor, the modeling indicates TSS concentrations would be reduced to below the threshold through settling and dispersion within approximately 1 hour of cessation of the half-day of jetting and drilling for the initial well section. 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 was rated as **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 densities of receptors (e.g., fish and photosynthetic organisms) are expected to be low in zones affected by short-lived higher TSS concentrations. Furthermore, photosynthetic impacts are less relevant to the area near the seafloor, which is well below the photic zone.

Impact Significance and Mitigation Measures – Increased TSS from Drill Cuttings Discharge

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for marine water quality impacts from increased TSS concentrations during drilling. Based on this rating, no mitigation is recommended.

7.1.4.4 *Characterization of Impacts – Changes to Water Quality and Temperature*

Project-Related Discharges Impacting Water Quality and Temperature

The Project will include several discharges with the potential to impact water quality and temperature. These discharges, based on the preliminary design information, are listed in Table 7-12.

Table 7-12 Summary of Project-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)	≤ 500,000 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	25,000 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)	400 bbl total	None	N/A

Production Discharges			
Produced Water • Oil & Grease • Residual production and water treatment chemicals	≤ 100,000 bpd	Oil in water content: 29 mg/L (monthly average); 42 mg/L (daily maximum) Temperature rise <3°C at 100 m from discharge	Yes
Cooling Water • Hypochlorite: ≤ 5 ppm	≤ 700,000 bpd	No visible oil sheen on receiving water Temperature rise <3°C at 100 m 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	≤ 100,000 bpd	None	N/A
Subsea Hydraulic Fluid Discharge • Water soluble, low-toxicity	≤ 5 bpd	None	N/A
FPSO Bilge Water	1,800 bpd	Oil in water content: <15 mg/L	Yes
Inert Gas Generator Cooling Water	Negligible	None	N/A
FPSO Slop Tank Water	Negligible	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	N/A
Tanker Ballast Water	1,100,000 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	N/A
Rain Water/Deck Drainage/Wash Down Water	Rainfall dependent	No visible oil sheen on receiving water	N/A

Gray Water	5,000 bpd	None	N/A
Black Water (sewage)	4,000 bpd	Total residual chlorine as low as practical but not less than 1 ppm	Yes
Food Preparation Wastes	<30 bpd	Macerated to <25 mm diameter	Yes

Notes:
bbl = barrels
bpd = barrels per day

Based on the above estimated discharge rates, cooling water, produced water, and brines from the Sulfate Removal Unit (SRU) and freshwater Reverse Osmosis (RO) 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 associated marine water quality impacts. Additionally, although the discharge of hydrotest water and commissioning fluids will occur over only a short time period during the installation and SURF 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 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 modeled for each of these discharges are listed in Table 7-13. The constituents are associated with potential indirect impacts on marine aquatic life, as indicated in the table.

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 marine environment water temperature) 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 avoidance of the discharge area by aquatic species. Residual chlorine may interact with naturally occurring organic matter, resulting in chlorinated by-products 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. Residual chlorine toxicity depends not only on doseage (concentration and exposure time), but also on individual species' sensitivity. This makes defining a single impact threshold for residual chlorine exposure difficult.

Table 7-13 Summary of Discharges and Modeled Constituents for Installation and Production Operations

Discharge	Modeled Constituents	Potential Indirect Impacts on Marine Aquatic Life
Cooling Water	• Temperature • Residual Chlorine	Temperature increase and associated impacts on marine species. Increased residual chlorine concentrations and associated toxicity impacts on marine species.
Produced Water	• Oil & Grease (O&G) • Temperature • Residual production and water treatment chemicals (e.g., scale and corrosion inhibitors)	Increased concentrations of O&G, production 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 concentrations of hydrate inhibitor and associated toxicity impacts on marine species.

Discharge of produced water containing O&G and residual quantities of certain production and water treatment chemicals can result in locally increased 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.

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, hydrate inhibitor discharge, and initial FPSO ballast discharge will occur only during a limited time period during SURF installation and commissioning activities, unlike the discharge of cooling water, produced water, and wastewater, all of which will occur continuously during production operations.

Magnitude of Impacts – Changes to Water Quality and Temperature

The model used to predict the nature and extent of discharge plumes from the various discharges was USEPA's CORMIX dilution model. 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. As the design for the Project has not been finalized, conservative assumptions were used for the modeled pipe diameter. Pipe diameters that are smaller than those considered in the modeling will result in increased mixing (and reduced concentrations at the edge of mixing zone).

For the receiving environment, the ambient currents selected for modeling consisted of *bounding* cases (5^{th} and 95^{th} percentile for the range of current velocities identified) as well as a *typical* case (50^{th} percentile for the range of current velocities identified). Ambient temperatures selected for modeling also consisted of *bounding* cases (1^{st} and 99^{th} percentiles) and a *typical* case (50^{th} 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, 3°C maximum temperature rise at a distance of 100 m from the discharge point was used as a reference point for cooling water and produced water discharges, consistent with recognized international benchmarks and a level appropriately protective of the marine environment. Table 7-14 summarizes the results of the modeling study of discharges for the most conservative bounding cases, including percent reduction in constituent concentrations at the 100 m reference distance. International standards and guidelines and established regulatory requirements provide appropriate benchmarks for O&G content in produced water, and MARPOL specifies limits on O&G in bilge water. There are no prescribed limits for the constituents contained in the other discharge streams.

Table 7-14 Summary of Modeling Results for Most Conservative Bounding Case (predictions at 100 m reference distance)

Discharge Scenario	Most Conservative Bounding Case Conditions	Modeled Parameters/ Constituents	Modeled Results at 100 m
Cooling Water (Thermal)	Minimum ambient temperature, maximum ambient current	Temperature Rise[22]	Ambient temperature rise <3°C
Cooling Water (Residual Chlorine)	Minimum ambient temperature, maximum ambient current	Residual Chlorine	89% reduction
Produced Water	Maximum ambient current	O&G[23] Temperature Rise Residual production chemicals	92% reduction
Sulfate Removal & Potable Water Processing Brines	Maximum ambient current	Hypochlorite Electrolytes Biocide Oxygen Scavenger Scale Inhibitor	98% reduction
Hydrotest Water	Minimum ambient current	Biocide Oxygen Scavenger Corrosion Inhibitor	99% reduction
Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Minimum ambient current (ethylene glycol); high ambient current (methanol)	Hydrate inhibitor (either methanol or ethylene glycol)	Concentration reduces to <32% of published No Observed Effect Concentrations (NOECs) under worst-case discharge conditions

In terms of impacts on marine water quality from hydrotesting and production operations, Table 7-15 summarizes the assigned magnitude ratings based on consideration of the extent of impact and concentrations relative to the marine aquatic life thresholds identified.

[22] Design specification for the cooling water discharge port were not finalized at the time of the EIA; modeling was conducted to determine the combinations of discharge port diameters and discharge depths that would result in a temperature rise less than 3°C at the edge of the 100m mixing zone.

[23] Discharges will adhere to a limit of 42 mg/L oil & grease (daily maximum) and 29 mg/L (monthly average) at the point of discharge (consistent with recognized international benchmarks and appropriately protective of the PDA marine environment).

Table 7-15 Magnitude Ratings for Modeled Hydrotesting and Production Operations Discharges

Discharge	Impact Magnitude Rating	Rationale for Magnitude Rating
Cooling Water	Small	Modeling indicates the temperature differential in the water column will reduce to no greater than the reference temperature within the recommended 100 meter mixing zone. At this same distance, chlorine concentrations are predicted to decrease by 89 percent.
Produced Water	Negligible	At the 100 meter reference distance, O&G, and residual production and water treatment chemicals are predicted to decrease by 92 percent, and temperature rise is predicted to be less than 3°C
Sulfate Removal & Potable Water Processing Brines	Negligible	At the 100 meter reference distance, hypochlorite, electrolyte, biocide, oxygen scavenger and scale inhibitor concentrations are predicted to decrease by 98 percent.
Hydrotest Water	Negligible	At the 100 meter reference distance, biocide, oxygen scavenger and corrosion inhibitor concentrations are predicted to decrease by 99 to 99.5 percent, depending on pipe diameter. In addition to the minimal size of the plume, the release is temporary (approximately 60 minutes or less).
Hydrate Inhibitor (Gas Injection Line Commissioning Fluid)	Negligible	At the 100 meter reference distance, hydrate control fluid (methanol or monoethylene glycol) is predicted to decrease by 99.6 to 99.9 percent, depending on the fluid selected. In addition to the minimal size of the plume, the release is temporary (matter of hours).

Considering the information presented above, the magnitude of quality and temperature impacts on marine water quality was rated as **Negligible**.

Sensitivity of Resource – Changes to Water Quality and Temperature

The sensitivity of the marine environment to elevated constituent concentrations and increased temperature is considered **Low**, as the marine fauna (used as representative receptors) would not be sensitive to chemical constituent concentrations or temperatures at the modeled levels; furthermore, species would only be expected to be present in the area of discharge for a limited time.

Impact Significance/Mitigation Measures – Changes to Water Quality and Temperature

These individual magnitude and sensitivity ratings lead to a significance rating of **Negligible** for marine water quality impacts from the individual discharges.

7.1.4.5 Summary of Impact Significance Ratings

Table 7-16 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on marine water quality, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter. Although the modeling results for the individual discharges predict that the impacts associated with each discharge would be individually insignificant, the potential synergistic effects of these discharges on sensitive marine biota supports a higher rating than what would otherwise be supported by the impact ratings for each individual discharge. Therefore, the overall magnitude of the water quality impacts has been elevated to **Small** for all Project stages.

Table 7-16 Marine Water Quality - Pre-Mitigation and Residual Impact Significance Ratings

Stage	Resource Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation	Increased TSS concentrations	Small	Low	Minor	None	Minor
Drilling and Installation Production Operations	Water quality and temperature changes	Small	Low	Minor	None	Minor
Decommissioning	Water quality changes	Small	Low	Minor	None	Minor

7.2 Biological Resources

For the purposes of this EIA, "biological resources" is intended to include flora, fauna, and the habitats on which they depend.

7.2.1 Protected Areas and Special Status Species

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

7.2.1.1 Protected Areas

Planned activities of the Project and associated air emissions, effluent discharges, and sound generation, which will occur approximately 190 km (~120 mi) offshore, will not impact Shell Beach Protected Area (SBPA), which is Guyana's only designated protected area within the Project AOI. The Project's only potential impacts on SBPA would be as a result of an unplanned event, which is discussed in Section 7.4.

7.2.1.2 Special Status Species

Relevant Project Activities and Potential Impacts

Project-related impacts on special status species can be considered a subset of the biological resource impacts; however, potential impacts on special status species require special consideration because these species are assumed to have a diminished capacity to recover due to their conservation status. A list of species occurring in Guyana and their conservation status is provided in Appendix H.

As all of the marine turtles occurring in Guyana's waters carry a ranking of Critically Endangered, Endangered, or Vulnerable, the assessment of potential impacts to marine turtles (Section 7.2.6) effectively covers the assessment of potential impacts to special status marine turtles. One of the marine mammals species observed in the PDA carries a Vulnerable status. Accordingly, the assessment of potential impacts to marine mammals (section 7.2.5) effectively covers the assessment of potential impacts to marine mammals. For these reasons, marine turtles and marine mammals are not discussed in this section on special status species.

With respect to fishes, four Critically Endangered species (Atlantic goliath grouper, daggernose shark, Caribbean electric ray, and largetooth sawfish) and six Endangered species (Nassau grouper, golden tilefish, whale shark, squat-headed hammerhead, scalloped hammerhead, and Atlantic bluefin tuna) have the potential to occur in the nearshore and offshore areas of Guyana. All have been listed as Critically Endangered or Endangered due to a combination of fishing mortality (both as target species or bycatch), habitat loss, slow maturation rates, and low fecundity. For the Critically Endangered fish species (all estuarine and nearshore fish species), habitat loss is an important driver, whereas for the Endangered fish species (fish distributed farther offshore), habitat loss is a much less important driver than fishing-related mortality.

As the Critically Endangered fish species are estuarine and nearshore species, the planned activities of the Project will not directly impact habitat for these species. As the Endangered fishes are distributed farther offshore, they will have the potential to encounter the Project marine vessels; however, the Project will not permanently alter habitat conditions for these species. The Project will not impact fishing-related mortality rates for any fish species. Furthermore, the Project will not impact any of the underlying causes for these species' declines across their ranges as cited by the IUCN.

Giant otter (*Pteronura brasiliensis*) is also listed as Endangered. Giant otters are Endangered due to a combination of the legacy impacts of historically widespread hunting and present-day destruction of riparian tropical forests, especially along large interior rivers (IUCN, 2014). The Project will not impact giant otter habitat, nor will it impact the species' capacity to recover or rate of recovery from legacy impacts.

Vulnerable species (other than whales and turtles) include a mix of elasmobranchs (sharks and their relatives), marine mammals (West Indian manatee), fish (groupers and snappers), and the Agami heron (*Agamia agami*). Deforestation, hunting, and use of pesticides are the primary factors for the Agami heron's Vulnerable status (BirdLife International, 2012b). Numerous factors including habitat loss have been implicated in the declines of fish, and the manatee. The Near Threatened category comprises fishes (almost entirely of elasmobranchs), the neotropical otter (*Lontra longicaudis*), and the semipalmated sandpiper (*Calidris pusilla*). The elasmobranchs and bony fishes in both categories are listed primarily due to overfishing, slow maturation rates, and low fecundity. The neotropical otter is Near Threatened due to a combination of habitat destruction and local conflicts with fishermen, and is also sensitive to chemical and organic pollution (Rheingantz, 2015). Deforestation, hunting, and use of pesticides are the primary factors for the semipalmated sandpiper's Near Threatened status (BirdLife International, 2012c). Overfishing is the primary factor implicated in the status of the Near Threatened bony fish (groupers, snappers, and tunas).

The Project will be located within offshore habitat for several of these Vulnerable and Near Threatened species and near inshore habitats, but will not alter the value of the habitats or the capacity of these habitats to support these species. The Project will not affect rates of coastal habitat loss/recovery, hunting, or residual pesticide concentrations in the Agami heron's or neotropical otter's habitat, so it will not affect these species' capacity to recover from these impacts. The combination of overfishing, slow maturation rates, and low fecundity contribute to long recovery times for listed fishes, but the Project will have no effect on these species capacity to recover.

Characterization of Impacts

Tables 7-17 and 7-18 provide the definitions used to assign impact magnitude and receptor sensitivity ratings for special status species (the same rating definitions are employed for marine turtles and marine mammals in their respective sections).

Table 7-17 Definitions for Magnitude Ratings for Special Status Species

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 change in and recovery of the population (or another dependent on it) is not possible either at all, or within several generations due to natural recruitment (reproduction, immigration from unaffected areas).

Table 7-18 Definitions for Receptor Sensitivity Ratings for Special Status Species

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 Project-related impacts.

Criterion	Definition
	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.

For the marine fish species addressed in this section, the starting assumption was that the same impact magnitude ratings used for potential impacts to marine fish in general (section 7.2.7) are applicable for special status marine fish. However, additional considerations were applied to the specific special status species to assess whether these magnitude ratings are appropriate. Based on these additional considerations, magnitudes for the various special status marine fish categories were assigned as follows:

- Critically Endangered:
  - These species are all nearshore species, and thus will not be subject to the same level of potential interactions with planned Project activities that form the basis for the various potential impacts to marine fish in general. Accordingly, a magnitude of **Negligible** was assigned.
- Endangered:
  - While Nassau grouper is listed as occurring in Guyana waters, 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, 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 VSP or pile driving sound, 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 7.2.7 are all assigned a magnitude rating of **Negligible** for Endangered fish species.
  - As described above, the Project will not impact giant otter habitat, nor will it impact the species' capacity to recover from legacy impacts, resulting in a magnitude rating of **Negligible**.
- Vulnerable:

- While the same logic applies for some of the Vulnerable fish species as for the Endangered species described above, some other Vulnerable species are likely to have similar behavioral characteristics as the marine fish in general; accordingly, as a conservative measure, the magnitude ratings from Section 7.2.7 were applied (**Small** for several potential impacts).
- The Agami heron is a coastal species unlikely to be subject to significant interaction with Project activities, resulting in a **Negligible** impact magnitude.

- Near Threatened:
  - The same approach was used for Near Threatened fish species as for Vulnerable fish species (i.e., a magnitude of **Small** was assumed, consistent with marine fish in general).
  - The neotropical otter and semi-palmated sandpiper, are coastal species unlikely to be subject to significant interaction with Project activities, resulting in a **Negligible** impact magnitude.

Considering the information above, Table 7-19 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on special status species, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-19 Special Status Species - Pre-Mitigation and Residual Impact Significance Ratings

Group	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Atlantic goliath grouper, daggernose shark, Caribbean electric ray, and largetooth sawfish (Critically Endangered)	Negligible	High	Negligible	None	Negligible
Nassau grouper, golden tilefish, whale shark, squat-headed hammerhead, scalloped hammerhead, and Atlantic bluefin tuna (Endangered)	Negligible	High	Negligible	None	Negligible
Giant otter (Endangered)	Negligible	High	Negligible	None	Negligible

Group	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Several elasmobranchs (sharks and their relatives), fish (Vulnerable).	Small	Medium	Minor	None	Minor
Agami heron (Vulnerable)	Negligible	Medium	Negligible	None	Negligible
Several fishes (almost entirely elasmobranchs), (Near Threatened)	Small	Medium	Minor	None	Minor
Neotropical otter, semipalmated sandpiper (Near Threatened)	Negligible	Medium	Negligible	None	Negligible

7.2.2 Coastal Habitats

The planned Project activities and associated air emissions, effluent discharges, and sound generation, which will occur approximately 190 km (~120 mi) offshore, will not impact any coastal habitats. Operation of the Guyana shorebase(s) will have little to no impact on coastal habitat. The shorebase(s) are expected to be located in existing developed areas. The Project's only potential impact on coastal habitats would be as a result of an unplanned event, which is discussed in Section 7.4.

7.2.3 Coastal Wildlife and Shorebirds

The planned Project activities will not impact any coastal wildlife or shorebirds. 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 190 km (~120 mi) offshore, will not impact these species. The use of the Guyana shorebase(s) will have little to no impact on coastal 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 and shorebirds would be as a result of an unplanned event, which is discussed in Section 7.4.

7.2.4 Seabirds

7.2.4.1 *Introduction*

This section discusses potential impacts on seabirds from planned Project activities. Thirty 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 late summer, with many remaining through winter. 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[24] 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.

7.2.4.2 *Relevant Project Activities and Potential Impacts*

Table 7-20 summarizes the potential impacts of planned Project activities on seabirds.

[24] Rafting is a common seabird behavior involving a tight aggregation of seabirds floating on the ocean surface to form a "raft."

Table 7-20 Project Activities and Potential Impacts – Seabirds

Stage	Project Activity	Key Potential Impact
Drilling and 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	• Strike-related injury or mortality, particularly with rafting seabirds. • 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 or metabolic impacts.
	Discharge of wastewater effluents	
	Marine aviation	• Bird strike by helicopters.
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.
	Discharge of cooling water and produced water	• Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts.
	Discharge of wastewater effluents	
	Operation of supply and support vessels	• Strike-related injury and mortality, lighting, disturbance.
	Non-routine flaring	• Mortality or injury from bird exposure to radiant heat from the flare.
	Marine aviation	• Bird strike by helicopters.
Decommissioning	Decommissioning activities PDA and related vessel traffic	• Ship and helicopter strike-related injury or mortality. • Light and sound disturbance from decommissioning activities leading to attraction to or avoidance of the exposed area. • Removal of a 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 would rapidly mix with ambient water, and the numbers of seabirds potentially exposed to the effluents is expected to be low. Sections 7.1.3 and 7.1.4 provide further analysis of the impacts of these discharges on marine sediment and water quality, respectively. While individual seabirds could be significantly impacted through contact with the 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, the assessment of potential impacts on seabirds is focused on: a) direct mortality and injury of seabirds related to attraction to offshore Project facilities; and b) direct mortality and injury related to vessel (ship or air) strikes.

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 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.

7.2.4.3 *Characterization of Impacts – Direct Mortality and Injury Related to Attraction to Offshore Project Facilities*

Magnitude of Impact – Direct Mortality and Injury Related to Attraction to Offshore Project Facilities

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 negative impacts of 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 time there will be a considerable source of artificial light in an otherwise dark environment. 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 km (2 to 3 mi) 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 ranges 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 resulting in mortality or injury, which can 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 that seabirds may be exposed to by the Project. Further, the Project area 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 small, meaning the Project would 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**.

Sensitivity of Receptor – Direct Mortality and Injury Related to Attraction to Offshore Project Facilities

Seabirds are expected to occur in the PDA throughout the year but at low densities and primarily as transients moving with prey resources. All of the 30 species of seabirds known to occur in the area are listed on the IUCN Red List as Least Concern. Several impact exposure events are likely to occur for seabirds; however, taking into account their conservation status and that only a few individuals are likely to be impacted rather than whole populations, the sensitivity of the seabird receptor is considered **Low**.

Impact Significance and Mitigation Measures – Direct Mortality and Injury Related to Attraction to Offshore Project Facilities

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for direct mortality and injury impacts on seabirds related to attraction to offshore Project facilities.

7.2.4.4 <u>*Characterization of Impact – Direct Mortality and Injury Related to Vessel or Helicopter Strikes*</u>

Magnitude of Impact – 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 duration and number of 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 when transiting to and from PDA, where safe and feasible, if the birds do not move out of the vessel's path, as well as the limited number of helicopter flights per day to the Project facilities and vessels, the magnitude of this potential impact is **Small**.

Sensitivity of Receptor – Direct Mortality and Injury Related to Vessel or Helicopter Strikes

On the same basis as described in Section 7.2.4.3, the sensitivity of the seabird receptor to this impact is considered Low.

Impact Significance and Mitigation Measures – Direct Mortality and Injury Related to Vessel or Helicopter Strikes

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for direct mortality and injury impacts on seabirds related to vessel or helicopter strikes.

7.2.4.5 <u>*Impacts Related to Decommissioning*</u>

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 potential for ship and helicopter strike-related injury or mortality, and light and sound disturbance from decommissioning activities leading to avoidance of the exposed areas. As stated previously in this section, these impacts are expected to impact individual seabirds but have negligible impacts on seabirds at the population level. Once decommissioning activities are completed, the absence of the FPSO and the activities of the related support vessels (ships and helicopters) will remove the attraction - and strike-related risks and impacts to seabirds, providing a benefit due to the elimination of ongoing risks and impacts. However, should the FPSO become an attractant for seabird prey or a regular resting place for migrating seabirds during the production operations stage, removal of the facility could have a temporary adverse impact due to the removal of a reliable food source and/or rest area. This impact would be temporary since the birds should quickly adjust to the changed condition.

7.2.4.6 Summary of Impact Significance Ratings

Table 7-21 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on seabirds, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-21 Seabirds - Pre-Mitigation and Residual Impact Significance Ratings

Stage	Receptor – Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation Production Operations	Seabirds – direct mortality and injury from attraction to offshore Project facilities.	Small	Low	Negligible	None	Negligible
All Project stages	Seabirds – direct mortality and injury from vessel or helicopter strikes.	Small	Low	Negligible	None	Negligible

7.2.5 Marine Mammals

7.2.5.1 Introduction

As described in Section 6.2.6, toothed whales (sperm, melon headed, and pilot whales) and dolphins (pantropical and bottlenose) are the most likely marine mammal species that could be encountered in the PDA. Bryde's whales 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.

7.2.5.2 Relevant Project Activities and Potential Impacts

As shown in Table 7-22, certain planned Project activities could impact marine mammals either through direct mortality (vessel strikes), or through disturbance leading to changes in behavior and reduced vigor (i.e., as a result of light, sound and/or actions from Project activities).

Table 7-22 Project Activities and Potential Impacts – Marine Mammals

Stage	Activity	Key Potential Impact
Drilling and Installation	Vessel operations	• Injury and mortality from vessel strikes • Sound exposure leading to permanent threshold shift (PTS) injury • Sound disturbance leading to deviation from area
	Power generation	• Sound exposure leading to PTS injury • Sound disturbance leading to deviation from area
	VSP	
	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 fishes, and therefore as a secondary attractant for some marine mammals.
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts.
	Permitted liquid waste discharge	
Production Operations	Well stream production, processing, and storage operations	• Sound exposure leading to PTS injury • Sound disturbance leading to deviation from area
	Power generation	
	Permitted cooling and produced water discharge	• Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts.
	Permitted other liquid waste discharge	
	Lighting on FPSO	• Offshore lighting is not considered to have a negative impact on marine mammals; it is considered to be an attractant for fishes, and therefore as a secondary attractant for some marine mammals.
	Operation of tankers, tugs, and supply and support vessels	• Injury and mortality from vessel strikes • Sound exposure leading to PTS injury • Sound disturbance leading to deviation from area
Decommissioning	Vessel operations	• Injury and mortality from vessel strikes • Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts. • Sound disturbance leading to deviation from area

7.2.5.3 *Characterization of Impacts*

Injury and Mortality from Vessel Strikes

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 shorebases, but even at the peak of drilling and installation the incremental increase in traffic near shorebases will represent a small increase in overall risk to marine mammals. 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 shorebases. 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 utilize the following embedded controls measure for the Project (see Section 2.11):

- 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.

Injury from Underwater Sound

The main sources of underwater sound associated with drilling activities are from the vertical seismic profiler (VSP)[25] activities (generating impulsive sound) and marine vessels (generating non-impulsive sound). The primary sources of sound from installation activities is from impulsive sources (impact pile drivers for the FPSO mooring system and for selected SURF equipment such as manifolds) as well as non-impulsive sources (marine vessels). Sound from production operations and decommissioning activities is primarily limited to non-impulsive sources (marine vessels).

Underwater sound can cause impacts on marine mammals due to behavioral changes impacting life functions (e.g., feeding, breeding, migration route deviations), direct physical impacts

[25] The VSP has a small source that produces seismic impulses over a period of time (for the purposes of this assessment, is 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.

affecting auditory systems, or in extreme cases other physical damage or behavioral reactions leading to death.

7.2.5.4 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 study, results are presented for both the Southall et al. (2007) M-weighting functions and the weighting functions suggested by Finneran (2015).

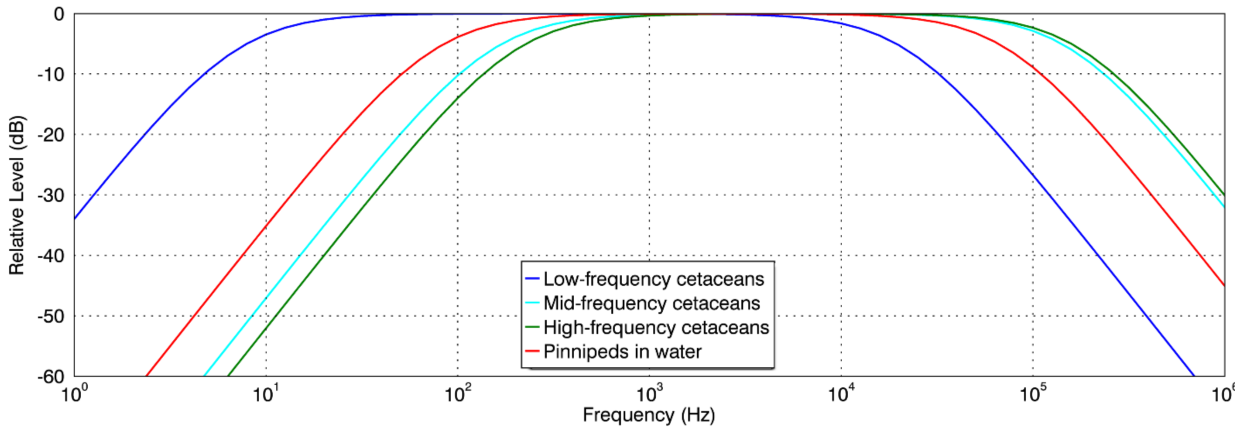
Southall et al. (2007) proposed M-weighting functions for five functional hearing groups of marine mammals:

- Low-frequency cetaceans (LFCs)—mysticetes (baleen whales);
- Mid-frequency cetaceans (MFCs)—some odontocetes (toothed whales);
- High-frequency cetaceans (HFCs)—odontocetes specialized for using high-frequencies;
- Pinnipeds in water[26]—seals, sea lions, and walrus; 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 curve for pinnipeds in water. In 2015, a U.S. Navy Technical Report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows 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 the NOAA (2013). More information on the marine mammal auditory weighting functions described above, including the analytical formulation of these metrics, is provided in the document *Underwater Sound Associated with Liza Phase 1 Project Activities* (JASCO, 2016). The auditory weighting functions recommended by Southall et al. (2007) and Finneran (2015) are shown on Figure 7-4 and 7-5, respectively.

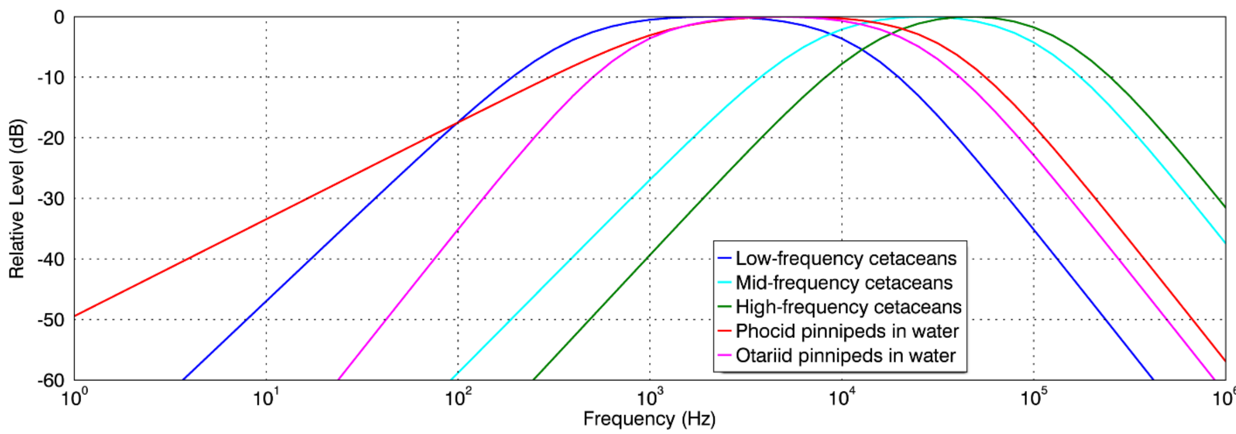
[26] Pinnipeds were included in Southall, et al 2007, but are not relevant to the analysis of auditory impacts because pinnipeds are either very rare or likely extinct offshore Guyana.

Figure 7-4 Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Southall el al. (2007)



Source: JASCO 2016

Figure 7-5 Auditory Weighting Functions for Marine Mammal Hearing Groups as Recommended by Finneran (2015)



Source: JASCO 2016

LFCs (including baleen whales) and MFCs (including dolphins and small whales) have been observed within or near the PDA, so this section focuses on these marine mammal hearing groups only. JASCO Applied Sciences conducted underwater sound modeling for the proposed Project activities (JASCO, 2016). 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 through 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 would 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[27], MONM[28], and FWRAM[29]) 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][30]) 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. 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
- Interactions between different elements in the array

For the modeling, source level spectra from measurements of surrogate vessels, including FPSO, drill ship, pipelaying vessel, tugs, and support vessels, were adjusted to the specifications of the proposed Project vessels. Surrogate vessels were chosen based on the similarity in vessel specifications and types of operation.

Underwater sound propagation (i.e., transmission loss) was modeled with JASCO's MONM and FWRAM[4]. 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 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 received sound level reported at each point in the horizontal plane is the maximum predicted sound level over all modeled depths for that point.

[27] Airgun Array Source Model

[28] Marine Operations Noise Model

29 Full Waveform Range-dependent Acoustic Model

[30] PTS is a sound-induced impact that results in a permanent loss in hearing sensitivity due to destruction of sensory cells in the inner ear. This damage can be caused by long-term exposure to sound or acoustic trauma (https://www.osha.gov/dts/osta/otm/noise/health_effects/effects.html).

Based on these reported sound levels in the horizontal plane, two distance parameters were reported for each threshold:

- R_{max}, maximum horizontal distance from the source where the predicted sound level reaches the threshold; and
- R95%, maximum horizontal distance from the source where the predicted sound level reaches the threshold after the 5% of the predicted threshold-exceeding area farthest from the source is excluded. Regardless of the geometric shape of the "maximum-over-depth" footprint, R95% is the predicted range encompassing at least 95% of the area (in the horizontal plane) that would be exposed to sound at or above the threshold.

Six scenarios were considered in this modeling study, which include:

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, and
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 subsea flowlines and risers, at Drill Center 2-P, approximately 13 km (~8 mi) 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 the document *Underwater Sound Associated with Liza Phase 1 Project Activities* (JASCO, 2016).

Underwater Sound Criteria

No regulations regarding underwater sound exist for Guyana. Accordingly, in the absence of any such limits, auditory impacts of the Project 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 7-23).

Table 7-23 Acoustic Threshold Levels for Onset of Permanent Threshold Shifts (PTS) in Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs)

Marine Mammal Hearing Group	Estimated Auditory Bandwidth	PTS Onset Acoustic Thresholds (Injury Criteria)			
		Impulsive		Non-impulsive	
		Peak Sound Pressure Level (unweighted) (dB peak)	Sound Exposure Level (SEL) (M-weighted) (SEL_{24h}; dB re 1 μPa².s)	Peak Sound Pressure Level (unweighted) (dB peak)	Sound Exposure Level (SEL) (M-weighted) (SEL_{24h}; dB re 1 μPa².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
MFC (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz	230	187	Not available	199

Hz = hertz, kHz = kilohertz, dB = decibel; SEL = sound exposure level, 24h = 24 hour exposure, μPa = micro Pascal, s = second, m = meters

Modeling Results

Tables 7-24 to 7-29 present the above-referenced distance parameters describing modeled horizontal distances to PTS onset acoustic thresholds for LFCs and MFCs, according to Southall et al. (2007) and Finneran (2015) criteria, for the Scenarios 1 to 6, respectively. Decommissioning activities are currently not included in the scope for underwater sound modeling. Activities during the decommissioning stage would be similar to those of installation activities in terms of types of sound sources (i.e., marine vessels only). However, decommissioning activities would 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 less than or similar to those of the installation scenario (Scenario 3).

The results presented in the tables below account for embedded underwater control measures. Specifically, EEPGL will utilize the following embedded underwater sound control measures for the Project (see Section 2.11):

- Gradually increasing intensity of seismic impulses to allow sensitive species to vacate the area before injury occurs (i.e., soft starts), use of Marine Mammal Observers (MMOs) during VSP, and implementation of other measures recommended by the Joint Nature Conservation Committee (JNCC, 2010), 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 7-24 Modeled Horizontal Distances to PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs): 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 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	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

SEL = sound exposure level, 24h = 24 hour exposure, dB = decibel, μPa = micro Pascal, s = second, m = meters, Rmax = the maximum distance from the source at which the given threshold is predicted in the modeled maximum-over-depth sound field over all azimuths; R95% = the maximum distance from the source at which the given threshold is predicted in the modeled maximum-over-depth sound field over all azimuths, after the 5% of the threshold-exceeding area farthest from the source is excluded.

Table 7-25 Modeled Horizontal Distances to PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs): 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 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 $\mu Pa^2.s$)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	215	<5	<5	207	<5	<5
Mid-frequency cetaceans	215	No value	No value	199	--	--

Source: JASCO, 2016

SEL = sound exposure level, 24h = 24 hour exposure, dB = decibel, μPa = micro Pascal, s = second, m = meters, R_{max} = the maximum distance from the source at which the given threshold is predicted in the modeled maximum-over-depth sound field over all azimuths; $R_{95\%}$ = the maximum distance from the source at which the given threshold is predicted in the modeled maximum-over-depth sound field over all azimuths, after the 5% of the threshold-exceeding area farthest from the source is excluded

"---" = predicted sound levels at all locations are below injury criteria in the mid-frequency range

Table 7-26 Modeled Horizontal Distances to PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs): 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 μPa².s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa².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

SEL = sound exposure level, 24h = 24 hour exposure, dB = decibel, μPa = micro Pascal, s = second, m = meters, R_{max} = the maximum distance from the source at which the given threshold is predicted in the modeled maximum-over-depth sound field over all azimuths; $R_{95\%}$ = the maximum distance from the source at which the given threshold is predicted in the modeled maximum-over-depth sound field over all azimuths, after the 5% of the threshold-exceeding area farthest from the source is excluded

"---" = predicted sound levels at all locations are below injury criteria in the mid-frequency range.

Table 7-27 Modeled Horizontal Distances to PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs): Scenario 4 – Operation of a Vertical Seismic Profiler

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 μPa².s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa².s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	73	68	192	39	36
Mid-frequency cetaceans	198	35	32	187	--	--

Table 7-28 Modeled Horizontal Distances to PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs): 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 μPa².s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 μPa².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

Table 7-29 Modeled Horizontal Distances to PTS Onset Acoustic Thresholds for Low-Frequency Cetaceans (LFCs) and Mid-Frequency Cetaceans (MFCs): 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 µPa².s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted) (SEL_{24h}; dB re 1 µPa².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

NV – No value

Modeling results for the six scenarios are presented 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 – Marine Vessels during FPSO Operations

Modeling predicted that non-impulsive underwater sound for Scenario 1 would attenuate to PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 6 and <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 PTS onset acoustic thresholds for LFCs at a maximum horizontal distance of <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 PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 9 and <5 meters, respectively (based on the more conservative injury criteria for the marine mammal hearing groups).

Scenario 4 – Vertical Seismic Profiler during Drilling and SURF Installation

Modeling predicted that impulsive underwater sound from the VSP for Scenario 4 would attenuate to PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 73 and 35 meters (~240 and ~115 ft), 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 PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 1,300 and 762 meters (~4,270 and ~2,500 ft), respectively (based on the more conservative injury criteria for the marine mammal hearing groups). These maxima occur at depths of greater than 1000 meters.

Scenario 6 – Pile Driving during FPSO Installation

Modeling predicted that impulsive underwater sound for Scenario 6 would attenuate to PTS onset acoustic thresholds for LFCs and MFCs at maximum horizontal distances of 1,375 and 725 meters (~4,510 and ~2,380 ft), respectively (based on the more conservative injury criteria for the marine mammal hearing groups). These maxima occur at depths of greater than 1000 meters.

Summary of Potential for Injury Due to Underwater Sound

Modeling results indicate sound levels from vessels and the VSP are insignificant compared to the predicted sound levels from impact pile driving. The distances to injury thresholds for both LFCs and MFCs would be determined by sound from pile driving both at the FPSO and the drill center(s), although the area within which injury could potentially occur would be over 40% smaller for MFCs than for LFCs. Regardless of which type of pile installation methodology (impact driven or suction) is used, neither group of marine mammals would be expected to result in a population-level impact. Based on the premise that marine mammals would actively avoid physical discomfort associated with Project-related sound, if impact-driven piles are used MFCs would be expected to generally avoid the area within at least ~700 m from the location where pile driving is taking place and LFCs would be expected to generally avoid the area within at least ~ 1,400 m of the activity. Both categories of cetaceans would avoid these areas for the duration of the pile driving activity. Some species, including many of the larger baleen whales and dolphins would naturally avoid the area of potential effect (especially around Drill Center 2) because it would be deeper than their typical maximum dive depths. Others, such as sperm whales, dive deep enough that they could potentially be exposed to injurious sound levels throughout the PDA; however they would not be expected to dive to sufficient depths for a sufficient duration to be exposed to potential injury. 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, piling driving is not expected to cause permanent injury to marine mammals or irreversible effects on their hearing abilities.

Disturbance from Underwater Sound

Anthropogenic sounds below 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 major 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 (NMFS undated).

Although the above changes could occur in the PDA as a result of Project-generated sound, findings from US territorial waters suggest that the population-level significance of disturbance from impulsive sound over a small area such as the PDA would 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." (NMFS, 2006). BOEM found that despite over 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. Therefore, individual animals may divert around an operating pile driver or VSP to avoid Project-generated sound, but no significant impacts to life functions or potential population-level implications from underwater sound are expected.

Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges would begin during the drilling and installation stages and continue into the decommissioning stage. As described in Section 7.1.4, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, marine mammals would be transient in the PDA and their exposure to any discharges would be very limited. Any impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone.

Impacts from Artificial Lighting

Artificial lighting is not known to directly attract or disturb marine mammals, so any 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.

Summary of Impact Significance Ratings

As discussed in Section 7.2.1, because one of the marine mammals observed in the PDA is listed as Vulnerable by IUCN, the impact assessment was conducted with the conservative assumption that this Vulnerable species (i.e., sperm whale) would be the receptor for the potential impact. Accordingly, the sensitivity rating definitions used for special status species (Table 7-30) was used for all potential impacts.

Table 7-30 Definitions for Receptor Sensitivity Ratings for Impacts to Special Status Species

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 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.

Considering the description of potential impacts above, Table 7-31 summarizes the impact magnitude and receptor sensitivity ratings for each potential impact, together with the rationale for the ratings.

Table 7-31 Impact Magnitude and Receptor Sensitivity Ratings - Marine Mammals

Key Potential Impact	Sensitivity Rating	Magnitude Rating	Rationale for Magnitude Ratings
Injury and mortality from vessel strikes	Medium	Negligible	Although vessel traffic will be substantial during installation, the likelihood of a collision event with an Project vessel would be mitigated due to embedded controls such as standing instructions to vessel operators, low vessel operating speeds and typical marine navigation good practices. Accordingly, the magnitude of impact considering embedded controls is considered to be Negligible.
Injury (PTS) from underwater sound	Medium	Negligible	With no control measures in place, magnitude ratings for VSP and pile driving would be Medium based on the predicted extent of impact zones; however the Negligible magnitude rating is based on several factors, including:

Key Potential Impact	Sensitivity Rating	Magnitude Rating	Rationale for Magnitude Ratings
			• The activity that presents the greatest risk of injury to marine mammals (pile driving) would only occur during the initial stages of the installation phase and at great depth and therefore represents a short term risk to mammals. • 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. • Many marine mammals do not dive to the depths that would be required or remain submerged for sufficient time to be exposed to impacts above injury thresholds, especially near Drill Center 2. • 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	Medium	Medium	The potential impact zone for disturbance effects is expected to be larger than the extent for potential injury effects; accordingly, the magnitude of potential impact is considered Medium.
Impacts from permitted discharges	Medium	Negligible	Permitted discharges will be treated as needed prior to discharge and will reduce in concentration rapidly with increasing distance from the discharge point. The magnitude is therefore considered Negligible.
Impacts from artificial lighting	Positive	Positive	Impacts to marine mammals from Project lighting are considered to be Positive, due to the potential for attraction of food sources and no documented adverse effects on marine mammals from lighting.

Table 7-32 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	Injury from vessel strikes	Negligible	Medium	Negligible	None	Negligible
	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	Not applicable	Positive
Drilling and Installation	Injury from sound exposure	Negligible	Medium	Negligible	None	Negligible
	Disturbance from sound exposure	Medium	Medium	Moderate	None, but robust implementation of embedded controls (e.g., soft start procedures for VSP and pile driving)	Moderate

Based on consideration of all of the potential impacts on marine mammals assessed, the overall residual significance rating for potential impacts on marine mammals from planned Project activities is considered to be **Negligible** to **Moderate**.

7.2.6 Marine Turtles

7.2.6.1 *Introduction*

As described in Section 6.2.6, five sea turtle species are found in the 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.

7.2.6.2 *Relevant Project Activities and Potential Impacts*

As shown in Table 7-33, planned Project activities could potentially impact marine turtles through direct mortality (from vessel strikes), disturbance leading to changes in behavior (from underwater sound, lighting and/or actions from Project activities), and exposures to permitted discharges. Key potential sources of impact include impulsive sound from acoustic sources (VSP activity, driven piles) and non-impulsive sound from marine vessels (FPSO, drill ship, supply vessels, work vessels, barges, light installation vessels, pipelay vessels, multi service vessels, field intervention vessels, large crane vessels, and tug boats).

Table 7-33 Project Activities and Potential Impacts – Marine Turtles

Stage	Project Activity	Key Potential Impact
Drilling and Installation	Vessel operations	• Injury and mortality from vessel strikes. • Displacement from habitat to avoid disturbance from vessel activity.
	Power generation	• Displacement from habitat to avoid disturbance from vessel activity.
	VSP and pile driving	
	ROV operations	
	Lighting on drill ship and installation vessels	• Disturbance leading to reduced fecundity.
	Permitted drill cuttings and fluids discharge	• Exposures to permitted discharges, potentially leading to toxicological or metabolic 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.
	Permitted cooling and produced water discharge	• Exposures to permitted discharges,

Stage	Project Activity	Key Potential Impact
	Other permitted liquid waste discharge	potentially leading to toxicological or metabolic impacts.
	Lighting on FPSO	• Disturbance leading to reduced fecundity.
Decommissioning	Decommissioning vessels, ROVs	• Injury and mortality from vessel strikes. • Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts. • Displacement from habitat to avoid disturbance from vessel activity.

7.2.6.3 *Characterization of Impacts*

Injury and Mortality from Vessel Strikes

Collisions with vessels can injure or kill marine turtles. Sea 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. Sea 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 and reduced opportunity to maneuver in shallow water. 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 vessel entering/exiting shorebases; the anticipated options for shorebases are all located over 100 km away from the nearest portion of the SBPA, where most sea turtle nesting in Guyana occurs. 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 shorebases. 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 and mortality from vessels strikes, EEPGL will utilize the following embedded control measure for the Project (see Section 2.11):

- 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.

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 Hz (Bartol and Musick, 2003). Startle responses to sudden sounds have also been observed in sea turtles. For example, McCauley et al. (2000) found that turtles showed behavioral responses to approaching seismic survey sound at approximately 166 dB re 1 uPa, and more significant disturbance at 175 dB re 1 uPa. Startle responses and other behavioral changes are more likely from high level pulsed sound sources such as those produced during VSP activities and pile driving, rather than from non-pulse sources such as those from vessels.

Since turtles have been shown to respond to low frequency sounds, modeling results pertinent to low-frequency cetaceans (LFCs) (see Section 7.2.5) were used as a proxy for injury predictions for marine turtles. Modeling predicted that impulsive underwater sound from VSP and pile driving activities would attenuate to PTS onset acoustic thresholds for LFCs at maximum horizontal distances of 73 and 1,300 meters (~240 and ~4,270 ft), based on the more conservative injury criteria for the LFC marine mammal hearing group.

Dive-profile data from tagged Kemp's ridleys showed that they spent an average of 97 percent (day) or 87 percent (night) of their time within 1 m of the surface, and observational records suggest that most sea turtles show a similar pattern. The VSP source for the Project will be located within 5 m of the ocean surface, so marine turtles may be present at the same general depth as the source. However, since the sound pressure field is zero at the surface, the sound levels in excess of the proxy injury threshold will be limited to depths well below the zone where marine turtles will typically be present. While the horizontal extent of the modeled potential impact zone is significantly larger for pile driving than for VSP, turtles are not known to dive a sufficient depth (>1000 m) to enter the zone within which PTS would occur as a result of pile driving. The only low frequency sound that marine turtles could potentially be exposed to, other than VSP and pile driving, would derive mainly from vessels operating in the Project area, and vessel sounds will decrease below the threshold for injury to LFCs at 5 to 6 meters from the source. At that range, injury from a collision with the vessel poses a more likely risk to a marine turtle than injury from sound.

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 sea turtles and turtles do not vocalize or use sound for communications, so the potential risk of impacts from masking is considered insignificant.

The highest potential for auditory impacts on marine turtles will occur during VSPs, and the use of marine observers to detect sea turtles and soft start techniques will further reduce the risks to sea turtles when VSPs are occurring.

With respect to the potential for injury from underwater sound, EEPGL will utilize the following embedded underwater sound control measures for the Project (see Section 2.11):

- 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 (although use of MMOs is more effective for identification of marine mammals, these individuals can also detect marine turtles depending on weather conditions, and they will be tasked with observing for marine turtles as well) and implementation of other measures recommended by the Joint Nature Conservation Committee (JNCC, 2010), 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

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 PDA. Marine turtles are not known to be sensitive to human activity while at sea, so this increase in human activity is expected to have little or no impact on them within the PDA. Project activity related to potential disturbance would decrease during the production operations phase, so impacts on sea turtles would decrease as well. There would be a small increase in human activity during decommissioning, but that increase would be of relatively short duration and would not rise to the same level of activity associated with drilling and installation. In summary, disturbance from human activity would be expected to have little to no impact on marine turtles throughout the duration of the Project.

Exposure to Permitted Discharges

The Project will involve routine, permitted discharges of waste streams to the sea. These discharges would begin during the drilling and installation stage and continue into the decommissioning stage. As described in Section 7.1.4, these discharges will be treated (as needed) in accordance with industry guidelines. Furthermore, sea turtles would be transient in the PDA and their exposure to any discharges would be very limited. Any impacts would be expected to be acute and recovery would be expected to occur quickly after the affected individual(s) exit the mixing zone.

Disturbance to Nesting from Artificial Lighting

Sea turtles are known to be sensitive to artificial light in close proximity to nesting beaches, because artificial light can cause a variety of impacts on the behavior of nesting turtles and hatchlings including 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 significant impacts on marine turtles because sea turtles are not known to be sensitive to artificial light in the open ocean and the PDA is located so far offshore that light from the PDA will not be visible from the shore.

Summary of Impact Significance Ratings

As discussed in Section 7.2.1, because the marine turtles occurring in the PDA carry listings of Critically Endangered, Endangered, or Vulnerable by IUCN, the impact assessment was conducted with the conservative assumption that the Critically Endangered or Endangered species (i.e., Hawksbill, green, loggerhead) would be the receptor for the potential impact. Accordingly, the sensitivity rating definitions used for special status species (Table 7-34) was used for all potential impacts.

Table 7-34 Definitions for Receptor Sensitivity Ratings for Impacts to Special Status Species

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 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.

Table 7-35 summarizes the impact magnitude and receptor sensitivity ratings for marine turtles. Table 7-36 summarizes the potential impact significance ratings for marine turtles, based on the discussion presented above. The impact significance ratings were assigned based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Based on consideration of all of the potential impacts on marine turtles assessed, the overall residual significance rating for potential impacts on marine turtles from planned Project activities is considered to be **Negligible** to **Minor**.

Table 7-35 Impact Magnitude and Receptor Sensitivity Ratings - Marine Turtles

Key Potential Impact	Sensitivity Rating	Magnitude Rating	Rationale for Ratings
Injury and mortality from vessel strikes	High	Small (drilling and installation) Negligible (other Project stages)	Although vessel traffic will be substantial during installation, the likelihood of a collision event with a Project vessel would be mitigated due to embedded controls such as standing instructions to vessel operators, low vessel operating speeds, and typical marine navigation good practices. The magnitude of impact considering embedded controls is considered to be Small during drilling and installation (when higher vessel traffic level will occur) and Negligible during other stages.
Injury (PTS) from underwater sound	High	Negligible	Sea turtles spend most of their time within a few meters of the sea surface where the intensity of sound from VSP will be highest, but sound from pile driving will be lowest. Considering the relatively small size of the PTS radius surrounding the VSP and the embedded controls described above, the likelihood of marine turtle exposure to sound levels above injury thresholds is low, resulting in an overall magnitude rating of Negligible.
Displacement from habitat to avoid disturbance from vessel activity	Low	Small	Increased activity in the PDA and between the PDA and shorebases, could cause turtles approaching nesting beaches from the northeast to deviate from their normal migration route, but marine turtles are not known to be sensitive to human activity while at sea. Accordingly, sensitivity is considered Low; this is used in lieu of the special status rating based on the lack of an anticipated sensitivity. The increase in vessel traffic between the shorebases and PDA could cause general avoidance in the nearshore area, but would represent an incrementally insignificant increase in total vessel traffic in the area.
Impacts from permitted discharges	High	Negligible	Permitted discharges will be treated as needed prior to discharge and will reduce in concentration rapidly with increasing distance from the discharge point. The magnitude is therefore considered Negligible.
Disturbance to nesting from artificial lighting	Low (open ocean) High (on or near shore)	Small (open ocean) Negligible (on or near shore)	Adults and newly hatched turtles are highly sensitive to artificial light in the immediate proximity to nesting beaches, but much less sensitive while offshore. Accordingly, an overall sensitivity rating of Low for the open ocean and Medium for the nearshore environment was assigned; the open ocean rating is used in lieu of the special status rating based on the lack of an anticipated sensitivity for this impact. Project vessels will constitute a source of light that is distinct from the surrounding environment, yielding a magnitude rating of Small for the offshore environment. The PDA is located so far offshore that light from the PDA will not be visible from the shore, yielding a magnitude rating of Negligible for the nearshore environment.

Table 7-36 Summary of Impacts Significance Ratings and Recommended Mitigation Measures - Marine Turtles

Stage	Key Potential Impact	Sensitivity Rating	Magnitude Rating	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project Stages	Disturbance from offshore lighting	Low to Medium	Small to Negligible	Negligible	None	Negligible
Drilling and Installation	Injury from vessel strikes	Medium	Small	Minor	None	Minor
	Injury from sound exposure	Low	Negligible	Negligible	None	Negligible
	Displacement from habitat to avoid disturbance from vessel activity	Low	Small	Negligible	None	Negligible
	Exposures to permitted discharges (elevated TSS concentrations, liquid effluent discharges containing various chemical substances, discharge of hydrotesting fluids)	Low	Negligible	Negligible	None	Negligible
Production Operations; Decommissioning	Injury from vessel strikes	Medium	Negligible	Negligible	None	Negligible
	Injury from sound exposure	Low	Negligible	Negligible	None	Negligible
	Displacement from habitat to avoid disturbance from vessel activity	Low	Negligible	Negligible	None	Negligible
	Exposures to permitted discharges (liquid effluent discharges containing various chemical substances, and elevated temperature streams)	Low	Negligible	Negligible	None	Negligible

7.2.7 Marine Fish

7.2.7.1 Introduction

This section describes the potential impacts of the Project 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 ship, and major installation vessels.

Marine Fish receptors will include pelagic and demersal marine fishes. These groups include a combination of migratory and resident species. Some receptors will receive a larger proportion of certain impacts than others. For example, surface dwelling pelagic fish will potentially experience greater water quality impacts related to planned discharges than will bottom-dwelling species, and bottom dwelling species will be more impacted by changes in physical habitat structures than pelagic species.

7.2.7.2 Relevant Project Activities and Potential Impacts

Table 7-37 summarizes the Project stages and activities associated with each potential impact assessed. The highest number of impacts would be expected to occur during the initial stages of the Project, when most habitat-disturbing activities take place and human/vessel activity in the PDA will be highest. At this stage, 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 return to equilibrium and most of the ongoing impacts will be isolated to the upper portions of the water column and to the pelagic segment of the fish community.

Table 7-37 Project Activities and Potential Impacts – Marine Fish

<table>
<tr><th>Stage</th><th>Project Activities</th><th>Key Potential Impact</th></tr>
<tr><td rowspan="4">Drilling and Installation</td><td>Drilling operations and VSP</td><td rowspan="4">• Gill fouling and reduced visibility caused by TSS.
• 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 or metabolic impacts.</td></tr>
<tr><td>Artificial lighting on drill ship and major installation vessels</td></tr>
<tr><td>Installation of FPSO moorings and SURF equipment, including pile driving</td></tr>
<tr><td>Permitted liquid waste discharge</td></tr>
</table>

Stage	Project Activities	Key Potential Impact
	Permitted drill cuttings and fluids discharge	
Production Operations	Permitted liquid waste discharge (primarily cooling water and chlorinated effluent)	• Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts.
	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 (TSS). • Permanent loss of structural habitat (FPSO only) and artificial light due to decommissioning.
	Permitted liquid waste discharge	• Exposures to permitted discharges, potentially leading to toxicological or metabolic impacts.

7.2.7.3 *Discussion of Potential Impacts*

Changes in the Distribution of Fish Due to Altered Water Quality

The Project will routinely discharge several waste streams to the sea. These discharges would begin during the drilling and installation stages and continue into the decommissioning stage.

Two discharges unique to the drilling and installation phases will be discharges of drilling fluids and cuttings. For the initial well sections which will use WBDF, the cuttings and fluids will be discharged either at the seafloor, causing turbidity around the immediate vicinity of each well, or from the drill ship. For subsequent well sections, cuttings and residual drilling fluids will be discharged from the drill ship. For discharges from the drill ship, turbidity plumes will impact a larger area as the cuttings fall through the water column, but the turbidity plume will be diluted across a larger area, thereby reducing impacts in any single location. Fish will be expected to generally avoid these turbidity plumes while drilling is occurring, reducing respiratory impacts associated with gill fouling, but would be 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 7.1.4, most of the planned discharges that would occur during production operations are not known to have negative impacts on marine life or would occur at negligible volumes, but the increased temperature and chlorine concentrations in the cooling water discharges were identified as having the potential to negatively impact marine life. 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). Under the conservative assumptions described in Section 7.1.4, localized sea surface temperatures are expected to increase as a result of the Project, but these increases are predicted to diminish to 3 ˚C above ambient temperatures within 100 m (~330 ft) horizontal distance from the discharge outlet. This finding indicates that within 100 m (~330 ft) of the FPSO, the thermal impact of routine discharges would 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 would occur near the surface in the PDA. Pelagic species would be much more likely to move away from a thermal mixing zone that exceeds their optimum range than would structure-oriented species, so not only would thermal impacts affect a very small area of the ocean surface but the species that occur within the PDA would 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. There are no regulatory limits for residual chlorine in marine discharges in Guyana. Chlorine toxicity depends not only on dosage (concentration and exposure time) but also on individual species' sensitivity to chlorine. This makes defining a single impact threshold for chlorine exposure difficult. While chlorine concentrations within the immediate vicinity of the FPSO could exceed levels that may result in toxicity impacts to fish (assuming the fish remained in the area long enough to experience the impact), concentrations are expected to decrease by approximately 89 percent within 100 m of the discharge point.

The combined impact of increased temperature and chlorine concentrations would 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 would be in the most direct contact with elevated temperatures and chlorine concentrations.

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 would be expected to negatively impact fish abundance in the immediate vicinity of the well heads, SURF, and drill ship during drilling and installation, the FPSO and tanker(s) during production operations, and the SURF during decommissioning, but would not be 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 7.2.1), but they will likely cause limited 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 abundance of certain fish species, even under slightly impaired water quality conditions. The net impact in this case is often a 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 would be expected to be acute, and affected individuals would be expected to recover quickly after exiting the mixing zone.

Auditory Impacts to Fish from Vessel Activity, Vertical Seismic Profiling, and Pile Driving

The same sound sources associated with the Project that could impact marine mammals (Section 7.2.5) could also impact 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[31] 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 recent 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 south eastern U.S. in 2014 (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 would actually occur is highly dependent on the hearing abilities and sensitivities

[31] 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 specialists are distinguished from hearing generalists, which hear equally well across a wider range of frequencies, but do not possess the acuity of the specialists within their specific frequency range.

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 rating Project-related auditory impacts on fish because of the following:

- 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[32] than others 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; and
- As described in Section 7.1.2, impulsive sound from driven piles and VSP would 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 1µPa with onset/decay times less than 1 ms. Turnpenny and Nedwell (1994) reviewed historical studies of seismic impacts on fish and determined that for exposures at close range (<10 m) transient behavioral impacts began appearing at 192 dB re 1µPa, a variety of injuries appeared at about 220 dB re 1µPa, and mortality began appearing at exposures above 230 dB re 1µPa, although these impacts did not always occur and some exposures up to 240 dB re 1µPa 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 would be expected to be most severe in resident fish that are oriented to structural bottom habitats and would therefore be exposed to repeated impulses at a given location over time. One such genus (*Sebastes spp*)., showed startle and alarm responses to 10-min exposures of seismic impulses at 180 dB re 1 µPa at ranges from 11m 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

[32] 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.

between 195-218 dB re 1µPa at ranges of 5.3-109 m (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 180-195 dB re 1 µPa, and that injury could occur at peak sound pressures around 220 dB re 1 µPa.

Given the most sensitive receptors do not always experience impacts from impulsive sound, they usually recover from such impacts, and impulsive sound would 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 7.2.1).

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, but fouled gills can lead to respiratory distress over long exposures. The turbidity plumes are expected to dissipate rapidly downcurrent, and fish will be 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 would be expected to return to the vicinity of the Project subsea infrastructure once seafloor disturbance activities are complete.

Some of the deepwater species from the "red fish" zone and all of the reef-associated species identified in the McConnell study (Section 6.2.7) 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 would be 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 in the Project AOI 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 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 discussion in Section 7.2.1), but they will cause small changes in the distribution and composition of the fish community within the PDA.

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 floodlights on offshore petroleum infrastructure (Hastings et al. 1976, Stanley & Wilson 1997, Lindquist et al. 2005). Results from studies of platforms in the northern Gulf of Mexico suggest that platforms benefit all life stages 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; Nightingale et al., 2103). The artificial light produced from vessels will not be substantial enough to alter fish populations, nor will it significantly impact sensitive or important species (see discussion in Section 7.2.1), but 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. .

Entrainment in Water Intakes

Seawater will be withdrawn from the ocean to provide water to inject into the reservoir, to cool the FPSO's processing equipment during the production operations stage, and for ballast of 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 and has been 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) and 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). Cooling and ballast water intakes on the FPSO and drill ships will be equipped with screens to prevent fish entrainment. Entrainment will not significantly impact sensitive or important species (see discussion in Section 7.2.1).

7.2.7.4 *Characterization of Impacts*

Magnitude of Impact

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 7-38.

Table 7-38 Definitions for Magnitude Ratings for Potential Impacts to 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 change in and recovery of the population (or another dependent on it) is not possible either at all, or within several generations due to natural recruitment (reproduction, immigration from unaffected areas).

The Project includes several embedded controls that will reduce the magnitude of impacts on marine fish, including:

- 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 <15 ppm (per MARPOL) for bilge water;
- Use of Water-Based Drilling Fluids (WBDF) and low-toxicity IOGP Group III NABF;
- Utilization of solids control and drill cuttings dryer systems to treat cuttings prior to discharge;
- Gradually increase intensity of seismic pulses during VSP and hammer energy (during pile driving) to allow sensitive species to vacate the area before injury occurs; and
- Provide screening on vessels for cooling water and ballast water intakes for FPSO and drill ship to minimize the entrainment of fish

Sensitivity of Receptor

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 7-39.

Table 7-39 Definitions for Receptor Sensitivity Ratings for Impacts to 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.

Impact Significance and Mitigation Measures

Table 7-40 summarizes the magnitude, sensitivity, and impact significance ratings for the potential impacts on marine fish discussed above. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-40 Summary of Impact Significance Ratings and Recommended Mitigation Measures - Marine Fish

Stage	Key Potential Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Auditory impacts on fish from vessel activity (pelagic species)	Small	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)	Small	Medium	Minor	None	Minor
	Exposure to permitted discharges (elevated TSS	Negligible	Low	Negligible	None	Negligible

Stage	Key Potential Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	concentrations, liquid effluent discharges containing various chemical substances, discharge of hydrotesting fluids)					
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

7.2.8 Marine Benthos

7.2.8.1 Introduction

This section describes the potential impacts of the Project on marine benthic biological resources. 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 in the cuttings) and as a result of disturbance of the seafloor during installation of Project components.

7.2.8.2 Relevant Project Activities and Potential Impacts

The PDA is located in the eastern portion of the Stabroek Block in water depths ranging from approximately 1500-1900 m. This area's macrofauna community is dominated by polychaete worms as the most abundant major taxonomic group, followed by crustaceans, mollusks, and other taxa. Benthic epifauna appear scarce on the basis of the EBS survey results; however, tube building polychaetes (possibly Sabellidae and Terebellidae) and burrowing shrimp were observed.

The Project has the potential to impact these organisms through smothering (from deposition of drill cuttings), toxicological impacts (from NABF adhered to deposited cuttings) and crushing or displacement (from placement of subsea infrastructure). These 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 provide small amounts of hard substrate available for colonization.

Table 7-41 summarizes potential Project impacts on marine benthos.

Table 7-41 Project Activities and Potential Impacts – Marine Benthos

Stage	Project Activity	Key Potential Impacts
Drilling and 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 NABF adhered to deposited drill cuttings. • Crushing of benthos where subsea infrastructure is placed.
Production Operations	Presence of (non-moving) infrastructure on seafloor	• Creation of artificial substrate for use by benthos, temporary for duration of production operations (positive).
Decommissioning	Presence (abandonment) of subsea infrastructure on the seafloor	• Creation of artificial substrate for use by benthos (positive).

7.2.8.3 *Characterization of Impacts – Drill Cuttings Deposition*

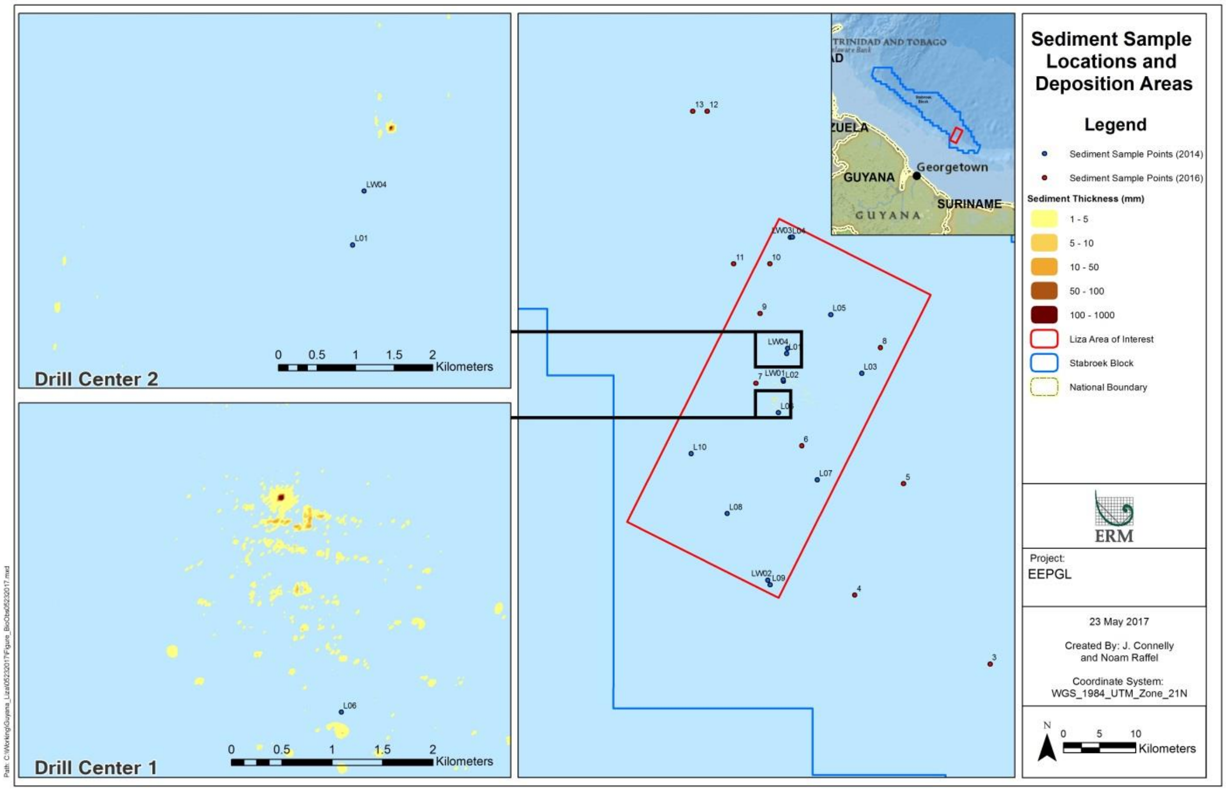
Magnitude of Impact – Drill Cuttings Deposition

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 cm per month for smothering impacts to benthic communities is recommended based on publications by Ellis and Heim (1985) and MarLIN (2011). Smaller threshold values as low as 1 mm have 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 7.1.3, modeling of drill cuttings discharges for four well/current combination scenarios indicated the maximum depositional thickness of cuttings on the seafloor is predicted to be between 19 cm and 75 cm, depending on currents and well locations. The model predicted extent of cuttings deposition above the 5 cm per month threshold will be confined to within a relatively short distance from the well locations, with the largest area predicted to be approximately 43 m (~141 ft) in diameter. Figure 7.6 depicts the maximum total accumulated cuttings as predicted by modelling in the vicinity of both drill centers.

Figure 7-6 Sediment Sample Locations and Deposition Areas



deposited cuttings over time, and additional (non-cutting) sediments will gradually mix with and overlay the cuttings, gradually returning the surficial sediment layer to a chemical state similar to existing conditions. Additionally, the NABF 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. Based on consideration of the above, the overall magnitude of drill cuttings deposition impacts on marine benthos was rated as **Negligible**.

Sensitivity of Receptor - 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 deep-sea 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.

With respect to toxicity impacts, contaminants deposited on the seafloor can pose risks to those deep-sea 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 and Mitigation Measures – Drill Cuttings Deposition

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for impacts on marine benthos from drill cuttings deposition. Based on this rating, no mitigation is recommended.

7.2.8.1 *Characterization of Impacts – FPSO and SURF Installation*

Magnitude of Impact – FPSO and SURF Installation

The shallow sediment layer would 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. With respect to installation impacts, as indicated in Table 7-42, which summarizes the area that will be disturbed by installation of various infrastructure components, approximately 390,000 m² (30 ha, ~74 acres) (incorporating a 50 percent contingency factor) will be subject to essentially one-time disturbance by the installation activity. The use of anchors by vessels other than the FPSO is not expected; other vessels will utilize dynamic positioning to maintain station offshore.

Table 7-42 Area of Benthic Habitat Disturbed by FPSO and SURF Subsea Infrastructure Installation

Equipment	Quantity	Unit Area / Width	Subtotal (m²)
Trees	17	21 m²	357
Flying Leads	2,474 m	1 m width	2,474
Production Manifolds	2	12.5 m²	25
Flowline Structures	5	70 m²	350
Flowlines	29,809 m	3 m width	89,427
Water Injection (WI) Manifolds	2	12.5 m²	25
WI Pipeline Structures	2	70 m²	140
WI Pipeline	16,491 m	3 m width	49,473
Gas Injection (GI) Manifolds	1	12.5 m²	13
GI Pipeline Structures	1	70 m²	70
GI Pipeline	4,352 m	3 m width	13,056
Production Umbilical	13,168 m	3 m width	39,504

Equipment	Quantity	Unit Area / Width	Subtotal (m²)
Injection Umbilical	4,259 m	3 m width	12,777
Subsea Distribution Units (SDUs)	4	40 m²	160
FPSO Anchor Piles and Chains	16	250 m²	4,000
FPSO Mooring Leg Prelay	16	3000 m²	48,000
		Subtotal	259,851
		Total w/~50% Contingency	390,000

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 Stabroek Block (approximately 0.001 percent by area).

From a benthic population standpoint, this leads to an impact magnitude rating of **Negligible**.

Sensitivity of Receptor - 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.

Impact Significance and Mitigation Measures – FPSO and SURF Installation

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for impacts on marine benthos from FPSO and SURF installation. Based on this rating, no mitigation is recommended.

7.2.8.2 *Characterization of Impacts – Presence (and Abandonment) of Subsea Infrastructure*

Magnitude of Impact – Presence (and Abandonment) of Subsea Infrastructure

As described in Section 2.12, 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. 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. These effects will occur over a small area of the direct AOI. The magnitude of the net effect on marine benthos will be **Small**.

This positive impact is also relevant for the production operations stage, as benthic organisms will have the opportunity to colonize elements of subsea infrastructure which remain stationary through the production operations stage. These positive impacts will be temporary for any infrastructure that is removed at the time of decommissioning.

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 would 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 and Mitigation Measures – Presence (and Abandonment) of Subsea Infrastructure

These magnitude and sensitivity ratings lead to a significance rating of **Negligible** for impacts on marine benthos from the presence and subsequent abandonment of subsea infrastructure. Based on this rating, no mitigation is recommended.

7.2.8.3 *Summary of Impact Significance Ratings*

Table 7-43 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on marine benthos, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-43 Marine Benthos - Pre-Mitigation and Residual Impact Significance Ratings

Stage	Key Potential Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation	Smothering and/or toxicity impacts Injury or disturbance	Low	Negligible	Negligible	None	Negligible
Production Operations Decommissioning	Marine benthos – from creation of artificial substrate	Low	Positive	Negligible	None	Negligible

7.2.9 Ecological Balance and Ecosystems

7.2.9.1 *Introduction*

This section describes the potential impacts of the Project on the key components and functions of the marine ecosystem. For over 30 years, the US National Oceanographic and Atmospheric Administration (NOAA) has used 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 ha or ~80,000 mi^2) or greater, adjacent to the 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. Its width varies, but it extends roughly 500 km (~300 mi) off the coast of Guyana (NOAA, 2016).

7.2.9.2 *Discussion of Potential Impacts*

All of the Project activities are broadly relevant to an assessment of impacts on ecological balance and ecosystems because the potential impacts will occur within the ecosystem and could impact one or more of its components. 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 impacts identified in Sections 7.2.1 through 7.2.8 that could 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.

Changes in the 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 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 7.1.4, the Project is predicted to have negligible impacts on water quality, and these impacts are predicted to be limited to a relatively small, localized mixing zone around the FPSO. These impacts are likely to reduce nutrient uptake by phytoplankton within the mixing zone, but based on the significance of water quality impacts as assessed in Section 7.1.4 and the very small portion of the North Brazil Shelf LME that would be exposed to these impacts, the Project is predicted to have little if any ecosystem-level impacts on nutrient cycling.

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 impacted large scale current patterns or prevented 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.

Impacts on Biodiversity

The Project is predicted to have numerous impacts 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 SURF components and some pelagic species may be locally displaced from the surface mixing zone that will form around the wastewater outfall, but these impacts would 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 exacerbate any of the risk factors that have contributed to the listing of the special status species assessed in Section 7.2.1.

Ballast Water and Invasive Species

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 of these organisms may survive and establish themselves in the new environment if the habitat conditions are suitable. The global movement of ballast water is considered to be the largest transfer mechanism for marine non-indigenous species (Ruiz et al., 2005). If the non-indigenous species become invasive, they may cause serious 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 (ESMA, 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 2.5.8.4, ballast water will be required for FPSO transit from the shipyard to the site. Once on site, the unneeded ballast water from the FPSO may be discharged overboard. 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 500,000 barrels of ballast water would be discharged into Guyanese waters (Table 2-5) during this time. In order to mitigate the risk of invasive species, the ballast water taken on 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 similar to the conditions in the PDA, which means that at least some organisms discharged into the PDA would be likely to survive the event, but it also means that these organisms would 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 1,100,000 barrels of ballast water (Table 2-5) will be discharged during each loading. These ballast water discharges would be conducted in accordance with internationally recognized standards and in compliance with IMO requirements. The ecological effect would 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.

7.2.9.3 *Characterization of Impacts*

Magnitude of Impact

The Project's predicted ecosystem-level impacts are indirect impacts that would 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 from the potential impacts described above 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 would drive the indirect ecosystem-level impact. The magnitude of potential ecosystem-level impacts is defined according to the definitions provided in Table 7-44.

Table 7-44 Definitions for Magnitude Ratings for Potential Impacts to 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 7.2.9.1.

	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 7.2.9.1.
	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 7.2.9.1.

All of the embedded controls identified in Section 2.11 will minimize 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 the ecosystem.

Sensitivity of Receptor

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 7-45.

Table 7-45 Definitions for Receptor Sensitivity Ratings for Impacts to 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.

Impact Significance and Mitigation Measures

Table 7-46 summarizes the magnitude, sensitivity, and impact significance ratings for the potential ecosystem level impacts discussed above. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-46 Summary of Impact Significance Ratings and Recommended Mitigation Measures – Ecological Balance and Ecosystems

Stage	Resource / Receptor Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Nutrient uptake by phytoplankton; localized and temporary changes in species distribution	Low	Small	Negligible	None	Negligible
Production Operations	Marine biota that could be affected by invasive species introduced by ballast water	Low	Medium	Minor	None	Minor

7.3 Socioeconomic Environment

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 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. This general approach and methodology has been adapted for use in evaluating impacts to socioeconomic receptors. The evaluation criteria used to determine impact magnitude and sensitivity for specific socioeconomic receptors are summarized in Table 4-2.

Stakeholder engagement is critical to a robust impact assessment process. A range of stakeholders were interviewed to deepen ERM's understanding of the existing socioeconomic conditions (presented in Chapter 6). The information gathered was also used to inform the sensitivity and magnitude designations used in this assessment. The following socioeconomic resources 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
- Land use
- Ecosystem services
- Indigenous Peoples
- Cultural Heritage

7.3.1 Project Activities and Receptors

As the Project's primary activities are located more than 190 kilometers (~120 miles) offshore, impacts on socioeconomic resources as a result of planned Project activities are expected to be limited. The main Project activities[33] with potential to result in socioeconomic impacts are:

- Installation and operation of the FPSO and SURF
- Drilling of wells
- Government revenue generation from Project
- Project employment and procurement
- Worker presence in the Georgetown area

[33] Other Project activities considered in this assessment include discharges of process and waste waters; utilization of an FPSO marine exclusion zone; changes in land use; and aviation activities. However, impacts on socioeconomic conditions from these activities were considered negligible.

- Project use of emergency and health services in the Georgetown area
- Project use of roads and transportation services in the Georgetown area
- Marine vessel transit between the PDA and shorebase facilities in Guyana and Trinidad

Potential receptors for socioeconomic impacts during planned Project activities are outlined in Table 7-47, along with the rationale for their inclusion and the associated potential impacts:

Table 7-47 Socioeconomic Receptors and Potential Impacts as a Result of Project Activities

Receptor	Rationale for Inclusion	Potential Impacts
General Guyanese population	The Project could have far-reaching economic impacts throughout the country, which could impact 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 that offshore-based Project workers (those who are foreign) will be onshore will likely be spent in transit in Georgetown, where they will interact with and make use of the same resources and infrastructure as the local population. Project procurement and increased worker spending level may result in higher demand for goods and services. The Project may result in induced influx of job-seekers from other areas of Guyana to the Georgetown area. 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.	• Changes to community dynamics, identity, and sense of safety/security. • Increased cost of living. • Increased risk of communicable disease transmission. • Decreased accessibility or quality of medical and health service.
Road users in Georgetown (both motorized and non-motorized [e.g., cyclists, pedestrians] modes)	The Project will use existing roads for transporting materials and equipment from warehouses or storage facilities to the Georgetown area shorebases.	• Increased traffic congestion. • Increased risk of property damage and injury due to 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 in Georgetown Harbour and coastal waters between Georgetown and the PDA. • Increased risk of marine accidents.
Marine vessel operators in the vicinity of the PDA	The Project will establish marine safety exclusion zones around the FPSO, drill ship, and major installation vessels, precluding use of this area for other activities such as fishing.	• Reduced availability of ocean areas for non-Project livelihood activities such as fishing.

Receptor	Rationale for Inclusion	Potential Impacts
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 historical sites.

7.3.2 Economic Conditions

7.3.2.1 *Introduction*

This section assesses potential Project impacts on economic conditions in the Project AOI. The key impacts considered for planned Project activities include: 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 extent and type of Guyanese employment and procurement opportunities are outside the scope of the EIA. Such considerations will be addressed as part of EEPGL's preparation of a local content plan consistent with the requirements of the petroleum agreement.

7.3.2.2 *Relevant Project Activities and Potential Impacts*

The Project would contribute directly and positively to increased national revenues through a petroleum agreement between EEPGL and the government. The Project would also benefit the economy through local procurement of select goods and services, limited direct local employment, and spending in local communities by Project workers.

In addition to direct expenditures and employment, the Project would also likely generate induced economic benefits as other non-Project related businesses benefiting from direct Project purchases or worker spending will re-invest locally or expand spending in the area, thereby also generating 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 the potential for cost of living to increase due to a higher demand for some goods and services, either through direct Project procurement or through Project worker purchases.

Potential impacts on economic conditions from the Project are summarized in Table 7-48.

Table 7-48 Project Activities and Potential Impacts – Economic Conditions

Stage	Receptor(s)	Project Activity	Key Potential Impacts
All Project stages	Guyanese population	Project revenue generation	• Potential government investment in social services and economic development/ diversification. • Potential government infrastructure projects.
		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.
		Project worker spending	
		Limited local employment (direct and indirect)	

7.3.2.3 *Magnitude of Impact - Economic Conditions*

The Project has the potential to impact economic conditions both positively and negatively. Project revenues to the government through its revenue sharing 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 select local Project procurement and through Project worker spending.

An 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.

Economic benefits of the Project are expected to outweigh potential negative impacts such that overall impacts on the economy are expected to be **Positive**. As described in Chapter 4, this assessment does not develop ratings for positive impacts.

7.3.2.4 *Sensitivity of Receptors - Economic Conditions*

The receptors most likely to be most impacted by impacts to economic conditions are residents in the Georgetown area. As discussed below, vulnerable (lower-income) populations are considered to be more sensitive to this impact and are therefore considered separately. Sensitivity of the receptors is determined based on the definitions in Table 7-49.

Table 7-49 Definitions for Receptor Sensitivity for Impacts to Economic 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 resource sectors. 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[34].

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 would 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.

7.3.2.5 *Impact Significance and Mitigation Measures - Economic Conditions*

As discussed above, this impact is considered to be **Positive**, for both the general population and the low-income subpopulation in the Georgetown area. As described in Chapter 4, this assessment does not develop significance ratings for positive impacts.

[34] According to the BSG, 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.

As this is a positive impact, no mitigation measures are required. To enhance the benefits from this positive impact, the Project intends to procure select Project goods and services locally to the extent reasonably practicable. While it is expected that the number of Guyanese workers will be small, the Project also intends to utilize Guyanese nationals where reasonably practicable.

Table 7-50 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on economic conditions, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-50 Economic Conditions – Pre-Mitigation and Residual Impact Significance Ratings

Phase	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	Guyanese population including lower income subpopulation - increased government revenues, increased employment, increased local business activity, potential for increased cost of living.	Not assessed	Medium High (lower socio-economic groups)	Positive	None	Positive

7.3.3 Employment and Livelihoods

7.3.3.1 *Introduction*

This section assesses potential Project impacts on employment and livelihoods in the Project AOI. The key impacts considered for planned Project activities are: potential increased local business activity and employment due to select Project employment and select Project procurement and due to Project worker spending; potential occupational health and safety impacts to Project workers; and potential for restricted access to fishing locations, and damage to fishing vessels and equipment from Project vessel movements.

The extent and type of Guyanese employment and procurement opportunities are outside the scope of the EIA. Such considerations will be addressed as part of EEPGL's preparation of a local content plan consistent with the requirements of the petroleum agreement.

7.3.3.2 *Relevant Project Activities and Potential Impacts*

The primary Project activities will occur approximately 190 kilometers (~120 miles) offshore and are not expected to significantly impact non-Project activities occurring on the Guyana coast. Project workers onboard the FPSO and other Project vessels may be exposed to occupational hazards which will be managed through training and the use of protective equipment as appropriate. The only direct planned Project activities that will be perceptible from the shore will be support vessel trips originating from and returning to shorebase facilities in Georgetown. In addition, the Project will engage select local companies for the provision of various goods and services (e.g., catering, transportation, logistics) to support Project activities. Table 7-51 summarizes potential Project impacts on employment and livelihoods.

Table 7-51 Project Activities and 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 coastal area	Transit of Project vessels between the PDA and shorebase(s) in Georgetown and in Guyanese waters between PDA and shorebase(s) in Trinidad and Tobago	• Damage to fishing vessels and equipment impacting fishing livelihoods

7.3.3.3 *Magnitude of Impact - Employment and Livelihoods*

The assessment of the Project's magnitude of 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 7-52.

Table 7-52 Definitions for Scale Ratings for Potential Impacts on Employment and Livelihoods

Criterion	Definition
Scale	Negligible: 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 the 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.

Few 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 therefore the FPSO marine safety exclusion zone will have little or no impact on existing current fishing activity. There is an emerging deepwater tuna fishery that may approach the southern boundary of the PDA, and abandoned fishing gear has been found entangled in the mooring lines for the metocean instruments described in Section 6.1.1.1. If this fishery continues to develop in the vicinity of the PDA, then the number of industrial fishing vessels affected by Project-related activities offshore may increase modestly in the future. Considering the small number of operators that are currently participating in this fishery, the uncertainty concerning the ultimate size of the fishery, and the relatively small area of ocean that would be affected, the magnitude of the Project-related impacts on industrial fishing operations is considered **Small**. As a mitigation measure, the Project intends to issue notices to mariners via MARAD, the 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 communicate major vessel movements to commercial cargo, commercial fishing, and subsistence fishing vessel operators 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.

The highest probability for Project interactions with fisherfolk would likely remain limited to encounters with support vessels transiting between the PDA and the shorebases in Georgetown and Trinidad and Tobago. This could result in some limited and temporary disruption to fishing activity. Unlike the deepwater industrial fisheries, the artisanal fisheries would not lose access to any fishing areas or be affected by expansion of oil and gas industry-related traffic into areas where it does not currently exist, however the increase in shipping traffic near the coast and within the Demerara Harbour carries a small increase in the potential for support vessels to cause damage to fishing vessels or equipment such as nets during transiting. 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. Considering the occasional and temporary nature of impacts on subsistence fishing activity from the Project-related marine traffic balanced with the above-mentioned limitations on the effectiveness of the measures proposed to manage these impacts, the magnitude of the impacts is considered to be **Small**.

In addition to direct employment, the Project will result in the indirect employment of workers through procurement of select local goods and services such as food, transportation, and logistical support. 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. This impact is considered to be **Positive** and as such, a magnitude rating is not assigned.

7.3.3.4 *Sensitivity of Receptors - Employment and Livelihoods*

Potential receptors for employment and livelihood impacts are the general population in Georgetown and its vicinity; subsistence and commercial fisherfolk as well as farmers operating on the Guyanese coast; and Project workers based offshore. The receptor sensitivity ratings for employment and livelihoods are defined according to the definitions provided in Table 7-53.

Table 7-53 Definitions for Receptor Sensitivity Ratings for Employment and Livelihood Impacts

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.

The Guyanese population continues to rely heavily on primary sector livelihoods such as agriculture and fisheries; however, the share of primary sector jobs has been decreasing steadily in favor of more secondary and tertiary (service) sector jobs. Based on the definitions above, the general Guyanese population is considered to have a **Medium** level of sensitivity to potential employment and livelihood impacts from planned Project activities. Fisherfolk engaging in fishing on the Guyanese coast are also considered to have a **Medium** level of sensitivity to such impacts.

7.3.3.5 *Impact Significance and Mitigation Measures - Employment and Livelihoods*

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of livelihood and employment impacts on fisherfolk operating in the coastal area is **Minor**. The significance of livelihood and employment impacts for Project workers based offshore is also **Minor**.

As discussed above, the positive impacts on employment and livelihoods that will result from Project employment, procurement, and worker spending will outweigh potential adverse impacts for an overall **Positive** impact. As discussed above, the Project will (as a mitigation measure) seek to enhance positive benefits by procuring select goods and services locally (potentially leading to enhanced local employment and livelihood benefits) to the extent reasonably practicable, and this has been considered as part of the **Positive** rating.

Beyond these mitigation measures, no additional mitigation measures for potential adverse impacts are necessary.

Table 7-54 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on employment and livelihoods, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-54 Employment and Livelihoods – Pre-Mitigation and Residual Impact Significance Ratings

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
	Fisherfolk - Impacts on fishing livelihoods (exclusion from PDA for commercial fishing operations; nearshore navigation and safety for subsistence fishing operations)	Small	Medium	Minor	None	Minor

7.3.4 Community Health and Wellbeing

7.3.4.1 *Introduction*

This section assesses potential impacts from the Project 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 from interactions with Project activities, and decreased availability of emergency medical and health services. Increased risks of marine and road accidents to the public are assessed in Section 7.3.5 and Section 7.3.6, respectively.

7.3.4.2 *Relevant Project Activities and Potential Impacts*

The Project will involve a range of activities that could potentially impact public 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. The potential for these impacts are limited due to the Project's limited onshore footprint.

Table 7-55 Project Activities and 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.
	Road users in Georgetown and vicinity Marine users in vicinity of Georgetown shorebase(s)	Project transportation (marine and road)	• Increased risk of vessel collisions and vehicle accidents (refer to assessments in section 7.3.5 and 7.3.6).

7.3.4.3 Magnitude of Impact - Community Health and Wellbeing

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 7-56.

Table 7-56 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.
	Small: Changes to health status occur in some individuals and households, but changes are minor, temporary and reversible without medical or public health intervention.
	Medium: Changes to health status occur at the population level and are reversible over time or with medical or public health intervention.
	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.

Population shifts caused by the influx of workers from other parts of the country or from foreign countries has 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 not known. 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, 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 one 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 impact is expected to be **Negligible**.

Increases in population, and the presence of transient populations has the potential to contribute to increased rates of crime. Georgetown has a high rate of crime, 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 would contribute significantly to local crime rates. Furthermore, the Project workforce will represent less than one percent of the population of Georgetown, and workers' onshore presence will be limited and occasional. As such, the magnitude of impact is expected to be **Negligible**.

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 that an offshore worker requires medical evacuation/referral onshore, a medical professional will be available 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 would be medically evacuated to a healthcare facility in Georgetown and potentially outside of Guyana, depending on the type of medical issue. Reliance on 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 Guyanese physician, 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 facilities will be limited, the magnitude of impact is therefore considered to be **Small**.

7.3.4.4 *Community Health and Wellbeing - Sensitivity of Receptors*

The receptors that could potentially experience health and wellbeing impacts as a result of planned Project activities are residents of Georgetown and its vicinity.

The receptor sensitivity ratings for community health and wellbeing are defined according to the definitions provided in Table 7-57 below.

Table 7-57 Definitions for Receptor Sensitivity Ratings for Community Health and Wellbeing Impacts

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.
	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.
	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 Guyanese population is in a transitional phase whereby both communicable and non-communicable diseases contribute considerably to the burden of illness and mortality. However, urban populations have measurably higher health status than rural populations, and are less likely to suffer from some communicable diseases such as malaria, lymphatic filariasis, and soil-transmitted helminths. 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 through the Georgetown Public Hospital Corporation (GPHC) and with assistance from Vanderbilt University had been established, with seven ambulances and 21 trained emergency medical technicians (EMTs). 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 transfer injured patients from mining areas in the hinterland and to respond to serious vehicle collisions that occur on Guyana's roads. Hospital capacity is also lacking; at this time the GPHC has 450 beds but requires about 600 to adequately serve the population (ERM Personal Communication 7).

Based on the definitions above, the population in Georgetown has a **Medium** level of sensitivity to community health and wellbeing impacts.

7.3.4.5 *Impact Significance and Mitigation Measures - Community Health and Wellbeing*

Based on the magnitude of impact and receptor sensitivity ratings, the significance of increased communicable disease risk is **Negligible**, while the significance of impacts on public safety is **Negligible** and impacts on emergency health services access are **Moderate**. Assessment of transportation safety risks are presented in Sections 7.3.5 and 7.3.6.

Given the **Negligible** significance of communicable disease and public safety impacts from the Project, mitigation measures are not required, but the Project will nonetheless work closely with police and other public safety authorities to address any related concerns. In addition, the Project workers will be required to adhere to a worker code of conduct.

Table 7-58 summarizes the impact magnitude and resource sensitivity ratings for potential Project impacts on community health and wellbeing, and the impact significance ratings resulting therefrom. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-58 Community Health and Wellbeing – Pre-Mitigation and Residual Impact Significance Ratings

Stage	Resource/ Receptor Impact	Sensitivity	Magnitude	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
All Project stages	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	None	Negligible
	General population of Georgetown and vicinity – reduced access to emergency and health services	Medium	Small	Minor	None	Minor

7.3.5 Marine Use and Transportation

7.3.5.1 *Introduction*

The Project involves the drilling of development wells, the installation and long-term operations of an FPSO and SURF, and transit of Project support vessels between the PDA and the Guyana shorebases, as well as between the PDA and shorebases in Trinidad and Tobago.

The specific shorebase(s) and onshore support facilities (e.g., warehouses, laydown yards) to be utilized in Guyana have not yet been identified by EEPGL. Accordingly, ERM has performed the impact assessment on the basis that the Project will utilize existing shorebase(s) located in Georgetown. Should any new or expanded shorebase(s) or onshore support facilities be utilized, 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 the EIA.

The assessment of potential impacts on marine use and transportation from these Project activities was based on the following assumptions:

- Most support vessel trips would originate from (and return to) shorebase facilities in Georgetown, while larger-draft vessels, such as drill ships, could transit between the PDA and shorebases in Trinidad and Tobago.
- The 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.

7.3.5.2 *Relevant Project Activities and Potential Impacts*

Table 7-59 summarizes the relevant Project activities and their potential impacts on marine use and transportation.

The FPSO will be anchored to the seafloor for the duration of the production operations stage, which is intended to last approximately 20 years. During the production operations stage, the FPSO will have a 2 nautical mile (nm) radius marine safety exclusion zone (covering approximately 4,300 ha), in which no unauthorized vessels will be allowed to enter. In addition, the drill ship and drill centers will have 500-meter radius marine safety exclusion zones during drilling operations and well workovers; a 500-meter radius marine safety exclusion zone will also be maintained around major installation vessels during the installation stage. Notices to mariners would be issued via MARAD to the Trawler's Association and fishing co-ops for planned Project marine vessel movements, including the FPSO, drill ship, and major installation vessels to be utilized during the installation stage. 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, and where possible communicate Project activities to those individuals to aid them in avoiding Project vessels through the stakeholder engagement process.

The Project would generate a variety of marine support vessel trips throughout the Project life. Support vessel activities would consist of:

- Approximately five vessels conducting re-supply trips to the FPSO and drill ships;
- Tanker movements and tugs supporting tanker loading activities;
- Subsea installation and maintenance activities; and
- Other vessels supporting installation activities.

Based on similar developments, the Project would generate an average of 12 vessel round-trips (between the PDA and shorebase) per week during development drilling and FPSO/SURF installation, and 7 vessel round-trips per week during FPSO/SURF production operations.

These vessel round-trips would originate from and return to shorebase facilities in Guyana and/or Trinidad and Tobago.

As described in Section 2.9, End of Operations, EEPGL has not prepared detailed plans for the decommissioning phase. As such, the number of vessel trips associated with decommissioning is not known. 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: 12 vessel round trips per week.

For the purposes of the impact assessment, marine safety exclusion zones are an embedded control, considered part of the Project design. Accordingly, the "pre-mitigation" impact assessment considered the inclusion of this measure.

Table 7-59 Project Activities and Potential Impacts – Marine Use and Transportation

Stages	Project Activity	Key Potential Impacts
Drilling and Installation	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. • Increased risk of marine casualty event (e.g., collision, grounding) involving third parties and Project vessels in Georgetown Harbour or in coastal waters.
	Presence of FPSO, drill ship, and 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. • Increased risk of marine casualty events (e.g., collision, grounding) involving third parties and the FPSO in transit and while anchored, as well as drill ship installation vessels in transit and on station.
Production Operations	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. • Increased risk of marine casualty event (e.g., collision, grounding) involving third parties and Project vessels in Georgetown Harbour or in coastal waters.
	Presence of FPSO, tanker, drill ship, 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. • Increased risk of marine casualty event (e.g., collision, grounding) involving third parties FPSO, tanker, drill ship, and tankers on station.
Decommissioning	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.
	FPSO removal and decommissioning vessel support	• Increased risk of marine casualty events (e.g., collision, grounding) involving third parties and the FPSO in transit, as well as decommissioning support vessels.

7.3.5.3 *Magnitude of Impact - Marine Use and Transportation*

Table 7-60 summarizes the definitions used to rate impact scale of the Project's potential impacts on marine use and transportation. Considering these definitions, Table 7-61 summarizes the assigned impact magnitude ratings for the various impacts. The Project's marine activities would impact cargo vessel traffic into and out of the Port of Georgetown, open-ocean shipping in the vicinity of the Stabroek Block in Guyanese waters, and commercial and subsistence fishing activity throughout impacted portions of Guyana's coastal waters. As described in Section 7.3.5.1, support vessel traffic would be higher during the development drilling stage relative to the production operations stage. Because the FPSO and support vessels would be present throughout the duration of the Project, the nature of impacts on marine use and transportation would generally be similar across various stages of the Project.

Vessels transiting the PDA would need to avoid the marine safety exclusion zones around the drill ships, major installation vessels, and the FPSO. The FPSO marine safety exclusion zone would require non-Project vessels to avoid approximately 4,300 ha (~10,600 acres) (approximately 0.2 percent) of the Stabroek Block's approximately 2.7 million ha (~6,671,845 acres) for approximately 20 years. Because the FPSO will be anchored to the seafloor, its marine safety exclusion zone would essentially be a permanent navigation feature until the decommissioning stage. The marine safety exclusion zones around the drill ships/drill centers would be small (~79 ha), and would be in force only during development drilling activity, which is anticipated to last approximately 3 years, and on occasion during well workover activity in later years. Similar sized marine safety exclusion zones around major installation vessels would occur only during the installation stage, or in the event repairs or maintenance.

The Stabroek Harbour Master has advised EEPGL that Jamaican and Trinidadian vessel shipping lanes intersect the Stabroek Block. As such, shipping traffic could potentially intersect the PDA, as well. Shipping lane maps indicate the FPSO would likely be more than 30 nautical miles from the nearest generalized shipping lane. More importantly, 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 would have ample warning and space to navigate, and there is no reason to believe that the Project would 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 would lose use of the defined marine safety exclusion zones for fishing activities, and as described in Sections 6.3.2 and 6.3.3, most subsistence fishing occurs in nearshore areas. Most commercial fishing occurs between the coast and the edge of the continental shelf (i.e., shoreward of the PDA), but as described in Section 7.3.3.3, the recovery of derelict fishing gear from the PDA indicates that some fishing acitivity does take place within or near the PDA and the emerging deepwater tuna fishery may potentially increase this activity in the future. The highest potential for interactions between fishing vessels and Project vessels in Guyana waters is near the Port of Georgetown and the Demerara River mouth, where commercial vessel traffic is already present. As a result, the Project's impacts on marine use 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 social and economic impacts of the Project's exclusion zones on commercial and subsistence fishing are described in Sections 7.3.2 and 7.3.3.

With respect to commercial fishing, the majority of the PDA is in deeper waters that are less often used for commercial fishing, and the size of the FPSO marine safety exclusion zone is negligible relative to the water available for fishing. As a result, the Project's impacts on marine use for current commercial fishing activities also are likely to be limited.

During development drilling and again during decommissioning, the Project could generate one or two daily vessel departures and arrivals from the Port of Georgetown. Although call data for the Port are not available, this frequency of activity is unlikely to exceed the Port's vessel throughput capacity. Support vessels would typically be smaller and more maneuverable than the cargo or tanker vessels that call on the Ports of Georgetown or ports in Trinidad and Tobago, and thus would not present significant incremental navigation hazards within or near these ports.

The scale of potential impacts on maritime use and transportation are defined according to the definitions provided in Table 7-60 below.

Table 7-60 Definitions for Scale Ratings - Potential Impacts on Maritime 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, and does not measurably increase safety risks on waterways.
	Medium: Increased transportation activity or marine infrastructure demand is perceptible, reduces transportation system or infrastructure capacity, and/or measurably increase safety risks on waterways. These impacts do not require a change in typical travel behavior.
	Large: Increased transportation activity or marine infrastructure demand causes substantial delay, congestion, and/or increased safety risks on waterways, to the point where vessel operators or other users of infrastructure must consistently and frequently change their typical daily behavior.

Table 7-61 Magnitude Ratings – Potential Impacts on Marine Use and Transportation

Stage	Potential Impact	Magnitude	Rationale for Rating
Drilling and Installation Decommissioning	Maritime safety in Georgetown Harbour and shipping channel	Small	The drilling and installation stages would involve regular supply vessel trips in and out of Georgetown Harbour.
	Offshore maritime travel and safety	Small	While the marine safety exclusion zones around the FPSO and drill ships would be medium- to long-term, the FPSO will remain moored in one location, and the drill ships would only move between the two established drill centers.
Production Operations	Maritime safety in Georgetown Harbour and shipping channel	Small	Operations stage marine transport activity would be similar to, but less frequent than, for the drilling and installation stages.
	Offshore maritime travel and safety	Small	The FPSO will be stationary for the life of the Project, and its associated marine safety exclusion zones would become a known, mapped navigation feature for other vessel operators.

7.3.5.4 *Sensitivity of Receptors – Marine Use and Transportation*

Potential receptors for the Project's marine use and transportation impacts include current users of Georgetown Harbour and Guyanese coastal waters. Table 7-62 defines the receptor sensitivity ratings used in the assessment.

Table 7-62 Definitions for Receptor Sensitivity Ratings – Potential Impacts to Maritime 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 7-63 identifies and characterizes the sensitivity of receptors that could potentially experience marine use and transportation impacts from the Project.

Table 7-63 Sensitivity Ratings for Marine Use and Transportation Receptors

Receptor	Definition and Rationale for Inclusion	Sensitivity/ Vulnerability 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 would occur in areas potentially used by commercial shipping organizations, and would 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 vessel would lose access to fishing areas that are currently available to them, and would have to avoid Project-related vessel traffic where none currently exists; however industrial 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.
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.

7.3.5.5 *Impact Significance and Mitigation Measures – Marine Use and Transportation*

To further reduce the possibility and severity of marine use and transportation impacts, 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 Project activities to those individuals/entities to aid them in avoiding major Project vessels where possible, as further mitigation. No additional mitigation measures have been proposed related to vessel activity or maritime navigation.

Considering these mitigations, Table 7-64 summarizes the pre-mitigation and residual significance of the Project's potential maritime use and transportation impacts. Residual impacts related to maritime capacity, navigation, and safety are **Negligible** to **Minor**. As discussed above, impacts during decommissioning are assumed to be similar to those experienced during drilling and installation.

The Project may induce shorebase operators to make improvements to existing facilities to make the shorebase(s) fit for purpose. These improvements would enhance the valuable of the shorebase(s) as material assets. Assuming that these improvements were small in scale and did not require physical expansion of the existing facilities, they would be considered a **Positive** impact on Guyana's marine infrastructure. Larger scale improvements would be outside the scope of the EIA.

The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter. Considering all of the individual impacts listed in Table 7-64, the Project would have overall **Negligible** residual impact significance for marine use and transportation.

Table 7-64 Marine Use and Transportation Pre-Mitigation and Residual Impact Significance Ratings

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 and maritime safety	Marine safety exclusion zones around FPSO, drill ship, and major installation vessels.	Small	Low	Negligible	Communication and notification	Negligible
	Commercial fishing vessels—exclusion from PDA		Small	Low	Negligible	Communication and notification	Negligible
	Commercial cargo vessels—offshore navigation and maritime safety		Small	Low	Negligible	Communication and notification	Negligible
	Commercial fishing vessels—offshore navigation and maritime safety		Small	Medium	Minor	Communication and notification	Minor
	Subsistence fishing vessels—nearshore navigation and maritime safety		Small	Medium	Minor	Communication and notification	Minor
Production Operations	Commercial cargo vessels—port and channel operations and maritime safety	Marine safety exclusion zones around FPSO and major installation vessels.	Small	Low	Negligible	Communication and notification	Negligible
	Commercial fishing vessels— exclusion from PDA		Small	Low	Negligible	Communication and notification	Negligible
	Commercial cargo vessels—offshore		Small	Low	Negligible	Communication and notification	Negligible

Stage	Resource/ Receptor Impact	Embedded Controls	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
	navigation and maritime safety						
	Commercial fishing vessels—offshore navigation and maritime safety		Small	Medium	Minor	Communication and notification	Minor
	Subsistence fishing vessels—nearshore navigation and maritime safety		Small	Medium	Minor	Communication and notification	Minor

7.3.6 Social Infrastructure and Services

7.3.6.1 *Introduction*

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 and impact public safety). The impacts associated with these two Project activities are assessed separately in this section. Impacts on health service access are assessed in Section 7.3.4.

7.3.6.2 *Housing and Utilities*

Relevant Project Activities and Potential Impacts

The Project's limited onshore activity during drilling, installation, production operations, and decommissioning has the potential to impact housing and utilities in the Georgetown area. Table 7-65 summarizes the potential impacts on housing and utilities.

Table 7-65 Project Activities and Potential Impacts – Social Infrastructure and Services (Housing and Utilities)

<table>
<tr><th>Stage</th><th>Receptor(s)</th><th>Project Activity</th><th>Key Potential Impacts</th></tr>
<tr><td rowspan="2">All Project Stages</td><td rowspan="2">General population in Georgetown and vicinity</td><td>Project worker presence in Georgetown area</td><td rowspan="2">• Increased demand or use of housing and utilities service and infrastructure, leading to reduced availability and/or increased cost</td></tr>
<tr><td>(Induced) influx of job-seekers to Georgetown area</td></tr>
</table>

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 7-66.

Table 7-66 Definitions for Scale Ratings for Potential Impacts on Housing and Utilities

Criterion	Definition
Scale	Negligible: 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 of drilling and installation stages, and up to approximately 140 workers during the production operations stage. Since the majority of the workforce for these stages will be based offshore, the limited time spent onshore would be in temporary accommodations such as hotels. As such, the Project workforce is not expected to impact for-sale or rental housing stock, and thus would not be expected to require any new utilities connections. It is not anticipated that the Project's worker presence onshore at any given time would 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 efforts to communicate the Project's limited workforce requirements to stakeholders.

Based on the definitions presented in Table 7-66, the magnitude of impact on housing and utilities is considered to be **Minor** during the drilling, installation, and decommissioning stages of the Project and **Negligible** during the production operations stage.

Sensitivity of Receptors - Housing and Utilities

The receptors that could be potentially impacted by changes to housing and utilities are the current general population of Georgetown. The receptor sensitivity ratings for housing and utilities are defined according to the definitions provided in Table 7-67.

Table 7-67 Definitions for Receptor Sensitivity Ratings for Housing and Utilities Impacts

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 has a **Medium** level of sensitivity to increased demand for housing and utilities infrastructure.

Impact Significance and Mitigation Measures - Housing and Utilities

Based on the magnitude of impact and receptor sensitivity ratings, the significance of housing and utilities impacts for the drilling, installation, and decommissioning stages is **Minor**. During the production operations stage, this is reduced to a **Negligible** level of significance.

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 in order to reduce the potential for induced population influx.

The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter. Table 7-68 below summarizes potential Project impacts on housing and utilities. The impact will remain **Negligible** after mitigation.

Table 7-68 Housing and Utilities Pre-Mitigation and Residual Impact Significance Ratings

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling, Installation and Decommissioning	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	General Georgetown population and vicinity – Decreased availability/ increased cost of housing and utilities	Negligible	Medium	Negligible	None	Negligible

7.3.6.3 *Onshore and Air Transportation*

Relevant Project Activities and Potential Impacts

The specific shorebase(s) and onshore support facilities (e.g., warehouses, laydown yards) to be utilized in Guyana have not yet been identified by EEPGL. Accordingly, ERM has performed the impact assessment on the basis that the Project will utilize existing shorebase(s) located in Georgetown. Should any new or expanded shorebase(s) or onshore support facilities be utilized, 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 the EIA.

The travel route, frequency, and type of vehicle trips between the Georgetown shorebase(s) and offsite facilities (i.e., not contained within the shorebases) are not known. Such offsite activity could impact onshore transportation by adding vehicle trips (likely in the form of heavy truck trips) between the offsite facility and the Georgetown shorebase(s). As was the case for the Liza exploration activities, a Road Safety Management Procedure would be developed for all Project-related land transport activities.

This assessment includes a qualitative analysis of the impacts of those land-based trips. The impact scenario assumes vehicle movements between an offsite facility somewhere along the East Bank Demerara Road and a shorebase within the Port of Georgetown. Table 7-69 summarizes the potential impacts to onshore transportation.

The Project would also generate up to 35 round-trip helicopter flights per week during development drilling and installation, and up to 25 round-trips per week during production operations. All round-trip flights would originate from and return to Correia International Airport (hereafter referred to as “Ogle Airport”), east of Georgetown.

As described in Section 2.9, End of Operations, EEPGL has not prepared detailed plans for the decommissioning stage. As such, the level of onshore and air transportation activity associated with decommissioning is not known. For purposes of impact analysis, onshore and air traffic associated with Project decommissioning is assumed to be similar to that of the drilling and installation stage.

Table 7-69 Project Activities and Potential Impacts – Onshore 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 Ogle Airport	Helicopter flights to/from PDA	• Increased air traffic leading to potential impacts on Ogle Airport capacity.

Magnitude of Impact – Onshore and Air Transportation

If offsite storage/warehousing facilities are required, materials would be transported between the offsite facilities and the shorebases by road. The Project's land activities would impact vehicle traffic in Georgetown, particularly in the vicinity of the shorebases and any offsite yards or warehouses. As stated above, the assessment assumes that land transport would include heavy truck trips along the East Bank Demerara Road. The number and frequency of these trips is unknown. It is assumed that truck trips would occur over the course of the Project. During this period of time, truck trips are unlikely to measurably change existing traffic congestion, due to the relatively small number of likely truck trips.

Project-related air activity would include approximately five helicopter flights per day during the drilling, installation, and decommissioning stages and three to four flights per day during the production operations stage. This level of activity is unlikely to meaningfully impact Ogle Airport's capacity or operations.

The assessment of the Project's magnitude of impacts on onshore and air transportation is summarized in Table 7-70.

Table 7-70 Magnitude of Impacts – Onshore and Air Transportation

Stage	Impact	Magnitude	Rationale for Rating
Drilling and Installation; Decommissioning	Road capacity and congestion from transportation of materials to the Georgetown shorebases.	Small	Although the number of trips between yards/warehouse sites is not known, these trips are unlikely to contribute to traffic congestion.
	Capacity limitations and safety risks from Project-related helicopter flights to and from Ogle Airport.	Negligible	Five helicopter round trip flights per day (i.e., less than one movement per daylight hour) are unlikely to meaningfully impact operations or air safety.
Production Operations	Road capacity and congestion from transportation of materials to the Georgetown shorebases.	Negligible	Similar type of impacts, but lower traffic volume than during the drilling and installation stages.
	Capacity limitations and safety risks from Project-related helicopter flights to and from Ogle Airport.	Negligible	Three to four helicopter round trip flights per day (i.e., less than one movement per daylight hour) are unlikely to meaningfully impact operations.

Sensitivity of Receptors – Onshore and Air Transportation

The receptors that could potentially experience impacts on onshore transportation include current users of the Georgetown road network. Existing drivers would have a medium level of sensitivity. This rating reflects relatively high traffic volumes and existing congestion in the vicinity of the Demerara Harbour Bridge, as well as the lack of travel alternatives (i.e., other travel routes or modes of transportation) for non-Project drivers.

Receptors for air transportation impacts include airport and airspace users and commercial, cargo, and private pilots, crew, and passengers. The receptor sensitivity ratings for onshore and air transportation are summarized in Table 7-71.

Table 7-71 Receptor Sensitivity Ratings – Onshore and Air Transportation

Receptor	Definition and Rationale for Inclusion of Receptors	Sensitivity Rating	Rationale for Rating
Drivers of motor vehicles	Includes existing travelers in and around Georgetown, who could interact with and be impacted by Project-related traffic.	Medium	Drivers already experience substantial traffic congestion and road safety risks in parts of Georgetown. Additional traffic would likely be viewed as incremental, but not a fundamental shift in conditions.
Airport and airspace users	Includes existing air travelers who could be impacted by Project-related aviation operations.	Low	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 other aircraft.

Impact Significance and Mitigation Measures – Onshore and Air Transportation

Based on the magnitude of impact and receptor sensitivity ratings, the significance of onshore transportation impacts for the drilling, installation, and decommissioning stages will be **Minor**. During the production operations stage, this is reduced to **Negligible**. The significance of air transportation impacts would be **Negligible**. No mitigation measures are required to address potential impacts on onshore and air transportation.

Table 7-72 below summarizes potential Project impacts on onshore and air transportation. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-72 Onshore and Air Transportation – Summary of Pre-Mitigation and Residual Impacts

Stage	Resource/ Receptor Impact	Embedded Controls	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation Decommissioning	Non-Project drivers—Project-related traffic congestion	None identified	Small	Medium	Minor	None	Minor
	Air travelers—air operations	None identified	Negligible	Low	Negligible	None	Negligible
Production Operations	Non-Project drivers—Project-related traffic congestion	None identified	Negligible	Medium	Negligible	None	Negligible
	Air travelers—air operations	None identified	Negligible	Low	Negligible	None	Negligible

7.3.7 Cultural Heritage

7.3.7.1 *Introduction*

This section assesses potential Project impacts on cultural heritage. The laws and conventions governing the protection and management of Guyana's cultural heritage include Guyana's National Trust Act (1972), Guyana's Maritime Zones Act (2010), the 1972 United Nations Educational, Scientific and Cultural Organization (UNESCO) Convention on Cultural Heritage, and the 2001 UNESCO Convention on Underwater Cultural Heritage. Guyana's National Trust Act, as well as the 2001 UNESCO Convention on Underwater Cultural Heritage, urge the protection of submerged "monuments" within Guyana's territorial waters, and encourage the practice of in situ preservation of cultural heritage whenever possible.

7.3.7.2 *Relevant Project Activities and Potential Impacts*

Project drilling and 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.

The Project is not expected to require ground-disturbing activities in onshore areas that have not already been disturbed by prior development. Furthermore, any construction/expansion of onshore facilities, which would disturb new onshore areas, would be performed by the owners/operators of such facilities, and would be out of the scope of this EIA. As a result, the Project will not impact any terrestrial archaeological sites. Onshore logistical support would 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.

Table 7-73 summarizes potential Project impacts on marine cultural heritage.

Table 7-73 Summary of Relevant Project Activities and Potential Key Impacts

Stage	Project Activity	Key Potential Impact
Drilling and Installation	Drilling of Development Wells.	Damage to Shipwrecks and Submerged Archaeological Sites
	Installation of FPSO Anchoring Structures	
	Installation of SURF Components.	

7.3.7.3 *Magnitude of Impact – Cultural Heritage*

The assessment of the Project's magnitude of 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 7-74.

Table 7-74 Definitions for Scale Ratings for Potential Impacts on Cultural Heritage Impacts

Criterion	Definition
Scale	Negligible: No discernible change in the physical condition, setting, or accessibility of sites.
	Small: A small part of sites are lost or damaged, resulting in a loss of scientific or cultural value; setting undergoes temporary or permanent change that has limited impact on the sites' perceived value to stakeholders; stakeholder/public or scientific access to the sites is temporarily impeded.
	Medium: A significant portion of sites are lost or damaged, resulting in a loss of scientific value; setting undergoes permanent change that permanently diminishes the sites' perceived value to stakeholders; sites become inaccessible for the life of the Project to stakeholders including traditional users or researchers.
	Large: Entire sites are damaged or lost, resulting in a nearly complete or complete loss of scientific or cultural value; setting is sufficiently impacted to cause sites to lose nearly all or all cultural value or functionality; sites become permanently inaccessible to stakeholders including traditional users or researchers.

The Project will not impact any known underwater cultural heritage based on the geophysical survey and remote sensing studies conducted for the Project. However, there is the potential for previously unrecorded cultural remains, or chance finds, to 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 and remote sensing studies. 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 a previously unidentified cultural heritage site. 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**. For the production operations stage, disturbance of the seafloor will not occur; accordingly, the magnitude rating for this stage is **Negligible**.

7.3.7.4 *Sensitivity of Resource - Cultural Heritage*

The resource sensitivity ratings for cultural heritage are defined in Table 7-75.

Table 7-75 Definitions for Sensitivity Ratings for Potential Impacts on Cultural Heritage

Criterion	Definition
Sensitivity	Low: Site is not specifically protected under local, national, or international laws or treaties; site can be moved to another location or replaced by a similar site, or is of a type that is common in surrounding region; site has limited or no cultural value to local, national, or international stakeholders; and/or site has limited scientific value or similar information can be obtained at numerous sites.
	Medium: Site is specifically or generally protected by local or national laws, but laws allow for mitigated impacts; site can be moved or replaced, or data and artifacts recovered in consultation with stakeholders; site has considerable cultural value for local and/or national stakeholders; and/or site has substantial scientific value but similar information can be obtained at a limited number of other sites.
	High: Site is protected by local, national, and international laws or treaties; site cannot be moved or replaced without major loss of cultural value; legal status specifically prohibits direct impacts or encroachment on site and/or protection zone; site has substantial value to local, national, and international stakeholders; and/or site has exceptional scientific value and similar site types are rare or non-existent.

Depending on the nature of the specific resources encountered, encountered shipwrecks and/or submerged archaeological sites could be specifically protected by national laws such as the Guyana National Trust Act, or international conventions such as the 2001 UNESCO Convention on 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 of **Medium**.

7.3.7.5 *Impact Significance and Mitigation Measures – Cultural Heritage*

Based on the magnitude of impact and the receptor sensitivity ratings, the significance of potential cultural resource impacts during drilling and installation is **Minor**. Since production operations are not anticipated to involve any seabed-disturbing activities, the significance of potential cultural resource impacts during production operations is **Negligible**.

As discussed in Chapter 6, ERM has conducted a survey of the planned seabed disturbance area to assess the presence of any marine cultural heritage. This has significantly increased the level of certainty that planned Project activities will not disturb significant cultural heritage.

In any case, ERM has developed a Chance Finds Procedure, 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 Guyana National Trust and other cultural heritage stakeholders, as appropriate. The Chance Finds Procedure also addresses monitoring and training requirements to support the Procedure.

Considering the implementation of the measures outlined in the Chance Finds Procedure, the scale of impact would be expected to be reduced, as activities would be adjusted/curtailed upon discovery of a previously unidentified cultural resource. This would reduce the impact significance rating to **Negligible**.

Table 7-76 summarizes potential Project impacts on cultural heritage. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-76 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
Drilling and Installation	Marine cultural heritage – destruction from Project activities disturbing the seabed	Low	Medium	Minor	Implement Chance Finds Procedure as needed	Negligible
Production Operations	Marine cultural heritage – destruction from Project activities disturbing the seabed	Negligible	Medium	Negligible	N/A	Negligible

7.3.8 Land Use

7.3.8.1 *Introduction*

This section assesses potential impact on land use and ownership by the Project. The key potential impacts considered are conversion of land from one use to another, physical/economic displacement, and change of land ownership type.

7.3.8.2 *Relevant Project Activities and Potential Impacts*

The majority of the Project's activities will occur offshore. Some limited onshore activities will occur, particularly at the beginning of the drilling and installation stage while wells are being drilled and SURF infrastructure is being installed. These facilities would not be owned or operated by EEPGL. 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 would be addressed by the owners/operators of such facilities, and would be out of the scope of this EIA.

Table 7-77 summarizes the potential impacts on land use from Project activities.

Table 7-77 Project Activities and 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 Project materials storage	Conversion of land from other use(s)

7.3.8.3 *Magnitude of Impact – Land Use*

The assessment of the Project's magnitude of 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 7-78.

Table 7-78 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 may require the use of offsite onshore storage facilities for Project materials (e.g., pipe joints). At this time, potential storage facility locations are not known, but it is expected that any such facility will be located as near to the shorebase(s) as possible to minimize hauling time.

Given that the storage facilities will likely be located in an industrial area, rather than natural or agricultural in character, it is not expected that major changes in land use types, or any change in land ownership type, would occur. The magnitude of impact is therefore considered to be **Small**.

7.3.8.4 *Sensitivity of Receptors - Land Use*

Receptors for this impact would be the current owner(s) of the land to be used for the storage facility, as well as the user(s) or beneficiaries of that land, if any. The receptor sensitivity ratings for land use are defined in Table 7-79.

Table 7-79 Definitions for Receptor Sensitivity Ratings for Land Use Impacts

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, it is not known whether the onshore storage facilities will be required, or where such a facility would be located if it is required. However, assuming that the property used for the storage facility will be on land currently used for industrial purposes, it is not expected that this property would be relied upon for residential, agricultural, commercial, or recreational use. As such, receptors are expected to have a **Low** level of sensitivity.

7.3.8.5 *Impact Significance and Mitigation Measures – Land Use*

Based on the magnitude of impact and receptor sensitivity ratings, the significance of land use impacts for the drilling and installation stage is **Negligible.**

No mitigations are required or planned since it is not yet known whether the offsite storage facilities will be required. If it is decided a storage facility is required, the owners/operators of the facilities will select the site in a manner that will avoid or minimize land use impacts.

Table 7-80 below summarizes potential Project impacts on land use. The significance of impacts was assessed based on the impact assessment methodology described in Chapter 4 and summarized at the beginning of this chapter.

Table 7-80 Summary of Pre-Mitigation and Residual Impacts – Land Use

Stage	Resource/ Receptor Impact	Magnitude	Sensitivity	Pre-Mitigation Significance Rating	Proposed Mitigation Measures	Residual Significance Rating
Drilling and Installation	Current owner(s) or user(s) of land at site of future storage facility	Small	Low	Negligible	None	Negligible

7.3.9 Ecosystem Services

Planned Project activities will not impact ecosystem services[35]. Although the Project will have minor impacts on water quality, benthic communities, and marine wildlife in the immediate vicinity of the SURF components and in the mixing zones surrounding the FPSO and the tanker, these impacts are not expected to have significant impacts on ecosystem services. They are not expected to impact the processes that regulate the physio-chemical attributes of the North Brazil Shelf 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. There are no human communities located offshore of Guyana so the offshore environment does not provide any cultural services that could be impacted.

The only Project-related impacts in nearshore marine waters would be an incremental increase in ship traffic in and out of Georgetown Harbour as ships transit between the shorebase(s) and the PDA. As discussed previously, an increase in ship traffic could have minor effects on marine life, but none that would be significant at the ecosystem level. Therefore the Project would have no impacts on ecosystem services provided by the nearshore marine ecosystem.

The Project will not involve any direct disturbance of any coastal habitats and the Project's air emissions, water discharges, and sound generation, all of which will occur approximately 190 km (~120 mi) offshore, will not impact these habitats. Project use of the Guyana shorebase(s) and onshore support facilities will have no impact on ecosystem services. The Project's only potential impact on ecosystem services would be as a result of an unplanned event, which is discussed in Section 7.4.

7.3.10 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 190 km (~120 mi) offshore, will not impact their communities or associated habitats. Project use of the Guyana shorebases and onshore support facilities will have no impact on indigenous peoples. These facilities are well removed from any traditional indigenous communities. The Project's only potential impact on indigenous peoples would be as a result of an unplanned event, which is discussed in Section 7.4.

[35] 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.

7.4 Unplanned Events

7.4.1 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 will occur. Three levels of likelihood are used: unlikely, possible, and likely, as defined in Table 7-81.

Table 7-81 Levels of Likelihood for 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; and
Likely	The event is expected to occur during the life of the facility.

As described in Chapter 4, 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.

Figure 7-7 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 Project, 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
- Marine vessel collision
- 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 realistic probability of occurrence, but which would not significantly impact any resources/receptors considered in this EIA. These other unplanned events would occur on the drill ship, 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 and its contractors' health and safety policies and procedures, which are beyond the scope of this EIA.

The specific shorebase(s) and onshore support facilities (e.g., warehouses, laydown yards) to be utilized in Guyana have not yet been identified by EEPGL. Accordingly, ERM has performed the impact assessment for unplanned events on the basis that the Project will utilize existing shorebase(s) located in Georgetown. Should any new or expanded shorebase(s) or onshore support facilities be utilized, 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.

7.4.1.1 Hydrocarbon Spill

Producing, processing, storing, and offloading oil are core Project activities. There are multiple layers of control in place with respect to these activities; however, if multiple controls fail there is the potential for an 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 coordinator manner using regional resources as needed; and
- Tier III – Spill is large, 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, lubricating oil, and non-aqueous drilling fluid (NADF). EEPGL and ERM have identified nine possible spill scenarios, categorized below in Table 7-82 by tier. These scenarios consider spills at the Guyana shorebases (Georgetown area basis), into the Demerara River or other estuarine waters (e.g., from supply vessels), and into the Atlantic Ocean (e.g., from drill ship, supply vessels, tankers, and the FPSO).

Table 7-82 Possible Hydrocarbon Spill Scenarios by Tier

#	Tier	Location	Possible Scenario	Potential Impact	Potential Response Strategies
1	I	Shorebase	Onshore spill of less than 10 bbl (e.g., partial loss of diesel storage tank contents)	Contained onshore; no shoreline impact.	• Onshore/Near Shore Response • Waste Management • Decontamination • Demobilization
2	I	Drill ship or FPSO offshore	Offshore spill of less than 50 bbl (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.	• Surveillance and Monitoring • Assisted Natural Dispersion • Offshore Containment and Recovery • Wildlife Response • Waste Management • Decontamination • Demobilization
3	I	Supply vessel offshore	Offshore spill of less than 50 bbl (e.g., accidental discharge of untreated bilge water)	Hydrocarbons enter water, creating sheen on the water surface; no shoreline impact likely.	• Surveillance and Monitoring • Assisted Natural Dispersion • Offshore Containment and Recovery • Wildlife Response • Waste Management • Decontamination • Demobilization
4	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.	• Onshore/Near Shore Response • Surveillance and Monitoring • Assisted Natural Dispersion • Waste Management • Decontamination • Demobilization
5	II	Drill ship / well offshore	Offshore release of 2,200 bbl of NADF due to loss of riser contents after emergency disconnect due to Dynamic Positioning (DP) station keeping failure	NADF enters water near the seafloor; no shoreline impact likely.	• Surveillance and Monitoring • Assisted Natural Dispersion
6	II	Supply vessel at shorebase	On water release of 500 bbl of diesel (e.g., shore to vessel bunkering)	Diesel enters Demerara River estuary; possible shoreline impact.	• Onshore/Near Shore Response • Surveillance and Monitoring • Assisted Natural Dispersion

#	Tier	Location	Possible Scenario	Potential Impact	Potential Response Strategies
					• Waste Management • Decontamination • Demobilization
7	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 release rate prior to containment	Hydrocarbons enter Atlantic Ocean; no shoreline impact likely.	• Surveillance and Monitoring • Assisted Natural Dispersion • Offshore Containment and Recovery • Dispersant Application • Wildlife Response • Waste Management • Decontamination • Demobilization
8	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.	See above
9	III	Drill ship / well offshore	Offshore release of oil from well control event (30 day duration at 20,000 bpd)	Oil enters Atlantic Ocean; possible shoreline impact.	See above

Hydrocarbon releases under Scenarios 1 through 4 would all be small and under control quickly, 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 small area, a very sensitive receptor (e.g., plankton and possibly some shorebirds) may be locally affected, but 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 this EIA.

A hydrocarbon release under Scenario 5 would involve a spill of approximately 2,200 bbl of NADF into the ocean near the seafloor. Under this scenario, the spill would be somewhat controlled because the volume is limited to the capacity of the drilling riser. There is the potential for temporary impacts on several resources/receptors, such as water quality and marine fish and wildlife, but these impacts would be generally short term and limited in area, with rapid resource/receptor recovery expected.

A hydrocarbon release under Scenario 6 would involve a spill of approximately 500 bbl of diesel into the Demerara River. Under this scenario, the spill would be quickly controlled and contained because of the relatively small volumes and the ready access to spill control equipment. There is the potential for impacts on several resources/receptors, such as water quality and coastal fish and wildlife, but these impacts would occur in a more developed urban harbor setting, be generally short term, limited in area, and readily mitigated, with rapid resource/receptor recovery expected.

Hydrocarbon releases under Scenarios 7 (minor well control release during drilling), 8 (release during offloading from FPSO to tanker), and 9 (major well control incident) would all involve an 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 20,000 BOPD for a duration of 30 days) and the location of the spill differ (i.e., at seafloor or ocean surface), the resources/receptors at risk are similar, although the magnitude of the risk increases from Scenario 7 to Scenario 9. Oil spill modeling and coastal sensitivity mapping have been conducted to identify and characterize the resources/receptors with the potential to be exposed to oil. An overview of this modeling and mapping for Scenarios 8 and 9 is provided in Sections 7.4.1.4 and 7.4.1.5. 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 2.11 (Embedded Controls) provides a description of the embedded controls related to spill prevention.

Despite the unlikely probability of an oil spill, the impacts assessment addresses potential impacts associated with Scenario 6, which are referred to as "Coastal Oil Spill," as well as Scenarios 7, 8, and 9, which are collectively referred to as "Marine Oil Spills." Scenario 5 is referred to as a "NADF Release" and impacts on relevant receptors are assessed as a separate category of release.

7.4.1.2 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 7-8). 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, Undated; ITOPF No. 2, Undated; Dicks, 1998). The oil produced from the Liza field is a "light crude" oil with a specific gravity less than water. If spilled, this oil would rise quickly to the water surface, other than small fragmented droplets that become entrained in the water column due to mixing energy. As a result, the potential for persistent slicks, shoreline impacts, and smothering is reduced relative to heavy hydrocarbon products. The Project will use low-toxicity NADF, which is denser than the light crude 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 during an emergency disconnect scenario.

Figure 7-8 Typical Impacts on Marine Organisms across a Range of Oil Classes

Source: ITOPF, Technical Information Paper 13, undated

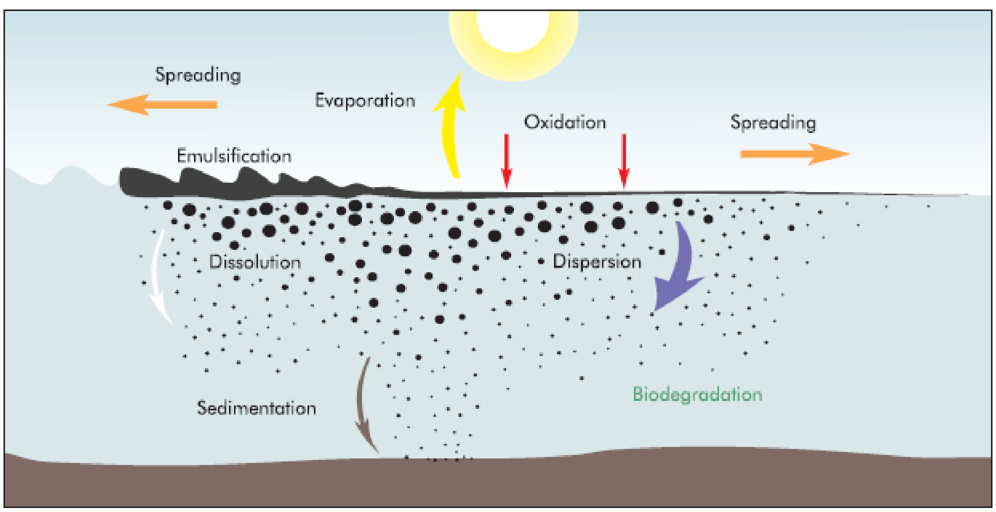
The well control event considered for the purpose of this EIA would occur in the ocean approximately 190 km (approximately 120 miles) offshore from Guyana. The open waters of the ocean, and associated pelagic and seabed communities, are typically more resilient to spills than are shoreline environments (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 AOI are warm, typically ranging from 24 to 30°C, which results in the oil remaining fluid and increasing spill response options.

7.4.1.3 *Weathering Processes*

As soon as hydrocarbons are introduced to the ocean, advection and spreading begin immediately and result in a rapid increase in the exposure area of the product to subsequent "weathering" processes (Figure 7-9). 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.

Figure 7-9 Weathering Processes Acting on Spilled Oil



Source: ITOPF, 2013

The products of these processes may include hydrocarbon fractions and reaction products introduced to 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 processes are occurring, biological processes, including degradation of oil by microorganisms to carbon dioxide or organic components in intermediate oxidation stages, uptake by larger organisms and subsequent metabolism, storage, or discharge also act on the different fractions of the original oil.

Although not all of the same processes (e.g., photochemical oxidation, evaporation) occur at the depths that a NADF Release could occur, the NADF would be exposed to biological degradation. Biological degradation proceeds slower under anoxic conditions than under well-oxygenated conditions, so biological degradation tends to occur most rapidly when the NADF is thinly distributed over a wide area of seafloor rather than in thicker clumps over a small area.

7.4.1.4 Oil Spill Modeling Overview

Oil spill models have been in use for over 30 years to support the development of Oil Spill Response Plans (OSRP). Trajectory and fate models simulate oil transport and predict the changes the oil undergoes as it interacts with water, air, and land (oil fate). The models simulate spill events using the best available characterization of the wind and hydrodynamic (marine currents) forces that drive oil transport. The models quantify the potential consequences from a spill, which can then be used to guide response planning and prioritize response asset deployment. There are typically two modes under which the models can be used: 1) the **stochastic** (statistical) mode that examines *many potential releases* from the same point utilizing the full range of historical data for wind and currents; and, 2) the **deterministic** mode that examines a *single potential release* utilizing specific historic wind and hydrodynamic datum from the range of potential data, or utilizing forecast data for an ongoing or future event.

Extreme weather events are considered qualitatively in the oil spill modeling. The PDA is not in a seismically active area. The Project is designed to withstand other potential extreme events (e.g., hurricanes, unusual temperatures, high winds, strong currents). In fact, these extreme events have little to no effect on the wells, which are located approximately 1500 to 1900 m below the ocean surface. Weather forecasts provide advance notice of these events and would enable EEPGL to take appropriate precautions with the FPSO.

A typical approach to using oil spill models in OSRP is to first apply the stochastic model 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 and generating a map that is a *composite* of all of the trajectories and provides a *probability footprint* showing the most likely path for a given spill scenario. Spill scenarios are typically modeled in stochastic mode to provide composite footprints to estimate probability and timing for each season or wind regimes in the region.

Each stochastic scenario results in a probability map of the extent and mass of sea surface oiling, the extent of shoreline oiling, and the minimum time of oil arrival in each location contaminated by the oil. Examples of stochastic maps are shown in Section 7.4.1.5 (Oil Spill Modeling Results). Calculation of the probabilities is based on oil present in excess of a specified thickness threshold. The thresholds are specific to the purpose of the modeling or the type of impact being considered, including ecological and socioeconomic. They are used in the determination of oiling probability to determine if oil is present in a quantity exceeding the 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 OSRP planning and environmental impact analysis.

When considering oil contamination thresholds, surface oil thickness is typically expressed in units of mass per unit area (e.g., grams per square meter [g/m^2]). Table 7-83 lists approximate thickness and mass per unit area ranges for surface oil of varying appearance.

Table 7-83 Oil Thickness (g/m^2) and Appearance on Water (NRC, 1985)

Minimum	Maximum	Appearance
0.05	0.2	Colorless and silver sheen
0.2	0.8	Rainbow sheen
1	4	Dull brown sheen
10	100	Dark brown sheen
1,000	10,000	Black oil

Oil spill deterministic models predict where spilled oil from a single release will go and, how quickly it travels and arrives at given locations. The trajectory of the spill is determined by the specific modeled wind and current and the properties of the discharged oil. The model determines 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 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. 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 (habitats and species) 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 spill response activities such as mechanical recovery, dispersant application, and in-situ burning. Model simulations run with and without spill mitigation measures calculate the effectiveness of different response strategies and equipment which 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 identified based on the desired criterion, a deterministic map showing the trajectory and fate of the spill is generated along with a graphical representation of the oil quantities predicted to reach the different parts of the environment. This breakdown of the oil quantities by environmental compartment, referred to as an oil mass balance, provides a time history of the entire spilled oil mass over the period of the model simulation. The trajectory maps and oil mass balance graphs can be generated for a range of spill scenarios and included in an OSRP. Examples of these and other deterministic maps and oil mass balance graphs are shown in Section 7.4.1.5 (Oil Spill Modeling Results).

When applied to OSRP 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 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 fate.

The trajectory and fate model provides input to the OSRP process by determining spill pathways and quantifying potential spill consequences. Determining the consequences from a spill typically has two components: determining the likelihood that a spill will contaminate a given part of the environment, and; what will be its ecological and socioeconomic consequences.

7.4.1.5 Oil Spill Modeling Results

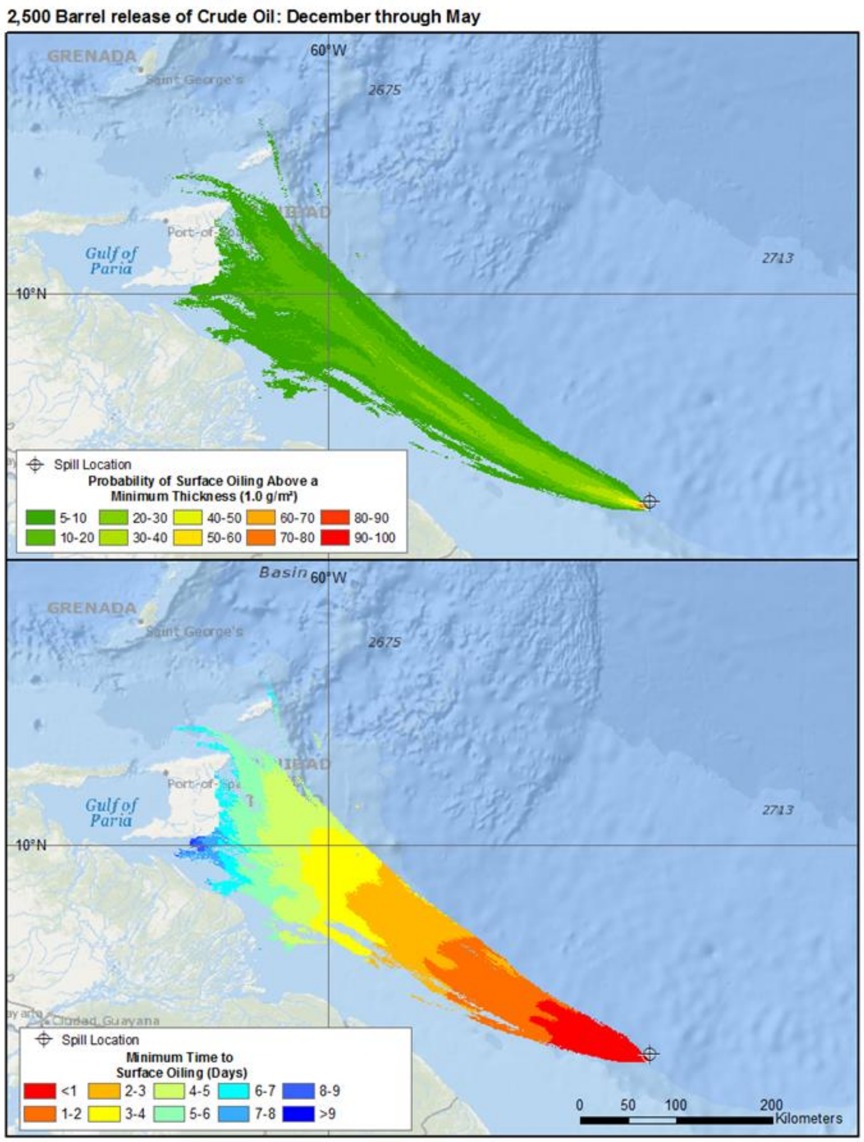
Oil spill modeling results for oil spill Scenarios 8 and 9 are summarized in this section. Additional modeling results are included in the OSRP. Scenario 8 includes the modeling of a 2,500 bbl leak associated with FPSO offloading to a conventional tanker. Scenario 9 includes the modeling of a 20,000 BOPD well control event of a 30-day spill duration, which included an extension of an additional 15 days after oil discharge ceased.

The model was run two ways: the initial model runs showed potential impacts in the absence of spill response measures, which represent a "worst-case" for each scenario. Then the deterministic model was run again factoring in response measures, which would be expected to significantly reduce the severity and extent of a spill and its impacts. Subsequent sections of this document describe how EEPGL and its contractors will respond to mitigate environmental impacts in the unlikely event of an incident similar to or less severe than the modeled scenario.

Spills originating at the seafloor were simulated using the OILMAP DEEP model to predict the discharge plume geometry, droplet size distribution discharged into the water column, and the fate of the oil plume. The SIMAP model system was used to predict the probability of the extent of oil contamination on the sea surface and the shoreline, taking into account the weathering profile of the oil that would result in a proportion of the product evaporation or dispersing into the water column. Spills were simulated taking into consideration the quantity of product released, the type of product and its characteristics (e.g., density), historical seasonal wind and current patterns, and water depth, among other factors.

Modeling has been performed for the summer season (June through November), as well as the winter season (December through May). The results of modeling for the winter season are presented in the figures below, as they provide more conservative results for the purposes of the EIA based on higher current speeds and more northerly winds.

Figure 7-10 Stochastic Map for Scenario 8 – Unmitigated 2,500-Barrel Release of Crude Oil (December through May)



The top panel of Figure 7-10 is a stochastic map which, based on hundreds of simulations, shows the probability of surface oiling above a minimum thickness of 1.0 g/m^2 in the winter season from a 2,500 barrel spill that originates at the FPSO location. This stochastic map indicates there is a zero percent probability that oil at that thickness would make contact with the Guyanese coast.

The bottom panel of Figure 7-10 is a stochastic map, based on hundreds of simulations, which shows the minimum amount of time for surface oiling above a minimum thickness of 1.0 g/m^2 to occur from a 2,500 barrel spill that originates at the FPSO location in the winter season. Figure 7-11 is a deterministic map that predicts where a simulation of a 2,500 bbl spill from the FPSO location would go under a set of wind and current conditions typical of the winter season. This deterministic map indicates that oil would not make contact with the Guyanese coast. The gray area shows the "swept area" which is the path the oil spill is projected to follow. The black area shows the fate of the surface oil. The red area shows the fate of the oil that makes shoreline contact. Figure 7-12 shows the same deterministic model run as Figure 7-11, but with mitigation measures applied. No coastline would be impacted and the potential area of impact by such a release to the marine environment has been dramatically reduced.

Figure 7-11 Deterministic Map for Scenario 8 – Unmitigated 2,500-Barrel Release of Crude Oil (December through May) Depicting Weathering and Fate

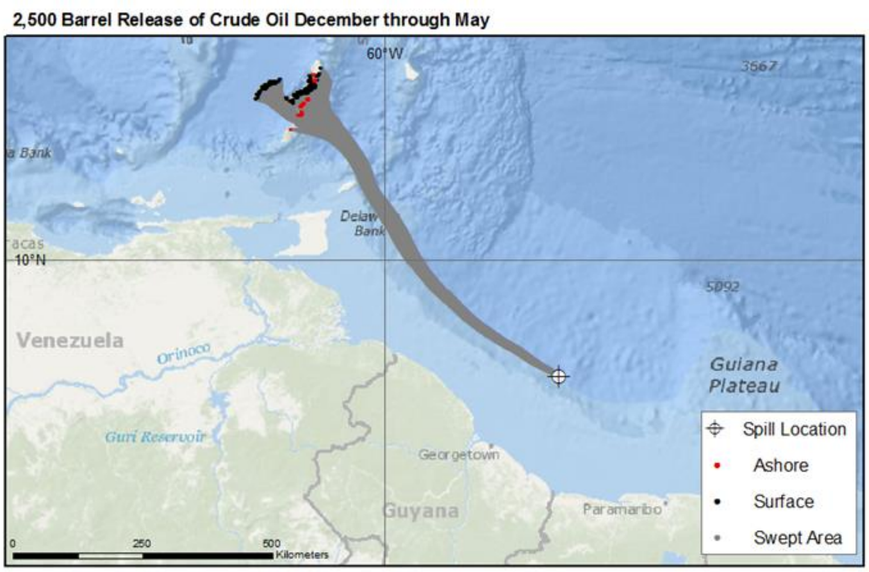


Figure 7-12 Deterministic Map for Scenario 8 – Mitigated 2,500-Barrel Release of Crude Oil (December through May) Depicting Weathering and Fate

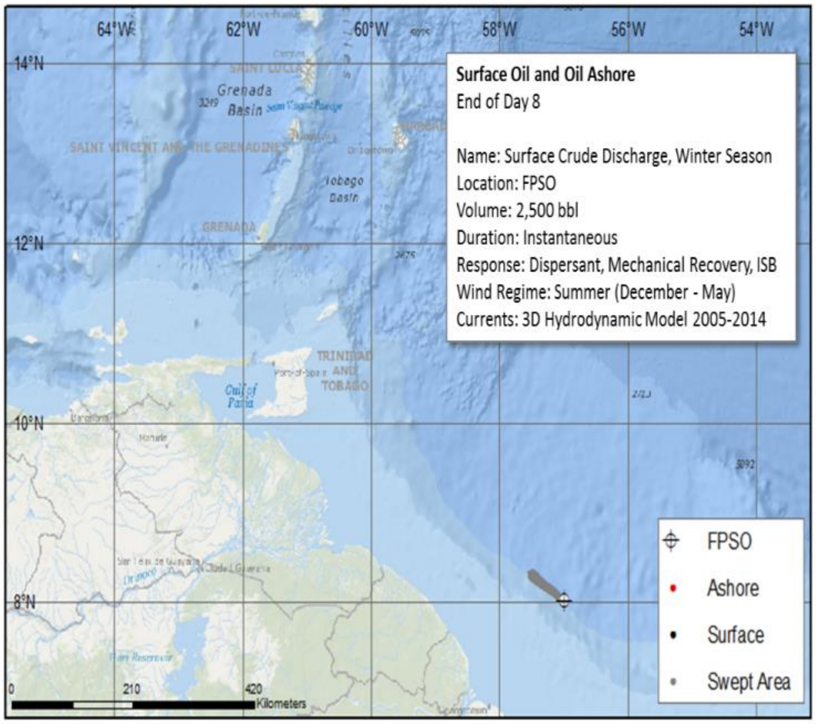
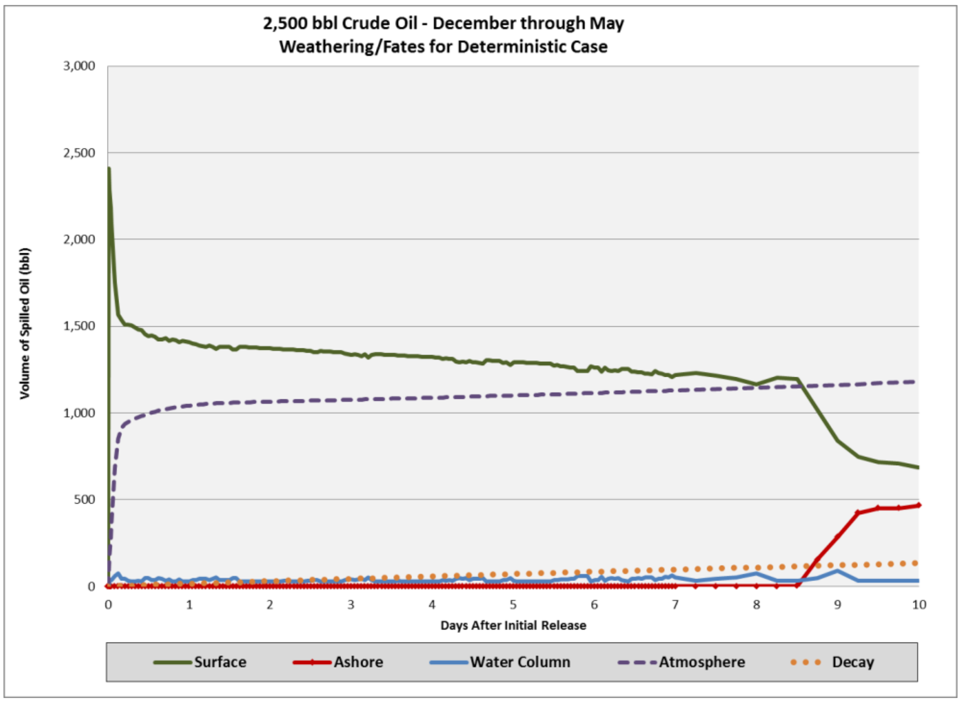


Figure 7-13 is an oil mass balance graph that is associated with the deterministic map in Figure 7-11 (which shows where a simulation of a 2,500 bbl spill from the FPSO location would go in the winter season). Figure 7-13 provides a graphical representation of the oil quantities predicted to reach different parts of the environment over time.

The green line represents the volume of spilled oil which would be on the ocean surface over time. The red line represents the volume of spilled oil which would make coastal contact (in this case, outside of Guyana) over time. The blue line represents the volume of spilled oil which would remain in the water column over time. The dotted orange line represents the volume of spilled oil which would decay over time. The dotted gray line represents the volume of spilled oil which would be released to the atmosphere over time, which represents the vast majority of the spill volume (approximately 50 percent). For perspective, a Scenario 8 oil spill has the potential to occur during the production operations stage (at least 20 years).

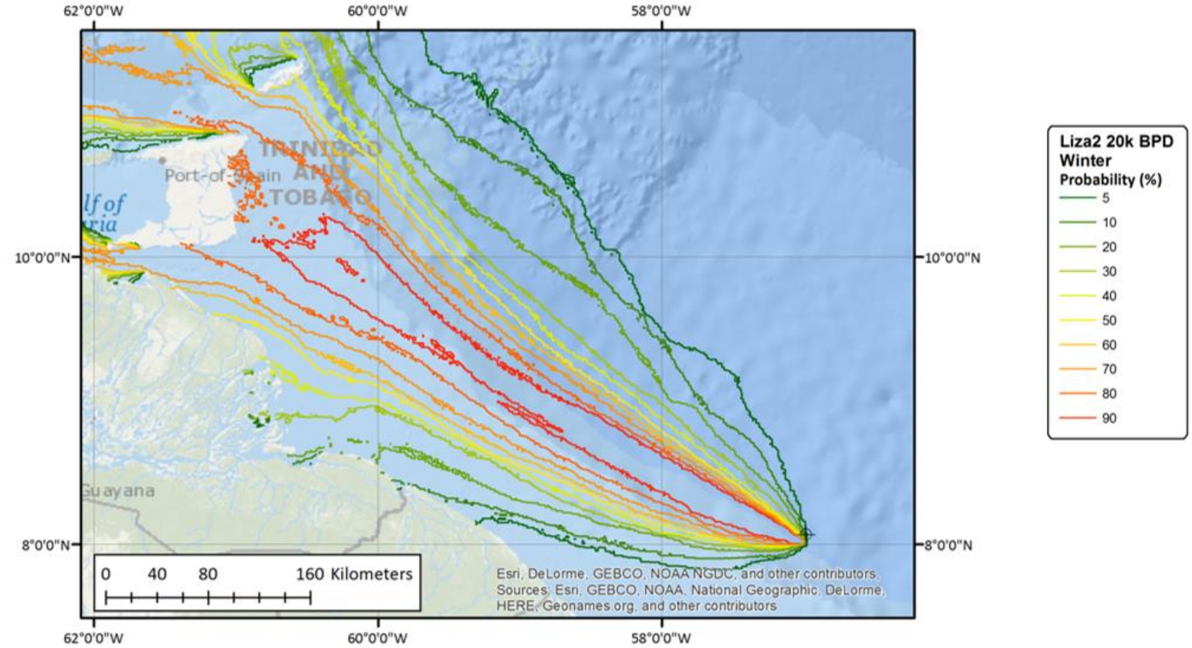
Figure 7-13 Oil Mass Balance Graph for Scenario 8 – Unmitigated 2,500-Barrel Release of Crude Oil (December through May) Depicting Weathering and Fate



The top panel of Figure 7-14 is a stochastic map which, based on hundreds of simulations, shows the probability of surface oiling above a minimum thickness of 1.0 g/m² in the winter season from a 20,000 bpd spill that originates at a well location in the PDA and lasts for 30-days. This stochastic map indicates there would be a 5 to 10 percent probability that oil at that thickness would make contact with the northwest-most area of the Guyanese coast. The value of 1.0 g/m² is commonly used as a threshold in oil spill modeling as it represents the mass of oil where biological impacts can occur, based on research and experience (McCay, 2016).

The bottom panel of Figure 7-14 is a stochastic map which, based on hundreds of simulations, shows the minimum amount of time for surface oiling above a minimum thickness of 1.0 g/m² to occur from a 20,000 bpd spill that originates at a well location in the PDA and lasts for 30-days in the winter season. Minimum time for reaching the northwest-most area of the Guyanese coast would be approximately 5 to 10 days, although some of the oil may arrive in the 10 to 15 day time period.

Figure 7-14 Stochastic Map for Scenario 9 – Unmitigated 20,000-Barrel-per-Day Release of Crude Oil for 30 days (December through May)



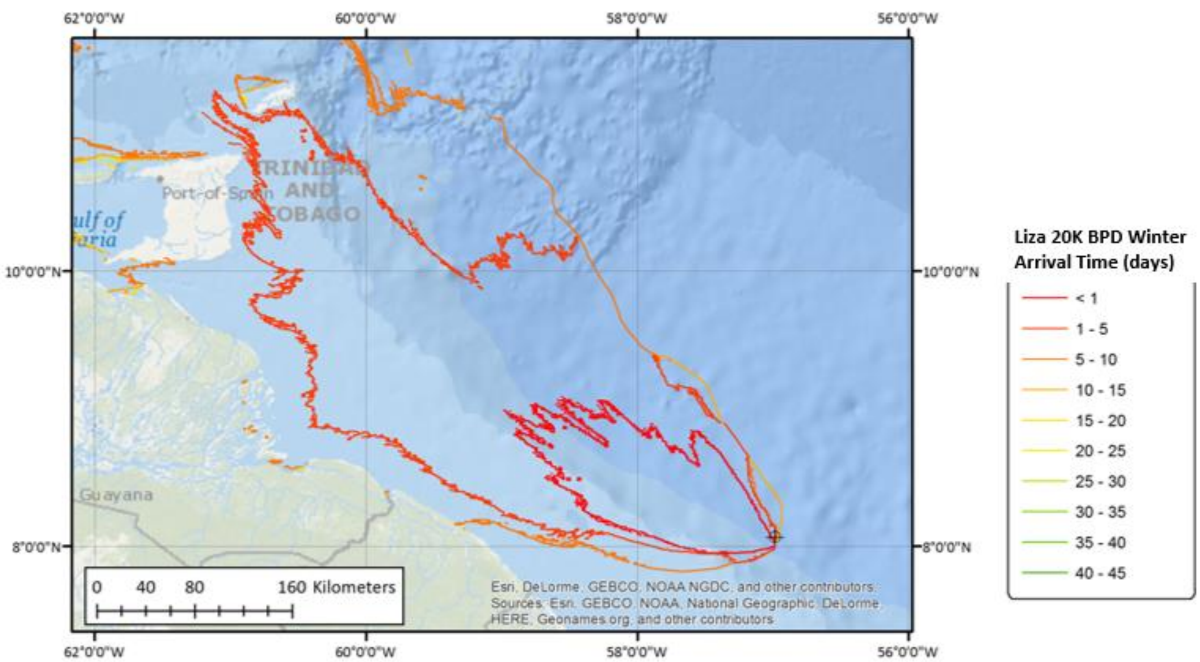


Figure 7-15 is a deterministic map which predicts the fate of a simulation of a 20,000 bpd spill that originates at a well location in the PDA and lasts for 30-days in the winter season. This deterministic map indicates that oil would not make contact with the Guyanese coast. The gray area shows the "swept area" which is the path the oil spill is projected to follow. The black area shows the fate of the surface oil. The red area shows the fate of the oil that makes shoreline contact. Figure 7-16 shows the same deterministic model run as Figure 7-15 when mitigation measures have been applied, the release has been stopped, containment has been restored in 21 days, and a capping stack is in place. No coastlines would be impacted and the potential area of impact by such a release to the marine environment has been significantly reduced.

Figure 7-15 Deterministic Map for Scenario 9 – Unmitigated 20,000-Barrel-per-Day Release of Crude Oil for 30 days (December through May) Depicting Weathering and Fate

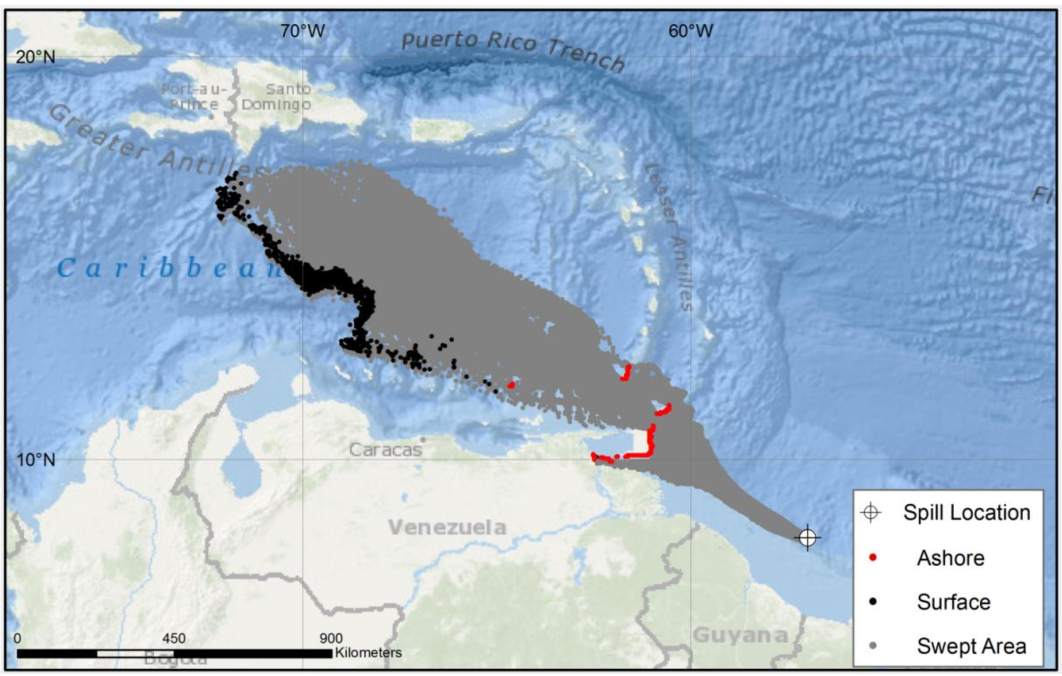


Figure 7-16 Deterministic Map for Scenario 9 – Mitigated 20,000-Barrel-per-Day Release of Crude Oil for 21 days (December through May) Depicting Weathering and Fate

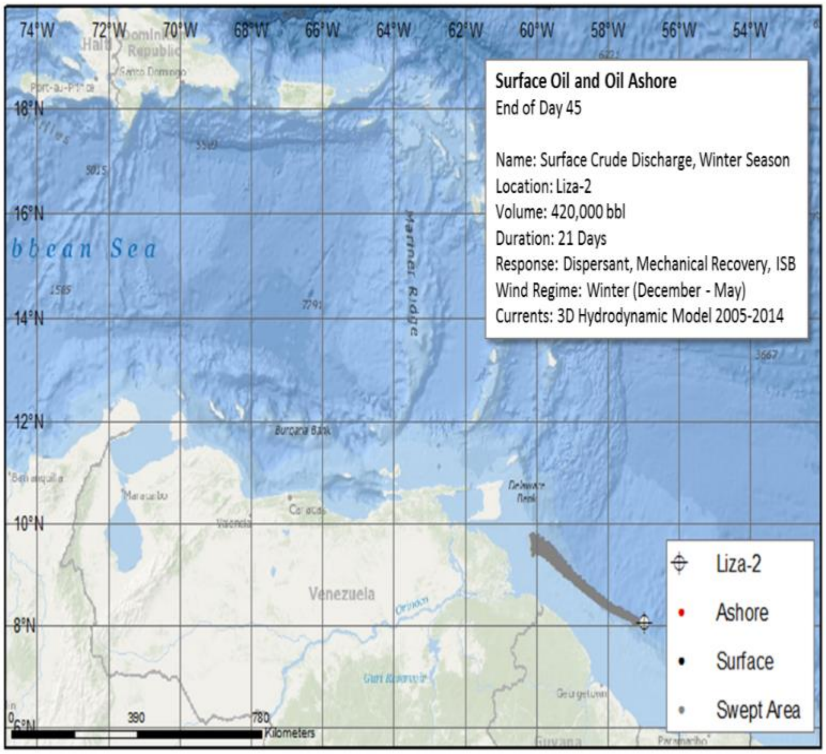
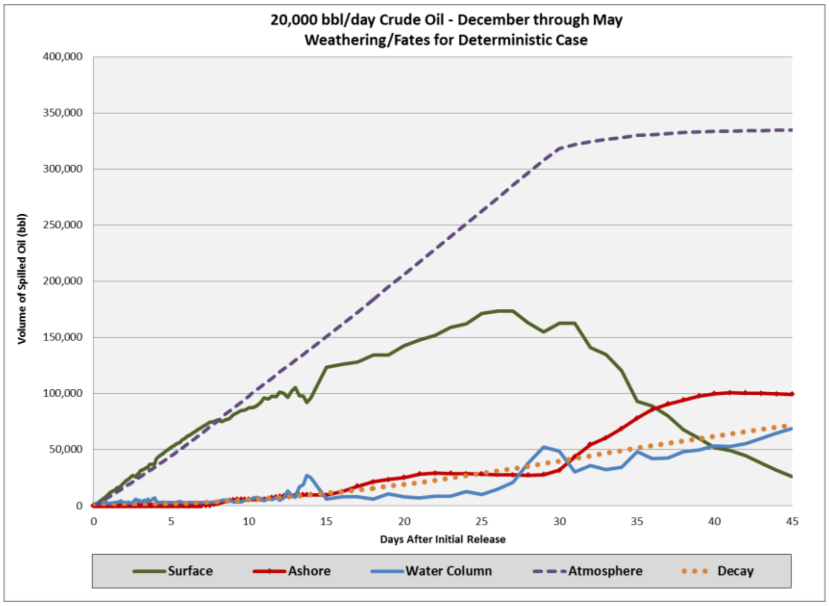


Figure 7-17 is an oil mass balance graph that is associated with the deterministic map in Figure 7-15 (which shows where a simulation of a 20,000 bpd spill that originates at a well location in the PDA and lasts for 30 days in the winter season).

This panel provides a graphical representation of the oil quantities predicted to reach different parts of the environment over time. The green line represents the volume of spilled oil which would be on the ocean surface over time. The red line represents the volume of spilled oil which would make coastal contact (in this case, outside of Guyana) over time. The blue line represents the volume of spilled oil which would remain in the water column over time. The dotted orange line represents the volume of spilled oil which has decayed over time. The dotted gray line represents the volume of spilled oil which would be released to the atmosphere over time, which represents the vast majority of the spill volume (approximately 50 percent). For perspective, the Scenario 9 oil spill has the potential to occur during the drilling stage (approximately up to four years).

Figure 7-17 Oil Mass Balance Graph for Scenario 9 – Unmitigated 20,000-Barrel-per-Day Release of Crude Oil for 30 days (December through May) Depicting Weathering and Fate



7.4.1.6 Coastal Sensitivity Mapping

Coastal sensitivity mapping was conducted for the entire coastal area identified in the oil spill modeling as being potentially exposed to hydrocarbons as a result of a Tier III Marine Oil Spill (Scenario 9). The mapping included the following resources and receptors:

- Environmental – protected areas, wetlands, mangroves, beach types, seagrass beds, coral reefs, and other sensitive habitats; and
- Socioeconomic – coastal and/or indigenous peoples communities (e.g., location and socioeconomic characteristics), coast-dependent commercial and artisanal activities (e.g., fishing, foraging), other industrial activities, and infrastructure (e.g., water intake facilities).

This information enables EEPGL to prioritize the mobilization of emergency response resources (manpower and equipment) to those areas most sensitive to a spill. These maps are included in the OSRP.

7.4.1.7 Oil Spill Prevention, Control, and Emergency Response Measures

Regarding spill prevention controls associated with Scenario 9 (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 mature OIMS that emphasizes attention to safety, well control, and environmental protection. Measures to avoid any 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, the use of physical barriers including automatic BOPs, personnel training and proficiency drills for well control, and the use of drilling fluids to control pressures within the well. See Chapter 2 for additional information. A summary list of the spill prevention, mitigation measures and embedded controls found in the EIA and supporting plans can also be found in Appendix F of the OSRP.

Regarding spill prevention controls associated with Scenario 8 (FPSO offloading spill), the major spill prevention controls associated with FPSO offloading include: FPSO and tanker collision avoidance controls described in Section 7.1.4.8; 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 FPSO control room; and use of leak detection controls including infrared leak detection, flood lighting for night operations, and volumetric checks during offloading. See Section 2.11 Embedded Controls for additional information. Spill controls associated with other Scenarios are also included in Section 2.11.

In addition to the established spill prevention controls, EEPGL also has developed a detailed Oil Spill Response Plan (OSRP), which is included in 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. The OSRP describes the response measures which are dependent 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 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 MARAD, which falls under the Ministry of Public Works and Communication. Maritime responsibilities are handled by several departments and ministries, though the Coast Guard, under the auspices of MARAD, which enforces all maritime regulations and is the primary response organization in any marine pollution incident in navigable waters. In addition, the Guyana Defense Force and the Fire Service also assume an operational role for pollution response.

Due to the precautionary measures utilized by EEPGL to prevent and control an oil spill, as described above and in Chapter 2, the likelihood of a Tier II or III oil spill occurring is expected to be **Unlikely**.

7.4.1.8 Vessel Collision

Two scenarios for vessel collisions, which can be enabling incidents for oil spills, have been considered based on the nature of Project operations:

- Collision between the FPSO and an offloading tanker – during offloading of crude oil for export, the offloading tanker must approach at a controlled, safe speed within about 120 m (~390 ft) of the FPSO. To minimize the risk of collision during the approach to the FPSO and during offloading, EEPGL will utilize a Mooring Master onboard 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 upon completion of offloading. Up to three assistance tugs will assist in positioning the offloading tanker during the approach to the FPSO to maintain a safe separation from the FPSO. During offloading, these tugs along with a hawser (taunt line connecting the FPSO and tanker) will help ensure the offloading tanker maintains a safe distance from the FPSO at all times (see Figure 2-18). Offloading will only occur when weather and sea conditions allow for safe operations. If the environmental conditions prior to the commencement of offloading are not suitable, the tanker will standby at a safe distance away until conditions are within acceptable limits. If unexpected adverse weather (e.g., a squall) occurs during offloading operations, the offloading operation will be stopped, and the tanker disconnected and moved away from the FPSO until conditions are again within approved safe limits. Considering these precautions, the potential for a collision between the FPSO and the offloading tanker is considered **Unlikely**. In the unlikely event that a collision would occur during the tanker approach to or departure from the FPSO, the risk of a hull breach is greatly reduced by the design of the vessels (i.e., double hull) and the fact that the FPSO would be stationary and the offloading tanker would be travelling at a very slow maneuvering speed (assisted by tugs), therefore, there is not expected to be sufficient collision energy to breach the hulls.

- <u>Collision near shore between a Project supply vessel and another (non-Project) vessel or structure</u> – there are a variety of vessels that will supply and support drilling, installation, and production operations activities. These vessels will operate from Guyana and Trinidad shorebases. There is the potential for collisions between these vessels and other vessels/structures in the Georgetown Harbour/Demerara River or the grounding of a vessel. Such an incident may result from navigation error or a temporary loss of power that affected the ability of a vessel to steer. The potential environmental impacts from such a collision might result from a spill of fuel oil or lubricating oils from the vessels involved in the incident. Damage to structures may result in the requirement for repairs, and in extreme cases, temporary closure of the structure, which have occurred before in Guyana (e.g., damage to and temporary closure of the Demerara Harbour Bridge). Note the Georgetown shorebase(s) are downstream of the Demerara Harbour Bridge, which reduces the probability of collision with this structure.

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 perform regular inspections of their vessels which address marine safety and maintenance considerations, which should reduce the risk of loss of power incident scenario. In addition, vessels operating within the Georgetown Harbour or other coastal areas will be adhering to speed restrictions and navigation aids. Therefore, the risk of vessel accidents causing any significant damage to vessels or structures, or significant injury is considered *unlikely*.

Other vessel collisions (e.g., collisions between drill ship, 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:

- MARAD will issue notices to mariners concerning safety at sea and the location of the drill ship, installation vessels, and 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, and where possible communicate Project activities to those individuals to aid them in avoiding Project vessels through the stakeholder engagement process. Marine safety exclusion zones with a 500 m (~1,640 ft) radius will be established around the drill ship 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.
- EEPGL will utilize a Simultaneous Operations procedure to safely manage Project marine vessels which 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 ship, support vessels) to maintain station in the offshore environment.

7.4.1.9 Onshore Vehicular Accident

The Project will result in an increase in onshore vehicular traffic generated primarily by additional activity around the Georgetown base(s) that support the Project. As a result of this increased traffic, there will be an increased risk of vehicular accidents that could cause property damage and/or injury to third parties.

The likelihood of a vehicular accident causing a major injury or fatality is considered *possible* given the relatively low Project-related traffic volumes and the generally low vehicular speeds in Georgetown. EEPGL will implement a Road Safety Management Procedure –as described in Section 7.4.4.2 to minimize this risk.

7.4.1.10 Summary of Unplanned Events Interactions with Resources/Receptors

Table 7-84 indicates which resources/receptors would potentially be impacted by a NADF Release (Scenario 5), oil spills (i.e., Coastal Oil Spill [Scenario 6] and Marine Oil Spill [Scenarios 7, 8, and 9], and by vehicular or vessel accidents. The remainder of Section 7.4 evaluates the significance of these unplanned events on each of these 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 7-84 Resources/Receptors Potentially Impacted by Unplanned Events

Resource/Receptor	Oil Spill			Vehicular or Vessel Accident
	Marine	Coastal	NADF	
Physical Resources				
Air Quality and Climate	X			
Sound (airborne)				
Marine Geology and Sediments	X		X	
Marine Water Quality	X		X	
Biological Resources				
Protected Areas and Special Status Species	X	X		
Coastal Habitats	X	X		
Coastal Wildlife and Shorebirds	X	X		
Seabirds	X			
Marine Mammals	X			
Marine Turtles	X			
Marine Fish	X		X	
Marine Benthos	X		X	
Ecological Balance and Ecosystems	X		X	
Socioeconomic Resources				
Economics Conditions/ Employment and Livelihoods	X	X		
Community Health and Wellbeing	X	X		X
Marine Use and Transportation	X	X		X
Social Infrastructure and Services	X	X		X
Cultural Heritage	X	X	X	
Land Use				
Ecosystem Services	X	X		
Indigenous Peoples	X			

7.4.2 Physical Resources

As shown in Table 7-84, the only unplanned event with the potential to significantly impact physical resources is a Marine Oil Spill event in the Project AOI. Accordingly, discussions of potential impacts in this section relate to that unplanned event only.

7.4.2.1 Air Quality and Climate

Crude oil is a mixture of hydrocarbons, 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 PPE would be provided as necessary to those oil spill response workers who are exposed.

For an offshore spill, the potential for any harmful concentrations of air contaminants to reach the Guyana coastline is considered very low even for a large Marine Oil Spill considering prevailing winds away from the mainland and the distance to shore (approximately 190 km [~120 miles]). Further, any air quality impacts would be temporary. Similarly, in the event of a spill reaching shorelines, air contamination would be generally localized to the area where the oil came ashore. Therefore, the consequence to air quality of an oil spill is considered **Low**. In combination with a likelihood rating of **Unlikely** for a large Marine Oil Spill, the overall risk to air quality from an oil spill is **Minor**.

With respect to climate impacts, there would be an indirect impact associated with additional fossil fuel combustion by response vessels and equipment and with some potential for release of methane to the atmosphere, resulting in increased GHG emissions as compared to planned activities. However, the scale and duration of these additional GHG emissions would be limited, leading to a consequence rating of **Low**. In combination with a likelihood rating of **Unlikely** for an oil spill, the overall risk to climate from an oil spill is **Minor**.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure for the drill ship, lighter oil fractions would likely rise into the mid 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, a NADF Release would have no impact on air quality or climate.

Table 7-85 Risk Rating for Oil Spill Impacts to Air Quality

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measure	Residual Risk Rating
Marine Oil Spill	Air Quality	Unlikely	Low	Minor	Implement OSRP, air quality monitoring during response, provision of PPE to response workers	Minor
	Climate	Unlikely	Low	Minor	None	Minor

7.4.2.2 Marine Geology and Sediments

An 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 well release offshore and in the nearshore wave zone. One study determined that less than 1 percent of the oil from a major loss of well control event in the U.S. Gulf of Mexico was found in sediments, and this was principally within an 8 km (5-mile) radius of the release point (U.S. National Research Council, 1985). The heavier oil fractions that may sink to the seafloor would continue to be subjected to weathering processes. 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). Therefore, the consequence of an oil spill on the seabed and marine sediments is considered **Low**. In combination with a likelihood rating of **Unlikely** for a large Marine Oil Spill, the overall risk to marine geology and sediments from an oil spill is **Minor**.

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 NADF would remain suspended in the water column and have no effect on sediments, but the cuttings would accumulate on the seafloor. Cuttings deposits would tend to be deeper and coarser in the immediate vicinity of the wellhead, and decrease in thickness and grain size with increasing distance from the well. 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 sediment 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 IOGP Group III NABF with low to negligible aromatic content, reducing the potential that changes in marine sediments as a result of discharge of the NADF will lead to toxicological impacts on benthic infauna. Given the short-term nature of such an event, the low-toxicity NADF, and that the total volume of material that would be discharged would be limited to the volume of the riser, the consequence of a release of NADF on the seabed and 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 is **Minor**.

Table 7-86 Risk Rating for Oil Spill Impacts on Marine Geology and Sediments

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Sediments	Unlikely	Low	Minor	None	Minor
NADF Release	Marine Sediments	Unlikely	Low	Minor	None	Minor

7.4.2.3 Marine Water Quality

As described in Section 7.4.1, marine oil spills are subject to a range of weathering processes that will result in the hydrocarbon partitioning in different parts of the marine environment, and include the loss of some of the spill by way of evaporation and photo-oxidation. Microbial and photochemical degradation processes will gradually remove remaining contamination from the marine environment. The proportion of the spill that becomes entrained in the water column through wave energy will be subject to rapid, high levels of three-dimensional dilution along with biodegradation. Some oil constituents, especially aromatics, are also soluble in water. Together the entrained and dissolved fractions will increase hydrocarbon concentrations in the water column and result in localized reductions in water quality. Monitoring of oil spills 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 source (ITOPF, Undated). The oil that would be released from a spill in the PDA would be what is known as a light crude. Lighter crude oils generally have higher biological availability and are generally associated with higher toxicity impacts versus heavier crudes. This impact, however, is offset by the relatively rapid dissipation of light oils through evaporation and dispersion, which means light oils may be less impacting to the environment overall, relative to heavier oils, as long as sensitive resources are sufficiently distant from the immediate source of the spill.

The mixing energy resulting from a loss of well control event may result in higher levels of entrained and dissolved hydrocarbons than a surface spill, as the slick will be fragmented into smaller droplets by reservoir pressure.

Accordingly, a Marine Oil Spill is considered to have a **High** severity 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 relatively rapid loss of lighter fractions. In combination with a likelihood rating of **Unlikely** for a large Marine Oil Spill, the overall risk to marine water quality from an oil spill is **Moderate**. Even with implementation of the OSRP, the residual risk rating remains **Moderate.**

As discussed in Section 7.4.2.3, NADF would be exposed to 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 WBDF. Conditions favoring eutrophication and hypoxia 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 persist. Eutrophication and resulting hypoxia at the seafloor or within the pore water could be sufficient to cause localized changes in the marine biota, but these changes would likely be short term. 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 will lead to toxicological impacts. Therefore, a NADF Release is considered to have a **Medium** severity rating with respect to impacts on water quality. In combination with a likelihood rating of **Unlikely**, the overall risk to marine water quality from a NADF Release is **Minor**.

Table 7-87 Risk Rating for Oil Spill Impacts on Water Quality

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Water Quality	Unlikely	High	Moderate	Implement OSRP	Moderate
NADF Release	Water Quality	Unlikely	Medium	Minor	None	Minor

7.4.3 Biological Resources

The only unplanned events with the potential to impact biological resources would be a Marine Oil Spill, a Coastal Oil Spill, or a NADF spill (collectively referred to as oil spills). Oil spills can impact marine biological resources both as a result of physical smothering and toxic impacts. The severity of the impact typically depends on the location of the spill, the quantity and type of hydrocarbon spilled, the environmental conditions (e.g., wind, currents), and the sensitivity of the impacted receptors and their habitats ultimately exposed to the oil (ITOPF, undated).

Due to rapid dilution of hydrocarbons in the water column, the most significant impacts on biological resources are generally impacts on seabirds and other species that encounter surface slicks. Impacts may also occur in shallow subtidal or intertidal areas that are exposed to higher concentrations where hydrocarbons are entrained by breaking waves or where species are foraging on sand, mudflats, or wetlands.

7.4.3.1 *Protected Areas and Special Status Species*

Potential impacts from a Marine Oil Spill or a Coastal Oil Spill on protected areas and special status species are discussed in this sub-section.

Protected Areas

The Shell Beach Protected Area (SBPA) provides habitat for numerous coastal wildlife and shorebird species, including several species of critically endangered/endangered marine turtles. The SBPA would be highly sensitive to a large Marine Oil Spill if it were to reach the shoreline. However, as discussed in Section 6.1.4.1, Guyana's oceanic waters are influenced by the Guiana Current and the North Brazil Current, and oil spill modeling indicates that oil spilled from the modeled loss of well control event would have a 5 to 10 percent probability would reach the Guyana shoreline, without considering the effects of emergency spill response. Nevertheless, SBPA has been included in the coastal sensitivity mapping, and in the event of an oil spill, resources and equipment would be mobilized to protect Shell Beach as necessary.

Based on the sensitivity of the SBPA, the consequence of an oil spill reaching the SBPA would be **High**. The low probability (5 to 10 percent) of oil from a large Marine Oil Spill actually reaching the Guyana shoreline supports a likelihood rating of **Unlikely**. Therefore, the overall risk to the SBPA from a large 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 (e.g., Scenario 6 from Table 7-82) would not be expected to impact SBPA because it would be limited to near Project shorebases and onshore support facilities, which would be distant from SBPA.

A NADF spill would not be expected to impact the SBPA because of the limited volume spilled, and the depth and distance to shore at which the spill would occur.

Special Status Species

Special Status Species include critically endangered, endangered, threatened, and vulnerable species that are found in the Project AOI.

The Critically Endangered species in the AOI are all coastal fish species that would only exposed to oil if it reached coastal waters. If oil were to reach the coast in sufficient quantities to cause lethal or sublethal impacts on fish, the loss of even a few individuals in this category could cause significant impacts at the population level. Based on this rationale, the consequence or severity of an oil spill on Critically Endangered species is considered **High**. A large Marine Oil Spill or a Coastal Oil Spill are the only spill scenarios that could result in such quantities of oil reaching coastal waters and these events are considered **Unlikely**. Therefore, the overall risk of a large Marine Oil Spill or a Coastal Oil Spill to Critically Endangered species is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the probability of oil reaching the Guyana coast line.

There are a few terrestrial special status species, such as the Agami heron and Semipalmated sandpiper that could encounter weathered oil along the coast, or ingest fish that had been exposed to or ingested oil themselves. This would be most likely to occur under a large Marine Oil Spill or Coastal Oil Spill in which oil could approach or reach the Guyana coast. Such an event could cause significant impacts at the population level, depending on the size of the spill and the proportion of available forage and habitat affected. Therefore the consequence or severity of an oil spill on Critically Endangered species is considered **High**. The likelihood rating of such an event occurring is considered **Unlikely** for the same reasons cited above for Critically Endangered species. Therefore, the overall risk of a large Marine Oil Spill or a Coastal Oil Spill to terrestrial special status species is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the probability of oil reaching the Guyana coast line.

The Endangered and Vulnerable species are primarily open water fish that would occur in the PDA. 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 Endangered and Vulnerable species are pelagic species that would be expected to rapidly vacate areas with harmful concentrations of oil in the water column, so exposure times would be brief. Losses of a small numbers of individuals of Endangered or Vulnerable species could have significant population level effects, but would have less of an impact than losses of equivalent numbers of Critically Endangered species.

Based on this rationale the consequence or severity of a large Marine Oil Spill on Endangered or Vulnerable species is considered **Medium**. The severity of a spill event's impacts on green sea turtles and black capped petrels would be higher than on the fishes that comprise most of the Endangered and Vulnerable categories, and impacts of unplanned events on sea birds and sea turtles are assessed in other sections, with the higher sensitivities of these two species to oil spills are not sufficient to elevate the consequence rating for impacts on the remaining species in the Endangered and Vulnerable categories. Therefore, the overall risk of a large Marine Oil Spill to Endangered and Vulnerable species is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by further reducing the probability of oil reaching the Guyana coast line.

The Near Threatened category includes a mix of offshore and coastal species, but most species are primarily found offshore. These species are considered less at-risk than Endangered or Vulnerable species, so the consequence or severity of a large Marine Oil Spill or Coastal Oil Spill on these species is considered **Medium**. Most species in the Endangered and Vulnerable categories occur offshore, so the likelihood of an oil spill impacting these species is rated as **Unlikely** based on the same rationale presented above for Endangered or Vulnerable species. Therefore, the overall risk of a large Marine Oil Spill or Coastal Oil Spill to Endangered and Vulnerable species is considered **Minor**. Effective implementation of the OSRP would further reduce the geographic extent of a spill.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure for the drill ship, lighter oil fractions would likely rise into the mid water column and dissipate laterally as they rise, while the NADF would remain at or near the seafloor. A few of the deepwater-adapted special status fishes (e.g., hollownose grenadier and frilled shark) may occur occasionally in the shallowest portion of the PDA, but the PDA is too deep to be within the preferred habitat of any special status species. Therefore, a NADF Release would not be expected to have a population-level impact on special status species.

Table 7-88 Risk Rating for Oil Spill Impacts on Protected Areas and Special Status Species

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Protected Areas (SBPA)	Unlikely	High	Moderate	Implement OSRP	Minor
Marine Oil Spill or Coastal Oil Spill	Special Status Species					
	Critically Endangered Species	Unlikely	High	Moderate	Implement OSRP	Minor
	Endangered Fish and Black Capped Petrel	Unlikely	High	Moderate	Implement OSRP	Minor
	Vulnerable/ Near Threatened Species	Unlikely	Medium	Minor	Implement OSRP	Minor

7.4.3.2 Coastal Habitats

As indicated in Table 7-84, the unplanned events with the potential for any measureable impacts on coastal habitats would be from a large Marine Oil Spill or Coastal Oil Spill.

In Guyana, the coastal habitats most at risk from an oil spill would be mangroves and other wetland habitats (e.g., mudflats). Other habitats that are known to be sensitive to oil spills are coral reefs and seagrass beds, but which are not present in Guyana.

Mangroves, of which the largest remaining stands in Guyana occur in the SBPA, 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; and
- 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 or severity of a large Marine Oil Spill on mangroves is considered **High**. However, oil spill modeling of a loss of well control event indicates a 5 to 10 percent chance of oil reaching the Guyana shoreline, supporting a likelihood rating of **Unlikely**. Therefore, the overall risk of a Marine Oil Spill on 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 coast line.

There is also the potential for a Coastal Oil Spill in the Demerara River or near shorebases located elsewhere in Guyana (see Section 7.5 for discussion of shorebases in Trinidad). Scenario 6 (Table 7-82) assumes a spill of 500 bbl of diesel oil, which may occur during bunkering. Under this scenario, the spill 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** and the occurrence of this event is considered **Unlikely**. Therefore, the overall risk of a Coastal Oil Spill 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.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure on the drill ship, the NADF would not be expected to reach the coast. Therefore, a NADF Release would have no impact on coastal habitats.

Table 7-89 Risk Rating for Oil Spill Impacts on Coastal Habitats

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	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

7.4.3.3 *Coastal Wildlife and Shorebirds*

As indicated in Table 7-84, the unplanned events with the potential for any measureable impacts on coastal wildlife and shorebirds would be a large Marine Oil Spill or a Coastal Oil Spill.

As described in Section 6.2.3, the Guyana coastal habitats support a rich and diverse collection of species, including shorebirds. 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 upstream 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 and giant river otter. 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.

For these reasons, the consequences or severity of a large Marine Oil Spill on coastal wildlife and seabirds is considered **High**. However, oil spill modeling of a loss of well control event indicates a 5 to 10 percent chance of oil reaching the Guyana shoreline, supporting a likelihood rating of **Unlikely**. Therefore, the overall risk of a large oil spill on coastal wildlife and shorebirds is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by reducing the probability of oil reaching the Guyana coast line.

A Coastal Oil Spill (e.g., Scenario 6 from Table 7-82) would more directly impact estuarine wildlife than the small portion of a larger Marine Oil Spill that reaches the coastal portion of Guyana. The giant river otter, however, is not found in estuarine waters, and emergency response measures should be able to prevent any hydrocarbons from a spill like this from migrating upstream into fresh water habitats where this species may be found. There could be impacts to the neotropical otter, which can be found in estuarine areas, shorebirds, and other wildlife from oiling, but because of the more limited magnitude of the 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 and shorebirds is considered **High** and the occurrence of this event is considered **Unlikely**. Therefore, the overall risk of a Coastal Oil Spill on 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.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure on the drill ship, the NADF would not be expected to reach the coast. Therefore, a NADF Release would have no impact on coastal wildlife or shorebirds.

Table 7-90 Risk Rating for Oil Spill Impacts on Coastal Wildlife and Shorebirds

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Coastal Wildlife and Shorebirds	Unlikely	High	Moderate	Implement OSRP	Minor
Coastal Oil Spill	Coastal Wildlife and Shorebirds	Unlikely	High	Moderate	Implement OSRP	Minor

7.4.3.4 Seabirds

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on seabirds would be a Marine Oil Spill.

During most oil spills, seabirds are harmed and killed in greater numbers than other kinds of creatures (NOAA, 2016b). 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 identified in Guyana. For colonial nesting 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 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. Reproducing 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).

Given their susceptibility and sensitivity, the consequence of a Marine Oil Spill on seabirds is considered **High**. This is offset to some extent by the **Unlikely** likelihood of a Marine Oil Spill. Therefore, the overall risk of an oil spill on seabirds is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by limiting the geographic extent of the oil spill and the number of individual birds impacted.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure on the drill ship, the NADF would not be expected to reach the surface of the ocean where seabirds are active. Therefore, a NADF Release would have no impact on seabirds.

Table 7-91 Risk Rating for Oil Spill Impacts on Seabirds

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Seabirds	Unlikely	High	Moderate	Implement OSRP	Minor

7.4.3.5 Marine Mammals

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on marine mammals would be a Marine Oil Spill.

In the unlikely event of an oil spill, marine mammals (i.e., whales, dolphins, 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 because of the potential for oil to foul their baleen plates if the whales filter feed in the vicinity of the oil spill. Although not the most common whales in the Project AOI, three species of baleen whales have been documented in the area: Sei, Minke, and Bryde's whales. 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.

Despite these risks, 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 take evasive action and avoid areas impacted by spills. Depending on time of year, however, marine mammals could be directly exposed to oil and suffer a range of health consequences.

For these reasons, and especially 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 **Unlikely** likelihood of an oil spill. Therefore, the overall risk of an oil spill on marine mammals is considered **Moderate**. 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 remains **Moderate**.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure for the drill ship, lighter oil fractions would likely rise into the mid water column and dissipate laterally as they rise, while the NADF would remain at or near the seafloor. This is deeper than most marine mammals occur, and it would be too deep to affect the preferred forage species of any marine mammal species known occur in the AOI. Therefore, a NADF Release would have no impact on marine mammals.

Table 7-92 Risk Ratings for Oil Spill Impacts on Marine Mammals

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Mammals	Unlikely	High	Moderate	Implement OSRP	Moderate

7.4.3.6 Marine Turtles

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on marine turtles would be a Marine Oil Spill.

In the unlikely event of an oil spill, several aspects of sea 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 because there is oil in the nest or the adult turtles pick up oil 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 sea turtle behavior also compound their biological susceptibility to oil. These behaviors include:

- 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 to Critically Endangered by the IUCN.

The consequence of a Marine Oil Spill on marine turtles is considered **High** taking into consideration their susceptibility to oil contamination, their presence and important nesting site in the Project AOI, and their threatened status. As explained previously, a large Marine Oil Spill from a well control event is considered **Unlikely**, with oil spill modeling indicating a 5 to 10 percent chance that oil would reach the Guyana shoreline and Shell Beach. Therefore, considering both consequence and likelihood, the overall risk to marine turtles from an oil spill is **Moderate**. Effective implementation of the OSRP would reduce the overall risk by reducing the probability of oil reaching the Guyana coast line. However, given the Critically Endangered and Endangered IUCN classifications for several of these turtle species, the residual (post-mitigation) risk rating remains **Moderate**.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure for the drill ship, lighter oil fractions would likely rise into the mid water column and dissipate laterally as they rise, while the NADF would remain at or near the seafloor. No marine turtles are known to dive to the depths that occur in the PDA, and it would be too deep to affect the preferred forage species of any marine turtle species known occur in the AOI. Therefore, a NADF Release would have no impact on marine turtles.

Table 7-93 Risk Rating for Oil Spill Impacts on Marine Turtles

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Turtles	Unlikely	High	Moderate	Implement OSRP	Moderate

7.4.3.7 Marine Fish

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on marine fish would be a Marine Oil Spill.

Impacts to fish are related to both water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily polynuclear aromatic hydrocarbons, or PAH). Contamination in the water column changes rapidly in space and time, such that exposures are typically brief (i.e., typically measures in hours). Exposure to microscopic oil droplets may also impact aquatic biota either mechanically (especially 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 spill than adults for several reasons, including:

- Most marine fishes spend at least their initial larval stages in the plankton, which renders them unable to move away from oil at the surface;
- Oil tends to concentrate at the water surface, at least initially following a release; and
- 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 (Press, 2015).

Despite the susceptibility of juvenile stages of fish to relatively low concentrations of oil in the upper 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.

Although adult fish tend to be resilient to the impacts of oil spills in the open ocean, fish at all life stages can be substantially impacted in some circumstances, especially when oil spills into shallow or confined waters. In exceptional circumstances, depletion of a year class for a particular species has been recorded in industry, but mass fish mortalities as a result of an oil spill are rare. Mortalities that have occurred have been associated with very high, localized concentrations of dispersed oil in the water column in storm conditions, with the release of substantial quantities of light oils into breaking surf along a shoreline, or with spills in rivers (ITOPF, Undated). If a spill were to reach these areas and penetrate the shallow creeks and lagoons within the mangroves, mortality of adult and subadult life stages could be much higher. The consequence of an oil spill impacting marine fish is therefore considered **Moderate**.

The likelihood of oil reaching the coast, where fish would be most vulnerable to adverse impacts, would be highest under a large Marine Oil Spill scenario. But even if such an event occurred during the season when winds and currents were most favorable for oil to reach the coast, the probability of oil actually reaching the Guyanese coast would remain between 5 to 10 percent, supporting a likelihood rating of **Unlikely**. This means that the impacts of most oil spills on marine fish would be mostly confined to early life stages of pelagic fish and would have limited impacts at the population or species level. Considering the consequence and likelihood ratings, the risk to marine fish from a Marine Oil Spill is rated as **Minor**. Effective implementation of the OSRP would further reduce the risk by limiting the geographic extent of the oil spill.

In the event of a Tier II or Tier III marine oil spill, implementation of the OSRP may include use of dispersants (Secenarios 7, 8, and 9 in Table 7-82. EEPGL is seeking pre-approval from the EPA for the potential use of the three primary (i.e., most broadly approved and studied) dispersants: Corexit 9500, 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

US EPA, Corexit 9500A was found to be practically non-toxic[36] to *Menidia spp.* (which is commonly used as a biological model representing fish in general) 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 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.

The same factors that will cause rapid dilution of oil in the open ocean (e.g.; marine currents, wind, and wave action) will 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, so the responsible use of dispersants generally does not represent an additional risk to marine biota.

In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure for the drill ship, lighter oil fractions would likely rise into the mid water column and dissipate laterally as they rise, while the NADF would remain at or near the seafloor. In the event of a release of NADF caused by an emergency riser disconnect due to DP station keeping failure on the drill ship, the NADF would remain at or near the seafloor. Such an event would expose deepwater-adapted fishes within the PDA to NADF, but a NADF release would be expected to only temporarily affect a small area around the release point. Therefore, the risk to marine fish from a NADF Release is rated as **Minor**.

Table 7-94 Risk Rating for Oil Spill Impacts on Marine Fish

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Fish	Unlikely	Moderate	Minor	Implement OSRP	Minor
NADF Release	Marine Fish	Unlikely	Low	Minor	None	Minor

7.4.3.8 Marine Benthos

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on marine benthos would be a Marine Oil Spill.

[36] The US EPA classifies substances with LC50 values (concentration that will kill 50% of the test animals with a single exposure) of >100 ppm as "practically nontoxic".

Benthic resources would be in close proximity to spilled oil from a loss of well control event. The impact of oil contamination on deep-sea benthic biological resources, however, is poorly understood by academia and industry. As discussed previously, most of the spilled oil 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 km (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 kill the well by injection of drilling fluids into the open wellhead rather than the loss of well control. 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 (Xerces Society, 2014).

In a 2010 study conducted by the US EPA, Corexit 9500A was found to be slightly toxic[37] to *Mysid* shrimp (which are commonly used as a biological model representing crustaceans and other benthos in general) during standard acute toxicity tests (USEPA, 2010). As described above, oil spill scenarios 7, 8, and 9 as identified in Table 7-82 and in the OSRP could require the application of an estimated total of between 2 m^3 and 159 m^3 of dispersant, but if subsea application of dispersant were to be used, the upper end of that range would decrease by a factor of five to a total of approximately 32 m^3. This means that although subsea application would place the disperant closer to the seafloor where benthos are located, the incremental increase in relative toxicity to benthos (as compared to fish) would be largely balanced by the much smaller amount of dispersant that would be required in such an application.

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**. Combined with the **Unlikely** event of a large Marine Oil Spill, the overall risk to marine benthos from an oil spill is considered **Minor**. There is little in the way of mitigation that would minimize the impacts of an 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.

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 the 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

[37] The US EPA classifies substances with LC50 values (concentration that will kill 50% of the test animals with a single exposure) of 10-100 ppm as "slightly nontoxic".

Scenario 5 (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 7.4.2.2 and 7.4.2.3, marine currents in the AOI would mitigate the potential for burial 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. While the NADF to be used by EEPGL contains IOGP Group III NABF with low to negligible aromatic content, reducing the potential that changes in marine sediments as a result of discharge of the NADF will lead to toxicological impacts on marine benthos, a NADF Release is considered to have a **Medium** severity rating with respect to impacts on marine benthos. In combination with a likelihood rating of **Unlikely**, the overall risk to marine water quality from a NADF Release is **Minor**.

Table 7-95 Risk Rating for Oil Spill Impacts on Marine Benthos

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Marine Benthos	Unlikely	Low	Minor	None	Minor
NADF Release	Marine Sediments	Unlikely	Medium	Minor	None	Minor

7.4.3.9 Ecological Balance and Ecosystems

As described in Section 7.2.9.2, maintaining ecological balance in the North Brazil Shelf LME is essential to maintaining nutrient cycling, gene flow, and biodiversity. As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on ecological balance and ecosystems would be a large Marine Oil Spill.

Impacts on the Marine Nutrient Cycle

Nitrogen, phosphorous, and silicon all enter the marine food web through metabolism by phytoplankton (Nihoul and Chen, 2008), so the impact on the food web from an 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, localized, and the proportion 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 plankton not impacted would be carried into the Project AOI from unaffected areas to the east by the Guiana Current. 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 phytoplankton's short generation times relative to other marine taxa.

Impacts on Gene Flow

As described in Section 7.2.9.2, obstacles to efficient gene flow occur when physiochemical barriers to migration, breeding, or dispersal/colonization occur. A large Marine Oil Spill would 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 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 if they inhaled vapors or oil at the surface prior to vacating the area. Sea turtle and birds would more sensitive to impacts on gene flow because they do congregate to breed in portions of the Project AOI (see Sections 7.4.3.4 and 7.4.3.6).

Impacts on Biodiversity

A large 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 declines in vigor. Small spill events would have little if any long-term impact on biodiversity across the North Brazil 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 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. For taxonomic groups that could experience significant reproductive and/or gene flow impacts depending on the timing, duration, and extent of the spill (such as sea turtles), declines in biodiversity could be regional and span multiple generations.

Trophic Impacts

A large Marine Oil Spill from a well control event could have ecosystem-level trophic level impacts if hydrocarbons persisted in the food web and had toxic impacts on organisms, or if underlying changes in abundance or distribution of prey caused 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).

Most marine taxa would be able to avoid oil spills and would be able to recover relatively quickly from impacts should they occur. 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).

For these reasons, the consequence of impacts from a large Marine Oil Spill on ecological balance and ecosystems is rated Medium. Combined with the Unlikely event of a large Marine Oil Spill occurring, the overall risk to ecological balance and ecosystems from an oil spill is considered **Minor.** Additionally, at the onset of an oil release, a wildlife response program would be established to help minimize these impacts.

Release of NADF near the seafloor as described under Scenario 5 would enrich the nutrient content of the marine sediment down current of the wellhead due to the presence of biodegradable organic material in the fluid, and the eutrophic condition that could result would cause temporary shifts in the food chain as the makeup of the marine benthos changed. It is unlikely that these changes in the benthic community would cause substantial changes in upper trophic levels, however, so a NADF Release is considered to have a **Low** severity rating with respect to impacts on ecological balance and ecosystems. In combination with a likelihood rating of **Unlikely**, the overall risk to ecological balance and ecosystems from a NADF Release is **Minor**.

Table 7-96 Risk Rating for Oil Spill Impacts on Ecological Balance and Ecosystems

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Ecological Balance and Ecosystems	Unlikely	Medium	Minor	Wildlife Oil Response Program	Minor
NADF Release	Ecological Balance and Ecosystems	Unlikely	Low	Minor	None	Minor

7.4.4 Socioeconomic Resources

The only unplanned events with the potential to impact socioeconomic resources would be a large Marine Oil Spill or a Coastal Oil Spill. A NADF spill would not be expected to impact socioeconomic resources, with the possible exception of submerged cultural heritage, because of the limited volume of the potential spill, and the water depth and distance to shore at which the spill would occur.

7.4.4.1 Economic Conditions / Employment and Livelihoods

As indicated in Table 7-84, the unplanned events with the potential for any measureable impacts on economic conditions or employment and livelihoods in the Project AOI would be a large Marine Oil Spill or a Coastal Oil Spill, which through decreased fishery and agricultural yields could potentially impact the fishery and agriculture sectors that currently account for a large part of the country's GDP.

The economy in Regions 1, 2 and 3 are highly dependent on fishing and agriculture for employment, income generation, and subsistence. Although the economy in Region 4 is relatively diversified, populations in the rural areas also rely on agriculture and fishing, with the largest number of fishermen in the country located in Region 4. These economies would be sensitive to any impact on fisheries and crop production that could result from an oil spill. These potential impacts are discussed below.

Fisheries could be impacted by a large Marine Oil Spill, especially if the oil reaches near-coastal waters where most artisanal and commercial fishing occurs. Although considered unlikely based on the results of modeling and the sensitivity of fish species to spills, as discussed above, these 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 potential tainting of commercial products. Impacts on mangrove habitats could impact fishery nursery grounds and impact 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 7.4.3.7). Further, oil spill modeling for a well control event indicates 5 to 10 percent probability of oil reaching near-coastal waters in the unlikely event an oil spill occurs. There would be several days advance notice before any oil would reach the Guyana coast, so fisherfolk would be able to move their boats to unaffected areas.

Therefore, while the consequence of a large Marine Oil Spill impacting commercial fisheries could be considered **High**, given that a large Marine Oil Spill reaching the Guyana coast is considered **Unlikely**, the risk to commercial fishing is considered **Moderate**. The coastal sensitivity mapping that supports the OSRP includes mangroves as a sensitive coastal resource and in the unlikely event of an oil spill; EEPGL will deploy emergency response equipment to protect these sensitive resources, as appropriate. Effective implementation of the OSRP would reduce this risk to **Minor** by reducing the probability of oil reaching the Guyana coast. Additionally, a claims process would be established at the onset of a large Marine Oil Spill incident to compensate fisherfolk for loss of harvest due to regional fisheries closures that were attributed to the oil spill.

In the event that a spill reaches the shore, there would be the potential to impact agriculture. Rice farming, which makes up the majority of agricultural activity in the coastal area of Region 2, would not be impacted by potential oiling of the coastline since rice fields are irrigated from inland water conservancies. Non-traditional crops such as fruits, vegetables, and coconuts, particularly along the Pomeroon River, have the potential to be impacted by contaminated seawater entering the drainage system through sluice gates, but this is considered highly unlikely as the movement of oil upstream would be limited by tidal action, 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. Therefore, the consequence of an oil spill that reaches the Guyana coast on economic conditions in coastal communities is considered **Medium**, and considering the **Unlikely** likelihood of an oil spill that reaches the Guyana shoreline, the overall risk to agricultural activities in coastal communities is considered **Minor**. Effective implementation of the OSRP and a claims process would further reduce this risk by reducing the probability of oil reaching the Guyana coast line and compensating for economic losses.

In the event of a smaller 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, because of its proximity to fishing grounds, to impact fisherfolk. These impacts, however, would be **Minor** because of the limited affected area, short duration of the impact, and the relatively rapid expected environmental recovery. Although the response time would be less for a small oil spill relative to a larger oil spill, response efforts should be able to prevent oil from reaching agricultural areas because of the limited geographic areas impacted.

Table 7-97 Risk Rating for Oil Spill Impacts on Economic Conditions / Employment and Livelihoods

Unplanned Event	**Resource/ Receptor**	**Likelihood**	**Severity/ Consequence**	**Risk Rating**	**Proposed Mitigation Measures**	**Residual Risk Rating**
Marine Oil Spill	Coastal Communities - Fishing	Unlikely	High	Moderate	Implement OSRP and claims process	Minor
	Coastal Communities - Agriculture	Unlikely	Medium	Minor	Implement OSRP and claims process	Minor
Coastal Oil Spill	Coastal Fishing and Agricultural Communities	Unlikely	Medium	Minor	Implement OSRP and claims process	Minor

7.4.4.2 *Community Health and Wellbeing*

As indicated in Table 7-84, unplanned events with the potential for any measureable impacts on community health and wellbeing include a large Marine Oil Spill, Coastal Oil Spill, and vehicle accidents. Guyana is one of the poorest countries in South America, and this is particularly in 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 often sold locally at markets or roadside stands. In indigenous communities in Regions 1 and 2, crabbing, shrimping and hunting of coastal game such as caiman and shorebirds are also practiced for subsistence. 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.

Given their dependence on the coastal environment for subsistence and income, their high rate of poverty, and the current health challenges faced by the coastal population in Guyana, the health consequences of an oil spill impacting food availability in coastal communities is considered **High**. Oil spill modeling indicates that the probability of the oil from a well control event actually reaching the Guyana coast, with the potential for contaminating crops or coastal game, is 5 to 10 percent, supporting a likelihood rating of **Unlikely**. Accordingly, the overall risk to community health and wellbeing from a large Marine Oil Spill is considered **Moderate**. Effective implementation of the OSRP would reduce this risk to **Minor** by reducing the probability that oil would reach the Guyana coast.

A Coastal Oil Spill (e.g., Scenario 6 from Table 7-82) could also have similar **Minor** effects on community health and wellbeing as a large Marine Oil Spill. The geographic area affected, however, would be more limited, which would create more potential for subsistence fisherfolk to access alternative areas for fishing.

With regard to the impact of onshore traffic accidents on community health, increased vehicular trips would be expected to increase the risk of vehicular accidents, the severity of which may be greater when industrial trucks are involved. However, the Project-related increase in traffic is expected to be a minor incremental addition to the existing traffic. The relatively low traffic speeds in Georgetown due to existing congestion may reduce the likelihood of serious injuries, although the presence of bicyclists and pedestrians increases that risk. Overall, vehicular accidents are considered **Possible** and the consequence could range from **Low** to **High** depending on the extent of damage or the severity of injury. This leads to a risk rating for vehicular accidents of **Minor** to **Major**.

Consistent with international best practice, 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 typical, primary travel routes;
- 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 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;
- 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.

With the implementation of these measures, the risk rating for vehicular accidents could be reduced to **Minor** to **Moderate**. Accidents involving Project vessels in Georgetown Harbor or near shorebases could lead to consequences ranging from cosmetic damage to injury or loss of life. Vessels operating in these areas, however, will be adhering to speed restrictions and navigation aids, which should reduce the potential for significant injury or loss of life, so the potential severity of these accidents is considered Low. Project contractors will utilize their own safety, health, and environmental programs, and EEPGL will provide active oversight of its contractors to minimize safety, health, and environmental risks. Therefore, the overall risk to Community Health and Wellbeing is considered **Minor.**

Table 7-98 Risk Rating for Oil Spill and Vehicle/Vessel Impacts on Community Health and Wellbeing

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	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 High	Minor to Major	Road Safety Management Plan	Minor

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Vessel Collision	Community Health and Wellbeing	Unlikely	Low	Minor	None Required	Minor

7.4.4.3 Marine Use and Transportation

As indicated in Table 7-84, the unplanned events with the potential for measureable impacts on marine use and transportation would be a large Marine Oil Spill and a Coastal Oil Spill. As an oil spill would likely have some impact on marine use and transportation as additional marine vessels and resources would need to be mobilized to support spill response, likely resulting in increased congestion in Georgetown Harbour and/or near shorebases, and vessel movement may be restricted in some areas. The severity of these impacts could be higher if the spill occurred/drifted close to shore and impacted nearshore vessel traffic, but oil spill modeling indicates that the probability of the oil from a well control event actually reaching the Guyana coast is 5 to 10 percent for a large oil spill scenario. Accordingly, the severity of impacts on marine use and transportation from a spill is considered **Low**.

Therefore, considering that an oil spill is considered **Unlikely**, the overall risk to marine use and transportation is considered **Minor**. Effective implementation of the OSRP would further reduce the risk by reducing the probability that oil would spread in coastal areas. In the event of a loss of DP on the drill ship, the drill ship would move away from the exact drilling location as a result of ocean currents until DP power is restored and it could be brought back on station, but the event would be short term and would not constitute a hazard to shipping, so it would have no impact on marine use and transportation.

Accidents involving Project vessels in Georgetown Harbor or coastal areas (e.g., groundings or collisions) could interfere with marine use and transportation. Vessels operating in these areas, however, will be adhering to speed restrictions and navigation aids, which should reduce the likelihood and severity of such an event. Prompt emergency response in the event of such an accident and removal of any grounded or damaged vessel would limit the severity of the event, so the overall risk for marine use and transportation is considered **Minor**.

Table 7-99 Risk Rating for Oil Spill/Vessel Collision on Marine Use and Transportation

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measure	Residual Risk Rating
Marine Oil Spill	Marine Use and Transportation	Unlikely	Low	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

7.4.4.4 Social Infrastructure and Services

As indicated in Table 7-84, both unplanned events considered herein (a Marine Oil Spill, a Coastal Oil Spill, and a vehicular accident) have the potential to result in measureable impacts on social infrastructure and services.

A large Marine Oil Spill could impact social infrastructure and services primarily as a result of supporting spill response and clean-up teams. These teams could overburden housing, medical, and other infrastructure and services in Guyana. 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, then 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 are concentrated. If oil were to reach the Guyana shoreline, then land-based clean-up would be required, potentially in Regions 1, 2, and/or 3, where little infrastructure or service capacity exists. Oil spill modeling, however, indicates the probability of oil reaching the Guyana shoreline in the unlikely event of a large oil spill associated with a well control event is only 5 to 10 percent. The consequence of an oil spill on social infrastructure and services is therefore considered **Medium**, given the anticipated temporary impact on services. Given that a large Marine Oil Spill is considered **Unlikely**, the overall risk to social infrastructure and services is considered **Minor**. Effective implementation of the OSRP would further reduce this risk by reducing the probability that oil would reach the Guyana coast. A smaller Coastal Oil Spill would not require spill response measures and teams that would cause any meaningful impact to social infrastructure and services. Response to a release of NADF under Scenario 5 would involve a fraction of the crew and vessels that would be required to respond to a large Marine Oil Spill, so it would not be expected to cause any impact on social infrastructure and services.

With regard to impacts of vehicular accidents on social infrastructure and services, accident rates from ground transportation associated with the Project (e.g., workers commuting, truck transport of materials) are expected to be low and would represent a negligible fraction of the accidents occurring in Georgetown. As a result, the potential consequence level for isolated, temporary impacts on road congestion and healthcare utilization resulting from vehicle accidents would be **Low**. The risk of vehicle accidents associated with the Project causing measurable impact on congestion or healthcare utilization is considered **Minor**. Consistent with international best practice, EEPGL will develop and implement a Road Safety Management Procedure, as summarized in Section 7.4.4.2, to further reduce this risk.

Table 7-100 Risk Rating for Oil Spill and Vehicular Accident Risks to Social Infrastructure and Services

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Social Infrastructure	Unlikely	Medium	Minor	Implement OSRP	Minor

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
	and Services					
Coastal Oil Spill	Social Infrastructure and Services	Unlikely	Medium	Minor	Implement OSRP	Minor
Vehicular Accident	Social Infrastructure and Services	Possible	Low	Minor	Road Safety Management Procedure	Minor

7.4.4.5 *Cultural Heritage*

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on cultural heritage would be a large Marine Oil Spill or a Coastal Oil Spill.

Desktop research identified two known ceramic/pottery sites near the coastline. Based on the ubiquity of past human occupations (and thus archaeological sites), especially along coastlines, it is likely that there are many more unidentified archaeological resources along Guyana's coastline. It should be noted, however, that Marine Oil Spills from well control events that reach the coast (5-10 percent probably of contacting the coast) generally only impact the intertidal zone, unless the spill coincides with a significant storm surge. 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.

Some oil would be expected to settle to the seafloor and could damage submerged cultural heritage (e.g., shipwrecks), but this would be expected to be in proximity to the spill source. No shipwrecks or associated artifact scatters were identified within the PDA, and therefore the risk to underwater cultural heritage is considered **Low**. The same factors would apply to a release of NADF, so the risk to underwater cultural heritage posed by Scenario 5 is also considered **Low.**

As a result, the consequence of a large Marine Oil Spill or release of NADF on coastal archaeological sites and submerged cultural heritage is considered to be **Low.** NADF is not expected to reach the coast under any conditions and considering the **Unlikely** likelihood of an oil spill that reaches the Guyana shoreline, the overall risk to coastal cultural heritage from an oil spill or NADF Release is considered **Minor**. The consequence of a Coastal Oil Spill on archaeological sites would be similar to that for a large Marine Oil Spill. Effective implementation of the OSRP would further reduce the risk of a large oil spill by reducing the probability and limiting the geographic extent of oil reaching the Guyana coast.

Table 7-101 Summary of Oil Spill Risk to Cultural Heritage

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Cultural Heritage	Unlikely	Low	Minor	Implement OSRP	Minor
Coastal Oil	Cultural	Unlikely	Low	Minor	Implement	Minor

Spill	Heritage				OSRP	
NADF Release	Cultural Heritage	Unlikely	Low	Minor	None	Minor

7.4.4.6 Land Use

As indicated in Table 7-84, none of the identified unplanned events are expected to have any impact on land use.

7.4.4.7 Ecosystem Services

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on ecosystem services would be a large Marine 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 sugarcane 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 but a number of other natural resource-based activities take place, particularly by indigenous communities. Along the coast and at the river mouths, these include fishing, crabbing, hunting, and trapping. Some communities also hunt shorebirds and sea turtles, as well as collect sea turtle eggs 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.

In addition to provisioning services, the marine and coastal ecosystems in Guyana render 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. This includes the coastal flood protection offered by mangrove forests and wildlife habitat provided by mangrove forests, mud banks, and coastal swamps. In the unlikely event of an oil spill from a well control event 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 Regions 1 and 2. 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 irrigation and drainage canals as in Regions 2 to 6.

In terms of cultural services, the coast is 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.

Table 7-102 provides a summary of the potential ecosystem services impacts that could be experienced by various receptor groups as a result of a large Marine Oil Spill from a well control event. A Coastal Oil Spill would affect a limited geographic area and would not be considered to pose any significant risk to ecosystem services other than in the localized area of the spill.

Table 7-102 Potential Ecosystem Services Receptors and Impacts from a Large Marine Oil Spill

Receptor(s)	Key Potential Impacts
Coastal population in Regions 1, 2, 3 and 4	• Impacts on agriculture (non-traditional crops e.g.; coconut, palm hearts) and fisheries • Impacts on shoreline protection provided by mangroves
Hindu population in Regions 1, 2, 3 and 4	• Disruption of religious ceremonies (funeral and cleansing ceremonies)
Afro-Guyanese population in Region 4	• Disruption of traditional ceremonies (emancipation ceremonies)
Coastal indigenous communities in Regions 1 and 2	• Impacts on agriculture, fishing, crabbing, hunting, trapping, non-timber forest product harvesting • Impacts on shoreline protection provided by mangroves

Considering the reliance of much of the population of Regions 1, 2, 3, and to a lesser extent Region 4, on ecosystem services (e.g., for food, housing materials, medicinal plants, income producing products), the extent these services would be impacted by an oil spill if it were to reach shore, and the lack of alternatives to replace the lost sources of sustenance and income, the consequence of a large Marine Oil Spill from a well control event reaching the coast is rated as **High**. As explained previously, such an oil spill is considered unlikely, and even if one were to occur, the probability of oil reaching the Guyana coastline is only 5 to 10 percent according to the oil spill modeling, supporting a likelihood rating of **Unlikely**. Therefore, the overall risk of an oil spill to ecosystem services is considered **Moderate**.

The Project will establish an OSRP that will be followed in the event of a spill of any size. Additionally, a claims process would be established at the onset of a large Marine Oil Spill incident to compensate for loss of sustenance and income. Effective implementation of the OSRP and a claims process would further reduce this risk to **Minor** by reducing the probability of oil reaching the Guyana coast line and compensating for economic losses.

Table 7-103 Risk Rating for Oil Spill Impacts on Ecosystem Services

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Rating	Proposed Mitigation Measures	Residual Risk Rating
Marine Oil Spill	Ecosystem Services	Unlikely	High	Moderate	Implement OSRP and	Minor

					claims process	
Coastal Oil Spill	Ecosystem Services	Unlikely	Medium	Minor	Implement OSRP and claims process	Minor

7.4.4.8 *Indigenous Peoples*

As indicated in Table 7-84, the only unplanned event with the potential for any measureable impacts on indigenous peoples would be a large Marine Oil Spill.

Indigenous peoples are often among the most marginalized segments of the population in their respective societies. The majority of Guyana's indigenous people live in remote portions of the country and many continue to operate outside of the formal economy, depending on a subsistence way of life. Those living on the coast, including along the coastal road of Regions 2, 3, and 4, tend to be culturally integrated with the Afro- and Indo-Guyanese population, but indigenous groups typically have a lower overall standard of living than the general population.

As discussed in Section 7.3.9, 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, Father's Beach, and Unity Grant. Indigenous villages located 5 to 10 km (~3 to 6 mi) inland from the coast in Regions 1 and 2 are Santa Rosa, Waramuri, Manawurin, Assakata, and Wakapau. These communities engage in a number of natural resource-based activities including agriculture, fishing, crabbing, shrimping, hunting, palm harvesting, and natural medicine harvesting on the coast. In the SBPA, fishing and crabbing activity is particularly active at the westernmost end of Shell Beach, at the mouth of the Waini River, although these activities also occur to a lesser extent at the eastern end of Shell Beach by the community of Father's Beach. The percent of indigenous people in Regions 3 and 4 is less than the national average.

Indigenous communities in remote areas of Regions 1 and 2 rely on the coastal habitats for subsistence and livelihoods and have less availability of alternative food, particularly in Region 1. In the event of an oil spill reaching the coast, provisioning resources could be adversely impacted. In the event that mangrove forests and swamps along the coast are oiled, species such as fish, crabs and caiman, which are depended upon for protein, are likely to be impacted.

For these reasons, the consequence of a Marine Oil Spill on coastal Indigenous Peoples communities could be **High**. As explained previously, a large Marine Oil Spill from a well control event is considered unlikely, and even if one was to occur, oil spill modeling indicates a 5 to 10 percent chance oil would reach the Guyana shoreline, supporting a likelihood rating of **Unlikely**. Therefore, considering both consequence and likelihood, the overall risk to Indigenous Peoples of a large Marine Oil Spill is **Moderate**.

The area potentially impacted by a Coastal Oil Spill would be limited to areas near Project shorebases, which are not expected to occur in the more remote areas supporting larger indigenous populations. The Project will establish an OSRP that will be followed in the event of a spill of any size. Additionally, a claims process would be established at the onset of a large Marine Oil Spill incident to compensate for loss of sustenance and income. Effective implementation of the OSRP and a claims process would reduce this overall risk to **Minor** by reducing the probability of oil reaching the Guyana coast line and compensating for economic losses.

Table 7-104 Risk Rating for Oil Spill Impacts on Indigenous Peoples

Unplanned Event	Resource/ Receptor	Likelihood	Severity/ Consequence	Risk Level	Proposed Mitigation Measures	Residual Risk Level
Marine Oil Spill	Indigenous Peoples	Unlikely	High	Moderate	Oil Spill Response Plan	Minor

7.4.5 Transboundary Impacts

The planned Project is not predicted to have any measureable "transboundary impacts" (i.e., impacts outside the Guyana Exclusive Economic Zone [EEZ]). All impacts from planned activities will occur within the Guyana EEZ. However, there is the potential for transboundary impacts to result from unplanned events, such as oil spills, that may occur. As the oil spill modeling indicates, transboundary impacts may occur under Scenarios 8 (2,500 bbl offloading spill) and 9 (20,000 bpd release from a well control event over 30 days) as defined in Table 7-82. The unmitigated model results indicate that there is the potential for oil to reach at least portions of Venezuela, Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, and St. Lucia (see Figure 7-14) although this would be much less likely in a real-world scenario in which mitigation measures would be applied.

The unmitigated models predict 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 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 the Caribbean Sea.

Impacts on resources and receptors in these other countries would be similar to those discussed in Sections 7.4.2 to 7.4.4 for Guyana. Although the likelihood of a spill remains unlikely, there would be the potential to impact water quality; sediments; protected areas; marine fish, turtles, mammals, and seabirds; coastal fish and wildlife; coastal communities and indigenous peoples who rely on coastal resources for their livelihoods or sustenance. There are, however, some resources (e.g., coral reefs) found in these other potentially affected countries that are not found in Guyana. The coastal mapping that was conducted, as described in Section 7.4.1, included the coastal regions of the countries that could be impacted by a large Marine Oil Spill event, and include these other potentially affected resources; therefore, this information is available to support the OSRP. A general overview of potential effects on these countries is provided below.

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 Marine Oil Spill (i.e., Scenario 9 from Table 7-82) reaching the Trinidad and Tobago coastline ranges up to approximately 90 percent, with the time of first arrival ranging from 5 to 15 days for a spill occurring during both the winter and summer seasons, respectively. The mitigated scenarios show oil travelling in generally the same direction. However, effective application of multiple response strategies prevents oil from reaching any coastline including Trinidad and Tobago as indicated in Figure 7-16.

The coastal sensitivity mapping indicates that Trinidad and Tobago have several marine resources that could be 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 west 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 sea turtles (hawksbill, leatherback, green, and olive ridley) nest on Trinidad, and all of these except olive ridley nest on Tobago. Significant numbers of both island's nesting beaches would be exposed to oiling by a 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 a spill reached Trinidad. The most sensitive coastal species to an oil spill reaching Trinidad and Tobago is probably the West Indian manatee. Its known habitat in the country is exclusively located on east coast of Trinidad in an area that would have up to a 90 percent probability of being oiled in the event of an unmitigated large Marine Oil Spill from a well control event.

Several marine Important Bird Areas ("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 Marine Oil Spill. 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 km (12 mi) offshore. Further north in the vicinity of Salybia, Sena, and Saline Bays fishing is concentrated slightly further offshore, approximately 15 to 30 km (9 to 18 mi) from the coast. All of these areas would have a high probability of being impacted by a large unmitigated Marine Oil Spill from a well control event.

Potential Effects on Venezuela

The probability of shoreline oiling is high for the coast of Venezuela because of the predominant westerly current flow through the Stabroek block. The Gulf of Paria in Venezuela is located west of Trinidad and would be mostly protected from the impacts of a spill approaching from the east, however, southern portions of the gulf could be impacted by a large unmitigated Marine Oil Spill if it penetrated west of Trinidad. In such a scenario the probability of oiling would vary widely. 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 Orinoco River Delta would have a 5 to 10 percent probability of being oiled during the summer season, but that probability would increase to approximately 40 percent if a large unmitigated Marine Oil Spill were to occur in the winter. The unmitigated oil spill modeling indicates that the time of first arrival would be about 15 to 25 days for a spill occurring during the summer season and approximately 5 to 10 days during the winter season.

The most important areas in Venezuela that could be impacted by a large unmitigated Marine Oil Spill 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 sea turtles and marine mammals, and artisanal and commercial fisheries (Miloslavich et al., 2011). Several marine IBAs of global or regional importance to seabirds have been designated in Venezuela.

Potential Effects on Other Islands

The probability of shoreline oiling from an unmitigated spill is less for the other potentially affected countries (i.e., Grenada, St. Vincent and the Grenadines, and St. Lucia) and would be less than for Trinidad and Tobago and Venezuela, ranging from 5 to 40 percent with the time of first arrival ranging from 10 to 15 days, depending on the island 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. These islands are important tourist destinations and support valuable coral reefs, seagrass beds, and other habitats and species sensitive to oil.

Summary

It should be noted that the oil spill modeling did not take into consideration any emergency response actions. Implementation of the OSRP would help minimize transboundary impacts just as it would minimize impacts within the Guyana EEZ. EEPGL will work with representatives for the respective countries to be prepared for the unlikely event of a spill by:

- Establishing operations and communication protocols between different command posts.
- Creating a transboundary workgroup to manage waste from a product release – including identifying waste-handling locations in the impacted region and managing commercial and legal issues.
- Identifying places of refuge in the impacted region where vessels experiencing mechanical issues could go for repairs and assistance.
- Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to move to assist in a spill response outside the Guyana EEZ.
- Assigning or accepting financial liability and establishing a claims process during a response to a transboundary event.
- Informing local communities regarding response planning.

-Page Intentionally Left Blank-

8.0 CUMULATIVE IMPACT ASSESSMENT

Cumulative impacts arise as a result of Project-related impacts on a resource/receptor interacting with impacts on that same resource/receptor from other (non-Project) activities. Cumulative impacts can potentially result from individually insubstantial, but collectively substantial, actions undertaken over time or from the collective effect of modest impacts stemming from different sources acting on a receptor at the same time. Cumulative impact assessment considers interaction between potential impacts from the Project and impacts of other (non-Project) activities, relevant existing activities, or sufficiently approved/planned activities that are considered reasonably foreseeable.

The cumulative impact assessment for this EIA included the following two major tasks:

- Determining the scope of the cumulative impact analysis, including identification of:
  - *Potentially eligible* resources/receptors;
  - Other relevant existing/planned activities that are part of (or caused by) the Project;
  - *Relevant* resources/receptors (i.e., those that might be affected by the non-Project activities); and
  - Appropriate geographic extent and time frame of analysis

- Conducting the cumulative impacts analysis on *relevant* resources/receptors.

The specific shorebase(s) and onshore support facilities (e.g., warehouses, laydown yards) to be utilized in Guyana have not yet been identified by EEPGL. Accordingly, ERM has performed the impact assessment on the basis that the Project will utilize existing shorebase(s) located in Georgetown. Should any new or expanded shorebase(s) or onshore support facilities be utilized, 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 is not included in the scope of this EIA.

8.1 Scope of the Cumulative Impact Analysis

8.1.1 Potentially Eligible Resources

Resources/receptors considered initially in the cumulative impacts analysis are those that would be impacted by the Project. If the residual impacts on a resource/receptor of at least one phase of the Project was rated **Minor** or higher, the resource/receptor was identified as *potentially eligible* for the cumulative impact analysis. Unplanned events (i.e., oil spills) were not considered in this analysis, as their likelihood is considered to be **Unlikely**. Positive impacts are also excluded from the analysis. Table 8-1 lists the resources/receptors identified as *potentially eligible* for the cumulative impacts assessment based on the Project's residual impact significance ratings presented in Chapter 7.

Table 8-1 Eligibility of Resources/Receptors for Cumulative Impact Analysis

Resource	Highest Residual Impact Significance Rating	Potentially Eligible for Cumulative Impact Analysis
Special Status Species	Minor	Yes
Marine Mammals	Moderate	Yes
Marine Turtles	Minor	Yes
Marine Fish	Minor	Yes
Community Health and Wellbeing	Minor	Yes
Marine Use/Transportation	Minor	Yes
Social Infrastructure/Services	Minor	Yes
Air Quality and Climate	Negligible	--
Sound	None[a]	--
Marine Geology/Sediments	Negligible	--
Marine Water Quality	Minor	Yes
Protected Areas	None[a]	--
Coastal Habitats	None[a]	--
Coastal Wildlife/Shorebirds	None[a]	--
Seabirds	Negligible	--
Marine Benthos	Negligible	--
Ecological Balance & Ecosystems	Minor	Yes
Economic Conditions	Positive	--
Employment/Livelihoods	Minor	Yes
Cultural Heritage	Minor	
Land Use	Negligible	--
Ecosystem Services	None[a]	--
Indigenous Peoples	None[a]	--

[a] None = the planned Project activities are not expected to have any impact on the resource/receptor.

8.1.2 Other (non-Project) Relevant Activities

Two other (non-Project) activities have been identified as relevant with respect to the potential for their impacts to interact with Project impacts on a given resource/receptor.

First, although no confirmed plans are in place, there is a reasonable likelihood that oil and gas companies will conduct oil and gas exploration and/or development offshore of Guyana outside of the scope of the proposed Project. As an example, depending on the experience gained from the proposed Project, EEPGL may identify opportunities to expand the development of the Liza Field. Further, EEPGL or other operators may pursue activities targeting resources outside of the Stabroek block. Future activities by EEPGL or other operators could include seismic surveys, drilling of wells, installation of subsea or surface production infrastructure, and/or production operations.

Although other operators may conduct their activities concurrently with the Project, their activities would occur outside the Stabroek Block (with exception of periodic transit). The closest that another operator's activities could be expected to approach the Project would be approximately 20 km (12 mi), which is well beyond the geographical range of the Project's impacts. There would therefore be no opportunity for cumulative effects between the Project and activities in other blocks, so interactions between the Project and other operator's activities, as well as potential EEPGL activities in other blocks, are not considered further in this analysis.

Second, the Government of Guyana is currently considering replacement of the heavily used Demerara Harbour Bridge as a means of relieving congestion of both vehicular road and river-based vessel traffic induced by opening or closing, respectively, of the retractor spans that allow large vessels to pass. In November 2015, the Ministry of Public Infrastructure sought Expressions of Interest (EOIs) to complete a feasibility study and design for a new bridge across the Demerara River. The EOIs were due by December 1, 2015 (Kaieteur News Online, 2015), but it is currently unclear when or if the replacement project will proceed. The bridge is located several kilometers upriver from the shorebases that EEPGL currently may use to support the Project. If construction of a new bridge moves forward, there is a chance it might occur contemporaneously with some stages of the proposed Project.

8.1.3 Relevant Resources

Table 8-2 presents the results of the analysis to determine whether or not there is a reasonable potential for Project impacts and the impacts of at least one of the identified other relevant activities identified in Section 8.1.2 to be experienced by the *potentially eligible* resources/receptors listed above. If a reasonable potential for non-Project related impacts was identified, the resource/receptor was considered to be a *relevant* resource/receptor and was therefore included in the cumulative impact analysis. Therefore, the cumulative impact assessment effort focuses on impacts on resources that ate *potentially eligible* because they will be affected by the Project, and *relevant* because they would also be exposed to impacts of one or more non-Project activities. In this case, eight *eligible* resources/receptors were determined to be *relevant* resources/receptors with respect to at least one of the cumulative impact sources. In the cases of Marine Water Quality and Ecological Balance and Ecosystems, the effects of the Project would have to persist beyond the boundaries of the Stabroek Block in order for the Project to contribute to cumulative impacts on these resources, which is unlikely given the relatively small footprints of the Project and its predicted impacts on water quality. Therefore these receptors were not considered relevant to the cumulative impact assessment because they would not be exposed to impacts from the Project *and* one or more non-Project activities.

Table 8-2 Identification of Relevant Resources/Receptors for the Cumulative Impact Analysis

Resource/Receptor	Highest Residual Impact Significance Rating	Potential Interaction between impacts of Project and …		Included in Cumulative Impact Analysis as Relevant Resource/ Receptor?
		Future Offshore O&G Activity?	Demerara Harbour Bridge Replacement?	
Special Status Species	Minor	Yes	No	Yes
Marine Mammals	Minor	Yes	No	Yes
Marine Turtles	Minor	Yes	No	Yes

Resource/Receptor	Highest Residual	Potential Interaction between impacts of Project and …		Included in Cumulative
Marine Fish	Minor	Yes	No	Yes
Community Health/Wellbeing	Minor	Yes	Yes	Yes
Marine Use/Transportation	Minor	Yes	Yes	Yes
Social Infrastructure/ Services	Minor	Yes	Yes	Yes
Employment and Livelihoods	Minor	Yes	Yes	Yes
Marine Water Quality	Minor	No	No	No
Ecological Balance and Ecosystems	Minor	No	No	No

8.1.4 Geographical Extent of Analysis

The geographic extent of the cumulative impacts analysis was defined as the direct and indirect AOI for the Project (see Chapter 4), excluding the area associated with a potential unplanned event (i.e., oil spill).

8.1.5 Time Frame for Analysis

Potential impacts of the Project will have the possibility of interacting with other non-Project impacts throughout the Project life cycle (i.e., extending approximately 20 years from the start of production operations). However, there is naturally a limit to the knowledge of what other relevant activities may occur during this period. Considering the other relevant activities described above, it was assumed that the Demerara Harbour Bridge replacement project would occur within the Project lifecycle and that other oil and gas exploration and development would extend through the end of anticipated Project production operations. Accordingly, the time frame for the cumulative impact analysis was defined as the Project life cycle.

8.2 Resource/Receptor-Specific Cumulative Impact Assessment

This section contains a summary of the cumulative impacts that would potentially result from the impacts of the Project interacting with impacts of the other relevant activities on the *relevant* resources/receptors listed in Table 8-2.

8.2.1 Special Status Species

The Project was rated as having a **Negligible** significance for residual impacts on several species listed as Critically Endangered, Endangered, Vulnerable, and Near Threatened. The Project was rated as having a **Minor** significance for residual impacts on several fish species. Similar to Chapter 7, the assessment of potential impacts on marine mammals (Section 8.2.2) effectively covers the assessment of potential impacts to marine mammals and the assessment of potential impacts to marine turtles (Section 8.2.3) effectively covers the assessment of potential impacts to special status marine turtles. This section is limited cumulative impacts on special status fish species.

8.2.1.1 *Cumulative Impacts from Future EEPGL Activities*

While additional production activities within the Stabroek Block may occur in the future, currently such activities are undefined (e.g., timing, location, and development concept). Cumulative impacts of future production activities have therefore not been considered in this assessment, but would be included as appropriate in future assessments. However, future exploration activities within the Stabroek block and in close proximity to the Liza field would likely include many of the same impacts on fish associated with the Project (e.g., auditory impacts, entrainment in water withdrawals, permitted discharges). The Critically Endangered species are coastal and would not be affected by the Project. The Endangered species are mostly wide ranging marine pelagic species that could be exposed to effects of the Project as well as other EEPGL activities across the Stabroek Block, but these activities would be focused on other areas of the Stabroek Block and the species would be expected to recover from temporary exposures to Project-related impacts in the immediate vicinity of the Project before encountering similar impacts elsewhere. The Vulnerable and Near Threatened categories contain a mix of pelagic fish that would also be expected to recover from short-term exposures at individual projects, and resident species which would not move between projects and therefore would not be exposed to impacts from multiple projects. Provided that impacts from other EEPG activities would not occur in the same place and time as Project related impacts, there would be no significant cumulative effects on pelagic or resident fish, and the significance of cumulative impacts on special status fish would not increase above **Minor.**

8.2.1.2 *Cumulative Impacts from the Demerara Harbour Bridge Replacement*

The Critically Endangered fishes in the Project Area are generally estuarine species, and most of the remaining Endangered and Vulnerable species are exclusively marine. None of the special status fishes potentially affected by the Project would also be expected to be present in the vicinity of the Demerara Harbour Bridge project, so no cumulative impacts on special status fishes would be expected as a result of the bridge replacement project. Based on the factors discussed above, the significance rating for potential cumulative impacts on special status species was set equal to the individual Project significance rating (**Minor).**

8.2.2 Marine Mammals

The Project was rated as having a **Minor** significance for residual impacts on marine mammals, resulting primarily from behavioral disturbance.

8.2.2.1 *Cumulative Impacts from Future EEPGL Activities*

In terms of potential cumulative impacts between other EEPGL activities within the Stabroek Block and the Project, there is potential for spatial overlap between the impacts of individual activities but the extent of this potential overlap is currently unknown. While additional production activities within the Stabroek Block may occur in the future, currently such activities are undefined (e.g., timing, location, and development concept). Cumulative impacts of future production activities have therefore not been considered in this assessment, but would be included as appropriate in future assessments. However, many of EEPGL's future activities within the Stabroek block and in close proximity to the Liza field would likely include many of the same impacts associated with the Project (e.g., additional vessel traffic, permitted discharges). The potential for oil and gas related impacts on marine mammals would logically rise in proportion to an increase in exploration activity, but EEPGL's future exploration activities would likely be focused on areas outside of the Project's Direct AOI. EEPL's future development activities could occur within the Project's Indirect AOI and could therefore have potential cumulative auditory impacts on marine mammals, but only if they occurred simultaneously with the installation phase of the Project when auditory impacts will be most severe, which is extremely unlikely.

The greatest additional risk of ship strike would occur in near shore areas where vessels would congregate to enter and after exiting Georgetown Harbour; however, this increased risk would represent a minimal increment to the existing risk posed by fishing and commercial vessels transiting to and from the port at Georgetown, and other fishing vessels operating in coastal waters west of Georgetown. Provided that the areas within which marine mammals could be affected by future exploration activities (e.g.; mixing zones surrounding future exploration vessels, auditory disturbance/injury thresholds) do not co-occur at the same place and time as Project related impacts, there would be no increase in the significance of cumulative impacts on marine mammals. The significance of cumulative impacts on marine mammals would not increase above **Minor.**

8.2.2.2 *Cumulative Impacts from the Demerara Harbour Bridge Replacement*

A few marine mammals could be present in the vicinity of the Demerara Harbour Bridge project including boto, Guyana dolphin, tuxuci, and West Indian manatee. All of these species are known to enter estuarine settings so they could encounter activities at the Georgetown shorebase(s) that the Project will be utilizing, as well as the Demerara Harbour Bridge. Pile driving and other sources of impulsive noise from bridge construction activity are likely to have a much greater effect on the underwater soundscape and hence the potential for auditory injury than the occasional (a few times a day) transit of Project vessels, which would represent a minor increment to existing river traffic. Considering the typical patterns of bridge construction activity and the low speeds at which Project vessels would be travelling within the harbor, there is no expectation of an interaction between the activities leading to increased probability of vessel strikes.

Based on the factors discussed above, the significance rating for potential cumulative impacts on marine mammals was set equal to the individual Project significance rating (**Minor).**

8.2.3 Marine Turtles

Many of the same factors that determine cumulative potential impacts on marine mammals are relevant to marine turtles. The Project would have **Minor** significance for residual impacts on marine turtles primarily as a result of potential injury from vessel strikes.

8.2.3.1 *Cumulative Impacts from Future EEPGL Activities*

Just as there is potential for spatial overlap between the impacts of individual future EEPGL activities on marine mammals, the impacts of future EEPGL activities on marine turtles could also overlap with impacts from the Project but their sensitivity to some Project impacts differs from that of mammals. Like marine mammals, turtles would not be expected to congregate around Project vessels. Marine turtles are less susceptible to auditory impacts than marine mammals, but spend much of their time at the sea surface and are generally slower than marine mammals, so the most likely potential for cumulative impacts between the Project and future offshore oil and gas exploration would likely be vessel strikes. Although vessel strikes are generally rare, the potential for oil and gas related vessel strikes of turtles would logically rise in proportion to the amount of oil and gas exploration activity offshore. However, collective oil and gas-related shipping would be expected to represent a small incremental increase in risk compared to the existing risk posed by fishing and commercial vessels transiting to and from the port at Georgetown, and other fishing vessels operating in coastal waters west of Georgetown. The significance of cumulative impacts on marine turtles would not be expected to increase above **Minor.**

8.2.3.2 *Cumulative Impacts from the Demerara Harbour Bridge Replacement*

The marine turtle species considered in this EIA are not found within the Demerara River. As a result, the Demerara Harbour Bridge project would not be expected to contribute to potential cumulative impacts on marine turtles.

Based on the factors discussed above, the significance rating for potential cumulative impacts on marine mammals was set equal to the individual Project significance rating (**Minor).**

8.2.4 Marine Fish

The Project was rated as having a **Minor** significance for potential residual impacts on bottom-oriented fish species as a result of altered bottom habitats (e.g., from cuttings discharge during drilling, and from disturbance/coverage by installation of SURF infrastructure) and on pelagic fish species as a result of altered water quality and potential for entrainment in water intakes during production operations, as well as of potential auditory impacts from VSP during drilling and from pile driving during installation. These impacts would be most significant during drilling and installation, when most of the habitat-disturbing activities and vessel traffic would occur.

8.2.4.1 *Cumulative Impacts from Future EEPGL Activities*

With respect to bottom-oriented and resident species, impacts related to disturbance of bottom habitats will be temporary in nature, and fish would be expected to return to the vicinity of subsea infrastructure once seafloor disturbance activities are complete. Further, these effects would be limited to the immediate locality of Project drilling operations, and SURF infrastructure and would not overlap with impacts of additional exploration activities, which would be focused on other areas of the Stabroek Block. Impacts on pelagic species from future operations within the Stabroek Block would also be expected to be limited to the immediate vicinity of the vessels engaged in those activities and those activities would be focused on other areas of the block, so interaction between the impacts of Project and those of other activities is not expected. Provided that impacts on fish associated with future exploration activities (e.g.; mixing zones surrounding future exploration vessels, auditory disturbance/injury thresholds) do not overlap spatially and temporally with Project related impacts, there would be no interaction between them, and therefore no increase in the significance of cumulative impacts on marine fish. The significance of cumulative impacts on fish would not increase above **Minor.**

8.2.4.2 Cumulative Impacts from the Demerara Harbour Bridge Replacement

The marine fish species that would be present offshore in the PDA are generally not found within the Demerara River, and to the extent that they may enter the Demerara River as vagrants or use the mangroves in the harbor as nursery habitat, the harbor bridge would have insignificant impacts on adults and would not be expected to affect existing mangroves to a significant degree. As a result, the Demerara Harbour Bridge project would not be expected to contribute to potential cumulative impacts on marine fish.

Based on the factors discussed above, the significance rating for potential cumulative impacts on marine mammals was set equal to the individual Project significance rating (**Minor).**

8.2.5 Community Health and Wellbeing

The Project was rated as having a **Minor** significance on community health and wellbeing due to potential residual impacts on medical and health service accessibility during all Project stages.

8.2.5.1 Cumulative Impacts from Future EEPGL Activities

In the event of a serious medical emergency for either offshore or onshore personnel, the Project may rely on some local Guyanese health resources. However, such events are expected to be rare. Further, the Project will have the capability to provide medical services offshore and onshore, and has protocols to acquire medical support outside of Guyana when required. Therefore it is expected that the Project impacts on emergency medical services would be rare and of very limited duration. EEPGL would scale its own onshore medical capacity and on its vessels to the size of its workforce, so additional EEPGL projects would exert very little to no additional demand on local Guyanese health resources. Therefore the significance of cumulative impacts from other EEPGL activities on medical and health services would not increase above **Minor.**

8.2.5.2 Cumulative Impacts from the Demerara Harbour Bridge Replacement

While the Demerara Harbour Bridge project will be short-term in duration relative to the Project, its location near Georgetown means that most medical emergencies would likely be handled at medical facilities in Georgetown. As such, cumulative impacts on medical and health services from the bridge replacement project and the Project, as well as any potential future offshore oil and gas activity, are possible. However, cumulative impacts on health service accessibility are still considered to be **Minor** due to the short-term construction period for the bridge project, the likely availability of project site-based medical facilities for minor medical issues in the case of potential future offshore oil and gas projects, the low frequency of occurrence of severe injuries, the limited numbers of personnel involved, and the limited duration of patient stays. As a result, the Demerara Harbour Bridge project would not be expected to contribute to significant cumulative impacts on the accessibility of health services.

Based on the factors discussed above, the significance rating for potential cumulative impacts on community health and wellbeing was set equal to the individual Project significance rating (**Minor).**

8.2.6 Marine Use and Transportation

The Project was rated as having a **Minor** significance for potential residual impacts on commercial fishing vessels due to loss of access to fishing areas, and subsistence fishing vessels due to potential difficulties notifying these vessels of increased vessel traffic during drilling, installation, and production operations.

8.2.6.1 Cumulative Impacts from Future EEPGL Activities

EEPGL has exclusive rights to oil and gas-related activity in the Stabroek Block and will manage its own future operations to avoid conflicts with other vessels and ensure maritime safety, in cooperation with MARAD. Therefore cumulative impacts on marine use and transportation as a result of future EEPGL activities are considered to be **Minor**.

8.2.6.2 Cumulative Impacts from the Demerara Harbour Bridge Replacement

The Demerara Harbour Bridge project would involve construction vessels, which would add to the vessel traffic on the Demerara River. Bridge construction activities and thus most of the bridge construction vessel traffic, however, would be focused near the bridge site. The site for the new bridge is not yet determined, nor has the shorebase(s) to be used by the Project been selected. However, the shorebases being considered are seaward of the existing bridge location, which would limit Project vessel interaction with the new bridge construction area. Project-related vessel traffic along the river is expected to be modest, limited to a few vessels per day, and are not expected to appreciably affect the volume of vessel traffic on the river. Thus, cumulative impacts on marine use and transportation from the bridge replacement project are considered to be **Minor**.

Based on the factors discussed above, the significance rating for potential cumulative impacts on marine use and transportation was set equal to the individual Project significance rating (**Minor).**

8.2.7 Social Infrastructure and Services

Residual impacts on housing and utilities during the drilling and installation stage of the Project were rated as **Minor** in significance, as this stage will require the largest number of Project workers (up to approximately 1,500 at peak, of which approximately 150 would be based onshore) and would likely have the most potential for induced population influx to the Georgetown area by job seekers. Operations stage impacts were rated as **Negligible** and are therefore out of scope for the cumulative impact assessment.

8.2.7.1 *Cumulative Impacts from Future EEPGL Activities*

At this time, the number, nature, and timing of additional offshore activities that EEPGL may undertake during the Project life cycle, and thus the number of workers at any given time, cannot be predicted. However, increases in the offshore workforce would likely occur gradually or at different stages over a relatively long timeframe, during which time housing markets and utility providers would be able to respond to increases in demand. Given the uncertainty regarding the extent of additional EEPGL activities during the life of the Project, the significance of cumulative impacts on housing and utilities combined with other offshore oil and gas activity is considered to range from **Minor** to **Moderate** in significance, depending on the scale of worker and job-seeker influx associated with potential future offshore projects.

8.2.7.2 *Cumulative Impacts from the Demerara Harbour Bridge Replacement*

Construction of the Demerara Harbour Bridge may potentially attract workers and job-seekers from other areas of the country. The bridge replacement project would likely coincide with the Project's production operations stage, when the Project's offshore workforce is estimated at about 100 to 140 workers, and most of these workers would be based on the FPSO except when off rotation. Onshore workers for the Project during this period are estimated at about 100. The bridge replacement project is also expected to be of short duration relative to the Project.

Given the short duration of the Demerara Harbour Bridge replacement project relative to the Project, and the likelihood that it would overlap primarily with the operations and productions phases of the Project when traffic is expected to be relatively low, the cumulative impact on onshore transport generated from the bridge replacement project and the Liza Phase 1 Project is considered to be **Minor**.

8.2.8 Employment and Livelihoods

The Project was rated as having a **Minor** significance for potential residual impacts on commercial fishing vessels due to loss of access to fishing areas, and subsistence fishing vessels due to potential difficulties notifying these vessels of increased vessel traffic during drilling, installation, and production operations.

These potential for the Project and other potential future activities to interact and create cumulative impacts on fishing operations is assessed under Marine Use and Transportation in Section 8.2.6. The minor impacts on fishing livelihoods will be driven entirely by the interactions discussed in Section 8.2.6, which set the significance rating for potential cumulative impacts on marine use and transportation as Minor. Based on this impact rating and the fact that impacts on fishing livelihoods will be driven by the same factors that affect Marine Use and Transportation, the significance rating for potential cumulative impacts on employment and livelihoods was also set at **Minor**, which is equal to the individual Project significance rating on this receptor**.**

9.0 ENVIRONMENTAL AND SOCIOECONOMIC MANAGEMENT PLAN FRAMEWORK

9.1 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 to the environment and communities.

The scope of this chapter includes the following:

- Provide an overview of the policy framework underpinning the ESMP;
- Describe the ESMP structure;
- Describe general ESMP guiding principles;
- Describe the general content of the Management Plans; and
- Describe how changes to the ESMP will be managed.

The individual Management Plans that comprise the ESMP have been prepared consistent with this framework. Management Plans are required to be completed prior to Environmental Authorisation of the Project, and will be updated to include final conditions from the Environmental Authorisation.

9.2 Regulatory and Policy Framework

The Project is subject to various regulatory requirements as further described in Chapter 3 of the EIA, as well as the conditions established by the Guyana EPA upon issuance of the environmental authorization for the Project, and the conditions of the Petroleum Production Licence and approval of the Project Development Plan by the GGMC. Other Guyana government agencies including, but not limited to, the Fisheries Department of the Ministry of Agriculture (MoA), Guyana Revenue Authority (GRA), Civil Defense Commission (CDC), and Maritime Administration (MARAD) have regulatory authority over aspects of the Project.

EEPGL is committed to ensuring compliance with the laws and regulations of Guyana, while conducting business in a manner that is compatible with the environmental and socioeconomic needs of the communities in which it operates, and in a manner that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental, and Product Safety policies. These policies are put into practice through a disciplined management framework called the Operations Integrity Management System (OIMS), which is described in Section 3.4.

9.3 ESMP Structure

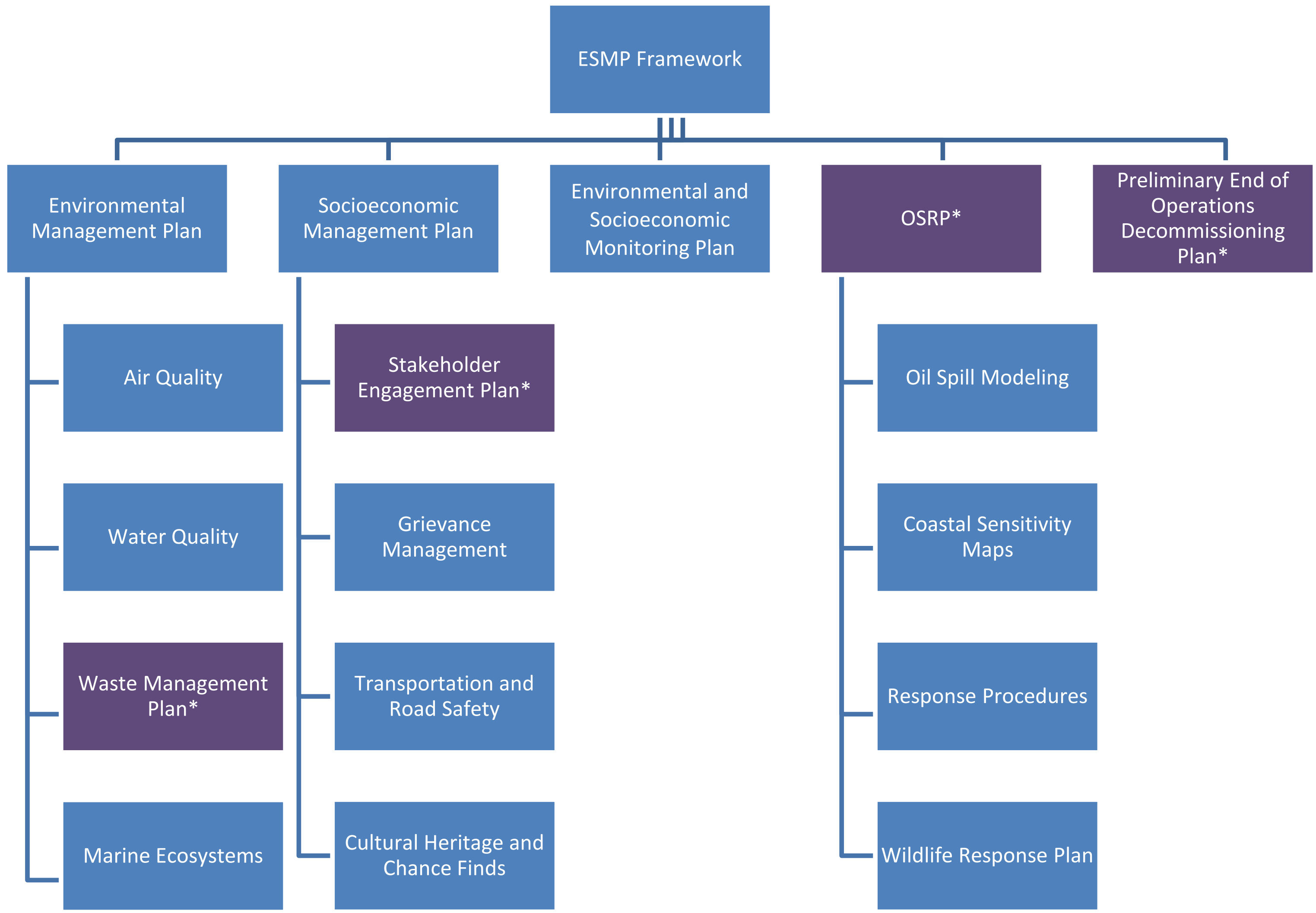
The overall structure of the Project ESMP is depicted in Figure 9-1. The specific Project Management Plans are organized into five categories:

- Environmental Management Plan (EMP)
- Socioeconomic Management Plan (SMP)
- Environmental and Socioeconomic (E&S) Monitoring Plan
- Oil Spill Response Plan (OSRP)
- Preliminary End of Operations Decommissioning Plan[38]

Each of these categories includes one or more specific management plans, which are included in this document unless otherwise noted, as shown in Figure 9-1.

[38] In alignment with the EPA's Initial Closure and Reclamation Plan

Figure 9-1 ESMP Structure



** Due to the size and/or complexity of these documents, these are standalone plans, and are provided either as an Appendix to this ESMP or as a separate volume to the regulatory submittal for the Liza Phase 1 Project (i.e., OSRP).*

9.4 General ESMP Guiding Principles

The overall ESMP, and each of the specific Management Plans it contains, have been developed consistent with these guiding principles. Each

- Covers all Project stages (i.e., there are not separate Management Plans for each Project stage), although there is a Preliminary End of Operations Decommissioning Plan ;
- Contains a level of detail for each individual Management Plan that is fit for purpose and varies among the individual Management Plans;
- Represents a "living document" which may be revised or amended as the Project progresses in response to changing circumstances, lessons learned, or other appropriate reasons; and
- Reflects all regulatory commitments and obligations including those from the EIA, supporting plans, and environmental authorizations.

9.5 Management Plan Contents

The Management Plan 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 are based on the Embedded Controls provided in this EIA. The plans also include the following information for each control/measure:

- The specific Project stage or component that will be responsible for implementing the Management Measure (e.g., FPSO, Support Vessels, Shorebase, etc.)
- The specific stage or stages of the Project during which each measure will be implemented (e.g., Drilling, Installation, Production Operations)
- Operational requirements; and
- Monitoring requirements

9.6 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 change. The EPA will be notified of any significant planned changes to the ESMP and will be provided with an updated version of the document for their records and use. The ESMP is also envisioned to be a "living and adaptive document" that will be updated to reflect continuous learning and improvements and shared with the Government of Guyana.

10.0 CONCLUSIONS AND SUMMARY OF IMPACTS

This section summarizes the predicted environmental and socioeconomic impacts of the Project resulting from planned activities and potential unplanned events (specifically an oil spill), as well the Project's contributions to cumulative impacts on important resources and receptors.

10.1 Planned Events

The planned Project is predicted to have minor impacts on physical resources (i.e., air quality, marine sediments, water quality), no impacts on coastal biological resources, minor impacts on marine biological resources, little, if any, noticeable negative impact on communities, and largely positive impacts on socioeconomics. These predictions are based on the fact that the bulk of the Project will occur approximately 190 km (~120 miles) offshore, and the Project will capture and re-inject recovered natural gas (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., installation of infrastructure will only physically disturb about 0.3 km^2 of benthic habitat), and use MMOs during VSP operations to minimize the potential for auditory damage and injury from ships strikes 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.

10.2 Unplanned Events

Unplanned events, such as a potential oil spill, are considered unlikely to occur because of the extensive preventative measures employed by EEPGL; but, nevertheless, an oil spill is considered possible. The number of resources that would be impacted and the extent of the impact on those resources would depend on the volume and duration of the release as well as the time of year the release were to occur, but impacts would tend to be most significant for a well control event 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 190 km (~120 miles) offshore, prevailing northwest currents, the light nature of the Liza field crude oil, and the region's warm waters would all help minimize the severity of a spill. Accounting for these factors, the unmitigated modeling indicates only a 5 to 10 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 well control spill at a Liza well would likely impact marine resources found near the well, such as sea turtles and certain marine mammals (especially baleen whales) that may transit or inhabit the area impacted by a spill. Air quality, water quality, seabirds, and marine fish 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 fishermen if commercial fish and shrimp were impacted. The magnitude of this impact would depend on the volume and duration of the release as well as the time of year the release were to occur (e.g., whether a spill would coincide with the time of year [May to September] when these species are more common in the PDA). Effective implementation of the OSRP would reduce this risk by further reducing the ocean surface area impacted by a spill and thereby reducing the exposure of these species to oil.

10.3 Cumulative Impacts

The Project's expected contribution to cumulative impacts would be limited by its distance offshore and by the small number of projects or activities either operating or currently planned to be operating offshore Guyana. There is the potential for other future offshore Guyana oil and gas exploration and possibly development. If such non-Project activities were to occur, the Project and non-Project activities together could cumulatively impact some resources such as Marine Mammals (via vessel strikes or sound), Marine Turtles (vessel strikes), Marine Fish (degraded water quality and cooling and ballast water entrainment), Community Health and Wellbeing (increased demand for limited medical treatment capacity), Marine Use and Transportation (marine congestion especially near Georgetown harbor), and Social Infrastructure and Services (increased demand for limited housing, utilities, and services). 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. All of these potential cumulative impacts were considered to be of Negligible to Minor significance.

10.4 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 0.3 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 recolonization of the impacted areas. Even in the unlikely event of an 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 on the volume and duration of the release as well as the time of year the release were to occur.

10.5 Project Benefits

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

- Through revenue sharing with the Government of Guyana, although the details of this revenue sharing is confidential. 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 and outside the scope of the EIA;
- By procuring select Project goods and services from Guyanese businesses to the extent reasonably practicable; and
- By hiring Guyanese nationals where reasonably practicable, although the potential magnitude of hiring will be limited.

In addition to direct revenue sharing, expenditures, and employment, the Project would also likely generate induced economic benefits as other non-Project related businesses benefiting from direct Project purchases or worker spending will re-invest locally or expand spending in the area, thereby also generating more local value-added tax. These beneficial "multiplier" impacts will occur throughout the Project life.

10.6 Summary

Table 10-1 provides a summary of the predicted residual (taking into consideration proposed mitigation measures) impact significance ratings for impacts to each of the resources/ receptors that may result from each of the Project stages (i.e., well drilling/SURF/FPSO installation, Production Operations, and Decommissioning), unplanned event (i.e., oil spill), and cumulative impacts.

Table 10-1 Summary of Residual Impact Ratings

Resource	Drilling and Installation	Production Operations	Decommissioning	Oil Spill*	Cumulative Impacts
Air Quality and Climate	Negligible	Negligible	Negligible	Minor	Negligible
Sound[39]	None	None	None	Minor	None
Marine Geology/Sediments	Negligible	None	None	Minor	Negligible
Marine Water Quality	Minor	Minor	Minor	Moderate	Minor
Protected Areas	None	None	None	Minor	None
Special Status Species:**					
• Critically Endangered and Terrestrial Species	Negligible	Negligible	Negligible	Minor	Minor
• Vulnerable/Near Threatened Species (sharks & bony fish)	Minor	Minor	Minor	Minor	Minor
• Endangered Fish and Black Capped Petrel	Negligible	Negligible	Negligible	Minor	Minor
Coastal Habitats	None	None	None	Minor	None
Coastal Wildlife/Shorebirds	None	None	None	Minor	None
Seabirds	Negligible	Negligible	Negligible	Minor	Negligible
Marine Mammals	Moderate	Negligible	Negligible	Moderate	Minor
Marine Turtles	Minor	Negligible	Negligible	Moderate	Minor
Marine Fish	Minor	Negligible	Negligible	Minor	Minor
Marine Benthos	Negligible	Negligible	Negligible	Minor	Negligible
Ecological Balance & Ecosystems	Negligible	Minor	Negligible	Minor	Negligible
Economic Conditions	Positive	Positive	Positive	Minor	Negligible
Employment/Livelihoods	Positive	Positive	Positive	Minor	Negligible
Community Health & Wellbeing:	Minor	Minor	Minor	Minor	Minor
Marine Use/Transportation					
• Commercial cargo	Negligible	Negligible	Negligible	Minor	Minor
• Commercial fishing	Minor	Minor	Minor	Minor	Minor
• Subsistence fishing	Minor	Minor	Minor	Minor	Minor
Social Infrastructure /Services	Negligible	Negligible	Negligible	Minor	Minor
Cultural Heritage	Negligible	Negligible	Negligible	Minor	Negligible
Land Use	Negligible	Negligible	Negligible	None	Negligible
Ecosystem Services	None	None	None	Minor	None
Indigenous Peoples	None	None	None	Minor	None

*Based on oil spill modeling of an unmitigated well control event in the PDA that indicates oil reaching Guyana shoreline is highly unlikely (5-to 10 percent probability).
** Excludes listed sea turtles, which are covered in the Marine Turtles resource category.

[39] Sound-related impacts on Marine Mammals are factored into the Marine Mammal impact assessment.

11.0 RECOMMENDATIONS

ERM recommends the following measures be considered by EPA, GGMC, and the EAB as conditions of any approval of the Project:

- Embedded Controls – incorporate all of the proposed embedded controls (see Table 11-1).
- Mitigation Measures – adopt the recommended mitigation measures (see Table 11-2).
- Management Plans – implement the proposed Environmental and Socioeconomic Management Plan to manage and mitigate the impacts identified in the EIA. The ESMP includes the following Management Plans:
    - Environmental and Socioeconomic Management Plan Framework
    - Environmental Management Plan, including:
        - Air Quality Management
        - Water Quality Management
        - Waste Management Plan
        - Marine Ecosystems Management
    - Socioeconomic Management Plan, including:
        - Stakeholder Engagement Plan
        - Grievance Management
        - Transportation and Road Safety Management
        - Cultural Heritage Management and Chance Finds
    - Environmental and Socioeconomic Monitoring Plan
    - Preliminary End of Operations Decommissioning Plan
    - Oil Spill Response Plan, including Oil Spill Modeling, Coastal Sensitivity Mapping, results of the Net Environmental Benefit Analysis, Emergency Preparedness and Response Procedures, and the Wildlife Response 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 spill is unlikely. But given the sensitivity of many of the resources that could be impacted by a spill (e.g., Shell Beach Protected Area, marine mammals, critically endangered and endangered sea turtles, Amerindian 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, 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 1 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 11-1 List of Proposed Embedded Controls

Embedded Control Measures	Resources/Receptors Benefitted
Drilling and SURF/FPSO Installation and Commissioning	
• Utilize WBDF to the extent reasonably practicable and in other cases use low-toxicity IOGP Group III NABF.	Marine sediments, water quality, mammals, turtles, fish, and benthos
• When NADF is used, utilize a solids control and cuttings dryer system to treat drill cuttings prior to discharge such that end of well maximum weighted mass ratio averaged over all well sections drilled using non-aqueous fluids shall not exceed 6.9 percent wet weight base fluid retained on cuttings.	Marine sediments, water quality, mammals, turtles, fish, and benthos
• For VSP activities, commence such operations during daylight hours after a suitable pre-watch by Marine Mammal Observers (MMOs) is performed and begin with soft start procedures in accordance with JNCC guidelines, which incrementally increase source sound levels in order to allow marine mammals and turtles time to move away from the activity before full sound source energy is utilized.	Marine mammals, marine turtles
• With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: o Change liquid hydrocarbon transfer hoses periodically o Utilize dry-break connections on liquid hydrocarbon bulk transfer hoses o Utilize a liquid hydrocarbon checklist before every bulk transfer o Perform required inspections and testing of all equipment prior to deployment/installation; o Utilize certified Blowout Prevention (BOP) equipment; o Regularly test certified BOP equipment and other spill prevention equipment; o Utilize overbalanced drilling fluids to control wells while drilling; o Perform operational training certification (including well control training) for drill ship supervisors and engineers; o Regularly audit field operations on the drill ships, FPSO, and shorebase(s) to ensure application of designed safeguards; and o Controls for mitigating a failure of the DP (dynamic positioning) system on the drill ships and maintain station keeping, which include: ▪ Use of a Class 3 DP system, which includes numerous redundancies; ▪ Rigorous personnel qualifications and training; ▪ Seatrials 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 sediments, marine water quality, protected areas, sensitive species, coastal habitats, coastal wildlife and shorebirds, marine mammals, turtles, fish, benthos, ecology and ecosystems

Embedded Control Measures	Resources/Receptors Benefitted
• During pile driving activities, gradually increase the intensity of hammer energy to allow sensitive species to vacate the area before injury occurs (i.e., soft starts).	Marine mammals
• Maintain marine safety exclusion zones with a 500 m (~1,640 ft) radius around drill ships and major installation vessels to prevent unauthorized vessels from entering potentially hazardous areas.	Marine use and transportation safety
Production Operations	
• Re-inject produced gas which is not utilized as fuel gas on the FPSO to avoid routine flaring. With respect to non-routine flaring, the following measures will be implemented: o Monitor flare performance to maximize efficiency of flaring operation; o Ensure flare equipment is appropriately inspected and function tested prior to production operations; and o Ensure flare equipment is appropriately maintained and monitored during production operations.	Air quality
• Treat produced water on the FPSO to limit oil and grease (O&G) content to 29 mg/L monthly average and 42 mg/L daily maximum.	Marine water quality, mammals, turtles, fish, and benthos, seabirds, ecology and ecosystems
• Design produced water and cooling water processes to avoid increases in ambient water temperature of more than 3˚C at 100m (~328 ft) from the FPSO when discharging.	Marine water quality, mammals, turtles, fish, and benthos, seabirds, ecology and ecosystems
• Perform onboard waste incineration for certain categories of waste.	Land use
• 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 safety
• Utilize support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.	Marine use and transportation safety
• 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 safety
• FPSO offloading to tankers will occur 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 the offloading operations, and may disconnect and safely maneuver away from the FPSO as appropriate.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Utilize a marine bonded, double-carcass floating hose system certified by Class or other certifying agency that complies with the recommendations of OCIMF Guide to Manufacturing and Purchasing Hoses for Offshore Moorings (GMPHOM) 2009 Edition or later.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Utilize breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds

Embedded Control Measures	**Resources/Receptors Benefitted**
• Utilize a load monitoring system in the FPSO control room to support FPSO offloading.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Utilize leak detection controls during FPSO offloading which include: o Leak detection for breach of the floating hose that complies with the recommendations of OCIMF GMPHOM 2009 Edition or later; o Utilization of instrumentation/procedures to perform volumetric checks during offloading.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Provide trained medical personnel on board the FPSO and major installation vessels to minimize reliance on medical infrastructure and facilities in Guyana.	Community health and wellbeing
• Utilize marine safety exclusion zone of 2 nautical miles around the FPSO to prevent unauthorized vessels from entering potentially hazardous areas.	Marine use and transportation safety
• Project vessels will conduct ballasting operations in accordance with IMO regulations.	Ecological Balance and Ecosystems
General Measures	
• Maintain equipment, marine vessels, and helicopters in good working order and operate in accordance with manufacturer's specifications in order to reduce atmospheric emissions and sound levels to the extent reasonably practicable.	Air quality, water quality, marine mammals, marine turtles
• Regularly inspect and service shorebase cranes and construction equipment in order to mitigate the potential for spills and to maintain air emissions at optimal levels.	Air 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 practical.	Water quality
• Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.	Water quality
• Perform regular audits of field operations on the drill ship, FPSO, and shorebase to ensure application of designed safeguards.	Air quality, water quality
• Treat sewage to applicable standards under MARPOL 73/78.	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• For those wastes that cannot be reused, treated, or discharged/disposed on the drill ship or FPSO they will be 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.	Land use

Embedded Control Measures	Resources/Receptors Benefitted
• Utilize oil/water separators to limit oil in water content in bilge water to <15 parts per million (ppm; per MARPOL).	Marine sediments, water quality, mammals, turtles, fish, benthos, and seabirds
• Provide standing instruction to Project dedicated vessel masters to avoid marine mammals and 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 safety
• Project workers will be subject to health screening procedures to minimize risks of communicable diseases.	Community health and wellbeing
• Utilize an established SSHE program to which all Project workers and contractors will be required to mitigate against risk of injury/illness to workers. • All workers and contractors will receive training on implementation and will be required to adhere to its principles.	Occupational and community health, safety, and wellbeing
• Maintain an 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
• Where practicable, direct lighting on FPSO and major vessels to required operational areas rather than at the sea surface or skyward.	Seabirds and marine turtles
• Provide screening on FPSO and drill ships for seawater intakes to minimize the entrainment of aquatic life, where practical.	Marine fish

Table 11-2 List of Proposed Mitigation Measures

Proposed Mitigation Measure	Resources/Receptors Benefitted
• Report direct 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.	Climate
• Procure select goods and services locally to the extent reasonably practicable (enhancement measure).	Economic Conditions, Employment and Livelihoods
• Utilize Guyanese nationals where reasonably practicable (enhancement measure).	Economic Conditions, Employment and Livelihoods
• The Project 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.	Marine Use and Transportation

Proposed Mitigation Measure	**Resources/Receptors Benefitted**
• Augment ongoing stakeholder engagement process to identify commercial cargo, commercial fishing, and subsistence fishing vessel operators who might not ordinarily receive Notices to Mariners, and where possible communicate Project activities to those individuals to aid them in avoiding Project vessels.	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
• Project workers will be required to adhere to a Worker Code of Conduct, which will address shore-leave considerations.	Community Health and Wellbeing
• Develop and implement a Road Safety Management Procedure to mitigate increased risk of vehicular accidents associated with Project-related land transport activities. The procedure will include, at a minimum, the following components: o Definition of travel routes; o Definition of required driver training, including defensive driving, loading/unloading procedures, and safe transport of passengers, if applicable; o Designation and enforcement of speed limits, through speed governors, GPS, or other monitoring systems; o Avoidance of deliveries during typical peak traffic hours as well as scheduled openings of the Demerara Harbour Bridge, to the extent reasonably practicable; o Monitoring and management of driver fatigue; o Definition of vehicle inspection and maintenance protocols that include all applicable safety equipment; and o Community outreach to communicate information relating to major delivery events or periods.	Community Health and Wellbeing
• Implement the OSRP in the unlikely event of an oil spill, including: o Conduct air quality monitoring during emergency response; o Require use of appropriate PPE by response workers; o Implement a Wildlife Oil Response Program, as needed; and o Implement a claims process for damage caused by an oil spill, as needed.	All resources

12.0 PROJECT TEAM

Table 12-1 identifies the primary members of ERM's team and their roles in preparing this EIA. It also lists their educational qualifications (highest degree) and years of professional experience. Signatures and curriculum Vitae (CVs) for each of these team members listed in Table 12-1 are included in Appendix A and B, respectively.

Table 12-1 Project Team

Name	Role	Education (Highest Degree)	Years of Experience
David Blaha	Project Director	MS Environmental Management	35
Jason Willey	Project Manager and Marine Fish, Mammals, and Turtles	MS Environmental Science and Policy	15
Greg Lockard	EIA Coordinator and Cumulative Effects	PhD Anthropology	21
Kamal Govender	ESMPs	MS Environmental and Geographical Science	13
Karin Nunan	Social Lead	MS International Relations and Conflict Resolution	20
Peyun Kok	Social Specialist	MES Urban and Regional Planning	7
Kristina Mitchell	Stakeholder Specialist	MA International Relations	15
Benjamin Siegel	Maritime Archaeology	MA Historical & Maritime Archaeology	10
Mark Garrison	Air Quality and dispersion modeling	MS Environmental Science	2
Adeyinka Afon	Noise and Air Quality	MSE Environmental Process Engineering	12
Michael Fichera	Water Quality	MS Environmental Engineering	23
Shwet Prakash	Water Quality	MS Civil Engineering	13
Matt Erbe	Geologist	MS Hydrogeology	18
Dusty Insley	Geologist	BS Geology	10
Jonathan Connelly	Environmental Specialist	BA Environmental Studies	10

Name	Role	Education (Highest Degree)	Years of Experience
Melinda Todorov	Environmental Specialist	MS Aquatic Ecology	9
Julia Tims	Biodiversity	MS Natural Resources Management/Ecology	22
Benjamin Sussman	Transportation	MCRP (City and Regional Planning)	17
Noam Raffel	GIS Analyst	MS Geographic Information Sciences	3
Erin Rykken	Technical Editor	MA English MLS Library Science	15
Subcontractors			
Hance Thompson	Guyana Environmental and Regulatory Support, Ground Structures Engineering Consultants, Inc (GSEC), Guyana	BS, Biology; MS, Environmental and Earth Resources Management	13
Noella Arispe	Coastal Sensitivity Mapping (Venezuela), Independent Consultant	BS, Architecture; MS, Planning and Development	41
Hema David	Coastal Sensitivity Mapping (Trinidad and Tobago), Ecoengineering Consultants Limited, Trinidad	AS, Environmental Management; BS, Environmental and Natural Resources Management	7

13.0 REFERENCES

Introduction

EPA (Guyana Environmental Protection Agency). 2004. Volume 1 Environmental Impact Assessment Guidelines: Rules and Procedures for Conducting and Reviewing EIAs. Version 5. 34 pgs.

Administrative Framework

OAS (Organization of American States). 2013. National Constitution of Guyana. Retrieved from: http://www.oas.org/juridico/mla/en/guy/en_guy-int-text-const.pdf

Kaiteur News. 2016. Policy finally completed to Guide Guyana's developing Oil and Gas Industry. June 9, 2016. Retrieved from: http://www.kaieteurnewsonline.com/2016/06/09/policy-finally-completed-to-guide-guyanas-developing-oil-and-gas-industry/

Description of the Existing Environment

Physical Resources

<u>*Air Quality and Climate Change*</u>

Hydromet. 2014. Climate Fact Sheet. Retrieved from: http://www.hydromet.gov.gy/climate.html

NOAA (National Oceanic and Atmospheric Administration). 2008. U.S. Department of Commerce, National Oceanographic and Atmospheric Administration. Currents. Retrieved from: http://oceanservice.noaa.gov/education/kits/currents/05currents1.html

Yale University. 2016. Global Metrics for the Environment. Environmental Performance Index 2016 Report. Retrieved from: http://epi.yale.edu/country/guyana

<u>*Noise and Vibration*</u>

Finneran, J. J. 2015. Auditory weighting functions and TTS/PTS exposure functions for cetaceans and marine carnivores. San Diego: SSC Pacific.

Hildebrand, J. A. 2009. Anthropogenic and natural sources of ambient noise in the ocean. Marine Ecology Progress Series, 395: 5–20.

JASCO (JASCO Applied Sciences). 2016. Underwater Sound Associated with Liza Phase 1 Project Activities.

NOAA (National Oceanic and Atmospheric Administration). 2013. Draft Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammals. December 23, 2013.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. Greene, Jr., D. Kastak, D. R. Ketten, J. H. Miller. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals, 33(4): 411–521.

Marine Geology and Sediments

CGX (CGX Resources Inc.). 2009. Strategic Environmental Assessment for Offshore Exploration Drilling Corentyne License Area, Guyana. June 2009.

Clark, R. C. and M. Blumer. 1967. Distribution of n-paraffins in marine organisms and sediments. Limnol Oceanography, 12: 79–87.

Macdonald, D. D., R. S. Carr, and F. D. Calder. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology, 5(1996): 253.

Eisma, D. and H. van der Marel. 1971. Marine muds along the Guyana coast and their origin from the Amazon Basin. Contrib. Mineral. Petrol., 31: 321–334.

FUGRO EMU Limited. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd. March 2016.

NDS (National Development Strategy). 1997. Guyana's National Development Strategy. Retrieved from: http://www.guyana.org/NDS/NDS.htm

North Sea Task Force. 1993. North Sea Subregion 8 Assessment Report. State Pollution Control Authority, (SFT): 1–79.

Strømme, T. and G. Sætersdal. 1989. Final Report - Surveys of the Fish Resources in the Shelf Areas between Suriname and Colombia 1988. Bergen: Institute of Marine Research. Retrieved from: ftp://ftp.fao.org/docrep/nonfao/fns/x6078e.pdf

TDI-Brooks (TDI-Brooks International, Inc.). 2014. Geotechnical Report Guyana Liza-Sorubim EBS & Geotechnical Investigation Offshore Guyana, South America.

Thompson, S. and G. Eglinton. 1978. The fractionation of a recent sediment for organic geochemical analysis. Geochim. Cosmochim. Acta, 42: 199–207.

Wedepohl, K. H. 1995. The Composition of the Continental Crust. Geochimica et Cosmochimica Acta, 59: 1,217–1,239.

Workman, W. G. 2000. Special Report: Geophysics and Geology. Guyana Basin: A new exploration focus. WorldOil Online, 221(5). Retrieved from: http://www.worldoil.com/May-2000-Guyana-basin-A-new-exploration-focus.html

Youngblood, W. W., M. Blumer, R. Guilard, R. Fiore. 1971. Saturated and unsaturated hydrocarbons in marine benthic algae. Mar. Biol., 8 (3): 130–201.

Oceanographic Conditions/Marine Water Quality

De Master, D. J. and R. H. Pope. 1996. Nutrient dynamics in Amazon shelf waters: results from AMASSEDS. Cont. Shelf Res, 16(3): 263–289.

FAO. 2005. Fishery Country Profile: The Republic of Guyana. Retrieved from: http://www.fao.org/fi/oldsite/FCP/en/GUY/profile.htm.

FUGRO EMU Limited. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd. March 2016.

Gyory, J., A. J. Mariano, E. H. Ryan. 2013. The Guiana Current. Ocean Surface Currents. Retrieved from: http://oceancurrents.rsmas.miami.edu/atlantic/guiana.html.

Maxon Consulting, Inc. and TDI Brooks International, Inc. 2014. Environmental Baseline Study, Guyana Stabroek Block.

Morel, F. M. M., A. J. Milligan, M. A. Saito. 2006. Marine bioinorganic chemistry: the role of trace metals in the oceanic cycles of major nutrients. In: H.D. Holland and K.K. Turekian (eds). The Oceans and Marine Geochemistry. Vol 6. Oxford: Elsevier–Pergamon.

Moustafa, Y. M. and R. E. Morsi. 2012. Biomarkers, Chromatography and Its Applications. Retrieved from: http://www.intechopen.com/books/chromatography-and-its-applications/biomarkers

Nittrouer, C. A. and D. J. De Master. 1987. Sedimentary processes on the Amazon continental shelf. New York: Pergamon Press.

Sherman, K. and G. Hempel. 2009. The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's regional seas. UNEP Regional Seas Report and Studies No. 182. 2nd printing. Nairobi, Kenya: United Nations Environment Programme.

TDI-Brooks International, Inc. 2014. Geotechnical Report Guyana Liza-Sorubim EBS & Geotechnical Investigation Offshore Guyana, South America.

TDI-Brooks International, Inc. 2014. Geotechnical Report Guyana Liza-Sorubim EBS & Geotechnical Investigation Offshore Guyana, South America.

USEPA (United States Environmental Protection Agency). 2016. National Recommended Water Quality Criteria – Aquatic Life Criteria Table. Accessed: August 8, 2016. Retrieved from: https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table

Biological Resources

<u>*Beaches, Mangroves, Vegetation, and Wetland Habitats*</u>

Bovell, Owen. 2011. Guyana Mangrove Nursery Manual. Guyana Mangrove Restoration Project. Retrieved from: http://www.gcca.eu/sites/default/files/catherine.paul/guyana_mangrove_nursery_manual_2011.pdf

Charles, Reuben, Mark Bynoe, Jennifer Wishart, Martin Cheong. 2004. Shell Beach Protected Area Situation Analysis. GMTCS publication.

EPA (Guyana Environmental Protection Agency). Undated. Guyana's Protected Areas System. Accessed: November 28, 2016. Retrieved from: http://www.epaguyana.org/index.php/2014-02-10-20-21-58?task=document.download&id=154

GMTCS (Guyana Marine Turtle Conservation Society). 2011. Proposed Shell Beach Delineation Process, Final Report. University of Guyana. Pp.1–41.

GNBSAAP (Guyana's National Biodiversity Strategy and Action Plan). 2015. Environmental Protection Agency and the Ministry of National Resources and the Environment, Guyana. Retrieved from: http://faolex.fao.org/docs/pdf/guy156992.pdf

IUCN and UNEP-WCMC (International Union for Conservation of Nature and United Nations Environment Programme's World Conservation Monitoring Centre). 2016. The World Database on Protected Areas (WDPA) Online. September 2016. Cambridge, UK: UNEP-WCMC. Retrieved from: www.protectedplanet.net

IUCN (International Union for Conservation of Nature). 2001. IUCN Red List Categories and Criteria: Version 3.1. Second edition. IUCN: Gland, Switzerland and Cambridge, UK: .

IUCN (International Union for Conservation of Nature). The IUCN Red List of Threatened Species. Version 2016-2. Accessed: November 29, 2016. Retrieved from: www.iucnredlist.org

Kandaswamy, Suresh V. 2014. Shell Beach Management Plan. Volume 1 and 2. Protected Areas Commission.

Prince, Waldyke et al. 2004. Report on the Rapid Biodiversity Assessment of the proposed Shell Beach Protected Area. GMTCS Publication.

Pritchard, P. 2001. Shell Beach as a Protected Area. Occasional Paper, Georgetown.

Prince, Waldyke, Michael Patterson, Floraia Francis, Romeo Defreitas, David Rodriques. 2014. Rapid Biodiversity Assessment of the Proposed Shell Beach Protected Area. August – October 2014. In cooperation with the Guyana Environmental Protection Agency, Fauna and Flora International (FFI), and the Guyana Marine Turtle Conservation Society (GMTCS).

Protected Areas

Da Silva, Phillip. 2014. Avifaunal Diversity in a Mangrove Reserve in Guyana, South America. International Journal of Science, Environment and Technology, 3(1): 23–32.

Guyana Mangrove Restoration Project (GMRP). 2010. National Mangrove Management Action Plan 2010. Retrieved from: http://www.mangrovesgy.org/images/stories/Documents/Project%20reports/NATIONAL%20MANGROVE%20MANAGEMENT%20ACTION%20PLAN%20%202010-2012.pdf

GNBSAAP (Guyana's National Biodiversity Strategy and Action Plan). 2015. Environmental Protection Agency and the Ministry of National Resources and the Environment, Guyana. Retrieved from: http://faolex.fao.org/docs/pdf/guy156992.pdf

Ilieva. Undated. The socioeconomic importance of mangroves in Guyana. Ecosystem services evaluation. Ca'Foscari University of Venice, Italy.

Mann, K. 1982. Ecology of coastal waters: a system approach. Berkeley: University of California.

Mestre, L. A. M., R. Krul, V. S. Moraes. 2007. Mangrove bird community of Paranaguá Bay - Paraná, Brazil in Brazilian Archives of Biology and Technology, 50(1): 75–83. Retrieved from: http://www.scielo.br/scielo.php?

Prince, Waldyke, Michael Patterson, Floraia Francis, Romeo Defreitas, David Rodriques. 2014. Rapid Biodiversity Assessment of the Proposed Shell Beach Protected Area. August – October 2014. In cooperation with the Guyana Environmental Protection Agency, Fauna and Flora International (FFI), and the Guyana Marine Turtle Conservation Society (GMTCS).

WWF (World Wildlife Fund). 2016. Eastern South America: Coastal French Guiana, Suriname, Guyana, and southeastern Venezuela. Accessed: September 23, 2016. Retrieved from: http://www.worldwildlife.org/ecoregions/nt1411

Seabirds

Bayney, Annalis and Philip Da Silva. 2005. The Effect of Birding on Local and Migrant waterfoul populations along the coast of Guyana. Centre for the Study of Biological Diversity. University of Guyana, Faculty of Natural Sciences, Turkeyen Campus. Georgetown, Guyana.

BirdLife International. 2016. Country profile: Guyana. Retrieved from: http://www.birdlife.org/datazone/countryguyana

Birdlife International. 2016b. Marine IBA e-atlas. Accessed: September 28, 2016. Retrieved from: https://maps.birdlife.org/marineIBAs/default.html

Braun, M. J., D. W. Finch, M. B. Robbins, B. K. Schmidt. 2007. A Field Checklist of the Birds of Guyana, 2nd Ed. Smithsonian Institution, Washington, D.C.

Devenish, C., D. F. Diaz, R. P. Clay, I. J. Davidson, I. Y. Zabala. 2009. Important Bird Areas in the Americas. Priority Sites for Conservation. Quito, Ecuador: BirdLife International (BirdLife Conservation Series No. 16).

Ebird Caribbean. Retrieved from: http://ebird.org/ebird/caribbean/country/GY?yr=all

GEPA (Guyana Environmental Protection Agency), Flora and Fauna International, and the Guyana Marine Turtle Conservation Society. 2004. Rapid Biodiversity Assessment of the Proposed Shell Beach Protected Area. August-October 2004. 53 pp.

The citation for this should be changed to GEPA (Guyana Environmental Protection Agency). 2015. Guyana's National Biodiversity Strategy and Action Plan. May 2015. 101 pp. Retrieved from: http://faolex.fao.org/docs/pdf/guy156992.pdf

IUCN Red List of Threatened Species. 2016. Version 2016:2. Retrieved from: http://www.iucnredlist.org/

Lentino, M. and D. y Esclasans. 2009. Important birds Areas: Venezuela. Pages 393 – 402 in C. Devenish, D. F. Díaz Fernández, R. P. Clay, I. Davidson & I. Yépez Zabala Eds. Important Bird Areas Americas - Priority sites for biodiversity conservation. Quito, Ecuador: BirdLife International (BirdLife Conservation Series No. 16).

Mendonca, Sean, Michelle Kalamandeen, Robin S. McCall. 2006. A Bird's Eye View: Coastal Birds of Shell Beach. Proceedings of International Conference on the Status of Biological Sciences in Caribbean and Latin American Societies.

RPS. 2016. Marine Fauna Observer Report. Prepared by ExxonMobil.

Schreiber, E. 2001. Biology of Marine Birds. Edited by E. I. Schreiber and Johanna Burger. CRC Press. 740 pp.

White, G. 2008. Trinidad and Tobago. Pp 351 – 356. In: Devenish, C., D. F. Díaz Fernández, R. P. Clay, I. Davidson, I. Yépez Zabala (eds). Important Bird Areas Americas - Priority sites for biodiversity conservation. Quito, Ecuador: BirdLife International (BirdLife Conservation Series No. 16).

Marine Turtles

Bjorndal K. A., and J. B. C. Jackson. 2003. Roles of sea turtles in marine ecosystems: Reconstructing the past. In: Lutz P., J. A. Musick, J. Wyneken (eds). The Biology of Sea Turtles. Vol. 2. CRC Press; 2003. p. 259–273.

Bjorndal, K. A. 1997. Foraging ecology and nutrition of sea turtles. In: Lutz P. L. and Musick J. A. (eds). The biology of sea turtles, 1. CRC Press, Boca Raton, FL, p 199−231.

CREE. 2014. Retrieved from: http://conservationforpeople.org/sea-turtles-guyana/.

Eckert, K. L. 1999. Designing a conservation program. In: Eckert, K. L. et al. (eds). Research and management techniques for the conservation of sea turtles. IUCN/SSC Marine Turtle Specialist Group Publication, 4: pp. 6–8.

Eckert, K. L. 1999. Designing a conservation program. In: Eckert, K. L. et al. (eds). Research and management techniques for the conservation of sea turtles. IUCN/SSC Marine Turtle Specialist Group Publication, 4: pp. 6–8.

Jackson, J. B. C. 2001. What was natural in the coastal oceans? Proceedings of the National Academy of Sciences, USA 98: 5,411–5,418.

National Marine Fisheries Service & U.S Fish and Wildlife Service. 2007. Proceedings of the 14th annual symposium on sea turtle biology and conservation. March 1-5, 1994. Hilton Head, South Carolina, USA. National Marine Fisheries Service, Southeast Fisheries Science Center. NOAA Technical Memorandum NMFS-SEFSC-351.

Piniak, W. D. and K. L. Eckert. 2011. Sea turtle nesting habitat in the Wider Caribbean Region. Endang. Species Res., 15: 129–141.

Pritchard, P. C. H. 1973. International migrations of South American sea turtles (Cheloniidae and Dermochelidae). Animal Behavior, 21: 18–27.

Pritchard, P. H. C. 1991. Sea Turtle Conservation and Research and in Guyana. Unpublished report. 63pp.

Project Global. 2007. Global Bycatch Assessment of Long Lived Species. Country Profile, Guyana. Blue Ocean Institute and WIDECAST. 17pp.

Tambiah, C. R. 1994. Saving sea turtles or killing them: the case of US regulated TEDs in Guyana and Suriname, pp. 149–151. In: Proceedings of the 14th annual symposium on sea turtle biology and conservation. March 1-5, 1994. Hilton Head, South Carolina, USA. National Marine Fisheries Service, Southeast Fisheries Science Center. NOAA Technical Memorandum NMFS-SEFSC-351.

Troeng, S., D. Chacon, B. Dick. 2004. Possible decline leatherback turtle Dermochelys coriacea nesting in Caribbean Central America. Oryx, 38: 1–9.

Troeng, S., P. H. Dutton, D. Evans. 2005. Migration of hawksbill turtles Eretmochelys imbricata from Tortuguero, Costa Rica. Ecography, 28: 394–402.

Marine Turtles

Charles, Reuben, Mark Bynoe, Jennifer Wishart, Martin Cheong. 2004. Shell Beach Protected Area Situation Analysis. GMTCS publication.

Mannocci, L., R. Monestiez, J. Bolaños, G. Doremus, S. Jérémie, S. Laran, R. Rinaldi, O. Van Canneyt, V. Ridoux. 2013. Megavertebrate communities from two contrasting ecosystems in the western tropical Atlantic. Journal of Marine Systems, 111: 208–222. Retrieved from: http://dx.doi.org/10.1016/j.jmarsys.2012.11.002

Minasian, S. M., K. C. Balcomb, L. Foster. 1984. The Worlds Whales: The Complete Illustrated Guide. Smithsonian Books, 224 pp.

Marine Fish

CRFM. Undated. Sargassum Seaweed Invasion: What, Why, and What We Can Do? Retrieved from: http://www.crfm.net/~uwohxjxf/images/documents/Sargassum_Pamphlet-_Final.pdf

MOA (Guyana Ministry of Agriculture, Fisheries Department). 2013. Marine Fisheries Management Plan 2013-2018.

Nihoul, J. C. J. and C. T. A. Chen. 2008. Oceanography. Volume 1. Encyclopedia of Life Support Systems.

NOAA (National Oceanic and Atmospheric Administration). 2016. Large Marine Ecosystems of the World. XVI-52 North Brazil Shelf: LME #17. Retrieved from: http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=55:north-brazil-shelf-lme-17&catid=16&Itemid=114

Palandro, 2016. Persistence of Sargassum in Guyana EEZ and Stabroek Lease Block. ExxonMobil Upstream Research Company.

Ross. 2010. Sargassum: A Complex 'Island' Community at Sea. National Oceanographic and Atmospheric Administration. United States Department of Commerce. Retrieved from: http://oceanexplorer.noaa.gov/explorations/03edge/background/sargassum/sargassum.html

Marine Benthic Habitat

Davies, C. E., D. Moss, M. O. Hill. 2004. EUNIS Habitat Classification Revised 2004. Retrieved from: http://eunis.eea.europa.eu/references/1473.

EPA (Environmental Protection Agency, Guyana). 2010. Fourth National Report to the Convention on Biological Diversity. Retrieved from: http://www.cbd.int/doc/world/gy/gy-nr-04-en.pdf.

Flach, E., J. Vanaverbeke, C. Heip. 1999. The meiofauna:macrofauna ratio across the continental slope of the Goban Spur (north-east Atlantic). Journal of the Marine Biological Association of the United Kingdom, 79: 233–241. Retrieved from: https://pure.knaw.nl/portal/files/472420/Flach_ea_2380.pdf

Freiwald, A., J. H. Fosså, A. Grehan, T. Koslow, J. M. Roberts. 2004. Cold-water Coral Reefs. UNEP-WCMC, Cambridge, UK. Retrieved from: http://www.unep-wcmc.org/biodiversity-series-22_103.html

FUGRO EMU Limited. 2016. Environmental Baseline Survey Report. Liza Development, Offshore Guyana. Prepared for Esso Exploration and Production Guyana Ltd, March 2016. Fugro Job No. 2415-3066-EBS. 125 pgs.

Maxon Consulting, Inc. and TDI Brooks International, Inc. 2014. Environmental Baseline Study. Guyana Stabroek Block. Prepared for Esso Exploration and Production Guyana Ltd. July 2014. Ref. 14024. 106 pgs.

NOAA. 2014. National Marine Fisheries Services. Marine Habitat Protection Program: Deep-Sea Corals. Retrieved from: http://www.habitat.noaa.gov/protection/corals/deepseacorals.html

Poore, G., and M. Schotte. 2009. Malacanthura truncata (Hansen, 1916). In: Boyko, C.B, N. L. Bruce, K. L. Merrin, Y. Ota, G. C. B. Poore, S. Taiti, M. Schotte, G. D. F. Wilson (eds). 2008 (onwards). World Marine, Freshwater and Terrestrial Isopod Crustaceans database. Accessed: October 3, 2016. Retrieved from: World Register of Marine Species at http://www.marinespecies.org/aphia.php?p=taxdetails&id=118479

Poore, G. and M. Schotte, M. 2015. Leptanthura guianae Kensley, 1982. In: Boyko, C. B., N. L. Bruce, K. L. Merrin, Y. Ota, G. C. B. Poore, S. Taiti, M. Schotte, G. D. F. Wilson (eds). 2008 (onwards). World Marine, Freshwater and Terrestrial Isopod Crustaceans database. Accessed: October 3, 2016. Retrieved from: World Register of Marine Species at http://www.marinespecies.org/aphia.php?p=taxdetails&id=255553

Rowe, G. T., P. Polloni, R. L. Haedrich. 1982. The deep-sea macrobenthos on the continental margin of the northwest Atlantic Ocean. Deep-Sea Research 29A: 257–278.

Wei C. L., G. T. Rowe, G. F. Hubbard, A. H. Scheltema, G. D. F. Wilson, I. Petrescu, J. M. Foster, M. K. Wicksten, M. Chen, R. Davenport, Y. Soliman, Y. Wang. 2010. Bathymetric zonation of deep-sea macrofauna in relation to export surface phytoplankton production. Marine Ecology Progress Series 399:1-14. Accessed: November 2016. Retrieved from: http://www.int-res.com/articles/feature/m399p001.pdf

Socioeconomic Resources

Economic Activities

Bureau of Statistics Guyana. 2012. 2012 Population & Housing Census Compendium.

Minority Rights Group International. 2008. World Directory of Minorities and Indigenous Peoples – Guyana: Indigenous Peoples.

Protected Areas Commission. 2014. Shell Beach Protected Area Management Plan, 2015-2019.

Employment and Livelihoods

CIA World Factbook. 2016. Education Expenditures. Retrieved from: https://www.cia.gov/library/publications/the-world-factbook/fields/2206.html

Bureau of Statistics Guyana. 2012. 2012 Population & Housing Census Compendium.

Minority Rights Group International. 2008. World Directory of Minorities and Indigenous Peoples - Guyana: Indigenous Peoples.

UNICEF (United Nations Children's Fund). 2015. Guyana Multiple Indicator Cluster Survey 2014, Final Report.

Community Health and Wellbeing and Living Conditions

CCI (Climate Change Initiative). 2012. Land Cover map for 1998-2012 epoch. Retrieved from: http://www.esa-landcover-cci.org/?q=node/158

FAO (Food and Agriculture Organization of the United Nations). 2015. AQUASTAT Regional Report: Southern America, Central America and the Caribbean - Guyana. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/index.stm

IDB (Inter-American Development Bank). 2010. Guyana Property Rights Study: Discussion Paper IDB-DP-141.

Marine Use and Transportation

Guyana Tourism Authority. 2016. Annual Tourism Data: All Visitors by Main Markets and Monthly Visitors.

FAO (Food and Agriculture Association of the United Nations). 2015. AQUASTAT Regional report: Guyana. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/index.stm

GGMC (Guyana Geology and Mines Commission). 2010. The Mineral Industry in Guyana.

Guyana Bureau of Statistics. 2015. Trade Statistics System. Retrieved from: http://www.statisticsguyana.gov.gy/trade.html

Guyana Chronicle. 2016. Pomeroon to become Guyana’s coconut capital. July 18, 2016. Retrieved from: http://guyanachronicle.com/pomeroon-to-become-guyanas-coconut-capital/

Ministry of Agriculture. 2016a. Agriculture, fisheries and apiculture annual statistics.

Ministry of Finance. 2015. Mid-Year Report 2015. Retrieved from: http://finance.gov.gy/documents-publications/category/mid-year-reports

Ministry of Finance. 2016. Mid-Year Report 2016. Retrieved from: http://finance.gov.gy/documents-publications/category/mid-year-reports

MOA (Guyana Ministry of Agriculture). 2013. Fisheries Department. Marine Fisheries Management Plan 2013-2018.

PAC (Protected Areas Commission). 2014. Shell Beach Protected Area Management Plan, 2015-2019.

Private Sector Commission of Guyana. 2015. Annual Report 2015.

Stabroek News. 2016. Pomeroon farmers cashing in on coconut water market. Retrieved from: http://www.stabroeknews.com/2016/business/05/13/pomeroon-farmers-cashing-coconut-water-market/

UNDP (United Nations Development Programme). 2005. Guyana: Socio-economic Assessment of the Damages and Losses Caused by the January-February 2005 Flooding. Retrieved from: http://www.cepal.org/cgi-bin/getProd.asp?xml=/publicaciones/xml/0/26950/P26950.xml&xsl=/publicaciones/ficha-i.xsl&base=/publicaciones/top_publicaciones-i.xsl#

World Bank. 2016. Retrieved from: http://www.worldbank.org/en/country/guyana/overview

Social Infrastructure and Services

Guyana Bureau of Statistics. 2016. 2012 Census - Compendium 3: Economic Activity.

ECLAC (Economic Commission for Latin American and the Caribbean). 2011. An Assessment of the Economic Impact of Climate Change on the Agriculture Sector in Guyana. Retrieved from: http://repositorio.cepal.org/bitstream/handle/11362/38586/LCCARL323_en.pdf;jsessionid=6A80E60D052D8EB7A38956A1033254D8?sequence=1

Ministry of Agriculture. 2016b. News: FAO Country Rep Lauds Guyana's Efforts to Stop Illegal Fishing. Retrieved from: http://agriculture.gov.gy/2016/04/15/fao-country-rep-lauds-guyanas-efforts-to-stop-illegal-fishing/

Ministry of Finance. 2015. Mid-Year Report 2015. Retrieved from: http://finance.gov.gy/documents-publications/category/mid-year-reports

Protected Areas Commission. 2014. Shell Beach Protected Area Management Plan, 2015-2019.

Minority Rights Group International. 2008. World Directory of Minorities and Indigenous Peoples - Guyana: Indigenous Peoples.

Land Use

Ministry of Public Health. 2013a. Guyana Strategic Plan for the Integrated Prevention and Control of Chronic NCDs and their Risk Factors 2013-2020. Retrieved from: http://www.health.gov.gy/moph/strategies/NCD%20Strategic%20Plan%202013-2020.pdf

Ministry of Public Health. 2013b. Health Vision 2020: A National Health Strategy for Guyana, 2013-2020. Retrieved from: http://www.health.gov.gy/moph/strategies/Health%20Vision%202020.pdf

Ministry of Public Health. 2014. Communication Strategy for Malaria Control, 2014-2016.

Ministry of Public Health. 2016. Regional Health Facilities. Retrieved from: http://www.health.gov.gy/moph/

Pan-American Health Organization. 2005. Health Situation Report: Floods in Guyana – January/February 2005. Retrieved from: http://www.paho.org/disasters/index.php?option=com_content&view=article&id=714%3Afloods-in-guyana-january%2Ffebruary-2005&Itemid=0&lang=en

UNAIDS. 2015. Guyana AIDS Response Progress Report. Retrieved from: http://www.unaids.org/sites/default/files/country/documents/GUY_narrative_report_2015.pdf

UNDP (United Nations Development Programme). 2005. Guyana: Socio-economic Assessment of the Damages and Losses Caused by the January-February 2005 Flooding. Retrieved from: http://www.cepal.org/cgi-bin/getProd.asp?xml=/publicaciones/xml/0/26950/P26950.xml&xsl=/publicaciones/ficha-i.xsl&base=/publicaciones/top_publicaciones-i.xsl#

UNICEF (United Nations Children's Fund). 2014. Guyana Multiple Indicator Cluster Survey 5.

WHO (World Health Organization). 2014. World Suicide Report: Preventing Suicide: A Global Imperative. Retrieved from: http://www.who.int/mediacentre/news/releases/2014/suicide-prevention-report/en/

Cultural Heritage

EEPGL. 2016. Stabroek Block – Final Report on Survey of Suspected Subsea Cable and SGSCS Cable. Report to Guyana Geology & Mines Commission. April 14.

NGIA (National Geospatial-Intelligence Agency). 2014. Sailing Directions (Enroute), East Coast of South America. Publication 124, Fourteenth Edition. Accessed: September 16, 2016. Retrieved from: http://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/SD/Pub124/Pub124bk.pdf

Ecosystem Services

Guyana Bureau of Statistics. 2002. 2002 Population & Housing Census – Guyana National Report.

FAO (Food and Agriculture Organization of the United Nations). 2015. AQUASTAT RegionalReport: Guyana. Retrieved from: http://www.fao.org/nr/water/aquastat/countries_regions/guy/index.stm

Guyana Ministry of Education. 2013. List of Schools by Region. Retrieved from: http://education.gov.gy/web/index.php/downloads

IDB (Inter-American Development Bank). 2010. Guyana Property Rights Study. Discussion Paper No. IDB-DP-141.

IDB (Inter-American Development Bank). 2016. The State of Social Housing in Six Caribbean Countries.

Ministry of Finance. 2015. Mid-Year Report 2015. Retrieved from: http://finance.gov.gy/documents-publications/category/mid-year-reports

OSAC (Overseas Security Advisory Council). 2016. Guyana 2016 Crime and Safety Report. United States Department of State, Bureau of Diplomatic Security. Retrieved from: https://www.osac.gov/pages/ContentReportDetails.aspx?cid=19622

PSC (Private Sector Commission of Guyana). 2015. Annual Report 2015.

Social Infrastructure and Services

MA (Millennium Ecosystem Assessment). 2005. Ecosystems and Human Well-being: A Framework for Assessment.

Ministry of Agriculture. 2016. Agriculture, fisheries and apiculture annual statistics.

WWF (World Wildlife Fund). 2016. Eastern South America: Coastal French Guiana, Suriname, Guyana, and southeastern Venezuela. Accessed: September 23, 2016. Retrieved from: http://www.worldwildlife.org/ecoregions/nt1411

Assessment of Potential Impacts

Physical Resources

Air Quality and Climate Change

WHO (World Health Organization). 2000. WHO Air Quality Guidelines for Europe, 2nd edition.

WHO (World Health Organization). 2005. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide - Global Update 2005.

World Resources Institute and the World Business Council for Sustainable Development. 2004. The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.

Yale University. 2016. Global Metrics for the Environment. Environmental Performance Index 2016 Report. Retrieved from: http://epi.yale.edu/country/guyana

Noise and Vibration

Finneran, J.J. 2015. Auditory weighting functions and TTS/PTS exposure functions for cetaceans and marine carnivores. San Diego: SSC Pacific.

JASCO (JASCO Applied Sciences). 2016. Underwater Sound Associated with Liza Phase 1 Project Activities.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C. R. Greene, Jr., D. Kastak, D.R. Ketten, J. H. Miller. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals, 33(4): 411–521.

Marine Geology and Sediments

Ellis D. V. and C. Heim. 1985. Submersible surveys of benthos near a turbidity cloud. Mar Poll Bull, 16(5): 197–203.

MarLIN (Marine Life Information Network). 2011. Benchmarks for the Assessment of Sensitivity and Recoverability. The Marine Biological Association of the UK, Citadel Hill, Plymouth, Devon, U.K. Retrieved from: http://www.marlin.ac.uk/sensitivitybenchmarks.php

Biological Resources

Beaches, Mangroves, Vegetation, and Wetland Habitats

BirdLife International. 2012a. Pterodroma hasitata. The IUCN Red List of Threatened Species 2012: e.T22698092A38940168. Accessed: October 2, 2016. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T22698092A38940168.en

BirdLife International. 2012b. Agamia agami. The IUCN Red List of Threatened Species 2012: e.T22697200A40244589. Accessed: October 2, 2016. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T22697200A40244589.en

BirdLife International. 2012. Calidris pusilla. The IUCN Red List of Threatened Species 2012: e.T22693373A38788283. Accessed: October 2, 2016. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T22693373A38788283.en

IUCN. 2014. The IUCN Red List of Threatened Species. Version 2016-2. Accessed: November 29, 2016. Retrieved from: www.iucnredlist.org

Rheingantz, M .L. and C. S. Trinca. 2015. Lontra longicaudis. The IUCN Red List of Threatened Species 2015: e.T12304A21937379. Accessed: October 2, 2016. Retrieved from: http://dx.doi.org/10.2305/IUCN.UK.2015-2.RLTS.T12304A21937379.en

Seabirds

Baird, P. H. 1990. Concentrations of seabirds at oil-drilling rigs. Condor, 92: 768–771.

Deda, P., I. Elbertzhagen, M. Klussmann. 2007. Light pollution and the impacts on biodiversity, species and their habitats. In C. Marín and J. Jafari (eds) Starlight – A common heritage. Starlight Initiative, Instituto de Astrofísica de Canarias (IAC), La Palma, Canary Islands, Spain, April 19-20, 2007.

Gaston K. J., J. Bennie, T. W. Davies, J. Hopkins. 2013. The ecological impacts of nighttime light pollution: a mechanistic appraisal. Biol Rev, 88: 912–927.

Marquenie, J. 2007. Green Light to Birds: Investigation into the Effect of Bird-Friendly Lighting. Retrieved from: http://www.waddenzee.nl/fileadmin/content/Dossiers/Energie/pdf/green_light_to_birdsNAM.pdf

Platteeuw, M. and R. Henkens. 1997. Possible Impacts of Disturbance to Waterbirds: Individuals, Carrying Capacity, and Populations. Wildfowl, 48: 225–236.

Ronconi, Robert A., Karel A. Allard, Philip D. Taylor. 2015. Bird interactions with offshore oil and gas platforms: Review of impacts and monitoring techniques. Journal of Environmental Management, 147: 34–45.

RPS. 2016. Marine Fauna Observer Report. Prepared by ExxonMobil.

Wiese F. K., W. A. Montevecchi, G. K. Davoren, F. Huettmann, A. W. Diamond. 2001. Seabirds at Risk around Offshore Oil Platforms in the North-west Atlantic. Marine Pollution Bulletin, 42: 1,285–1,290.

Marine Fish

Barnthouse, L.W. 2013. Impacts of entrainment and impingement on fish populations: A review of the scientific evidence. Environmental Science & Policy, 31: 149–156. August 2013.

BOEM (Bureau of Ocean Energy Management). 2014. Programmatic Environmental Impact Statement for Atlantic OCS Proposed Geological and Geophysical Activities in the Mid-Atlantic and South Atlantic Planning Areas. US Department of the Interior. Gulf of Mexico OCS Region.

Brungs, W.A. 1973. Effects of Residual Chlorine on Aquatic Life. Journal of the Water Pollution Control Federation, 45(10): 2,180–2,193. (Oct., 1973)

Donelson, J. M., M. I. McCormick, D. J. Booth, P. L. Munday. 2014. Reproductive Acclimation to Increased Water Temperature in a Tropical Reef Fish. PLoS One, 9(5): e97223.

Hastings R. W., L. H. Ogren, M. T. Mabry. 1976. Observations on the fish fauna associated with offshore platforms in the northeastern Gulf of Mexico. US Natl Mar Fish Serv Fish Bull, 74: 387–402.

Keenan, S. F., M. C. Benfield, J. K. Blackburn. 2007. Importance of the artifical light field around offshore petroleum platforms for the associate fish community. Marine Ecology Progress Series, 331: 219–231. 2007.

Lindquist D., R. Shaw, F. Hernandez. 2005. Distribution patterns of larval and juvenile fishes at offshore petroleum platforms in the north-central Gulf of Mexico. Estuar Coast Shelf Sci, 62: 655–665.

Martinez-Andrade, F. and D. M. Baltz. 2003. Marine and Coastal Fishes Subject to Impingement by Cooling-Water Intake Systems in the Northern Gulf of Mexico: An Annotated Bibliography. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-040. 113 pp.

Pankhurst, N. W. and P. L. Munday. 2011. Effects of climate change on fish reproduction and early life history stages. Marine and Freshwater Research, 62: 1,015–1,026.

Stanley D. R. and C. A. Wilson. 1997. Seasonal and spatial variation in the abundance and size distribution of fishes associated with a petroleum platform in the northern Gulf of Mexico. Can J Fish Aquat Sci, 54: 1,166–1,176.

Svecevicius G, J., P. Syvokiene, L. Stasiŭnaite, L. Mickeniene. 2005. Acute and chronic toxicity of chlorine dioxide (ClO2) and chlorite (ClO2-) to rainbow trout (Oncorhynchus mykiss). Environ Sci Pollut Res Int. Sep, 12(5): 302–5.

US EPA. 2010. Comparative Toxicity of Eight Oil Dispersant Products on Two Gulf of Mexico Aquatic Test Species. U.S. Environmental Protection Agency Office of Research and Development. Retrieved from: https://archive.epa.gov/bpspill/web/pdf/comparativetoxtest.final.6.30.10.pdf

WaterReUse. 2011. Desalination Plant Intakes-Impingement and Entrainment Impacts and Solutions. Retrieved from: https://www3.epa.gov/region1/npdes/schillerstation/pdfs/AR-026.pdf

Marine Benthic Habitat

Ellis, D. and C. Heim. 1985. Submersible surveys of benthos near a turbidity cloud. Marine Pollution Bulletin, 16(5): 197–203.

IOGP. 2016. Environmental fates and effects of ocean discharge of drill cuttings and associated drilling fluids from offshore oil and gas operations. Retrieved from: http://www.iogp.org/pubs/543.pdf

Jones, D., J. Cruz-Motta, D. Bone, J. Kaariainen. 2012. Effects of oil drilling activity on the deep water megabenthos of the Orinoco Fan, Venezuela. Journal of the Marine Biological Association of the United Kingdom, 92: 245–253. Retrieved from: https://www.researchgate.net/publication/259418552_Effects_of_oil_drilling_activity_on_the_deep_water_megabenthos_of_the_Orinoco_Fan_Venezuela

Kilgour, M. J., and T. C. Shirley. 2008. Bathymetric and spatial distribution of decapod crustaceans on deep-water shipwrecks in the Gulf of Mexico. Bulletin of Marine Science, 82: 333–344. Retrieved from: https://www.researchgate.net/publication/259418552_Effects_of_oil_drilling_activity_on_the_deep_water_megabenthos_of_the_Orinoco_Fan_Venezuela

MarLIN (Marine Life Information Network). 2011. Benchmarks for the Assessment of Sensitivity and Recoverability. The Marine Biological Association of the UK, Citadel Hill, Plymouth, Devon, U.K. Accessed" April 2011. Retrieved from: http://www.marlin.ac.uk/sensitivitybenchmarks.php

Smit, M. G. D., J. E. Tamis, R. G. Jak, C. C. Karman, G. Kjeilen-Eilertsen, H.Trannum, J.Neff. 2006. Threshold levels and risk functions for non-toxic sediment stressors: burial, grain size changes and hypoxia. Summary. TNO Report no. TNO 2006-DH-0046/A – Open

Special Status Species

Nihoul, J. C. J. and C. T. A. Chen. 2008. Oceanography. Volume 1. Encyclopedia of Life Support Systems. ISBN:978-1-905839-62-9

NOAA (National Oceanic and Atmospheric Administration). 2016. Large Marine Ecosystems of the World. XVI-52 North Brazil Shelf: LME #17. Retrieved from: http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=55:north-brazil-shelf-lme-17&catid=16&Itemid=114

Ecological Balance and Ecosystems

Caribbean Invasive Alien Species Network. 2010. Green mussel (Perna virdis). Available at: http://www.ciasnet.org/2010/08/10/green-mussel-perna-virdis/. Accessed Fbruary, 2017.

European Maritime Safety Agency. 2017. Ballast Water. Available at: http://www.emsa.europa.eu/implementation-tasks/environment/ballast-water.html. Accessed February 2017.

Maritime and Coastguard Agency. 2008. Marine Guidance Note MGN 363 (M+F). The Control and Management of Ships' Ballast Water and Sediments. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440722/MGN_363.pdf. Accessed February 2017.

Ruiz, G., Murphy, K.R., Verling, E, Smith, G, Chaves, S., and A.H. Hines. 2005. Ballast Water Exchange: Efficacy of treating ships' ballast water to reduce marine species transfers and invasion success? Final Report Submitted to: U.S. Fish & Wildlife Service, American Petroleum Institute, & Prince William Sound Regional Citizens' Advisory Council. Available at: http://www.psmfc.org/ballast/wordpress/wpcontent/uploads/2011/05/Ballast_Water_Exchange_PWS_Ak_Ruiz_2005.pdf. Accessed February 2017.

Socioeconomic Resources

Marine Water Quality

ITOPF, undated. Effects of Oil Pollution on the Marine Environment. Technical Information Paper No. 13. Retrieved from: http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP13EffectsofOilPollutionontheMarineEnvironment.pdf

Ecological Balance and Ecosystems

Chanton, J. P., J. Cherrier, R. M. Wilson, J. Sarkodee-Adoo, S. Bosman, A. Mickle, W. M. Graham. 2012. Radiocarbon evidence that carbon from the Deepwater Horizon spill entered the planktonic food web of the Gulf of Mexico. Environmental Research Letters, (7) 4.

GOMRI (Gulf of Mexico Research Initiative). 2015. Studies Identify Oil Spill Effects in Deep Sea Fish. Retrieved from: http://gulfresearchinitiative.org/studies-identify-oil-spill-effects-in-deep-sea-fish/

ITOPF, undated. Effects of Oil Pollution on the Marine Environment. Technical Information Paper No. 13. Retrieved from: http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP13EffectsofOilPollutionontheMarineEnvironment.pdf

MBC (MBC Applied Environmental Sciences). 2011. Life History Parameters of Common Southern California Marine Fishes. Prepared for the California Energy Commission Public Interest Energy Research Program. Retrieved from: http://www.energy.ca.gov/2011publications/CEC-500-2011-008/CEC-500-2011-008.pdf

Montagna, P. A., J. G. Baguley, C. Cooksey, J. L. Hyland. 2013. Deepwater Horizon Oil Spill: Assessment of Potential Impacts on the Deep Soft-Bottom Benthos. Interim Data Summary Report. NOAA Technical Memorandum NOS NCCOS 166. NOAA, National Centers for Coastal Ocean Science, Charleston, SC. 32 p.

Moreno, R., L. Jover, C. Diez, F. Sarda, C. Sanpera. 2013. Ten Years After the Prestige Oil Spill: Seabird Trophic Ecology as Indicator of Long-Term Effects on the Coastal Marine Ecosystem. PLoS One, 8(10): e77360.

Neff, J. 2002. Bioaccumulation in Marine Organisms: Effect of Contamination from Oil Well Produced Water. Elsevier Inc. 468 pp.

Nihoul, J. C. J. and C. T. A. Chen. 2008. Oceanography. Volume 1. Encyclopedia of Life Support Systems. ISBN:978-1-905839-62-9

NOAA (National Oceanic and Atmospheric Administration). 2016. How Oil Harms Animals and Plants in Marine Environments. Retrieved from: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/how-oil-harms-animals-and-plants-marine-environments.html

Ozhan, K., M. L. Parsons, S. Bargu. 2014. How Were Phytoplankton Affected By the Deepwater Horizon Oil Spill. Bioscience, 64(9).

Piatt, J. F. and P. Anderson. 1996. Response of Common Murres to the Exxon Valdez Oil Spill and Long-Term Changes in the Gulf of Alaska Marine Ecosystem. American Fisheries Society Symposium, 18: 720–737.

Press, 2015. How Oil Damages Fish Hearts: Five Years of Research Since the Deepwater Horizon Oil Spill. Retrieved from: http://www.fisheries.noaa.gov/stories/2015/04/dwh_5yrs.html

Teal, J. M. and R. W. Howarth. 1984. Oil spill studies: A review of ecological effects. Environmental Management, 8: 27. doi:10.1007/BF01867871.

Graham W. M., R. H. Condon, R. H. Carmichael, I. D'Ambra, H. K. Patterson, L. J. Linn, F. J. Hernandez. 2010. Oil carbon entered the coastal planktonic food web during the Deepwater Horizon oil spill. Environmental Research Letters, 5(4):045301.

Marine Fish

ITOPF. Undated. Effects of Oil Pollution on the Marine Environment. Technical Information Paper No. 13. Retrieved from: http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP13EffectsofOilPollutionontheMarineEnvironment.pdf

Press, 2015. How Oil Damages Fish Hearts: Five Years of Research Since the Deepwater Horizon Oil Spill. Retrieved from: http://www.fisheries.noaa.gov/stories/2015/04/dwh_5yrs.html

Transboundary Impacts

Miloslavich, P., A. Martín, E. Klein, Y. Díaz, C. A. Lasso, J. J. Cárdenas, O .M. Lasso-Alcalá. 2011. Biodiversity and Conservation of the Estuarine and Marine Ecosystems of the Venezuelan Orinoco Delta. In Ecosystems Biodiversity. O. Grillo and G. Venora (eds). ISBN 978-953-307-417-7, 474 pages, Publisher: InTech, DOI: 10.5772/913

Personal Communications

ERM Personal Communication 1. Interview with the Guyana Rice Producers' Association. September 6, 2016.

ERM Personal Communication 2. Interview with the Guyana Association of Trawler Owners and Seafood Processors. September 5, 2016.

ERM Personal Communication 3. Interview with the Department of Tourism. August 30, 2016.

ERM Personal Communication 4. Interview with Mainstay/Whyaka Amerindian Village. September 2, 2016.

ERM Personal Communication 5. Interview with Pomeroon Women's Agro-Processors Association. August 31, 2016.

ERM Personal Communication 6. Interview with Supenaam-Parika Speedboat Operators Association. August 31, 2016.

ERM Personal Communication 7. Interview with Ministry of Public Health. August 29, 2016.

ERM Personal Communication 8. Interview with Ministry of Communities. August 29, 2016.

ERM Personal Communication 9. Interview with Ministry of Public Infrastructure. September 2, 2016.

ERM Personal Communication 10. Interview with Private Sector Commission of Guyana. September 2, 2016.

ERM Personal communication 11. Interview with Guyana Marine Turtle Conservation Society. September 5, 2016.

ERM Personal Communication 12. Interview with Guyana Hindu Dharmic Sabha. September 2, 2016.

ERM Personal Communication 13. Interview with African Culture Development Association. September 25, 2016.

ERM Personal Communication 14. Interview with Ministry of Agriculture. September 5, 2016.

ERM Personal Communication 15. Interview with West End Agricultural Development Society. September 2, 2016.ERM Personal Communication 16. Interview with fisherman in Lima. August 31, 2016.

ERM Personal Communication 16. Email from Denzil Roberts with fish bycatch from shrimp trawling fishery. October 4, 2016."

ERM Personal Communication 17. Interview with anonymous fisherman in Charity. August 31, 2016.

ERM Personal Communication 18. Interview with National Aquaculture Association. September 6, 2016.

ERM Personal Communication 19. Interview with Vilvordeen/Fairfield Women's Association. August 31, 2016.

ERM Personal Communication 20. Interview with Member of Lima Fisherman's Development Co-operative. August 31, 2016.

ERM Personal Communication 21.Interview with Fish processor in Lima area. August 31, 2016.