ExxonMobil Guyana Limited

Oil Spill Response Plan
for Guyana Operations

Revision 14
March 2024

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Oil Spill Response Plan for Guyana Operations

Endorsed by:

3/6/24

Adam Cantu II
Safety, Security, Health & Environment Manager

Date

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Amendment Record

Revision	Date	Summary of Amendment	Endorsed by
Rev 0	February 2016	Initial issue for use.	J. Simons
Rev 1	February 2017	EMGL OSRP Amendment Amended to reflect further spill scenarios associated with Liza Phase 1 FPSO Development Project and addition of Wildlife Response Plan.	J. Simons
Rev 2	May 2017	Final edits/revisions based on comments received to Liza Phase 1 FPSO Development Project EIA and OSRP.	R. Henson
Rev 3	May 2018	Transitioned OSRP to a single plan covering all Guyana operations. Amended to reflect further oil spill modelling associated with Liza Phase 2 FPSO Development Project, updates to align with the Guyana National Contingency Plan, and EMGL tactical response maps and equipment.	R. Henson
Rev 4	September 2018	Final edits/revisions based on comments received on Liza Phase 2 Development Project EIA and OSRP.	R. Henson
Rev 5	August 2019	Amended to reflect inclusion of Payara Development Project.	R. Henson
Rev 6	November 2019	Amended to include WCD for Liza Phase 1 and Liza Phase 2	R. Henson
Rev 7	July 2020	Edits/revisions based on comments received on Payara Development Project EIA and OSRP	A. Routledge
Rev 8	March 2022	Edits/revisions based on Guyana National Oil Spill Contingency Plan; Yellowtail Development Project	M. Persaud
Rev 9	November 2022	Addition of Demerara River modelling	M. Persaud
Rev 10	March 2023	Addition of Uaru Development Project modelling; Update to include Net Environmental Benefit Analysis (NEBA)/Spill Impact Mitigation Analysis (SIMA) for Uaru replacing NEBA completed for Payara Development Project (2020); Updated Wildlife Response Plan; Updated GRP summary; Summary of exercise, drills	M. Persaud
Rev 11	May 2023	Addition of Stabroek 35-Well Environmental Impact Assessment of Cumulative Effects (CIA) modelling	M. Persaud
Rev 12	August 2023	Addition of Whiptail Development Project modelling	M. Persaud
Rev 13	September 2023	Addition of Canje 12-well CIA modelling	M. Persaud
Rev 14	March 2024	2024 Annual Update; Addition of Operational & Scientific Monitoring Program framework	A. Cantu

Approved updates to the OSRP shall be distributed to the following per EMGL protocols:

- EMGL core management team
- EMGL asset management teams
- EMGL project management teams
- EMGL EP&R Plan Owner and Administrator
- Select agencies (e.g., Environmental Protection Agency (EPA), Civil Defence Commission (CDC), Ministry of Natural Resources (MNR), Maritime Administration Department (MARAD), Guyana Geology and Mines Commission (GGMC), Guyana Energy Agency (GEA)

Contents

Tables [1]

[1] Figures and tables from the Appendices are not listed.

Figures

Appendices

Acronyms and Abbreviations

Name	Description
µg/g	micrograms per gram
µg/L	micrograms per liter
bbl	barrel(s)
BOEM	US Bureau of Ocean Energy Management
BOP	Loss of Well Control Preventer
BSEE	US. Department of the Interior Bureau of Safety and Environmental Enforcement
CBT	Computer Based Training
CDC	Civil Defense Commission
CIA	Environmental Impact Assessment of Cumulative Effects
CSS	Capping Stack Systems
EIA	Environmental Impact Assessment
EMGL	ExxonMobil Guyana Limited
EPA	Environmental Protection Agency (Guyana)
ERP	Emergency Response Plan
ERT	Emergency Response Team
ESG	Emergency Support Group
FDA	US Food and Drug Administration
FPSO	Floating Production Storage and Offloading
FRT	First Response Toolkit
FSV	Fast Supply Vessel
GCG	Guyana Coast Guard
GEA	Guyana Energy Agency
GIS	Geographic Information System
GoM	US Gulf of Mexico
GRIP	Global Rapid Intervention Package
GRP	Geographic Response Plan
GSI	Gemini Solutions, Inc.
ICS	Incident Command Structure
IMH	Incident Management Handbook
IMT	Incident Management Team
KBD/KBPD	Thousand Barrels Per Day
MARAD	Maritime Administration Department

Name	Description
MCWCD	Most Credible Worst Case Disharge
MNR	Ministry of Natural Resources
MSRC	Marine Spill Response Corporation
MWCC	Marine Well Containment Company
NADF	Non-aqueous Drilling Fluid
NEBA	Net Environmental Benefit Analysis
NDC	Neighbourhood Democratic Councils
NOAA	US National Oceanic and Atmospheric Administration
NRC	National Response Corporation
OIMS	Operations Integrity Management System
OSMP	Operational & Scientific Monitoring Plan
OSPD	US BSEE Oil Spill Preparedness Division
OSRL	Oil Spill Response Limited
OSRO	Oil Spill Response Organization
OSRP	Oil Spill Response Plan
PAH	Polycyclic Aromatic Hydrocarbons
ppm	parts per million
PSV	Project Support Vessel
RDC	Regional Democratic Councils
ROV	Remotely Operated Vehicle
RRT	Regional Response Team
SIMA	Spill Impact Mitgation Assessment
SIRT	Subsea Incident Response Toolkit
SLA	Service Level Agreement
SOPEP	Shipboard Oil Pollution Emergency Plan
SSHE	Safety, Security, Health, and Environment
SWIS	Subsea Well Intervention Service
TRG	The Response Group
US EPA	United States Environmental Protection Agency
VOO	Vessel Of Opportunity
WCD	Worst Case Discharge
WRP	Wildlife Response Plan

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1. INTRODUCTION

The Government of Guyana is conscious of the need to preserve and protect the environment and seeks to safely develop its oil and other mineral resources. It recognizes that a degree of risk is associated with the infrastructure built to support the development of these resources thus it's incumbent for organizations with oil spill risk potential to accept that oil spill response preparedness is a necessary function of their business.

This Oil Spill Response Plan for Guyana Operations (OSRP) delineates responsibilities for the operational preparedness, efficient response to, containment of and/or recovery to marine and terrestrial ecosystem emergencies, which could result from an unplanned discharge or release of a petroleum product. Furthermore, it addresses the engagement between the Operator (ExxonMobil Guyana Limited [EMGL]), the Guyana Authorities (e.g., Environmental Protection Agency [EPA], Civil Defense Commission [CDC], Maritime Administration Department (MARAD), and Guyana Coast Guard [GCG]), the ExxonMobil Corporate support team, and use of third-party support organizations.

This document is a country-wide management plan[2] which covers all aspects of EMGL's operations in Guyana as they pertain to unplanned spillage events. The information in this document serves as a supplement to, and not replacement for, the information in the EMGL Emergency Response Plan (ERP). The information in the ERP continues to apply in the case of an unplanned spill-related event including but not limited to incidents associated with the shorebases utilized by EMGL as well as the offshore operations in the geographic response area, including the possibility of hydrocarbon and chemical releases, search and rescue, offshore medical evacuation, medical emergency, fatality, fire or explosion at a work site, natural disaster, and security or civil disturbance. While the ERP is the primary document for use in all emergencies, it is supplemented by this OSRP in the specific case of an oil spill. This document addresses information specific to spill contingency or mitigation, response and recovery activities not covered in the ERP.

The OSRP is a "evergreen document" that will be revised or amended as Project development progresses and production operations commence in response to changing circumstances, lessons learned, or other appropriate reasons. This document supersedes previously published EMGL Oil Spill Response Plans.

1.1 Scope

Given the sensitivity to many of the resources that could potentially be impacted by an unplanned discharge or release, EMGL has conducted multiple risk assessments and identified various spillage-type 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

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[2] Noted in EMGL Environmental Impact Assessments, under the Environmental and Socioeconomic Management Plan (ESMP) or Environmental and Socioeconomic Monitoring and Management Plan (ESMMP) Framework chapter, the OSRP is a specific management plan following the ESMP/ESMMP guiding principles.

shorebase(s) and on vessels in the Demerara River estuary (e.g., from a supply vessel) or in the Atlantic Ocean (e.g., from a well, drill ship, supply vessel, tanker, FPSO). This OSRP describes the spill response framework, equipment and facilities used to tactically respond, and how the organization will collaborate with Guyana agencies.

1.1.1 Response Priority

The primary response objectives of all countermeasure operations will be to minimise the threat to human health, ensure the safety of the responders and the public, reduce the impact to the environment by protecting terrestrial and marine ecosystems as well as other economically relevant facilities and amenities at risk.

1.1.2 Covered Operations

EMGL will be drilling, producing, processing, storing, offloading crude oil as its core activity, and has proactively embedded many controls into the Project design to prevent and/or mitigate a loss of containment or spill from occurring.

This document covers all of EMGL's business operations in Guyana, and is focused on those operations where there is a risk of a spillage or release of product to the environment, such as but not limited to:

- Exploration operations (e.g., exploration and appraisal drilling, seismic surveys);
- Project development (inclusive of all phases, e.g., drilling, installation, production operations, decommissioning);
- Other supporting field operations (e.g., marine logistics, aviation logistics, and ancillary survey programs such as geotechnical, geophysical, environmental, metocean).

1.2 Regulatory Requirements

The legal framework consists of key general and resource-specific environmental and socioeconomic laws that have either a direct or indirect relevance to the management of potential impacts from oil and gas development. Statutes that impose specific legal obligations on EMGL under Guyana law include, but are not limited to:

- The National Constitution of Guyana (1980);
- The Environmental Protection Act (1996);
- The Guyana Geology and Mines Commission Act (1979);
- The Defence (Amendment) Act 1990 (also referred to as the Coast Guard Act);
- Maritime Zones Act 2010;
- Guyana Energy Agency (Amendment) Act 2003;
- Petroleum Activities Act (2023);
- Petroleum and Petroleum Products Regulations 2014;

- Environmental Protection (Hazardous Waste Management) Regulations 2000;
- Environmental Protection (Water Quality) Regulations 2000;
- Protected Areas Act 2011;
- Wildlife Conservation Management Act 2016.

Resource-specific environmental and socioeconomic laws and associated regulatory reporting requirements are covered in either EMGL's Emergency Response Plan (ERP) or in the Environmental Impact Assessment (EIA) for the respective Projects.

1.2.1 Guyana National Oil Spill Contingency Plan (NOSCP)

The Government of Guyana sees the importance of defining measures that can aid in the prevention and if unavoidable, prompt effective actions to minimise the harm which may result from an unplanned spillage or chemical release into the environment. In August 2020, under the Chairmanship of the Civil Defense Commission (CDC), the National Oil Spill Committee created and submitted to the Government of Guyana the National Oil Spill Contingency Plan (NOSCP) which is a Hazard Specific Annex or Sub-Plan to the Guyana National Multi-Hazard Disaster Preparedness and Response Plan.

Key aspects of the Guyana National Oil Spill Contingency Plan are highlighted below:

- The CDC is the lead agency for maintaining the oil spill response plan, which includes the management of the National Emergency Operating Centre (NEOC).
- Defines lead incident positions and use of the Incident Command System. Authorised incident management positions are:
  - The Competent National Authority or CNA (Incident Commander) is the Director General, CDC;
  - Deputy Incident Commander (Maritime) is the Director Maritime Safety, MARAD;
  - Deputy Incident Commander (Land) is the Chief Executive Officer, Guyana Energy Agency.
- Defines agency specific Lead / Support responsibilities based on response type.
- Any oil spill (as defined) 5 imperial gallons and over shall be reported to the respective National Focal Point (NFP) – MARAD for maritime, or GEA if on land.
- Annexes provide are but not limited to the following reference/guidance:
  - Agency contact lists;
  - Use of Dispersants criteria;
  - In-Situ Burning protocols;
  - Deepwater Response Requirements

Reference: National Oil Spill Contingency Plan, dated Aug 2020

1.2.2 International Conventions & Agreements

The Government of Guyana is signatory to and has ratified the following international conventions on the oil and gas industry:

- International Oil Pollution Preparedness and Response Cooperation (OPRC) Convention (1990);
- The Civil Liability Convention (1992);
- The International Oil Pollution Compensation Fund (1992);
- The International Convention for the Prevention of Pollution from Ships of 1973, as modified by the protocol of 1978 relating thereto (MARPOL 1973/1978);
- Bilateral Agreements with Trinidad and Tobago, and Suriname.

1.2.3 Transboundary Impacts

Working jointly with the Government of Guyana and, as appropriate, with the government(s) of other potentially impacted jurisdictions to support bi-lateral oil spill response agreements in the region, in alignment with the principles and protocols of the Guyana National Oil Spill Contingency Plan. In the event there is an oil spill incident that impacts areas outside the Guyana Exclusive Economic Zone, EMGL – with support and approval from the Government of Guyana – will work closely with representatives for the respective locations to:

- Coordinate oil spill response operations and communication between different command posts in the region;
- Create a spill-specific transboundary workgroup to manage waste from a product release – including identifying waste-handling locations in the impacted regions and managing commercial and legal issues;
- Work with nominated spill response vessel owners/operators to identify places of refuge in the impacted regions where vessels could go for repairs and assistance;
- Determine how EMGL and the impacted regional stakeholders can work together during a spill response to allow equipment and personnel to move to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions;
- Determine spill-specific financial liability during a response to a transboundary event; and
- On a spill-specific basis, work with local communities within the impacted areas to raise awareness of oil spill planning and preparations.

1.3 Shared Services and Contractual Relations

Standing contracts with Oil Spill Response Organizations, equipment and personnel providers, and other mutual aid agreements shall be maintained as business activities warrant. These resources are documented within the EMGL ERP.

1.4 Using the Document

The principal users of the Plan include EMGL employees and contractors, government officials (as appropriate), and other personnel that are expected to participate in or are concerned with response activities and recovery operations.

1.5 OSRP Owner Responsibility

Owner and Administrator: The EMGL Safety, Security, Health & Environment Manager is the Owner of the EMGL OSRP and the EMGL Emergency Preparedness & Response Advisor is the OSRP Administrator.

Plan Review: The OSRP Administrator and Owner review and update this plan on a periodic basis, including any time a significant change occurs to:

- As stated in the Introduction, this is an “evergreen document” and will be managed as EMGL in-country operations change, spill response strategies/tactics evolve, spill response capabilities grow, and/or regulatory requirements dictate; or as a result of application of key learnings from a response or exercise/simulation/drill reveal.

Site Specific Plans: Other Activity or Site-specific ERPs for shorebases and those individual vessels owned and operated by others are the responsibility of the site-specific Emergency Response owners and administrators for those companies. These include the following planned vessel Shipboard Oil Pollution Emergency Plans (SOPEPs).

- Onshore:
  - Fuel Storage Terminal Owner/Operator ERP; and
  - Shorebase(s) Owner/Operator ERP.
- Offshore:
  - FPSO(s) Owner/Operator SOPEPs;
  - Conventional Crude Oil Tanker Owners/Operators SOPEPs;
  - Drill ship Owners/Operators SOPEPs; and
  - Other Installation, Supply, Support Vessel Owners/Operators SOPEPs.

EMGL’s On-Scene Incident Commander will communicate and coordinate with the owners/ operators of such assets to ensure they have effectively implemented their ERP/SOPEP in the event of an unplanned spill or release.

2. EMERGENCY MANAGEMENT

Emergency management is the organization and management of the resources and responsibilities for dealing with all aspects of emergencies. The aim is to reduce the harmful effects of all hazards, including disasters.

2.1 Response Relationships

Fundamentally, Emergency Management consist of the following focus areas or combinations thereof:

- Emergency Response – Is the initial recognition of an abnormal condition or unplanned incident is occurring, rising awareness, taking protective measures, and initiating immediate mitigation actions. These emergencies are usually small-scale, localized incidents which tend to resolve quickly using local resources. However, even small-scale emergencies can escalate when initial efforts, preparedness, equipment, or other resources are insufficient. From the ICS Planning cycle this is the reactive phase, e.g., a life safety, process safety demand on safety system, or limited environmental impact.
- Business Continuity – Is a proactive phase event triggered by an outcome other than the usual or expected business process or operating environment. It addresses program or system risks for an exceptional hazard or loss that would have catastrophic business consequences.
- Disaster Recovery or Consequence Management – Is when an unplanned occurrence or loss of containment (i.e., spillages, gas releases, product igniting, explosion or catastrophic source control failure) leads to a prolonged impact moving beyond the reactive phase capabilities, requiring continuous response endeavours and extended recovery efforts. These crises or disasters are typically large-scale, exceed local response tactics and resources, and potentially extend across geographic boundaries.

2.1.1 Localized Emergency Response Efforts

Each operating location maintains an Emergency Response Team (ERT) governed by their Facility Response Plan (FRP) that addresses the immediate actions required upon the discovery of an abnormal condition or emergency. This OSRP may highlight some tactics, including the notification process, but it is not intended to be all inclusive of initial response actions.

2.1.2 Business Continuity

Business continuity efforts are not covered in this OSRP.

2.1.3 Consequence Management / Disaster Recovery

The primary focus of the OSRP is to mitigate consequences, address response and recovery efforts associated with unplanned spillage or release of a product to the environment. Such consequences, include the elimination and maximum collection of spilled products in order to prevent its approach to the coast and subsequent stranding on the shoreline.

2.2 Geographic Response Area

A geographic response survey captures coastal and shoreline waterways, and highlights sensitive natural, cultural and economic resources. Identifying these geographic response areas allows EMGL to tailor a spill response and protect a specific sensitive area from potential impacts following an unplanned release or discharge.

Oil spill modelling, based on various spill scenarios, has determined potential natural geographic areas that could be impacted by an unplanned spillage. Based on this modelling, the geographic response area generally covers Guyana's territorial waters North/Northwest of Georgetown. Although it is unlikely a fully mitigated oil spill would reach outer Guyana territorial waters, EMGL's geographic response areas do extend into other regional territories including those of Venezuela, Trinidad and Tobago, and the Lesser Antilles. EMGL maintains the capability to broaden its geographic response area as needed.

EMGL will manage and coordinate the response efforts primarily from Georgetown, Guyana. As appropriate, EMGL has the capability to setup support operations from other countries, where it is safe to operate, and where the authorities allow such support within their jurisdictions.

2.3 Tiered Response Overview

ExxonMobil has a tiered response approach to oil spill planning globally. Table 2-1 summarizes the tiered response approach and chain of command for operational coordination of an incident adopted by EMGL which is in agreement with the Guyana National Oil Spill Contingency Plan.

Table 2-1: Tiered Oil Spill Response Approach

Tier	Description	Operational Coordination of Incident
I	Incident is small or incipient stage, under control, and may involve a local company-managed resource response. (Local Response)	On-scene Emergency Response Team (EMGL or designated contractor) is responsible for managing the incident.
II	Incident is larger, partial controlled or spill source not immediately under control, and involves mutual aid cooperative response. (Regional Response)	EMGL onshore IMT will typically manage the incident, supported by the on-scene ERT and regional/international Oil Spill Response Organizations (OSROs).
III	Incident is large, uncontrolled, requires prolonged response and specialized resources. (International Response)	EMGL onshore IMT, complemented by RRT, will manage the incident, supported by the on-scene ERT and regional/international OSROs.

The on-site ERT will manage Tier I incidents in accordance with the site-specific ERP covering its field operations and rely on resources locally available to the asset (e.g., FPSO).

Figure -1 depicts the emergency response escalation model, which further defines the operational coordination responsibilities in Table 2-1. EMGL will proactively obtain additional support and resources to reduce the impact of a spill in the unlikely event it has the potential to exceed Tier I capabilities.

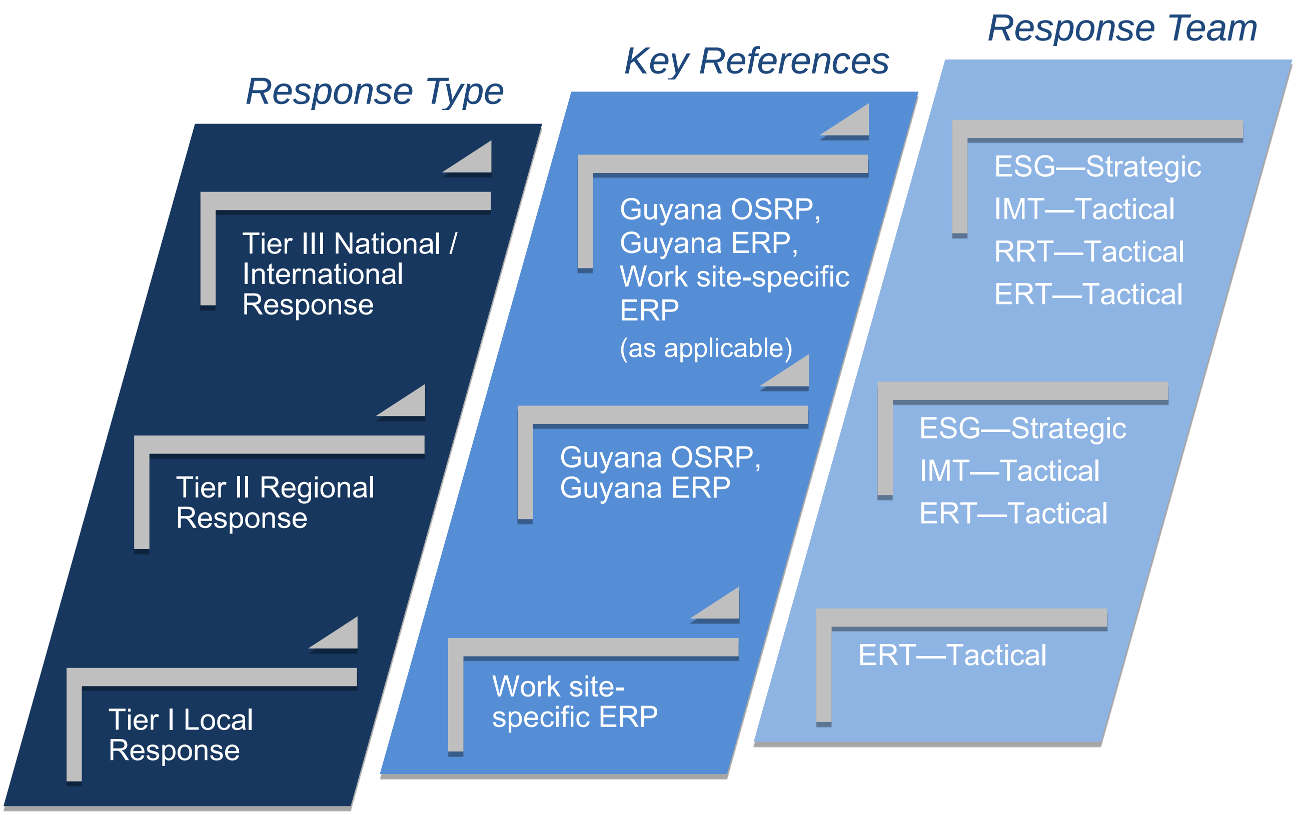

Figure 2-1: Emergency Response Escalation Model

Depending on the severity of the event, different staffing strategies will be executed to meet the needs for personnel within and outside of Guyana. For smaller Tier 1 responses, EMGL resources will be utilised and supplemented by subject matter experts from outside Guyana, if needed. For larger events that exceed the staffing of contractors in Guyana, EMGL will call on contracts with multiple oil spill response organizations to assist in the response. In addition, for larger events, it is anticipated that local resources will be used to support the response in several ways. These include lodging, food, transportation, waste management, and various capacities in the field.

Consistent with international response protocols, EMGL's spill management team will maintain contact with the appropriate authorities in Guyana and any other affected countries, which will include rapid development of a plan to identify and engage potentially affected stakeholders and communities. EMGL continues to work cooperatively with Guyanese regulators, agencies, and interested stakeholders.

To supplement in-country response resources, EMGL is collaborating and pursuing other cooperatives with regional OSRO(s) to support Tier II+ spill response efforts, should additional OSROs with appropriate capabilities be identified, and should there be interest among other regional organizations in industry to participate. Whether using a direct agreement or a cooperative, Tier II+ oil spill response readiness in-country is critical, as such spills could potentially have transboundary impacts to neighboring countries.

3. PLANNING AND SCENARIO DEVELOPMENT

The best scenario is to never have an oil spill, and EMGL's workforce takes significant precautions by reinforcing preventative safeguards to prevent spills from occurring. Although the goal is to prevent spills, planning for emergencies also serves to protect health and safety of the community, local businesses, regional industries and sensitive ecosystems. Thus, preparing for a potential oil spill response is essential. Should an unlikely event occur, well-defined strategies and access to selective response capable tools and resources will enable a successful outcome.

3.1 Spill Properties and Behaviours

The physical and chemical changes oil undergoes in an aquatic environment is collectively known as weathering. Understanding the release behaviour is vital to implementing an optimal spill response strategy. Important factors that influence the behaviour and fate of spilled oil include:

- Physical and chemical characteristics, such as viscosity, specific gravity, volatility, and maximum water content;
- The quantity of oil spilled;
- The prevailing weather and sea state conditions.

Figure -1 below depicts these processes, which are further described in the Oil Spill Response Field Manual published by ExxonMobil.

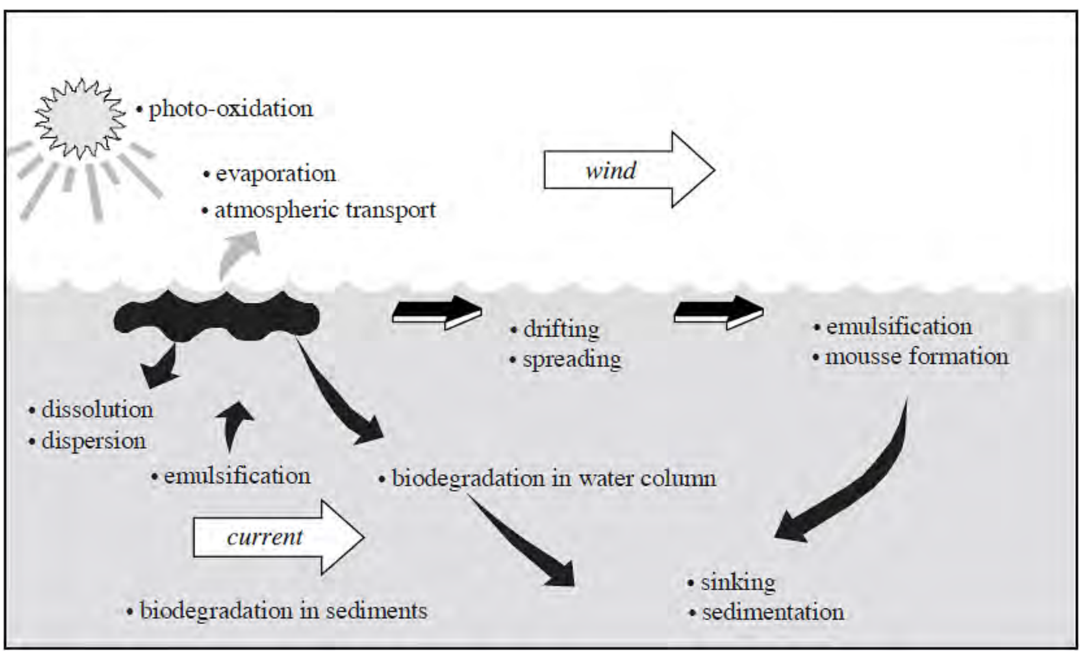

Figure 3-1: Processes Acting on Spilled Oil

Today, oil modelling programs account for the region's weathering effects and oil behaviour characteristics to accurately predict physical movement, evaporation and dispersion transfer amongst other weathering results.

3.2 Unplanned Hydrocarbon Release Sources

A small degree of unplanned risks is associated with the development of Guyana's natural resources despite the engineering design and selection, mitigative and preventive measures incorporated, and continuous hazard awareness focus of facility personnel. The majority of these unplanned events or accidents are attributed to minor occurrences (i.e., dropped objects, slipping or tripping incidents, minor fluid spillage within containment, etc.) and a few could result in a worker injury, generally they would not impact the environment or the receptors noted within the EIAs for the respective projects.

For a selected group of unlikely but possible events, various hydrocarbon release scenarios in terms of location, hydrocarbon type, volume, and potential environmental impacts were studied. Table 3-1 summarizes the possible hydrocarbon release scenarios and classifies the potential consequence in terms of the Plan's tiered response approach. These scenarios are generally representative of the range of risks associated with the EMGL Development Projects, Exploration Drilling, and Production Operations, with the exception of the Worst-Case Discharge (WCD) scenarios.

Ultimately, the key is to prevent oil spills rather than respond to them. Today, EMGL and other industry organizations continue to advance spill control technology to reduce, control, and eliminate accidental releases. These pioneering efforts will further reduce the frequency, release volume, and/or duration of accidental releases going forward.

The following are examples of potential locations where a hydrocarbon release during EMGL operations in Guyana could occur:

- Guyana fuel terminal;
- Guyana shorebase(s);
- Drill ship(s);
- FPSO(s);
- Tanker(s) (during offloading from FPSO);
- Installation vessel(s);
- Marine support vessel(s); and
- Survey vessel(s).

3.3 Potential Release Scenarios

Hydrocarbons potentially released include crude oil, marine diesel, fuel oil, aviation fuel, lubricating oil, and non-aqueous drilling fluid. Summarized with the scenarios and potential impacts outlined in Table 3-1, are the most appropriate response strategies for a given incident based on the given hydrocarbon properties. For example, heavy oils tend to persist in the environment longer than lighter hydrocarbons. Diesel and aviation fuels are non-persistent materials; a significant fraction of any spilled diesel fuel may be expected to evaporate and naturally disperse more readily.

Table 3-1: Possible Hydrocarbon Release Scenarios by Tier

#	Tier	Location	Possible Scenario	Potential Impact [a]	Potential Response Strategies
1	I	Shorebase	Onshore spill of less than 10 bbl of fuel (e.g., partial loss of diesel storage tank contents)	Contained onshore; no shoreline impact likely	Onshore/Nearshore Response Waste Management Decontamination Demobilization
2	I	Shorebase	On-water spill of less than 100 bbl of fuel (e.g., shore to vessel bunkering spill)	Diesel enters water; possible minor shoreline impact	Onshore/Nearshore Response Surveillance and Monitoring Assisted Natural Dispersion Waste Management Decontamination Demobilization
3	I	Supply vessel at shorebase	On-water release of less than 500 bbl of fuel (e.g., shore to vessel bunkering)	Diesel enters water; shoreline impact likely	Onshore/Nearshore Response Surveillance and Monitoring Assisted Natural Dispersion Waste Management Decontamination Demobilization
4	I	Supply vessel at shorebase or nearshore	On-water spill of less than 100 bbl of fuel (e.g., resulting from grounding or collision with a non-Project vessel or structure)	Diesel enters water; possible minor shoreline impact	Onshore/Nearshore Response Surveillance and Monitoring Assisted Natural Dispersion Waste Management Decontamination Demobilization
5	I	Supply vessel or remotely operated vehicle/Subsea Hydraulic Power Unit offshore	Offshore spill of less than 50 bbl of fuel or hydraulic oil	Hydrocarbons enter water, creating sheen on the water surface; no shoreline impact likely	Onshore/Nearshore Response Surveillance and Monitoring Assisted Natural Dispersion Waste Management Decontamination Demobilization
6	I	Drill ship or FPSO offshore	Offshore spill of less than 50 bbl of fuel (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely	Surveillance and Monitoring Assisted Natural Dispersion Offshore Containment and Recovery Wildlife Response Waste Management Decontamination Demobilization

#	Tier	Location	Possible Scenario	Potential Impact [a]	Potential Response Strategies
7	II	Drill ship or FPSO offshore	Offshore spill of less than 250 bbl of fuel (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely	Surveillance and Monitoring Assisted Natural Dispersion Offshore Containment and Recovery Wildlife Response Waste Management Decontamination Demobilization
8	I	Helicopter offshore	Offshore spill of less than 50 bbl of fuel resulting from helicopter ditching and resultant release of fuel tank contents	Enters offshore Atlantic Ocean; no shoreline impact likely	Surveillance and Monitoring Assisted Natural Dispersion
9	I	FPSO offshore	Offshore spill of less than 50 bbl of fuel resulting from discharge of hydrocarbons along with washover of firewater	Contained on deck of vessel or enters offshore Atlantic Ocean; no shoreline impact likely	Surveillance and Monitoring Assisted Natural Dispersion Offshore Containment and Recovery Wildlife Response Waste Management Decontamination Demobilization
10	I	FPSO offshore	Offshore spill of less than 50 bbl of crude oil from FPSO topsides (e.g., leak or release due to human error or failure of equipment)	Contained on deck of vessel or enters offshore Atlantic Ocean; low probability of shoreline impact	Surveillance and Monitoring Assisted Natural Dispersion Offshore Containment and Recovery Wildlife Response Waste Management Decontamination Demobilization
11	II	Drill ship/well offshore	Loss of well control release of less than 250 bbl of crude oil (e.g., well becomes unbalanced during the drilling process and begins flowing prior to containment)	Hydrocarbons enter Atlantic Ocean; low probability of shoreline impact	Surveillance and Monitoring Assisted Natural Dispersion Dispersant Application Offshore Containment and Recovery Wildlife Response Waste Management Decontamination Demobilization

#	Tier	Location	Possible Scenario	Potential Impact [a]	Potential Response Strategies
12	II	FPSO, offloading tanker offshore	Offshore release of 2,500 bbl of crude oil (e.g., failure of offloading hose during offloading from FPSO to tanker)	Oil enters Atlantic Ocean; possible shoreline impact	Surveillance and Monitoring Assisted Natural Dispersion Dispersant Application Offshore Containment and Recovery Wildlife Response Waste Management Decontamination Demobilization
13	III	Drill ship /well offshore	Offshore release of crude oil from loss of well control event – Most Credible Worst Case Discharge (MCWCD)	Oil enters Atlantic Ocean; likely shoreline impact	Surveillance and Monitoring Assisted Natural Dispersion Onshore/Nearshore Response Dispersant Application Offshore Containment and Recovery Wildlife Response In-situ Burning Waste Management Decontamination Demobilization
14	III	Drill ship /well offshore	Offshore release of crude oil from loss of well control event – Worst Case Discharge (WCD)	Oil enters Atlantic Ocean; likely shoreline impact	Surveillance and Monitoring Assisted Natural Dispersion Onshore/Nearshore Response Dispersant Application Offshore Containment and Recovery Wildlife Response In-situ Burning Waste Management Decontamination Demobilization
15	II	Drill ship / well offshore	Offshore release of approximately 2,200 bbl of NADF due to loss of riser contents after emergency disconnect due to dynamic positioning station keeping failure	NADF enters water near the seafloor; no shoreline impact likely	Surveillance and Monitoring Assisted Natural Dispersion

bbl = barrel(s); NADF = non-aqueous drilling fluid; WCD = worst-case discharge
[a] Potential impact is based on modelling of a mitigated spill scenario.

The hydrocarbon crude properties and these modelling results were used to complete the predicted impacts of each spill scenario.

Table 3-2: Modelled Scenarios by Offshore Assets

	Scenario	Liza I	Liza II	Payara	Yellowtail	Uaru	Whiptail
Marine Diesel	50 bbl Surface	X	X	X			
	250 bbl Surface	X	X	X			
Crude Oil	50 bbl Surface	X	X	X			
	250 bbl Surface	X	X	X			
	2500 bbl Surface	X	X	X			
Wellbore Fluids/Crude Oil	5K bbl Well Head		X				
	20K bpd Well Head	X	X				
	Most Credible WCD			X	X	X	X
	WCD Well Head	X	X	X	X	X	X

3.4 Summary of Predicted Hydrocarbon Impacts

Hydrocarbon releases of less than 100 barrels (bbl) (e.g., Scenarios 1, 2, 4, 5, 6, 8, 9, and 10) are expected to be quickly brought under control and would be managed with local countermeasures and spill control equipment. Scenarios 9 and 10 assumed the product was contained to the vessel with no or minimal product expected to enter the ocean environment, thus these scenarios did not model potential shoreline impact. For the potential discharge of diesel fuel into the Demerara River, these non-persistent fuel material releases are known to be transient with a short duration in the environment and have been modelled. This information provides guidance on response strategies including the use of diversion booming.

The focus of Scenario 8 is the safety, rescue, and recovery of the helicopter personnel. The aviation fuel volume is relatively small and is not a hydrocarbon that is persistent in the environment. Considering the known transient nature of this fuel in the environment, no modelling was performed and no spill response is anticipated. A temporary, visible sheen on the water surface may occur, water quality would be temporarily impaired in a localized area, and sensitive receptors (e.g., plankton and possibly some seabirds or shorebirds) may be locally affected.

A hydrocarbon release under Scenario 15 involves a spill of approximately 2,200 bbl of non-aqueous drilling fluid (NADF). Under this scenario, the spill is limited to the volume capacity of the drilling riser. The potential release impact would primarily occur at or near the seabed and may include localized smothering and toxicity to benthic species. Other than a localized area where the material has deposited, any water quality or other effects would be short-term, as the product would disperse within the water column and be carried away by currents.

A hydrocarbon release under Scenario 3 involves a spill of approximately 500 bbl of diesel into an adjacent river or body of water near a shorebase. The natural dispersion and rapid evaporation of diesel, combined with dilution by water movement and tidal exchange, would be limited in duration and distance from spill site.

Hydrocarbon releases under Scenarios 11 (minor well control release during drilling), 12 (release during offloading from FPSO to tanker), and 13 -14 (larger well control incidents) would involve a spill response requiring local and regional mitigation and recovery resources as well as the use of other OSROs' technical teams and equipment.

3.5 Net Environmental Benefit Analysis (NEBA)/Spill Impact Mitigation Assessment (SIMA)

For spills larger in nature, the use of all available response resources, including mechanical recovery, burning product on water and the application of dispersants, is anticipated. Leveraging results of the Net Environmental Benefit Analysis (NEBA) or Spill Impact Mitigation Assessment (SIMA) for selection of response technologies is vital to the response decision making process. As identified in the Guidelines on implementing spill impact mitigation assessment (IPIECA-API-IOGP, 2017), "This SIMA methodology is not a process that quantifies the potential impacts of an oil spill. Rather, it assesses the relative impact mitigation potential of candidate response options, to choose those that will most effectively minimise the overall consequences of a spill."

Replacing the NEBA that was developed for the Payara Development Project and submitted as part of OSRP Revisions 8 and 9, EMGL hired a third-party consultant to conduct a Spill Impact Mitigation Assessment (SIMA) for the Yellowtail Development Project. In accordance with international petroleum industry standards, and to meet a condition 10.19 of the Uaru Project Environmental Permit (20220323-EEPGL), a new Assessment was completed (Appendix H). The SIMA was prepared to inform the most effective response strategies including the provisioning of suitable response equipment and supporting logistics. For use in response to an incident, the scenarios included in the SIMA (Appendix H) should be validated or adjust the assumptions and considerations to account for actual incident conditions. However, the SIMA included would be applicable in the early stages of offshore responses beyond the scenario of a loss of well control which was the spill scenario modeled to inform the SIMA process.

4. INITIAL RESPONSE ACTIONS

4.1 On-Scene Initial Response Actions

Figure -1 describes the immediate actions of an on-scene Emergency Response Team (ERT) upon discovery of an unplanned loss of containment incident (e.g., spill), including the initial situation analysis and identification of actual or potential health and safety hazards. More detailed site-specific procedures are found in each asset's Emergency Response Plan (ERP).

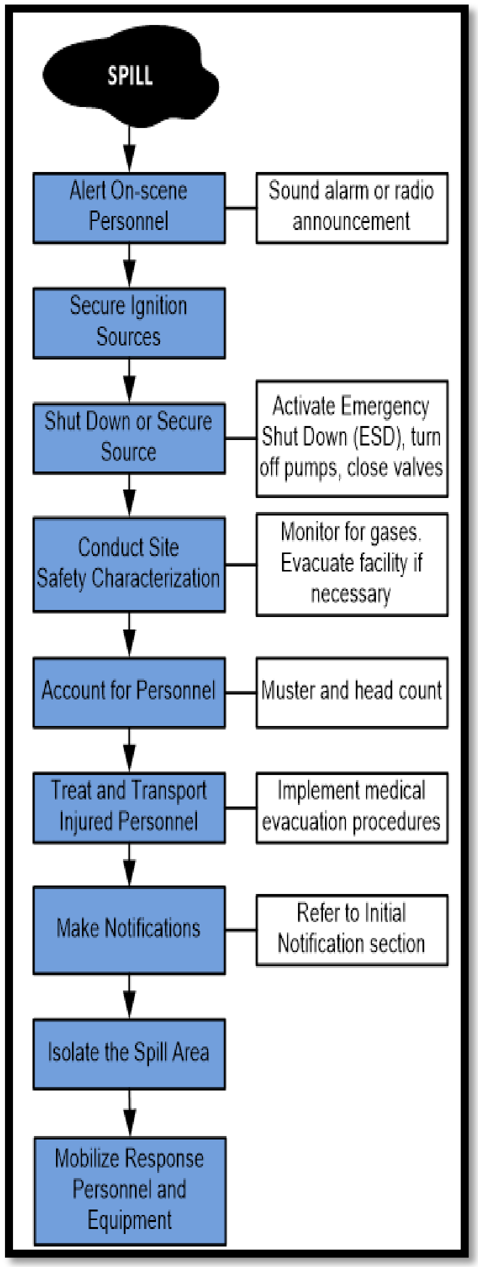

Figure 4-1: On-Scene Response Actions

4.2 On-Scene Incident Commander Initial Actions

The On-Scene Incident Commander is responsible for implementing the appropriate initial oil spill response actions as described in the site-specific ERP including, but not limited to, those in Table 4-1.

Table 4-1: Incident Commander Initial Checklist

✓	Action
	Notify EMGL Duty Manager immediately
	Request resources, if required, to carry out spill response activities.
	Activate personnel and equipment maintained by EMGL.
	Activate, if required, external oil spill response organizations.
	Act as liaison with the lead government organization.
	Authorise notification of applicable external organizations (Table 4-2).

For site-specific actions, refer to the appropriate ERPs and the ExxonMobil Oil Spill Response Field Manual.

The first few hours after an incident occurs are critical to a successful incident response. The attending On-Scene Incident Commander must implement the ERP while concurrently assessing the potential for the incident to escalate. Should there be potential for escalation to a Tier II or III event, the On-Scene Incident Commander will activate the EMGL Incident Management Team (IMT). This onshore emergency organization will assume overall command and control of the incident and resource allocations while the On-Scene Incident Commander and site resources solely focus on the operational tactics at the site.

4.3 Initial Notifications

The notifications matrix, Table 4-2, highlights external organizations to notify when a reporting threshold is potentially exceeded. Table 4-3 provides contact details for the entities listed in the notifications matrix. Contact information for named individuals is not included in a public document.

The Guyana National Oil Spill Contingency Plan outlines the inter-agency notification responsibilities should other government jurisdictions be impacted from a spill event. EMGL will adhere to good industry practices, such as providing the appropriate situational information for government-to-government notifications to successfully occur.

Table 4-2: Notifications Matrix (Abbreviated)

Regulatory Notification	Reporting Threshold	External Organizations								Timing		
		MNR	GGMC	EPA	CDC (NEMS)	MARAD (NFP – Maritime)	Harbour Master	GEA (NFP – Land)	OSRL Boots & Coots	Immediate Discharge Notification	Initial Notification	Follow-up Notification
Hydrocarbon Liquid (On-Land)	> 5 imperial gallons^ Oil	X	X	X	X			X		Within 24 hours	Within 48 hours	72 hours after initial
Hydrocarbon Liquid (On-Water)	> 5 imperial gallons^ Oil	X		X	X	X	X			Within 24 hours	Within 48 hours	72 hours after initial
	> 50 bbl	X	X	X	X	X	X	X	X	Within 24 hours	Within 48 hours	72 hours after initial
Chemical (general) Spills / Release	> 5 imperial gallons		X	X	X	Release to Water		Release to Land		Within 24 hours	Within 48 hours	72 hours after initial
Vapor Release	Requiring site evacuation		X	X	X	X					Immediate	as soon as practical
Emergency Offshore (Payara/Uaru/GTE Projects)	Discovery of emergency offshore			X						Within 12 hours	Within 48 hours	72 hours after initial
Emergency Onshore (GTE project)	Discovery of emergency onshore			X						Within 3 hours	Within 48 hours	72 hours after initial

NOTE: Table summarized from EMGL Internal and External Reporting Matrix

^ Guyana NOSCP, Section 5—Notifications, Alerts and Reporting.

Table 4-3: Regulatory Authorities Contact Details

Organization	Country	Contact Details
Civil Defence Commission (CDC)	Guyana	+592 226 8488 (All Hours) +592 226 1114 / 226 1117 (NEMS)
Environment Protection Agency (EPA)	Guyana	+592 661 6862 / +592 622 6320 (All Hours)
Guyana Energy Authority (GEA)	Guyana	+592 226 0394 (Business Hours) +592 615 3656 (All Hours)
Guyana Geology and Mines Commission (GGMC)	Guyana	+592 225 3047 (Business Hours) +592 225 2865 (ext 247) (All Hours)
Harbour Master Transport and Harbours Department Stabroek Georgetown	Guyana	+592 226 9871 (All Hours)
Maritime Administration Department (MARAD)	Guyana	+592 226 9871 (All Hours)
Ministry of Natural Resources (MNR)	Guyana	+592 620 0559 (All Hours)

4.4 Initial Source Control Actions

Initial source control actions and resources to control the source of operational spills, including the initial actions to a loss-of-well-control incident, are described in site-specific ERPs. Sustained source control response operations will be managed and coordinated by the EMGL IMT, including the Source Control Branch under the Operations Section. See Figure 4-2 for an example IMT with Source Control Branch.

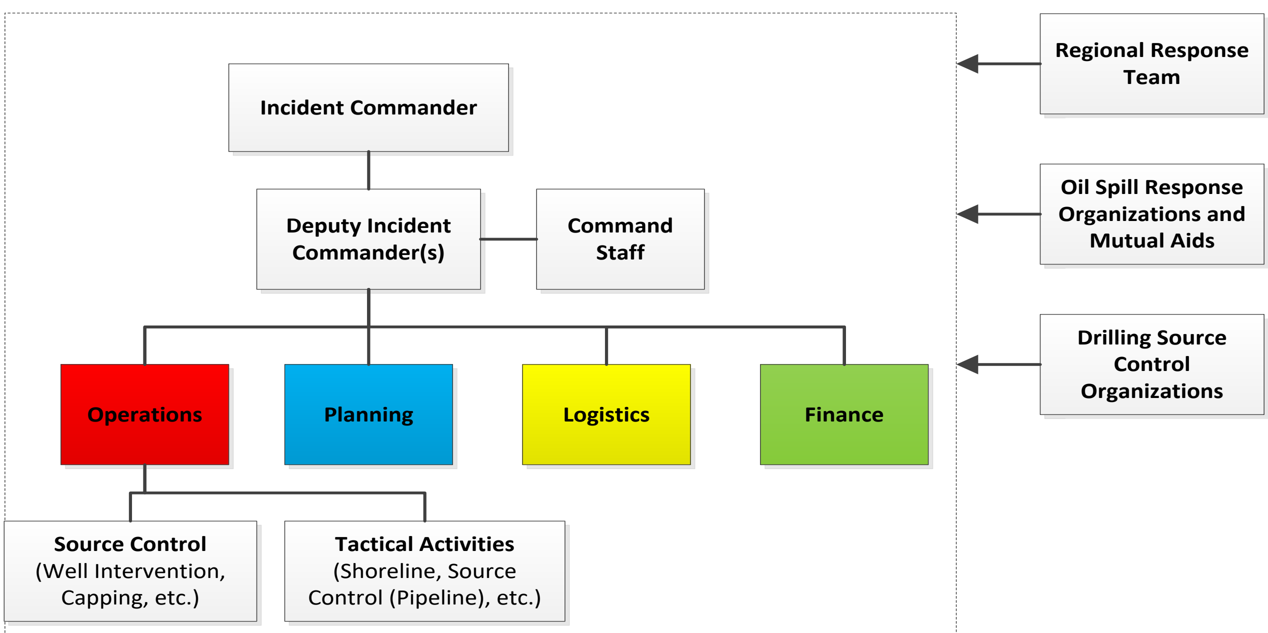

Figure 4-2: Example Incident Management Team with Operations-Led Source Control Branch

4.5 Spill Assessment

An accurate estimation of total spill volume, location, and movement is essential to determine the required response Tier, and to plan for and initiate spill response and clean-up operations. Quick estimation will aid in determining the:

- Equipment and personnel required;
- Potential threat to shorelines and/or sensitive areas, including ecological impact; and
- Waste storage and disposal requirements.

Typical response protocols initiated by EMGL include, but are not limited to:

- A systematic search to locate the spill and determine its coordinates.
- A spill size estimate and movement using coordinates, photographs, drawings, and other information received from vessels, aircraft, and satellite imagery.
- Modelling of the oil released to predict the oil's surface movement or trajectory.
- Conduct spill-specific NEBA/SIMA for response tool selection and agency submission.
- If necessary, the Source Control Branch will estimate the volume and rate of a subsea well release.

5. RESPONSE STRATEGIES AND TACTICS

A Tier II+ spill response typically requires command-generated strategies, key response objectives, defined tactics and executable plans all supported through a systematic organization with resource capabilities. In the course of any response, other constraints or variables must be evaluated for their impacts, such as, physical conditions, health and safety considerations, prevailing weather, sea states are examples of these possible constraints.

The following sections provide an overview and describe the implementation of each response strategy available to EMGL.

5.1 Response Strategy Overview

Any response strategy must start with an understanding of the regulatory framework in which the assets and operating units are located. It is paramount for the oil and gas industry to work with government entities to ensure clear understanding and common interpretation of national requirements. The fostering of these relationships and those of interested or concerned about response preparedness are vital to establishing healthy stakeholder engagements.

To define appropriate response strategies, EMGL leveraged reservoir data, tested fluid properties, gathered physical oceanographic and geological data, evaluated risks and selected oil spill planning scenarios to model for potential unmitigated environmental impacts. These results led to spill impact mitigation assessments, or SIMA, that dictated modelled oil movement and its potential environmental or socioeconomic impacts and the necessary response techniques to eliminate or mitigate possible harm.

EMGLs response strategy is to maintain a level of preparedness and readiness, often stated as Ready-to-Respond, should an unlikely oil spill event occur. While response objectives may vary depending on the specific spill circumstances, certain basic objectives will guide any response:

- Safeguarding the health and safety of people, both of responders and the communities,
- Minimizing environmental and community impacts,
- Securing the source of the spill as soon as possible, and
- Minimizing the risk and impacts of the oil.

5.2 Appropriate Response Strategies and Response Timing

Response to any unplanned or observed release will be expeditious, using all appropriate tools and tactics to minimise harm and shoreline impact. In addition to the safety of responders, response tactics depend upon a variety of environmental conditions. In consultation with the Guyana EPA, EMGL will develop Incident Response Plans that could include the following response strategies for an offshore release:

- Deploy aerially applied dispersants, which can be quickly deployed and treat large surface areas rapidly and efficiently;

- For subsea releases, implement subsea dispersant application as soon as possible, if warranted, to treat most if not all oil spilled at the source before it encounters surface water resources;
- Deploy in-situ burning equipment to burn thick oil near the source;
- Continue to use aerially applied dispersant as a response tool for oil further from the source where mechanical recovery/in-situ burning operations are less effective;
- Utilize aerial dispersant application during calm seas on emulsified oil;
- Outfit vessels with dispersant delivery and mechanical containment and recovery systems to provide a fleet of vessels that can be a line of defense against surface oil approaching shorelines.

Figure 5.1, Response Measures Deployment Timing, provides an overview of the deployment timing of resources that may brought to bear during a response. The below graphic is informational in nature and is not meant to be all-inclusive of the resources that would be made available as dictated by the circumstances of the incident.

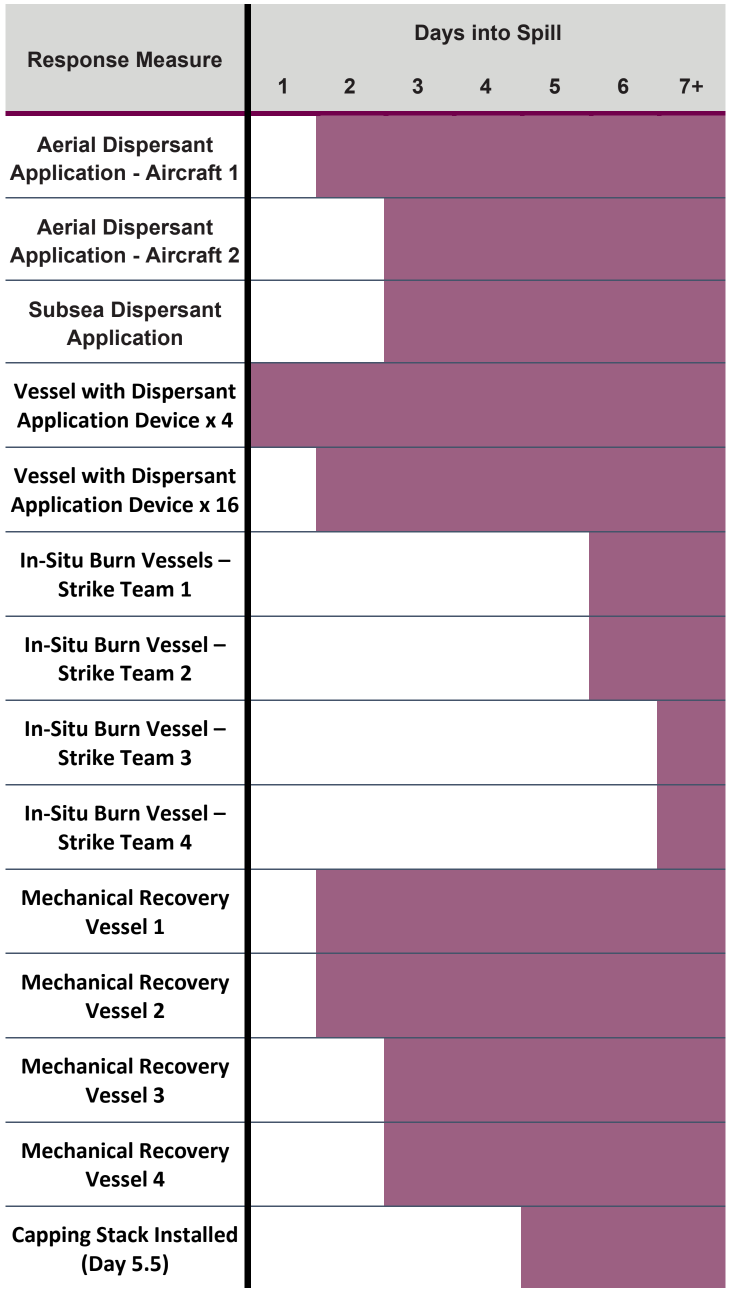

Figure 5-1: Response Measures Deployment Timing

Shoreline protection and/or clean-up may be needed for some scenarios, in which case, sensitive shorelines will receive prioritization for protective booming.

EMGL anticipates the use of all appropriate oil spill response tools with the aim to mitigate the impacts of oil on the environment. Due to the potential challenges of offshore mechanical recovery, the initial, and in certain cases, primary offshore response strategy is dispersant application. Depending on the volume, mechanical recovery at sea may be possible due to the anticipated oil thicknesses but can typically be difficult and unsafe due to the active metocean conditions.

Figure -2 shows the cone of response when responding to a loss-of-well-control event with loss of containment using all the available response strategies at once.

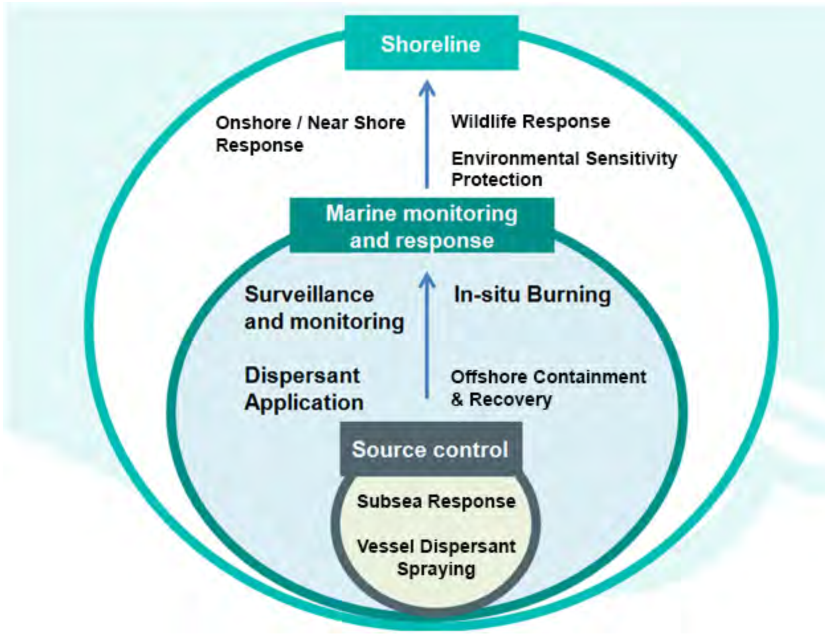

Figure 5-2: Cone of Response Diagram

There is a health and safety hazard posed by high atmospheric concentrations of hydrocarbons. Air quality should be monitored at all times and personnel should be evacuated immediately if an exclusion zone is required. Consideration for air quality monitoring is included in the Site Safety Plan.

5.3 Surveillance and Monitoring

Surveillance and monitoring is a key strategy relevant to all oil spills that enter the marine environment. The implementation of a monitoring and sampling plan (also known as a "Operational & Scientific Monitoring Plan") is an important component of a response to an oil spill. This activity begins immediately, to inform the response activities including the monitoring of the effectiveness of applied response strategies. The resources mobilized to carry out this activity will vary depending on the scale or complexity of the incident. If the scale of the operations expands, then an appropriate Operational & Scientific Monitoring Plan (OSMP) may be developed. A framework that identifies key elements of an OSMP can be found in Appendix K.

Surveillance and monitoring teams can fulfil the following response objectives:

- Verify oil spill scale and location;
- Monitor effectiveness of applied response strategies;
- Visually quantify spill volume (iterative as needed);

- Direct operations – dispersant application, containment and recovery, shoreline assessment, in-situ burning; and
- Monitor wildlife.

The resources mobilized will vary depending on the scale or complexity of the incident. At a minimum, personnel will take visual observations, and vessel owners/operators will implement their ERP/SOPEPs, deploying the Tier I response equipment they have onboard or at location. For Tier II or Tier III incidents, the optimal method of tracking the movement of oil on water is by aerial surveillance which includes helicopters, fixed wing aircraft, and satellite imagery. Apart from aerial surveillance, spill response management will undertake predictive analysis to better understand spill movement and trajectory in order to ensure the critical placement of spill response equipment and to the timing of spill response measures.

Figure -3 illustrates the key steps involved in surveillance and monitoring; refer to the ExxonMobil Oil Spill Response Field Manual and the OSRL Field Guides for further details.

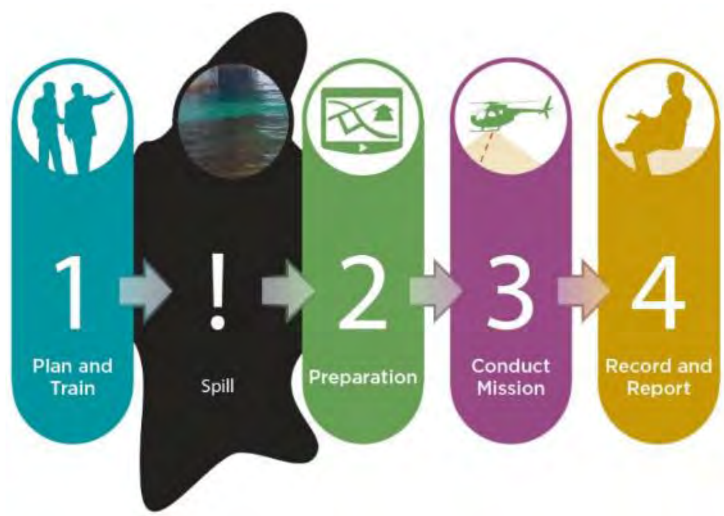

Figure 5-3: Surveillance and Monitoring Key Steps

5.4 Assisted Natural Dispersion

Assisted natural dispersion is the process of speeding up the natural breakdown of hydrocarbons without the use of chemicals. This strategy is suitable for smaller spills or in combination with other strategies for larger spills.

To assist the natural dispersion process, techniques such as prop washing or water hoses can be implemented to introduce energy and agitate the hydrocarbons, thereby assisting with the breakup of a surface slick and promoting biodegradation.

5.5 Operational Spill Clean-up

Operational spills are small in volume and easily contained on land, on deck or in very close proximity to a vessel. These spills can originate from shore facilities, vessels, or the drill ship.

Shorebases in Guyana (and Trinidad) have site-specific ERPs and are equipped with Tier I spill response kits;

- Vessels maintain a SOPEP and associated equipment onboard the vessel.

For further details on operational spill clean-up, refer to the ExxonMobil Oil Spill Response Field Manual, and the OSRL Field Guides.

5.6 Onshore/Nearshore Response

5.6.1 Harbour Containment and Recovery

EMGL will use harbour containment and recovery should a marine support vessel (e.g., PSV or FSV) release hydrocarbons in port. The harbour response team will employ a strategy that considers tides, currents, wind, vessel traffic, and local infrastructure with stakeholder input. EMGL will deploy equipment available on site and in the port (such as or similar to the equipment and trained personnel at the Guyana Fuel Terminals and resources held by NRC for Trinidad) immediately following a release.

Figure -4 illustrates the key steps involved in harbour containment and recovery; refer to the ExxonMobil Oil Spill Response Field Manual, and OSRL Field Guide for detailed information.

Figure 5-4: Harbour Containment and Recovery Key Steps

5.6.2 Shoreline Response

If surveillance or predictive modelling indicate that released hydrocarbons show the potential to affect a shoreline, prioritizing environmentally or socioeconomically sensitive areas is essential. These areas were ranked using an Environmental Sensitivity Index and corresponding resource/receptor ratings to identify those projected areas, special status species, fish, and other marine life on which these local coastal communities depend, as assessed in the EIAs for the FPSO Development Projects.

Shoreline response may consist of using vessel dispersant application on the surface to prevent approaching slick(s) from impacting socio-economically sensitive areas and using shoreline booming techniques to protect sensitive areas and provide collection points for hydrocarbon recovery.

In addition to the pre-identified environmentally and socioeconomically sensitive areas, Coastal Sensitivity Maps were developed which identify sensitive habitats/wildlife areas/features associated with the coastlines in the respective geographic response area. The Coastal Sensitivity Maps are included as an appendix to the initial Development Projects EIAs. Geographical Strategic Response Maps have also been developed to define the equipment needs in specific coastline areas of portions of the geographic response area, considering sensitive areas, access points, and likely response actions. The IMT will use this information for response planning, including development of protection strategies.

Figure -5 illustrates the key steps involved in a shoreline response; refer to the ExxonMobil Oil Spill Response Field Manual, and the OSRL Field Guide for detailed information.

Figure 5-5: Shoreline Response Key Steps

5.6.3 Shoreline Clean-up Strategies

Shoreline clean-up is often thought of as a three-phase process:

- Phase one involving the collection of bulk oil, either floating against the shoreline or stranded on it;
- Phase two involving removal or in-situ treatment of shoreline substrates subject to moderate to heavy contamination such as polluted sand or stone; and
- Phase three involving removal of the remaining residues of oil to complete the clean-up.

The first phase is often thought of as the emergency phase because of the urgency of collecting oil before it has the chance to move elsewhere, whereas phases two and three are often referred to as the project phase.

5.6.3.1 Debris Removal

One of the most effective ways to minimise both the effort required to clean a shoreline and the amount of oily waste for disposal is to remove debris from the shoreline or out of the path of the spill before the oil arrives and so avoid the debris becoming contaminated. This may be general flotsam and jetsam that have accumulated in natural collection points, seaweed thrown up by winter storms, or even tree trunks. However, in some situations, large natural debris can assist in stabilizing the shoreline and its large-scale removal could lead to erosion. Furthermore, stranded seaweed provides a valuable source of nutrients to littoral ecosystems.

To take account of both these concerns, an assessment should be conducted to determine whether, on balance, removal would be the best option. The areas where oil is most likely to strand are usually the same natural collection points where debris accumulates. These should be highlighted as priority areas for pre-stranding debris removal. Aerial observations of the movement of oil and oil spill trajectory modelling also provide warning of where there is an imminent threat of oil stranding. Given enough time, clearing beach debris prior to it becoming oiled may also allow the collected waste to be disposed of at non-hazardous waste processing facilities, depending upon local regulations. The oil spill modelling analyses indicate that sufficient time is available to clear shorelines of beach debris and protect critical habitats prior to the arrival of oil at a shoreline.

5.6.3.2 General Clean-up

Shoreline treatment following an oil spill typically involves manual or mechanical removal, washing, and/or chemical treatment. The differences in oiling conditions and variable shoreline and coastline characteristics of Northeast South America and the Caribbean preclude the use of a common clean-up method in all cases. Key considerations in selecting the clean-up methods for coastlines are minimization of sand and stone removal and therefore waste generation, minimization of restoration time for amenity beaches used for recreation, and maintenance of beach stability against storms. The removal of bulk and mobile oil in intertidal areas that poses a threat to adjacent habitats or resources may be necessary in areas of high environmental significance such as turtle-nesting areas, high-use tourist beaches, waterfront parks, and local residential areas. Amenity beaches that experience recurring oiling from remobilized oil or reworking of the shoreline by wind and wave action are also treated with continued oil removal operations.

5.6.3.3 Manmade Structures

Human-constructed shorelines of sea defences, seawalls, riprap, breakwaters, groins (low walls or timber barriers extending into the sea from a beach to check erosion), and jetties are treated by manual removal of bulk oil, followed by washing using a range of temperatures and pressures appropriate for the level of oiling and substrate. Manual equipment may include long-handle hand-mesh and screens, pitchforks with screens, pool nets for surface residue balls along the water line, and mechanical adaptations such as rotary screens for extended-reach backhoes working with surface residue and patties in water-saturated sand.

5.6.3.4 Sand and Stone Washing

A fixed washing system, constructed with a shaker sieve to remove large surface residue balls and patties along with debris, as well as heated wash units, may be appropriate. Any residual oil remaining in the treated sediments from this procedure is then removed by surf-washing operations. Oil stranded in the supratidal zone during storms requires extensive excavation, especially on amenity beaches. The use of heavy equipment may be limited because of concerns that mechanical methods would result in increased beach erosion, because of access in remote areas, and because of restrictions and prohibitions on the use of mechanical equipment at remote locations. Treatment criteria established in conjunction with regulatory authorities for oil above background on amenity beaches are important to establish early in the clean-up process.

5.6.3.5 Surf Washing

Surf washing, including the enhanced natural dispersion of oil by the formation of oil-mineral aggregates existing in the substrate, may be carried out depending upon the extent of beach contamination, and the sensitivity of the surrounding habitats. Surf washing by relocation of sediment to the lower intertidal zone does not cause significant sediment loss, nor does the technology increase hydrocarbon concentrations in intertidal or subtidal sediments or water.

5.6.3.6 Salt Marshes

Clean-up techniques for salt marshes and mangroves include natural attenuation, low-pressure ambient-temperature flushing (to float the oil), mobile vacuum systems, securely deployed containment sorbents or snares, manual removal (on sand or shell substrates only), and vegetation cutting from boats for limited access marshes. In salt marsh habitats where there is little or no risk of repeated oiling, bulk oil removal should be done once on a limited scale, conducted from floating platforms, skiffs, or shallow-draft barges fitted with flushing and vacuum systems. These floating craft should reach into oiled fringe wetlands to wash and recover mobile oil. When stranded oil is removed, it is primarily carried out by hand with sorbent material and by cutting oiled vegetation. The preferred oil spill response in salt marshes is natural attenuation.

5.6.3.7 Salt Marsh Impacts from Clean-up Operations

Physical destruction of marsh habitat during clean-up operations is the most common concern, but virtually all options will cause some damage to marshes during clean-up. Fertilizer, such as phosphorus, may be utilized to encourage regrowth of oiled marsh plants. In the examinations of previous industry oil spills, it has been determined that marshes will recover by natural attenuation because prior research has demonstrated their intrinsic resilience. Natural attenuation was the preferred option in the case of the *Deepwater Horizon* oil spill.

Aeration from tidal action, along with the addition of nitrogen in the form of ammonia, has been shown to significantly increase oil biodegradation in salt marsh sediments. Anaerobic biodegradation of oil in marsh sediments can be enhanced in the presence of mixed sulphate and nitrate. This enhancement is utilized in salt marsh sediments where anaerobes that degrade petroleum hydrocarbons coexist. The recovery rate will depend on the extent of oiling, depth of oil penetration into the sediments, and types of plant species affected.

5.6.3.8 Natural Attenuation

Natural attenuation is the “reduction in mass or concentration of a contaminant in the environment over time or distance from its source of release due to naturally occurring physical, chemical, and biological processes, such as biodegradation, dispersion, dilution, adsorption, and volatilization”. The natural attenuation of oil can be defined as the biotic and abiotic degradation and dispersion of oil that results in natural recovery of an oil-impacted environment. When oil enters the marine environment, abiotic weathering processes (evaporation to the air, dissolution in water, emulsification with water, dispersion, and photodegradation) alter properties of the oil (density, viscosity, water content, surface and interfacial tensions), which ultimately define its fate.

5.6.3.9 Biodegradation

A large number of microorganisms are capable of biodegrading hydrocarbons, and bacteria are the predominant hydrocarbon degraders in the marine environment. Biodegradation by microbial communities is the major process controlling the eventual removal of oil that enters the marine environment from natural seeps. Although much slower, anaerobic (oxygen absent) biodegradation of oil should not be underestimated as a strategy, because it has been shown to be a major process in anoxic marine sediments. Although normally present in small numbers in pristine environments, oil-degrading microbes multiply rapidly upon the introduction of oil.

5.7 Dispersant Application

The benefits of modern dispersants are widely recognized and have been documented to successfully reduce shoreline and surface impact during many oil spill incidents in industry. Dispersants are among the many tools available to address an oil spill. When used properly, dispersants can rapidly reduce the volume of oil on the sea surface and accelerate the natural biodegradation process. Dispersants can reduce or eliminate the potential for oil to impact shorelines. There are dispersants that have been pre-authorised by the EPA for use in Guyanese waters following their approval for application on a case-by-case basis. The application of dispersants will follow good industry practices such as, if there is a direct advantage to protecting environmental or socioeconomic sensitivities **and** where the EPA concurs with its spill-specific use and will include the findings of a NEBA and/or SIMA.

Vessel-mounted systems will generally be used to apply dispersant on the surface in small-scale incidents, and aircraft will generally apply dispersant on the surface for large oil slicks. A small supply of dispersant will be kept at the shorebase or other easily accessible location where it can be easily loaded on marine support vessels for application in small-scale spills. An OSRO will conduct aerial dispersant application on the surface for larger-scale spills and will likely base the operation out of the Georgetown or other Regional airport. In the unlikely event of a Tier III loss-of-well-control, dispersant will be injected subsea at the wellhead location near the seafloor using specialized equipment and remote operated vehicles (ROVs).

In Guyana, dispersant usage for a specific spill is subject to permission from the EPA and shall not be used unless approved by the EPA prior to application. EMGL and the EPA both recognize that pre-planning and operational readiness is essential for selecting the best strategy and achieving an effective and timely response. In the event of an incident, all relevant agencies will be notified and consulted on a spill-specific basis, as appropriate, prior to dispersant application. The SIMA conducted for the Uaru Development Project (Appendix H) provides valuable information during the initial stages of a spill when time is critical and presents a representative analysis for a Floating Production, Storage, and Offloading (FPSO) Development Project, such that results would be consistent for the Liza Destiny, Liza Unity, Payara and Yellowtail Development Projects, and for exploration activities in Guyana. Following the initial response, it is expected that additional NEBAs/SIMAs should be conducted to confirm the appropriateness of selected response options as the incident develops at a frequency to be determined by the EPA and/or Unified Command.

In Guyanese waters, there is the potential to use four primary dispersants: Corexit® 9500, Corexit® 9527A, Finasol OSR 52, and Dasic Slickgone NS. These dispersants have been found to be of low toxicity, are effective across a broad range of oil types and environmental conditions and are readily available globally. Significant research has been carried out on these beforementioned dispersants to better inform decision-makers. For reference, in a 2010 study conducted by the USEPA, Corexit® 9500A was found to be of lower toxicity during standard aquatic toxicity tests than several other commercially available products, i.e., slightly toxic to practically non-toxic (USEPA 2010). Safety Data Sheets for each of the above-mentioned products have been provided in Appendix D.

Delays in spill-specific acceptance of dispersant use at the time of an incident can delay and/or negatively impact the response and may result in a missed window of opportunity to apply dispersants, potentially increasing environmental damage. EMGL will use the Dispersant Spraying Considerations Flowchart as a guide for whether to use dispersants. Dispersant will be applied according to manufacturers' guidelines and the operating procedures of the spray applicators.

EMGL in partnership with the EPA will develop a dispersant application, monitoring, and evaluation strategy as part of a spill response strategy. Appendix I includes the following dispersant use application forms that would capture all relevant information to assist in this process: Dispersant Use Planning Form – Initial Incident Information; and Dispersant Use Planning Form – Application Tactics illustrates the key steps involved in dispersant operations; refer to the ExxonMobil Oil Spill Response Field Manual, and the OSRL Field Guides for further details. Refer to Section 8 for a list of available resources.

Figure 5-6: Dispersant Application Key Steps

5.7.1 Toxicity

Toxicity is a parameter associated with all materials. Every substance exhibits toxic effects at some concentration, so it is not a binary (i.e., yes or no) parameter. The essential element of toxicology is the magnitude of the effect on an organism caused by a chemical compound is dependent on the exposure of the organism to the chemical compound. Highly toxic materials require exposure to only very small concentrations of the substance, e.g., low part per billion levels, while low toxicity materials require exposure to much higher concentrations, e.g., 100s of parts per million (ppm). Exposure is the concentration of the chemical to which the organism is in contact, the route of that exposure (e.g., gills, lungs, skin, stomach), and the duration of exposure. Sections .2 through .5 discuss the potential toxic effects of dispersants.

5.7.2 Potentially Toxic Chemical Compounds in Oil

Most alkanes and cycloalkanes have a limited potential to cause toxic effects on marine organisms due to their low water solubility. Aromatic hydrocarbons are the components of crude and fuel oils that are generally considered to be toxic to aquatic organisms (Anderson et al. 1974; Di Toro et al. 2007).

5.7.3 Exposure to Oil, Dispersed Oil, and Water-Soluble Compounds from Oil

Once an oil spill has occurred, it is inevitable some marine organisms will be exposed to elevated concentrations of naturally dispersed oil droplets and water-soluble compounds from the oil in the upper water column (González et al. 2006). The one-ring aromatic compounds (or benzene, toluene, ethylbenzene, and xylene) will rapidly evaporate from floating oil into the air. There remains potential for toxic effects to be caused by the remaining oil (Neff et al. 2000).

The main cause of acute (short-term [48-to-96 hour], high concentration exposure) toxic effects in marine organisms is exposure to 2-ring polycyclic aromatic hydrocarbons (PAHs) (substituted naphthalenes) in the water through absorption across the gills and other organs.

The dispersion of oil as small droplets, either naturally or enhanced by dispersants, may increase the exposure of some marine life to these and other partly water-soluble compounds from the oil due to the increased oil/water surface area. However, the dispersion process does not increase the oil's toxicity. Modern dispersants are designed for low toxicity and the combination of these dispersants and dispersed oil are not more toxic than the oil alone.

The uppermost water layer typically contains high densities of planktonic organisms, including the developing spawn (embryos and larvae) of some fish species. These early life stages are known to be sensitive to low concentrations of 2- and 3-ring PAHs in the water (Carls et al. 2008). Plankton drifts with the currents in the water and cannot avoid exposure to the compounds from the oil, but any effects on plankton would be localized, and recovery by recruitment from outside of the affected area is rapid. Most oil spills are of limited area and short duration and the resulting impact, if any, would be limited and localized (Kingston 1999). Furthermore, the recovery of plankton occurs on the order of several weeks.

In water more than 10 metres deep, the concentration of naturally dispersed oil-and water-soluble compounds from the oil will be rapidly diluted to low levels in the underlying water. Adult fish can detect oil compounds in the water and are likely to avoid the contaminated area (Maynard and Weber 1981). There is no recorded case of any massive fish-kill being caused by an oil spill in the sea.

Fish swimming through water containing oil can absorb some of the water-soluble compounds (most usually the 2-ring aromatic compounds) from the oil into their tissues, but these compounds are quickly lost (depurated) by normal metabolic processes when the fish passes into clean water. Fishing bans or restrictions are often put in place as a precautionary measure to prevent fishing boats and their equipment being oiled, and to reassure the public and protect the reputation/viability of the seafood markets. These bans often benefit regional fish populations because greater numbers of the adult fish spawn to reproduce and remain in the population until fishing bans are eliminated.

5.7.4 Effect of Using Dispersants

Dispersants break up the oil slick into tiny droplets that move into the water column that are then diluted to non-toxic concentrations and ultimately biodegraded. However, dispersing more of the oil as small droplets into the water column will temporarily increase the exposure of all marine organisms in the upper water column (Singer et al. 1998). The increase in oil/water surface area will enable more of the partially water-soluble chemical compounds to transfer into the water. They will also be rapidly diluted, as long as sufficient water depth is available (Law and Kelly 1999; Bejarano et al. 2013). The elevated concentrations of these compounds (the 2- and 3-ring aromatic compounds) in the water column have the potential to cause toxic effects, with the magnitude of the effect depending on the duration of exposure (Kelly and Law 1998; Sterling et al. 2003; Bejarano et al. 2014). If dispersants are used on spilled oil over water deeper than 10 or 20 metres the concentrations of dispersed oil droplets and water-soluble chemical compounds from the oil will initially increase, but then rapidly decrease as they are diluted into the surrounding water. Marine organisms will therefore be exposed to a brief "spike" of elevated concentration of these compounds (Singer et al. 1991; Bragin et al. 1994; Clark et al. 2001), typically reaching a concentration around 50 ppm and rarely exceeding 100 to 200 ppm in the top few metres, and falling to about one ppm within a few hours. The overall levels of exposure in the marine environment are much lower than those used in standard laboratory toxicity testing procedures (Pace et al. 1995; Coelho et al. 2013).

5.7.5 Exposure of Marine Organisms by Ingestion of Dispersed Oil Droplets

Marine organisms may also be exposed to the higher molecular weight PAHs through ingestion of food. Filter-feeding organisms that prey on plankton can ingest naturally or chemically dispersed oil droplets when they are of similar size to some plankton. Relatively simple organisms, such as bivalves, cannot biochemically process the higher molecular weight PAHs in the oil, and these PAHs can build up (bioaccumulate) in some organs (Neff and Burns 1996). These compounds will subsequently be lost by depuration into clean water. Predators that consume oil-contaminated bivalves can therefore be exposed to elevated concentrations of the higher molecular PAHs by this ingestion route. Organisms, such as fish, that possess livers can metabolize PAH. Although some of these metabolites are harmful causing lesions and other effects, the magnitude of toxic effects caused by this exposure route in most circumstances are likely to be low and without population-level impacts.

In summary, the assessment of environmental effects from dispersing accidentally spilled oil requires that the effects be compared to that of oil alone. Crude oils are materials that contain constituents considered to be moderately toxic. When they enter a nearshore area or strand on a shoreline, they can potentially produce negative physical (smothering) and chemical environmental effects. The effects have the likelihood of being persistent because bulk oil does not readily degrade. Dispersing these oils into very small droplets will greatly reduce the persistence of the spilled oil and provide the ability of naturally occurring oil-degrading bacterial to remove it from the environment.

In the years since the 2010 Macondo spill in the Gulf of Mexico, numerous publications, e.g., Wise et al. (2014), have studied dispersant hazard on organism tissues among a variety of other test species. Unfortunately, most of these studies do not address risk (e.g., exposure x hazard) from dispersants. Rather, they report only the hazard or the concentration or dosage required to achieve a certain endpoint, whether mortality or some other biological observation.

The US EPA and US Food and Drug Administration (FDA) have determined, through a combination of pre- and post-application assessments and approvals for each of the chemical constituents of the Corexit® dispersants used in the Macondo response, that the effect of Corexit® dispersant products (and dispersants in general) in the environment is not greater than the effect of the oil alone. Table 5-1 lists these constituents and the following discussion explains how that determination was reached.

Table 5-1: Chemical Constituents of Corexit® Dispersants

Chemical Abstracts Service Registry Number [a]	
111-76-2	2-Butoxyethanol (ethylene glycol mono-n-butyl ether)
57-55-6	Propylene glycol
29911-28-2	Dipropylene glycol monobutyl ether
577-11-7	Dioctyl sodium sulfosuccinate
64742-47-8	Petroleum distillates, hydrotreated light fraction
1338-43-8	Sorbitan, mono-(9Z)-9-octadecenoate
9005-65-6	Polyoxy-1,2-ethanediyl derivatives of sorbitan, mono-(9Z)-9-octadecenoate
9005-70-3	Polyoxy-1,2-ethanediyl derivatives of sorbitan, tri-(9Z)-9-octadecenoate

[a] The Chemical Abstracts Service is a division of the American Chemical Society that monitors the scientific and chemical industry literature to identify and catalog recently discovered or synthesized chemical compounds.
Source: Dicky and Dickhoff undated.

5.7.6 Direct Human Exposure and General Environmental Safety of Dispersants

The USEPA collected over 600 samples of water from the Gulf of Mexico during the 2010 Macondo oil spill and analysed them for concentrations of dioctyl sodium sulfosuccinate (DSS). The USEPA's findings were that the vast majority of the samples did not have DSS concentrations above the 20 micrograms per litre (µg/L) limit of detection. The USEPA reported only one sample that exceeded the limit of detection (at 26 µg/L).[3] This is important because it represents the range of likely exposure concentrations for marine organisms. Other common uses of DSS include wetting and flavouring agents in food, industrial, and cosmetic applications, and a medicinal stool softener in over-the-counter use. The FDA has approved this compound as a "Generally Recognized as Safe"[4] ingredient, and as an indirect and direct food additive (Dickey and Dickhoff undated).

5.7.7 Safety of Dispersant Residues in Seafood

Following the Macondo spill, the USEPA developed a program to monitor dispersant residues in Gulf of Mexico seafood. The USEPA selected dioctyl sodium sulfosuccinate (DSS) as the indicator compound for potential Corexit® contamination in seafood due to its inclusion in both Corexit® formulations, extremely low volatility, and potential to persist in the environment (Dickey and Dickhoff undated). Mean DSS concentrations in muscle tissue of laboratory

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[3] Dispersants generally fall into the International Maritime Organization GESAMP (2013) rank of *slightly toxic* (toxicity observed at >10 ppm) or *practically non-toxic* (toxicity observed at 100 to 1,000 ppm). One ppm is equivalent to 1,000 µg/L, meaning that dispersants generally begin to have toxic effects on wildlife at concentrations 2 to 4 orders of magnitude above the detection limit for DSS.

[4] Under United States law, a substance may be designated as Generally Recognized as Safe in two ways: (1) through scientific analysis or (2) for substances used in food before 1958, through experience based on common use in food.

exposed and depurated oysters, fish, and crabs all declined by more than 95 percent within 72 hours of cessation of exposure, indicating that DSS has very little potential for bioconcentration and persistence in the edible tissues of seafood species. In retrospective analyses of 393 samples from seafood species, DSS was detected at or above the Level of Quantitation in less than 3.6 percent (14/393) of the re-opening samples tested and all were below safety thresholds determined for DSS in finfish (100 micrograms per gram [µg/g]), shrimp and crabs (500 µg/g), and oysters (500 µg/g) (Dickey and Dickhoff undated). This is not surprising given the low DSS concentrations in water measured by the USEPA.

5.7.8 Summary

In conclusion, all of the chemical constituents in Corexit® 9500 have either been pre-approved for use in dispersants by the USEPA or as a food additive by the FDA, and most have been approved by both agencies for use as dispersants and food additives respectively. The physical-chemical characteristics and scientific literature of Corexit® dispersants indicate that dispersant constituents are susceptible to chemical and biological degradation, and further indicate that dispersants are unlikely to pose a threat to the safety of seafood during or after their use (Dickey and Dickhoff undated).

5.8 Offshore Containment and Recovery

EMGL is likely to use containment and recovery operations for spills that enter the marine environment. EMGL and its contractors, including OSRL, will provide containment and recovery resources for an offshore response. EMGL will source Vessels of Opportunity (VOOs) to provide platforms for the containment and recovery systems. Barges will store and transport recovered waste in accordance with the Waste Management Plan. Refer to Section for more information.

EMGL anticipates the use of all appropriate oil spill response tools with the aim to mitigate the impacts of oil on the environment. Due to the potential challenges of offshore mechanical recovery, the initial, and in certain cases, primary offshore response strategy is dispersant application. Depending on the volume, mechanical recovery at sea is possible, but can typically be difficult and unsafe due to the active metocean conditions. OSRO/OSRL activation will be carried out to assist in providing the resources required for offshore containment and recovery.

Figure -7 illustrates the key steps involved in containment and recovery operations; refer to the ExxonMobil Oil Spill Response Field Manual, and OSRL Field Guide for detailed information. Refer to Section , for a list of available resources.

Figure 5-7: Containment and Recovery Key Steps

5.9 Wildlife Response

In the event of an oil spill, there is potential for wildlife to either become oiled or require protection from the oil. Both require specialist knowledge and regulatory authorization. A Wildlife Response Plan (WRP) specific to Guyana has been developed and provided to allow for a timely, coordinated, and effective protection, rescue, and rehabilitation of wildlife to minimise any negative impacts of a spill. The WRP outlines the measures to avoid and mitigate impacts to wildlife, as well as rescue and rehabilitation of affected or injured wildlife resulting from a spill from EMGL operations should such measures be required. Wildlife response can be provided in Guyana, in the region, and internationally as needed. Details of the wildlife that could be impacted are provided in initial Development Projects EIAs. Should a wildlife response be required, EMGL will call upon the Sea Alarm Foundation via OSRL, as well as Guyanese/regional organizations, to provide specialist advice and assistance with carrying out a response. Refer to Appendix F for additional details.

5.10 In-Situ Burning

In-situ burning is a technique for burning spilled hydrocarbons on the water's surface. EMGL is only likely to use in-situ burning for large-scale Tier III incidents.

Hydrocarbons must be contained within fire retardant boom with sufficient thickness to achieve a successful burn. Other factors that influence burn success include:

- Weather and sea state;
- Volatility of the hydrocarbons;
- Suitable vessel availability; and
- Regulatory approval.

Figure -8 illustrates the key steps involved in burning operations; refer to the ExxonMobil Oil Spill Response Field Manual, and OSRL Field Guide for detailed information. Refer to Section , for a list of available resources.

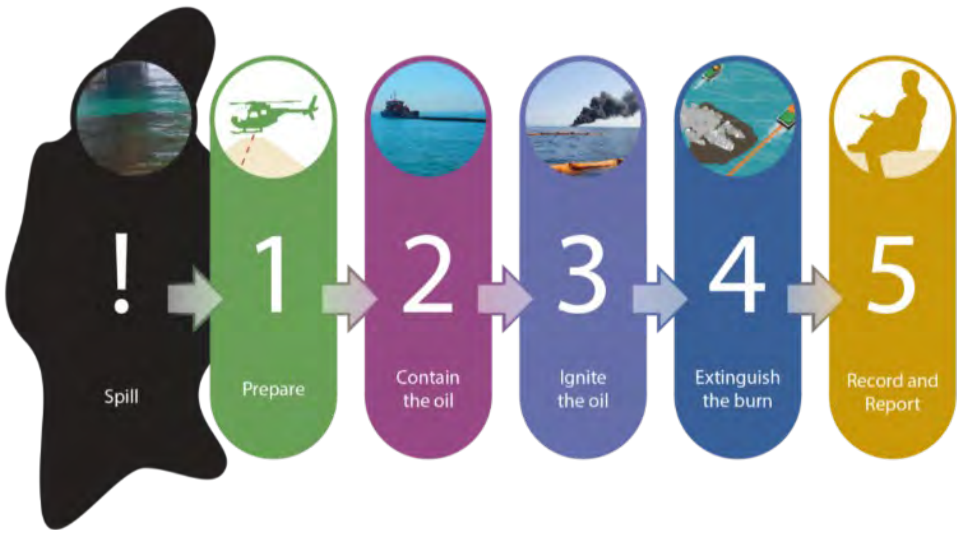


Figure 5-8: In Situ Burning Key Steps

5.11 Waste Management

EMGL will manage hazardous wastes resulting from clean-up activities and ensure appropriate disposal. Large spills can typically result in significant quantities of waste in various forms:

- Recovered oil;
- Oily water mixed with recovered oil;
- Sorbent materials;
- Oiled containment boom;
- Oiled PPE;
- Oiled sediment;
- Oiled vegetation;
- Oiled debris; and
- Deceased wildlife.

Effective waste management will minimise secondary contamination, thereby minimizing waste volume. EMGL maintains a Comprehensive Waste Management Plan (CWMP) which was developed to guide the operational and project phases of Projects. However, the CWMP may be adapted as required if a spill is likely to produce more waste than can be handled by existing waste contractors. Key provisions of the CWMP include the collection, segregation, storage, treatment, transportation, and disposal of both solid municipal and industrial hydrocarbon-contaminated wastes. Wastes collected in countries outside of Guyana will be handled according to the regulations required specific to that location.

EMGL's OSROs have waste management equipment, materials, supplies, and consumables that would be brought as part of the initial response to a Tier III spill. EMGL would also leverage both domestic and international waste management service providers, contractors, and specialists – as needed – to bring additional resources to the locations where such wastes and debris would be generated. Identification of existing local infrastructure is part of the initial planning and execution during a response for not only waste management facilities and services, but also for the necessary food, accommodations, transportation, containers, trucks, supplies, and consumables that would be mobilized to support a spill response.

Figure -9 illustrates the key steps involved in waste management; refer to the ExxonMobil Oil Spill Response Field Manual, and OSRL Field Guide for detailed information.

Refer to Section , for a list of available resources.

Figure 5-9: Waste Management Key Steps

5.12 Subsea Response

The Drilling ERP contains managerial and logistical details on debris clearance, subsea dispersant injection, well capping, and relief well drilling. The FPSO ERP will be implemented on the surface and subsea for a spill either from the FPSO or from SURF (Subsea, Umbilicals, Risers, Flowlines) equipment during production operations. Tankers (owned/operated by others) will have similar ERPs that would be implemented complementary to the FPSO ERP, for spills during offloading.

If a Tier III loss-of-well control incident occurs involving the release of wellbore fluids into the sea, EMGL will be responsible for containing the source. This team is responsible for performing site survey, conducting debris removal operations (as required), evaluating and executing well intervention options, installing subsea dispersant application hardware, and mobilizing and installing a capping device/auxiliary equipment as required. Initially, the team will attempt to operate the existing subsea well control equipment through intervention. If required, the team will mobilize and install a capping device to shut-in the well at the sea floor. Once under control, the forward plan will be designed and executed according to the details of the incident itself. If a relief well is required, it will be drilled to intersect the original well and address specific issues encountered in the original wellbore.

EMGL has access to a dedicated in-country First Response Toolkit (FRT). The FRT consists of a suite of site survey, loss of well control preventer (BOP) intervention, light debris removal, and subsea dispersant injection (SSDI) tooling designed to support the immediate response activities resulting from a subsea source control event. In addition, EMGL has access to the OSRL Subsea Well Intervention Service (SWIS), Oceaneering, Wild Well Control, Trendsetter Engineering, and Boots & Coots equipment. OSRL's SWIS provides EMGL with access to a Subsea Incident Response Toolkit (SIRT), the Global Dispersant Stockpile (GDS), and multiple Capping Stack Systems (CSSs). The CSS and SIRT include equipment that can be mobilized directly to the well site:

- Survey and debris clearance equipment;
- Intervention equipment;
- Dispersant hardware application system;[5] and
- CSSs and auxiliary equipment.

As per Condition 9.13 of the Yellowtail Development Project (20210406-YTPEX), within thirty (30) months of receipt of the Yellowtail Development Project Permit, the Permit Holder shall procure a Capping Stack to be maintained, tested, and stored in Guyana. Once the in-country capping stack is available, response time may be further reduced then what is currently modelled in Appendix B. Additionally, Yellowtail Development Project Permit Condition 9.15 requires within twenty-four (24) months of receipt of the Permit, EMGL, as the Permit Holder, shall supplement its in-country First Response Toolkit (FRT) to include heavy debris removal equipment. An in-country capping stack and the FRT with heavy debris removal equipment will further facilitate the activities required to manage a loss of well control event, potentially decreasing the time to stop the flow of oil from 5.5 days down to 3.5 days.

Figure -10 illustrates the key steps involved with a subsea response.

[5] Dispersant will be mobilized simultaneously through the OSRL GDS service via the EMGL IMT.

Figure 5-10: Subsea Response Key Steps

5.13 Decontamination

In the event of a spill, an incident-specific Decontamination Plan will be developed by EMGL relevant to the nature and extent of the spill to prevent further oiling through secondary contamination. Decontamination is the process of removing or neutralizing contaminants on personnel and any equipment that has come into contact with the oil or oily wastes. To ensure the safety of the responders and the public, and to prevent further potential impact to the environment, a Decontamination Plan and dedicated area with clearly delineated hot (exclusion), warm (contamination reduction), and cold (clean support) zones will be developed and established. Decontamination procedures are supplemental to the Site Safety Plan. The Planning Section of the RRT will support development of the Decontamination Plan with input from Operations and Logistics.

The decontamination procedures will depend on the type and volume of oil that has been spilled, and the type of equipment used during the clean-up operation. Regular decontamination during the response is necessary for the personnel involved with direct clean-up efforts, the vessels involved in the response, and a wide range of spill-related equipment. Any spill response contractor will follow established guidelines for decontamination operations in order to facilitate proper decontamination through the duration of the clean-up effort.

Establishing a field decontamination process is a priority. Regular decontamination will occur in the field, particularly during a large-scale response, so all personnel must be briefed on the decontamination requirements at the beginning of the spill response in order to ensure functioning decontamination operations.

Supervisory personnel are responsible for ensuring that all decontamination activities are occurring according to the guidelines. At the end of the response effort, all the vessels and equipment used at the site(s) will undergo a more thorough cleaning in order to ensure their suitability for future use, including normal operations.

For detailed information on the implementation techniques involved with decontamination, refer to the ExxonMobil Field Manual and OSRL Field Guide.

5.14 Demobilization

Once an incident has stabilized and response operations are being completed, a decision will be made to commence demobilization of resources (personnel and equipment) as appropriate. An incident-specific Demobilization Plan will be developed incorporating guidance from the Resource Unit Lead, Operations, Logistics, and Legal.

The Resource Unit will then coordinate demobilization of resources in accordance with the approved Demobilization Plan.

There are a number of tools available to assist in the determination of clean-up endpoints, including:

- Shoreline Assessment Manual, Third Edition (NOAA 2013);
- Shoreline Assessment Job Aid (NOAA 2007);
- Marine Oil Spill Response Options for Minimizing Environmental Impacts (NOAA 2010); and
- Options for Minimizing Environmental Impacts of Freshwater Spill Response (NOAA and API 1994).

6. RESPONSE RESOURCES

ExxonMobil and its subsidiary companies (including EMGL) are members of OSRL, and Marine Well Containment Company (MWCC); in addition, ExxonMobil and it subsidiary companies (including EMGL) have contracts in place with Marine Spill Response Corporation, Boots & Coots, Wild Well Control, Add Energy, and other OSRO vendors, and, as members/customers, have access to worldwide stocks of equipment. Table 6-1 lists or otherwise describes the international, regional, and local resources available to EMGL for each potential response strategy.

It should also be noted that ExxonMobil, OSRL, and other OSRO vendors regularly exercise spill response for projects around the world. As a result, the availability of aircraft, helicopters, response vessels, and associated equipment from various vendors is well understood and the receiving locations, timing for access, and utilization information are available. Table 6-2 through Table 6-8 provide a further summary of the representative oil spill response equipment in Guyana. Both EMGL and its OSRO contractors have robust inspection and maintenance programs to ensure oil spill response equipment identified in this plan is maintained in a state of operational readiness.

Table 6-1: Oil Spill Response Resources [a]

Response Strategy	Resources Available	Quantity (Based on business needs)	Location
Surveillance and Monitoring	Heliport/Shorebase	2	Guyana Airport/Shorebase (Examples: Correia International Airport/GYSBI Shorebase or similar, Guyana)
	Helicopters (5 Sikorsky S-92; 1 AgustaWestland AW-139)	6	Omni Inc./Infield helicopter provider
	Additional Helicopters	As required	National Helicopter Services Limited or similar, Trinidad
	Tracking Buoy	10	Georgetown Shorebase
	OSRL Trained personnel Fluorometry Satellite Imagery Tracking buoys	Refer: Section .2, OSRL	
Assisted Natural Dispersion	PSVs/FSV marine support vessels (vessels have mounted dispersant application monitors and one 1 m^3 tote of dispersant)	35	Infield
Operational Spill clean-up	SOPEP material Spill Equipment at shoreside facilities	As required	Georgetown Shorebase
Onshore/ nearshore	Onshore/nearshore package including fence boom, skimmersand temporary storage	Variable	Georgetown Shorebase
	OSRL	Refer: Section .2, OSRL	
	1,200-ft 8" x 16" Solid Float Containment Boom (24 ea. 50-ft Sections)	2	Georgetown Shorebase
	1,200 ft 6" x 12" TC Solid Float Containment Boom (12 ea. 100 ft Sections)	2	Georgetown Shorebase

Response Strategy	Resources Available	Quantity (Based on business needs)	Location
	CRUCIAL Drum Skimmer Package (Including Skimmer Head, Diesel Hydraulic Power Pack, PD75 Oil Transfer Pump, Hose Package, and Spares)	2	Georgetown Shorebase
	Weir Skimmer Head	2	Georgetown Shorebase
	Tow Bridles	8	Georgetown Shorebase
	Boom Repair Kit	4	Georgetown Shorebase
	20 lb Anchor	40	Georgetown Shorebase
	40 lb Anchor	8	Georgetown Shorebase
	Buoys	50	Georgetown Shorebase
	Spools of Rope	16	Georgetown Shorebase
	Box of Shackles, Fittings, etc.	2	Georgetown Shorebase
	End Opening Container	4	Georgetown Shorebase
	OSRL Vessel mounted spray equipment Aerial spray platform Trained personnel	Refer: Section .2, OSRL	
	Global Dispersant Stockpile	Refer: Section .6, Global Dispersant Stockpile	
	OSRL Offshore boom Offshore skimmers Temporary storage Trained personnel	Refer: Section .2, OSRL	
	Inflatable Offshore Boom (43in Inflatable Boom, 100-ft Sections)	1,400 ft	Georgetown Shorebase
	Hydraulic Boom Reel	2	Georgetown Shorebase

Response Strategy	Resources Available	Quantity (Based on business needs)	Location
	Tow Bridles with Tow Line	4	Georgetown Shorebase
	Inflation Blower with Hoses	2	Georgetown Shorebase
	Diesel Hydraulic Powerpack	2	Georgetown Shorebase
	Hydraulic Hoses (Pair)	2	Georgetown Shorebase
Offshore containment and recovery	Boom Spares Kit	2	Georgetown Shorebase
	Double door 20 ft Container (Opens both ends)	2	Georgetown Shorebase
	CRUCIAL Model C-Disc 13/24 skimmer	2	Georgetown Shorebase
	Diesel hydraulic power pack (Lamor model LPP-6 with Hatz diesel engine)	2	Georgetown Shorebase
	Spate PD75 oil transfer pump coupled on two wheel cart	2	Georgetown Shorebase
	Hose package	2	Georgetown Shorebase
	Towable bladders (approx. 5-6K gal total combined capacity of both bladders)	4	Georgetown Shorebase
	Spool rope	2	Georgetown Shorebase
	Spares package	2	Georgetown Shorebase
	Hose floats	16	Georgetown Shorebase
	20-ft standard shipping container (with doors on one end)	1	Georgetown Shorebase
Wildlife	OSRL	Wildlife response equipment	OSRL, Various Locations
	Sea Alarm Foundation	Technical expertise	
	ExxonMobil Biomedical Sciences, Inc.	Wildlife expertise	
In-Situ Burning	OSRL Fire resistant boom Ignition equipment Trained personnel	Refer: Section .2, OSRL	

<table>
<tr><th>Response Strategy</th><th colspan="2">Resources Available</th><th>Quantity
(Based on business needs)</th><th>Location</th></tr>
<tr><td rowspan="2">Waste Management</td><td colspan="2">Waste contractor</td><td>NA</td><td>Georgetown, Guyana</td></tr>
<tr><td colspan="2">OSRL</td><td>Refer: Section .2, OSRL</td><td></td></tr>
<tr><td rowspan="8">Subsea Response</td><td colspan="2">OSRL SWIS
15k air-freightable capping stack
15k capping stack
SIRT</td><td>Refer: Section .7, Subsea Well Response</td><td>Norway and Brazil</td></tr>
<tr><td colspan="2">Boots & Coots GRIP
15k capping stack</td><td>Refer: Section .4, Boots & Coots</td><td>Houston, TX, USA</td></tr>
<tr><td colspan="2">ROV contractor
ROVs onboard Technicians (4 person crew per vessel)</td><td>1-2 per Drill ship / MSV</td><td>Houston, TX, USA</td></tr>
<tr><td colspan="2">Trendsetter Engineering Inc.
Engineers/technicians to support capping equipment mobilization and installation</td><td>NA</td><td></td></tr>
<tr><td colspan="2">Additional available equipment:
Wild Well Control Well CONTAINED ™
Loss of Well Control Prevention (BOP) Intervention
Subsea Dispersant application kit
Debris removal kit
CSS</td><td colspan="2">See Well CONTAINED™</td></tr>
<tr><td colspan="2">Relief Well:
Halliburton Boots & Coots active ranging technology</td><td>Various</td><td>Houston, TX, USA</td></tr>
<tr><td>PSVs/FSV</td><td>PSV (Similar in class to Hornbeck Commander, 320 ft class)</td><td>4</td><td>Guyana</td></tr>
<tr><td>Trendsetter Engineering Inc.
Engineers/technicians to support capping equipment mobilization and installation</td><td>FSV (Similar in class to Chouest Fast Hauler)</td><td>1</td><td>Guyana</td></tr>
</table>

Response Strategy	Resources Available		Quantity (Based on business needs)	Location
	Installation Vessels	MPV (Multi-Purpose Support vessel)	1	Guyana
	Tugs	1x 120 MT Azimuth Stern Driven (ASD) Tug 2 x 80 MT ASD Tugs	3	Guyana
	Vessels of Opportunity	Various	Dependent on identified need	Guyana, Regionally
Multi strategy use	Drill ship	Multiple	Dependent on identified need	Guyana

ft = foot/feet
[a] Each oil spill is unique; the specific vessels and equipment required for one spill may not be appropriate for another spill. Many vessels change theatre of operations periodically and may not be in service at the time, which may require need for alternate vessels. Final configuration of the oil spill vessels and equipment will be performed by ExxonMobil, who has a division responsible for obtaining equipment and materials for its global operations through worldwide contracts with providers, including vessels and oil spill response equipment.

Table 6-2: Oil Spill Response Equipment Supplied – Oil Containment Boom (Vikoma)

GENERAL	QUANTITY	2
	DESCRIPTION	10-foot Containerized System with 300m Hi-Sprint Boom
	TYPE	Boom reel with integral power pack and air pack
	MANUFACTURER	Vikoma (or equivalent)
	MODEL	400 P (or equivalent)
	WEIGHT	5,140 kg

CONTAINER	TYPE	Stackable 10 foot ISO certified container with doors on both sides
	PAINT	Orange RAL 2008 two pack PU paint system
	VENT/EXHAUST	Louvre vents both sides, and exhaust outlet for the power pack
	FLOORING	Non-slip internal flooring coated with black Epidek non-slip paint
	DOORS	Doors with weather seals and lockable door latches with galvanized bolts
	ISO BLOCKS	ISO blocks in all four corners
REEL	TYPE	Boom reel with integral diesel/hydraulic power pack
	ENGINE	Single cylinder diesel, air cooled with electric start
		Safety Devices: Over-speed shut-down valve and spark arrestor
		Power: 7.4 kW @ 3,600 rpm
		Electrics: 12 volt – alternator charging
		Fuel Tank: 5.5 litres
		Hydraulic oil: 40 litres
	REEL DRIVE AND CONTROL (HYDRAULICS)	Double stage planetary gearbox driven by hydraulic motor
		Forward and reverse
		Dead-man's stop
		Low/high torque selection
		0-12 rpm
	CONSTRUCTION	Steel-tube and box section
	PAINT	Epoxy primer with two part sprayed polyurethane topcoat
AIR PACK	ENGINE	Single cylinder diesel, air cooled with electric start
		Safety Devices: Over-speed shut-down valve and spark arrestor
		Power: 4.1 kW @ 3,300 rpm
		Fuel Tank: 3.5 litres
	AIR FAN	Centrifugal, high volume, low pressure
		Control: Via engine speed
		Construction: Marine grade aluminum alloy

BOOM	TYPE	Hi-Sprint 1500
	LENGTH	300 m (in 50 m sections)
	MATERIAL	Reinforced double faced Neoprene
	MINIMUM HEIGHT	1500 mm (inflated)
	FREEBOARD	600 mm
	DRAFT	900 mm
	BOOM AIR PRESSURE	0.3 psig
	BUOYANCY / WEIGHT RATIO	31.5:1
	ACCESSORIES	Towing Bridles
		Tow bar: Marine grade aluminum, self-buoyant
		Strops: High integrity webbing (no metal)
		Rope: Polypropylene, self-buoyant
CERTIFIC-ATION	BOOM	ASTM F1523 – 94(2007)
		ASTM F1093 – 99(2012)
		ASTM F2438 – 04(2010)
		ASTM F962 – 04(2010)
	CONTAINER	ISO/ABS (IACS)

Table 6-3: Oil Spill Response Equipment Supplied – Skimmer System (Vikoma)

GENERAL	QUANTITY	2
	DESCRIPTION	Skimmer system with power pack and hose kit
	TYPE	Disc skimmer for recovery of oil with viscosity range per section 3.3
	MANUFACTURER	Vikoma
	MODEL	Komara 50 Skimmer System (or equivalent)
	WEIGHT	Skimmer/hoses – 618 kg; Power-pack – 690 kg
SKIMMER	TYPE	High capacity disc skimmer
	RECOVERY RATE	52 m^3/hr (maximum)
	EFFICIENCY	98 percent (oil-to-free water)
	UPPER STRUCTURE	Stainless steel (316) and F.R.P.
	FITTINGS	Stainless steel (316) and marine grade aluminum
	BUOYANCY	MDPE floats
	SCRAPERS	Flexible polymer
	DISCS	Oleophilic plastic
	HYDRAULICS	Operating pressure 150 bar max.
		Flow discs: max. 10 l/min @ 100 rpm (controller on power pack)
		Flow pump: max. 50 l/min (automatic control)
	OPERATING DRAFT	44 cm
	LIFTING	Single point
	ANCILLIARY EQUIPMENT	Lifting sling
		Operating and maintenance manual
POWER PACK	TYPE	Diesel hydraulic
	MODEL	GP35 (or equivalent)
	RATED OUTPUT	26.8kW at 3,000 rpm
	HYDRAULIC OUTPUT	65 l/min @ 160 bar (maximum)
	FRAME	Mild steel
	HYDRAULIC OIL TANK	Mild steel 60L working capacity

	DIESEL FUEL TANK	Aluminium alloy 29 l capacity
	PAINT FINISH	Two coats polyurethane primer and polyurethane top coat – Orange RAL 2008
	SAFETY DEVICES	Low oil pressure shut-down
		High coolant temperature shut-down
		Low hydraulic oil level shut-down
		Engine over-speed shut-down
		Exhaust spark arrestor
	LIFTING	Central single lift and fork pockets
	ANCILLIARY EQUIPMENT	Lifting sling and shackle
		Operating and maintenance manual
TRANS-FER PUMP	TYPE	Rotary lobe
	DRIVE	Hydraulic motor
	DISCHARGE	4.5 bar maximum
	SOLIDS HANDLING	20 mm maximum
HOSE KIT	HYDRAULIC	1 x 3/8" NB x 15 m long with quick release couplings on both ends
		1 x 3/4" NB x 15 m long with quick release couplings on both ends
		1 x 1" NB x 15 m long with quick release couplings ton both ends
	DISCHARGE	30 m length of 4" NB with quick release coupling from the skimmer pump
		2 x inflatable hose floats (foot pump included)
CERTIFIC-ATION	SKIMMER	ASTM F1778 – 97(2008)

Table 6-4: Oil Spill Response Equipment Supplied – Floating Storage (Vikoma)

GENERAL	QUANTITY	4
	CAPACITY	50 m^3
	TYPE	Floating Recovered Oil Storage Tank (F.R.O.S.T.)
	MANUFACTURER	Vikoma (or equivalent)
	MODEL	6050PL (or equivalent)
	WEIGHT	410 kg
FLOATING RECOVERED OIL STORAGE TANK F.R.O.S.T	APPLICATION	APPLICATION The floating recovered oil storage tank is a towable floating oil / water storage tank with hull shaped storage pocket. It can be used for recovered oil as collected from a skimmer, or may be used for transportation of all kinds of low-density products.
	MATERIAL	Neoprene.
	CONSTRUCTION	Superstructure composed of compartments with internal airtight conical bulkheads for increased integrity
	HANDLING	Eight lifting points with two four-legged slings for deployment (note: tank cannot be lifted when full)
		Tow point aft for connecting to another tank
	LENGTH	1100 cm
	WIDTH	460 cm
	DRAUGHT FULL	225 cm
	HORSE SHOE SHAPED HULL DIAMETER	90 cm
	AIR CHAMBER COMPARTMENTS	9
	INFLATABLE VOLUME	18 m^3
	TOWING SPEED	4.5 knots maximum when full
	INFLATION PRESSURE	0.15 bar (hot countries)
	ACCESSORIES	Top cover (PUA)
		Integral towing strop (forward and aft)
		Lifting sling
		Inflator / Deflator unit (ATEX approved)
		Repair kit

		Weatherproof aluminum alloy storage container (stackable) with certified
		Lifting points
		Relief valve inflation unit

Table 6-5: Oil Spill Response Equipment Supplied – Dispersant Spray System (Vikoma)

GENERAL	QUANTITY	2
	TYPE	Portable lightweight oil dispersant sprayer
	MANUFACTURER	Vikoma
	MODEL	Vikospray 1000 (or equivalent)
	WEIGHT	100 kg
SPRAY UNIT	APPLICATION	For both concentrate and dilute dispersant application
	LANCES (QTY)	2
	ACCESSORIES	Suction hose
		Trolley mounted
		Operation/maintenance manuals
PUMP UNIT	ENGINE	Single cylinder, 3 kW air cooled, diesel with recoil start and exhaust spark arrestor
	MAIN PUMP	Self-priming roller vane type
	PUMP DRIVE	Direct via coupling from engine (concentrate application)
	CHEMICAL PUMP	Liquid Jet type (for dilute application)
	MIXTURE CONTROL	Chemical/seawater ratio is controlled via a graduated valve on suction side of liquid jet pump working in conjunction with pressure relief valve.
	TOTAL OUTPUT	TOTAL OUTPUT Chemical/seawater mix = 18 l/min per lance maximum
		Chemical concentrate = 5 l/min per lance maximum
HOSE KIT	CHEMICAL SUCTION	1” NB x 4 m hose with strainer and non-return valve QCR to Vikospray
	WATER SUCTION	1” x 4 m hose with strainer QCR to Vikospray
	HAND LANCE	2 x 1/2” NB x 10 m hose and lance

Table 6-6: Oil Spill Response Equipment Supplied – Offshore Container (Vikoma)

GENERAL	QUANTITY	4
	TYPE	10-foot offshore container for skimmer and dispersant spray systems, inflator for FROST units and ten (10) drums (55 gallons each) of oil dispersant
	MANUFACTURER	Vikoma (or equivalent).
	WEIGHT	5,118 kg (with equipment)
CONTAINER	TYPE side	Stackable 10-foot ISO certified container with doors on one side
	PAINT	Orange RAL 2008 two pack PU paint system
	VENTS/EXHAUST	Louvre vents both sides
	FLOORING	Non-slip internal flooring coated with black Epidek non-slip paint
	DOORS	Doors with weather seals and lockable door latches with galvanized bolts
	ISO BLOCKS ISO	ISO blocks in all four corners
CERTIFI-CATION	CONTAINER	ISO/ABS (IACS)

Table 6-7: Oil Spill Dispersant (Guyana)

Dispersant Type	Volume (m^3)	Location
Corexit® 9527A	533	GYSBI (Georgetown)
Corexit® 9500 or Corexit® 9527A	33	Support Vessels (In-Field)
Dasic Slickgone	60	GYSBI (Georgetown)
In-Country Total	626	

Table 6-8: First Response Toolkit (Guyana)

Item	Element Description	Total Quantity	Part No. (if applicable)	Storage Location	Function / Use
Onshore					
1	8' x 20' Tooling and Spares Container	3	N/A	Onshore	Storage / Maintenance
2	Dual BOP Interface Manifold + Jumper Assembly	1	PN-ASY-000000584, PN ASY-000000617	Onshore	BOP Intervention
3	GR29 Hydraulic Grinder	2	PN-ASY-000000580	Onshore	Debris Clearance
4	Hydraulic Flange Spreader	2	PN-ASY-000000568	Onshore	
5	Hydraulic Nut Splitter, 1.13-1.56"	2	PN-ASY-000000565	Onshore	
6	Hydraulic Nut Splitter, 1.56-2.0"	2	PN-ASY-000000567	Onshore	
7	60" Chop Saw	1	PN-ASY-000000599	Onshore	
8	24" Diamond Wire Saw	1	PN-ASY-000000591	Onshore	
9	Pipe Grapple Tool, 10-24"	1	PN-ASY-000000594	Onshore	
10	Subsea Deployment Basket	1	PN-ASY-000000555	Onshore	
11	17H Hot Stab and Manifold, Dual Port, 15K, 0.25"	2	PN-ASY-000000606	Onshore	
12	17H Hot Stab and Manifold, Dual Port, 10K, 0.5"	2	PN-ASY-000000607	Onshore	
13	17H Hot Stab and Manifold, Quad Port, 3.6K, 0.375"	2	PN-ASY-000000609	Onshore	
14	Intensifier Panel	2	PN-ASY-000000583	Onshore	
15	IW12 Impact Wrench + Socket Set	1	PN-ASY-000000582, PN ASY-000000586	Onshore	
16	Coil Termination Panel	1	PN-ASY-000000585	Onshore	Subsea Dispersant Injection
17	HFL Deployment Frame (c/w 2x deployment racks and 2x 500' sections of 1" 5K HFL)	1	PN-ASY-000000556	Onshore	

Item	Element Description	Total Quantity	Part No. (if applicable)	Storage Location	Function / Use
18	Dispersant Wand Kit (c/w 1x 3' straight wand, 1x 3' 90° wand, 1x 3' 180° wand, 1x 6' straight wand, 1x 6' 90° wand, 1x 6' 180° wand)	1	PN-ASY-000000521	Onshore	
Offshore					
1	ROV Inspection Camera	2	N/A	Offshore (1x C-Installer MPV, 1x Kirt Chouest MPV) *	Site Survey
2	2D Sonar	2	N/A	Offshore (1x C-Installer MPV, 1x Kirt Chouest MPV) *	
3	BOP Intervention Skid	2	N/A	Offshore (1x C-Installer MPV, 1x Kirt Chouest MPV) *	BOP Intervention
4	IW12 Impact Wrench + Socket Set	1	N/A	Offshore (C-Installer MPV) *	Debris Clearance
5	ROV Knife	2	N/A	Offshore (1x C-Installer MPV, 1x Kirt Chouest MPV) *	Debris Clearance
6	Hydraulic Cutter	2	N/A	Offshore (1x C-Installer MPV, 1x Kirt Chouest MPV) *	
7	17D Torque Tool, Class 1-4	2	N/A	Offshore (1x C-Installer MPV, 1x Kirt Chouest MPV)	

Item	Element Description	Total Quantity	Part No. (if applicable)	Storage Location	Function / Use
Combined					
1	8 foot x 20 foot Tooling and Spares Container	3	N/A	Onshore	Storage/ Maintenance
2	ROV Inspection Camera	2	N/A	Offshore	Site Survey
3	2D Sonar	2	N/A	Offshore	
4	Dual BOP Interface Manifold + Jumper Assembly	1	PN-ASY-000000584, PN ASY-000000617	Onshore	BOP Intervention
5	BOP Intervention Skid	2	N/A	Offshore	
6	GR29 Hydraulic Grinder	2	PN-ASY-000000580	Onshore	Debris Clearance
7	Hydraulic Flange Spreader	2	PN-ASY-000000568	Onshore	
8	Hydraulic Nut Splitter, 1.13-1.56"	2	PN-ASY-000000565	Onshore	
9	Hydraulic Nut Splitter, 1.56-2.0"	2	PN-ASY-000000567	Onshore	
10	60" Chop Saw	1	PN-ASY-000000599	Onshore	
11	24" Diamond Wire Saw	1	PN-ASY-000000591	Onshore	
12	Pipe Grapple Tool, 10-24"	1	PN-ASY-000000594	Onshore	
13	Subsea Deployment Basket	1	PN-ASY-000000555	Onshore	
14	17H Hot Stab and Manifold, Dual Port, 15K, 0.25"	2	PN-ASY-000000606	Onshore	
15	17H Hot Stab and Manifold, Dual Port, 10K, 0.5"	2	PN-ASY-000000607	Onshore	
16	17H Hot Stab and Manifold, Quad Port, 3.6K, 0.375"	2	PN-ASY-000000609	Onshore	
17	Intensifier Panel	2	PN-ASY-000000583	Onshore	
18	IW12 Impact Wrench + Socket Set	2	PN-ASY-000000582, PN ASY-000000586 N/A	1x Onshore 1x Offshore	
19	ROV Knife	2	N/A	Offshore	

Item	Element Description	Total Quantity	Part No. (if applicable)	Storage Location	Function / Use
20	Hydraulic Cutter	2	N/A	Offshore	
21	17D Torque Tool, Class 1-4	2	N/A	Offshore	
22	Coil Termination Panel	1	PN-ASY-000000585	Onshore	Subsea Dispersant Injection
23	HFL Deployment Frame (c/w 2x deployment racks and 2x 500' sections of 1" 5K HFL)	1	PN-ASY-000000556	Onshore	
24	Dispersant Wand Kit (c/w 1x 3' straight wand, 1x 3' 90° wand, 1x 3' 180° wand, 1x 6' straight wand, 1x 6' 90° wand, 1x 6' 180° wand)	1	PN-ASY-000000521	Onshore	

6.1 Tier I Resources

6.1.1 Mobilization

Each onsite Emergency Response Team (ERT) is responsible for mobilizing resources to coordinate a Tier I spill response. In some cases, the onsite ERT may be contractor-managed and, in such circumstances, the associated ERPs will be vetted by EMGL. As part of their IMO certification, flag state requirements, and EMGL requirements, the major vessels supporting EMGL operations (e.g., FPSOs, installation vessels, drill ships, tankers) are required to have site-specific ERPs and SOPEPs in place.

The Tier I equipment held at EMGL's onshore and offshore operations, including shorebases, support vessels, drill ships, will be available for rapid onsite deployment in the event of an incident.

Each ERT will have an ERP which is a comprehensive document that addresses various types of site-specific emergency response scenarios, including oil spill response. Each ERT describes:

- Onsite response organizational structure;
- Team makeup and organizational roles and responsibilities;
- Interfaces with internal and external response organizations;
- Notification and contact information;
- Identification of oil spill response equipment;
- Tactical action plans for oil spill response;
- Drills, exercises, and simulations; and
- Training

6.2 Tier II Resources

The EMGL Incident Management Team (IMT) is responsible for mobilizing additional offsite resources to coordinate a Tier II response. The EMGL IMT is activated when an oil spill response escalates from Tier I to Tier II.

In-country equipment and trained personnel to support the EMGL IMT are available through the Guyanese terminals and shorebases supporting EMGL operations to initiate a response to a Tier II incident.

Vessel dispersant spray operations will be initiated from the PSVs and supported from the shorebases or other accessible locations as needed to supplement other Tier II response actions.

Given the type and quantity of hydrocarbons identified in the EIA impact analyses, the distance of the FPSOs and drill ships from the coastline, and the likelihood that oil from a marine oil spill offshore is unlikely to impact a shoreline in less than approximately 5-10 days; it is estimated that regional and international resources can be cascaded into a response in sufficient time to be effective. Therefore, in the event country/regional Tier II resources are insufficient, EMGL would immediately activate additional resources such as ExxonMobil's RRT and OSRL per Section (see Tier III Arrangements Section 2) early in an incident response operation.

In addition, the EMGL IMT could call upon its in-country contracted companies to provide specific technical or logistical assistance (e.g., aircraft, road transportation, waste management, equipment providers, deployment assistance) for Tier II incidents, as well as VOOs located in Guyana and Trinidad, as needed.

The EMGL IMT may also request Tier II assistance with the provision of equipment (e.g., boom, skimmers) and deployment assistance from the organizations/contractors supporting the Guyana National Oil Spill Contingency Plan.

6.3 Tier III Resources

6.3.1 ExxonMobil's Regional Response Teams

The EMGL IMT is responsible for mobilizing additional offsite resources to coordinate a Tier III response. The EMGL IMT will activate the Regional Response Team (RRT) when an oil spill response escalates to Tier III; it may also activate the RRT for Tier II support.

The ExxonMobil RRT is comprised of two geographically based units:

- Europe-Africa-Middle East/Asia-Pacific RRT; and
- Americas RRT.

The first point of contact for EMGL is the Emergency Preparedness and Response Coordinator for Americas RRT, who can initiate activation following instructions from the EMGL Country Manager or designated representative. Although organized geographically, resources from all RRT units can be mobilized to support the EMGL IMT.

The RRT is organized in accordance with the Incident Command System (Figure -1). The organization is led by in-country personnel and the incident managed by the Incident Commander and the Command Section, supported by Operations, Planning, Logistics, and Finance Sections. The support sections are further sub-divided into branches and units depending on the scale and type of incident.

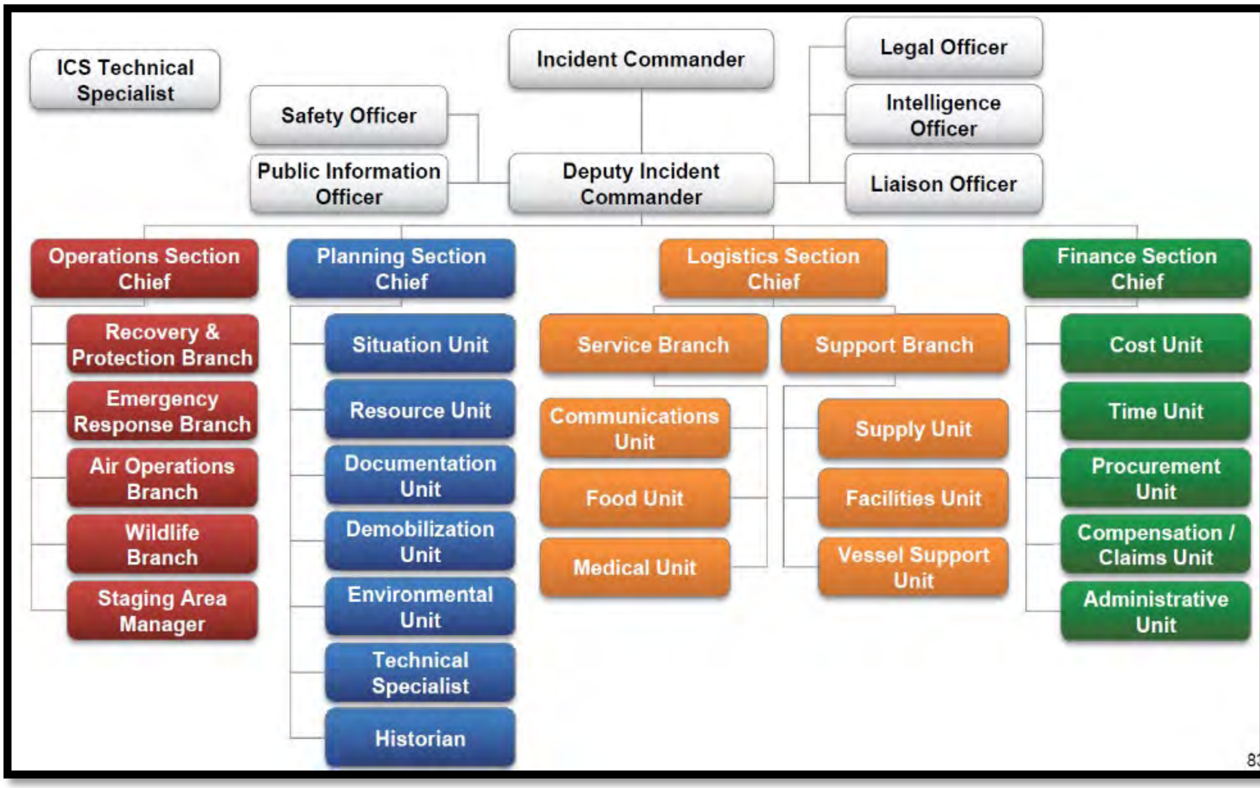


Figure 6-1: Sample Incident Command System Organization

The RRT includes trained individuals and specialists, with assigned roles and responsibilities, who can be deployed at short notice to address a broad range of emergency situations.

The RRT can be partially or fully activated. Partial activation may be implemented when functional support is required by ERTs at incident sites. Should this occur, RRT members will typically be deployed within the existing on-site ERT structure. For larger incidents, that require an extensive amount of tactical work, an intermediate group called the IMT may be established to provide tactical management support for the ERT. Additional company support can be called upon independent of RRT activation, if required.

For large emergencies and incidents in remote locations, full activation may be implemented. Partial or full activation of the RRT to support the EMGL IMT is likely for all Tier II and Tier III incidents in Guyana or in any area in the region affected by a spill from Guyana, to help manage a major tactical response. In the event that the RRT is activated, an RRT Command Centre will be established by the Americas RRT.

6.3.2 Oil Spill Response Limited (OSRL)

EMGL is a Participant member with OSRL and has a worldwide contract in place with OSRL, and therefore has immediate access to Tier III technical advice, resources, and expertise 365 days a year on a 24-hour basis. Table 6-9 summarizes the OSRL service level agreement (SLA) available to EMGL.

Table 6-9: OSRL Service Level Agreement Summary

Service	Service Standard		EMGL Membership Type: Participant	
Response notification, mobilization, service and advice	Notification of a spill contact information			
	OSRL BASE	Fort Lauderdale, USA		
	TELEPHONE	+1 954 983 9880		
	FAX	+1 954 987 3001		
	EMAIL	dutymanagers@oilspillresponse.com		
	FORMS	Refer to Appendix I: OSRL Notification Form		
	The Duty Manager will speak with and advise EMGL immediately, or call EMGL back within 10 minutes.			
Nominated Contact	OSRL must receive an official mobilization authorization from one of EMGL's Nominated Call-Out Authorities however anyone can notify OSRL.			
Spill response equipment	SLA response equipment is housed in secure facilities in Southampton, Fort Lauderdale, Bahrain, and Singapore. Response equipment is customs cleared response ready. Refer to: OSRL Yearbook for a complete list of equipment available, www.oilspillresponse.com and refer to the equipment stockpile status report http://www.oilspillresponse.com/activate-us/equipment-stockpile-status-report			
	As per the SLA, EMGL can mobilize up to 50 percent of the global stockpile. If there is more than one spill, EMGL can mobilize 50 percent of what remains.			
Dispersant stockpile	If there was an incident, the spiller is entitled to 50 percent of the ~680 m^3 of dispersant located in Southampton, Singapore, Fort Lauderdale, and Bahrain. OSRL may be able to obtain further dispersant through the Global Response Network (GRN) and other organizations, if required.			
World-wide transportation of equipment	Aircraft Type	Location	Dispersant Capacity	Range
	C-130 Hercules (1x aircraft)	Singapore, Seletar	13,000 litres	2,000 nm in 8 hours
	Boeing 727 (2x aircraft)	UK, Doncaster	17,500 litres	2,400 nm in 6 hours
	Aerial dispersant coverage is provided within a six hour notice period. 24-hour access to global network of cargo and passenger charter services through a dedicated broker.			
Oil spill trajectory and tracking	Trajectory and stochastic services for surface or subsurface oil spills on request, and backtrack services for surface oil spills using commercial modelling software:			
	OILMAP		Oil Spill Contingency and Response Model	
	Satellite imagery services can be provided on request. There are 10 satellite tracking buoys in Georgetown			

Service	Service Standard	EMGL Membership Type: Participant
Response Personnel	OSRL will provide the following response personnel on a first come, first served basis: 1 x Senior oil spill response manager 1 x Oil spill response manager 15 x Spill response specialists / responders 1 x Logistics Service branch coordinators	
	A Technical Advisor can be dispatched to offer support to EMGL when they have an oil spill incident or the potential for an incident to occur. This is provided free of charge for the initial assessment period of up to 48 hours. If a full response team is then mobilized, the technical advisor will form part of the available team headcount.	

m^3 = cubic metre

6.3.3 Marine Spill Response Corporation (MSRC)

ExxonMobil has a contract in effect with the MSRC that allows ExxonMobil to request personnel, services, and equipment on a 24-hours per day basis. Equipment availability is subject to approval based on factors including contract terms, current response activity, and regulatory needs. MSRC should be activated by calling the Toll-Free number below in Table 6-10 and providing the information requested.

Table 6-10: MSRC Contact Information

Company	International	Secondary #	Internet
Marine Spill Response Corporation (MSRC)	+1 (732) 417-0175	+1 (703) 326-5609	http://www.msrc.org
Spill Response Equipment	Dispersant aircraft, dispersants, mechanical response equipment, communications equipment, vessels, capping stacks		

6.3.4 Boots & Coots

EMGL has a subscription with Boots & Coots (in Houston, Texas, USA) for access to the Boots & Coots Global Rapid Intervention Package (GRIP) system, which includes a 15k capping stack, debris removal equipment, and other associated equipment. The GRIP system is an air-freightable system that is located adjacent to George Bush Intercontinental Airport. A response time analysis indicates that the capping stack deployment is possible within five days to the well site, assuming no debris removal activities are required. Once deployed, final capping operations could occur to shut in the well. Boots & Coots should be activated by calling the number below in Table 6-11 and providing the information requested.

Table 6-11: Boots & Coots Contact Information

Company	Toll-Free	Main	Internet
Boots & Coots	+1 (844) 307-8094	+1 (281) 931-8884	https://www.halliburton.com/en/integrated-services/well-control-prevention-services/well-control-response
Spill Response Equipment	Capping stacks, debris removal equipment, and other associated equipment		

6.3.5 Add Energy

Add Energy is a Norway-headquartered international consultancy provider to the energy industry that offers a range on engineering services in support of wells operations. These services include, but are not limited to, well kill support, well management, well engineering, well servicing, well integrity, reservoir and flow simulations, and loss-of-well-control contingency.

Table 6-12: Add Energy Contact Information

Company	Primary	Secondary	Internet
Add Energy	+47 66 98 32 90	+1 832 604 7326	https://addenergy.no/

6.3.6 Global Dispersant Stockpile

The Global Dispersant Stockpile (GDS) is an additional 5,000 cubic metres (m^3) of dispersant located across the OSRL bases and in France (see Table 6-13). The dispersant types are those with the largest worldwide approval. Copies of the Safety Data Sheets for all four of these products have been furnished as part of Appendix D.

Table 6-13: OSRL GDS Quantities and Locations

Dispersant	Quantity (m^3)	Storage Location
Slickgone NS	350	Singapore
	500	Southampton, UK
	800	Saldanha, South Africa
Finasol OSR52	350	Singapore
	500	Southampton, UK
	1,500	Vatry, France
Corexit® 9500	500	Rio de Janeiro, Brazil
	500	Fort Lauderdale, USA

OSRL and EMGL mobilization responsibilities depend on the location of the stockpile (see Figure -2). For all GDS dispersant located in Southampton, Singapore, and Fort Lauderdale, normal SLA logistics and mobilization agreements apply. OSRL will mobilize the GDS alongside all other Tier III equipment.

The GDS stockpile would complement the EMGL's in-country dispersant stockpile.

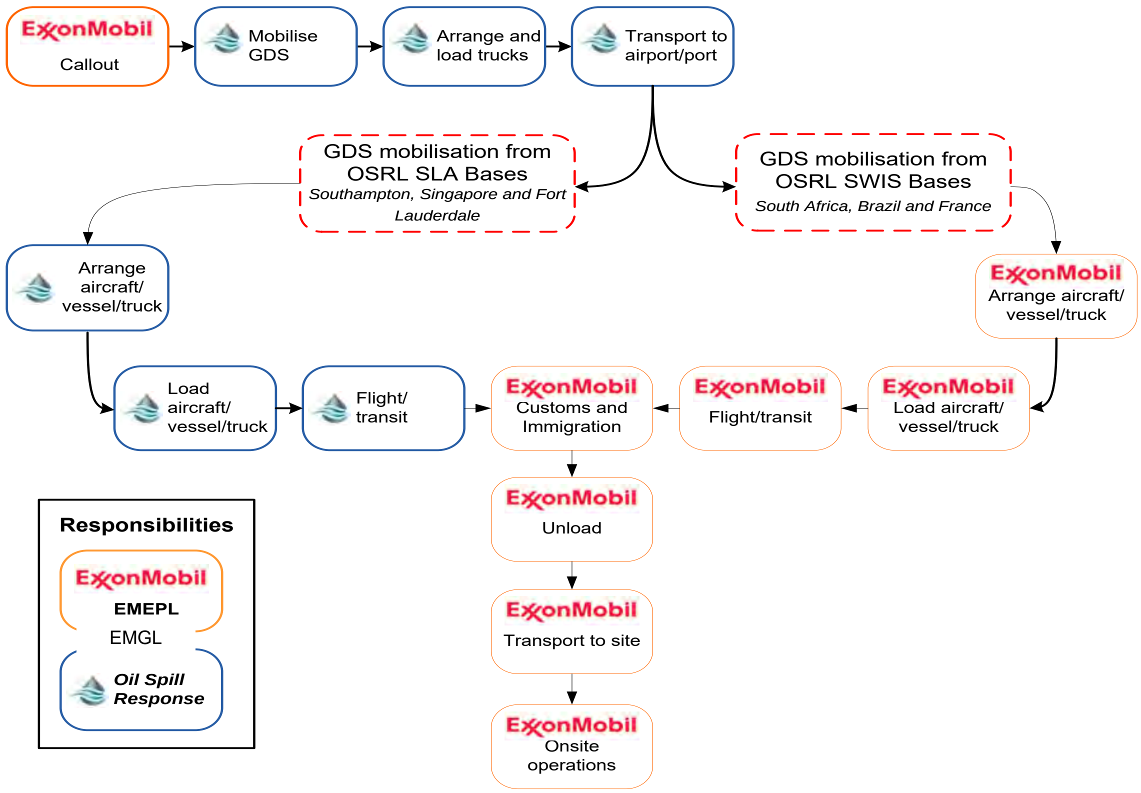


Figure 6-2: GDS Mobilization Responsibilities

EMGL would mobilize the GDS through the OSRL Duty Manager. EMGL can mobilize 100 percent of the GDS for a single incident; 5,000 m^3 is available to support both a subsea and/or surface response. The quantity of dispersant that is currently on hand in Georgetown is adequate to support the immediate response efforts, allowing sufficient time to transport additional supply from OSRL in Ft. Lauderdale, Florida and additional GDS stockpiles. Dispersant can expect to begin arriving from Ft. Lauderdale within two days.

Arrival of Tier III equipment and the SLA dispersant is expected in Cheddi Jagan International Airport within two to three days of callout. The re-supply to EMGL response operations will be arranged between EMGL and the dispersant manufacturers.

EMGL will be responsible for designating the preferred port, arranging the airplane/vessel (in the case of a subsea well response), accepting the dispersant at the port, coordinating customs clearance, in-country logistics, and confirming the authorised use of dispersant for the specific incident application with the EPA. The OSRL Duty Manager will advise the operator of the logistical requirements of the GDS.

6.3.7 Subsea Well Response

EMGL has access to the OSRL SWIS, Oceaneering, Wild Well Control, Trendsetter Engineering, and Boots & Coots equipment.

> ***Note***: The following two conditions of the Yellowtail Development Permit (20210406-YTPEX; signed April 2022) will be met which will supplement the equipment outlined in section 6.3.7:
>
> 9.13 Within thirty (30) months of receipt of this Permit, the Permit Holder shall procure a Capping Stack to be maintained, tested, and stored in Guyana.
>
> 9.15 Within twenty-four (24) months of receipt of this Permit, the Permit Holder shall supplement its in-country First Response Toolkit (FRT) to include heavy debris removal equipment and any additional elements of the Essential FRT in accordance with GIIP.

The OSRL SWIS provides EMGL with access to a SIRT and multiple subsea well CSS, as required. The CSS and SIRT include equipment that can be mobilized directly to the well site:

- Survey and debris clearance equipment;
- Intervention equipment;
- Dispersant hardware application system[6]; and
- CSSs and auxiliary equipment.

SWIS holds and maintains four CSSs and two SIRTs globally:

- 15,000 psi Subsea Well Capping Stack – Norway and Brazil;
- 10,000 psi Subsea Well Capping Stack – South Africa and Singapore; and
- SIRT – Norway and Brazil.

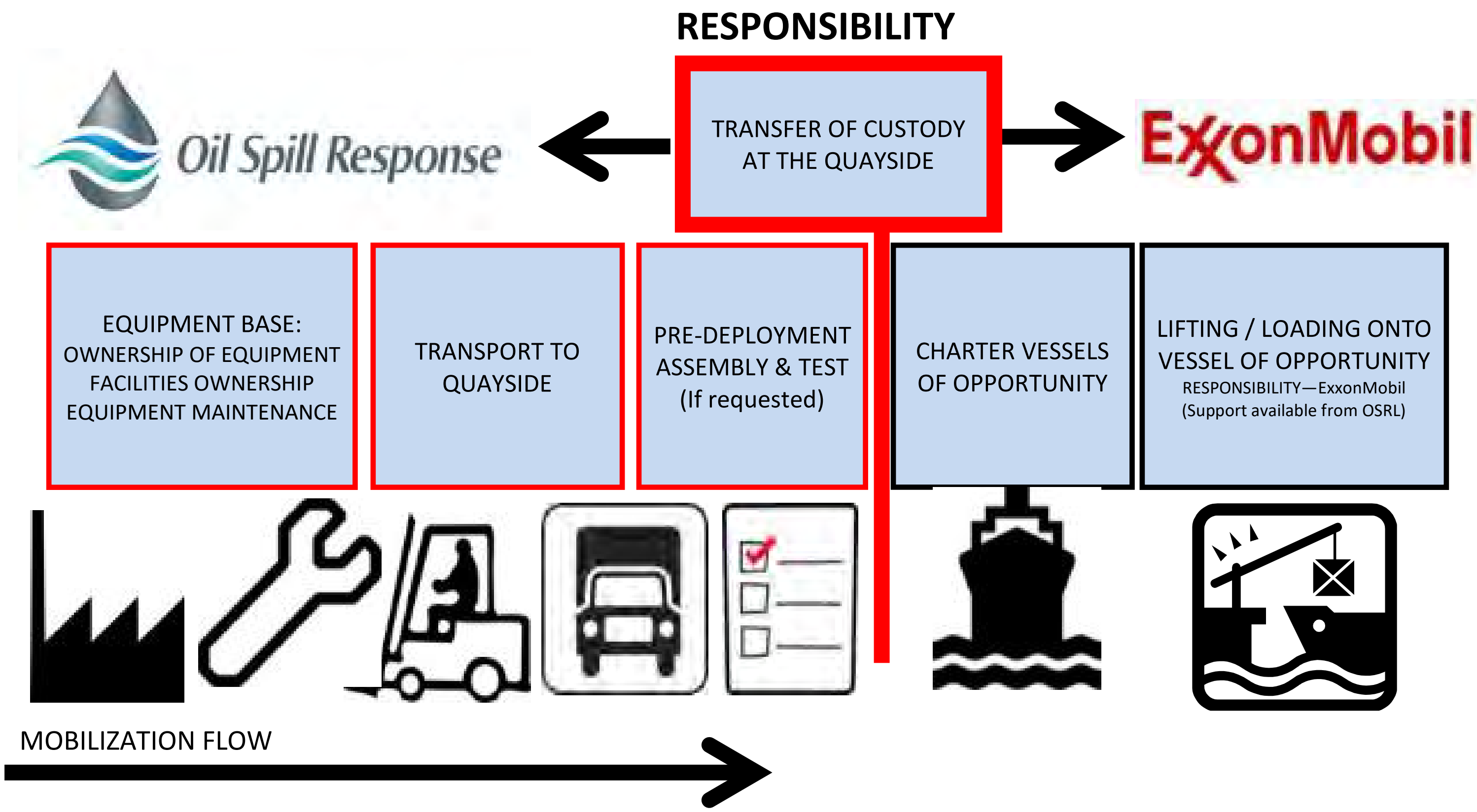
Boots & Coots well control company holds and maintains a GRIP in Houston, Texas (USA), for which EMGL has a subscription. Included as part of the GRIP is a 15,000 psi Subsea Well Capping Stack. The Boots & Coots GRIP would be deployed via air to Trinidad (due to current infrastructure limitations in Guyana), then transported to Chagterms Quayside where a deployment vessel can transport it directly to the well location (see Figure 6-3).

Through the subscription to access the Boots & Coots GRIP system, the capping stack deployment to the well site is possible within 5 days, assuming no debris removal activities are required. As this capping stack can arrive ahead of the capping stack from OSRL, EMGL would activate this stack first. Once deployed, the final capping operations would occur and the well could be shut in within 12 hours (planning standard). Therefore, oil spill modelling for the WCD scenarios has been based upon a 5.5-day installation of the capping stack and the cessation of

[6] Dispersant must be mobilized simultaneously through the OSRL GDS service via EMGL IMT.

oil flowing from the well, and that timing is therefore reflected in the mitigated scenarios modelling discussed herein.

Figure 6-3: Sea Mobilization Responsibilities for OSRL and ExxonMobil



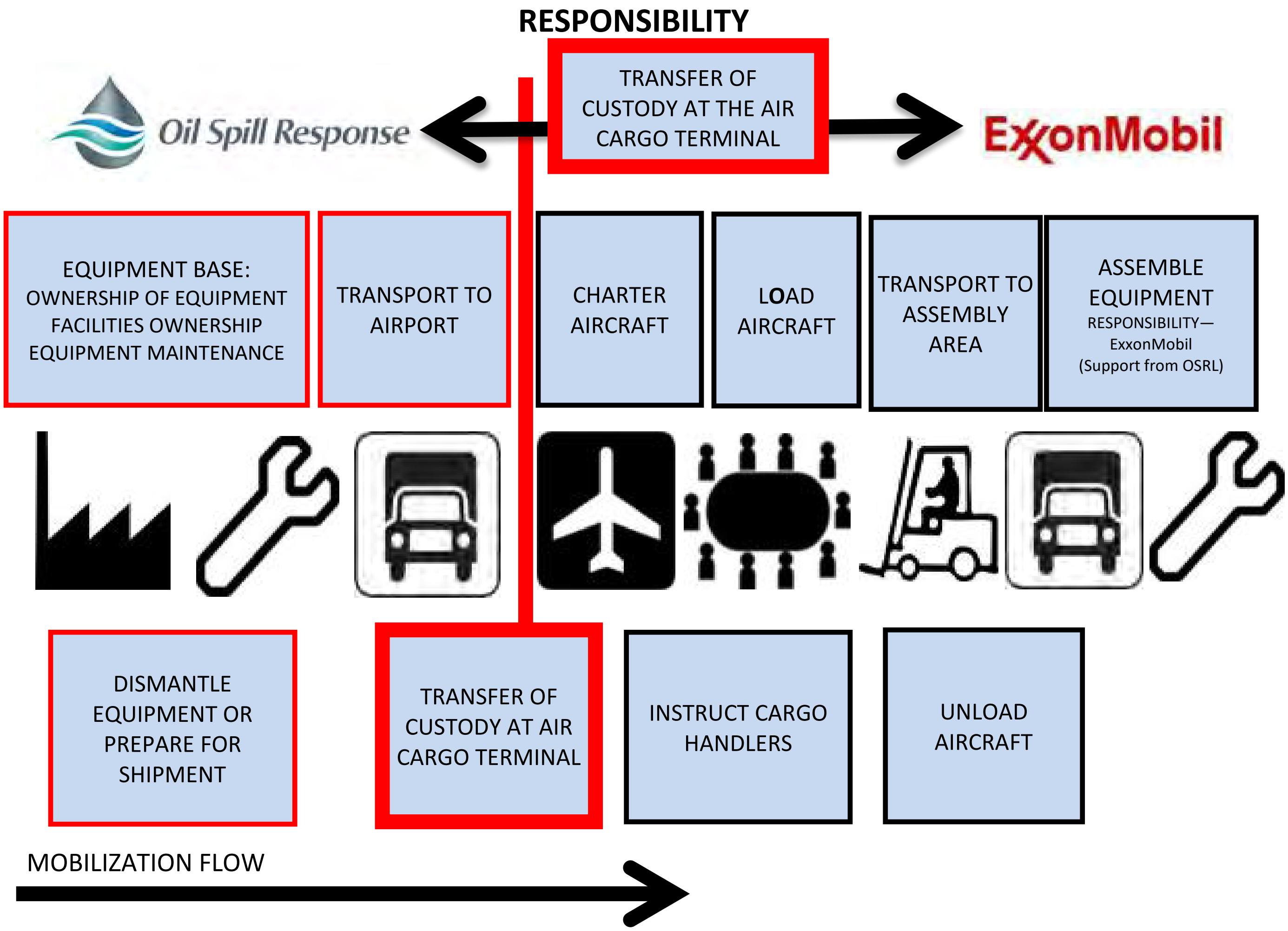
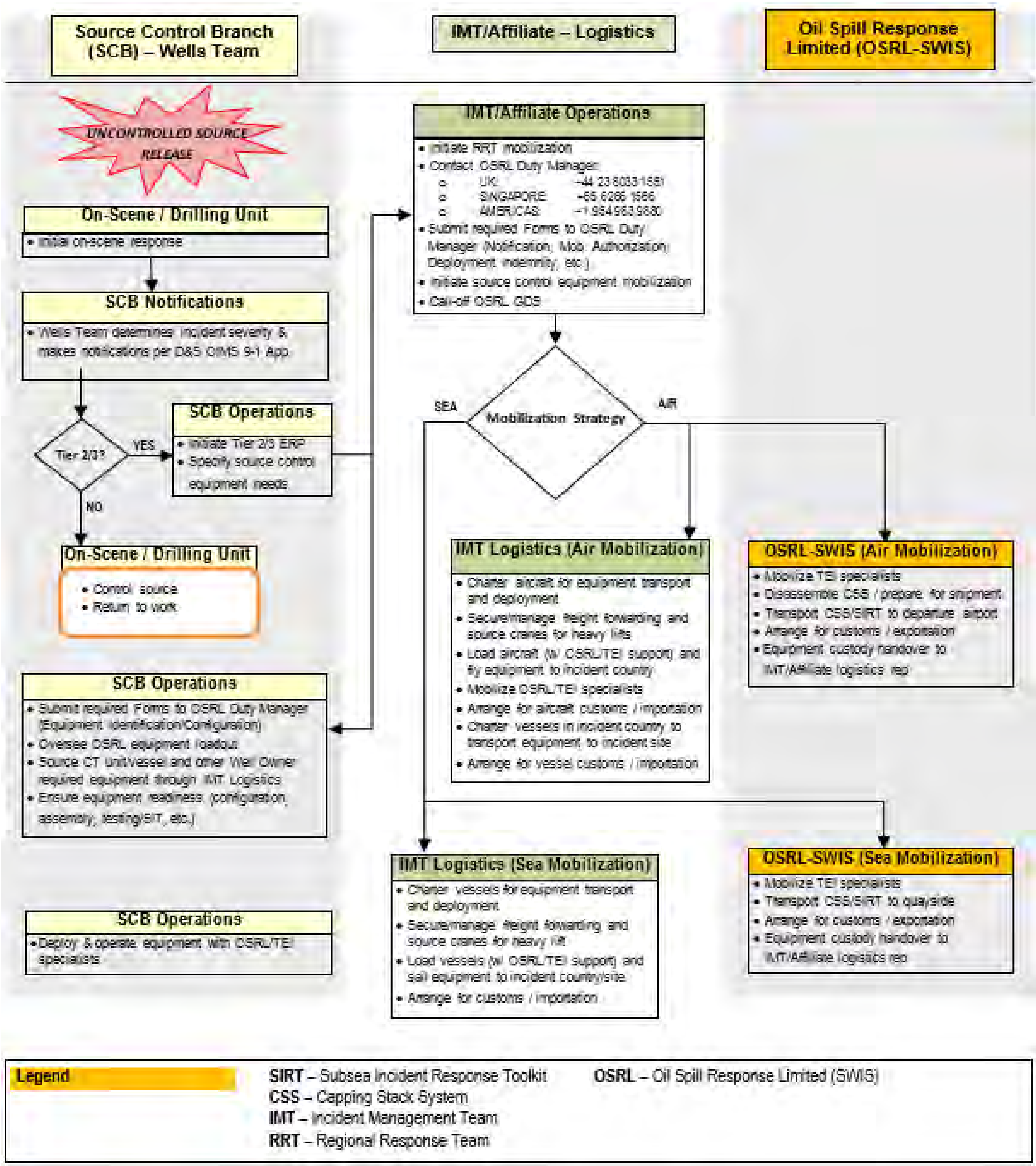


Figure 6-4: Air Mobilization Responsibilities for OSRL and ExxonMobil

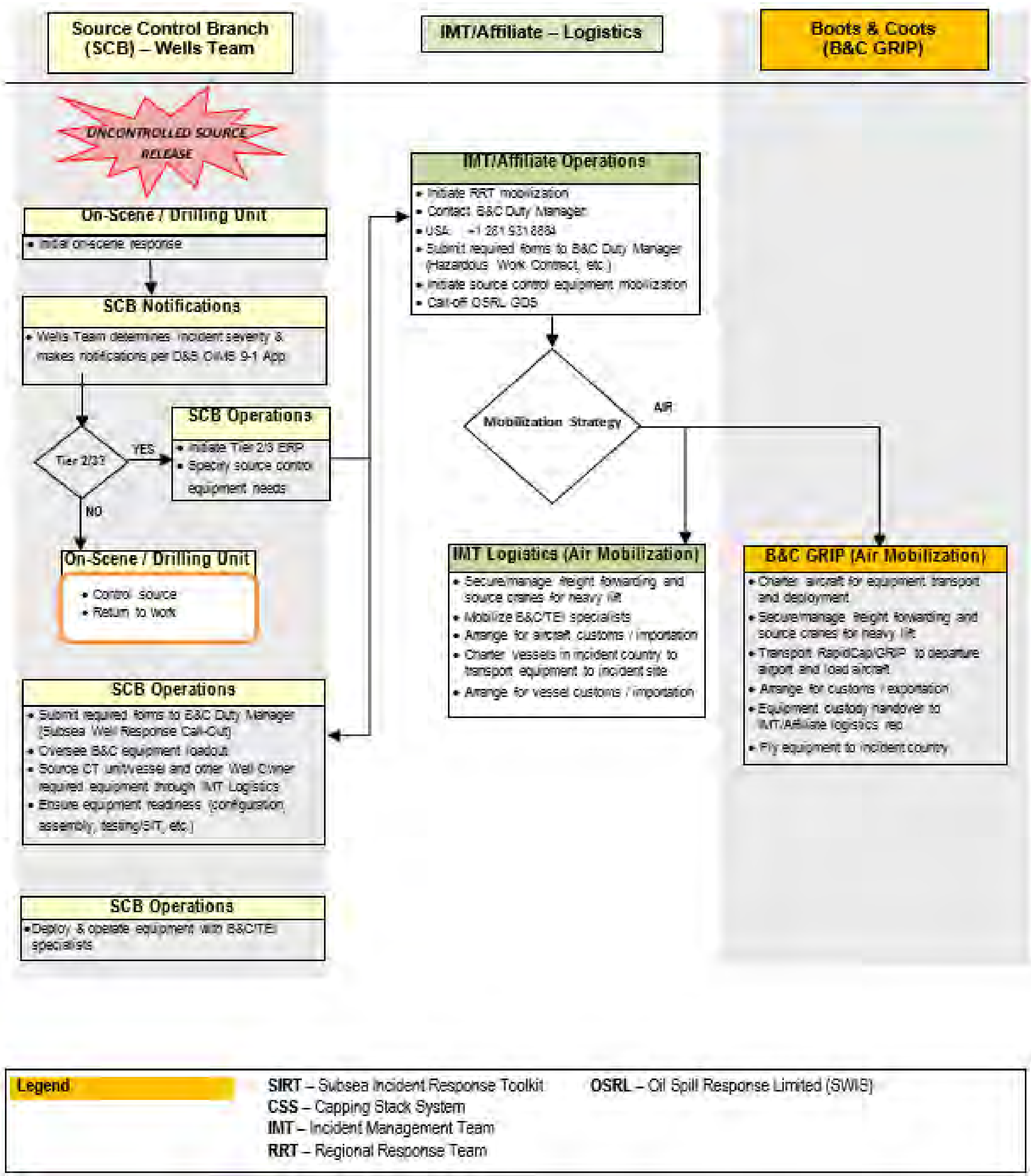
Additionally, the OSRL capping stacks located in Norway and Brazil can be deployed in approximately nine and 21 days, respectively. The Norway capping stack is air-freightable (via transport skid configured for transport by an Antonov AN124 aircraft) and its capability was demonstrated with a test flight out of the Solo Airport in late-2018. The Brazil capping stack is transported to well location by vessel. OSRL, with Company involvement, conducted a major mobilization exercise (Guyana simulation) in November 2017 which evaluated ability to export the Brazil capping stack outside of Brazil within three days. Results of the exercise demonstrated operational readiness of OSRL and allowed validation of the 21-day duration that OSRL estimates it needs to have the Brazil capping stack installed in Guyana.

In order to mobilize this equipment, the following flow charts should be considered.



Note: Flow chart above is intended to capture the key activities associated with equipment mobilization.

Figure 6-5: OSRL-SWIS Equipment Mobilization Process



Note: Flow chart above is intended to capture the key activities associated with equipment mobilization.

Figure 6-6: Boots & Coots Equipment Mobilization Process

7. EXERCISES AND TRAINING

EMGL conducts regular oil spill training courses and exercises (tabletop and field) for its operations in Guyana. Training, drills, and exercises familiarize emergency response personnel with their roles and responsibilities in the event of an oil spill and provide measurement of preparedness. ExxonMobil conducts exercises for operations around the world. In the event of a significant release in Guyana, response experts from ExxonMobil and Tier III OSROs such as OSRL would support the response to that spill from local, regional, and/or international response centres, as necessary.

7.1 Oil Spill Training

Training requirements depend on an individual's role on the IMT and emergency response experience. There is some overlap between the IMT and the ERT training. This is beneficial as it provides the IMT with a clear appreciation of the factors likely to affect the performance of a particular technique or piece of equipment, and at the same time gives the ERT a better understanding of the overall strategy.

EMGL ERT and IMT members, including the ExxonMobil America's RRT, will receive oil spill response training listed in Table 7-1 (or equivalent training such as XOM ICS 100/200 Computer Based Training [CBT]) based on their response position.

Table 7-1: Oil Spill Response Training Course Information

IMO Course Level	Oil Spill Incident Response Personnel	Course Outline
Level 1	ERT members	Training on practical aspects of oil properties, response techniques, health and safety, boom and skimmer deployment, dispersant application, use of sorbents, shoreline clean-up, debris/waste handling and disposal and wildlife casualties.
Level 2	On-Scene Incident Commanders and Key ERT Leaders	Training in oil spill behavior, fate and effects, spill assessment, operations planning, containment, protection and recovery, dispersant use, shoreline clean-up, site safety, storage and disposal of waste, media relations, record keeping, command and control management, communications and information, liability and compensation, response termination and post incident review/briefing.
Level 3	Key IMT members	An overview of the roles and responsibilities of senior personnel in the management of oil spill incidents, cause and effect of oil spills, response policy and strategies, contingency planning, crisis management, public affairs and media relations, administration and finance and liability and compensation.

7.2 Incident Command System Training

EMGL ERT and IMT members, including ExxonMobil Americas RRT, will receive the appropriate ICS Training listed in Table 7-2 based on their roles and responsibilities.

Table 7-2: ICS Training Course Information

ICS Course Level	Oil Spill Incident Response Personnel	Course Outline
100	Tactical Response Team Members	A web based course aimed at introducing the ICS, basic terminology, common responsibilities, ICS principles and features. A foundation is set that will allow personnel to function appropriately in an ICS. Completing ICS 100 is prerequisite to completing ICS 200.
200		This course is also web based that builds on the foundation information from ICS 100. ICS 200 is required for first level supervisors involved in responding to the incident at the site, Site Response Team. Completing ICS 200 is prerequisite to completing higher level ICS training. Topics covered should include: principles and features, organizational overview, incident facilities, incident resources and common responsibilities.
300	On-Scene Incident Commanders, Key ERT Leaders and IMT	This course provides description and details of the ICS organization and operations in supervisory roles on expanding incidents. Topics covered include: organization and staffing, resource management, Unified Command, transfer of Command, event and incident planning, air operations and establishing incident objectives.

7.3 Oil Spill Exercises

Oil spill response exercises test incident response personnel function and responsibilities. They improve oil spill incident response team's skills and awareness, and provide management with an opportunity to assess equipment, measure performance, obtain feedback from participants, update contingency plans, and give a clear message about the Company's commitment to oil spill prevention and response.

An exercise schedule is determined based upon local needs annually by the EMGL Management team, which is approved by the EMGL Country Manager or designated representative. A suggested guideline including schedule and type of oil spill exercise is outlined in Table 7-3.

Table 7-3: Oil Spill Exercise Overview and Schedule

Exercise Type	Description and Purpose	Frequency
OSRP Orientation	A contingency plan orientation exercise is a workshop which focuses on familiarizing the ERT and IMT with their roles, procedures and responsibilities in an oil spill. The aim is to review sections of the plan, encourage discussion, and by using local knowledge and expertise, make useful and practical improvements to the plan where required.	Upon assignment of ERT/IMT member
Notification and Callout Exercise	A notification exercise practices the procedures to test emergency alerts communication and update EMGL's call out lists. These tests are done using the ExxonMobil MIR3 Emergency Alert and conducted over the mobile app, email, text message or phone call. Site specific notification and communication exercices with the ERT are conducted over the radio or telephone, depending on the source of the initial oil spill report. They test communications systems, the availability of personnel, travel options and the ability to transmit information quickly and accurately. This type of exercise will typically last one-to-two-2 hours and can be held at any time of the day or night.	Quarterly
Practical Oil Spill Equipment Deployment Exercise	Simple deployment exercises give personnel a chance to become familiar with equipment, or they may be a part of a detailed emergency response scenario, where maps, messages, real-time weather and other factors are included. The exercise is designed to test or evaluate the capability of equipment, personnel, or functional teams within the oil spill response. In deployment exercises, the level of difficulty can be varied by increasing the pace of the simulation or by increasing the complexity of the decision-making and coordination needs. A deployment exercise would typically last from four-to-eight hours.	Annually
IMT Tabletop Exercise	A tabletop exercise uses a simulated oil spill to test teamwork, decision-making and procedures. The exercise needs to be properly planned with a realistic scenario, clearly defined objectives for participants, exercise inputs, and a well briefed team in control of the running and debriefing of the exercise. A tabletop exercise will typically last from two-to-eight hours.	Annually
Full-scale Incident Management Exercises	Full-scale exercises provide a realistic simulation by combining all of the elements of the tabletop exercise (maps, communications, etc.) and the deployment of related personnel and equipment. This complexity requires the response to be more coordinated than in basic tabletop or deployment exercises. The effort and expense in organizing a realistic full scale exercise means that it is recommended that they be run only once every two years or so. It may also be cost effective to run full-scale exercises in partnership with other organizations within the region and the ESG. Full-scale exercises can create a very intense learning environment that tests cooperation, communications, decision making, resource allocation and documentation. People involved in full-scale incident management exercises should have attended earlier tabletop exercises. Organizing a realistic full-scale exercise could take many months, and requires an experienced planner and a large support team to run the exercise. The full scale exercise will generally last at least one day and often carry on overnight into a second or third day.	Every 3 Years[a]

7. Exercise and Training

Exercise Type	Description and Purpose	Frequency
Joint Exercises (e.g., with other Operators or Regulators)	Joint exercises provide a realistic simulation by combining the full scale oil spill response equipment deployment and tabletop incident management to handle a major spill scenario. The spill scenario involves major consequences to a very wide range of resources, threatening national interests and requiring national and regional cooperation and coordination. Joint exercise involves very wide range of personnel from many different organizations, possibly in various locations, together with a range of equipment deployment opportunity. This exercise is designed to build confidence in EMGL's preparedness to effectively and efficiently deal with oil spills at all scales. This will also enhance the cooperation among the government and industry at national and regional level in responding to major and/or trans-boundary spills. A joint exercise will generally last at least one day and may carry on overnight into a second or third day. At least thirty (30) calendar days before the conduct of the exercises, EMGL will inform the EPA, in writing, of the dates of the exercises. The appropriate documentation evidencing the conduct of the exercises, will be submitted no later than thirty (30) calendar days following the excercise, and will include information concerning the: a. type of exercise; b. date and time of the exercise; c. description of the exercise; d. objectives met; and e. lessons learned.	Every 3 Years[a,b]

[a] Covers exploration and production operations.
[b] Oil Spill Response Plan (OSRP) will be exercised twice before April 2025.

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APPENDIX A – SPILL MODELLING CONCEPTS AND APPLICATIONS

This appendix describes the modelling methodology and attributes necessary to conduct plausible oil spill models for the identified unplanned hydrocarbon release scenarios.

A.1. Modelling Overview

Understanding spill trajectory and fate or the ultimate disposition of the spill volume in terms of location and condition is fundamental to spill response strategy and to ensuring that spill, response equipment is located appropriately.

A.2. OILMAPDEEP Model

OILMAPDeep[7] is comprised of multiple integrated model components used to predict the dynamics of the release of oil and gas to the water column from a deepwater subsea loss-of-well-control. The integrated system is primarily focused on predicting the dynamics of the plume and resulting intrusion layer, the dissolution of gas, formation of hydrates, and the oil droplet size distribution and concentrations. OILMAPDeep is focused on predicting the near-field dynamics of the release. Output from OILMAPDeep can then be utilized as input to the SIMAP (Spill Impact Model Application Package) spill model, which predicts the far field transport, fate, exposure, and effects of the release.

OILMAPDeep includes components to calculate the plume and oil droplet sizes. The plume model predicts the characteristics of the plume resulting from the oil and gas release, including its orientation, radius, velocity, entrainment rate, and oil and gas concentrations as a function of distance from the release location and the trapping height/depth (height is measured from the seabed and depth from the water surface). The trapping depth is the location where plume buoyancy is dissipated by entrainment and gas dissolution, which results in rapid radial spreading of the plume. The oil droplet size model predicts the oil droplet size distribution.

A.3. SIMAP Model

SIMAP, developed by RPS Ocean Science ("RPS"), is a fully three-dimensional and time-varying oil spill model system capable of analysing in two modes: stochastic or deterministic mode. It uses wind data, current data, and transport and weathering algorithms to calculate the mass of oil components in various environmental compartments (water surface, shoreline, water column, atmosphere, sediments, etc.), oil pathway over time (trajectory), surface oil distribution, and concentrations of the oil components in water and sediments as a result of a spill. SIMAP was derived from the physical fates and biological effects sub-models in the Natural Resource Damage Assessment (NRDA) Models for Coastal and Marine and Great Lakes Environments, which were developed for the US Department of the Interior as the basis of Comprehensive Environmental Response, Compensation and Liability Act of 1980 NRDA regulations for Type A

[7] RPS Group

assessments (Reed et al. 1995, French-McCay et al. 1996). SIMAP contains physical fate and biological effects models, which estimate exposure and impact on each habitat and species (or species group) in the area of the spill. Environmental, geographical, physical-chemical, and biological databases supply required information to the model for computation of fates and effects. The technical documentation for SIMAP is in French McCay 2002, French McCay 2003, French McCay 2004, French McCay et al. 2004, French McCay 2009, and French McCay 2016.

SIMAP runs in one of two modes: stochastic mode – where hundreds of simulations are made by varying inputs within a set of probability distributions, as well as in deterministic mode – where individual spills are simulated to examine representative or "worst case" 95th percentile scenarios of interest for examining impacts to particular resources.

A.4. Spill Modelling Approach

A.4.1. Fate and Trajectory

Fate (weathering) and trajectory (movement) models were used to simulate oil transport and predict the changes the oil undergoes as it interacts with water, air, and land. The models were used to simulate spill events using the best available characterization of the wind and hydrodynamic (marine currents) forces that drive oil movement. 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 examines numerous simulated releases from the same point utilizing historical data for wind and currents; and (2) the deterministic mode examines a single release utilizing a subset of historical wind and hydrodynamic data from the range of potential data, or utilizing forecast data for an ongoing or future event (e.g., worst case or 95th percentile scenarios of interest.

The coastal sensitivity maps used to identify and characterize the resources / receptors with the potential to be impacted by a spill based on the modelling results were based on the Liza Phase 2 Project and Payara Development Project Environmental Impact Assessments (EIAs).

A.4.2. Metocean Conditions

Currents in the upper water column off the Guyana coast are strong and flow toward the northwest along the coast of South America over the entire year. The Guiana Current is part of the regional flow between South America, Africa, and the Caribbean Sea, extending from Guyana to the Caribbean.

EMGL has deployed and maintained a series of deepwater current profile moorings and meteorological station buoys in the Stabroek Block, offshore of Guyana (RPS 2016; RPS 2017a, b, c). Processed final data sets of the observations were available for the first four mooring and buoy deployments spanning March 2016 through September 2017. There were five moorings deployed originally, four of which were instrumented.

Wind observations from the meteorological station buoys were compared to the US Navy Global Environmental Management (NAVGEM) model prediction and current observations were compared to the Hybrid Coordinate Ocean Model (HYCOM) model predictions previously utilized in modelling analyses.

The SAT-OCEAN current model used in the oil spill modelling analysis is based on the HYCOM that includes 3D current speeds in a 4°×4° grid over the Stabroek Block region (56°-60°W, 7°-11°N). The horizontal resolution of the model is 1/64°, and the model defines current speed and direction on 64 vertical layers through the water column. The time series data set defines 3D currents at a 3-hour interval for the 10 years between 2005 and 2014. The data from the SAT-OCEAN current model were calibrated by current data measured at a location offshore Guyana (8.08°N, 56.95°W) during 2015. Considering the extent of the historical record and calibration with measured data, these data are appropriately representative of the region and capture expected variability in the current forcing.

The objective of the model-to-observations comparison was to assess whether the hydrodynamic models are capable of capturing the important characteristics of the wind forcing (speed and direction frequency distribution) and the current speeds and circulation patterns (primarily the higher currents associated with the fluctuation of the Guiana Current or the passage of North Brazil Current (NBC) rings). An analysis of the previously used historical data and the measured data determined that the data were similar enough that utilization of the existing historical wind and current data utilized for Liza Phase 1 spill modelling were appropriate for the Liza Phase 2 and Payara spill modelling.

A.5. Spill Modelling Scenarios

A series of stochastic and deterministic model simulations were run to determine the fate of the oil released for three different products (marine diesel, crude oil, wellbore fluids) for various scenarios at an offshore location during two different seasons.

Unmitigated loss-of-well-control scenarios consist of an assumed 30-days of oil and gas discharge at the wellhead. The loss-of-well-control scenarios were simulated using the OILMAPDeep model to determine the discharge plume geometry, define the oil droplet sizes, and provide inputs for the SIMAP model simulations. All loss-of-well-control scenario simulations were run for the identified discharge period plus an additional number of identified days after oil discharge ceased.

A.6. Exposure Thresholds

Minimum oil thickness thresholds are used in the SIMAP model in the determination of the probability of oil contamination. The thresholds are specific to the type of impact being considered, either environmental or socioeconomic, and they are used in the calculation of oiling probability to determine if oil is present in a quantity sufficient to cause a particular impact.

Floating oil thickness is of interest because it can determine if mechanical recovery is possible and because different surface slick thicknesses will have different effects on waterfowl and other animals at the sea surface. Surface oil is often expressed in units of grams per square metre (g/m^2), where 1 g/m^2 corresponds to an oil layer that is approximately one micron (µm) thick. Table A-1 lists approximate thickness and mass per unit area ranges for surface oil of varying appearance. Dull brown sheens are about 1 µm thick. Rainbow sheens are about 0.2-0.8 g/m^2 (0.2-0.8 µm thick) and silver sheens are 0.05-0.2 g/m^2 (0.05-0.2 µm thick; NRC 1985). Crude and heavy fuel oil greater than one millimetre (mm) thick appears as black oil. Light fuels and diesel greater than 1 mm thick are not black in appearance but appear brown or reddish. Floating oil will not always have these appearances; however, as weathered oil could be in the form of scattered floating tar balls and tar mats where currents converge.

A typical approach to using oil spill models in oil spill response planning is to first apply the stochastic model to determine the probability and timing for the spill scenarios of interest. The stochastic approach captures variability in the trajectories 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 modelled in stochastic mode to provide composite footprints to estimate probability that a specific area would be impacted by the spill and timing of arrival of the spill at a particular area for each season or wind regime in the region.

Table A-1: Oil Thickness (µm) and Appearance on Water

Minimum	Maximum	Appearance
0.05	0.2	Colourless 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

Source: NRC 1985

The SIMAP model uses specific oil thickness thresholds for calculating the probability or likelihood of the presence of oil on the sea surface or shoreline. Oil thickness thresholds defining the minimum value for expected potential effects to the sea surface and shoreline are listed in Table A-2. Socio-economic thresholds were used in all modelling for this project (1 µm for surface oiling and 1 µm for shoreline oiling). All predictions of the probability of shoreline oiling and sea surface contamination are based on these oil thickness thresholds.

Table A-2: Oil Thickness Thresholds for Sea Surface and Shoreline Oiling

Threshold Type	Threshold (Mass/Unit Area)	Threshold (Thickness)	Rationale (Socioeconomic, Environmental)
Oil on Water Surface	1.0 g/m^2	1.0 µm, 0.001 mm	A conservative environmental threshold for consideration of sublethal effects on birds, marine mammals, and sea turtles from floating oil.

Threshold Type	Threshold (Mass/Unit Area)	Threshold (Thickness)	Rationale (Socioeconomic, Environmental)
Oil on Shoreline	1.0 g/m^2	1.0 µm, 0.001 mm	A conservative socioeconomic/ response threshold. This is a threshold for potential effects on socioeconomic resource uses, as this amount of oil may trigger the need for shoreline clean-up on amenity beaches, and affect shoreline recreation and tourism.

A.7. Determination of Worst-Case Discharge Requirements

There are no regional or Guyana-specific standards for determining a worst case discharge (WCD) volume; thus, for the purposes of this plan considered US requirements as generally accepted practice and approach. The U.S. Department of Interior Bureau of Safety and Environmental Enforcement's (BSEE) Oil Spill Preparedness Division (OSPD) is responsible for developing and managing regulations that supervise industry's preparedness to contain, recover, and remove oil discharges from offshore facilities. As required by the U.S. Federal Water Pollution Control Act and the Oil Pollution Act of 1990, these regulations require the operators of these offshore facilities submit an Oil Spill Response Plan (OSRP) that outlines the procedures they have in place and the spill Guyana has not established a mechanism for the determination of a Worst Case Discharge (WCD) or Most Credible WCD and therefore this plan is aligned with the guidelines as established by response resources they would contact in order to respond, to the maximum extent possible, to their WCD. It is important to note these U.S. laws and regulations are being cited only for guidance in conducting the modelling.

BSEE guidelines on WCD are published in the US Department of Interior BSEE Worst Case Discharge Analysis (Volume I, February 2016). Although WCD modelling results "present an extremely dire representation of the potential for contact between the discharged oil and the environment, they do provide a working baseline of datum that will be useful for further analysis" (BSEE, 2016).

The US Bureau of Ocean Energy Management (BOEM) defines the WCD as the single highest *daily flow rate* of liquid hydrocarbon during an uncontrolled wellbore flow event (i.e., the average daily flow rate on the day that the highest rate occurs, under worst-case conditions). It is neither the total volume spilled over the duration of the event, nor the maximum possible flow rate that would result from high-side reservoir parameters. It is a single value for the expected flow rate calculated under worst-case wellbore conditions using expected reservoir properties. The main purpose of a WCD calculation is to support oil spill response planning. The duration of the WCD release is typically 30-days unless shutting in the well with a capping stack or other technology is expected to occur earlier.

The estimate of flow rate from any wellbore normally begins with an inflow/outflow assessment. The inflow performance relationship (IPR) is determined by one of several possible methods, such as Darcy's Law for steady-state radial flow, the use of a numerical reservoir simulator, etc. This requires knowledge of the zones capable of flow, the rock and fluid properties of those zones, and the wellbore configuration. The result is an equation that describes the liquid flow vs.

the flowing bottom-hole pressure (BHP) in the well. An outflow correlation is used to calculate the pressure drop in the well from reservoir to surface at various flow rates, which is then used to calculate the flowing BHPs.

The flow rate and associated flowing BHP, is determined from the intersection of these two equations. The method chosen, between analytical techniques and numerical simulation depend on the amount of data available and the understanding of the reservoir. This can be quite different when drilling exploration / appraisal wells vs. development / production wells, and so, different methods may be employed. The tool selection should depend on the data available, the level of understanding, and also on the complexities of the reservoir. In most cases, the various tools and methods will yield similar results for the same set of reservoir and wellbore properties.

The WCD values represent an *open well condition in which no flow restrictions or well control technologies such as blow out preventers are in operation*. Although modelling of this scenario supports oil spill response planning, it represents an operational condition that is highly unlikely to be encountered during drilling operations. However, EMGL's response strategy – inclusive of a capping stack – is robust and would be adequate to cover the WCD. In a more representative scenario, apart from BOPs on the wellhead, there would be drill string, tubing, and/or other equipment in the wellbore during a well control event, which would partially constrain and restrict flow from the reservoir.

A.8. References

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APPENDIX B – OFFSHORE SPILL MODELLED RESULTS

This appendix summarizes the Development Projects stochastic and deterministic modelled results and provides a description with results for the oil spill modelling conducted. In addition, stochastic and deterministic modelled results for exploration drilling is included.

As indicated in Table 3-2: Modelled Scenarios by Offshore Assets for Liza Phase 1, Liza Phase 2, and Payara, various surface releases (i.e., 50 and 250 BBL marine diesel; 50, 250, and 2500 BBL crude oil) were modelled as well to inform response planning. As the locations of the Projects and the volumes for the surface releases did not create discernible differences in the modelling done for earlier projects, these hypothetical releases are used to establish the guidance for planning and response actions for those scenarios. However, modelling of wellhead Most Credible WCD (MCWCD) and WCD were carried out and results are presented in the following sections.

B.1. Payara Development Project Oil Spill Modelling

B.1.1. Payara Development Project Oil Properties

The physical and chemical properties of the oil are used by the OILMAPDEEP and SIMAP (Spill Impact Model Application Package) models in calculations of the transport and fate of the spill. The oil used in the models is medium crude that can incorporate water when spilled and increase both the volume and viscosity of the spilled oil. Assessment of this type of oil indicated that while it can take on water, it will not emulsify quickly as some heavier crude oils. This will serve to keep the oil relatively non-viscous for many hours depending on spill and environmental conditions, which improves the window of opportunity for oil spill response. The oil characterization utilized in this modelling study was determined from a chemical analysis of the oil collected in the field. The dispersibility of the oil was determined using a field sample of the oil in a laboratory test measuring dispersibility of the oil after weathering. Table B-1 lists some of the properties of the Payara oil used in the model simulations.

Table B-1: Properties of the Crude Oil Used in the Spill Modelling

Density (g/cm^3 at 15°C)	Viscosity	API Gravity	Pour Point (°C)	Maximum Water Content (%)
0.896	109.6 @4.4°C	26.5	-3.0	85

°C = degrees Celsius; API = American Petroleum Institute; cP = centipoise; g/cm^3 = grams per cubic centimetre

B.1.2. Payara Stochastic Modelling Results – Unmitigated

Stochastic simulations provide insight into the probable behaviour of potential oil spills in response to temporally and spatially-varying meteorological and oceanographic conditions in the study area. The stochastic model computes surface trajectories for an ensemble of hundreds of individual cases for each spill scenario, thus sampling the variability in regional and seasonal wind and current forcing by starting the simulation at different dates within the timeframe of interest. Thus, the stochastic results represent sensitivity to the environmental variability, as each trajectory experiences a different set of wind and current conditions that occur based on the model start date.

The stochastic analysis provides two types of information: 1) the footprint of sea surface areas that might be oiled and the associated probability of oil contamination; and 2) the shortest time required for oil to reach any point within the areas predicted to be oiled. The areas and probabilities of oil contamination are generated by a statistical analysis of all the individual stochastic runs. It is important to note that a single run will encounter only a relatively small portion of this footprint. In addition, the simulations provide shoreline oil contamination data expressed in terms of minimum and average times for oil to reach shore, and the percentage of simulations in which oil is predicted to reach shore.

The SIMAP model was used to predict the probability of oil contamination on the water surface and shoreline for spills occurring in two seasons corresponding to seasonal wind regimes. Results from the SIMAP stochastic modelling are provided in maps depicting the probability and timing of oil contamination on the water surface and maps depicting the probability and timing of oil contamination on the shoreline. Output from the selected spill events is provided as a map of the spill trajectory and as oil mass balance graphs showing the time history of oil volume in the environment.

Surface oil is predicted to travel towards the northwest in all scenarios during both the summer and winter seasons, although the trajectory with the potential to produce coastal impacts in Guyana and Venezuela is more likely to occur in the winter season. For those simulations predicted to reach the shoreline, the probability of shoreline oiling tends to be highest on the coast of Trinidad and Tobago due to the predominant current flow through the Stabroek Block and into the Caribbean Sea. Probabilities of shoreline oiling range between 5 and >90 percent on the coast of Trinidad and Tobago. Lower shoreline oiling probabilities (5-30 percent) are predicted as far north as Martinique and as far west as Colombia. The time of first arrival of oil on shore for spill events ranked as the 95th percentile ranges from 5 to 9 days. Differences in release volumes, as well as seasonal wind speed and direction, result in a wide range in sea surface contamination by oil (10 km^2 and 1,285,994 km^2) and shoreline length oiled (0 kilometres though 1,355 kilometres). For larger spill volumes, strong easterly winds (predominantly during winter) result in significant shoreline oiling in Trinidad and Tobago, Venezuela, Aruba, Bonaire, and Curacao, while lower wind speeds in summer would allow the surface plume to be transported further to the north and into a portion of the Caribbean Sea, oiling shorelines in Trinidad and Tobago, the southern Lesser Antilles, and the western Greater Antilles.

B.1.3. Payara Marine Diesel (June through November)

Payara Water Surface Results – 50 Barrel Scenario (Unmitigated)

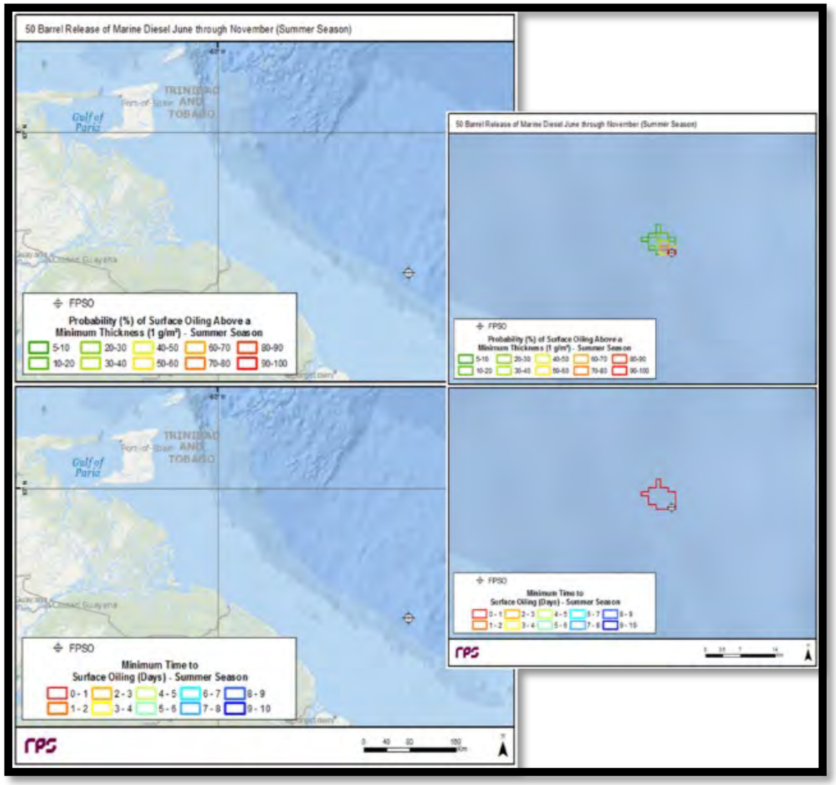


Figure B-1: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from June through November for a 50 bbl release of Marine Diesel. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

Payara Water Surface Results – 250 Barrel Scenario (Unmitigated)

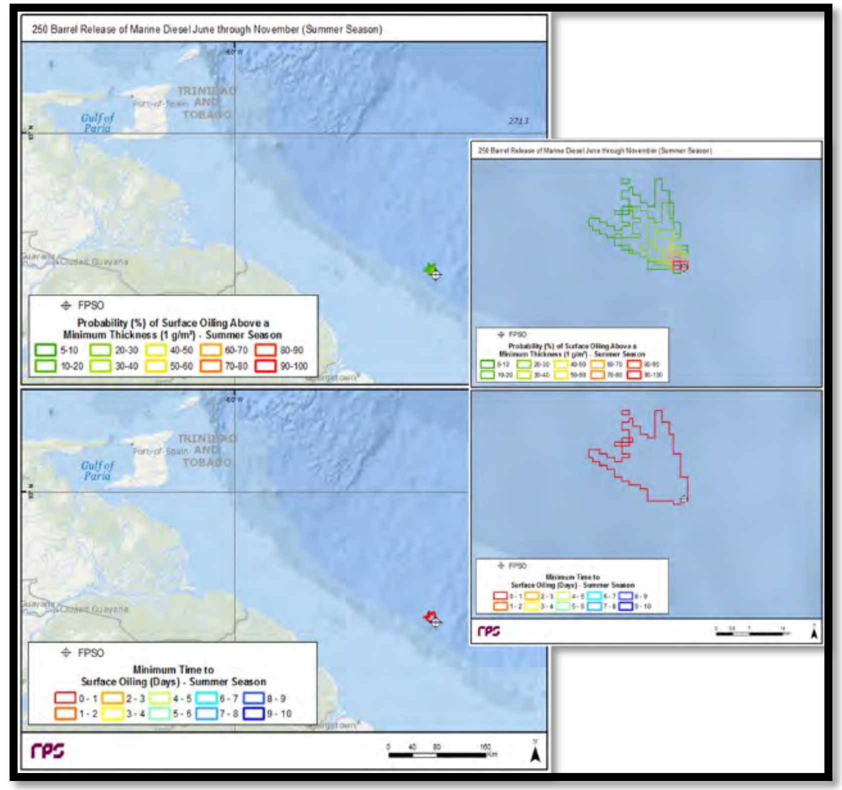


Figure B-2: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from June through November for a 250 bbl release of Marine Diesel. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

B.1.4. Payara Marine Diesel (December through May)

Payara Water Surface Results – 50 Barrel Scenario (Unmitigated)

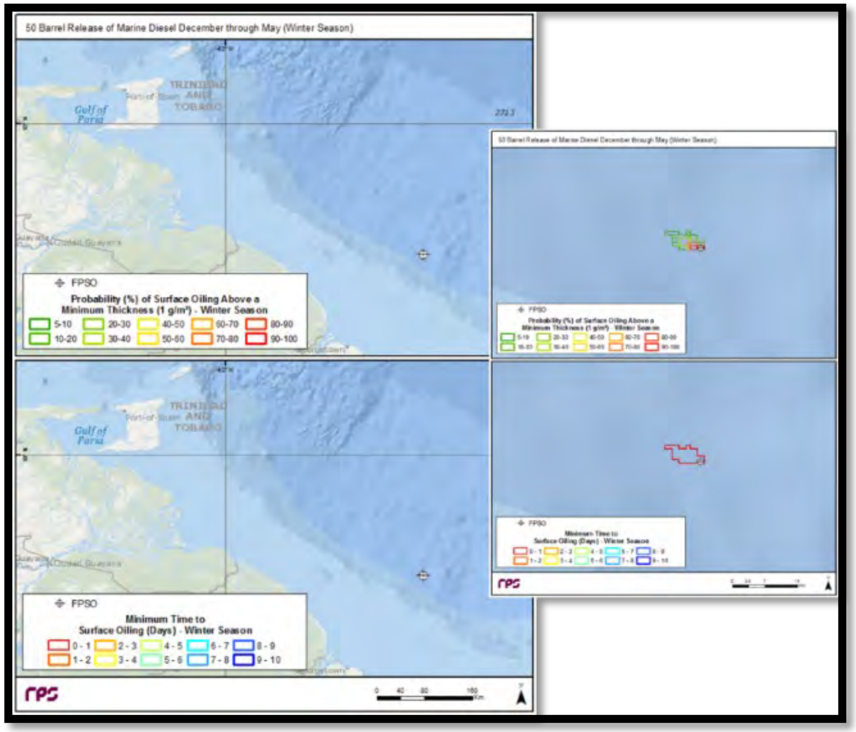


Figure B-3: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from December through May for a 50 bbl release of Marine Diesel. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

Payara Water Surface Results – 250 Barrel Scenario (Unmitigated)

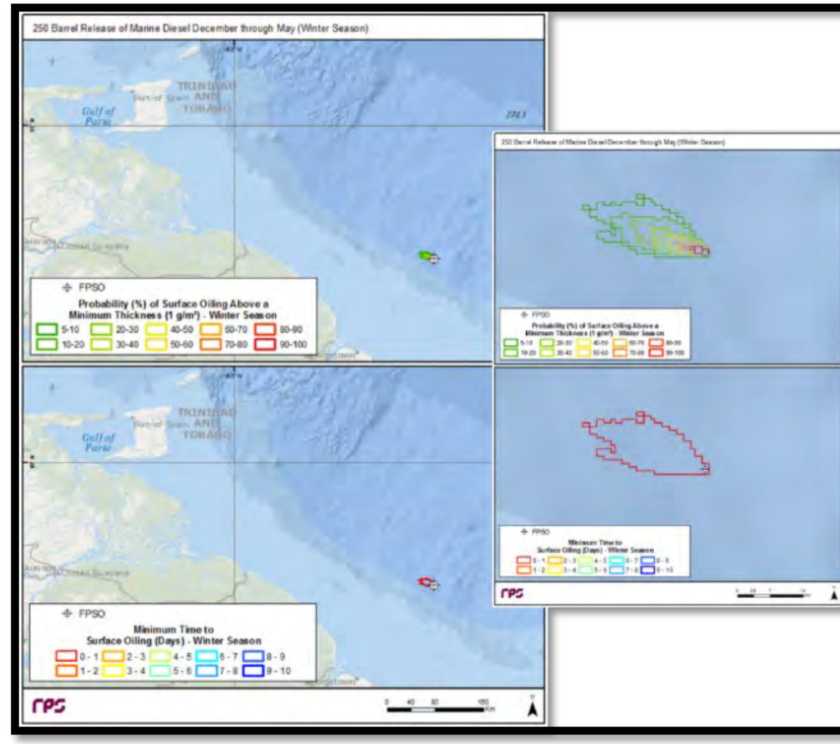


Figure B-4: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from December through May for a 250 bbl release of Marine Diesel. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail

B.1.5. Payara Crude Oil (June through November)

Payara Water Surface Results – 50 Barrel Scenario (Unmitigated)

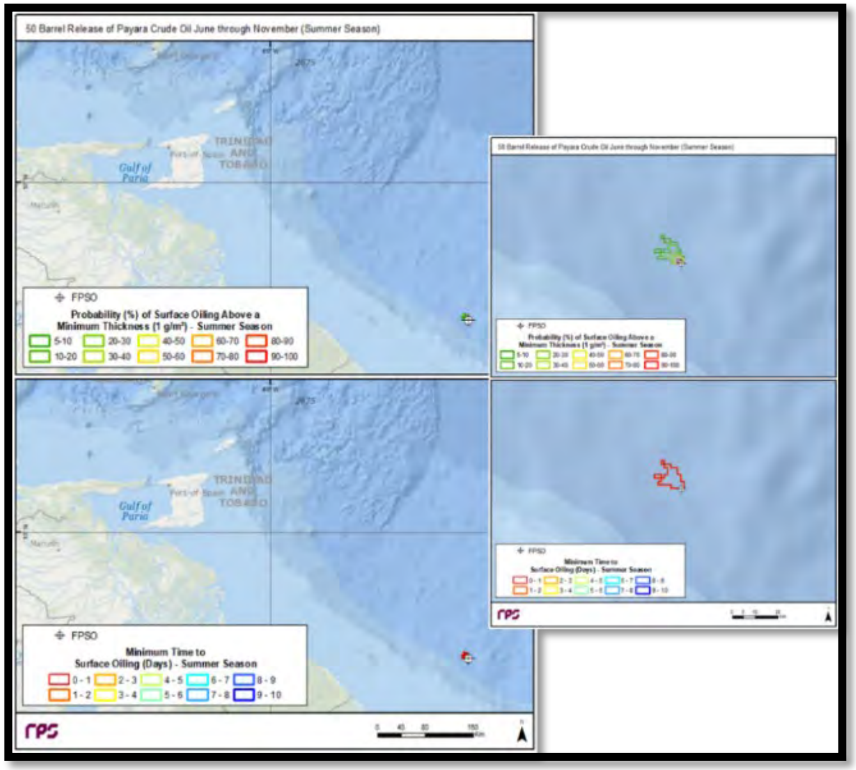


Figure B-5: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from June through November for a 50 bbl release of Crude Oil. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

Payara Water Surface Results – 2500 Barrel Scenario (Unmitigated)

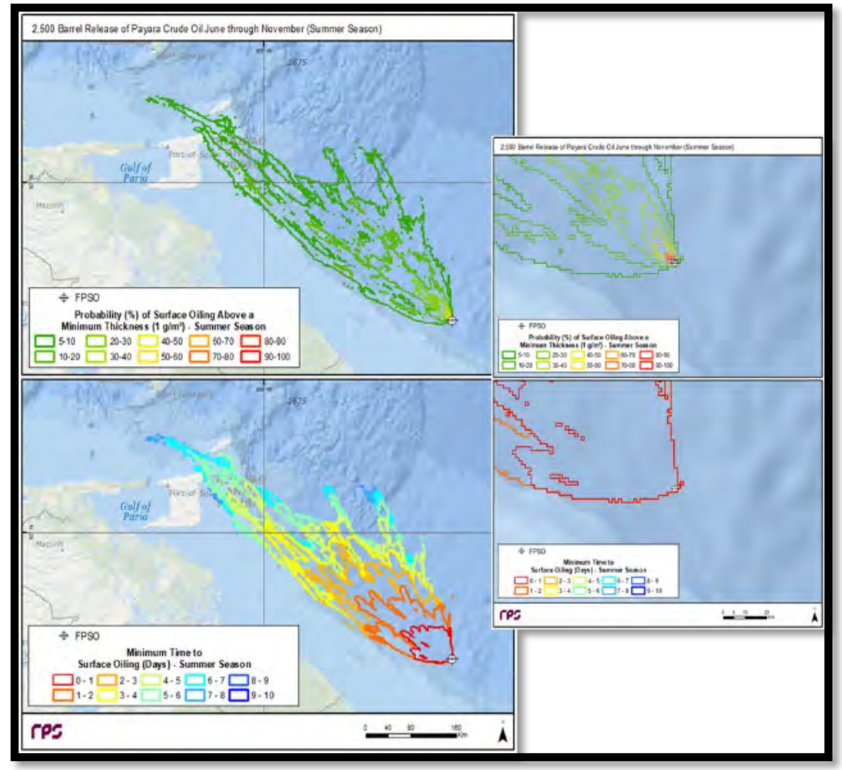


Figure B-6: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from June through November for a 2500 bbl release of Crude Oil. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

B.1.6. Payara Crude Oil (December through May)

Payara Water Surface Results – 50 Barrel Scenario (Unmitigated)

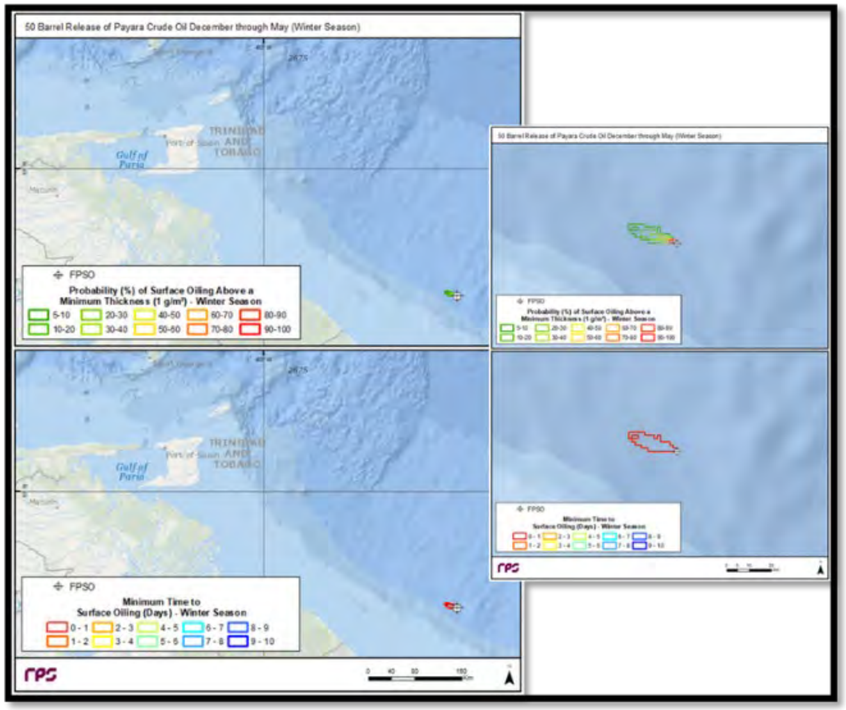


Figure B-7: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from December through May for a 50 bbl release of Crude Oil. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

Payara Water Surface Results – 2,500 Barrel Scenario (Unmitigated)

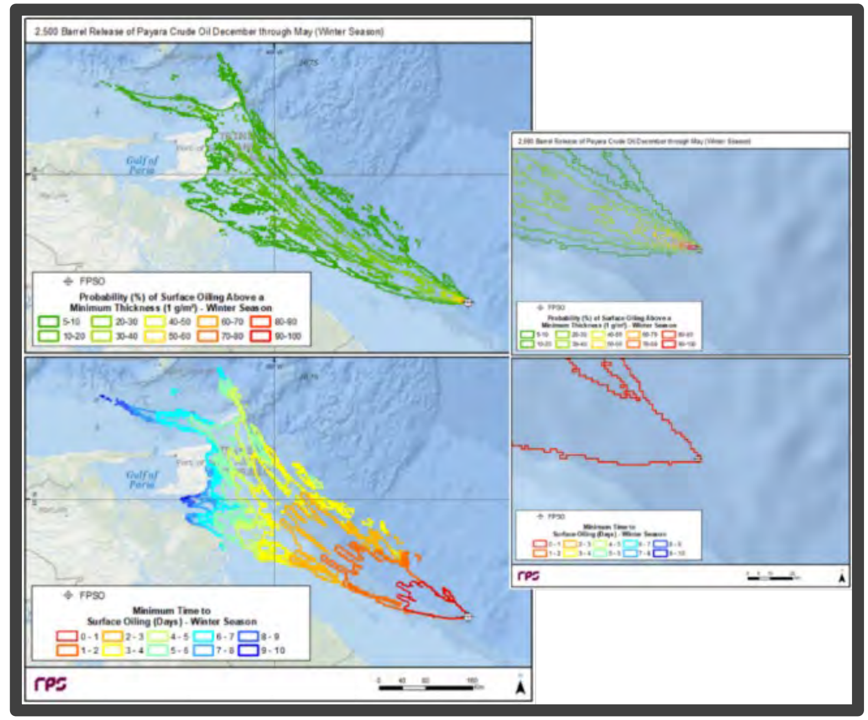


Figure B-8: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from December through May for a 2,500 bbl release of Crude Oil. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

B.1.7. Payara Wellbore Fluids (June through November)

Payara Water Surface Results – Maximum WCD: 202,192 BPD Scenario for 30 Days (Unmitigated)

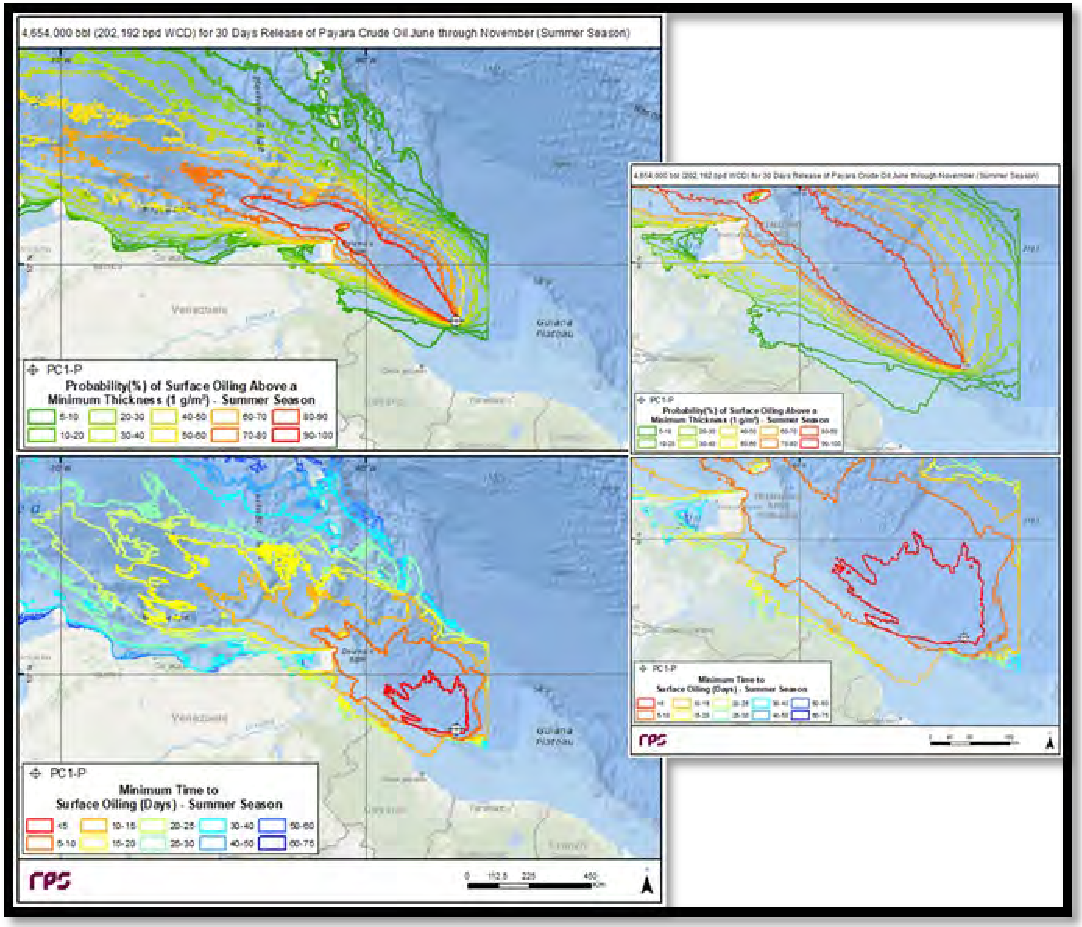


Figure B-9: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from June through November for a 202,192 bbl/day release (Maximum WCD) of Crude Oil. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

B.1.8. Payara Wellbore Fluids (December through May)

Payara Water Surface Results – Maximum WCD: 202,192 BPD Scenario for 30 Days (Unmitigated)

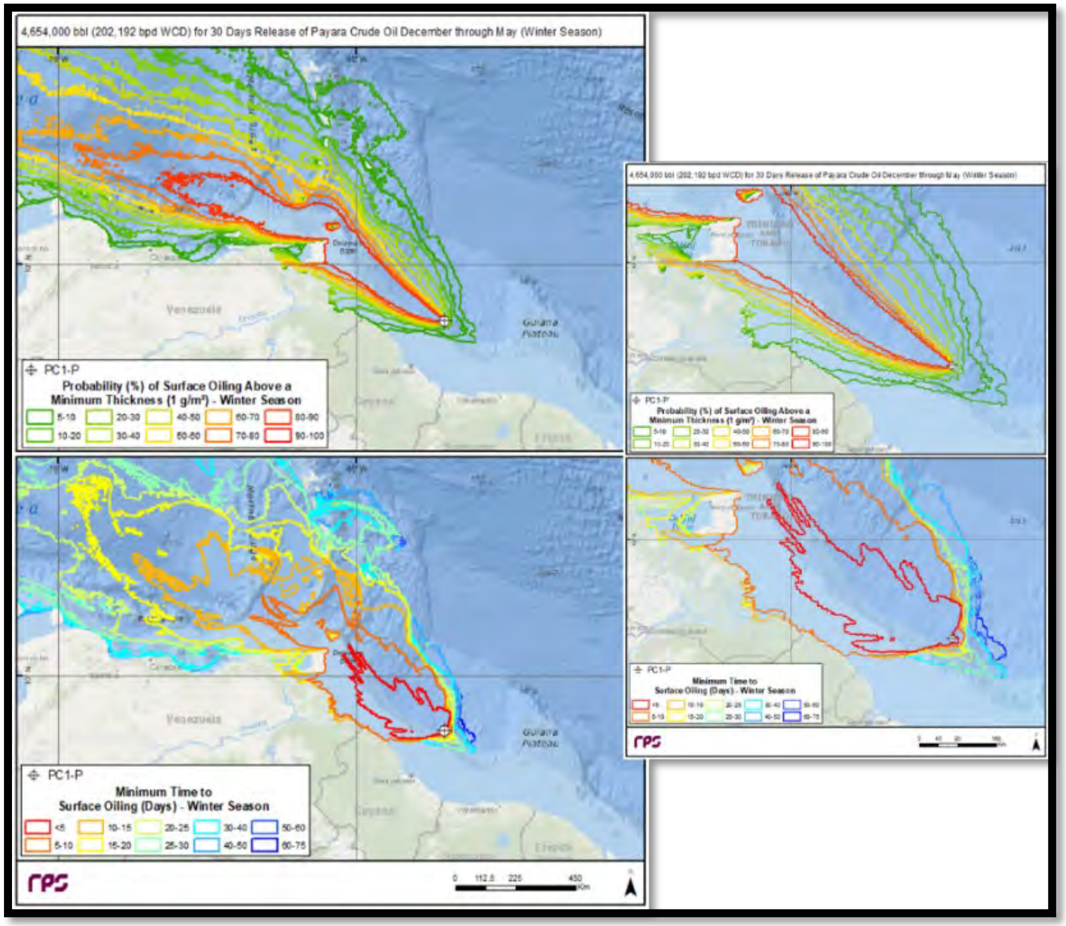


Figure B-10: Top Panel – Probability of surface oiling above a minimum thickness of 1 µm from December through May for a 202,192 bbl/day release (Maximum WCD) of Crude Oil for 30-day release. Bottom Panel – Minimum time for surface oil thickness to exceed 1 µm. Inset Panel – Detail.

B.1.9. Payara Deterministic Model Results – Unmitigated and Mitigated

For each stochastic scenario, one deterministic trajectory and fate simulation is run to investigate a specific "worst-case" spill event that could potentially occur using the same combination of winds and current forcing used in the corresponding stochastic simulation from which it was identified. The worst-case scenario is selected based on the degree of shoreline oil contamination. Different parameters or indicators can be used to compare and assess the degree of shoreline oil contamination, for example "time to reach the coast", "oil volume to reach the coast", or "total length of oiled coastline". Individual spill events simulated in each stochastic scenario were selected based on their rank according to the shortest time to reach shore during each season. A single deterministic spill event ranked as the 95th percentile for the shortest time to reach shore was then selected from each stochastic scenario. These spill events represent meteorological and oceanographic conditions that result in the near minimum time for shoreline oiling to occur. There were five stochastic scenarios in which fewer than five deterministic simulations (5 percent) were predicted to reach shore. For these scenarios, individual spill events simulated in each stochastic scenario were selected based on their rank according to the maximum water surface area oiled. Therefore, a single deterministic spill event ranked as the 95th percentile water surface area oiled was selected for these scenarios.

The time of first arrival of oil on shore for the spill events ranked as the 95th percentile ranges from 7 to 10 days. Differences in seasonal wind speed and direction, and variable release volumes result in a wide range in sea surface exposure to oil (10 km^2 and 1,285,994 km^2) and shoreline length oiled (0 kilometres though 1,355 kilometres). Strong easterly winds result in significant shoreline oiling in Trinidad and Tobago, while allowing additional surface oil transport to the northwest of Trinidad and Tobago into the Caribbean Sea, for larger volume spills.

Response measures were simulated for the summer and winter 2,500 bbl crude surface release, and the 202,192 BPD Maximum WCD loss-of-well-control scenario. The Maximum WCD value of 202,192 BPD represents the highest daily release rate (i.e., on Day 1). This volume decreases on a daily basis, such that the Maximum WCD release scenario discharges 4,654,000 bbl over the 30-day unmitigated release and 940,275 bbl over the 5-day mitigated release. Response measures reflected in the mitigated scenario included a capping stack applied to the well head after 5 days, dispersants applied aerially and by boat, burning, and mechanical removal. Response measures resulted in a reduction of shoreline oiling and a reduction in the surface area of oil contamination to water. Scenarios for the 50 bbl, 250 bbl, and 2,500 bbl surface releases were modelled for 10 days. Scenarios for the mitigated 202,192 BPD Maximum WCD scenario were modelled for 54 days.

At the time the Payara EIA was originally submitted, the response time associated with the Boots & Coots GRIP capping stack deployment was based on preliminary and conservative logistics assumptions. After establishing the subscription to the Boots & Coots GRIP system, and in conjunction with the ongoing capping stack study, the response time model has been refined to reflect current logistics strategies and it is now estimated that the capping stack deployment is possible within 5.5 days, assuming no debris removal activities are required.

Once deployed, final capping operations would occur and the well could be shut in. The WCD releases that were analysed would represent some of the largest offshore releases in the history of the industry. The responses that were applied to them represent credible responses in terms of both timing and scope. If a release of this magnitude occurred, the response would be monitored for performance and would be scaled-up as necessary to minimise shoreline impacts in the Caribbean. Additional response services would be initially sourced from ExxonMobil's OSR vendors in the nearby Gulf of Mexico region and would extend beyond that region, as needed. Releases of this magnitude are very rare and the response that was applied to them in the response Etkin provides insights and comparisons among the various projects regarding additional needs that would be needed should such an unlikely event occur. The summaries of mass balances at the end of the simulations are presented in Table B-2.

Table B-2: Representative worst-case scenario mass balance at the end of the simulation as percent (%) of the total column of oil released.

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation
Payara FPSO 50 bbl Marine Diesel Release – Summer Season	3.9	2.6	0.0	90.1	3.4
Payara FPSO 50 bbl Marine Diesel Release – Winter Season	<0.1	29.8	0.0	65.5	4.6
Payara FPSO 250 bbl Marine Diesel Release – Summer Season	1.1	20.5	0.0	75.2	3.2
Payara FPSO 250 bbl Marine Diesel Release – Winter Season	0.0	29.9	0.0	65.5	4.6
Payara FPSO 50 bbl Payara Crude Release – Summer Season	60.6	1.9	5.3	26.5	5.7
Payara FPSO 50 bbl Payara Crude Release – Winter Season	10.7	0.2	41.1	42.6	5.4
Payara FPSO 2,500 bbl Payara Crude Release – Summer Season	52.9	0.2	16.1	25.3	5.6
Payara FPSO 2,500 bbl Payara Crude Release – Winter Season	69.2	0.0	0.6	24.7	5.5
Mitigated Payara FPSO 2,500 bbl Payara Crude Release – Summer Season	0.0	62.4	0.0	23.4	13.7
Mitigated Payara FPSO 2,500 bbl Payara Crude Release – Winter Season	0.0	62.6	0.0	23.4	13.9

B. Offshore Spill Modelled Results

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation
Payara Wellhead 4,654,000 bbl (202,192 bpd) Payara Crude Release – Summer Season (Maximum WCD)	45.5	2.1	2.0	13.7	36.1
Payara Wellhead 4,654,000 bbl (202,192 bpd) Payara Crude Release – Winter Season (Maximum WCD)	44.2	2.1	3.4	13.7	36.1
Mitigated Payara Wellhead 940,275 bbl (202,192 bpd) Payara Crude Release – Summer Season (Maximum WCD)	2.4	30.0	1.1	7.1	56.8
Mitigated Payara Wellhead 940,275 bbl (202,192 bpd) Payara Crude Release – Winter Season (Maximum WCD)	4.7	27.4	2.9	7.3	55.8

B.1.10. Payara Marine Diesel (June through November)

Payara 50 Barrel Scenario (Unmitigated)

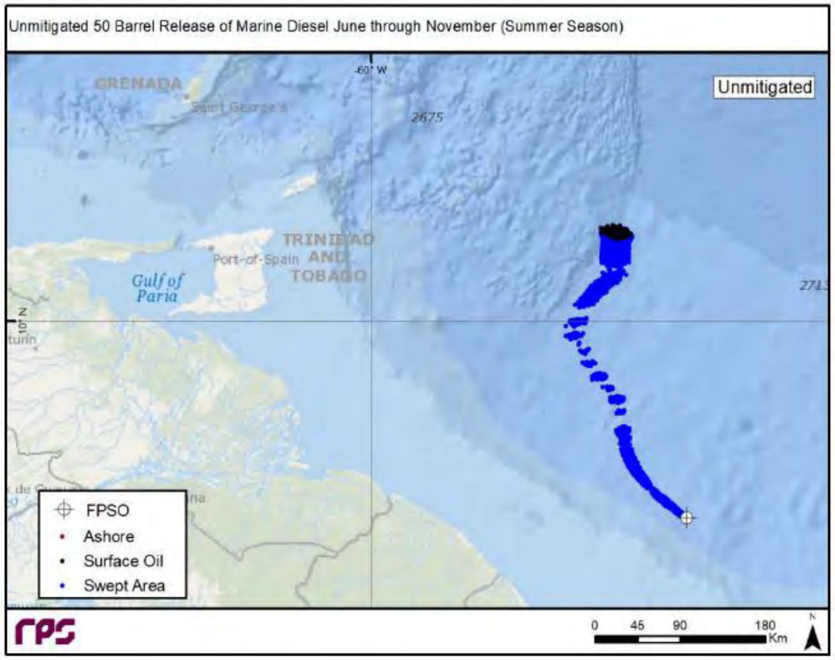


Figure B-11: Unmitigated area swept results for the 95th percentile surface area oiled 50 bbl Marine Diesel release during Jun-Nov season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red (none in this scenario).

Payara 250 Barrel Marine Diesel Scenario (Unmitigated)

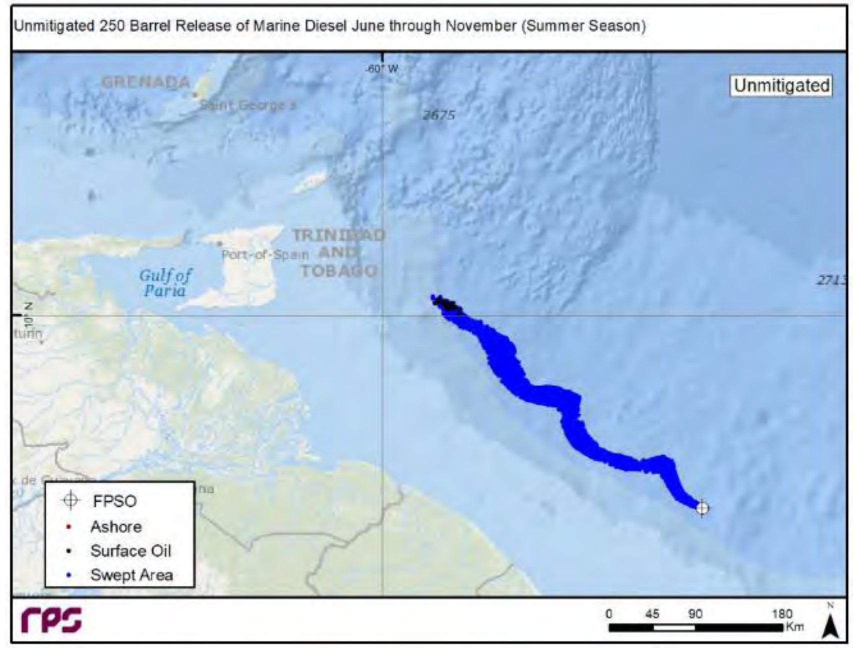


Figure B-12: Area swept results for the 95th percentile surface area oiled 250 bbl Marine Diesel release during Jun-Nov season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red (none in this scenario).

B.1.11. Payara Marine Diesel (December through May)

Payara 50 Barrel Scenario (Unmitigated)

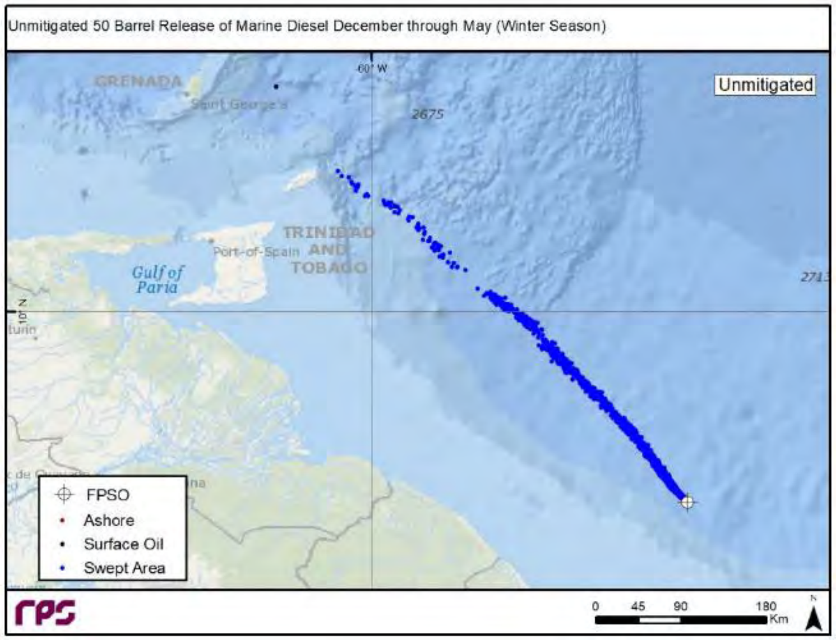


Figure B-13: Unmitigated area swept results for the 95th percentile surface area oiled 50 bbl Marine Diesel release during Dec-May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red (none in this scenario).

Payara 250 Barrel Marine Diesel Scenario (Unmitigated)

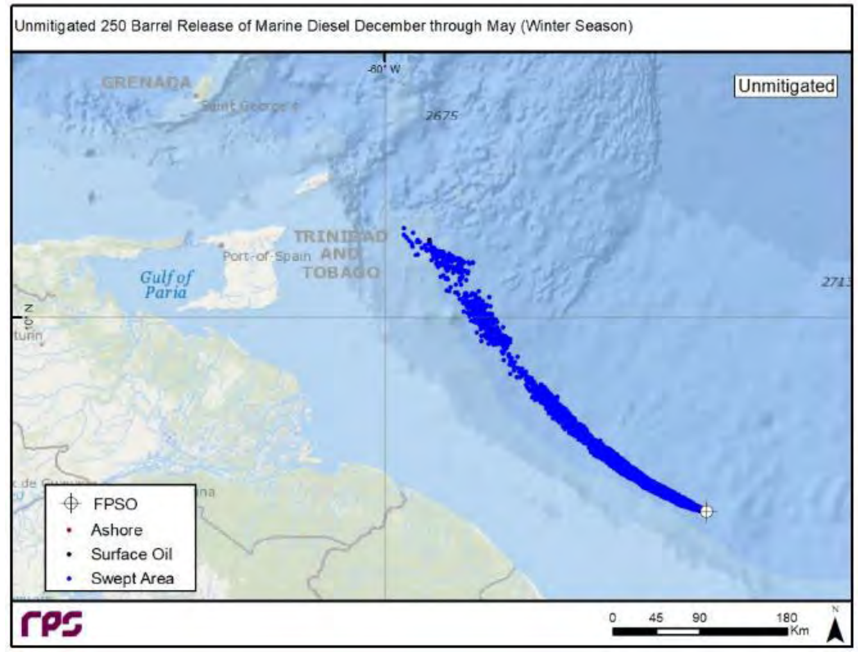


Figure B-14: Unmitigated area swept results for the 95th percentile surface area oiled 250 bbl Marine Diesel release during Dec-May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red (none in this scenario).

B.1.12. Payara Crude Oil (June through November)

Payara 50 Barrel Scenario (Unmitigated)

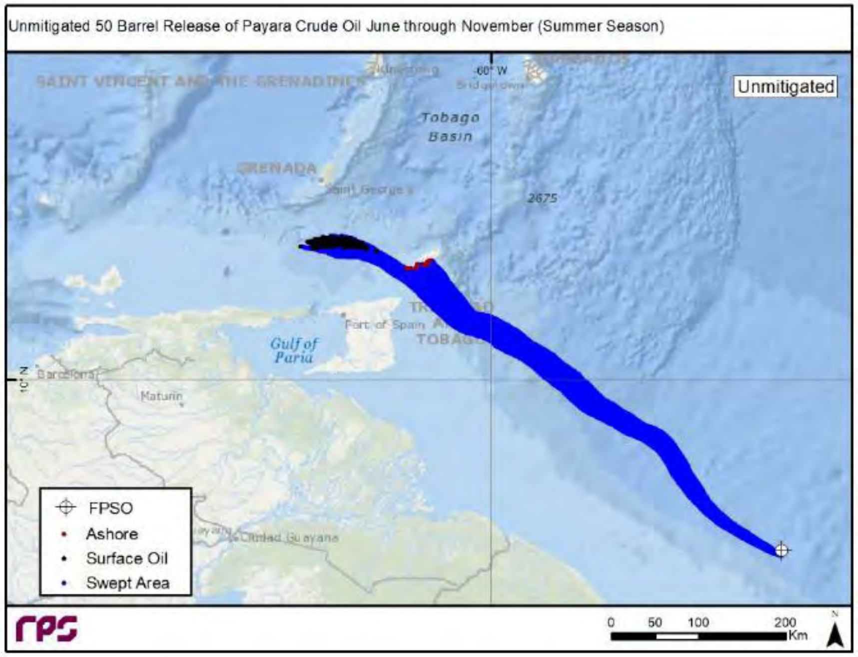


Figure B-15: Unmitigated area swept results for the 95th percentile minimum time to shoreline 50 bbl Crude Oil release during June through November season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red.

Payara 2,500 Barrel Crude Oil Scenario (Unmitigated)

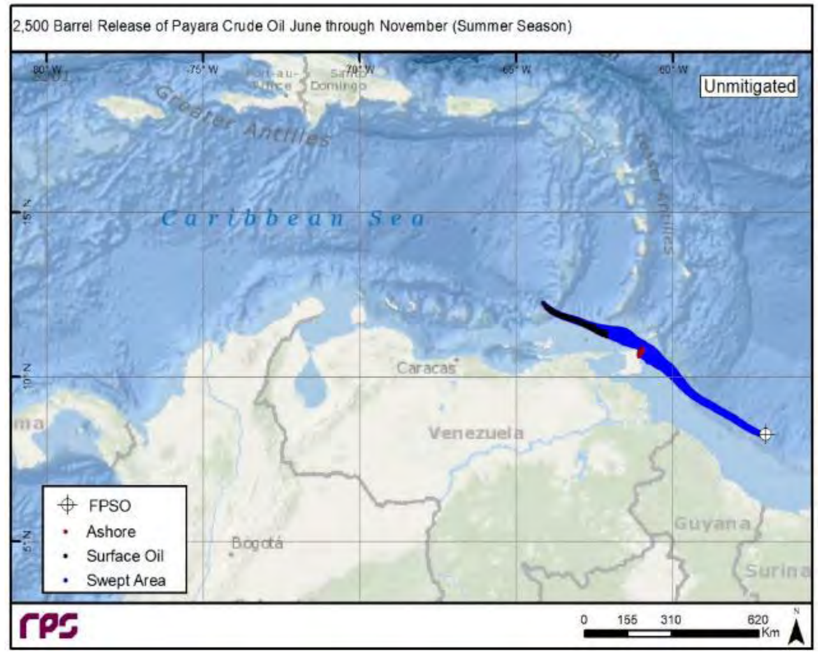


Figure B-16: Unmitigated area swept results for the 95th percentile minimum time to shoreline 2,500 bbl Crude Oil release during June through November season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red.

Payara 2,500 Barrel Crude Oil Scenario (Mitigated)

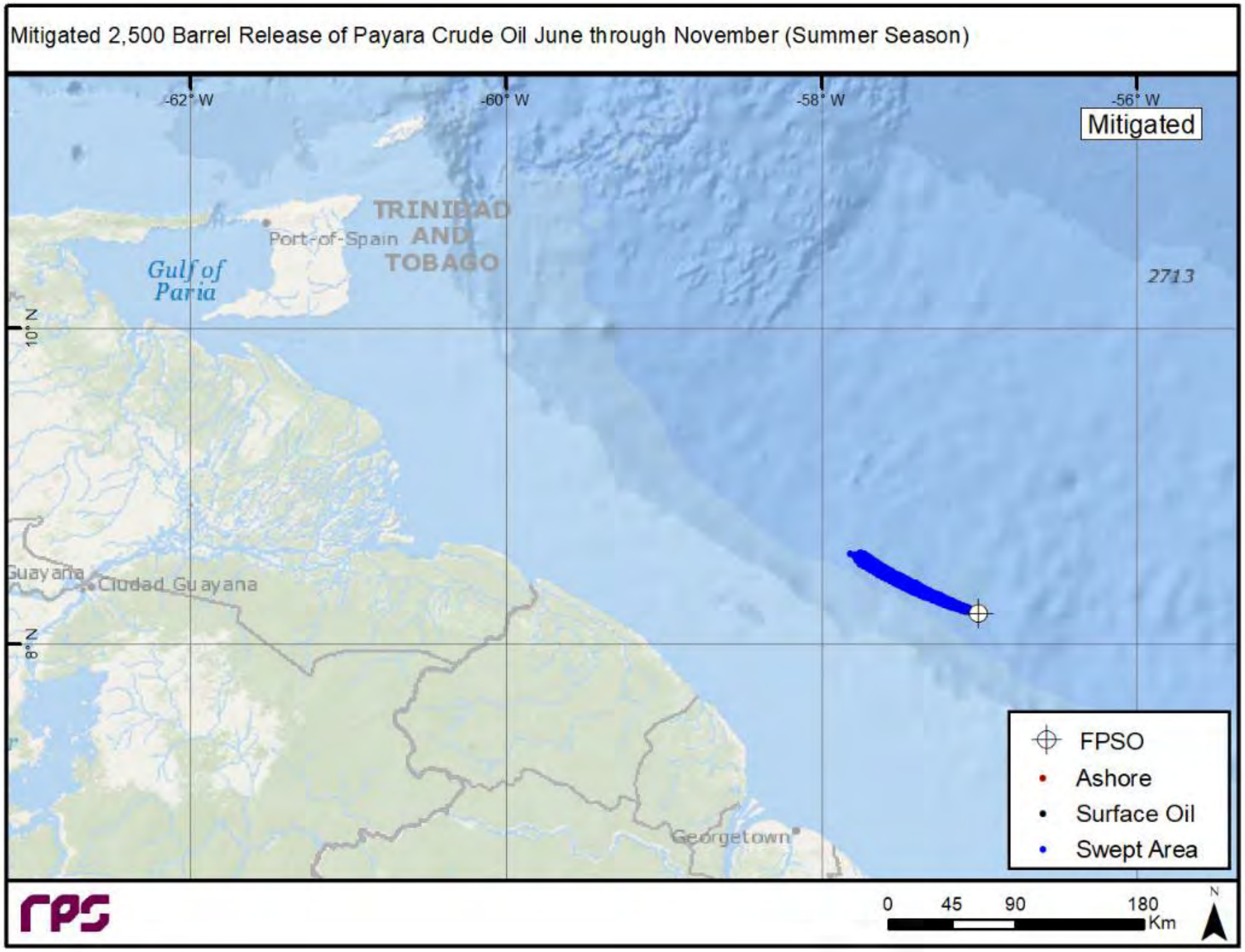


Figure B-17: Mitigated area swept results for the 95th percentile minimum time to shoreline 2,500 bbl Crude Oil release during June through November season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black (none in this scenario), and shoreline oiling is displayed in red (none in this scenario).

B.1.13. Payara Crude Oil (December through May)

Payara 50 Barrel Crude Oil Scenario (Unmitigated)

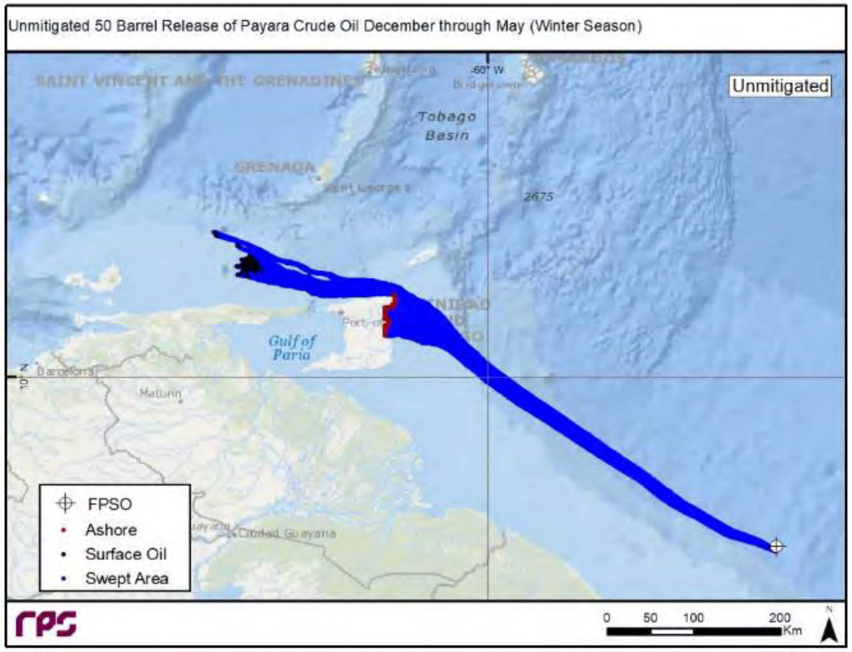


Figure B-18: Unmitigated area swept results for the 95th percentile minimum time to shoreline 50 bbl Crude Oil release during December through May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red.

Payara 2,500 Barrel Crude Oil Scenario (Unmitigated)

Figure B-19: Unmitigated area swept results for the 95th percentile minimum time to shoreline 2,500 bbl Crude Oil release during December through May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black, and shoreline oiling is displayed in red.

Payara 2,500 Barrel Crude Oil Scenario (Mitigated)

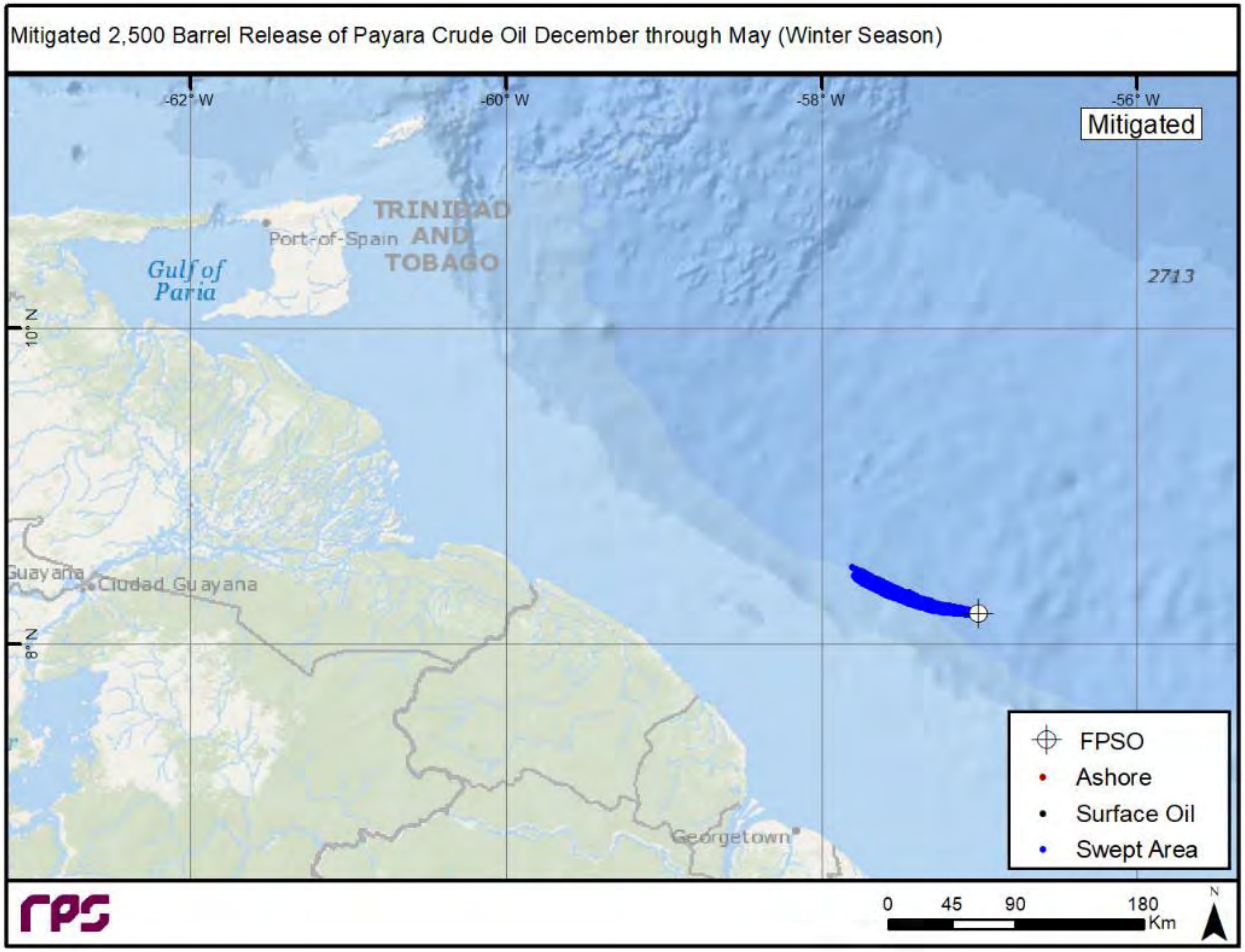


Figure B-20: Mitigated area swept results for the 95th percentile minimum time to shoreline 2,500 bbl Crude Oil release during December through May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of the 10-day scenario are presented in black (none in this scenario), and shoreline oiling is displayed in red (none in this scenario).

B.1.14. Payara Wellbore Fluids (June through November)

Payara Maximum WCD: 202,192 BPD Crude Oil Scenario for 30 Days (Unmitigated)

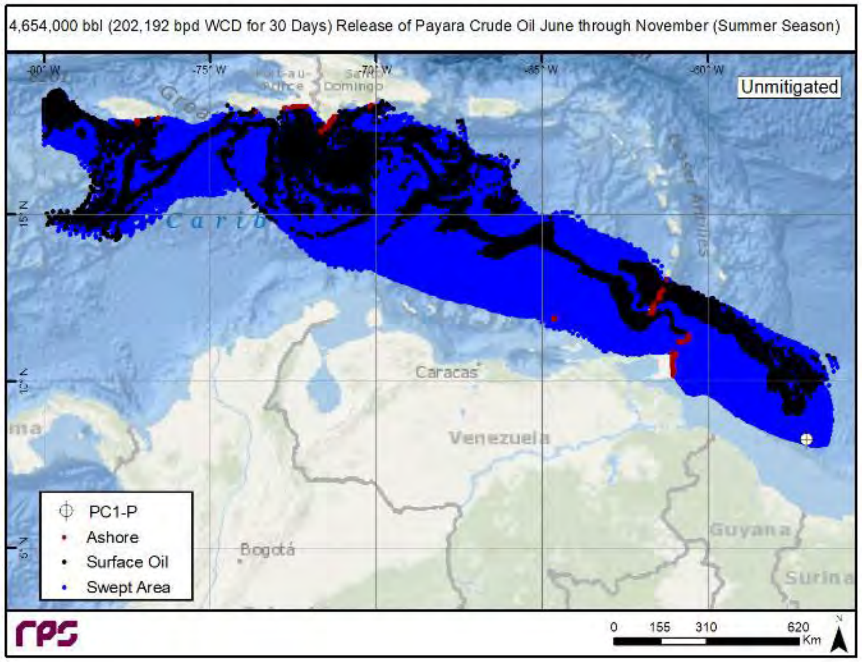


Figure B-21: Unmitigated area swept results for the 95th percentile minimum time to shoreline 202,192 bbl/day Crude Oil release (Maximum WCD) for 30 days during June through November season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of a 54-day scenario are presented in black, and shoreline oiling is displayed in red.

Payara Maximum WCD: 202,192 BPD Crude Oil Scenario for 5 Days (Mitigated)

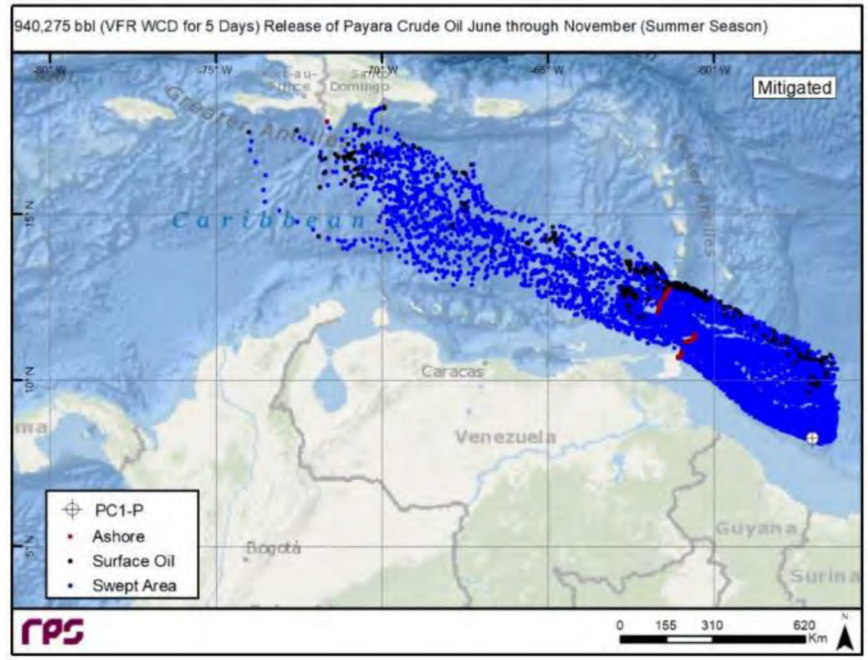


Figure B-22: Mitigated area swept results for the 95th percentile minimum time to shoreline 202,192 bbl/day Crude Oil release (Maximum WCD) for 5 days during June through November season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of a 54-day scenario are presented in black, and shoreline oiling is displayed in red.

B.1.15. Payara Wellbore Fluids (December through May)

Payara Maximum WCD: 202,192 BPD Crude Oil Scenario for 30 Days (Unmitigated)

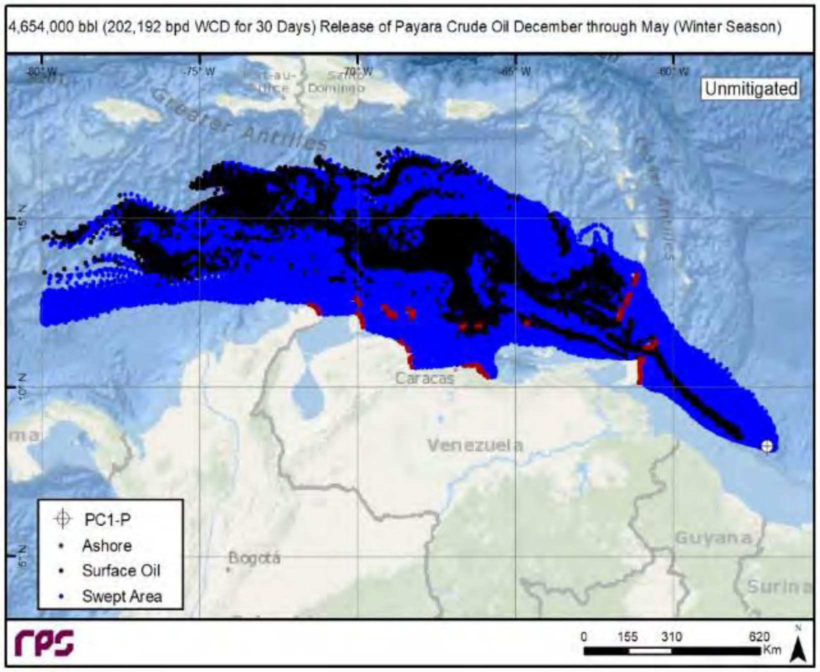


Figure B-23: Unmitigated area swept results for the 95th percentile minimum time to shoreline 202,192 bbl/day Crude Oil release (Maximum WCD) for 30 days during December through May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of a 54-day scenario are presented in black, and shoreline oiling is displayed in red.

Payara Maximum WCD: 202,192 Barrel per Day Scenario for 5 Days (Mitigated)

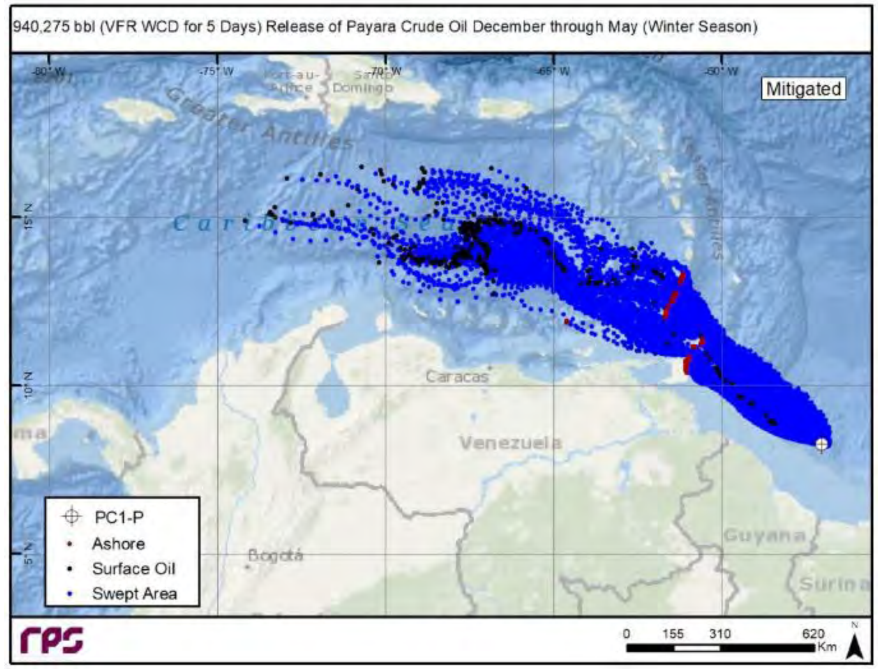


Figure B-24: Mitigated area swept results for the 95th percentile minimum time to shoreline 202,192 bbl/day Crude Oil release (Maximum WCD) for 5 days during December through May season. Area swept is displayed in dark blue, surface oil droplets remaining at the end of a 54-day scenario are presented in black, and shoreline oiling is displayed in red.

B.2. Yellowtail Development Project Oil Spill Modelling

B.2.1. Yellowtail Development Project Oil Properties

The transport and weathering of spilled oil are dependent on chemical and physical oil properties such as boiling point distribution, tendency to form stable or meso-stable water-in-oil emulsions, and oil viscosity. Table B-3 summarizes the characteristics of the hydrocarbon product, a Medium Crude Oil, used for this study. The client provided RPS with detailed information regarding the oil properties of the products and RPS assumed a proxy/generic oil to define any additional properties necessary to run the oil spill model. These properties were based on characterizations from the Environmental Technology Centre of Environment Canada.

Table B-3: Properties of the Crude Oil Used in the Yellowtail Development Project Spill Modelling

Density (g/cm^3 at 15°C)	Viscosity	API Gravity	Pour Point (°C)	Maximum Water Content (%)
0.8558	11 @ 15°C	32.5	-24.0	31

°C = degrees Celsius; API = American Petroleum Institute; cP = centipoise; g/cm^3 = grams per cubic centimetre

B.2.2. Introduction

RPS Ocean Science was contracted by Esso Exploration & Production Guyana Ltd. to assess the trajectory and fate of releases using RPS' SIMAP model in the offshore waters of Guyana both without and with spill response mitigation. This modelling is a continuation of previous modelling for offshore Guyana in the Payara Prospect and in the Liza prospect, completed for Phase 1 and Phase 2. This summary presents the results of the most credible worst-case discharge (Most Credible WCD) and worst-case discharge (WCD) components of the oil spill modelling for the Yellowtail discharge location.

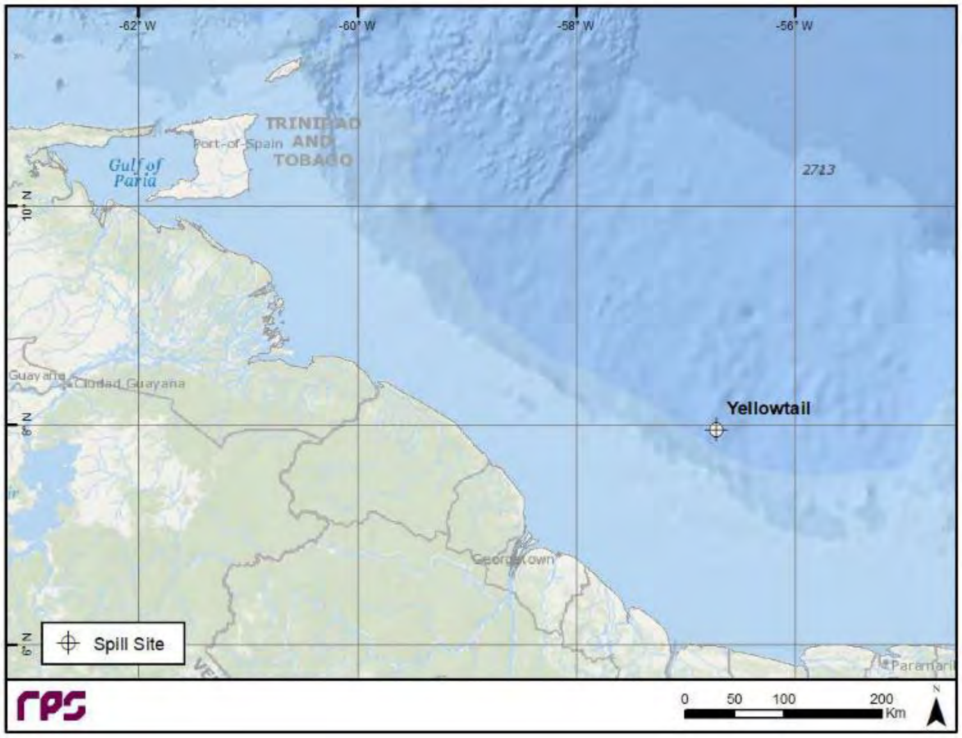
Consistent with Spill Modelling Concepts outlined in Appendix A, four hypothetical spill scenarios were modelled by RPS. The spill scenarios include 30-day loss-of-well-control of a Medium Crude oil modelled for 45 days. The model simulations were run using environmental conditions corresponding to different regimes in the summer (June through November) and winter (December through May) seasons defined in the analysis of long-term wind data at the spill site. Individual spill events were selected from these results based on shoreline exposure to oil. Spill events were selected based on a high WCD in both summer and winter seasons. The loss-of-well-control scenarios were simulated using the OILMAPDeep model to determine the discharge plume geometry, define the oil droplet sizes and provide inputs for the SIMAP model simulations.

B.2.3. Model Scenarios

One site within the Yellowtail Prospect in the Stabroek Block (Yellowtail wellhead) was used for all spill scenarios. The site is located offshore from Guyana, roughly 195 kilometres from the coastline. Table B-4 lists the spill location coordinates, and the figure below is a map showing the site location.

Table B-4: Location used for spill modelling in the Yellowtail prospect (Stabroek Block)

Site Location	Latitude (N)	Longitude (W)
Yellowtail	7.9571	56.7161



B.2.4. Yellowtail Stochastic Modelling Results – Unmitigated

Although explained above as part of the Payara Stochastic Modelling Results, it is important to understand the value of this type of modelling and what is provided. Stochastic simulations provide insight into the probable behaviour of potential oil spills in response to temporally and spatially-varying meteorological and oceanographic conditions in the study area. The stochastic analysis provides two types of information: 1) the footprint of sea surface areas that might be oiled and the associated probability of oil contamination; and 2) the shortest time required for oil to reach any point within the areas predicted to be oiled. The areas and probabilities of oil contamination are generated by a statistical analysis of all the individual stochastic runs. It is important to note that a single run will encounter only a relatively small portion of this footprint. In addition, the simulations provide shoreline oil contamination data expressed in terms of minimum and average times for oil to reach shore, and the percentage of simulations in which oil is predicted to reach shore.

The trajectory of spills at discharge sites from the Yellowtail well head is driven largely by the strong northwest flowing currents running parallel to the South American coast. The easterly and east-northeasterly winds drive oil ashore, but in general are not strong enough the overcome the transport by currents.

Surface oil is predicted to travel towards the northwest in all scenarios during both the summer and winter seasons in the Most Credible WCD and the WCD. These large volume releases in both summer and winter months are predicted to have a greater than 90 percent probability of reaching the shoreline.

The probability of oil contamination on the shoreline tends to be highest on the coast of Trinidad and Tobago, particularly during the winter months, because of the predominant current flow through the Stabroek Block and into the Caribbean. Lower shoreline oiling probabilities (<20 percent) are predicted as far north as Haiti and the Dominican Republic as far west as Colombia. Winter season spills generally show a higher oil stranding probability due to the faster currents and northeasterly winds prevalent during the winter. For the 30-day 88,728 bpd WCD loss-of-well-control scenarios of Medium Crude in the summer season (June – November), surface oil reaches the coast in some segments exceeding 90 percent probability, with the highest probabilities (>80 percent) primarily along the coast of Trinidad and Tobago and lower probabilities (<20 percent) as along Guyana and as far west as Venezuela and as far north as the Dominican Republic.

For the 30-day 88,728 bpd Most Credible WCD loss-of-well-control scenarios of Medium Crude in the winter season (December – May), the surface oil exposure footprint (above the 1 µm threshold) exceeding 50 percent predicted probability extends from the spill site approximately 1,200 kilometres to the northwest.

For the 30-day 177,157 bpd WCD loss-of-well-control scenarios of Medium Crude in the summer season (June – November), surface oil reaches the coast in segments exceeding 90 percent probability, with the highest probabilities (>80 percent) primarily along the coast of Trinidad and Tobago and lower probabilities (<20 percent) as far west as Colombia and as far north as Martinique.

B.2.5. Yellowtail Wellhead Crude (Most Credible WCD Release) Season 1: June through November

Water Surface Results – Most Credible WCD: 88,728 BPD Scenario for 30 Days (Unmitigated)

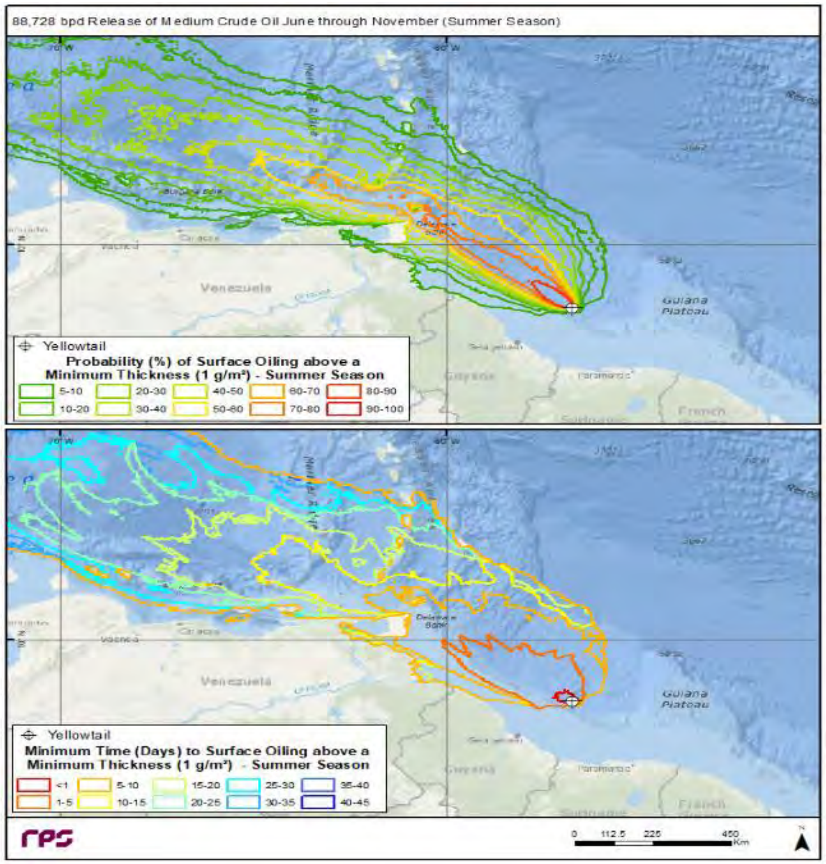


Figure B-25: Top panel displays probability of surface oil contamination ≥ 1 µm (1 g/m^2 on average over the grid cell) during the summer season for an 88,728 BPD Most Credible WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 µm.

Water Surface Results – Most Credible WCD: 88,728 BPD Scenario for 30 Days (Unmitigated) – DETAILED VIEW

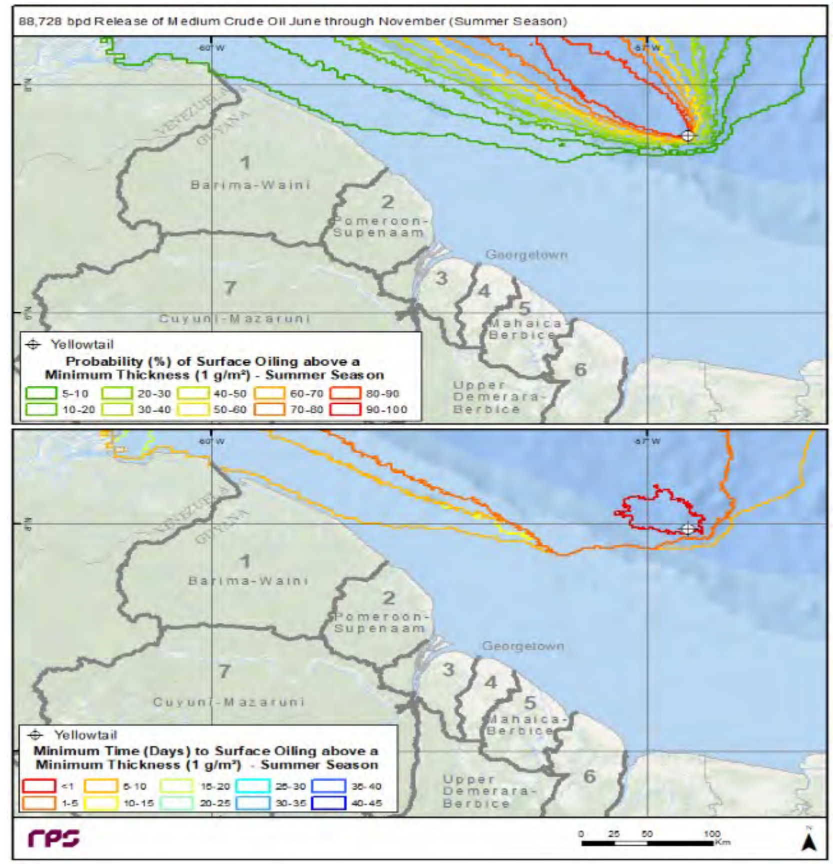


Figure B-26: Top panel displays probability of surface oil contamination ≥ 1 µm (1 g/m^2 on average over the grid cell) during the summer season for an 88,728 BPD Most Credible WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 µm.

B.2.6. Yellowtail Wellhead Crude (Most Credible WCD Release) Season 2: December through May

Water Surface Results – Most Credible WCD: 88,728 BPD Scenario for 30 Days (Unmitigated)

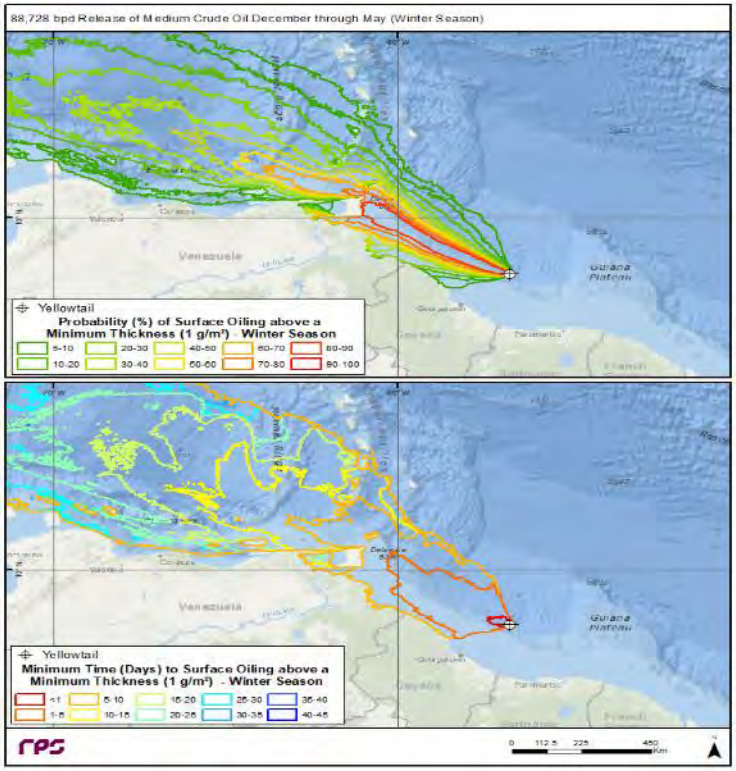


Figure B-27: Top panel displays probability of surface oil contamination ≥ 1 µm (1 g/m^2 on average over the grid cell) during the winter season for an 88,728 BPD Most Credible WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 µm.

Water Surface Results – Most Credible WCD: 88,728 BPD Scenario for 30 Days (Unmitigated) – DETAILED VIEW

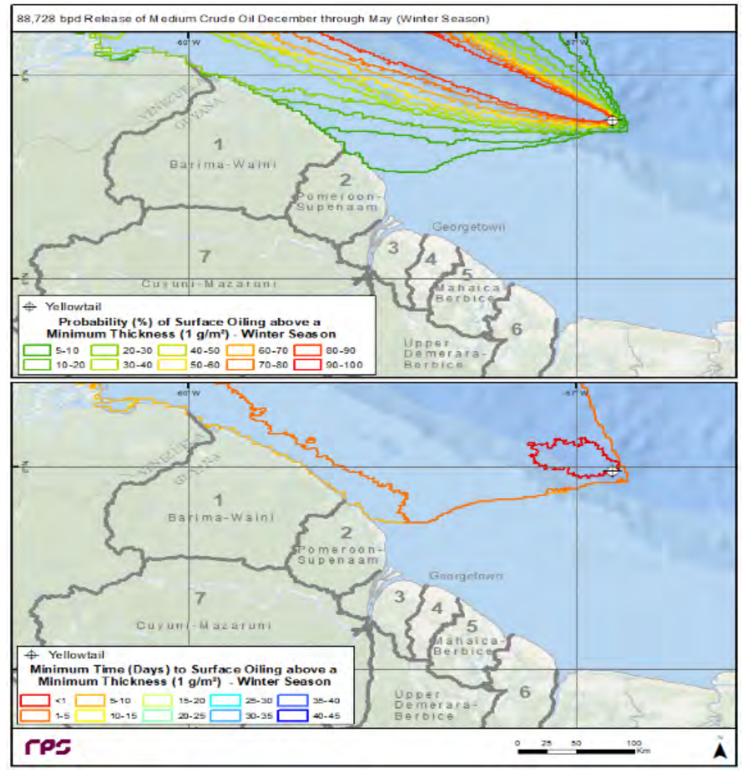


Figure B-28: Top panel displays probability of surface oil contamination ≥ 1 µm (1 g/m^2 on average over the grid cell) during the winter season for an 88,728 BPD Most Credible WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 µm.

B.2.7. Yellowtail Wellhead Crude (WCD Release) Season 1: June through November

Water Surface Results – WCD: 177,157 BPD Scenario for 30 Days (Unmitigated)

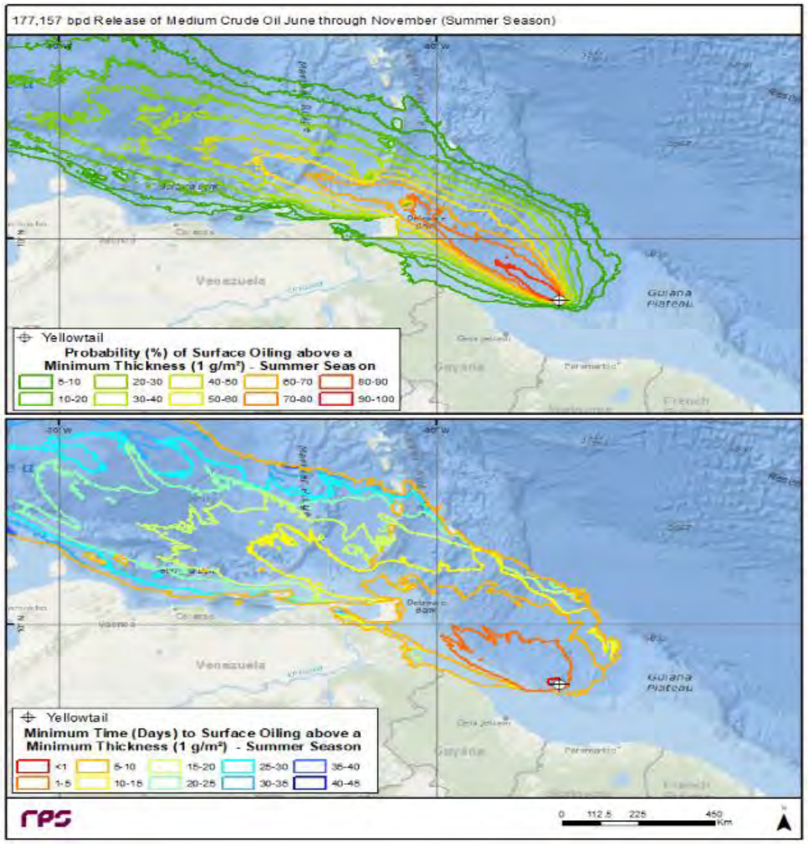


Figure B-29: Top panel displays probability of surface oil contamination ≥ 1 μm (1 g/m^2 on average over the grid cell) during the summer season for a 177,157 BPD WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 μm.

Water Surface Results – WCD: 177,157 BPD Scenario for 30 Days (Unmitigated) – DETAILED VIEW

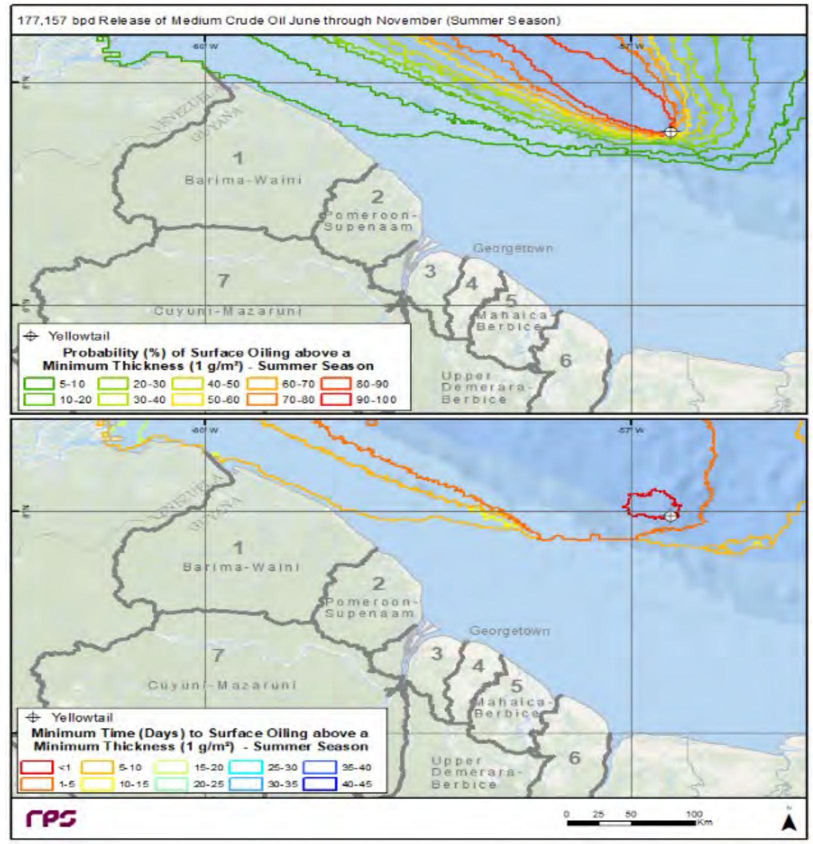


Figure B-30: Top panel displays probability of surface oil contamination ≥ 1 μm (1 g/m^2 on average over the grid cell) during the summer season for a 177,157 BPD WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 μm.

B.2.8. Yellowtail Wellhead Crude (WCD Release) Season 2: December through May

Water Surface Results – WCD: 177,157 BPD Scenario for 30 Days (Unmitigated)

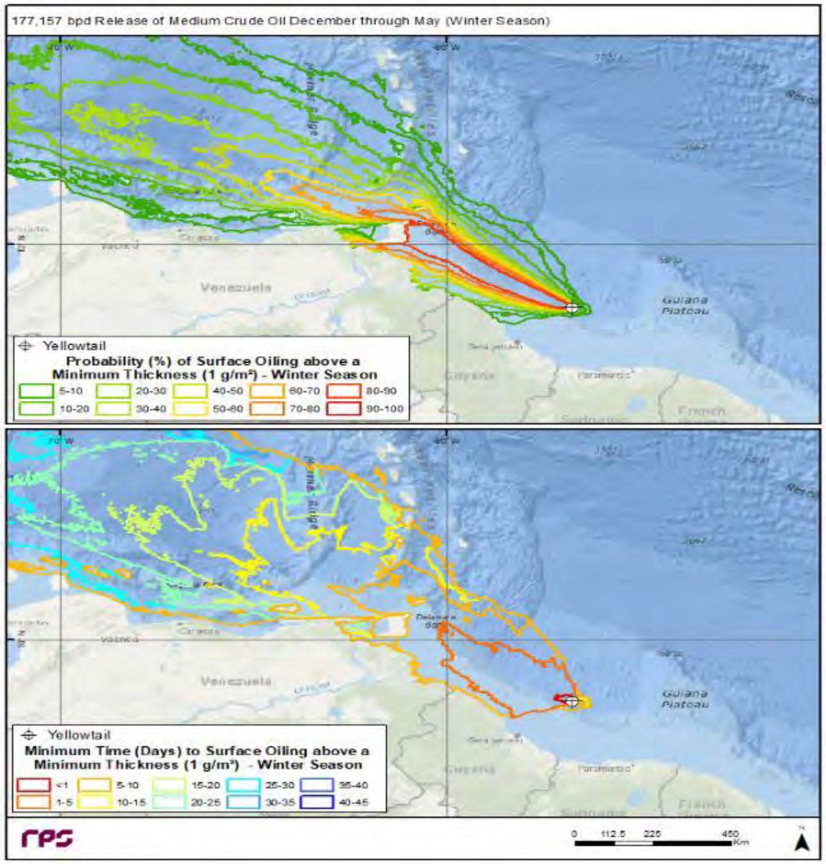


Figure B-31: Top panel displays probability of surface oil contamination ≥ 1 µm (1 g/m^2 on average over the grid cell) during the winter season for a 177,157 BPD WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 µm.

Water Surface Results – WCD: 177,157 BPD Scenario for 30 Days (Unmitigated) – DETAILED VIEW

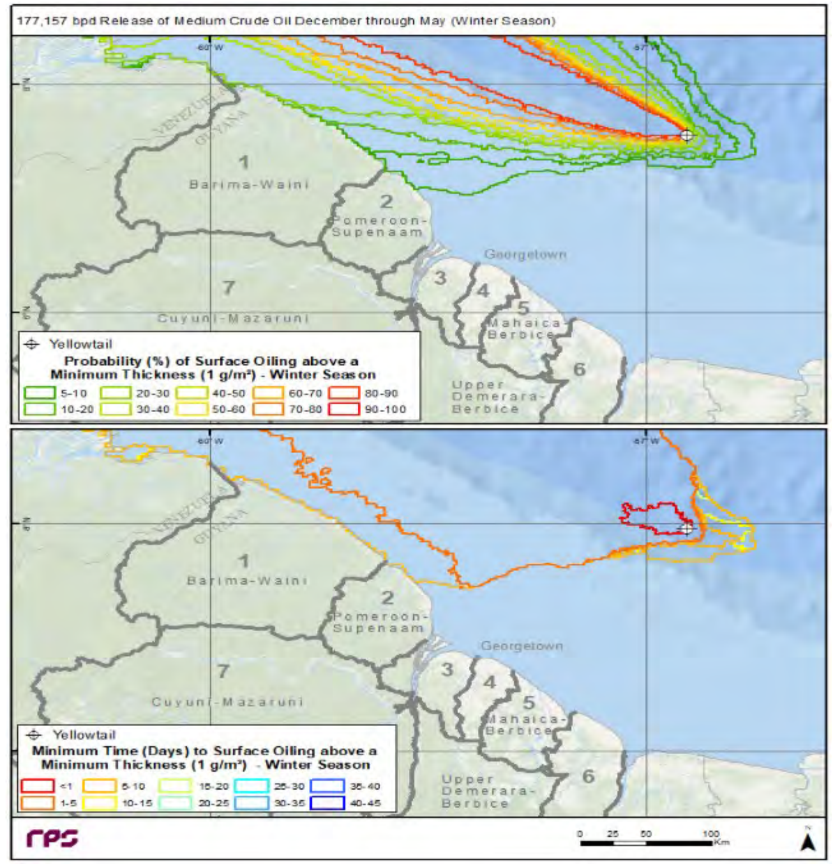


Figure B-32: Top panel displays probability of surface oil contamination ≥ 1 µm (1 g/m^2 on average over the grid cell) during the winter season for a 177,157 BPD WCD 30-day spill of Medium Crude at the Yellowtail wellhead. Bottom panel displays minimum time for surface oil to exceed 1 µm.

B.2.9. Yellowtail Deterministic Model Results – Unmitigated and Mitigated

Each individual spill event simulated in a stochastic scenario produces a unique spill trajectory. Depending on environmental conditions at the time of release, surface oil may be transported directly to shore or carried offshore, resulting in different effects. The 95th percentile spill events for minimum time to shore were selected from all stochastic spill scenarios simulated in each season for those stochastic scenarios with a greater than 5 percent probability of reaching shore. The model results are presented in maps and oiled shorelines depicted on the maps are determined by the presence of any oil amount regardless of a thickness threshold.

A summary of the mass balance at the end of the 45-day simulations in percent of released mass is provided in Table B-5. The predicted time of first arrival of oil on shore for the spill events ranked as the 95th percentile WCDs ranged from 6.5 to 8.5 days so oil is expected to be weathered by landfall. Depending on the scenario, the total oil ashore ranges from 0.0 to 8.6 km^2 for mitigated and 6.2 to 12.1 km^2 for unmitigated. Strong northwesterly transport resulted in significant shoreline oiling in Trinidad and Tobago, while allowing additional surface oil transport to the northwest of Trinidad and Tobago into the Caribbean Sea, making contact with the Greater Antilles for larger volume spills.

Response measures were performed on the summer and winter Most Credible WCD and WCD loss-of-well-control scenarios. Response measures included a capping stack applied after 5.5 days to the well head, dispersants applied at the well head, dispersants applied aerially and by boat, burning, and mechanical removal. Dispersants applied at the wellhead were effective in reducing the size of the oil droplets, leading to greater entrainment in the water column compared to the unmitigated cases. Response measures resulted in a reduction of shoreline oiling and a reduction in oil contamination to water surface area for both modelled scenarios.

Table B-5: Representative worst-case scenario mass balance at the end of the simulation as percent (%) of the total column of oil released.

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation	Sediment
Yellowtail Wellhead 2,661,840 bbl (88,728 bpd Most Credible WCD) Medium Crude Release Season 1: June through November	51.6	2.0	6.2	32.9	7.3	<0.1
Yellowtail Wellhead 2,661,840 bbl (88,728 bpd Most Credible WCD) Medium Crude Release Season 2: December through May	45.7	5.8	8.1	31.5	8.2	<0.1
Yellowtail Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release Season 1: June through November	48.8	3.4	6.3	27.2	14.2	<0.1
Yellowtail Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release Season 2: December through May	42.4	3.2	12.1	28.9	13.3	<0.1
Mitigated Yellowtail Wellhead 488,004 bbl (88,728 bpd Most Credible WCD) Medium Crude Release Season 1: June through November	<0.1	34.0	0	11.5	50.1	<0.1
Mitigated Yellowtail Wellhead 488,004 bbl (88,728 bpd Most Credible WCD) Medium Crude Release Season 2: December through May	<0.1	33.7	0	11.7	50.4	<0.1
Mitigated Yellowtail Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release Season 1: June through November	<0.1	33.7	<0.1	10.0	54.9	<0.1
Mitigated Yellowtail Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release Season 2: December through May	<0.1	28.4	8.6	10.2	50.2	<0.1

B.2.10. Yellowtail Wellhead Crude (*Most Credible WCD Release*) Season 1: June through November

Most Credible WCD: 88,728 BPD Scenario with 30 days release with 45-day model simulation (Unmitigated)

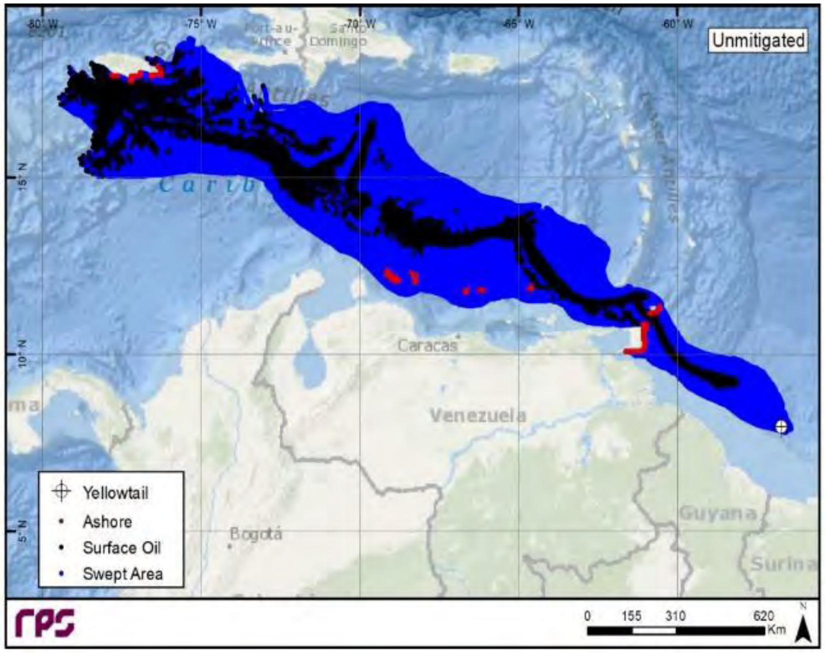


Figure B-33: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for an 88,728 BPD Most Credible WCD spill of Medium Crude at the Yellowtail wellhead during summer season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Most Credible WCD: 88,728 BPD Scenario with 5.5 days release with 45-day model simulation (Mitigated)

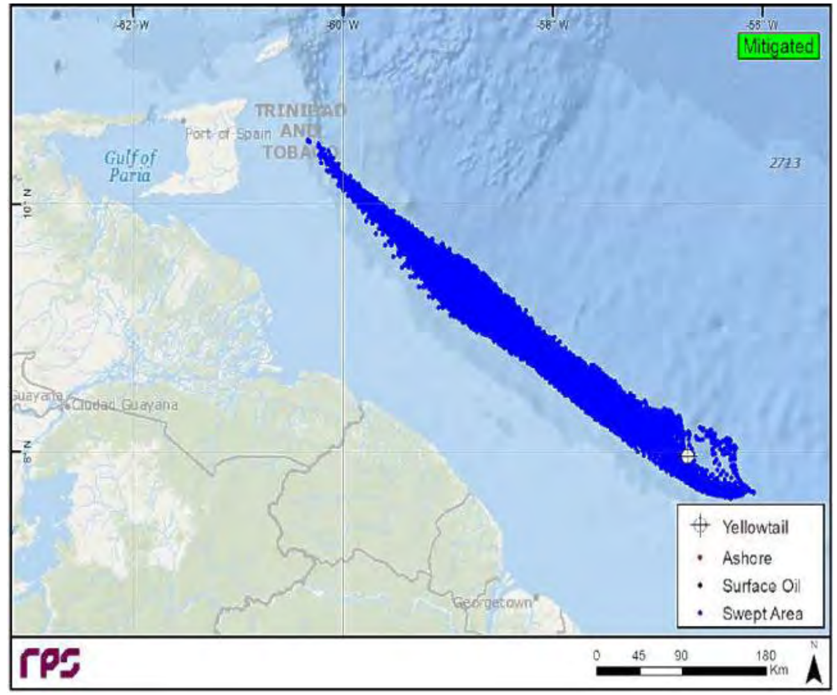


Figure B-34: Area swept results for the mitigated 95th percentile time to shore scenario for the 88,728 BPD Most Credible WCD for 5.5 Days release of Medium Crude Oil at the Yellowtail wellhead during summer season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

B.2.11. Yellowtail Wellhead Crude (*Most Credible WCD Release*) Season 2: December through May

Most Credible WCD: 88,728 BPD Scenario with 30 days release with 45-day model simulation (Unmitigated)

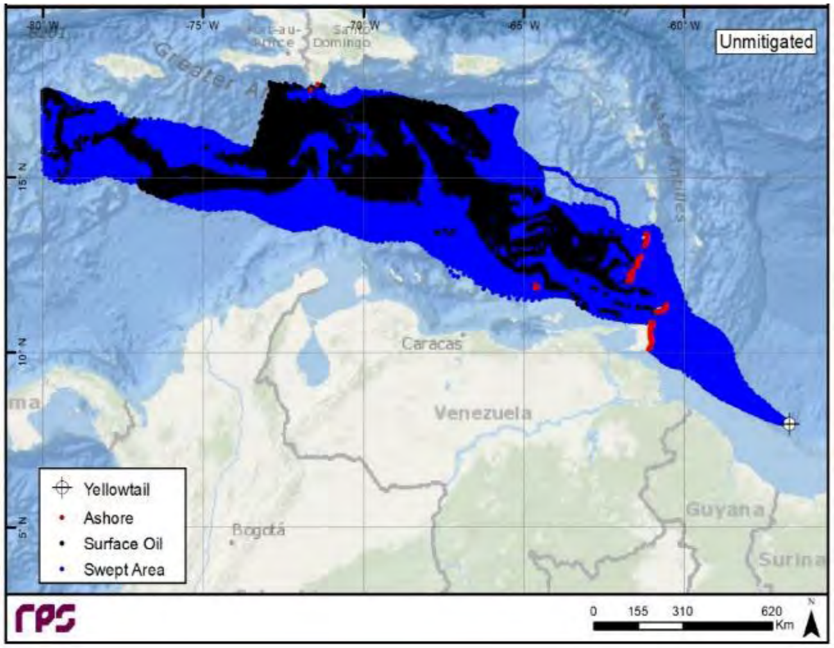


Figure B-35: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for an 88,728 BPD Most Credible WCD) spill of Medium Crude at the Yellowtail wellhead during winter season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Most Credible WCD: 88,728 BPD Scenario with 5.5 days release with 45-day model simulation (Mitigated)

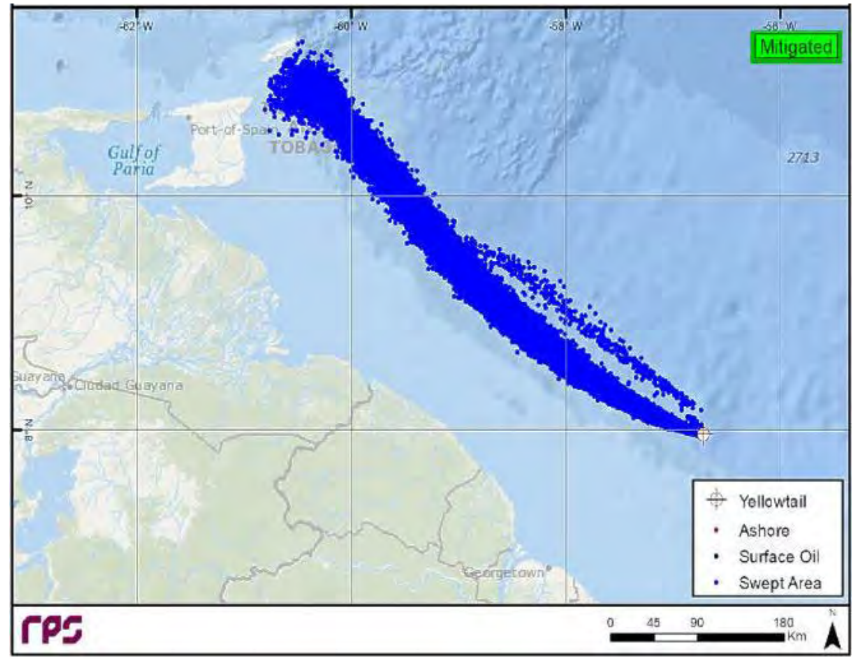


Figure B-36: Area swept results for the mitigated 95th percentile time to shore scenario for the 88,728 BPD Most Credible WCD for 5.5 Days release of Medium Crude Oil at the Yellowtail wellhead during winter season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

B.2.12. Yellowtail Wellhead Crude WCD Release Season 1: June through November

WCD: 177,157 BPD scenario with 30 days release with 45-day model simulation (Unmitigated)

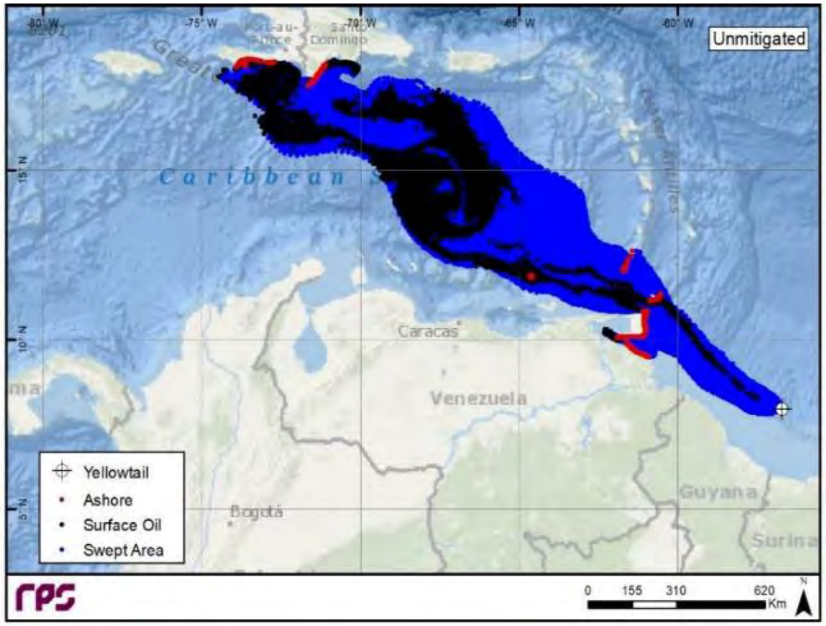


Figure B-37: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 177,157 BPD WCD spill of Medium Crude at the Yellowtail wellhead during summer season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation

WCD: 177,157 BPD scenario with 5.5 days release with 45-day model simulation (Mitigated)

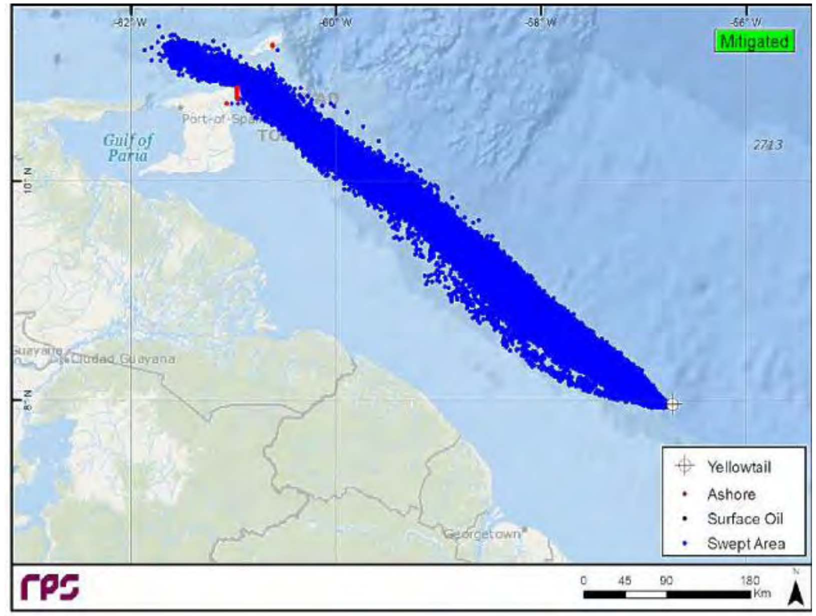


Figure B-38: Area swept results for the mitigated 95th percentile time to shore scenario for the 177,157 BPD WCD for 5.5 Days release of Medium Crude Oil at the Yellowtail wellhead during summer season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation.

B.2.13. Yellowtail Wellhead Medium WCD Release Season 2: December through May

WCD: 177,157 BPD scenario with 30 days release with 45-day model simulation (Unmitigated)

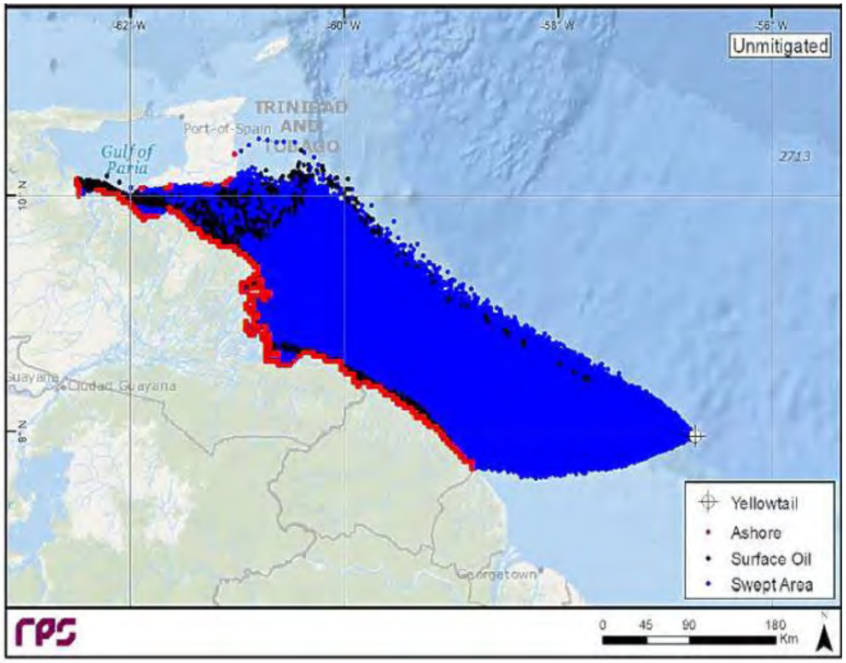


Figure B-39: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 177,157 BPD WCD spill of Medium Crude at the Yellowtail wellhead during winter season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation

WCD: 177,157 BPD scenario with 5.5 days release with 45-day model simulation (Mitigated)

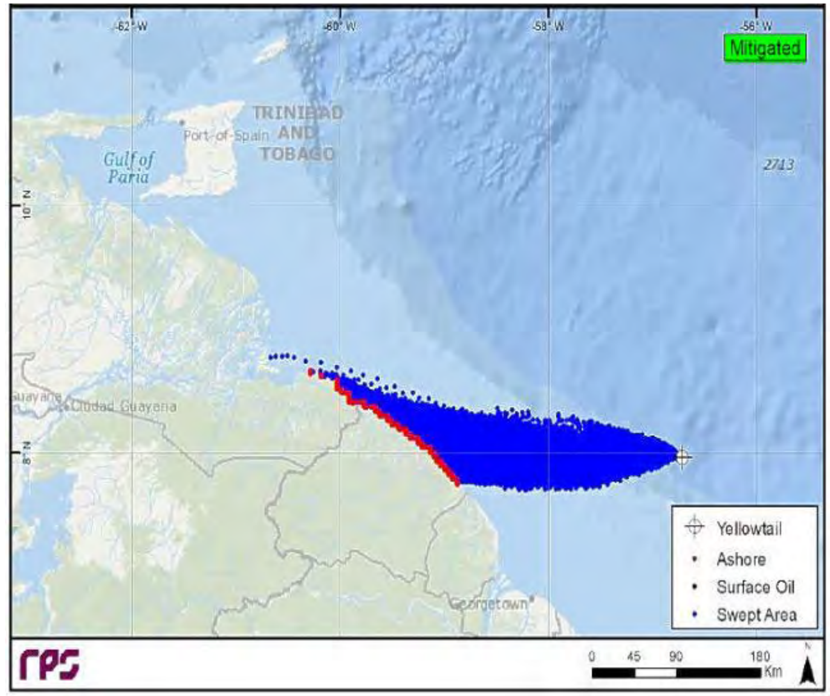


Figure B-40: Area swept results for the mitigated 95th percentile time to shore scenario for the 177,157 BPD WCD for 5.5 Days release of Medium Crude Oil at the Yellowtail wellhead during winter season. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

B.3. Uaru Development Project Oil Spill Modelling

B.3.1. Uaru Development Project Oil Properties

The transport and weathering of spilled oil are dependent on chemical and physical oil properties such as boiling point distribution, tendency to form stable or meso-stable water-in-oil emulsions, and oil viscosity. Table B-6 summarizes the characteristics of the representative hydrocarbon product, a medium crude oil, used for this study. The client provided RPS with detailed information regarding the oil properties of the products and RPS assumed a proxy/generic oil to define any additional properties necessary to run the oil spill model. These properties were based on characterizations from the Environmental Technology Centre of Environment Canada. If further information about the actual crude oil becomes available, the characterization of the oil provided by RPS and used in this modelling study should be reviewed to ensure that the representative oils are suitable.

Table B-6: Summary of the oil properties used in the modelling

Oil Type	Density (g/cm^3)	Viscosity (cP)	API Gravity	Maximum Water Content (%)
Medium Crude Oil	0.863	1.8 at 25°C	32.5	31

Viscosity and interfacial surface tension affect the degree of spreading of the oil, which in turn influences the rates of evaporation, dissolution, dispersion, and photo-oxidation. The maximum water content is a laboratory measurement of the tendency of the oil to form emulsions. Oils that form water-in-oil emulsions tend to be more persistent in the marine environment, as they are less likely to be dissolved and/or evaporated; this increases their potential for reaching the shoreline. Light products such as marine diesel and condensate have no tendency in forming an emulsion; thus, they are less persistent on the water surface relative to heavier oils (such as crude).

To classify oil products from a weathering point of view, crude oils and hydrocarbon mixtures can be broken into distillation cuts based on their boiling points. Total hydrocarbon concentrations (THC) in the oil weathering model include both aromatic (soluble) and aliphatic (insoluble) components. In general, the lighter aromatic compounds, such as Monocyclic and Polycyclic Aromatic Hydrocarbons (MAHs and PAHs, respectively), tend to rapidly evaporate to the atmosphere unless the product gets mixed into the water column. If oil is released below the water surface or gets entrained before it has weathered and lost the lower molecular weight aromatics to the atmosphere, dissolved MAHs and PAHs can reach concentrations where they can affect water column organisms or bottom communities (French-McCay and Payne 2001).

B.3.2. Introduction

RPS Ocean Science was contracted by Esso Exploration & Production Guyana Ltd. to assess the trajectory and fate of releases using RPS' SIMAP model in the offshore waters of Guyana both without and with spill response mitigation. This modelling is a continuation of previous modelling for offshore Guyana in the Payara Prospect and in the Liza prospect, completed for Phase 1 and Phase 2. This summary presents the results of the most credible worst-case discharge (Most Credible WCD) and worst-case discharge (WCD) components of the oil spill modelling for the Yellowtail discharge location.

Consistent with Spill Modelling Concepts outlined in Appendix A, four hypothetical spill scenarios were modelled by RPS. The spill scenarios include 30-day loss of well control of a Medium Crude oil modelled for 45 days. The model simulations were run using environmental conditions corresponding to different regimes in the Season 1 (June through November) and Season 2 (December through May) seasons defined in the analysis of long-term wind data at the spill site. Individual spill events were selected from these results based on shoreline exposure to oil. Spill events were selected based on a high WCD in both summer and winter seasons. The loss-of-well-control scenarios were simulated using the OILMAPDeep model to determine the discharge plume geometry, define the oil droplet sizes and provide inputs for the SIMAP model simulations.

The loss of well control scenarios modelled consisted of 30-day discharges at the wellhead using a medium crude oil. The loss of well control events were simulated using the OILMAPDeep loss of well control model to determine the discharge plume geometry and define the size of the oil droplets discharged into the water column. All SIMAP trajectory and fate model simulations were run for the 30-day discharge period plus an additional 15 days after oil discharge ceased (45-day total simulation length). A summary of the spill scenarios is presented in the Table B-7.

Table B-7: Spill scenarios modelled in the Uaru prospect (Stabroek Block), offshore Guyana.

Scenario ID	Spill Site	Spill Event	Oil Type	Spill Duration	Spill Rate	Model Duration
1	Uaru Project Wellhead	Most Credible WCD—loss of well control during Season 1 (June–November)	Medium Crude Oil	30 days	88,364 bbl/day	45 days
2		Most Credible WCD—loss of well control during Season 2 (December–May)			88,364 bbl/day	
3		WCD—loss of well control during Season 1 (June–November)			173,415 bbl/day	
4		WCD—loss of well control during Season 2 (December–May)			173,415 bbl/day	

The SIMAP model uses specific oil thickness thresholds for calculating the probability or likelihood of the presence of oil on the sea surface or shoreline. Shoreline and surface oil must be a minimum of 1 µm (1 g/m^2 on average over the grid cell) thick to be included in the probability calculations. Wind data used in the SIMAP oil spill model simulations were taken from two global models, NOGAPS and NAVGEM, to define wind speed and direction time series over the region. Data from the two models cover the same 10-year period as the hydrodynamics (2005-2014). Currents in the upper water column off the Guyana coast are strong and flow towards the northwest along the coast of South America over the entire year. The Guiana Current is part of the regional flow between South America, Africa and the Caribbean Sea, extending from Guyana to the Caribbean. Current data produced by the SAT-OCEAN model covering the area around the Stabroek Block were used in combination with currents extracted from the US Navy HYCOM global hindcast model as inputs to the SIMAP spill simulations.

The SIMAP model was used to predict the probability of oil contamination on the water surface and shoreline for spills occurring in two seasons corresponding to seasonal wind regimes. The model was also applied in deterministic mode to simulate individual spills selected as representative events from each scenario during each season. Results from the SIMAP stochastic modelling are provided in maps depicting the probability and timing of oil contamination on the water surface and maps depicting the probability and timing of oil contamination on the shoreline. An individual spill event was selected from each stochastic scenario based on the model predictions of the time of first arrival of oil onshore, or water surface area oiled for those stochastic scenarios with less than a 5 percent probability of shoreline oiling. Output from the selected spill events is provided as a map of the spill trajectory and as oil mass balance graphs showing the time history of oil volume in the environment. Surface oil is predicted to travel towards the northwest in all scenarios during both seasons.

For those simulations predicted to reach the shoreline, the probability of shoreline oiling is generally highest (>80 percent) on the coast of Trinidad and Tobago, as well as the Lesser Antilles, due to the predominant current flow through the Stabroek Block and into the Caribbean. Lower shoreline oiling probabilities (<20 percent) are predicted as far north as Haiti and the Dominican Republic and as far west as Colombia. Season 2 (December – May) spills generally show higher probability of shoreline oiling due to stronger, more northerly winds. The predicted time of first arrival of oil on shore for the unmitigated spill events ranked as the 95th percentile WCDs ranged from 7.0 to 11.4 days, so oil is expected to be well-weathered by landfall. Differences in seasonal wind and current velocities resulted in some differences in sea surface exposure to oil (1,937,000 km^2 to 3,146,000 km^2) and shoreline length oiled (256 km to 613 km). In the unmitigated models runs, the strong northwesterly transport resulted in significant shoreline oiling in Trinidad and Tobago, with additional surface oil transport past Trinidad and Tobago into the Caribbean Sea. The model predicted significant amounts of oil (>1,000,000 bbl) remaining on the surface at the end of the 45-day simulations in both seasons for the WCD scenario.

Response measures were assumed for the Season 1 and Season 2 Most Credible WCD and WCD loss of well control scenarios. Response measures included a capping stack applied after 5.5 days to the well head, dispersants applied at the well head, dispersants applied aerially and by boat, in-situ burning of collected oil, and mechanical removal. Dispersants applied at the wellhead were effective in reducing the size of the oil droplets, leading to greater entrainment in the water column compared to the unmitigated cases. The capping stack alone resulted in a reduction of discharged oil from the WCD of 5,202,450 bbl to the response-mitigated WCD of 953,783 bbl. Response measures resulted in a reduction of shoreline oiling and a reduction in oil contamination to water surface area for both modelled seasons. For example, the unmitigated WCD scenarios were predicted to result in >1,000,000 bbl on the surface at the end of the simulation (45 days), whereas the response-mitigated scenarios were predicted to result in no oil left floating on the surface at the end of the simulation (45 days).

B.3.3. Deterministic Model Results

Each individual spill event simulated in a stochastic scenario produces a unique spill trajectory. Depending on environmental conditions at the time of release, surface oil may be transported directly to shore or carried offshore, resulting in different effects. The 95th percentile spill events for minimum time to shore were selected from all stochastic spill scenarios simulated in each season for those stochastic scenarios with a greater than 5 percent probability of reaching shore. The model results are presented in maps and mass balance plots by spill size and season. Oiled shorelines depicted on the maps are determined by the presence of any oil amount regardless of a thickness threshold.

A summary of the mass balance at the end of the 45-day simulations in percent of released mass is provided in Table B-8. The deterministic results are also summarized in tables listing the surface area swept with a thickness greater than 1 µm (1 g/m^2 on average over the grid cell), the length of shoreline oiled with a thickness greater than 1 µm (1 g/m^2 on average over the grid cell), and the time to shore for the selected representative deterministic scenarios. The sea surface area swept is the maximum water surface area exposed to oil (not including overlapping) with a thickness exceeding the specified threshold. It is important to note when comparing the modelling results for the deterministic scenarios from the different phase studies, that dates chosen for the representative scenarios will be different across projects. Therefore, the differences in modelling results are also partially due to the specific metocean conditions of those selected dates and the spill site location, in addition to the difference in the persistence of the crude oil used in the this and previous modelling studies.

Table B-8: Representative worst-case scenario mass balance at the end of the simulation as percent (%) of the total column of oil released

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation	Sediment
Uaru Project Wellhead 2,650,920 bbl (88,364 bpd Most Credible WCD) Medium Crude Release – Season 1	28.1	29.1	2.1	22.2	18.6	<0.1
Uaru Project Wellhead 2,650,920 bbl (88,364 bpd Most Credible WCD) Medium Crude Release – Season 2	36,6	18.2	5.2	22.6	17.4	<0.1
Uaru Project Wellhead 5,202,450 bbl (173,415 bpd WCD) Medium Crude Release – Season 1	25.8	27.1	1.3	15	30.8	<0.1
Uaru Project Wellhead 5,202,450 bbl (173,415 bpd WCD) Medium Crude Release – Season 2	26.8	22.4	3.4	13.6	33.8	<0.1
Mitigated Uaru Project Wellhead 486,002 bbl (88,364 bpd Most Credible WCD) Medium Crude Release – Season 1	0.0	34.6	0.0	6.3	56.5	<0.1
Mitigated Uaru Project Wellhead 486,002 bbl (88,364 bpd Most Credible WCD) Medium Crude Release – Season 2 Season	0.0	33.5	<0.1	6.1	57.7	<0.1
Mitigated Uaru Project Wellhead 953,783 bbl (173,415 bpd WCD) Medium Crude Release – Season 1	0.0	32.1	0.0	2.0	63.1	<0.1
Mitigated Uaru Project Wellhead 953,783 bbl (173,415 bpd WCD) Medium Crude Release – Season 2	0.0	30.8	0.0	2.1	64.6	<0.1

Table B-9: Oil effects summary for the 95th percentile spill event. Surface area is the maximum sea surface area swept above a threshold of 1 µm (1 g/m² on average) thick. Shoreline length is length of shoreline oiled above a threshold of 1 µm (1 g/m² on average) thick.

Scenario	Volume (bbl)	Season	Surface Area (km²)	Shoreline Length (km)	Minimum Time to Shore (Days)
Uaru Project Wellhead Medium Crude – Most Credible WCD Release	2,650,920 (88,364 Most Credible WCD)	Season 1	416,807	256	11.4
Uaru Project Wellhead Medium Crude – Most Credible WCD Release		Season 2	452,314	583	7.3
Uaru Project Wellhead Medium Crude – WCD Release	5,202,450 (177,157 bpd WCD)	Season 1	476,478	274	11.3
Uaru Project Wellhead Medium Crude – WCD Release		Season 2	507,720	613	7.0
Mitigated Uaru Project Wellhead Medium Crude – Most Credible WCD Release	486,002 (88,364 bpd Most Credible WCD)	Season 1	3,849	0	NA
Mitigated Uaru Project Wellhead Medium Crude – Most Credible WCD Release		Season 2	5,944	6.0	7.83
Mitigated Uaru Project Wellhead Medium Crude – WCD Release	953,783 (173,415 bpd WCD)	Season 1	3,060	0	NA
Mitigated Uaru Project Wellhead Medium Crude – WCD Release		Season 2	5,160	0	NA

***Unmitigated* – Uaru Project Wellhead 2,650,920 (88,364 Most Credible WCD) Medium Crude Release – Season 1 (June – November)**

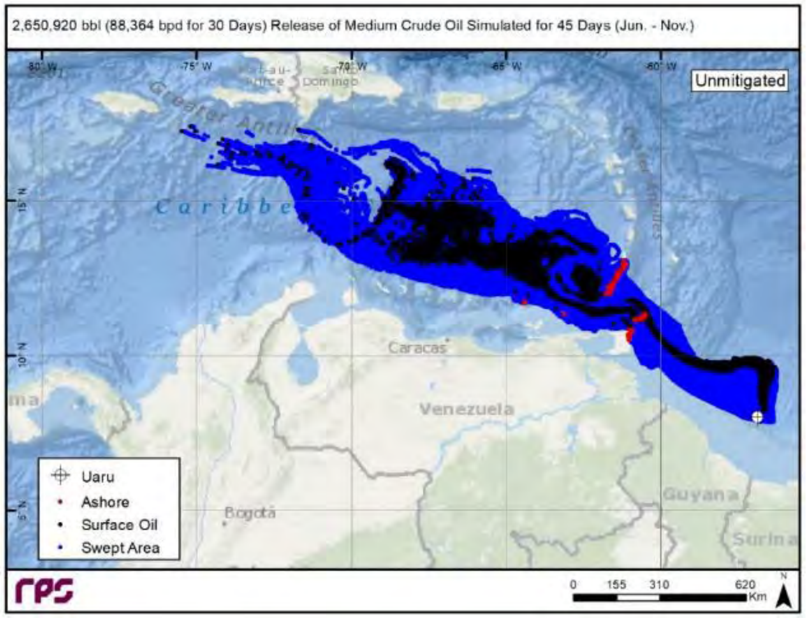


Figure B-41: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,650,920 bbl (88,364 bpd Most Credible WCD) spill of medium crude at the Uaru Project wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Uaru Project Wellhead 486,002 (88,364 bpd Most Credible WCD) Medium Crude Release – Season 1 (June – November)**

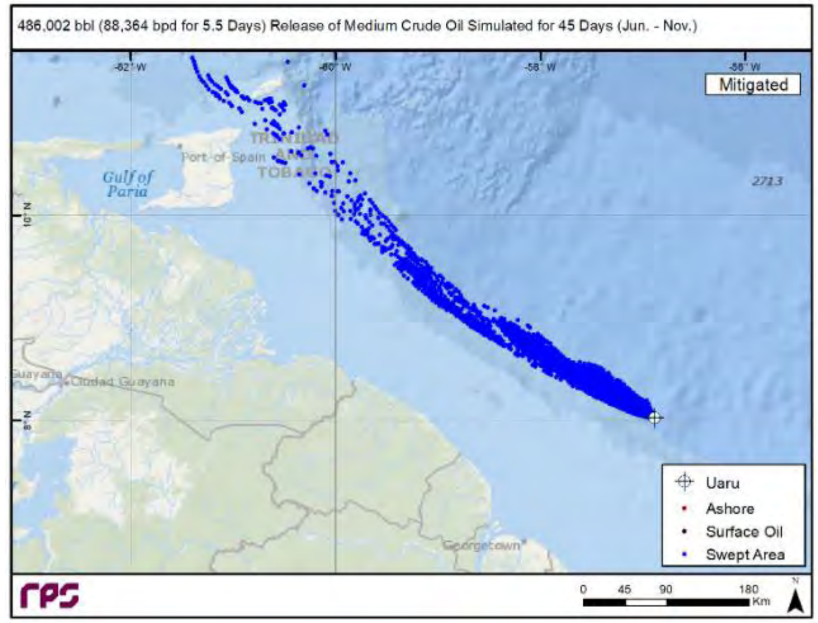


Figure B-42: Area swept results for the mitigated 95th percentile time to shore scenario for the 88,364 bpd Most Credible WCD release of a medium crude oil at the Uaru Project wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated **– Uaru Project Wellhead 2,650,920 (88,364 Most Credible WCD) Medium Crude Release – Season 2 (December – May)**

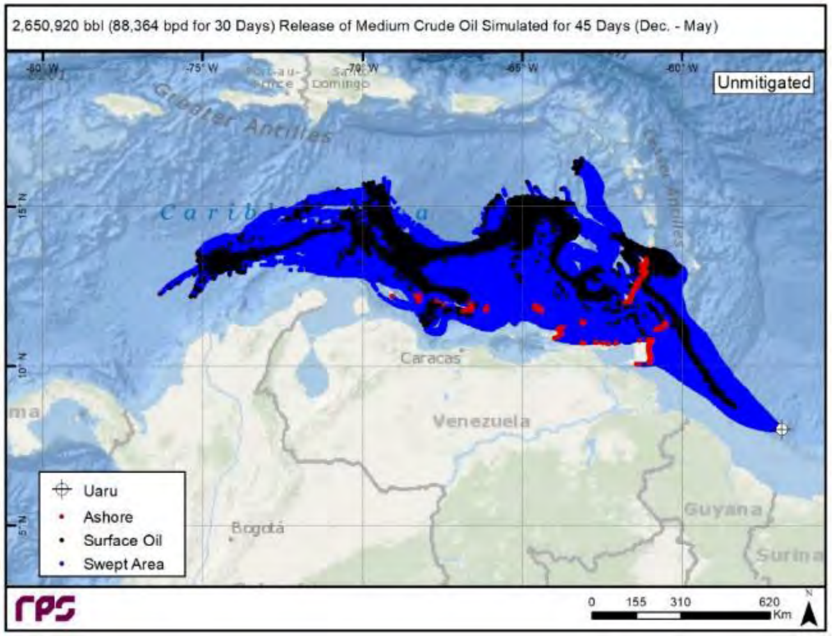


Figure B-43: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,650,920 bbl (88,364 bpd Most Credible WCD) spill of medium crude at the Uaru Project wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated **– Uaru Project Wellhead 486,002 (88,364 bpd Most Credible WCD) Medium Crude Release – Season 2 (December – May)**

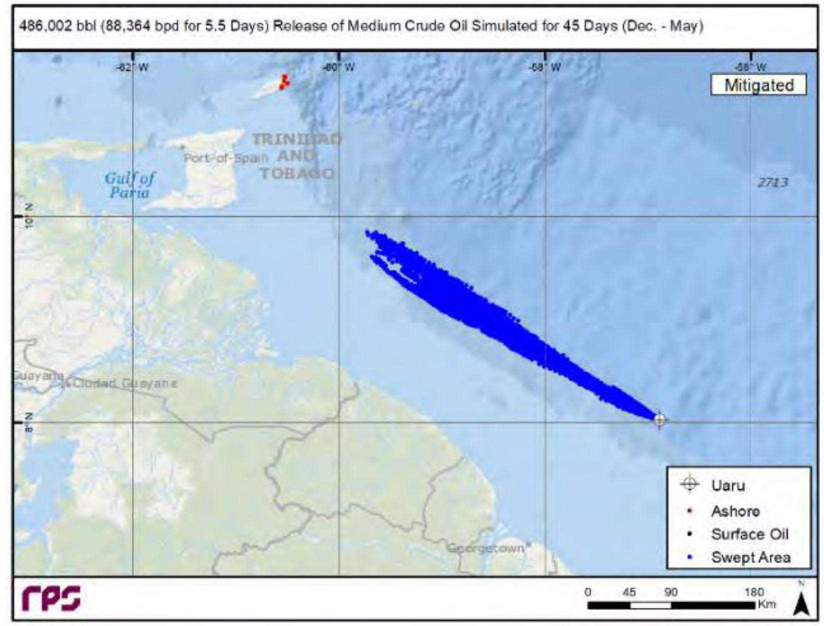


Figure B-44: Area swept results for the mitigated 95th percentile time to shore scenario for the 88,364 bpd Most Credible WCD release of a medium crude oil at the Uaru Project wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Uaru Project Wellhead 5,202,450 bbl (173,415 bpd WCD) Medium Crude Release – Season 1 (June – November)**

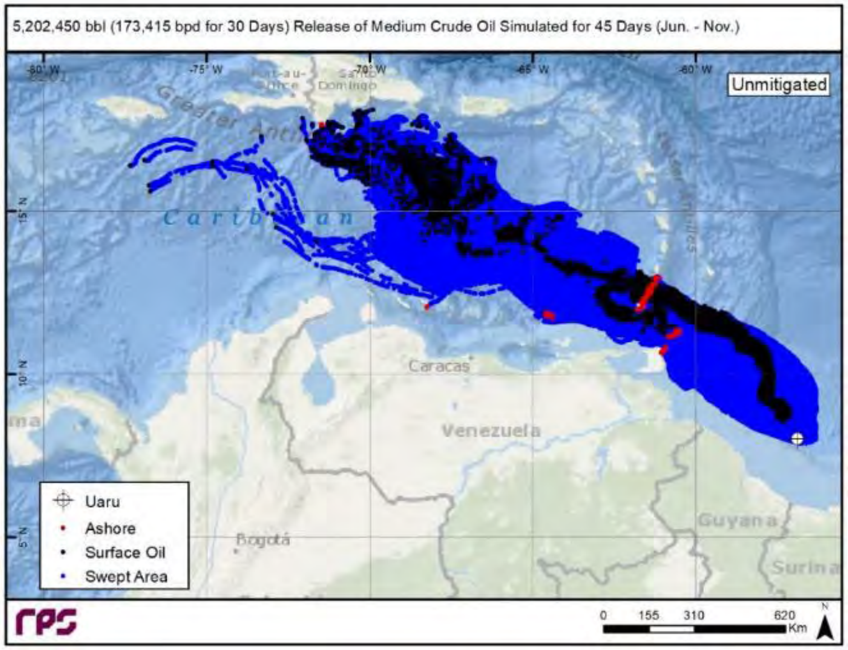


Figure B-45: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,202,450 bbl (173,415 bpd WCD) spill of medium crude at the Uaru Project wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Uaru Project Wellhead 953,782 bbl (173,415 bpd WCD) Medium Crude Release – Season 1 (June – November)**

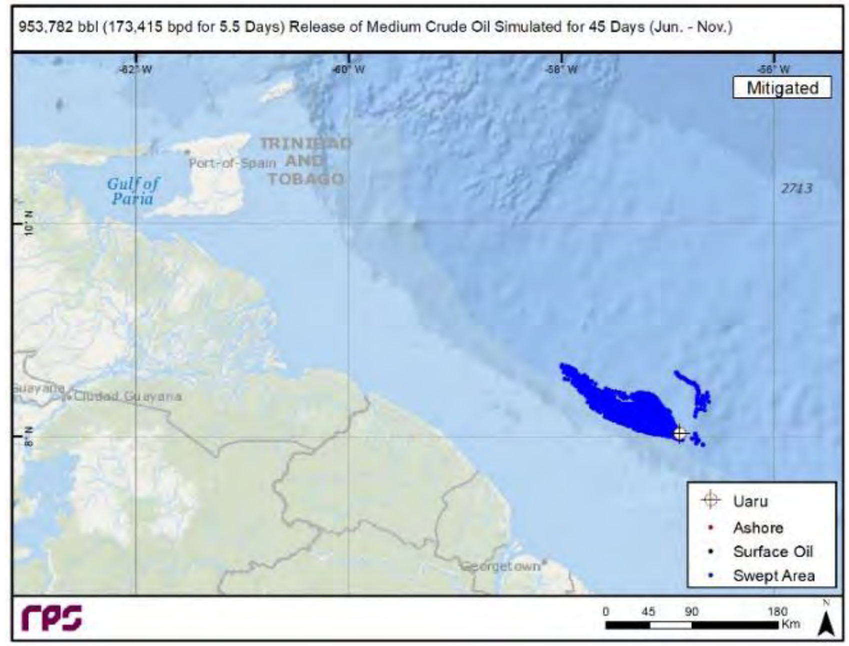


Figure B-46: Area swept results for the mitigated 95th percentile time to shore scenario for the 173,415 bpd WCD release of a medium crude oil at the Uaru Project wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated **– Uaru Project Wellhead 5,202,450 bbl (173,415 bpd WCD) Medium Crude Release – Season 2 (December – May)**

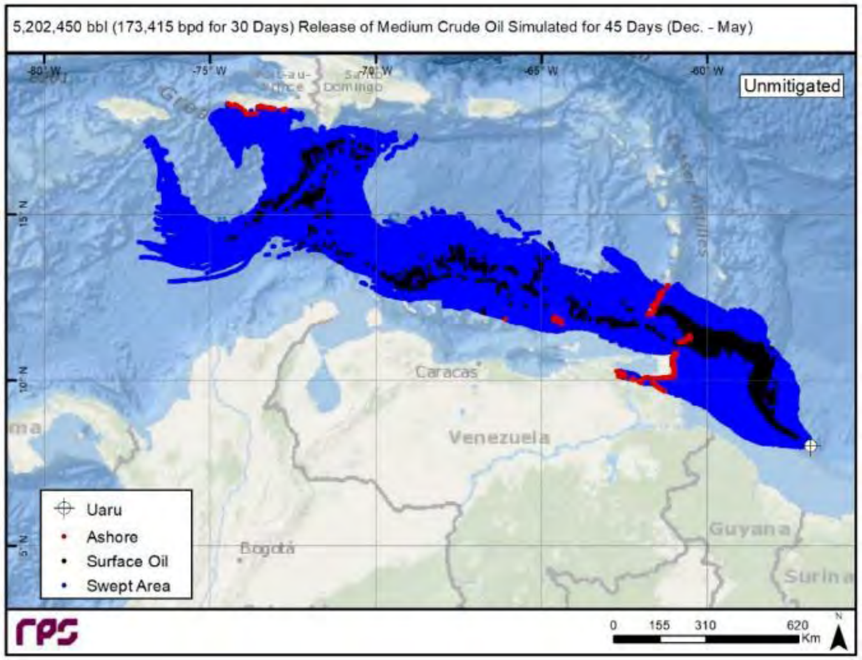


Figure B-47: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,202,450 bbl (173,415 bpd WCD) spill of medium crude at the Uaru Project wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated **– Uaru Project Wellhead 953,782 bbl (173,415 bpd WCD) Medium Crude Release – Season 2 (December – May)**

Figure B-48: Area swept results for the mitigated 95th percentile time to shore scenario for the 173,415 bpd WCD release of a medium crude oil at the Uaru Project wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

B.3.4. Summary and Conclusions

Stochastic Model Results

Similar to previous studies performed by RPS for EMGL in the Stabroek Block, the trajectory of spills at discharge sites from the Uaru Development Project wellhead are driven largely by the strong northwest flowing currents running parallel to the South American coast. The easterly and east-northeasterly winds drive oil ashore, but in general are not strong enough the overcome the transport by currents.

Surface oil is predicted to travel towards the northwest in all scenarios during both seasons in the Most Credible WCD and the WCD. These large volume releases in both seasons are predicted to have a greater than 90 percent probability of reaching the shoreline as stochastic modelling does not incorporate any mitigation measures (i.e., surface or subsea oil spill response tools) and therefore the oil properties and meteorological conditions determine the likelihood of shorelines impacts. The probability of oil contamination on the shoreline tends to be highest on the coast of Trinidad and Tobago, as well as the Lesser Antilles, particularly during Season 2 (December – May), because of the predominant current flow through the Stabroek Block and into the Caribbean. Lower shoreline oiling probabilities (<20 percent) are predicted as far north as Haiti and the Dominican Republic and as far west as Colombia. Season 2 (December – May) spills generally show a higher oil stranding probability due to the faster currents and northeasterly winds. During an individual spill event, the distribution of sea surface area contaminated by oil varies based on the volume of oil spilled and season. Predictably, there is a higher probability of sea surface oiling above a 1 g/m^2 thickness (on average) threshold closer to the release location.

Deterministic Model Results

The predicted time of first arrival of oil on shore for the spill events ranked as the 95th percentile WCDs ranged from 7.0 to 11.4 days, so oil is expected to be well-weathered by landfall. Differences in seasonal wind and current velocities resulted in some differences in sea surface exposure to oil (1,937,000 km^2 to 3,146,000 km^2) and shoreline length oiled (256 km to 613 km). Strong northwesterly transport resulted in significant shoreline oiling in Trinidad and Tobago, with additional surface oil transport past Trinidad and Tobago into the Caribbean Sea. Very large amounts of oil (>1,000,000 bbl) remained on the surface at the end of the 45-day simulations in both seasons for the WCD scenario.

Response measures were performed on the Most Credible WCD and WCD loss of well control scenarios. Response measures included a capping stack applied after 5.5 days to the wellhead, dispersants applied at the well head, dispersants applied aerially and by boat, burning, and mechanical removal. Dispersants applied at the wellhead were effective in reducing the size of the oil droplets, leading to greater entrainment in the water column compared to the unmitigated cases. The capping stack alone resulted in a reduction of discharged oil from the WCD of 5,202,450 bbl to the response-mitigated WCD of 953,783 bbl. Response measures resulted in a reduction of shoreline oiling and a reduction in oil contamination to water surface area for both modelled scenarios. For example, as noted above, the unmitigated WCD scenarios were predicted to result in >1,000,000 bbl on the surface at the end of the simulation (45 days), whereas the response-mitigated scenarios were predicted to result in no oil left floating on the surface at the end of the simulation (45 days). This is similar to the Yellowtail modelling where very little (<1 bbl) to no oil was predicted to be left floating on the water surface at the end of the simulations.

NOTE: These scenarios included additional vessels for surface dispersant application, compared to the previous rounds of modelling completed for EMGL (i.e., 20 PSVs compared to 1 PSV).

B.4. Regional Oil Spill Risk Assessment Stabroek Block

B.4.1. Introduction

RPS Ocean Science was contracted by ERM to assess the trajectory and fate of releases using RPS SIMAP model in the offshore waters of Guyana both without and with spill response mitigation for a Cumulative Impact Assessment (CIA) for EMGL The following summary report presents the results of most credible worst-case discharge (Most Credible WCD or MCWCD) and worst-case discharge (WCD) components of separate oil spill modelling for the Yellowtail-1, Fangtooth-1, Tarpon-1A, and Haimara-1 discharge locations (see Table B-10 and Figure B-49).

Table B-10: Locations used for spill modelling for Yellowtail-1, Fangtooth-1, Tarpon-1A, and Haimara-1

Spill Location	Latitude (N)	Longitude (W)	Water Depth (m)
Yellowtail-1	7.977922	-56.699201	1,845
Fangtooth-1	8.188073	-57.074316	1,838
Tarpon-1A	8.774203	-57.560559	2,379
Haimara-1	7.635383	-56.285789	1,402

Figure B-49: Locations used for spill modelling for Yellowtail-1, Fangtooth-1, Tarpon-1A, and Haimara-1

The model was applied using a stochastic approach to determine the probability of oil contamination within marine waters and shorelines. Selected individual hypothetical spill events based on the minimum time to reach the shore were examined to characterize spills predicted to travel to shore from the spill site.

Hydrocarbon release scenarios were simulated using the SIMAP oil spill modelling system in its two different modes, in order to first evaluate the probable impacts associated with varying environmental conditions (i.e., stochastic mode) and then evaluate the details of each spill type under a set of conditions representative of a worst-case situation (i.e., deterministic mode). SIMAP simulations were performed using wind conditions from two distinct seasonal regimes (Season 1 and Season 2) in order to capture the range of potential environmental conditions.

Representative worst-case spill events were identified from the suite of individual trajectories simulated in the stochastic analyses and were selected based on the minimum time for oil to reach the shoreline. These spills were used to characterize a probable event trajectory and oil mass balance. Furthermore, response modelling (i.e., subsurface dispersant application, surface dispersant application, skimming, and burning) was conducted on selected representative spill events. A summary of the spill scenarios is presented in the Table B-11.

Table B-11: Spill scenarios modelled in the Stabroek Block, offshore Guyana

Scenario ID	Spill Site	Spill Event	Oil Type	Spill Duration	Spill Rate	Model Duration
1	Yellowtail-1	MCWCD- Subsurface loss of well control during Season 1 (Jun.-Nov.)	Medium Crude Oil	30 d	88,728 bbl/day	45 d
2		MCWCD - Subsurface loss of well control during Season 2 (Dec.-May)			88,728 bbl/day	
3		WCD - Subsurface loss of well control during Season 1 (Jun.-Nov.)			177,157 bbl/day	
4		WCD - Subsurface loss of well control during Season 2 (Dec.-May)			177,157 bbl/day	
5	Fangtooth-1	MCWCD- Subsurface loss of well control during Season 1 (Jun.-Nov.)	Medium Crude Oil	30 d	88,728 bbl/day	45 d
6		MCWCD - Subsurface loss of well control during Season 2 (Dec.-May)			88,728 bbl/day	
7		WCD - Subsurface loss of well control during Season 1 (Jun.-Nov.)			177,157 bbl/day	
8		WCD - Subsurface loss of well control during Season 2 (Dec.-May)			177,157 bbl/day	
9	Tarpon-1A	MCWCD- Subsurface loss of well control during Season 1 (Jun.-Nov.)	Medium Crude Oil	30 d	88,728 bbl/day	45 d
10		MCWCD - Subsurface loss of well control during Season 2 (Dec.-May)			88,728 bbl/day	
11		WCD - Subsurface loss of well control during Season 1 (Jun.-Nov.)			177,157 bbl/day	

Scenario ID	Spill Site	Spill Event	Oil Type	Spill Duration	Spill Rate	Model Duration
12		WCD - Subsurface loss of well control during Season 2 (Dec.-May)			177,157 bbl/day	
13	Haimara-1	MCWCD- Subsurface loss of well control during Season 1 (Jun.-Nov.)	Medium Crude Oil	30 d	88,728 bbl/day	45 d
14		MCWCD - Subsurface loss of well control during Season 2 (Dec.-May)			88,728 bbl/day	
15		WCD - Subsurface loss of well control during Season 1 (Jun.-Nov.)			177,157 bbl/day	
16		WCD - Subsurface loss of well control during Season 2 (Dec.-May)			177,157 bbl/day	

The SIMAP model uses specific oil thickness thresholds for calculating the probability or likelihood of the presence of oil on the sea surface or shoreline. Shoreline and surface oil must be a minimum of 1 µm (1 g/m^2 on average over the grid cell) thick to be included in the probability calculations. Wind data used in the SIMAP oil spill model simulations were taken from two global models, NOGAPS and NAVGEM, to define wind speed and direction time series over the region. Data from the two models cover the same 10-year period as the hydrodynamics (2005-2014). Currents in the upper water column off the Guyana coast are strong and flow towards the northwest along the coast of South America over the entire year. The Guiana Current is part of the regional flow between South America, Africa and the Caribbean Sea, extending from Guyana to the Caribbean. Current data produced by the SAT-OCEAN model covering the area around the Stabroek Block were used in combination with currents extracted from the US Navy HYCOM global hindcast model as inputs to the SIMAP spill simulations.

The SIMAP model was used to predict the probability of oil contamination on the water surface and shoreline for spills occurring in two seasons corresponding to seasonal wind regimes. The model was also applied in deterministic mode to simulate individual spills selected as representative events from each scenario during each season. Results from the SIMAP stochastic modelling are provided in maps depicting the probability and timing of oil contamination on the water surface and maps depicting the probability and timing of oil contamination on the shoreline. An individual spill event was selected from each stochastic scenario based on the model predictions of the time of first arrival of oil onshore, or water surface area oiled for those stochastic scenarios with less than a 5 percent probability of shoreline oiling. Output from the selected spill events is provided as a map of the spill trajectory and as oil mass balance graphs showing the time history of oil volume in the environment. Surface oil is predicted to travel towards the northwest in all scenarios during both seasons.

B.4.2. Oil Properties

The transport and weathering of spilled oil are dependent on chemical and physical oil properties such as boiling point distribution, tendency to form stable or meso-stable water-in-oil emulsions, and oil viscosity. Table B-12 summarizes the characteristics of the representative hydrocarbon product, a medium crude oil, used for this study. The client provided RPS with detailed information regarding the oil properties of the products and RPS assumed a proxy/generic oil to define any additional properties necessary to run the oil spill model. These properties were based on characterizations from the Environmental Technology Centre of Environment Canada. If further information about the actual crude oil becomes available, the characterization of the oil provided by RPS and used in this modelling study should be reviewed to ensure that the representative oils are suitable.

Table B-12: Summary of the oil properties used in the modelling

Oil Type	Density (g/cm^3)	Viscosity (cP)	API Gravity	Maximum Water Content (%)
Medium Crude Oil	0.8558	11 @ 15°C	32.5	31

Viscosity and interfacial surface tension affect the degree of spreading of the oil, which in turn influences the rates of evaporation, dissolution, dispersion, and photo-oxidation. The maximum water content is a laboratory measurement of the tendency of the oil to form emulsions. Oils that form water-in-oil emulsions tend to be more persistent in the marine environment, as they are less likely to be dissolved and/or evaporated; this increases their potential for reaching the shoreline. Light products such as marine diesel and condensate have no tendency in forming an emulsion; thus, they are less persistent on the water surface relative to heavier oils (such as crude).

To classify oil products from a weathering point of view, crude oils and hydrocarbon mixtures can be broken into distillation cuts based on their boiling points. Total hydrocarbon concentrations (THC) in the oil weathering model include both aromatic (soluble) and aliphatic (insoluble) components. In general, the lighter aromatic compounds, such as Monocyclic and Polycyclic Aromatic Hydrocarbons (MAHs and PAHs, respectively), tend to rapidly evaporate to the atmosphere unless the product gets mixed into the water column. If oil is released below the water surface or gets entrained before it has weathered and lost the lower molecular weight aromatics to the atmosphere, dissolved MAHs and PAHs can reach concentrations where they can affect water column organisms or bottom communities (French-McCay and Payne 2001).

B.4.3. Response Modelling

RPS performed independent simulations of hypothetical oil spills resulting from a loss of well control event at each of four well sites within the Stabroek Block. Loss of well controls were simulated using the OILMAPDeep model to determine the fate of the oil and gas discharge plume. The SIMAP model system was used in deterministic mode to quantify the fate of the spilled oil for WCD and MCWCD spill events and to determine the effectiveness of different spill response activities. Spills were simulated using wind conditions from two distinct seasonal regimes in order to capture the range of potential environmental conditions. This section describes the spill scenario results and the response activities modelled.

Individual spill events were selected from these results based on shoreline exposure to oil. Spill events were selected based on the MCWCD and WCD in both Season 1 and Season 2. The loss of well controls were simulated using the OILMAPDeep model to determine the discharge plume geometry, define the oil droplet sizes and provide inputs for the SIMAP model simulations. The SIMAP model simulations of the unmitigated loss of well control events were run for the 30-day discharge period plus an additional 15 days for a total simulation length of 45 days.

The loss of well control events with mitigation measures applied were simulated assuming a capping stack stops the flow of oil and gas on day 5.5 and using direct dispersant injection at the wellhead, water surface dispersant application from aircrafts and vessels, mechanical recovery and in-situ burning (ISB) of surface oil. The model was run for an additional ~40 days after oil stopped flowing for a total length of simulation of 45 days (to match the unmitigated simulation duration). Table B-13 provides the timing of the various response options. Note that in reality, the timing of response measures could vary. For example, it is possible that surface dispersant application could start earlier than noted (in which case there is a potential for less surface oil than shown in the results).

Table B-13: Timing of response measures modelled. Shaded days represent when the response measure was active.

Response Measure	Days into Spill										
	1	2	3	4	5	6	7	10	12	14	21
Aerial Dispersant Application – Aircraft 1											
Aerial Dispersant Application – Aircraft 2											
Subsea Dispersant Application											
Vessel with Dispersant Application Device X 20 PSVs											
In-Situ Burn Vessels – Strike Team 1											
In-Situ Burn Vessel – Strike Team 2											
In-Situ Burn Vessel – Strike Team 3											
In-Situ Burn Vessel – Strike Team 4											
Mechanical Recovery Vessel 1											
Mechanical Recovery Vessel 2											
Mechanical Recovery Vessel 3											
Mechanical Recovery Vessel 4											
Capping Stack Installed (Day 5.5)											

B.4.4. Deterministic Model Results

Each individual spill event simulated in a stochastic scenario produces a unique spill trajectory. Depending on environmental conditions at the time of release, surface oil may be transported directly to shore or carried offshore, resulting in different effects. The 95th percentile spill events for minimum time to shore were selected from all stochastic spill scenarios simulated in each season for those stochastic scenarios with a greater than 5 percent probability of reaching shore. The model results are presented in maps and mass balance plots by spill size and season. Oiled shorelines depicted on the maps are determined by the presence of any oil amount regardless of a thickness threshold.

A summary of the mass balance at the end of the 45-day simulations in percent of released mass is provided in Table B-14. The deterministic results are also summarized in tables listing the surface area swept with a thickness greater than 1 µm (1 g/m^2 on average over the grid cell), the length of shoreline oiled with a thickness greater than 1 µm (1 g/m^2 on average over the grid cell), and the time to shore for the selected representative deterministic scenarios. The sea surface area swept is the maximum water surface area exposed to oil (not including overlapping) with a thickness exceeding the specified threshold. It is important to note when comparing the modelling results for the deterministic scenarios from the different phase studies, that dates chosen for the representative scenarios will be different across projects. Therefore, the differences in modelling results are also partially due to the specific metocean conditions of those selected dates and the spill site location in addition to the difference in the persistence of the crude oil used in this and previous modelling studies.

Table B-14: Representative worst-case scenario mass balance at the end of the simulation as percent (%) of the total column of oil released

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation
Yellowtail-1 MCWCD Medium Crude Oil - Season 1	47.6	4.3	7.3	31.1	9.5
Yellowtail-1 MCWCD Medium Crude Oil - Season 2	34.3	3.8	23	30	8.8
Yellowtail-1 WCD Medium Crude Oil - Season 1	44.9	7	6.6	26.6	14.8
Yellowtail-1 WCD Medium Crude Oil - Season 2	39.2	4.3	15.9	25.5	15.0
Fangtooth-1 MCWCD Medium Crude Oil - Season 1	45.8	7	6.7	30.5	9.9
Fangtooth-1 MCWCD Medium Crude Oil - Season 2	45.9	5.4	8.8	30.2	9.7
Fangtooth-1 WCD Medium Crude Oil - Season 1	49.4	3.5	5.5	26.5	15.1
Fangtooth-1 WCD Medium Crude Oil - Season 2	36.6	5	18.4	25.2	14.8
Tarpon-1A MCWCD Medium Crude Oil - Season 1	49.9	6.3	2.3	30.6	10.9
Tarpon-1A MCWCD Medium Crude Oil - Season 2	50.4	4.7	4	30.4	10.5
Tarpon-1A WCD Medium Crude Oil - Season 1	52.4	3.9	1.8	26.4	15.6
Tarpon-1A WCD Medium Crude Oil - Season 2	50.3	3.6	4.4	26.9	14.8
Haimara-1 MCWCD Medium Crude Oil - Season 1	46.7	2.2	10.8	31.7	8.5
Haimara-1 MCWCD Medium Crude Oil - Season 2	46.5	4.4	8	30.5	10.3
Haimara-1 WCD Medium Crude Oil - Season 1	50.2	0.9	7.5	27.5	13.9
Haimara-1 WCD Medium Crude Oil - Season 2	48.1	3.2	7.4	26.2	15.1
Mitigated Yellowtail-1 MCWCD Medium Crude Oil - Season 1	<0.1	31.3	<0.1	8.3	58.3
Mitigated Yellowtail-1 MCWCD Medium Crude Oil - Season 2	<0.1	30.8	0.2	8.8	58.3
Mitigated Yellowtail-1 WCD Medium Crude Oil - Season 1	<0.1	33.5	0	6.8	59
Mitigated Yellowtail-1 WCD Medium Crude Oil - Season 2	<0.1	31.4	0.4	6.7	60.9
Mitigated Fangtooth-1 MCWCD Medium Crude Oil - Season 1	<0.1	31.1	0	8.4	58.5
Mitigated Fangtooth-1 MCWCD Medium Crude Oil - Season 2	<0.1	30.1	0.2	8.2	59.6

B. Offshore Spill Modelled Results

Mitigated Fangtooth-1 WCD Medium Crude Oil - Season 1	<0.1	31.1	<0.1	6.9	61.3
Mitigated Fangtooth-1 WCD Medium Crude Oil - Season 2	<0.1	30.5	2.2	6.9	59.7
Mitigated Tarpon-1A MCWCD Medium Crude Oil - Season 1	<0.1	30.2	0	8.5	58.8
Mitigated Tarpon-1A MCWCD Medium Crude Oil - Season 2	<0.1	30.6	0.6	8.4	58.6
Mitigated Tarpon-1A WCD Medium Crude Oil - Season 1	<0.1	30.1	0.4	7.1	61.6
Mitigated Tarpon-1A WCD Medium Crude Oil - Season 2	<0.1	30.7	1.1	7	61.4
Mitigated Haimara-1 MCWCD Medium Crude Oil - Season 1	<0.1	31.5	0	8.5	58.2
Mitigated Haimara-1 MCWCD Medium Crude Oil - Season 2	<0.1	30.7	0	8.6	58.9
Mitigated Haimara-1 WCD Medium Crude Oil - Season 1	<0.1	31	0	7	61.3
Mitigated Haimara-1 WCD Medium Crude Oil - Season 2	<0.1	31	1.2	6.9	60.1

Table B-15: Oil effects summary for the 95th percentile spill event. Surface area is the maximum sea surface area swept above a threshold of 1 µm (1 g/m² on average) thick. Shoreline length is length of shoreline oiled above a threshold of 1 µm (1 g/m² on average) thick.

Scenario	Volume (bbl)	Surface Area (km²)	Shoreline Length (km)	Minimum Time to Shore (Days)
Yellowtail-1 MCWCD Medium Crude Oil - Season 1	2,661,840 (88,728 bpd MCWCD)	356,529	755	7.8
Yellowtail-1 MCWCD Medium Crude Oil - Season 2		72,013	1,086	6.8
Yellowtail-1 WCD Medium Crude Oil - Season 1	5,314,710 (177,157 bpd WCD)	369,141	621	8.1
Yellowtail-1 WCD Medium Crude Oil - Season 2		168,184	1,050	6.6
Fangtooth-1 MCWCD Medium Crude Oil - Season 1	2,661,840 (88,728 bpd MCWCD)	655,569	493	8.0
Fangtooth-1 MCWCD Medium Crude Oil - Season 2		643,993	0	6.2
Fangtooth-1 WCD Medium Crude Oil - Season 1	5,314,710 (177,157 bpd WCD)	552,387	874	7.5
Fangtooth-1 WCD Medium Crude Oil - Season 2		143,175	1,252	6.3
Tarpon-1A MCWCD Medium Crude Oil - Season 1	2,661,840 (88,728 bpd MCWCD)	637,520	410	7.0
Tarpon-1A MCWCD Medium Crude Oil - Season 2		507,771	486	5.6
Tarpon-1A WCD Medium Crude Oil - Season 1	5,314,710 (177,157 bpd WCD)	750,826	393	7.2
Tarpon-1A WCD Medium Crude Oil - Season 2		455,094	1,029	5.8
Haimara-1 MCWCD Medium Crude Oil - Season 1	2,661,840 (88,728 bpd MCWCD)	506,508	847	8.7
Haimara-1 MCWCD Medium Crude Oil - Season 2		522,427	660	15.8
Haimara-1 WCD Medium Crude Oil - Season 1	5,314,710 (177,157 bpd WCD)	463,790	813	9.3
Haimara-1 WCD Medium Crude Oil - Season 2		214,903	1,183	6.5

B. Offshore Spill Modelled Results

Mitigated Yellowtail-1 MCWCD Medium Crude Oil - Season 1	488,004 (88,728 bpd MCWCD)	18,633	3	9.1
Mitigated Yellowtail-1 MCWCD Medium Crude Oil - Season 2		16,030	19	7.0
Mitigated Yellowtail-1 WCD Medium Crude Oil - Season 1	974,364 (177,157 bpd WCD)	33,678	NA	NA
Mitigated Yellowtail-1 WCD Medium Crude Oil - Season 2		31,307	83	6.7
Mitigated Fangtooth-1 MCWCD Medium Crude Oil - Season 1	488,004 (88,728 MCWCD)	21,690	NA	NA
Mitigated Fangtooth-1 MCWCD Medium Crude Oil - Season 2		21,011	19	5.3
Mitigated Fangtooth-1 WCD Medium Crude Oil - Season 1	974,364 (177,157 bpd WCD)	25,476	1	9.8
Mitigated Fangtooth-1 WCD Medium Crude Oil - Season 2		30,545	215	5.3
Mitigated Tarpon-1A MCWCD Medium Crude Oil - Season 1	488,004 (88,728 bpd MCWCD)	16,354	NA	NA
Mitigated Tarpon-1A MCWCD Medium Crude Oil - Season 2		25,769	46	5.2
Mitigated Tarpon-1A WCD Medium Crude Oil - Season 1	974,364 (177,157 bpd WCD)	17,353	33	7.1
Mitigated Tarpon-1A WCD Medium Crude Oil - Season 2		26,778	63	5.8
Mitigated Haimara-1 MCWCD Medium Crude Oil - Season 1	488,004 (88,728 bpd MCWCD)	34,176	NA	NA
Mitigated Haimara-1 MCWCD Medium Crude Oil - Season 2		16,112	NA	NA
Mitigated Haimara-1 WCD Medium Crude Oil - Season 1	974,364 (177,157 bpd WCD)	19,779	NA	NA
Mitigated Haimara-1 WCD Medium Crude Oil - Season 2		27,050	140	6.1

***Unmitigated* – Yellowtail-1 Wellhead 2,661,840 bbl (88,728 bpd MCWCD) – Season 1 (June – November)**

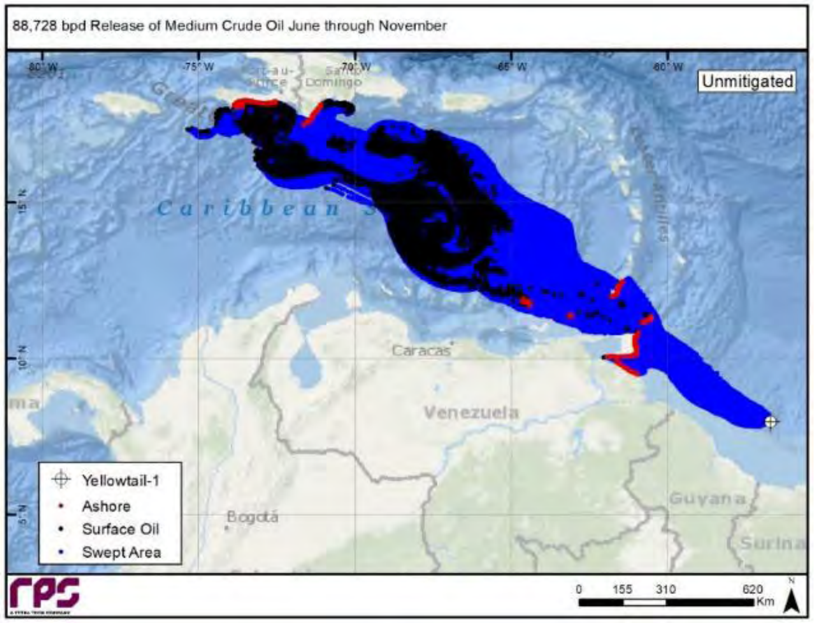


Figure B-50: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Yellowtail-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Yellowtail-1 Wellhead 486,002 (88,364 bpd Most Credible WCD) Medium Crude Release – Season 1 (June – November)**

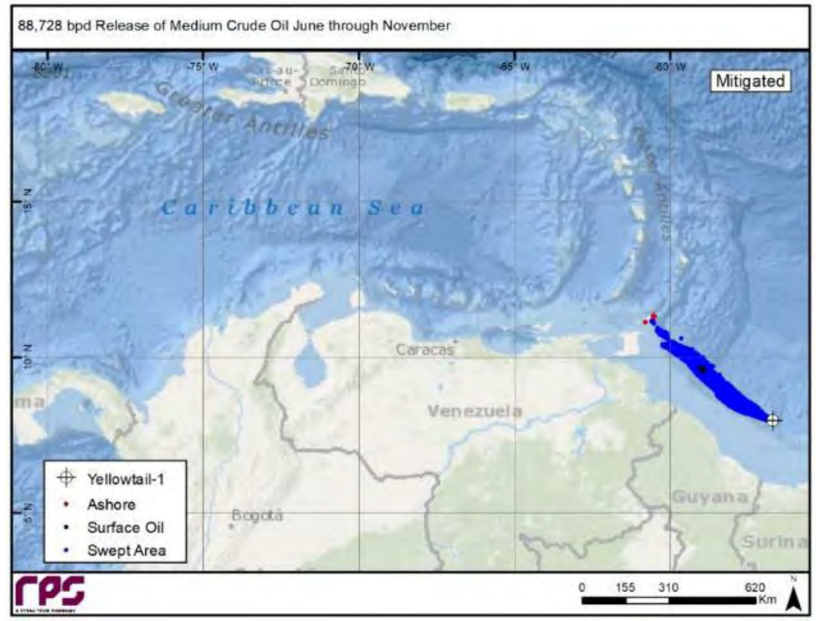


Figure B-51: Area swept results for the mitigated 95th percentile time to shore scenario for the 88,728 bpd MCWCD release of Medium Crude Oil at the Yellowtail-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Yellowtail-1 Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

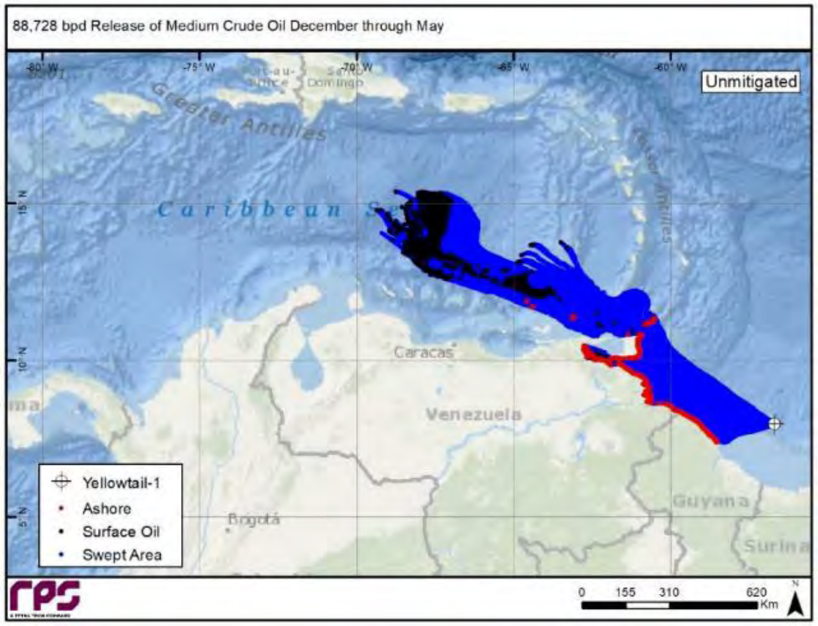


Figure B-52: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Yellowtail-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Yellowtail-1 Wellhead 486,002 (88,364 bpd Most Credible WCD) Medium Crude Release – Season 2 (December – May)**

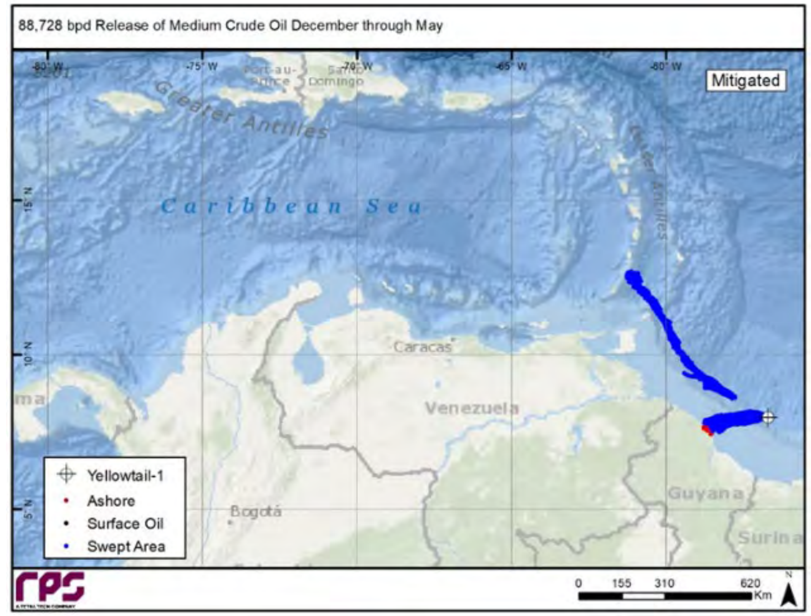


Figure B-53: Area swept results for the mitigated 95th percentile time to shore scenario for the 88,728 bpd MCWCD release of Medium Crude Oil at the Yellowtail-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated **– Yellowtail-1 Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)**

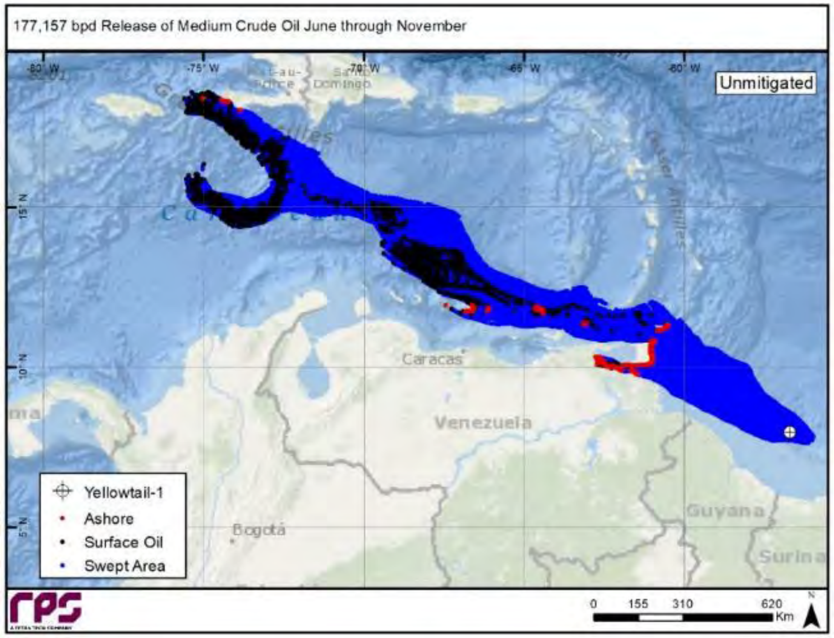


Figure B-54: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Yellowtail-1 Project wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated **– Yellowtail-1 Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)**

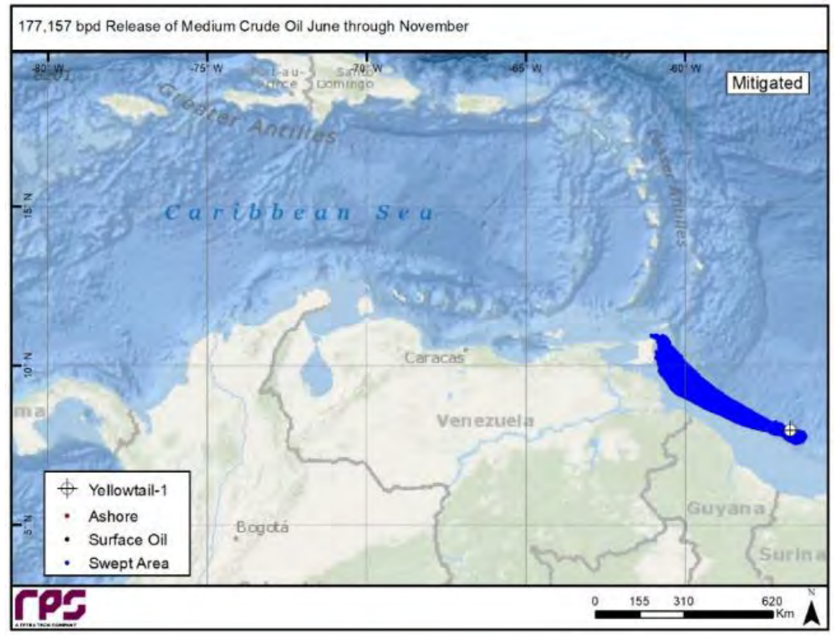


Figure B-55: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Yellowtail-1 Project wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated – Yellowtail-1 Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)

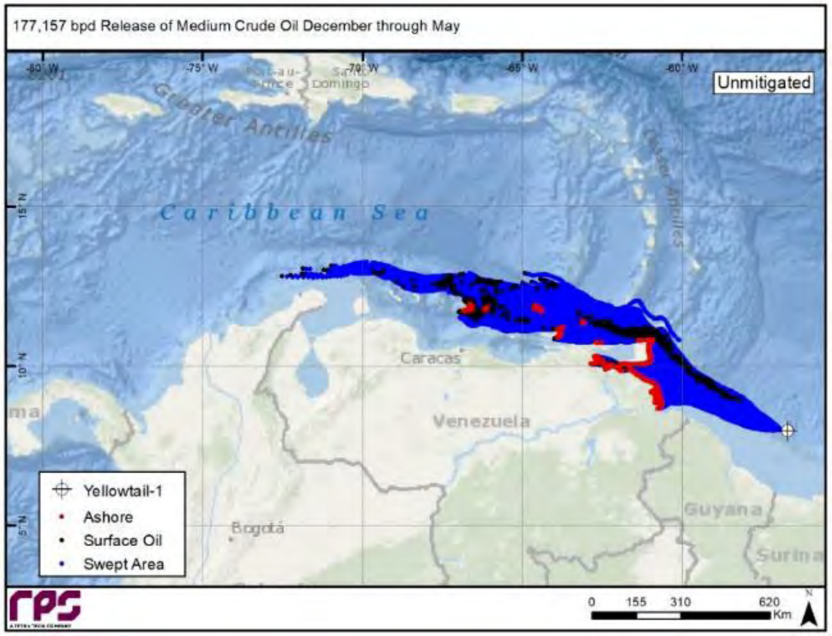


Figure B-56: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Yellowtail-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated – Yellowtail-1 Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)

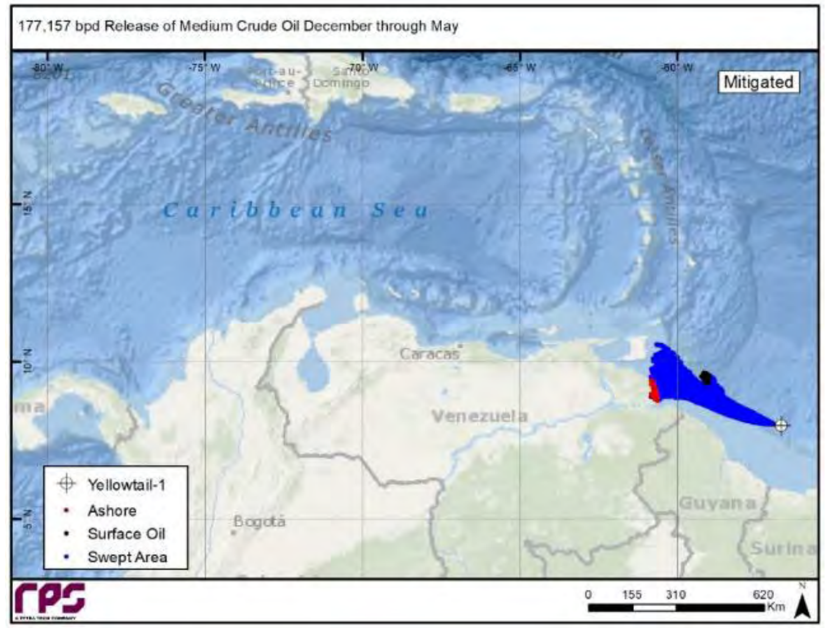


Figure B-57: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Yellowtail-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Fangtooth-1 Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 1 (June – November)**

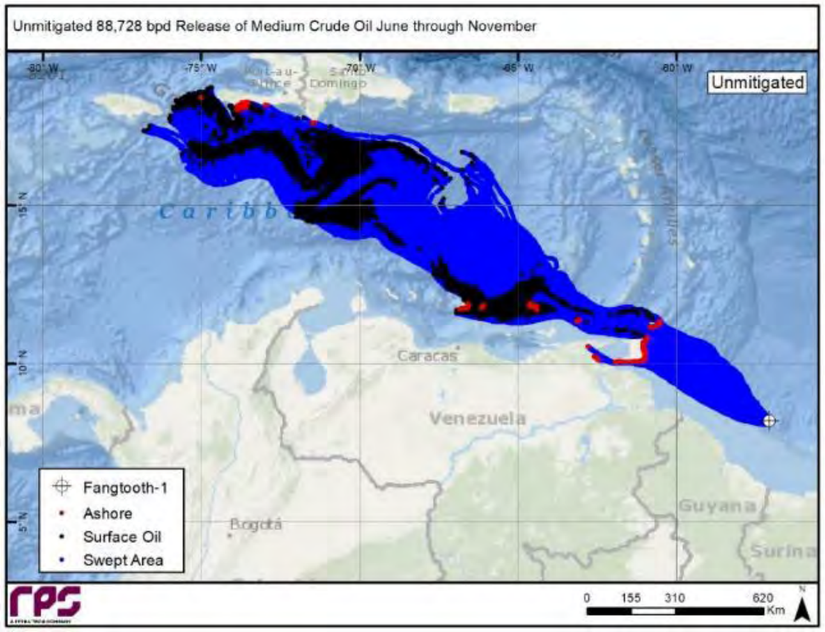


Figure B-58: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Fangtooth-1 Wellhead 486,002 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 1 (June – November)**

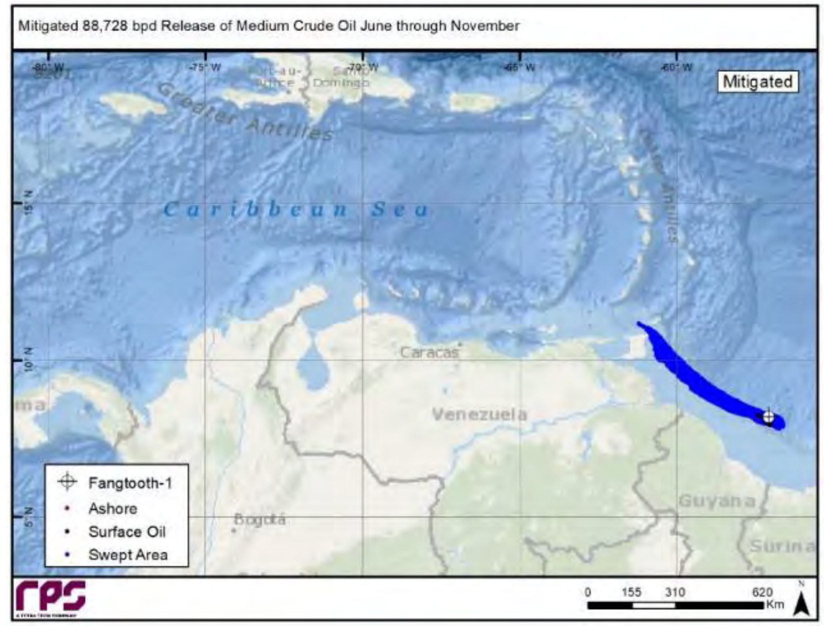


Figure B-59: Area swept results for the mitigated 95th percentile time to shore scenario for the 486,002 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Fangtooth-1 Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

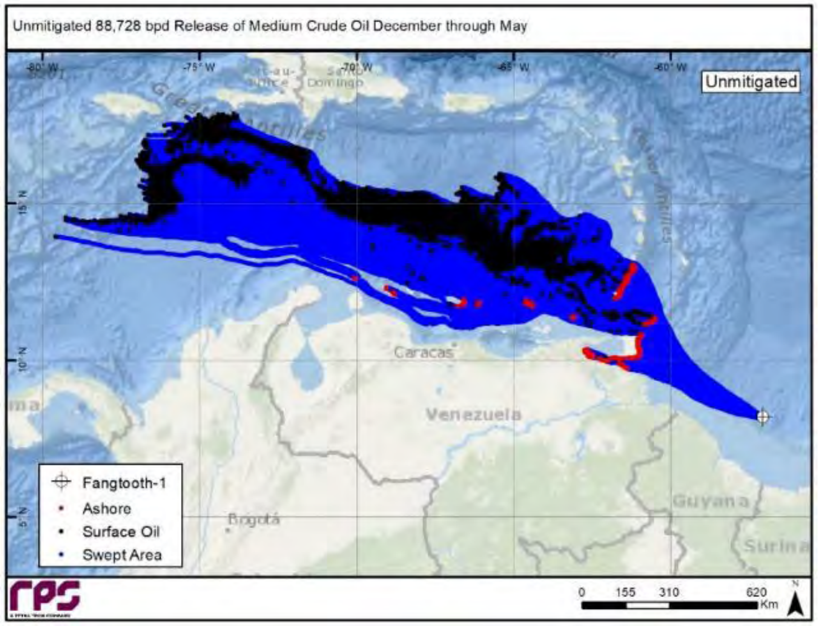


Figure B-60: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Fangtooth-1 Wellhead 486,002 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

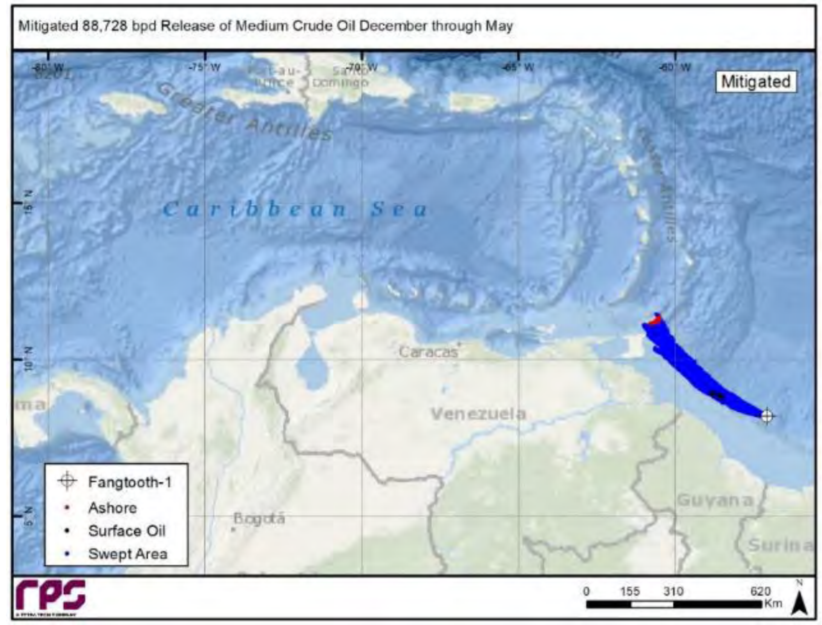


Figure B-61: Area swept results for the mitigated 95th percentile time to shore scenario for the 486,002 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Fangtooth-1 Wellhead Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)**

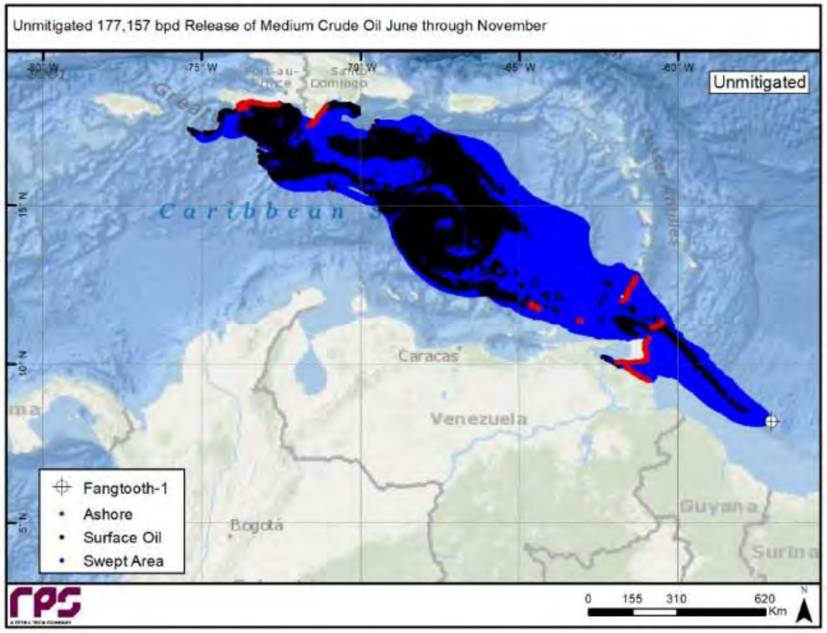


Figure B-62: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Fangtooth-1 Wellhead Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)**

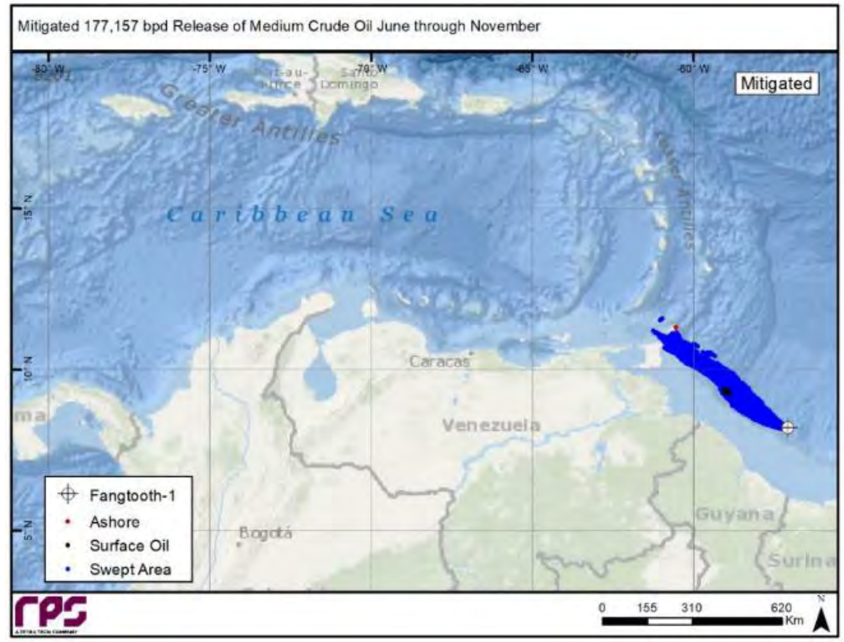


Figure B-63: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Fangtooth-1 Wellhead Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)**

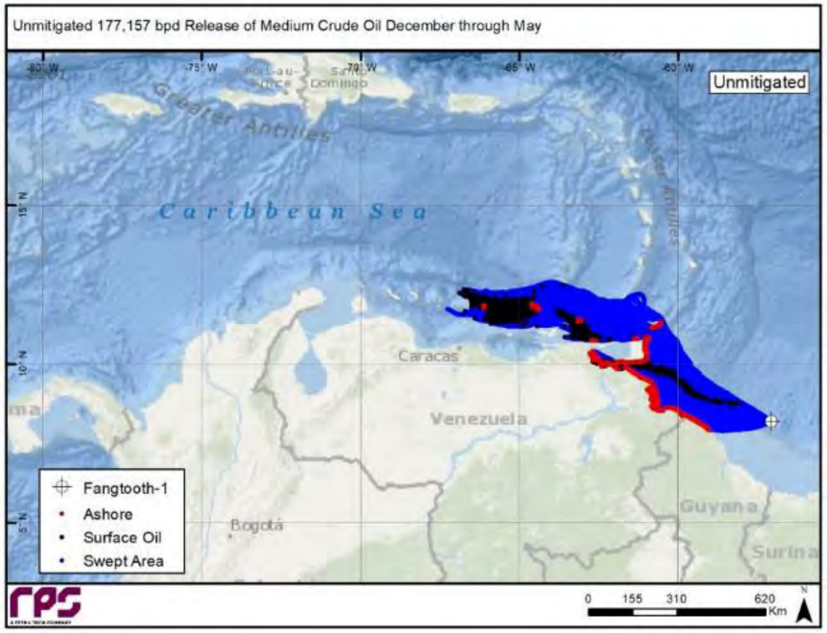


Figure B-64: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Fangtooth-1 Wellhead Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)**

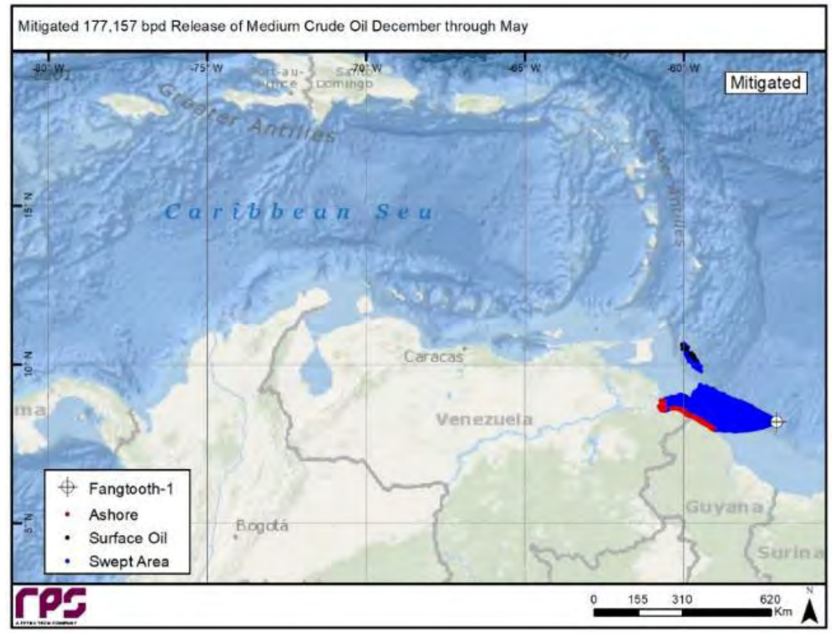


Figure B-65: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Tarpon-1A Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 1 (June – November)**

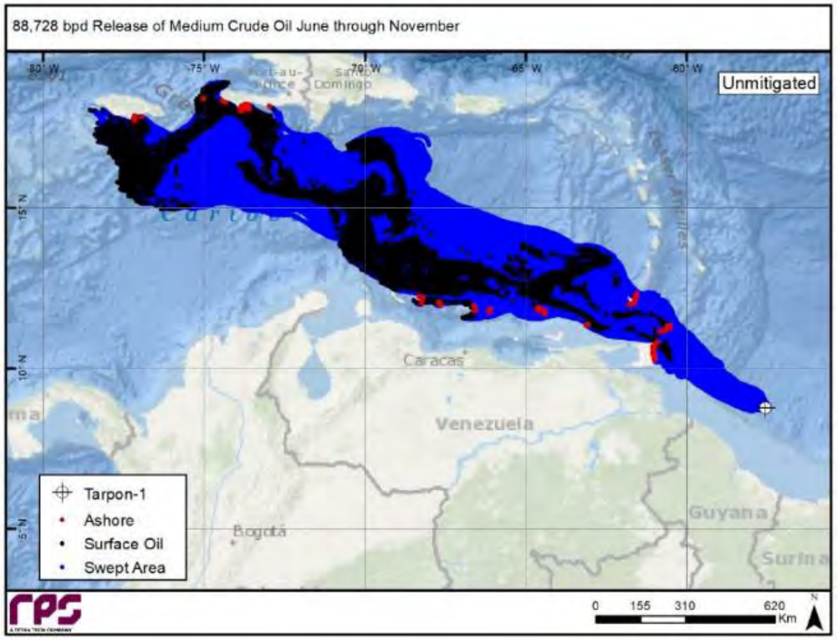


Figure B-66: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Tarpon-1A Wellhead 486,002 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 1 (June – November)**

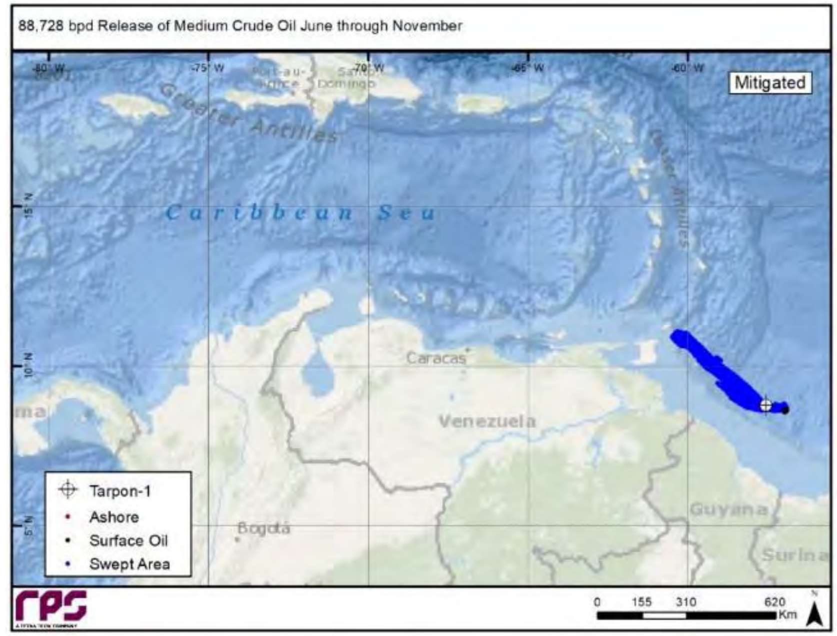


Figure B-67: Area swept results for the mitigated 95th percentile time to shore scenario for the 486,002 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Fangtooth-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Tarpon-1A Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

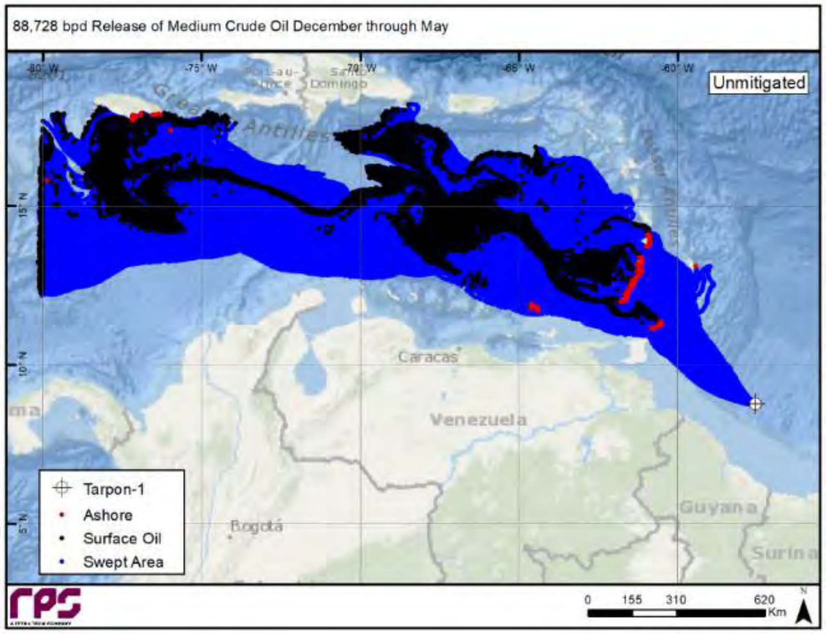


Figure B-68: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Tarpon-1A wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Tarpon-1A Wellhead 486,002 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

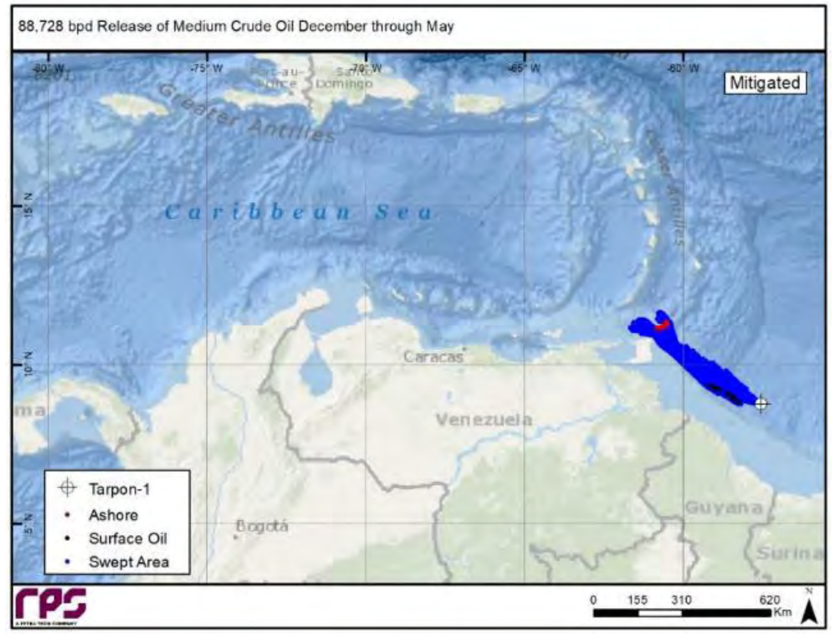


Figure B-69: Area swept results for the mitigated 95th percentile time to shore scenario for the 486,002 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Tarpon-1A wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Tarpon-1A Wellhead Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)**

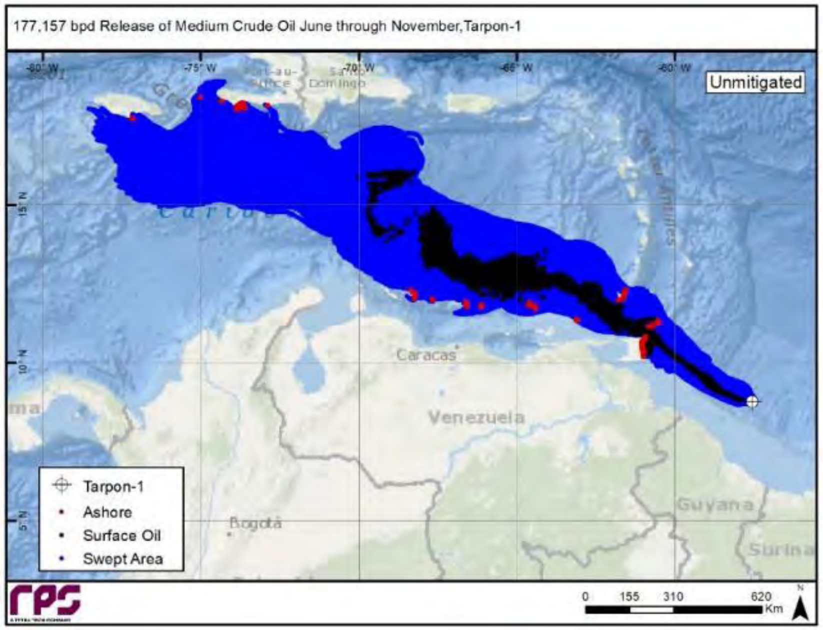


Figure B-70: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Tarpon-1A wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Tarpon-1A Wellhead Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)**

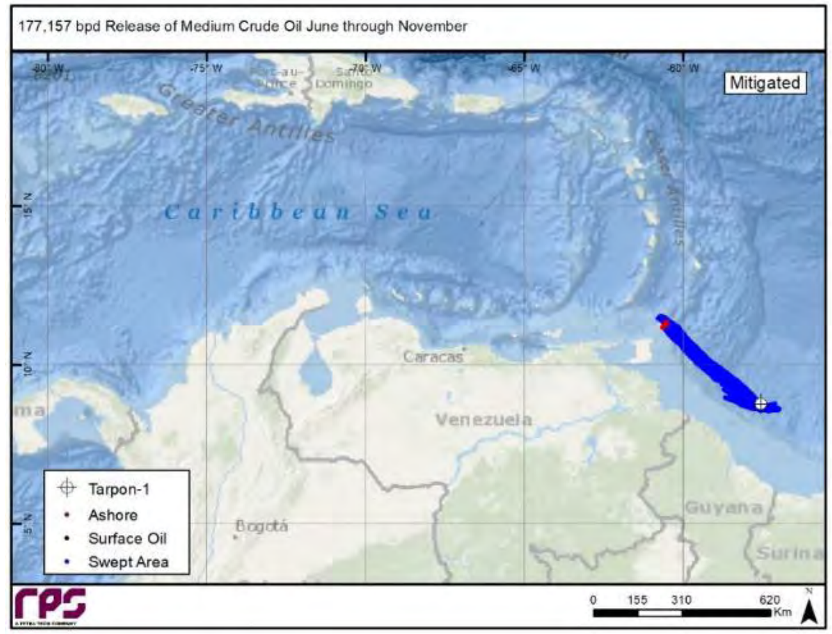


Figure B-71: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Tarpon-1A wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Tarpon-1A Wellhead Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)**

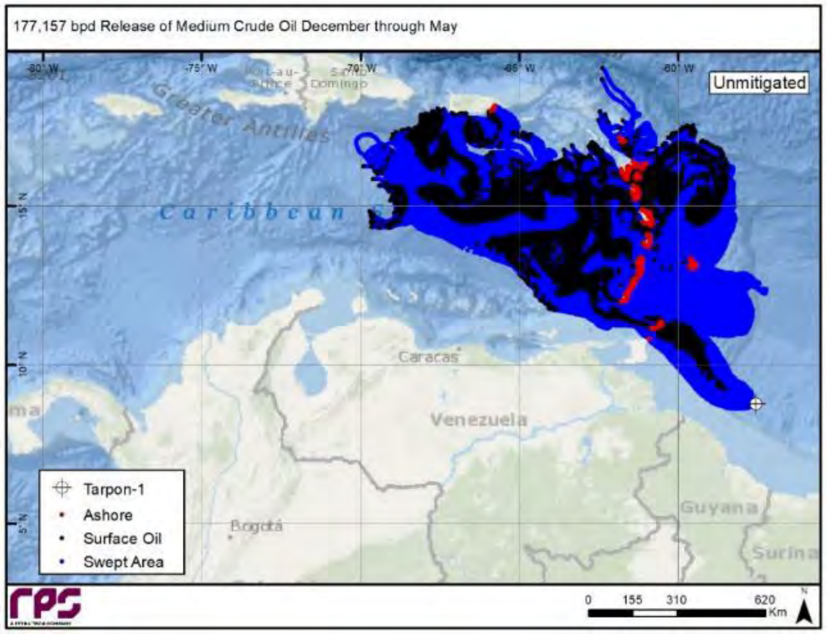


Figure B-72: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Tarpon-1A wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Tarpon-1A Wellhead Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)**

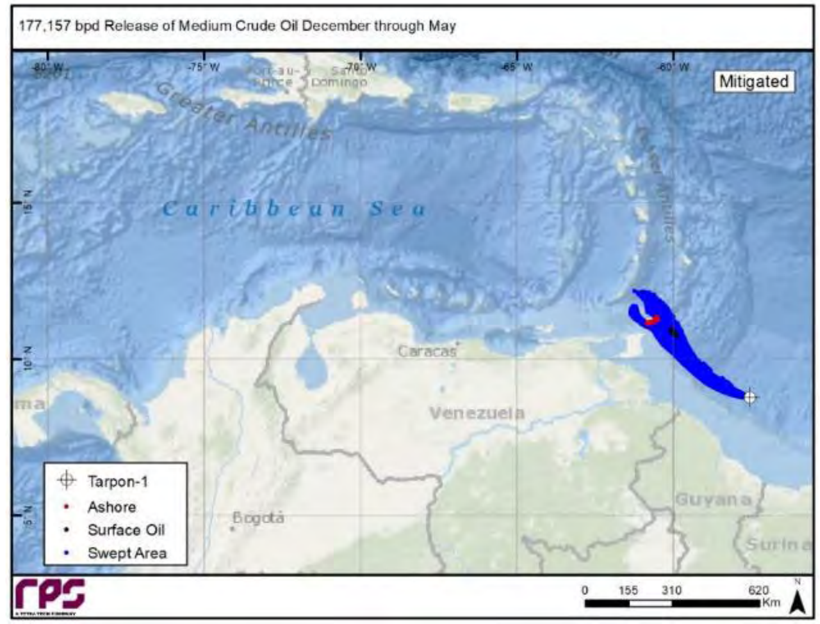


Figure B-73: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Tarpon-1A wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Haimara-1 Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 1 (June – November)**

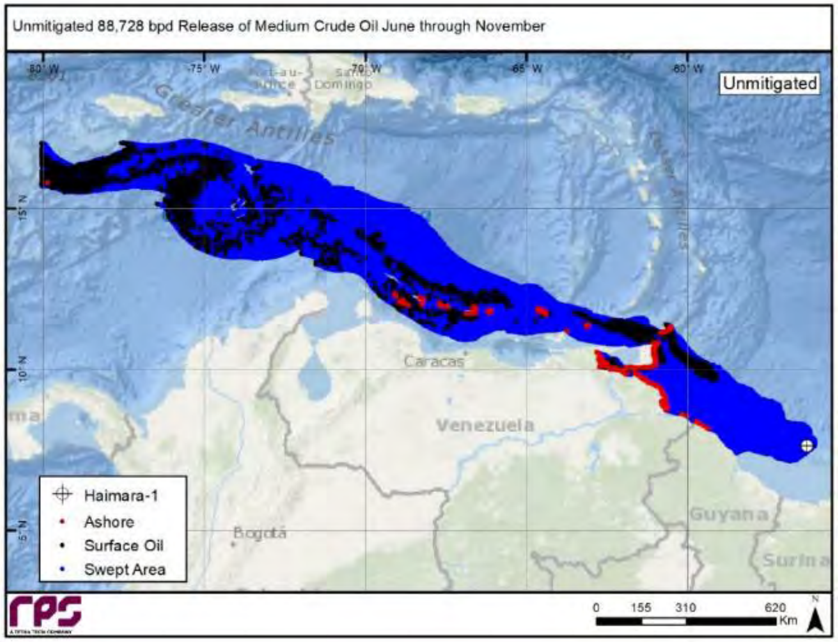


Figure B-74: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Haimara-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Haimara-1 Wellhead 486,002 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 1 (June – November)**

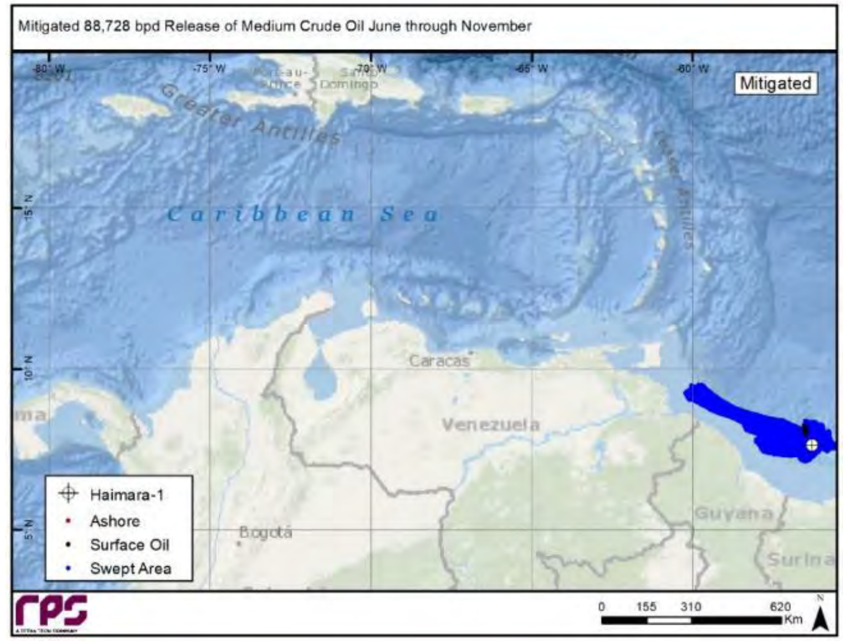


Figure B-75: Area swept results for the mitigated 95th percentile time to shore scenario for the 486,002 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Haimara-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – Haimara-1 Wellhead 2,661,840 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

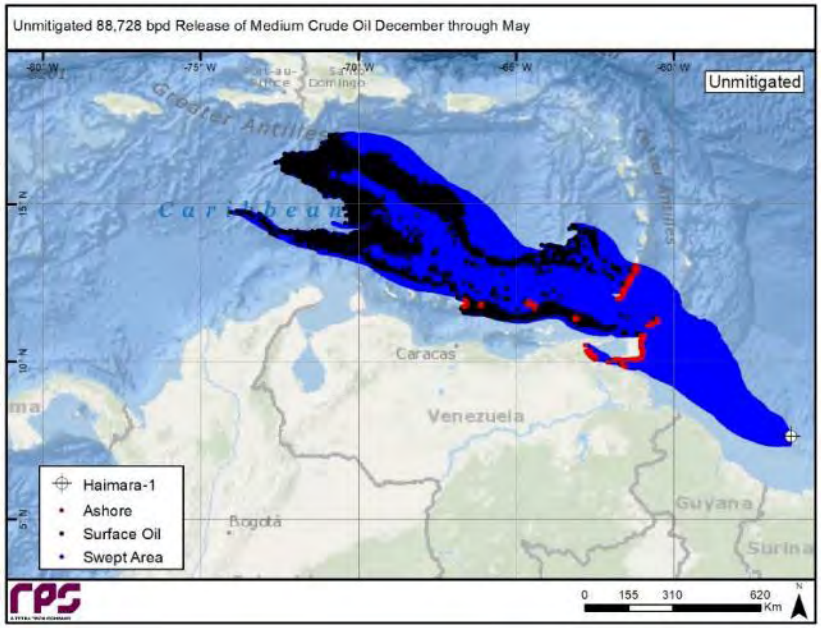


Figure B-76: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,661,840 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Haimara-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – Haimara-1 Wellhead 486,002 bbl (88,728 bpd MCWCD) Medium Crude Release – Season 2 (December – May)**

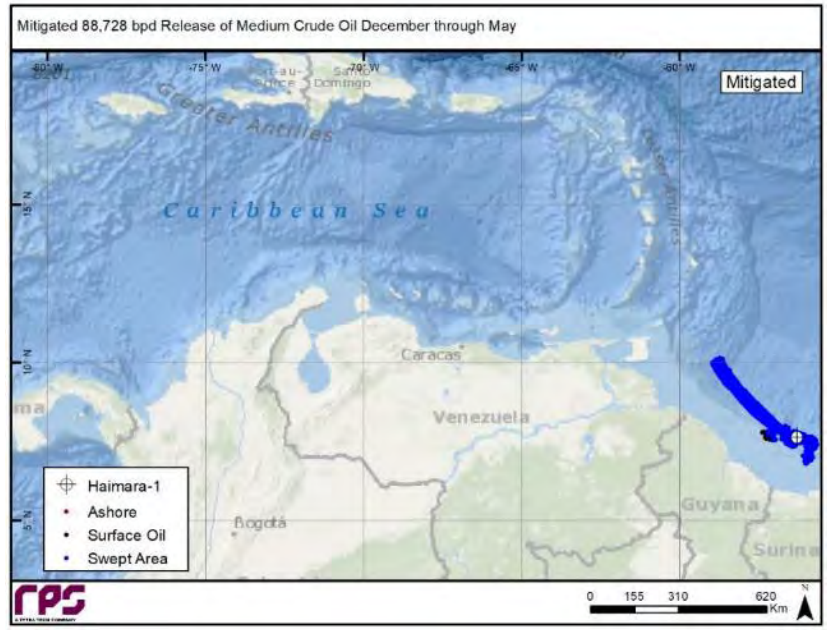


Figure B-77: Area swept results for the mitigated 95th percentile time to shore scenario for the 486,002 bbl (88,728 bpd MCWCD) spill of Medium Crude at the Haimara-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated – Haimara-1 Wellhead Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)

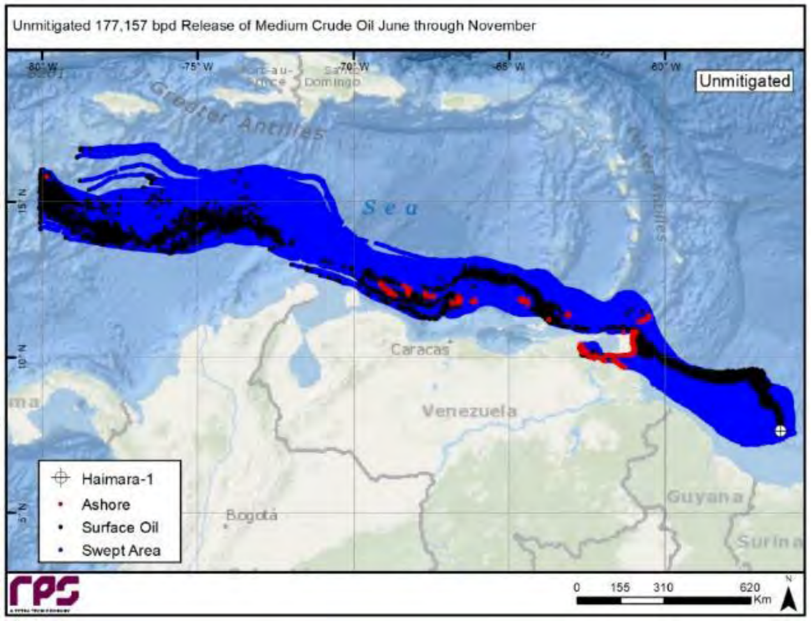


Figure B-78: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Haimara-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated – Haimara-1 Wellhead Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 1 (June – November)

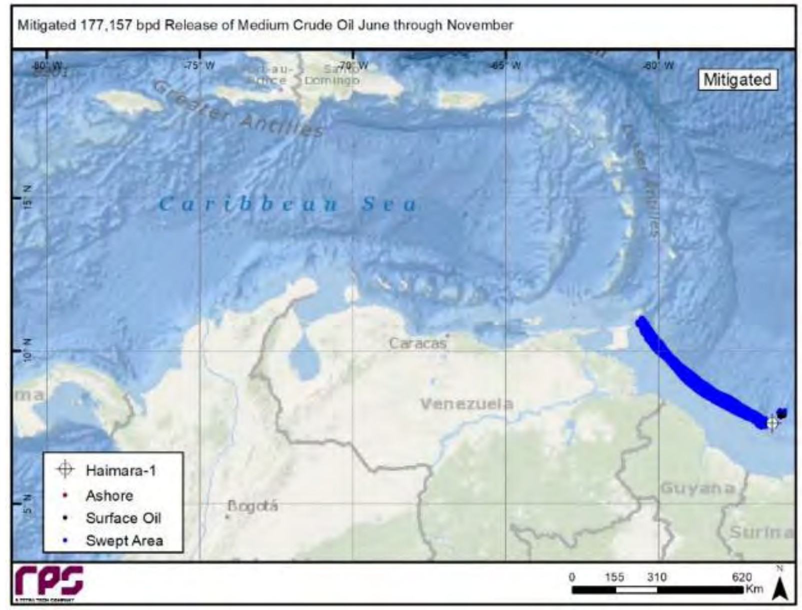


Figure B-79: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Haimara-1 wellhead during Season 1. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated **– Haimara-1 Wellhead Wellhead 5,314,710 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)**

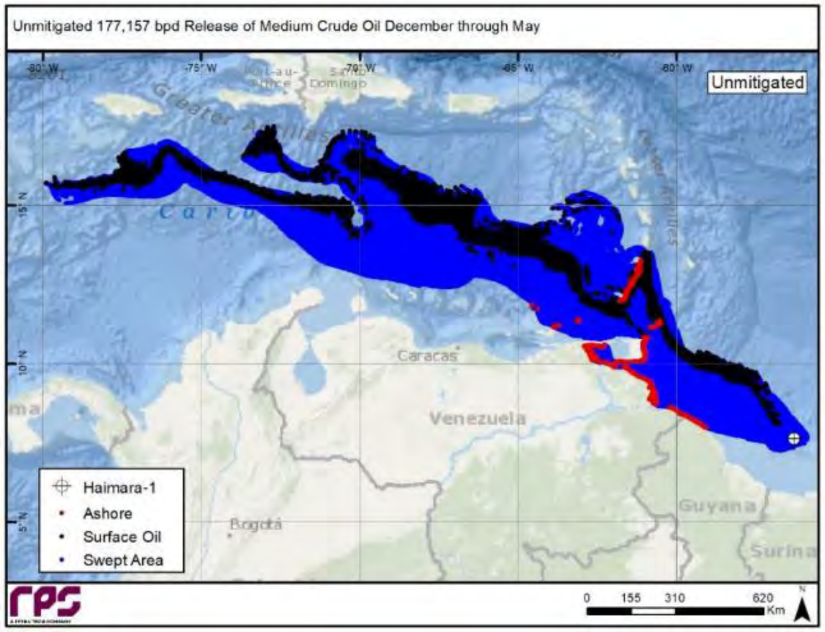


Figure B-80: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 5,314,710 bbl (177,157 bpd WCD) spill of Medium Crude at the Haimara-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated **– Haimara-1 Wellhead Wellhead 974,364 bbl (177,157 bpd WCD) Medium Crude Release – Season 2 (December – May)**

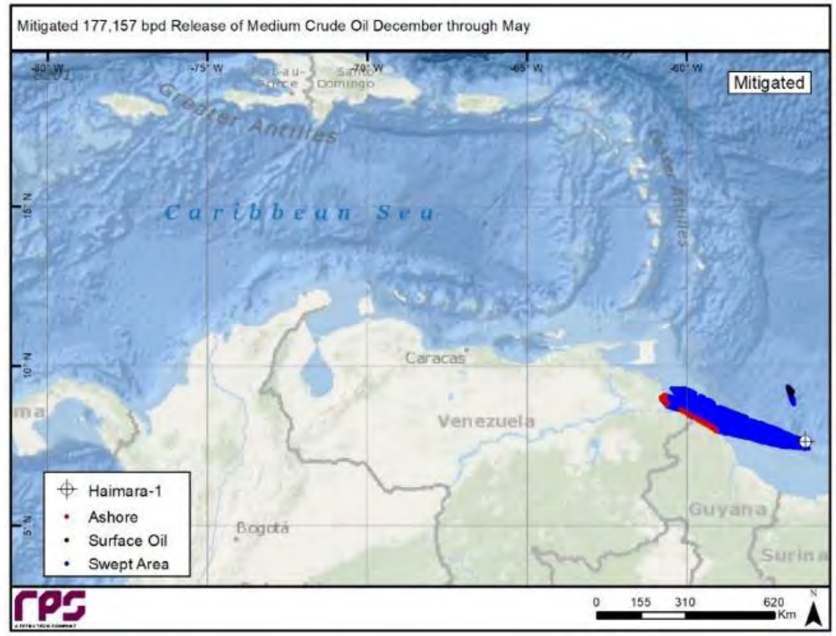


Figure B-81: Area swept results for the mitigated 95th percentile time to shore scenario for the 974,364 bbl (177,157 bpd WCD) spill of Medium Crude at the Haimara-1 wellhead during Season 2. Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

B.5. Whiptail Development Project Spill Modelling

B.5.1. Introduction

RPS Ocean Science was contracted by ERM to assess the trajectory and fate of releases using RPS SIMAP model in the offshore waters of Guyana both without and with spill response mitigation for the most credible worst-case discharge (Most Credible WCD or MCWCD) and worst-case discharge (WCD) components of the Whiptail Project.

Table B-16. Location of the spill location in the Whiptail prospect (Stabroek Block), offshore Guyana.

Spill Location	Latitude	Longitude
Whiptail WT5-P Wellhead	**8° 2' 30.4296"**	**9° 14' 29.983"**

The spill scenarios modelled are listed in Table B-17. The spill scenarios include 30-day loss of well control of light crude modelled for 45 days. The model simulations were run using environmental conditions corresponding to different regimes in Season 1 (June through November) and Season 2 (December through May) seasons defined in the analysis of long-term wind data at the spill site.

Volumes and release rates were provided by the client to RPS based on anticipated reservoir characteristics. The plume exit velocity is calculated from the total volumetric release rate and local gas to oil ratio (compressed at depth) considering reservoir properties, release depth, and the cross-sectional area of the release opening (Table B-18).

Table B-17. Spill scenarios modelled in the Whiptail prospect (Stabroek Block), offshore Guyana.

Scenario ID	Spill Site	Spill Event	Oil Type	Spill Duration	Spill Volume	Model Duration
1	Whiptail WT5-P	Most Credible WCD - Subsurface loss of well control during Season 1 (Jun–Nov)	Light Crude	30 d	82,100bbl/day (13,053 m^3/day)	45 d
2		Most Credible WCD - Subsurface loss of well control during Season 2 (Dec–May)		30 d	82,100 bbl/day (13,053 m^3/day)	45 d
3		WCD - Subsurface loss of well control during Season 1 (Jun–Nov)		30 d	154,444 bbl/day (24,555 m^3/day)	45 d
4		WCD - Subsurface loss of well control during Season 2 (Dec–May)		30 d	154,444 bbl/day (24,555 m^3/day)	45 d

B.5.2. Oil Properties

The transport and weathering of spilled oil are dependent on chemical and physical oil properties such as boiling point distribution, tendency to form stable or meso-stable water-in-oil emulsions, and oil viscosity. Table B-18 summarizes the characteristics of the hydrocarbon product, light crude, used for this study.

Table B-18. Summary of the oil properties used in the modelling.

Site	Density (g/cm3)	Viscosity (cP)	API Gravity	Maximum Water Content (%)
Whiptail WT5-P	0.838 at 15°C	7.1 at 15°C	37.4	64

B.5.3. Response Modelling

RPS performed simulations of hypothetical oil spills resulting from a loss of well control event at the Whiptail WT5-P well site. Loss of well controls were simulated using the OILMAPDeep model to determine the fate of the oil and gas discharge plume. The SIMAP model system was used in deterministic mode to quantify the fate of the spilled oil in the environment for both spill events and to determine the effectiveness of different spill response activities. Spills were simulated using wind conditions from two distinct seasonal regimes in order to capture the range of potential environmental conditions. This section describes the spill scenario results and the response activities modelled.

Individual spill events were selected from these results based on shoreline exposure to oil. Spill events were selected based on a Most Credible Worst Case Discharge (MCWCD) and a Worst Case Discharge (WCD) in both Season 1 and Season 2 (Table B-19). The unmitigated MCWCD and WCD loss of well control scenarios consisted of 2,463,026 and 4,633,389 bbl discharges, respectively, at the wellhead over 30 days. The loss of well controls were simulated using the OILMAPDeep model to determine the discharge plume geometry, define the oil droplet sizes and provide inputs for the SIMAP model simulations. The SIMAP model simulations of the unmitigated loss of well control events were run for the 30-day discharge period plus an additional 15 days for a total simulation length of 45 days.

The loss of well control events with mitigation measures applied were simulated assuming a capping stack stops the flow of oil and gas on day 5.5 and using direct dispersant injection at the wellhead, water surface dispersant application from aircrafts and vessels, mechanical recovery and in-situ burning of surface oil. The model was run for an additional 39.5 days after oil stopped flowing for a total length of simulation of 45 days. Table B-20 provides the timing of the various response options.

Table B-19. Oil spill scenarios defined for the modelling.

Scenario ID	Spill Location	Spill Response	Description	Season
1	Whiptail WT5-P	Most Credible WCD— Monitor & Observe	MCWCD 82,100 bpd (13,053 m³/day) loss of well control at the seabed for 30 days, simulated for 45 days	June–November
				December–May
2		Most Credible WCD— Mechanical, Dispersant, ISB	MCWCD 82,100 bpd (13,053 m³/day) loss of well control at the seabed for 5.5 days, simulated for 45 days	June–November
				December–May
3		WCD—Monitor & Observe	WCD 154,444 bpd (24,555 m³/day) loss of well control at the seabed for 30 days, simulated for 45 days	June–November
				December–May
4		WCD— Mechanical, Dispersant, ISB	WCD 154,444 bpd (24,555 m³/day) loss of well control at the seabed for 5.5 days, simulated for 45 days	June–November
				December–May

Table B-20. Timing of response measures modelled. Shaded days represent when the response measure was active.

Response Measure	Days into Spill						
	1	2	3	4	5	6	7+
Aerial Dispersant Application - Aircraft 1		■	■	■	■	■	■
Aerial Dispersant Application - Aircraft 2			■	■	■	■	■
Subsea Dispersant Application			■	■	■	■	■
Vessel with Dispersant Application Device x 4	■	■	■	■	■	■	■
Vessel with Dispersant Application Device x 16		■	■	■	■	■	■
In-Situ Burn Vessels – Strike Team 1						■	■
In-Situ Burn Vessel – Strike Team 2						■	■
In-Situ Burn Vessel – Strike Team 3							■
In-Situ Burn Vessel – Strike Team 4							■
Mechanical Recovery Vessel 1		■	■	■	■	■	■
Mechanical Recovery Vessel 2		■	■	■	■	■	■
Mechanical Recovery Vessel 3			■	■	■	■	■
Mechanical Recovery Vessel 4			■	■	■	■	■
Capping Stack Installed (Day 5.5)					■	■	■

B.5.4. Deterministic Model Results

Each individual spill event simulated in a stochastic scenario produces a unique spill trajectory. Depending on environmental conditions at the time of release, surface oil may be transported directly to shore or carried offshore, resulting in different effects. The 95th percentile spill events for minimum time to shore were selected from all stochastic spill scenarios simulated in each season for those stochastic scenarios with a greater than 5 percent probability of reaching shore. The model results are presented in maps and mass balance plots by spill size and season. Oiled shorelines depicted on the maps are determined by the presence of any oil amount regardless of a thickness threshold.

A summary of the mass balance at the end of the 45-day simulations in percent of released mass is provided in Table B-21. The deterministic results are also summarized in tables listing the sea surface area swept by oil with a thickness greater than 1 µm (1 g/m2 on average over the grid cell), the length of shoreline oiled with a thickness greater than 1 µm (1 g/m2 on average over the grid cell), and the time to shore for the selected representative deterministic scenarios (Table B-22).

Table B-21. Representative worst-case scenario mass balance at the end of the simulation as percent (%) of the total column of oil released.

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation	Cleaned
WT5-P Wellhead 82,100 bpd Most Credible WCD Whiptail Crude Release—June through November	25.0	18.1	3.1	44.2	9.7	NA
WT5-P Wellhead 82,100 bpd Most Credible WCD Whiptail Crude Release—December through May	22.5	21.7	3.3	41.8	10.7	NA
Mitigated WT5-P Wellhead 82,100 bpd Most Credible WCD Whiptail Crude Release—June through November	0.0	36.8	0.0	15.5	45.8	2.0
Mitigated WT5-P Wellhead 82,100 bpd Most Credible WCD Whiptail Crude Release—December through May	0.0	35.0	0.1	15.1	47.8	2.0
WT5-P Wellhead 154,444 bpd WCD Whiptail Crude Release—June through November	30.5	13.1	1.8	37.1	17.5	NA
WT5-P Wellhead 154,444 bpd WCD Whiptail Crude Release—December through May	35.4	8.1	2.4	36.0	18.2	NA
Mitigated WT5-P Wellhead 154,444 bpd WCD Whiptail Crude Release—June through November	0.0	33.7	0.4	15.1	48.3	2.5
Mitigated WT5-P Wellhead 154,444 bpd WCD Whiptail Crude Release—December through May	0.0	32.0	0.2	14.9	50.3	2.6

Table B-22. Oil effects summary for the 95th percentile spill event. Surface area is the maximum sea surface area swept above a threshold of 1 μm (1 g/m² on average) thick. Shoreline length is length of shoreline oiled above a threshold of 1 μm (1 g/m² on average) thick.

Scenario	Volume (bbl)	Season	Swept Surface Area (km^2)	Shoreline Length (km)	Minimum Time to Shore (Days)
WT5-P Wellhead Whiptail Crude Release	82,100 bpd Most Credible WCD	June–November	629,209	507	7
WT5-P Wellhead Whiptail Crude Release		December–May	839,044	608	6
Mitigated WT5-P Wellhead Whiptail Crude Release	82,100 bpd Most Credible WCD	June–November	21,187	NA	NA
Mitigated WT5-P Wellhead Whiptail Crude Release		December–May	26,876	41	6
WT5-P Wellhead Whiptail Crude Release	154,444 bpd WCD	June–November	551,805	378	8
WT5-P Wellhead Whiptail Crude Release		December–May	580,634	557	6
Mitigated WT5-P Wellhead Whiptail Crude Release	154,444 bpd WCD	June–November	28,714	61	8
Mitigated WT5-P Wellhead Whiptail Crude Release		December–May	41,014	34	6

***Unmitigated* – WT5-P Wellhead 2,463,026 bbl (82,100 bpd or 13,053 m^3/day MCWCD) Medium Crude Release – Season 1 (June – November)**

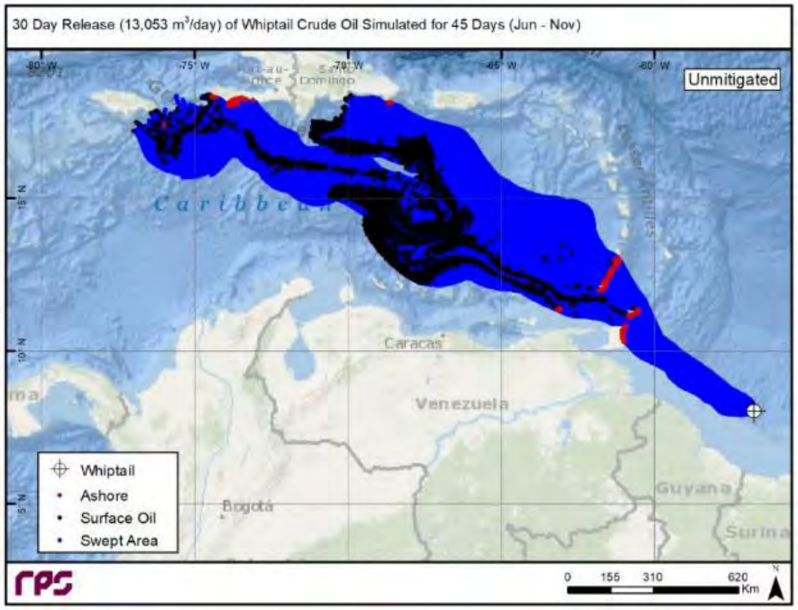


Figure B-82: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,463,026 bbl (82,100 bpd or 13,053 m^3/day MCWCD) Medium Crude Release – Season 1 (June – November). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – WT5-P Wellhead 451,550 bbl (82,100 bpd or 13,053 m^3/day MCWCD) Medium Crude Release – Season 1 (June – November)**

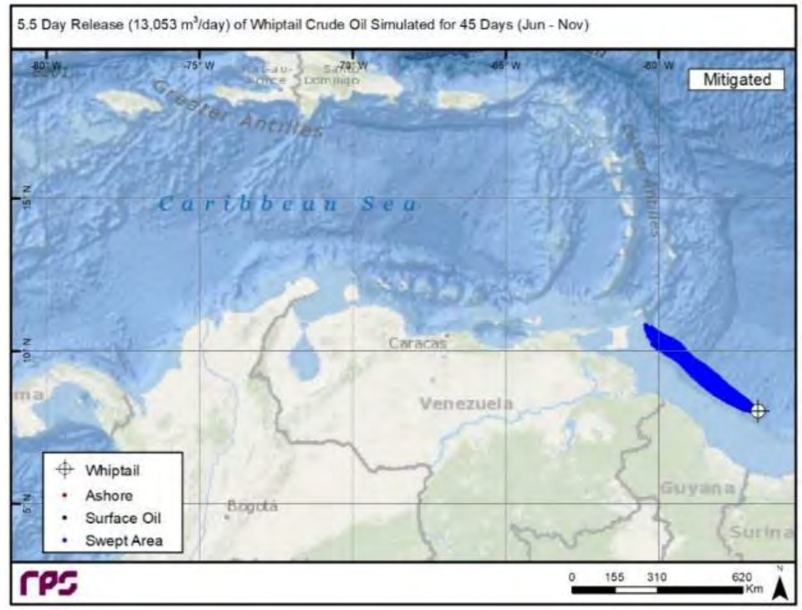


Figure B-83: Area swept results for the mitigated 95th percentile time to shore scenario for a 451,550 bbl (82,100 bpd or 13,053 m^3/day MCWCD) Medium Crude Release – Season 1 (June – November). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – WT5-P Wellhead 2,463,026 bbl (82,100 bpd or 13,053 m³/day) Medium Crude Release – Season 2 (December – May)**

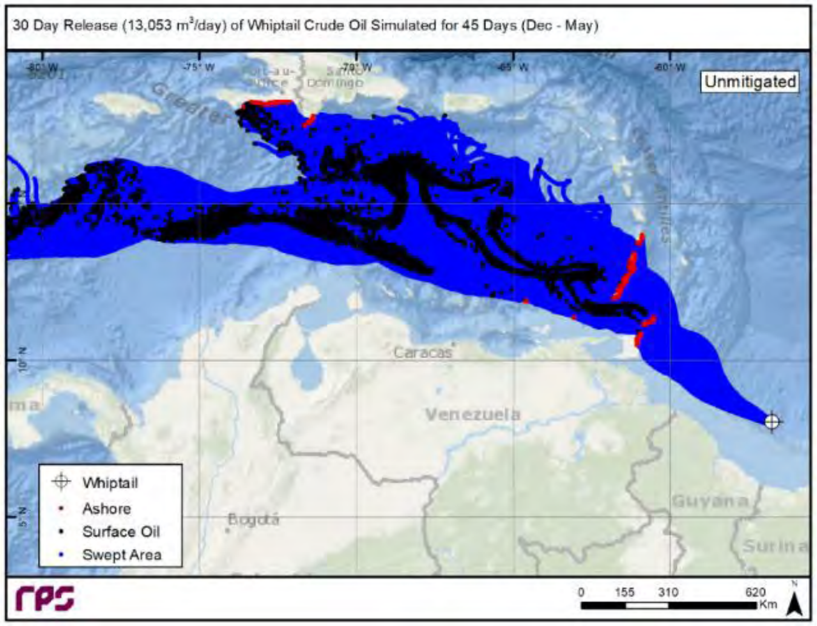


Figure B-84: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 2,463,026 bbl (82,100 bpd or 13,053 m³/day MCWCD) Medium Crude Release – Season 2 (December – May). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – WT5-P Wellhead 451,550 bbl (82,100 bpd or 13,053 m³/day MCWCD) Medium Crude Release – Season 2 (December – May)**

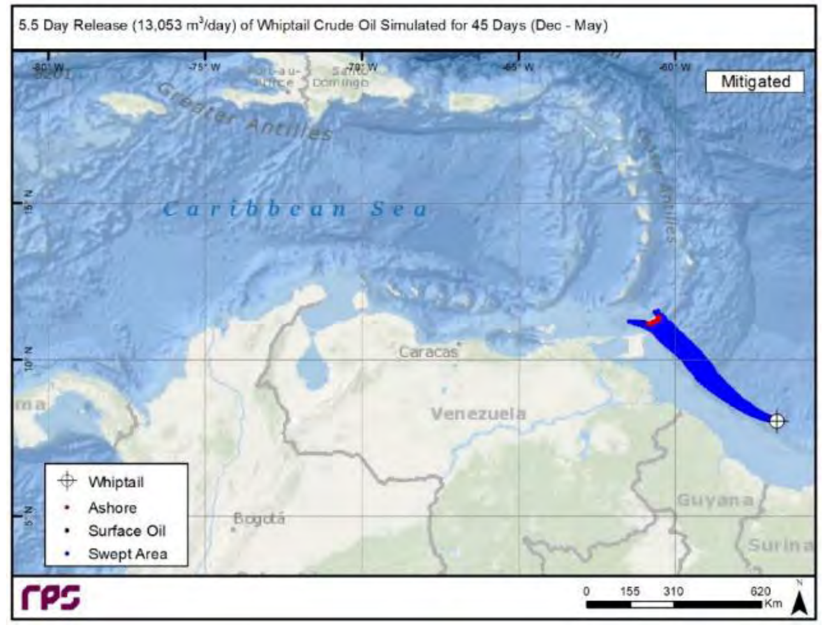


Figure B-85: Area swept results for the mitigated 95th percentile time to shore scenario for a 451,550 bbl (82,100 bpd or 13,053 m³/day MCWCD) Medium Crude Release – Season 2 (December – May). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Unmitigated* – WT5-P Wellhead 4,633,389 bbl (154,444 bpd WCD or 24,555 m^3/day) Medium Crude Release – Season 1 (June – November)**

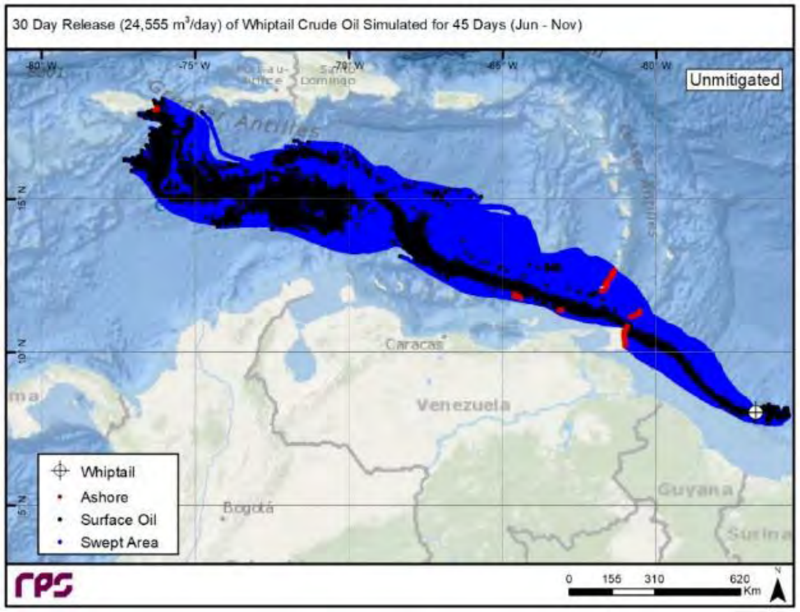


Figure B-86: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 4,633,389 bbl (154,444 bpd WCD or 24,555 m^3/day) Medium Crude Release – Season 1 (June – November). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

***Mitigated* – WT5-P Wellhead 849,442 bbl (154,444 bpd or 24,555 m^3/day WCD) Medium Crude Release – Season 1 (June – November)**

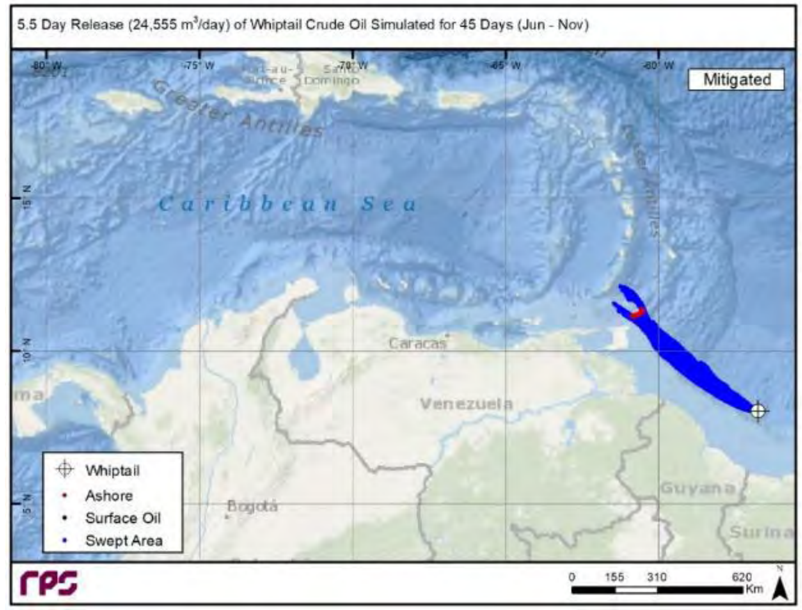


Figure B-87: Area swept results for the mitigated 95th percentile time to shore scenario for an 849,442 bbl (154,444 bpd or 24,555 m^3/day WCD) Medium Crude Release – Season 1 (June – November). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Unmitigated **– WT5-P Wellhead 4,633,389 bbl (154,444 bpd WCD or 24,555 m^3/day) Medium Crude Release – Season 2 (December – May)**

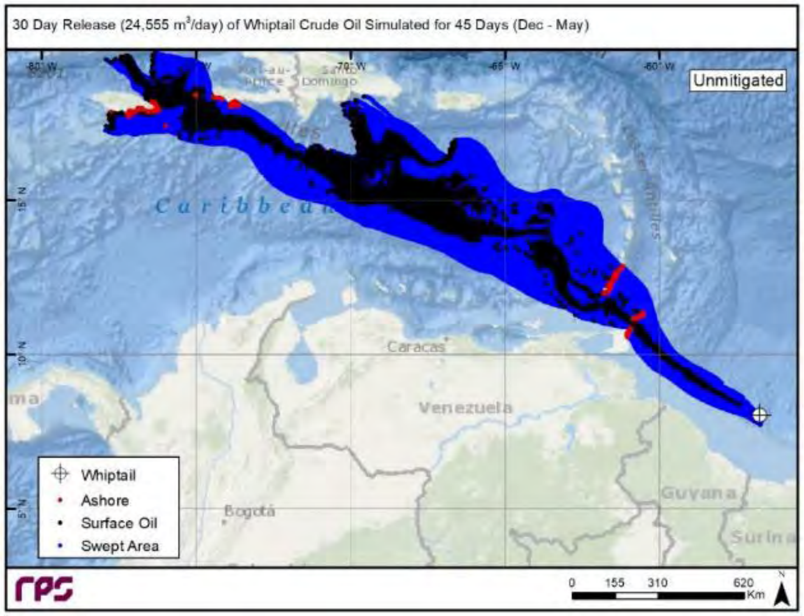


Figure B-88: Area swept by surface oil throughout 45-day model simulation for a 95th percentile minimum time to shore scenario for a 4,633,389 bbl (154,444 bpd WCD or 24,555 m^3/day) Medium Crude Release – Season 1 (June – November). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

Mitigated **– WT5-P Wellhead 849,442 bbl (154,444 bpd or 24,555 m^3/day WCD) Medium Crude Release – Season 2 (December – May)**

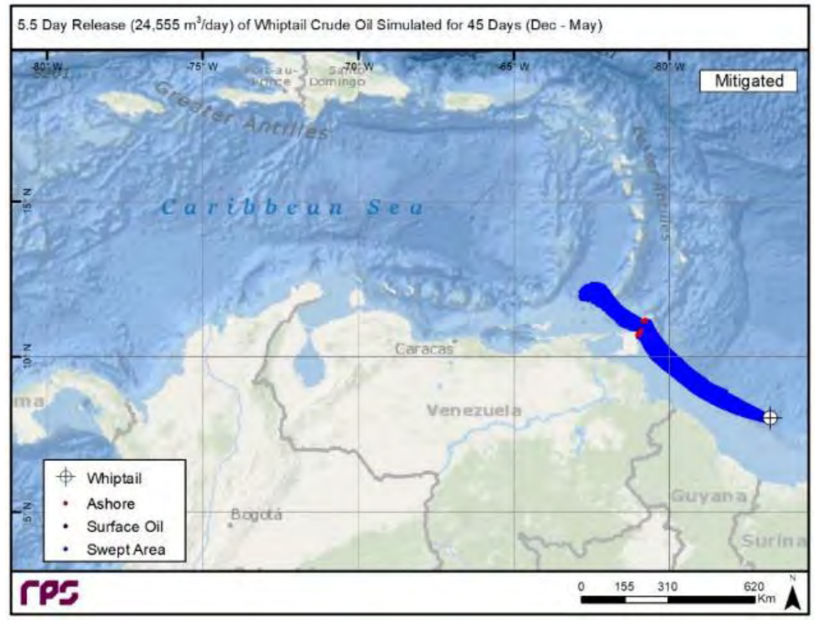


Figure B-89: Area swept results for the mitigated 95th percentile time to shore scenario for an 849,442 bbl (154,444 bpd or 24,555 m^3/day WCD) Medium Crude Release – Season 2 (December – May). Blue area represents surface area swept. Black points represent surface oil remaining at the end of the simulation. Red points represent shoreline oil remaining at the end of the simulation.

B.5.5. Summary and Conclusions

Stochastic Model Results

The trajectory of spills from the Whiptail WT5-P well head are driven largely by the strong northwest flowing currents running parallel to the South American coast. The easterly and east-northeasterly winds drive oil ashore, but in general are not strong enough the overcome the transport by currents.

Surface oil is predicted to travel towards the northwest in all scenarios during both seasons.

The probability of oil contamination on the shoreline tends to be highest on the coast of Trinidad and Tobago, particularly during December through May, because of the predominant current flow through the Stabroek Block and into the Caribbean. Lower shoreline oiling probabilities (<20 percent) are predicted as far north as Dominican Republic and Haiti and as far west as Venezuela. December through May spills generally show a higher oil stranding probability due to the faster currents and northeasterly winds prevalent.

Deterministic Model Results

The predicted time of first arrival of oil on shore for the spill events ranked as the 95th percentile WCDs ranged from 6 to 8 days so oil is expected to be well-weathered by landfall. Differences in seasonal wind and current velocities resulted in some differences in the unmitigated swept sea surface exposure to oil (551,805 km^2 to 839,044 km^2) and shoreline length oiled 378 km to 608 km). Strong northwesterly transport resulted in significant shoreline oiling in Trinidad and Tobago, with additional surface oil transport past Trinidad and Tobago into the Caribbean Sea, contacting the shores of Greater Antilles and northward to Haiti and Dominican Republic. Large amounts of oil (<503,000 bbl or >80,000 m^3) remained on the surface at the end of the 45-day simulations in both unmitigated WCD scenarios.

Response measures were performed on MCWCD and WCD loss of well control scenarios in both seasons. Response measures included a capping stack applied after 5.5 days to the well head, dispersants applied at the well head, dispersants applied aerially and by boat, burning, and mechanical removal. Dispersants applied at the wellhead were effective in reducing the size of the oil droplets, leading to greater entrainment in the water column compared to the unmitigated cases. Response measures resulted in a reduction of shoreline oiling and a reduction in oil contamination to water surface area for both modelled scenarios.

B.5.6. Oil thickness based on the modelled Lagrangian elements – example for Whiptail Development Project

B.5.6.1 Whiptail Development Project Oil spill modelling

ERM contracted RPS Ocean Science, on behalf of EMGL, to assess the trajectory and fate of hypothetical Worst-Case Discharges (WCDs) of oil resulting from loss of well control events occurring at a well site (WT5-P) in the Whiptail prospect within the Stabroek Block, offshore

Guyana. The SIMAP model system was used in stochastic mode to determine the probability of oil contamination to the sea surface and the shoreline, and in deterministic mode to quantify the fate of the spilled oil in the environment for representative spill events.

During modelling, components of oil were tracked as floating surface oil, entrained droplets of whole oil, stranded oil on shorelines and sediments, evaporated, and degraded. RPS delivered an oil spill modelling report with figures provided to depict the cumulative swept area footprint of surface and shoreline oil predicted to be within a region over the entire modelled duration. Therefore, the depicted footprints are much larger than the amount of oil that would be present in a region at any given time following the release of oil. Furthermore, the figures only feature oil location (based on Lagrangian elements, or “spillets”). These maps do not provide an indication of the concentration or thickness of oil in those locations and serve as a binary “yes/no” result of whether any oil passed through each identified area as opposed to thicknesses that may indicate the potential for acute mortality.

Based on conversations with ERM and EMGL, RPS created a sample figure that shows the oil thickness based on the modelled Lagrangian elements. Figure B-90 illustrates the predicted surface oil thickness at five specific time steps, or “snapshots” in time (days 5, 10, 20, 30, and 45), for the representative case of the 45-day WCD (i.e., 154,444 bpd for 30 days) in Season 2 (December to May) within the Whiptail lease prospect. Note the patchy and discontinuous nature of the predicted footprint as the released oil dispersed and thinned over time.

In general, the oil on the surface is transported by currents to the northwest. Throughout the 30-day release, there is heavily concentrated “Dark” or “Emulsified” oil (thicknesses > 200 um) oriented in a northwest trajectory. After the release stops, oil is predicted to continue to move towards the northwest, however the oil would go through natural weathering which then causes the oil to be in thinner, patchy, and discontinuous patches.

For reference, typical thresholds of concern used in RPS studies, and the Bonn Agreement Thickness chart are provided in the subsequent section (Table B-23).

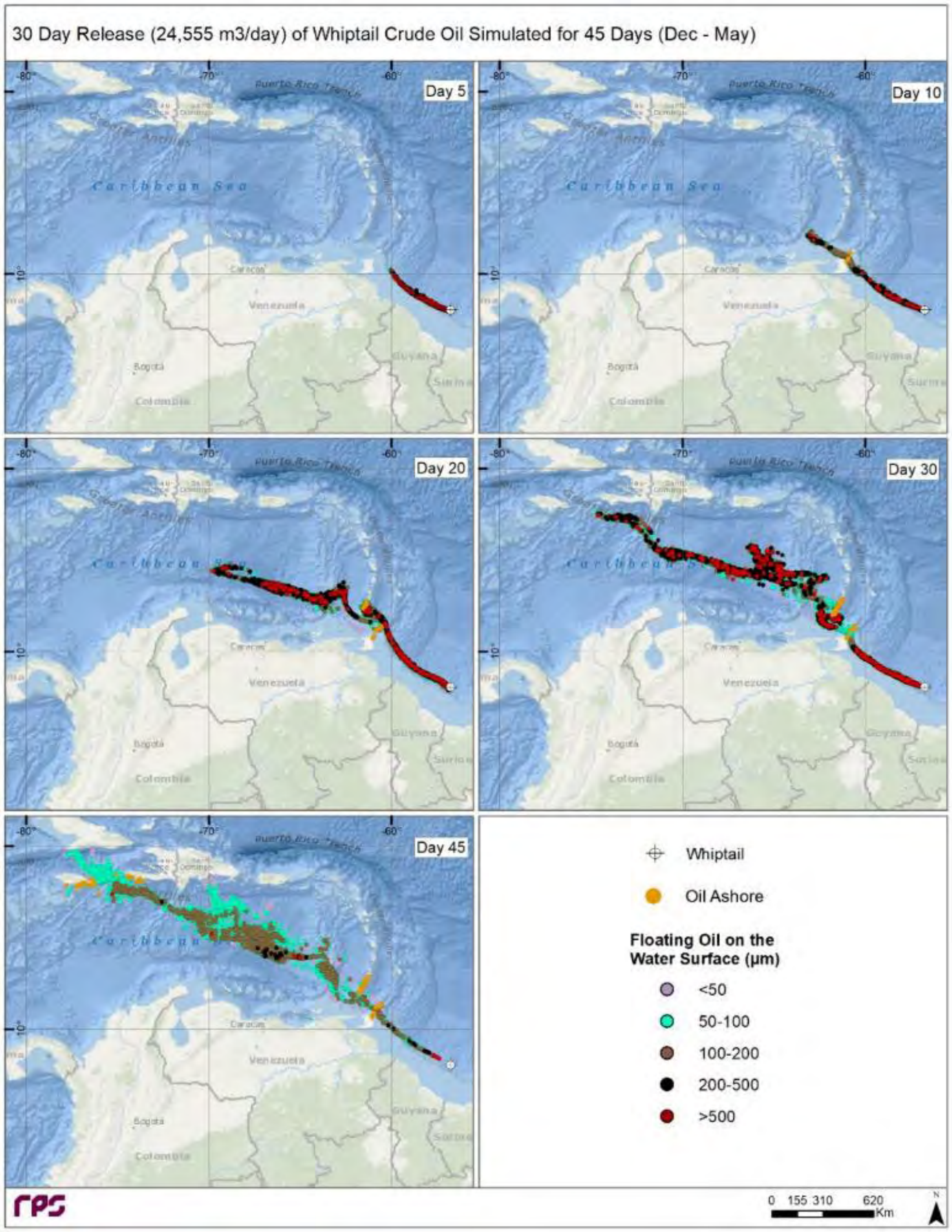


Figure B-90. Predicted surface oil thickness and oil ashore for the representative case for the 45-day WCD (i.e., 154,444 bpd or 24,555 m^3/day for 30 days) in Season 2 (December to May) at days 5, 10, 20, 30, and 45 to illustrate the variation in size of the surface oil footprint over the course of the model duration.

B.5.6.2 Thresholds of Concern/Interest

Floating surface oil is expressed as thickness (µm) based on the concentration of oil in a given spillet. Surface oil thickness is typically associated with visual appearance by aerial observation for responders (NRC, 1985; Bonn Agreement, 2009, 2011; NOAA, 2016; Table B-23).

As an example, barely visible sheens may be observed above 0.04 µm and silver sheens correspond with surface oil thickness of approximately 0.3 µm. Crude and heavy fuel oils greater than 1 mm thick typically appear as black oil, while light fuels and diesels that are greater than 1 mm thick may appear brown or reddish. Because of the differences between oils and their degree of weathering, as well as the weather conditions and sea state at the time of observations, floating oil will not always have the same appearance. As oil weathers, it may be observed in the form of scattered floating tar balls and tar mats where currents converge. Typically, oil slicks in the environment would be observed as patchy and discontinuous with a range of visual appearances including silver sheen, rainbow sheen, and metallic areas simultaneously, as a combination of thicknesses may be present (Table B-23).

Table B-23. Oil Appearances based on NOAA JobAid (2016) and BAOAC.

Code	Description	Layer-Thickness		Concentration	
		microns (µm)	Inches (in.)	m^3 per km^2	bbl/acre
S	Silver Sheen	0.04–0.30	1.6×10^{-6} - 1.2×10^{-5}	0.04–0.30	1×10^{-3} - 7.8×10^{-3}
R	Rainbow Sheen	0.30–5.0	1.2×10^{-5} - 2.0×10^{-4}	0.3–5.0	7.8×10^{-3} - 1.28×10^{-1}
M	Metallic Sheen	5.0–50	2.0×10^{-4} - 2.0×10^{-3}	5.0–50	1.28×10^{-1} - 1.28
T	Transitional Dark (or true) Color	50–200	2.0×10^{-3} - 8×10^{-3}	50–200	1.28 - 5.1
D	Dark (or true) Color	> 200	> 8×10^{-3}	> 200	> 5.1
E	Emulsified	Thickness range is very similar to that of dark oil.			

* Chart from Bonn Agreement Oil Appearance Code (BAOAC) May 2, 2006, modified by A. Allen

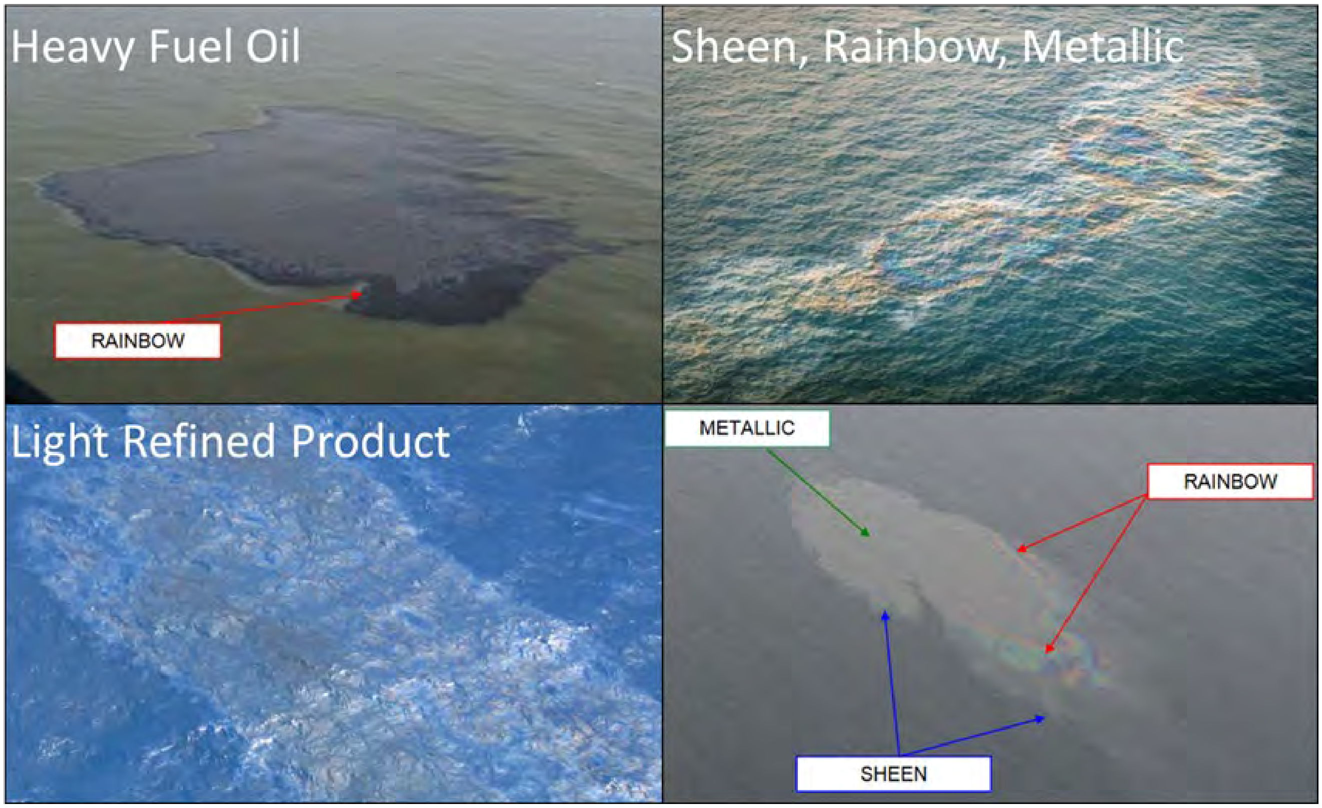


Figure B-91. Aerial surveillance images of released oil in the environment as examples of different visual appearances based on surface oil thickness and product type (Bonn Agreement, 2011).

B.5.6.3 References

Bonn Agreement. 2009. Bonn Agreement Aerial Operations Handbook, 2009. London, UK. Available: http://www.bonnagreement.org/site/assets/files/1081/ba-aoh revision 2 april 2012-1.pdf, Accessed 4 June 2015.

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APPENDIX C – DEMERARA RIVER MODELLED RESULTS

C.1 Introduction

In support of EMGL's Gas to Energy Project, RPS Ocean Science was contracted to assess the trajectory and fate of releases in the Demerara River using RPS' SIMAP (Spill Impact Model Application Package) model. This modelling is a continuation of previous modelling for offshore Guyana in the Payara Prospect (Rowe et al. 2018a) and in the Liza prospect, completed for Liza Phase 1 (Galagan 2017) and Liza Phase 2 (Rowe et al. 2018b). The modelling considers spills at two locations in the Demerara River (representative of vessel discharges of Marine Diesel).

Individual hypothetical spill events were modelled using representative high and low river flow conditions in the Demerara River. The oil spill scenarios were simulated using the SIMAP oil spill modelling system in its deterministic mode. The purpose of this modelling was to evaluate the details of each spill type under set conditions representative of a worst-case situation. SIMAP simulations were performed using wind conditions corresponding to two distinct river flow regimes (i.e., high flow and low flow) to capture the range of potential environmental conditions.

The following presents a summary of the modelling methodology, a description of the spill scenarios, and the oil types simulated.

C.2 Model Scenarios & Inputs

C.2.1 Model Scenarios

Two sites in the Demerara River in Georgetown, Guyana, were used for the oil spill scenarios: (1) a representative location at the Demerara River Bridge, and (2) at a Marine Offloading Facility (MOF) located on the western bank of the river (Table C-1; Figure C-1). The modelled Demerara Bridge site is located approximately 6 kilometres upstream of the mouth of the river, and the modelled MOF site is located approximately 27 kilometres upstream of the mouth of the river (Figure C-1).

Table C-1: Location of the spill sites in the Demerara River, Guyana.

Spill Location	Latitude (N)	Longitude (W)
Demerara River Bridge Location	6.770177	-58.187324
Marine Offloading Facility Location	6.633816	-58.2141

The modelled spill scenarios include instantaneous spills of Marine Diesel modelled for 5 days (Table C-2). The model simulations used representative environmental conditions corresponding to high river flow and low river flow conditions (Table C-3).

Table C-2: Oil spill scenarios modelled in the Demerara River, Guyana

Scenario ID	Spill Site	Spill Event	Flow Regime	Oil Type	Spill Duration	Spill Volume	Model Duration
1	Demerara River Bridge Location	On-water spill due to a vessel collision High Volume	High	Marine Diesel	Instantaneous	500 bbl	5 days
2			Low				
3	Demerara River MOF	On-water spill due to a vessel collision High Volume	High			500 bbl	
4			Low				

Table C-3: Environmental conditions of the representative High and Low River Flow scenarios

River Discharge Condition	Tidal Condition	Period for oil spill simulation
High Flow	Spring Tide	6/10/2018 – 6/15/2018
Low Flow	Neap Tide	3/5/2018 – 3/10/2018

Figure C-1: Location of the Spill Sites in the Demerara River Used in the Modelling

C.3 Oil Properties

The transport and weathering of spilled oil are dependent on chemical and physical oil properties such as boiling point distribution, tendency to form stable or meso-stable water-in-oil emulsions, and oil viscosity. Table C-4 summarizes the characteristics of the hydrocarbon product, Marine Diesel, used for this study. EMGL provided RPS with detailed information regarding the oil properties of the product and RPS assumed a proxy/generic oil to define any additional properties necessary to run the oil spill model. These properties were based on characterizations from the Environmental Technology Centre of Environment Canada.

Table C-4: Summary of the Oil Properties Used in the Modelling

Oil Type	Density (g/cm^3)	Viscosity (cP) @ 15°C	API Gravity	Pour Point (°C)	Maximum Water Content (%)
Marine Diesel	0.8316 @ 15°C	2.76	26.5	-50.0	0

Viscosity and interfacial surface tension affect the degree of spreading of the oil, which in turn influences the rates of evaporation, dissolution, dispersion, and photo-oxidation. The maximum water content is a laboratory measurement of the tendency of the oil to form emulsions. Oils that form water-in-oil emulsions tend to be more persistent in the marine environment, as they are less likely to be dissolved and/or evaporated; this increases their potential for reaching the shoreline. Light products (e.g., diesel, condensate) have no tendency in forming an emulsion; thus, they are less persistent on the water surface relative to heavier oils (such as crude).

To classify oil products from a weathering point of view, crude oils and hydrocarbon mixtures can be broken down into distillation cuts based on their boiling points. Total hydrocarbon concentrations (THC) in the oil weathering model include both aromatic (soluble) and aliphatic (insoluble) components. In general, the lighter aromatic compounds, such as Monocyclic and Polycyclic Aromatic Hydrocarbons (MAHs and PAHs, respectively), tend to rapidly evaporate to the atmosphere unless the product gets mixed into the water column. If oil is released below the water surface or gets entrained before it has weathered and lost the lower molecular weight aromatics to the atmosphere, dissolved MAHs and PAHs can reach concentrations where they can affect water column organisms or benthic communities (French-McCay and Payne 2001).

C.4 Model Approach

Oil spill trajectory and fate models are used to predict the consequences from spills. As such they are focused on simulating the transport of spilled oil and the interactions of that oil within the different parts of the physical and biological environments. Spill models use a “scenario” to define the location, volume, product, and other parameters of a spill event as inputs to a spill simulation.

The modelling for this study was conducted using RPS’ SIMAP oil spill modelling system. The SIMAP three-dimensional physical fates model calculates the distribution (as mass and concentrations) of whole oil and oil components on the water surface, on shorelines, in the water column, and in sediments. Oil fate processes included are oil spreading (gravitational and by shearing), evaporation, transport, randomized dispersion, emulsification, entrainment (natural and facilitated by dispersant), dissolution, volatilization of dissolved hydrocarbons from the surface water, adherence of oil droplets to suspended sediments, adsorption of soluble and sparingly-soluble aromatics to suspended sediments, sedimentation, and degradation. Description of the loss of well control and physical fates models and descriptions of deterministic simulations can be found in Rowe et al. (2018b).

C.5 Oil Spill Model Results

The model results are presented in maps and mass balance plots by spill location and river flow condition. Affected shorelines depicted on the particle maps are determined by the presence of any oil amount regardless of a thickness threshold. For each scenario, a figure showing the location of surface and shoreline oil at the end of the simulation and a tiled figure showing multiple timesteps (1, 4, 6, 12 hours, and 5 days) throughout the simulation are provided.

A summary of the mass balance at the end of the 5-day simulations in percent of released mass is provided in Table C-5. The deterministic results are also summarized in tables listing the sea surface area swept by oil with a thickness greater than one micrometre (µm) (one gram per square metre [g/m^2] on average over the grid cell), the length of shoreline affected with a thickness greater than 1 µm (1 g/m^2 on average over the grid cell), and the time to shore for the selected representative deterministic scenarios (Table C-6).

Table C-5: Representative Worst-Case Scenario Mass Balance at the end of the Simulation as Percent (%) of the Total Volume of Oil Released.

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation	Sediment
Demerara River Bridge Instantaneous 500 bbl Marine Diesel Spill High River Flow	0.0	5.1	19.2	75.2	0.5	<0.1
Demerara River Bridge Instantaneous 500 bbl Marine Diesel Spill Low River Flow	0.0	7.8	20.9	70.1	1.2	<0.1
MOF Instantaneous 500 bbl Marine Diesel Spill High River Flow	0.0	0.1	30.5	69.1	0.3	<0.1
MOF Instantaneous 500 bbl Marine Diesel Spill Low River Flow	0.0	0.2	30.0	69.5	0.3	<0.1

Table C-6: Spill Modelling Summary for the Deterministic Spill Events

Scenario	Surface Area Swept (km^2)	Affected Shoreline Length (km)	Minimum Time to Shore (hours)
Demerara River Bridge Instantaneous 500 bbl Marine Diesel Spill High River Flow	51	2.9	1.6
Demerara River Bridge Instantaneous 500 bbl Marine Diesel Spill Low River Flow	72	3.1	5.6
MOF Instantaneous 500 bbl Marine Diesel Spill High River Flow	8	2.9	<1
MOF Instantaneous 500 bbl Marine Diesel Spill Low River Flow	10	3.4	<1

Note: Surface area is the maximum area swept above a threshold of 1 µm thickness (1 g/m^2 on average). Shoreline length is length of shoreline affected above a threshold of 1 µm thickness (1 g/m^2 on average).

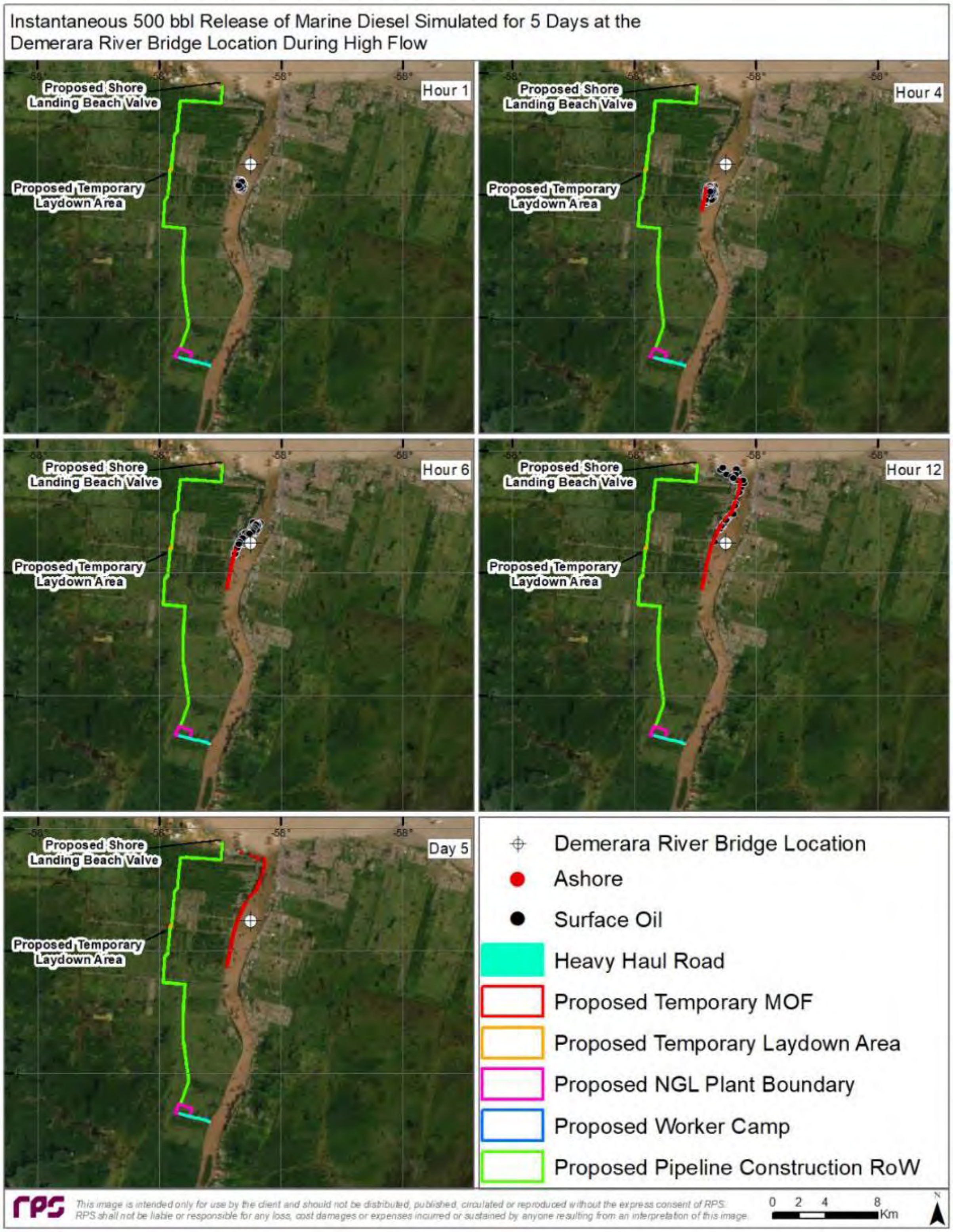


Figure C-2: Location of Surface Oil and Affected Shoreline at 1 hr., 4 hr., 6 hr., 12 hr., and 5 days into the Simulation for a 500 bbl Instantaneous Marine Diesel Spill at the Demerara River Bridge Location during High River Flow

C. Demerara River Modelled Results

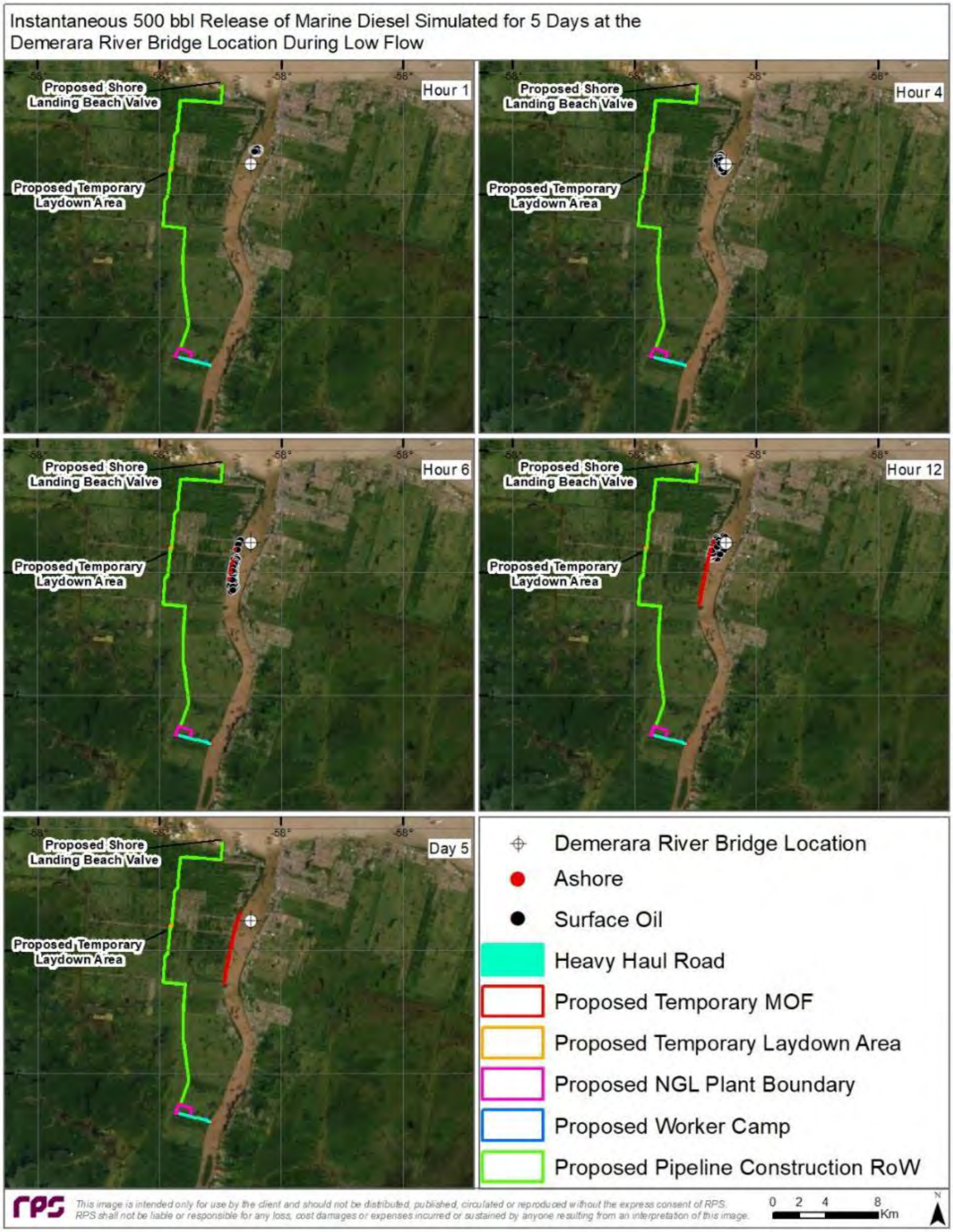


Figure C-3: Location of Surface Oil and Affected Shoreline at 1 hr., 4 hr., 6 hr., 12 hr., and 5 days into the simulation for a 500 bbl instantaneous Marine Diesel spill at the Demerara River Bridge location during Low River Flow.

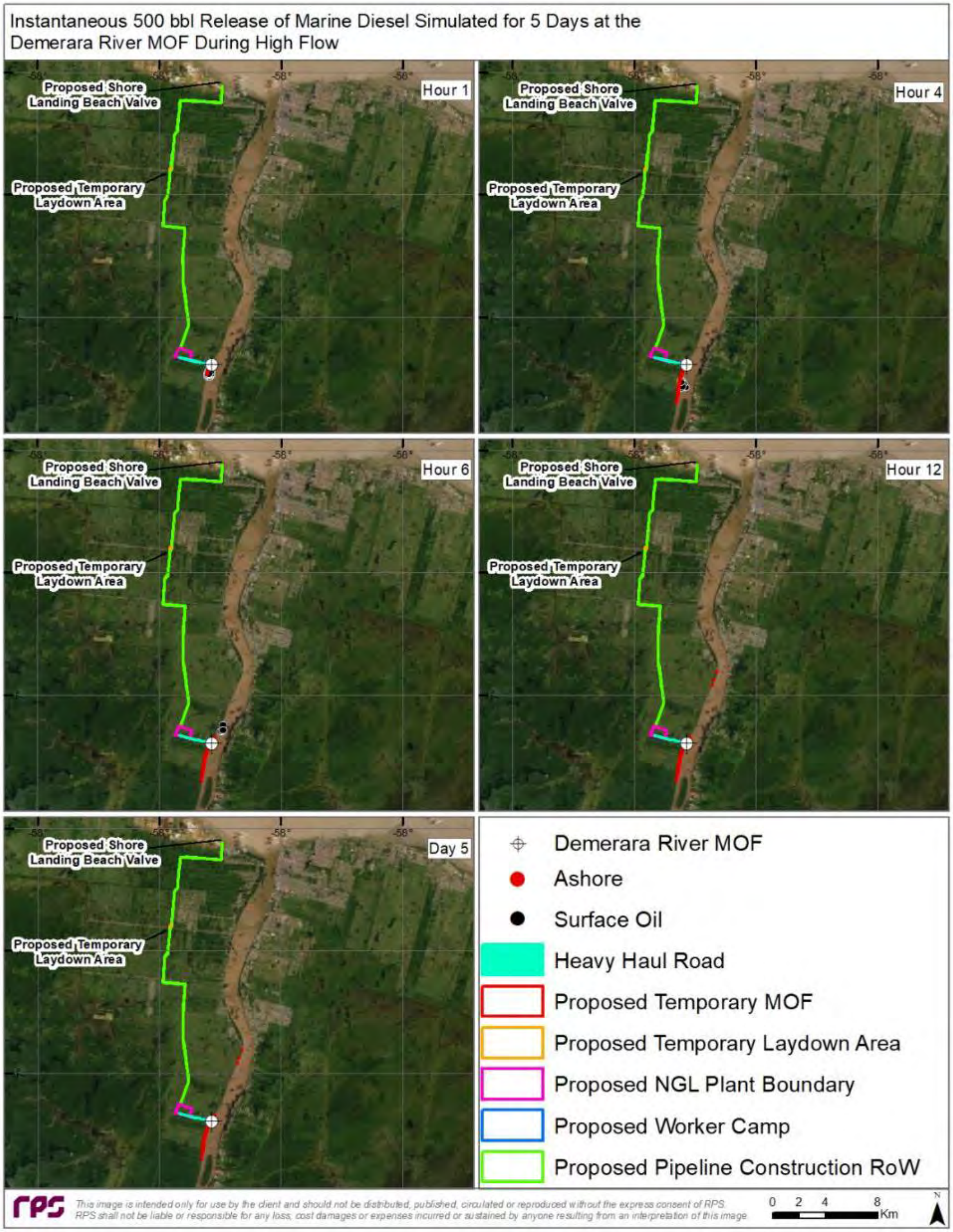


Figure C-4: Location of Surface Oil and Affected Shoreline at 1 hr., 4 hr., 6 hr., 12 hr., and 5 days into the Simulation for a 500 bbl Instantaneous Marine Diesel Spill at the Demerara River MOF Location during High River Flow

C. Demerara River Modelled Results

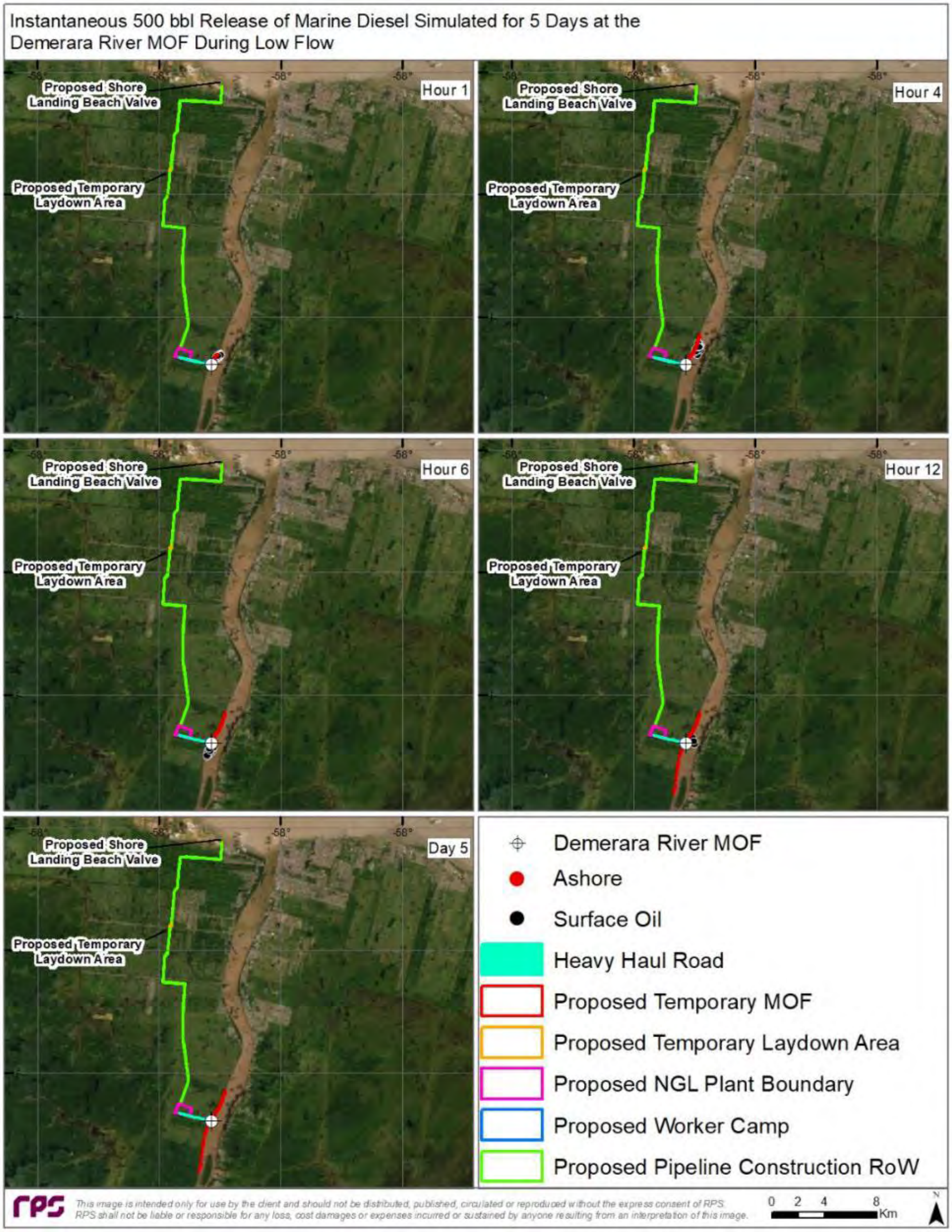


Figure C-5: Location of Surface Oil and Affected Shoreline at 1 hr., 4 hr., 6 hr., 12 hr., and 5 days into the Simulation for a 500 bbl Instantaneous Marine Diesel spill at the Demerara River MOF Location during Low River Flow

C.6 Summary and Conclusions

For all modelled scenarios, the released oil is predicted to travel from the spill sites towards the western shorelines. For the Demerara River Bridge location, there are some oil particles that are predicted to travel out of the river during high flow conditions due to proximity of the spill site to the mouth. During low flow conditions, oil travels to the western shorelines but does not travel downstream. At the MOF location, oil is discharged close to the shoreline and reaches the western shorelines in both the high and low river flow scenarios in less than one hour.

In general, the released diesel evaporates quickly, with approximately 70 percent of the oil evaporated within the first day for all modelled scenarios. Approximately 19 to 31 percent of the total volume released is predicted to strand on shorelines at the end of the five-day simulation along an approximate three-kilometre stretch. Note that there is no surface oil predicted to be floating on the water surface at the end of the simulation period in any of the modelled scenarios, as much of it evaporated or stranded on shorelines. Larger predicted swept surface areas are associated with the Demerara River Bridge location compared to the MOF location due to the proximity of the MOF location to the coastline, while the Demerara Bridge spill location is in the centre of the channel.

C.7 References

French-McCay, D. and J.R. Payne. 2001. Model of oil fate and water concentrations with and without application of dispersants. In Proceedings of the 24th Arctic and Marine Oil spill Program (AMOP) Technical Seminar, Emergencies Science Division, Environment Canada, Ottawa, ON, Canada, pp.611-645.

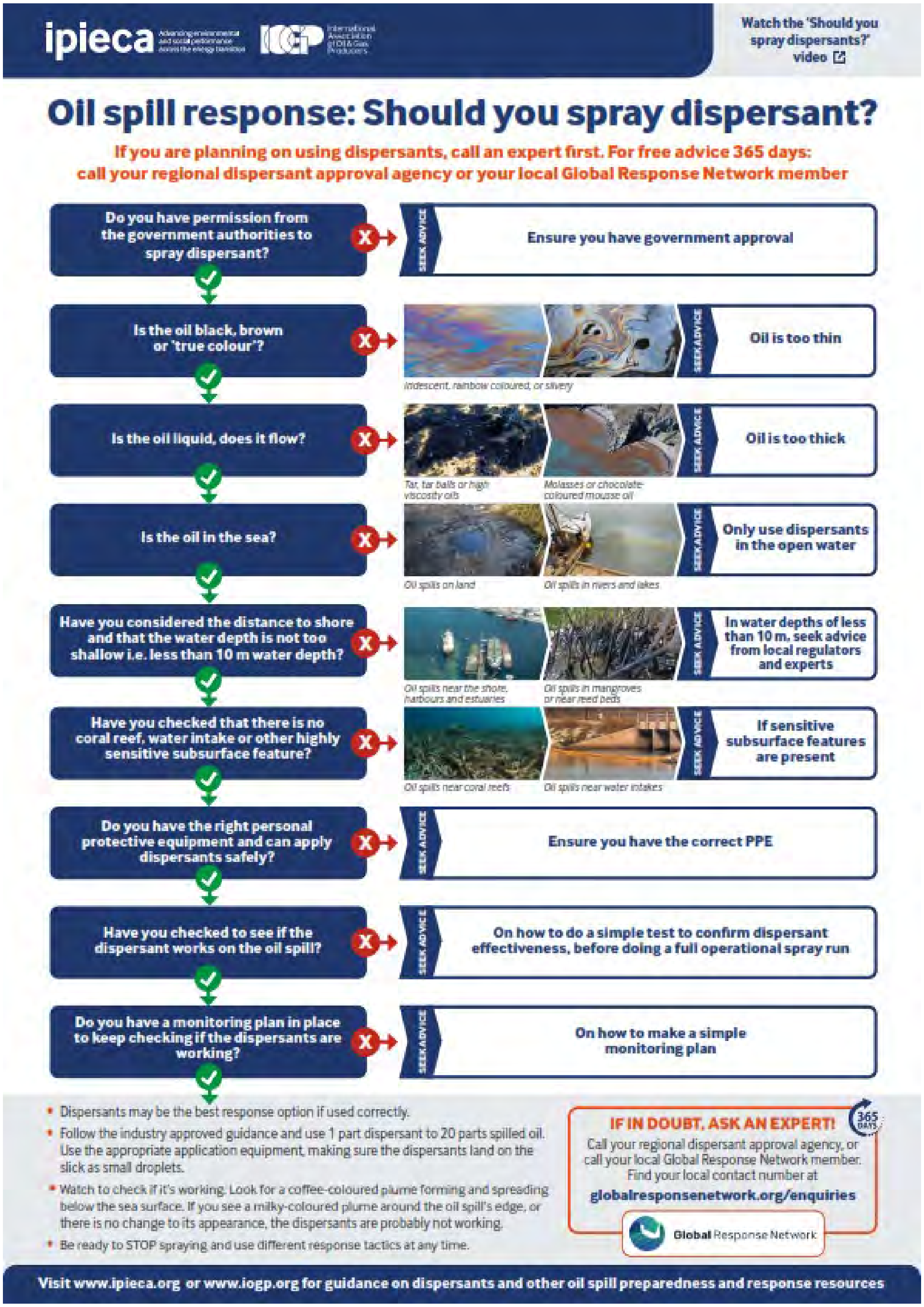
Galagan, C. 2017. Results from Oil Spill Trajectory and Fate Modeling to Support a NEBA Offshore Guyana. (Report no. 2017-010, RPS).

Rowe, J., Ducharme, J., Frediani., M., McStay, L., Mendelsohn, D., Tajalli Bakhsh, T., 2018a. Results from Oil Spill Trajectory and Fate Modeling – Phase II Offshore Guyana (Report no. 2018-022095, RPS).

Rowe, J., McStay, L., Frediani., M., Ducharme, J., Torre, D., Mahmud Monim, Tajalli Bakhsh, T., 2018b. ExxonMobil Offshore Guyana, Payara Prospect (Report no. 2018-201713, RPS).

APPENDIX D – DISPERSANT INFORMATION

D.1. Dispersant Application Considerations



D.2. Safety Data Sheets

NALCO

MATERIAL SAFETY DATA SHEET

PRODUCT

COREXIT® 9500

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME : **COREXIT® 9500**

APPLICATION : OIL SPILL DISPERSANT

COMPANY IDENTIFICATION : Nalco Energy Services, L.P.
P.O. Box 87
Sugar Land, Texas
77487-0087

EMERGENCY TELEPHONE NUMBER(S) : (800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING
HEALTH : 1 / 1 FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
Distillates, petroleum, hydrotreated light	64742-47-8	10.0 - 30.0
Propylene Glycol	57-55-6	1.0 - 5.0
Organic sulfonic acid salt	Proprietary	10.0 - 30.0

3. HAZARDS IDENTIFICATION

"EMERGENCY OVERVIEW"

WARNING
Combustible.
Keep away from heat. Keep away from sources of ignition - No smoking. Keep container tightly closed. Do not get in eyes, on skin, on clothing. Do not take internally. Avoid breathing vapor. Use with adequate ventilation. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of soap and water.
Wear suitable protective clothing.
Low Fire Hazard; liquids may burn upon heating to temperatures at or above the flash point. May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of sulfur (SOx) under fire conditions.

PRIMARY ROUTES OF EXPOSURE :
Eye, Skin

HUMAN HEALTH HAZARDS - ACUTE :

EYE CONTACT :
May cause irritation with prolonged contact.

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SKIN CONTACT :
May cause irritation with prolonged contact.

INGESTION :
Not a likely route of exposure. Can cause chemical pneumonia if aspirated into lungs following ingestion.

INHALATION :
Repeated or prolonged exposure may irritate the respiratory tract.

SYMPTOMS OF EXPOSURE :
Acute :
A review of available data does not identify any symptoms from exposure not previously mentioned.
Chronic :
Frequent or prolonged contact with product may defat and dry the skin, leading to discomfort and dermatitis.

AGGRAVATION OF EXISTING CONDITIONS :
Skin contact may aggravate an existing dermatitis condition.

4. FIRST AID MEASURES

EYE CONTACT :
Immediately flush with plenty of water for at least 15 minutes. If symptoms develop, seek medical advice.

SKIN CONTACT :
Immediately wash with plenty of soap and water. If symptoms develop, seek medical advice.

INGESTION :
Do not induce vomiting: contains petroleum distillates and/or aromatic solvents. If conscious, washout mouth and give water to drink. Get medical attention.

INHALATION :
Remove to fresh air, treat symptomatically. Get medical attention.

NOTE TO PHYSICIAN :
Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT :	181.4 °F / 83 °C (PMCC)
LOWER EXPLOSION LIMIT :	Not flammable
UPPER EXPLOSION LIMIT :	Not flammable

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EXTINGUISHING MEDIA :
Alcohol foam, Carbon dioxide, Foam, Dry powder, Other extinguishing agent suitable for Class B fires, For large fires, use water spray or fog, thoroughly drenching the burning material.
Water mist may be used to cool closed containers.

UNSUITABLE EXTINGUISHING MEDIA :
Do not use water unless flooding amounts are available.

FIRE AND EXPLOSION HAZARD :
Low Fire Hazard; liquids may burn upon heating to temperatures at or above the flash point. May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of sulfur (SOx) under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :
In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :
Restrict access to area as appropriate until clean-up operations are complete. Stop or reduce any leaks if it is safe to do so. Ventilate spill area if possible. Do not touch spilled material. Remove sources of ignition. Have emergency equipment (for fires, spills, leaks, etc.) readily available. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection). Notify appropriate government, occupational health and safety and environmental authorities.

METHODS FOR CLEANING UP :
SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. LARGE SPILLS: Contain liquid using absorbent material, by digging trenches or by diking. Reclaim into recovery or salvage drums or tank truck for proper disposal. Clean contaminated surfaces with water or aqueous cleaning agents. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :
Do not contaminate surface water.

7. HANDLING AND STORAGE

HANDLING :
Use with adequate ventilation. Keep the containers closed when not in use. Do not take internally. Do not get in eyes, on skin, on clothing. Have emergency equipment (for fires, spills, leaks, etc.) readily available.

STORAGE CONDITIONS :
Store away from heat and sources of ignition. Store separately from oxidizers. Store the containers tightly closed.

SUITABLE CONSTRUCTION MATERIAL :
Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use.

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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :
Exposure guidelines have not been established for this product. Available exposure limits for the substance(s) are shown below.

ACGIH/TLV :
Substance(s)

Oil Mist	TWA: 5 mg/m3 STEL: 10 mg/m3
Propylene Glycol	

OSHA/PEL :
Substance(s)

Oil Mist	TWA: 5 mg/m3 STEL: 10 mg/m3
Propylene Glycol	

AIHA/WEEL :
Substance(s)

ENGINEERING MEASURES :
General ventilation is recommended.

RESPIRATORY PROTECTION :
Where concentrations in air may exceed the limits given in this section, the use of a half face filter mask or air supplied breathing apparatus is recommended. A suitable filter material depends on the amount and type of chemicals being handled. Consider the use of filter type: Multi-contaminant cartridge. with a Particulate pre-filter. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :
Nitrile gloves, PVC gloves

SKIN PROTECTION :
Wear standard protective clothing.

EYE PROTECTION :
Wear chemical splash goggles.

HYGIENE RECOMMENDATIONS :
Keep an eye wash fountain available. Keep a safety shower available. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse.

HUMAN EXPOSURE CHARACTERIZATION :
Based on our recommended product application and personal protective equipment, the potential human exposure is: Low

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9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Liquid
APPEARANCE	Clear Hazy Amber
ODOR	Hydrocarbon
SPECIFIC GRAVITY	0.95 @ 60 °F / 15.6 °C
DENSITY	7.91 lb/gal
SOLUBILITY IN WATER	Miscible
pH (100 %)	6.2
VISCOSITY	177 cps @ 32 °F / 0 °C 70 cps @ 60 °F / 15.6 °C @ 104 °F / 40 °C
VISCOSITY	@ 32 °F / 0 °C @ 60 °F / 15.6 °C 22.5 cst @ 104 °F / 40 °C
POUR POINT	< -71 °F / < -57 °C
BOILING POINT	296 °F / 147 °C
VAPOR PRESSURE	15.5 mm Hg @ 100 °F / 37.8 °C

Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY

STABILITY :
Stable under normal conditions.

HAZARDOUS POLYMERIZATION :
Hazardous polymerization will not occur.

CONDITIONS TO AVOID :
Heat

MATERIALS TO AVOID :
Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :
Under fire conditions: Oxides of carbon, Oxides of sulfur

11. TOXICOLOGICAL INFORMATION

No toxicity studies have been conducted on this product.

SENSITIZATION :
This product is not expected to be a sensitizer.

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D. Dispersant Information

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CARCINOGENICITY :
None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

HUMAN HAZARD CHARACTERIZATION :
Based on our hazard characterization, the potential human hazard is: Moderate

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL EFFECTS :

The following results are for the product.

ACUTE INVERTEBRATE RESULTS :

Species	Exposure	LC50	EC50	Test Descriptor
Acartia tonsa	48 hrs	34 mg/l		Product
Artemia	48 hrs	20.7 mg/l		Product

MOBILITY :
The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM , provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models. If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	10 - 30%	50 - 70%

The portion in water is expected to float on the surface.

BIOACCUMULATION POTENTIAL
Component substances have a potential to bioconcentrate.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: Low
Based on our recommended product application and the product's characteristics, the potential environmental exposure is: Low

If released into the environment, see CERCLA/SUPERFUND in Section 15.

13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it could meet the criteria of a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261. Before disposal, it should be determined if the waste meets the criteria of a hazardous waste.

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MATERIAL SAFETY DATA SHEET

PRODUCT

COREXIT® 9500

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

Hazardous Waste: D018

Hazardous wastes must be transported by a licensed hazardous waste transporter and disposed of or treated in a properly licensed hazardous waste treatment, storage, disposal or recycling facility. Consult local, state, and federal regulations for specific requirements.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

LAND TRANSPORT :

For Packages Less Than Or Equal To 119 Gallons:

Proper Shipping Name :	PRODUCT IS NOT REGULATED DURING TRANSPORTATION

For Packages Greater Than 119 Gallons:

Proper Shipping Name :	COMBUSTIBLE LIQUID, N.O.S.
Technical Name(s) :	PETROLEUM DISTILLATES
UN/ID No :	NA 1993
Hazard Class - Primary :	COMBUSTIBLE
Packing Group :	III
Flash Point :	83 °C / 181.4 °F

AIR TRANSPORT (ICAO/IATA) :

Proper Shipping Name :	PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MARINE TRANSPORT (IMDG/IMO) :

Proper Shipping Name :	PRODUCT IS NOT REGULATED DURING TRANSPORTATION

15. REGULATORY INFORMATION

NATIONAL REGULATIONS, USA :

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :
Based on our hazard evaluation, the following substance(s) in this product is/are hazardous and the reason(s) is/are shown below.

Distillates, petroleum, hydrotreated light : Irritant
Propylene Glycol : Exposure Limit, Eye irritant
Organic sulfonic acid salt : Irritant

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CERCLA/SUPERFUND, 40 CFR 117, 302 :
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :
This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following indicated EPA hazard categories:

X	Immediate (Acute) Health Hazard
-	Delayed (Chronic) Health Hazard
-	Fire Hazard
-	Sudden Release of Pressure Hazard
-	Reactive Hazard

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :
This product does not contain substances on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA) :
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :
None of the substances are specifically listed in the regulation.

CLEAN AIR ACT, Sec. 111 (40 CFR 60, Volatile Organic Compounds), Sec. 112 (40 CFR 61, Hazardous Air Pollutants), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :
None of the substances are specifically listed in the regulation.

Substance(s)	Citations
• Propylene Glycol	Sec. 111

CALIFORNIA PROPOSITION 65 :
This product does not contain substances which require warning under California Proposition 65.

MICHIGAN CRITICAL MATERIALS :
None of the substances are specifically listed in the regulation.

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STATE RIGHT TO KNOW LAWS :
The following substances are disclosed for compliance with State Right to Know Laws:

Propylene Glycol	57-55-6

NATIONAL REGULATIONS, CANADA :

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS) :
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS CLASSIFICATION :
Not considered a WHMIS controlled product.

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) :
The substances in this preparation are listed on the Domestic Substances List (DSL), are exempt, or have been reported in accordance with the New Substances Notification Regulations.

16. OTHER INFORMATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: Low

* The environmental risk is: Low

Any use inconsistent with our recommendations may affect the risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommendations. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel Insight# CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS# CD-ROM Version), Micromedex, Inc., Englewood, CO.

D. Dispersant Information

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MATERIAL SAFETY DATA SHEET

PRODUCT

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EMERGENCY TELEPHONE NUMBER(S)
(800) 424-8300 (24 Hours) CHEMTREC

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS# CD-ROM Version), Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel Insight# CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH, (TOMES CPS# CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel Insight# (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel Insight# CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS# CD-ROM Version), Micromedex, Inc., Englewood, CO.

Prepared By : Product Safety Department
Date issued : 08/14/2005
Version Number : 1.6

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TOTAL

MATERIAL SAFETY DATA SHEET

according to Regulation (EC) No. 1907/2006

SDS # : 30033

FINASOL OSR 51

Date of the previous version: 2012-09-12*** **Revision Date:** 2012-02-22 **Version** 1.01

1. IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1. Product identifier

Product name	**FINASOL OSR 51**
Trade name	FINASOL OSR 51
Pure substance/mixture	Mixture

1.2. Relevant identified uses of the substance or mixture and uses advised against

Identified uses	dispersant.

1.3. Details of the supplier of the safety data sheet

Supplier

TOTAL FLUIDES
24, cours Michelet.
92800 PUTEAUX.
FRANCE
Tel: +33 (0)1 41 35 40 00
Fax: +33 (0)1 41 35 82 88

For further information, please contact

Contact Point	Service QSE : Tel : 01 41 35 33 64 / Fax : 01 41 35 33 50 Emergency number 24h/24h: +33 (0)1 41 35 65 00
E-mail Address	rmfs.fds@total.com

1.4. Emergency telephone number

+33 1 49 00 00 49 (24h/24, 7d/7)
Official National Emergency Telephone Number or Poison Control Center Number
In France : - PARIS : Hôpital Fernand Widal 200, rue du Faubourg Saint-Denis 75475 Paris Cedex 10 , Tel : 01.40.05.48.48. - MARSEILLE : Hopital Salvator, 249 bd Ste Marguerite 13274 Marseille cedex 5, Tel : 04.91.75.25.25. - LYON : Hopital Hedouard Herriot, 5 place d'Arsonvil, 69437 Lyon cedex 3, Tel : 04.72.11.69.11. - NANCY : Hopital central, 29 Av du Mal De Lattre de Tassigny, 54000 Nancy, Tel : 03.83.32.36.36 ou le SAMU : Tel (15)

2. HAZARDS IDENTIFICATION

2.1. Classification of the substance or mixture

REGULATION (EC) No 1272/2008
For the full text of the H-Statements mentioned in this Section, see Section 2.2.

Classification

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Aspiration toxicity - Category 1 - H304
Serious eye damage/eye irritation - Category 1 - H318

DIRECTIVE 67/548/EEC or 1999/45/EC
For the full text of the R-phrases mentioned in this Section, see Section 16

Symbol(s)
Xn - Harmful
Classification
Xn;R65 - Xi;R41 - R66

2.2. Label elements

Labelled according to: REGULATION (EC) No 1272/2008

Signal Word
DANGER

Hazard Statements
H304 - May be fatal if swallowed and enters airways
H318 - Causes serious eye damage

Precautionary Statements
P305 + P351 + P338 - IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing
P337 + P313 - If eye irritation persists: Get medical advice/attention
P280 - Wear protective gloves/ protective clothing/ eye protection/ face protection.
P301 + P310 - IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician
P331 - Do NOT induce vomiting

Supplemental Hazard Statements
EUH066 - Repeated exposure may cause skin dryness or cracking

2.3. Other hazards

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Physical-Chemical Properties Alkaline.
Combustible liquid.
Vapors may form explosive mixtures with air, at high temperatures.

Properties Affecting Health If swallowed accidentally, the product may enter the lungs due to its low viscosity and lead to the rapid development of very serious pulmonary lesions (medical survey during 48 hours) .

3. COMPOSITION/INFORMATION ON INGREDIENTS

3.2. Mixture

Chemical Name	EC-No	REACH registration No:	CAS-No	Weight %	Classification (Dir. 67/548)	Classification (Reg. 1272/2008)
Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, <2% aromatics	926-141-6	01-2119456620-43	^	60-70	Xn;R65 R66 ***	Asp. Tox. 1 (H304)
docusate sodium***	209-406-4	no data available	577-11-7	0.2-5	Xi;R38-41***	Skin Irrit. 2 (H315) Eye Dam. 1 (H318)

Additional Information 15%-30% : Non-ionic surfactants
0.2%-5% : Anionic surfactants

For the full text of the R-phrases mentioned in this Section, see Section 16
For the full text of the H-Statements mentioned in this Section, see Section 16.

4. FIRST AID MEASURES

4.1. Description of first-aid measures

General advice IN CASE OF SERIOUS OR PERSISTENT CONDITIONS, CALL A DOCTOR OR EMERGENCY MEDICAL CARE.

Eye contact Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes.

Skin contact Remove contaminated clothing and shoes. Wash off immediately with plenty of water for at least 15 minutes.

Inhalation In case of exposure to intense concentrations of vapours, fumes or spray, transport the person away from the contaminated zone, keep warm and allow to rest.

Ingestion If swallowed, do not induce vomiting - seek medical advice.
Risk of product entering the lungs on vomiting after ingestion. In this case, the casualty should be sent immediately to hospital.

Protection of First-aiders Use personal protective equipment.

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4.2. Most important symptoms and effects, both acute and delayed

Eye contact	Risk of serious damage to eyes.
Skin contact	Repeated exposure may cause skin dryness or cracking.
Inhalation	The inhalation of vapours or aerosols may be irritating for the respiratory tract and for mucous menbranes.
Ingestion	Harmful: If swallowed accidentally, the product may enter the lungs due to its low viscosity and lead to the rapid development of very serious inhalation pulmonary lesions (medical survey during 48 hours). Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea. May cause central nervous system depression.

4.3. Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician	Treat symptomatically.

5. FIRE-FIGHTING MEASURES

5.1. Extinguishing media

Suitable Extinguishing Media	Foam. Dry powder. Carbon dioxide (CO_2). Water spray.
Unsuitable Extinguishing Media	Do not use a solid water stream as it may scatter and spread fire.

5.2. Special hazards arising from the substance or mixture

Special Hazard	Incomplete combustion and thermolysis may produce gases of varying toxicity such as carbon monoxide, carbon dioxide, various hydrocarbons, aldehydes and soot. These may be highly dangerous if inhaled in confined spaces or at high concentration.

5.3. Advice for fire-fighters

Special protective equipment for fire-fighters	In case of a large fire or in confined or poorly ventilated spaces, wear full fire resistant protective clothing and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.
Other information	Cool containers / tanks with water spray. Fire residues and contaminated fire extinguishing water must be disposed of in accordance with local regulations.

6. ACCIDENTAL RELEASE MEASURES

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6.1. Personal precautions, protective equipment and emergency procedures

General information	Use personal protective equipment. Evacuate non-essential personnel. Ensure adequate ventilation, especially in confined areas. ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Do not touch or walk through spilled material.

6.2. Environmental precautions

General information	Prevent further leakage or spillage if safe to do so. Dike to collect large liquid spills. The product should not be allowed to enter drains, water courses or the soil. Local authorities should be advised if significant spillages cannot be contained.

6.3. Methods and materials for containment and cleaning up

Methods for cleaning up	Soak up with inert absorbent material. Keep in suitable, closed containers for disposal. Following product recovery, flush area with water.

6.4. Reference to other sections

Personal Protective Equipment	See Section 8 for more detail
Waste treatment	See section 13
Other information	Remove all sources of ignition.

7. HANDLING AND STORAGE

7.1. Precautions for safe handling

Advice on safe handling	For personal protection see section 8. Use only in well-ventilated areas. Do not breathe vapors or spray mist. Avoid contact with skin and eyes.
Technical measures	Ensure adequate ventilation.
Prevention of fire and explosion	Handle away from any source of ignition (open flame and sparks) and heat (hot manifolds or casings). Design installations (machinery and equipment) to prevent burning product from spreading (tanks, retention systems, interceptors (traps) in drainage systems). Take precautionary measures against static discharges.

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Hygiene measures — Ensure the application of strict rules of hygiene by the personnel exposed to the risk of contact with the product.
When using, do not eat, drink or smoke.
Do not dry hands with rags that have been contaminated with product.

7.2. Conditions for safe storage, including any incompatibilities

Technical measures/Storage conditions — Keep away from heat. Keep at temperatures between 5 and 35 °C. Use only containers, seals, pipes, etc... made in a material suitable for use with aromatic hydrocarbons.

Materials to Avoid — Strong acids. Oxidizing agents.

Packaging material — Keep only in the original container or in a suitable container for this kind of product: steel , Stainless steel.

7.3. Specific end uses

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1. Control parameters

Exposure limits — Ingredients with workplace control parameters

Legend — See section 16

DNEL Worker (Industrial/Professional)

Chemical Name	Short term, systemic effects	Short term, local effects	Long term, systemic effects	Long term, local effects
docusate sodium*** 577-11-7			31.3 mg/kg bw/day (dermal) 44.1 mg/m³ (inhalation)	

DNEL General population

Chemical Name	Short term, systemic effects	Short term, local effects	Long term, systemic effects	Long term, local effects
docusate sodium*** 577-11-7			18.8 mg/kg bw/day (dermal) 13 mg/m³ (inhalation) 18.8 mg/kg bw/day (oral)	

Predicted No Effect Concentration (PNEC)

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Chemical Name	Water	Sediment	Soil	Air	STP	Oral
docusate sodium*** 577-11-7	0.0066 mg/l (fw) 0.00066 mg/l (mw) 0.066 mg/l (or)	0.653 mg/kg dw (fw) 0.0653 mg/kg dw (mw)	0.138 mg/kg dw		122 mg/l	

8.2. Exposure controls

Occupational Exposure Controls

Engineering Measures Apply technical measures to comply with the occupational exposure limits.

Personal Protective Equipment

General Information These recommendations apply to the product as supplied. If the product is used in mixtures, it is recommended that you contact the appropriate protective equipment suppliers.

Respiratory protection When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.

Eye Protection Safety glasses with side-shields. If splashes are likely to occur, wear:. Face-shield.

Skin and body protection Wear suitable protective clothing. Protective shoes or boots.

Hand Protection Hydrocarbon-proof gloves. Please observe the instructions regarding permeability and breakthrough time which are provided by the supplier of the gloves. Also take into consideration the specific local conditions under which the product is used, such as the danger of cuts, abrasion.

Environmental exposure controls

General Information None in normal conditions.

9. PHYSICAL AND CHEMICAL PROPERTIES

9.1. Information on basic physical and chemical properties

Color dark brown To black
Physical State @20°C liquid
Odor Petroleum solvent

Property	Values	Remarks	Method
pH	6.5 - 8.5		ASTM D 1172
pH (as aqueous solution)	8	solution (10 %)	ASTM D 1172

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Boiling point/boiling range	180 - 240 °C 356 - 464 °F		
Flash point	>= 65 °C >= 149 °F		ISO 2719 ISO 2719.
Evaporation rate		No information available	
Flammability Limits in Air		No information available	
Vapor Pressure		No information available	
Vapor density		No information available	
Density	865 - 885 kg/m³	@ 20 °C	ISO 12185
Water solubility		No information available	
Solubility in other solvents		No information available	
logPow		Not applicable	
Autoignition temperature		No information available	
Viscosity, kinematic	7 - mm2/s	@ 40 °C	ISO 3104
Explosive properties	Not explosive		
Oxidizing Properties	No information available		
Possibility of hazardous reactions	No data available		

9.2. Other information

10. STABILITY AND REACTIVITY

10.1. Reactivity

10.2. Chemical stability

Stability Stable under recommended storage conditions.

10.3. Possibility of hazardous reactions

Hazardous Reactions None under normal processing.

10.4. Conditions to Avoid

Conditions to Avoid Heat, flames and sparks. Take precautionary measures against static discharges.

10.5. Incompatible Materials

Materials to Avoid Strong acids. Oxidizing agents.

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10.6. Hazardous Decomposition Products

Hazardous Decomposition Products Incomplete combustion and thermolysis may produce gases of varying toxicity such as carbon monoxide, carbon dioxide, various hydrocarbons, aldehydes and soot.

11. TOXICOLOGICAL INFORMATION

11.1. Information on toxicological effects

Acute toxicity Local effects Product Information***

Skin contact Repeated exposure may cause skin dryness or cracking.

Eye contact Risk of serious damage to eyes.

Inhalation Not classified.
The inhalation of vapours or aerosols may be irritating for the respiratory tract and for mucous menbranes.

Ingestion Harmful: If swallowed accidentally, the product may enter the lungs due to its low viscosity and lead to the rapid development of very serious inhalation pulmonary lesions (medical survey during 48 hours).
Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.
May cause central nervous system depression.

Acute toxicity Component Information

Chemical Name	LD50 Oral	LD50 Dermal	LC50 Inhalation
Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, <2% aromatics	LD50 > 5000 mg/kg bw (rat - OECD 401)	LD50 (24h) > 5000 mg/kg bw (rabbit - OECD 402)	LC50 (8h) > 5000 mg/m³ (vapour) (rat - OECD 403)
docusate sodium***	> 2100 mg/kg (Rat)	> 10000 mg/kg (Rabbit)	

Sensitization

Sensitization Not classified as a sensitizer.

Specific effects

Carcinogenicity Contains no ingredient listed as a carcinogen.

Mutagenicity Contains no ingredient listed as a mutagen.

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Reproductive toxicity Contains no ingredient listed as toxic to reproduction.

Repeated Dose Toxicity

Target Organ Effects (STOT)

Specific target organ systemic toxicity (single exposure) No known effect based on information supplied.

Specific target organ systemic toxicity (repeated exposure) No known effect based on information supplied.

Aspiration toxicity The fluid can enter the lungs and cause damage (chemical pneumonitis, potentially fatal).

Other information

Other adverse effects Frequent or prolonged skin contact destroys the lipoacid cutaneous layer and may cause dermatitis.

12. ECOLOGICAL INFORMATION

12.1. Toxicity

Acute aquatic toxicity Product information

Acute aquatic toxicity Component information

Chemical Name	Toxicity to algae	Toxicity to daphnia and other aquatic invertebrates	Toxicity to fish	Toxicity to microorganisms
Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, <2% aromatics ^	ErL50 (72h) > 1000 mg/l (Pseudokirchneriella subcapitata - OECD 201) EbL50 (72h) > 1000 mg/l (Pseudokirchneriella subcapitata - OECD 201) NOELR (72h) = 1000 mg/l (Pseudokirchneriella subcapitata - biomass - OECD 201) NOELR (72h) = 1000 mg/l (Pseudokirchneriella subcapitata - growth rate - OECD 201)	EL50 (48h) > 1000 mg/l (Daphnia magna - OECD 202)	LL50 (96h) > 1000 mg/l (Oncorhynchus mykiss - OECD 203)	
docusate sodium*** 577-11-7		EC50 (48h) = 6.6 mg/l Daphnia magna	LC50 (96h) = 49 mg/l Brachydanio rerio (semi-static)	

Chronic aquatic toxicity Product information

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Chronic aquatic toxicity Component Information

Chemical Name	Toxicity to algae	Toxicity to daphnia and other aquatic invertebrates	Toxicity to fish	Toxicity to microorganisms
Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, <2% aromatics A		NOELR (21d) = 1,22 mg/l (Daphnia magna - QSAR Petrotox)	NOELR (28d) = 0,17 mg/l (Oncorhynchus mykiss - QSAR Petrotox)	

Effects on terrestrial organisms
No information available.

12.2. Persistence and degradability

General Information
For :. Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, <2% aromatics.

Biodegradation						
Type:	Method	Sampling time	Specific effects	Values	Unit	Biodegradability
	OECD 301 F	28, days		69	%	Readily biodegradable

12.3. Bioaccumulative potential

Product Information The potential for bioaccumulation of the product in the environment is very low.

logPow Not applicable
Component Information No information available.

12.4. Mobility in soil

Soil Given its physical and chemical characteristics, the product is generally mobile in the ground.

Air The product evaporates readily.

Water soluble.

12.5. Results of PBT and vPvB assessment

PBT and vPvB assessment This product contains no substance considered as PBT and/or vPvB according to REACH regulation annex XIII criteria.

12.6. Other adverse effects

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General information	No information available.

13. DISPOSAL CONSIDERATIONS

13.1. Waste treatment methods

Waste from Residues / Unused Products	Dispose of in accordance with the European Directives on waste and hazardous waste.
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Empty containers may contain flammable or explosive vapors.
EWC Waste Disposal No.	According to the European Waste Catalogue, Waste Codes are not product specific, but application specific. Waste codes should be assigned by the user based on the application for which the product was used.

14. TRANSPORT INFORMATION

ADR/RID	Not regulated
IMDG/IMO	Not regulated
ICAO/IATA	Not regulated

ADN

UN/ID No	UN9003
Proper shipping name	Substances with a flash-point above 60 degrees C and not more than 100 degrees C
Proper shipping name	SUBSTANCES WITH A FLASH POINT ABOVE 60°C AND NOT MORE THAN 100°C
Hazard class	9
Description	UN9003, SUBSTANCES WITH A FLASH-POINT ABOVE 60 DEGREES C AND NOT MORE THAN 100 DEGREES C (Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, < 2% aromatics), 9, MIXTURE

15. REGULATORY INFORMATION

15.1. Safety, health and environmental regulations/legislation specific for the substance or mixture

European Union

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FINASOL OSR 51

Revision Date: 2012-02-22 **Version** 1.01

Take note of Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work

International Inventories

Related CAS	Hydrocarbons, C11-C14, n-alkanes, isoalkanes, cyclics, <2% aromatics 64742-47-8
EINECS/ELINCS	-
TSCA	-
DSL	-
ENCS	-
IECSC	-
KECL	-
PICCS	-
AICS	-
NZIoC	-

Legend
EINECS/ELINCS - European Inventory of Existing Commercial Chemical Substances/EU List of Notified Chemical Substances
TSCA - United States Toxic Substances Control Act Section 8(b) Inventory
DSL/NDSL - Canadian Domestic Substances List/Non-Domestic Substances List
ENCS - Japan Existing and New Chemical Substances
IECSC - China Inventory of Existing Chemical Substances
KECL - Korean Existing and Evaluated Chemical Substances
PICCS - Philippines Inventory of Chemicals and Chemical Substances
AICS - Australian Inventory of Chemical Substances
NZIoC - New Zealand Inventory of Chemicals

Further information

15.2. Chemical Safety Assessment

Chemical Safety Assessment Not applicable

16. OTHER INFORMATION

Full text of R-phrases referred to under sections 2 and 3
R41 - Risk of serious damage to eyes
R65 - Harmful: may cause lung damage if swallowed

Full text of H-Statements referred to under section 2 and 3
H304 - May be fatal if swallowed and enters airways
H318 - Causes serious eye damage

Version EU

TOTAL

SDS # : 30033

FINASOL OSR 51

Revision Date: 2012-02-22 **Version** 1.01

Abbreviations, acronyms
bw – body weight
bw/day – body weight/day
dw – dry weight
mw – marine water
fw – fresh water

Legend Section 8

+	Sensitizer	*	Skin designation
**	Hazard Designation	C:	Carcinogen
M:	Mutagen	R:	Toxic to reproduction

Revision Date: 2012-02-22
Revision Note (M)SDS sections updated: 3, ***
This safety data sheet complies with the requirements of Regulation (EC) No. 1907/2006

This safety data sheet serves to complete but not to replace the technical product sheets. The information contained herein is given in good faith and is accurate to the best of knowledge at the date indicated above.It is understood by the user that any use of the product for purposes other than those for which it was designed entails potential risk.The information given herein in no way dispenses the user from knowing and applying all provisions regulating his activity.The user bears sole liability for the precautions required when using the product.The regulatory texts indicated herein are intended to aid the user to fulfil his obligations. This list is not to be considered complete and exhaustive.It is the user's responsibility to ensure that he is subject to no other obligations than those mentioned.

End of the safety data sheet

Version EU

DASIC INTERNATIONAL LTD

SAFETY DATA SHEET

Slickgone NS

Revision 2
Revision date 16-Apr-2009

1. IDENTIFICATION OF THE SUBSTANCE / PREPARATION AND THE COMPANY

Product name	Slickgone NS
Description	Internationally approved dispersant for treating marine oil spills.
Company	Dasic International Ltd Winchester Hill Romsey Hampshire SO51 7YD UK www.dasicinter.com
Telephone	+44 (0)1794 512419
Fax	+44 (0)1794 522346
Emergency telephone number	+44 (0)1794 512419

2 HAZARDS IDENTIFICATION.

Main hazards	The product is classified as non hazardous. May cause degreasing of the skin. May cause irritation to eyes.

3 . COMPOSITION / INFORMATION ON INGREDIENTS.

Hazardous Ingredients

	Conc.	CAS	EINECS	Symbols/Risk phrases
Kerosine - odourless - distillates (petroleum), hydrotreated light	60-70%	64742-47-8	265-149-8	Xn; R65
Sodium dioctylsulphosuccinate	1-10%	577-11-7		Xi;R38 Xi;R36

4. FIRST AID MEASURES

Skin contact	Remove contaminated clothing. Wash with water. Seek medical attention if irritation or symptoms persist. Wash all contaminated clothing before reuse.
Eye contact	Rinse immediately with plenty of water for 15 minutes holding the eyelids open. Contact lenses should be removed. Seek medical attention.
Inhalation	Move the exposed person to fresh air. Seek medical attention if irritation or symptoms persist.
Ingestion	DO NOT INDUCE VOMITING. Rinse mouth thoroughly. Drink 1 to 2 glasses of water. Seek medical attention.
General information	Potential for aspiration if swallowed.

5. FIRE FIGHTING MEASURES

Extinguishing media	Alcohol resistant foam. Carbon dioxide (CO2) Dry chemical. Do NOT use water jet. Cool fire exposed containers with waterspray.
Fire hazards	Burning produces irritating, toxic and obnoxious fumes.
Protective equipment	In case of fire and/or explosion do not breathe fumes. Self-contained breathing apparatus.

D. Dispersant Information

Slickgone NS

Revision 2
Revision date 16-Apr-2009

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Wear suitable protective equipment. See section 8 for further information.
Environmental precautions	Prevent further spillage if safe. Do not allow product to enter drains. Do not flush into surface water. Do not let product contaminate subsoil. Advise local authorities if large spills cannot be contained.
Clean up methods	Absorb with inert, absorbent material. Transfer to suitable, labelled containers for disposal. Contact a licensed waste disposal company. Clean spillage area thoroughly with plenty of water.

7. HANDLING AND STORAGE

Handling	Wear protective clothing. See section 8 for further information.
Storage	Keep out of the reach of children. Avoid contact with: strong oxidising agents. Keep in a cool, dry, well ventilated area.
Suitable packaging	Store in original container.
Specific use	Obtain special instructions from the supplier.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure limits

Kerosine - odourless - distillates (petroleum), hydrotreated light	WEL 8-hr limit ppm: WEL 15 min limit ppm:	WEL 8-hr limit mg/m3: 1000 WEL 15 min limit mg/m3:

Engineering measures	Ensure adequate ventilation of the working area.
Respiratory protection	Not normally required. Wear suitable respiratory equipment when necessary. For short periods of work a combination of charcoal filter and particulate filter is suitable.
Hand protection	Chemical resistant gloves (PVC)
Eye protection	Approved safety goggles. Provide eye wash station.
Protective equipment	Apron (Plastic or rubber) Rubber boots.

9. PHYSICAL AND CHEMICAL PROPERTIES

Description	Viscous liquid.
Colour	Brown.
Odour	Mild.
Boiling point	192°C
Flash point	72°C
Relative density	0.87
Water solubility	slightly miscible in water.
Viscosity	Flow Time in 3mm ISO cup (ISO 2431) - 40

10. STABILITY AND REACTIVITY

Stability	Stable under normal conditions.
Conditions to avoid	Burning produces irritating, toxic and obnoxious fumes.
Materials to avoid	Strong oxidising agents.

Slickgone NS

Revision 2
Revision date 16-Apr-2009

11. TOXICOLOGICAL INFORMATION

Acute toxicity	Ingestion may cause nausea and vomiting.
Corrosivity	May cause irritation to eyes. May cause degreasing of the skin. Potential for aspiration if swallowed.
Repeated or prolonged exposure	Repeated or prolonged exposure may cause dermatitis.
Mutagenic effects	No mutagenic effects reported.
Carcinogenic effects	No carcinogenic effects reported.
Reproductive toxicity	No teratogenic effects reported.

12. ECOLOGICAL INFORMATION

Degradability	The surfactant(s) contained in this preparation complies(comply) with the biodegradability criteria as laid down in Regulation (EC) No.648/2004 on detergents. Data to support this assertion are held at the disposal of the competent authorities of the Member States and will be made available to them, at their direct request or at the request of a detergent manufacturer.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

General Information	Dispose of as special waste in compliance with local and national regulations.
Disposal of packaging	Dispose of in compliance with all local and national regulations.

14. TRANSPORT INFORMATION

Further information	The product is not classifed as dangerous for carriage.

15. REGULATORY INFORMATION

16. OTHER INFORMATION

Text of risk phrases in Section 3.	R36 - Irritating to eyes. R38 - Irritating to skin. R65 - Harmful: may cause lung damage if swallowed.

D.3. SDS COREXIT® EC9527A

COREXIT™ ENVIRONMENTAL SOLUTIONS

SAFETY DATA SHEET

COREXIT™ EC9527A

Section: 1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	COREXIT™ EC9527A
Other means of identification	:	Not applicable.
Recommended use	:	OIL SPILL DISPERSANT
Restrictions on use	:	Refer to available product literature or ask your local Sales Representative for restrictions on use and dose limits.
Company	:	COREXIT Environmental Solutions LLC 11177 S. Stadium Drive Sugar Land, Texas 77478 USA TEL: +1 (832) 851-5164
Emergency telephone number	:	(800) 424-9300 (24 Hours) CHEMTREC
Issuing date	:	08/30/2019

Section: 2. HAZARDS IDENTIFICATION

GHS Classification

Flammable liquids	:	Category 4
Acute toxicity (Oral)	:	Category 4
Acute toxicity (Dermal)	:	Category 4
Eye irritation	:	Category 2A

GHS Label element

Hazard pictograms :

Signal Word	:	Warning
Hazard Statements	:	Combustible liquid Harmful if swallowed or in contact with skin Causes serious eye irritation.
Precautionary Statements	:	**Prevention:** Keep away from heat/sparks/open flames/hot surfaces. - No smoking. Wash skin thoroughly after handling. Do not eat, drink or smoke when using this product. Wear protective gloves/ eye protection/ face protection. **Response:** IF SWALLOWED: Call a POISON CENTER or doctor/ physician if you feel unwell. Rinse mouth.IF ON SKIN: Wash with plenty of soap and water. Call a POISON CENTER or doctor/ physician if you feel unwell. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.If eye irritation persists: Get medical advice/ attention.Wash contaminated clothing before reuse. **Storage:** Store in a well-ventilated place. Keep cool.
Other hazards	:	None known.

D. Dispersant Information

SAFETY DATA SHEET

COREXIT™ EC9527A

Section: 3. COMPOSITION/INFORMATION ON INGREDIENTS

Pure substance/mixture : Mixture

Chemical Name	CAS-No.	Concentration: (%)
2-Butoxyethanol	111-76-2	30 - 60
Organic sulfonic acid salt	Proprietary	10 - 30
Propylene Glycol	57-55-6	1 - 5

Section: 4. FIRST AID MEASURES

In case of eye contact : Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention.

In case of skin contact : Wash off immediately with plenty of water for at least 15 minutes. Use a mild soap if available. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops and persists.

If swallowed : Rinse mouth. Get medical attention if symptoms occur.

If inhaled : Get medical attention if symptoms occur.

Protection of first-aiders : In event of emergency assess the danger before taking action. Do not put yourself at risk of injury. If in doubt, contact emergency responders. Use personal protective equipment as required.

Notes to physician : Treat symptomatically.

Most important symptoms and effects, both acute and delayed : See Section 11 for more detailed information on health effects and symptoms.

Section: 5. FIREFIGHTING MEASURES

Suitable extinguishing media : Foam
Carbon dioxide
Dry powder
Other extinguishing agent suitable for Class B fires
For large fires, use water spray or fog, thoroughly drenching the burning material.

Unsuitable extinguishing media : None known.

Specific hazards during firefighting : Fire Hazard
Keep away from heat and sources of ignition.
Flash back possible over considerable distance.

Hazardous combustion products : Decomposition products may include the following materials: Carbon oxides Sulphur oxides metal oxides

Special protective equipment for firefighters : Use personal protective equipment.

Specific extinguishing : Fire residues and contaminated fire extinguishing water must be disposed of in

SAFETY DATA SHEET

COREXIT™ EC9527A

methods		accordance with local regulations. In the event of fire and/or explosion do not breathe fumes.

Section: 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	Ensure adequate ventilation. Remove all sources of ignition. Ensure clean-up is conducted by trained personnel only. Refer to protective measures listed in sections 7 and 8.
Environmental precautions	:	Do not allow contact with soil, surface or ground water.
Methods and materials for containment and cleaning up	:	Eliminate all ignition sources if safe to do so. Stop leak if safe to do so. Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations (see section 13). For large spills, dike spilled material or otherwise contain material to ensure runoff does not reach a waterway. Flush away traces with water.

Section: 7. HANDLING AND STORAGE

Advice on safe handling	:	Avoid contact with skin and eyes. Take necessary action to avoid static electricity discharge (which might cause ignition of organic vapours). Do not ingest. Keep away from fire, sparks and heated surfaces. Wash hands thoroughly after handling. Use only with adequate ventilation.
Conditions for safe storage	:	Keep away from heat and sources of ignition. Keep away from oxidizing agents. Keep out of reach of children. Keep container tightly closed. Store in suitable labelled containers.
Suitable material	:	The following compatibility data is suggested based on similar product data and/or industry experience: Stainless Steel 316L, Hastelloy C-276, MDPE (medium density polyethylene), Nitrile, Plexiglass, TFE, HDPE (high density polyethylene), Neoprene, Aluminum, Polypropylene, Polyethylene, Carbon Steel C1018, Stainless Steel 304, FEP (encapsulated), Perfluoroelastomer, PVC, PTFE, Polytetrafluoroethylene/polypropylene copolymer, Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use.
Unsuitable material	:	The following compatibility data is suggested based on similar product data and/or industry experience: Copper, Mild steel, Brass, Nylon, Buna-N, Natural rubber, Polyurethane, Ethylene propylene, EPDM, Fluoroelastomer, Chlorosulfonated polyethylene rubber

Section: 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Form of exposure	Permissible concentration	Basis
2-Butoxyethanol	111-76-2	TWA	20 ppm	ACGIH
		TWA	5 ppm 24 mg/m3	NIOSH REL
		TWA	50 ppm 240 mg/m3	OSHA Z1
Propylene Glycol	57-55-6	TWA	10 mg/m3	AIHA WEEL

SAFETY DATA SHEET

COREXIT™ EC9527A

Engineering measures	:	Effective exhaust ventilation system. Maintain air concentrations below occupational exposure standards.

Personal protective equipment

Eye protection	:	Safety goggles Face-shield
Hand protection	:	Wear the following personal protective equipment: Standard glove type. Gloves should be discarded and replaced if there is any indication of degradation or chemical breakthrough.
Skin protection	:	Wear suitable protective clothing.
Respiratory protection	:	When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.
Hygiene measures	:	Handle in accordance with good industrial hygiene and safety practice. Remove and wash contaminated clothing before re-use. Wash face, hands and any exposed skin thoroughly after handling.

Section: 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Liquid
Colour	:	clear
Odour	:	Mild
Flash point	:	72.7 °C, Method: ASTM D 56, Tag closed cup, Does not sustain combustion.
pH	:	6.1,(100 %), (20 °C)
Odour Threshold	:	no data available
Melting point/freezing point	:	POUR POINT: -55 °C, ASTM D-97 POUR POINT: < -40 °C
Initial boiling point and boiling range	:	171 °C
Evaporation rate	:	0.1, (water=1)
Flammability (solid, gas)	:	no data available
Upper explosion limit	:	no data available
Lower explosion limit	:	no data available
Vapour pressure	:	< 5 mm Hg, (38 °C), similar to water
Relative vapour density	:	no data available
Relative density	:	0.98 - 1.02,
Density	:	0.98 - 1.02 g/cm3 , 8.2 - 8.5 lb/gal
Water solubility	:	completely soluble
Solubility in other solvents	:	no data available
Partition coefficient: n-octanol/water	:	no data available
Auto-ignition temperature	:	no data available
Thermal decomposition	:	no data available

SAFETY DATA SHEET

COREXIT™ EC9527A

Engineering measures	:	Effective exhaust ventilation system. Maintain air concentrations below occupational exposure standards.

Personal protective equipment

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pH	:	6.1,(100 %), (20 °C)
Odour Threshold	:	no data available
Melting point/freezing point	:	POUR POINT: -55 °C, ASTM D-97 POUR POINT: < -40 °C
Initial boiling point and boiling range	:	171 °C
Evaporation rate	:	0.1, (water=1)
Flammability (solid, gas)	:	no data available
Upper explosion limit	:	no data available
Lower explosion limit	:	no data available
Vapour pressure	:	< 5 mm Hg, (38 °C), similar to water
Relative vapour density	:	no data available
Relative density	:	0.98 - 1.02,
Density	:	0.98 - 1.02 g/cm3 , 8.2 - 8.5 lb/gal
Water solubility	:	completely soluble
Solubility in other solvents	:	no data available
Partition coefficient: n-octanol/water	:	no data available
Auto-ignition temperature	:	no data available
Thermal decomposition	:	no data available

SAFETY DATA SHEET

COREXIT™ EC9527A

		LC50 Common Mummichog: 81 mg/l Exposure time: 96 hrs Test substance: Product
		LC50 Pimephales promelas (fathead minnow): 316 mg/l Exposure time: 96 hrs Test substance: Product
		LC50 Common Mummichog: 92 mg/l Exposure time: 96 hrs Test substance: Product
		NOEC Turbot: 32 mg/l Exposure time: 96 hrs Test substance: Product
Toxicity to daphnia and other aquatic invertebrates	:	LC50 Acartia tonsa: 23 mg/l Exposure time: 48 hrs Test substance: Product
		LC50 Mysid Shrimp (Mysidopsis bahia): 24.14 mg/l Exposure time: 48 hrs Test substance: Product
		LC50 Artemia: 40 mg/l Exposure time: 48 hrs Test substance: Product
Toxicity to algae	:	EC50 Marine Algae (Skeletonema costatum): 9.4 mg/l Exposure time: 72 hrs Test substance: Product

Components

Toxicity to bacteria	:	2-Butoxyethanol 463 mg/l
		Propylene Glycol > 20,000 mg/l

Components

Toxicity to fish (Chronic toxicity)	:	2-Butoxyethanol NOEC: > 100 mg/l Exposure time: 21 d
		Propylene Glycol Chronic Toxicity Value: 2,500 mg/l Exposure time: 30 d

Components

Toxicity to daphnia and other aquatic invertebrates (Chronic toxicity)	:	2-Butoxyethanol NOEC: > 100 mg/l Exposure time: 21 d
		Propylene Glycol

SAFETY DATA SHEET

COREXIT™ EC9527A

NOEC: 13,020 mg/l
Exposure time: 7 d

Persistence and degradability

The organic portion of this preparation is expected to be readily biodegradable.

Mobility

The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.
If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	:	<5%
Water	:	10 - 30%
Soil	:	70 - 90%

The portion in water is expected to be soluble or dispersible.

Bioaccumulative potential

Based on a review of the individual components, utilizing U.S. EPA models, this material is not expected to bioaccumulate.

Other information

no data available

Section: 13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

Disposal methods	:	The product should not be allowed to enter drains, water courses or the soil. Where possible recycling is preferred to disposal or incineration. If recycling is not practicable, dispose of in compliance with local regulations. Dispose of wastes in an approved waste disposal facility.
Disposal considerations	:	Dispose of as unused product. Empty containers should be taken to an approved waste handling site for recycling or disposal. Do not re-use empty containers.

Section: 14. TRANSPORT INFORMATION

The shipper/consignor/sender is responsible to ensure that the packaging, labeling, and markings are in compliance with the selected mode of transport.

Land transport (DOT)

Proper shipping name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

SAFETY DATA SHEET

COREXIT™ EC9527A

Air transport (IATA)

Proper shipping name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Sea transport (IMDG/IMO)

Proper shipping name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

Section: 15. REGULATORY INFORMATION

TSCA list : Not relevant

EPCRA - Emergency Planning and Community Right-to-Know Act

CERCLA Reportable Quantity

This product does not contain a RQ substance, or this product contains a substance with a RQ, however the calculated RQ exceeds the reasonably attainable upper limit.

SARA 304 Extremely Hazardous Substances Reportable Quantity

This material does not contain any components with a section 304 EHS RQ.

SARA 311/312 Hazards : Flammable (gases, aerosols, liquids, or solids)
Acute toxicity (any route of exposure)
Serious eye damage or eye irritation

SARA 302 : No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 : The following components are subject to reporting levels established by SARA Title III, Section 313:

2-Butoxyethanol	111-76-2	38.62 %

California Prop. 65

This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

INTERNATIONAL CHEMICAL CONTROL LAWS :

United States TSCA Inventory

The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

Australia. Industrial Chemical (Notification and Assessment) Act

All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

Canadian Domestic Substances List (DSL)

The substances in this preparation are listed on the Domestic Substances List (DSL), are exempt, or have been reported in accordance with the New Substances Notification Regulations.

Japan. ENCS - Existing and New Chemical Substances Inventory

All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Existing and New Chemical Substances list (ENCS).

Korea. Korean Existing Chemicals Inventory (KECI)

SAFETY DATA SHEET

COREXIT™ EC9527A

All substances in this product comply with the Chemical Control Act (CCA) and are listed on the Existing Chemicals List (ECL)

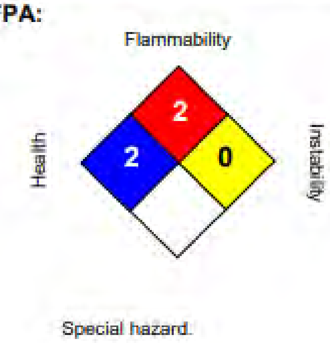
Philippines Inventory of Chemicals and Chemical Substances (PICCS)
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

China Inventory of Existing Chemical Substances
All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on or exempt from the Inventory of Existing Chemical Substances China (IECSC).

New Zealand. Inventory of Chemicals (NZIoC), as published by ERMA New Zealand
All substances in this product comply with the Hazardous Substances and New Organisms (HSNO) Act 1996,and are listed on or are exempt from the New Zealand Inventory of Chemicals.

Section: 16. OTHER INFORMATION

NFPA:



HMIS III:

HEALTH	2
FLAMMABILITY	2
PHYSICAL HAZARD	0

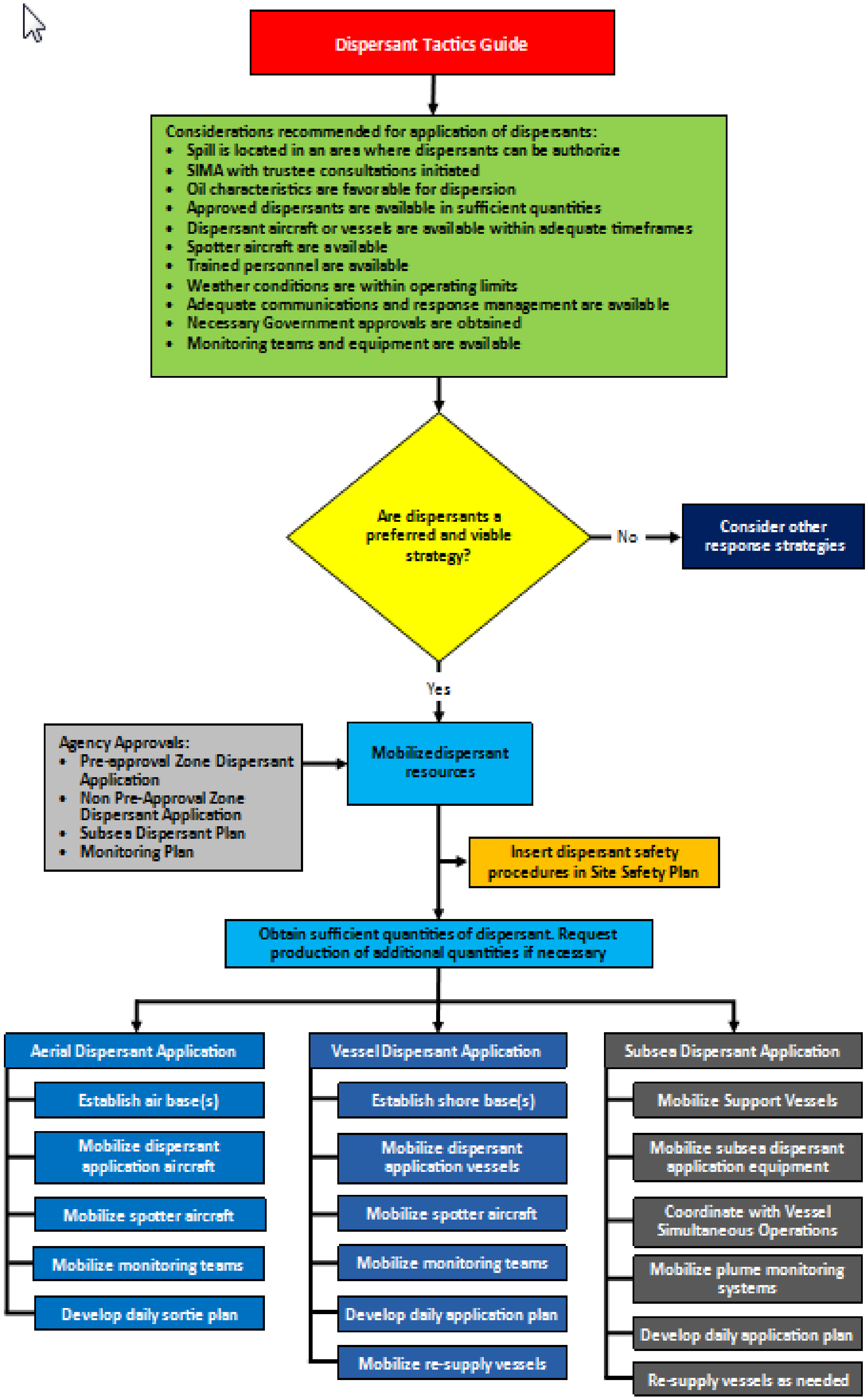
0 = not significant, 1 =Slight,
2 = Moderate, 3 = High
4 = Extreme, * = Chronic

Revision Date : 08/30/2019
Version Number : 0.0
Prepared By : Regulatory Affairs

REVISED INFORMATION: Significant changes to regulatory or health information for this revision is indicated by a bar in the left-hand margin of the SDS.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

D.4. General Surface and Subsea Dispersant Guide



D. Dispersant Information

Overview of Incident	
Describe the location and extent of spill, and spill volume (known or estimated).	
State oil type, API gravity, viscosity and pour point. (Attach SDS if available).	
State whether the spill is in a location approved for Dispersant use by Caribbean Island OPRC Plan 2012 or provide details of why use dispersant approval is required if outside of these parameters.	
State whether spill is instantaneous or continuous (include flow rate if known).	
Predicted oil spill movement (attach oil spill modelling trajectory if available).	
Predicted sub-surface dispersant plume flow (attach oil spill modelling trajectory if available).	
Distance from shoreline.	
Depth of water.	
Weather Conditions	
Are current weather conditions suitable for a dispersant application operation? Yes/No	In this section, include current and forecasted weather conditions and whether they are suitable for dispersant application
Wind (from) direction.	
Wind speed (knots).	
Current velocity (knots).	
Current (to) direction.	
Visibility (nautical miles).	
Sea state	
Dispersant Application Details	
Dispersant type (Attach SDS) What is the current Dispersant stockpile level available for the dispersant spraying operation?	In this section, describe the dispersant product to be used (name). Attach an SDS. Describe the dispersant application method, the expected amount of dispersant to be used and estimated timeline for the dispersant spaying operation.
Application Method. (Include proposed DOR, dosage rate (gpa /lpha) and maximum equipment application rate.	
Estimated Dispersant quantity to be used.	
Describe Dispersant Spraying Operational area. Include any environmental and socio-economic sensitivities in the region. Use maps / charts if available.	

D. Dispersant Information

<table>
<tr><th colspan="6">Dispersant Effectiveness Monitoring Program</th></tr>
<tr><td colspan="2">Describe the level of dispersant effectiveness monitoring to be applied during the dispersant spraying operations.</td><td colspan="4">State how observations will be carried out and documented. Describe how the dispersant spraying operations results will be communicated to the regulatory approvers.</td></tr>
<tr><th colspan="6">Dispersant Spraying Operation Approval Decision</th></tr>
<tr><td colspan="3">Approved

Provide Additional Comments as Required</td><td colspan="3">Not Approved

Provide Details on Why Approval was Not Granted</td></tr>
<tr><th colspan="2">Decision Makers Name and Position</th><th colspan="2">Contact Details</th><th colspan="2">Date and Time</th></tr>
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APPENDIX E – GEOGRAPHICAL RESPONSE PLAN

The Response Group (TRG) has generated a comprehensive Geographical Response Plan (GRP) for the coastlines of Guyana, Venezuela, and Trinidad and Tobago to support EMGL offshore operations in the Guyana region. First completed in 2019, TRG was contracted to update the earlier work by field verification in 2022 and to expand to include Grenada and St. Vincent and the Grenadines[1].The geographical footprint of the GRP was based on projected impacts from the (unmitigated) stochastic modelling of well control scenario(s) and the initially impacted shorelines as outlined in this Oil Spill Response Plan (OSRP). TRG conducted a full desktop review in detail at a scale of 1:5,000 to determine any potentially impacted sensitivities along the entire coastline of Guyana.

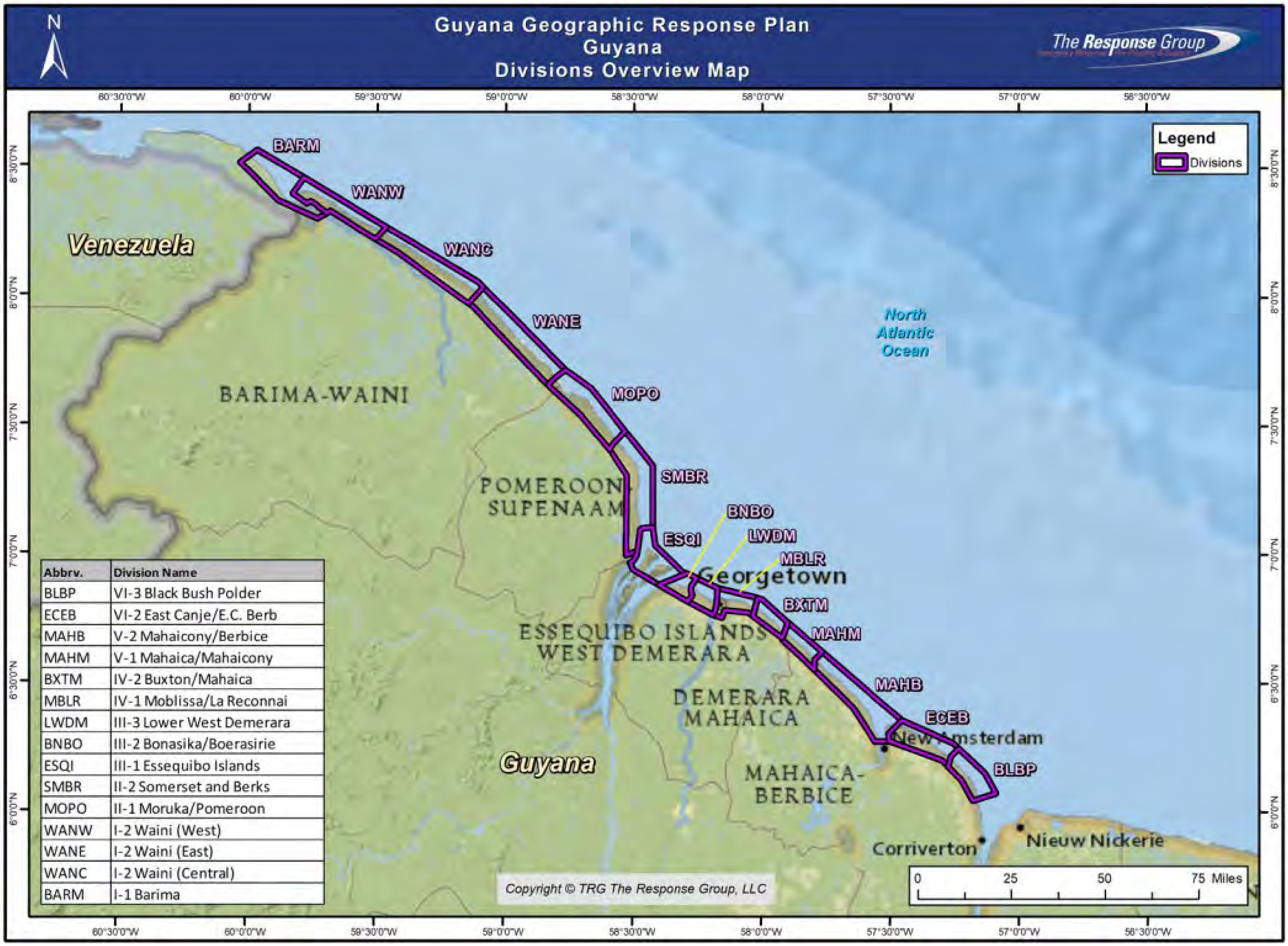
The aim is to provide responding organizations the GRP so that they are able to review locations of sensitivities, access points, response actions, as well as resource requirements. The GRP defines the equipment needs (totals) for each division to support efficient resource ordering practices upon utilization of the plan. To further support response activities, the GRP provides an appendix containing response methods by shoreline type, to support response activities and decision-making on impacted areas outside the scope of the GRP.

The GRP is an extensive document (750+ pages) and is managed outside of the OSRP for efficiency purposes. Example maps and tables are shown in this appendix to provide users with a conceptual overview. A full suite of Geographical Strategic Response Maps will be immediately available to the response team(s) in the event of an oil spill through the Incident Action Plan software provided by TRG.

[1] Field verification of the Venezuela Geographical Response Plan was not carried out in 2022.


Guyana Geographic Response Plan
Guyana Overview Map
The Response Group
St. Vincent and The Grenadines
Kingstown
SAINT VINCENT AND THE GRENADINES
SAINT LUCIA
Bridgetown
BARBADOS
Grenada
Saint George's
GRENADA
Tobago
Port of Spain
TRINIDAD AND TOBAGO
Trinidad
North Atlantic Ocean
Venezuela
Georgetown
Paramaribo
Guyana
Suriname
Roraima
Boa Vista
Ciudad Guayana
San Félix de Guayana
Legend
Countries
Copyright © TRG The Response Group, LLC
0 50 100 150 Miles

E.1. Example – Guyana Geographical Response Plan Information



Abbrv.	Division Name
BLBP	VI-3 Black Bush Polder
ECEB	VI-2 East Canje/E.C. Berb
MAHB	V-2 Mahaicony/Berbice
MAHM	V-1 Mahaica/Mahaicony
BXTM	IV-2 Buxton/Mahaica
MBLR	IV-1 Moblissa/La Reconnai
LWDM	III-3 Lower West Demerara
BNBO	III-2 Bonasika/Boerasirie
ESQI	III-1 Essequibo Islands
SMBR	II-2 Somerset and Berks
MOPO	II-1 Moruka/Pomeroon
WANW	I-2 Waini (West)
WANE	I-2 Waini (East)
WANC	I-2 Waini (Central)
BARM	I-1 Barima


Guyana Geographic Response Plan
VI-3 Black Bush Polder (Guyana)
Division Overview Map
N
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Legend
Response Sites
Protection
Mangroves
Divisions
Shoreline Type (TT)
10D-Scrub and Shrub Wetlands
BLBP-10
BLBP-9
BLBP-8
BLBP-7
BLBP-6
BLBP-5
BLBP-4
BLBP-3
BLBP-2
BLBP-1
VI-3 Black Bush Polder
North Atlantic Ocean
Guyana
I
II
III
IV
V
VI
VII
X
Copyright © TRG The Response Group, LLC
0 1 2 3 4 5 Miles
57°21'0"W
57°18'0"W
57°15'0"W
57°12'0"W
57°9'0"W
57°6'0"W
57°3'0"W
6°15'0"N
6°12'0"N
6°9'0"N
6°6'0"N
6°3'0"N


Guyana Geographic Response Plan
VI-3 Black Bush Polder Division: BLBP-1
Protection Site - Strategy Map
N
The Response Group
57°10'11"W
57°10'0"W
57°9'49"W
57°9'38"W
6°3'3"N
6°2'54"N
6°2'45"N
Boom
Resources | Qty | Qty UoM | Size | Size UOM
Hard Boom | 550 | ft | 18 | Inch
Lat: 6° 3' 1.013" N
Long: 57° 9' 45.966" W
VI-3
BLACK BUSH POLDER
FRONTLANDS AND EXTENSION
BLBP-1
350
100
100
North
Atlantic
Ocean
bing
Copyright © TRG The Response Group, LLC
Legend
Response Sites
Protection
Boom
Hard Boom
Guyana Subregions
0
500
1,000 Feet

GRP Area Maintenance				GRP Area: BLBP-1
		Resources Required		
Area Of Operation	***Resource Kind***	***Description***	***Quantity***	***Size***
BLBP-1	Boom	Hard Boom	550 feet	18 inch (es)
BLBP-1	Vessel	Work Boat	1 each	18 feet
BLBP-1	Boom Accessories	Anchor Stakes	18 each	
BLBP-1	Manpower: Responder	Responder	4 each	
BLBP-1	Manpower: Supervisor	Supervisor	1 each	
BLBP-1	Boom Accessories	Boom Anchors	5 each	20 pound(s)
BLBP-1	Manpower: Operator	Boat Operator	1 each	

Assignments

1.) Deploy a 350 ft section of hard boom in a chevron configuration to protect the inlet.
2.) Deploy (2) 100 ft sections of hard boom in a chevron configuration at the confluence.

Location of Work

Latitude: 6° 3' 1.013" N
Longitude: 57° 9' 45.966" W

EXAMPLE

GRP Area Maintenance

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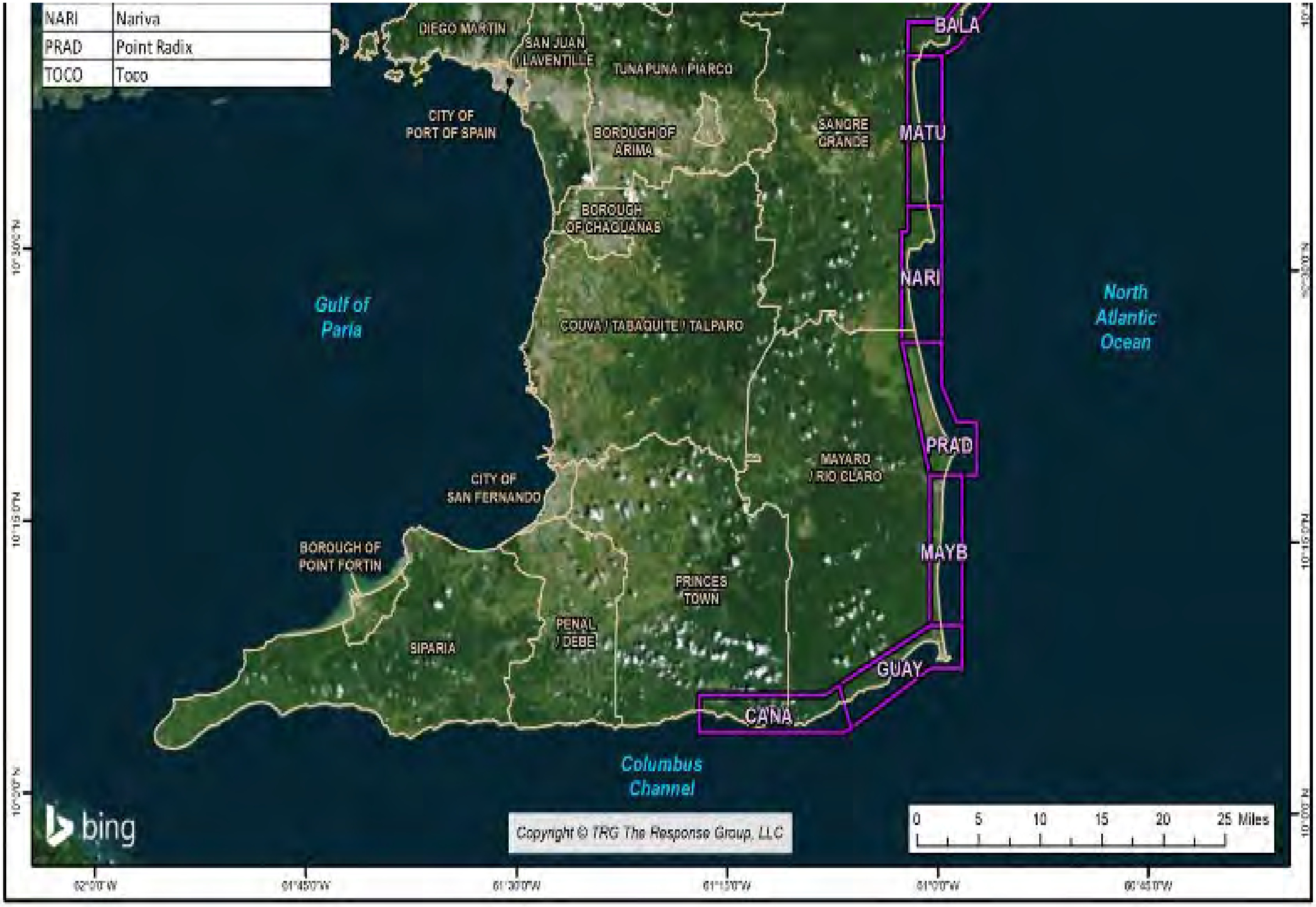
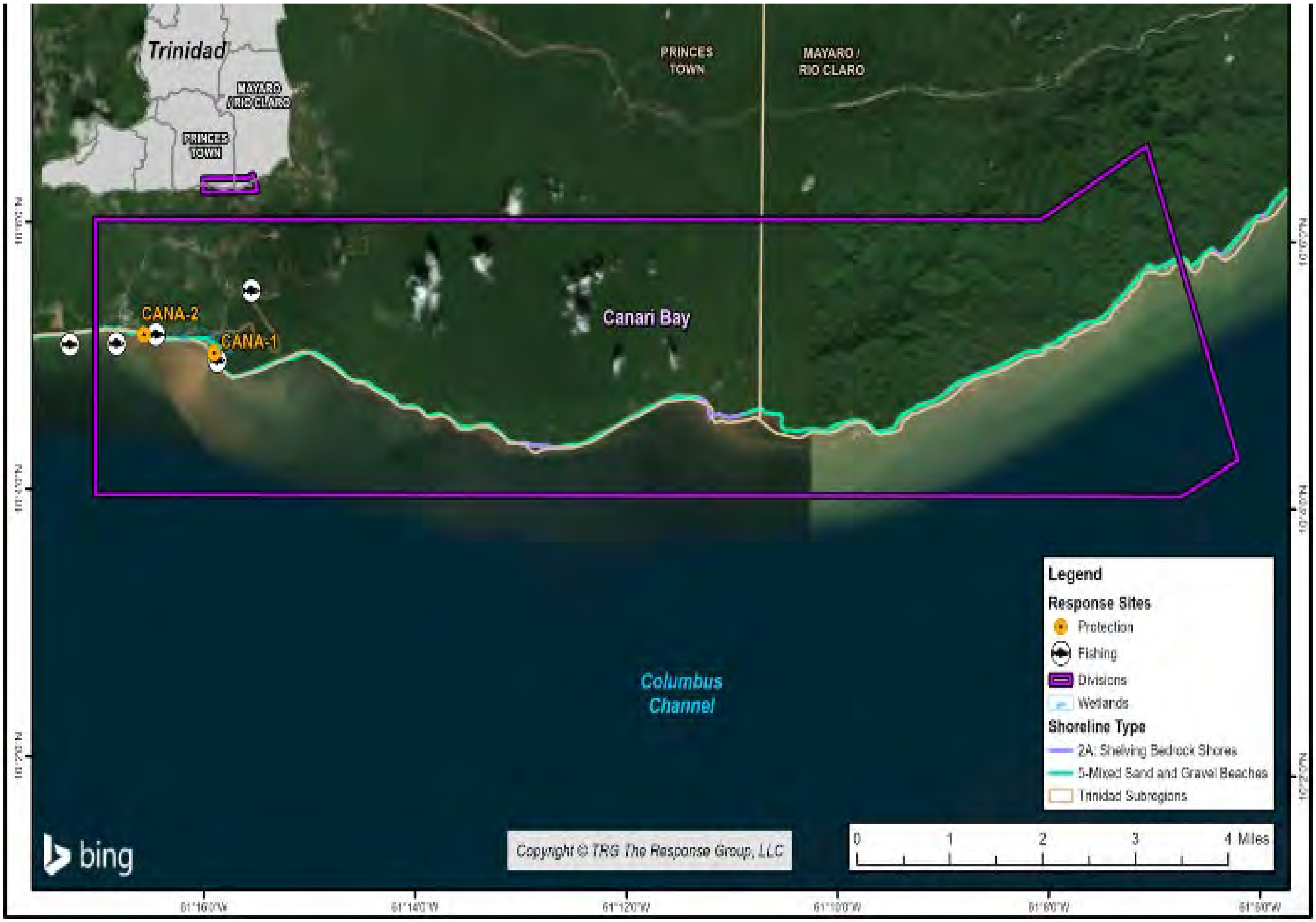
E.2. Example – Trinidad and Tobago Geographical Response Plan Information




Trinidad
MAYARO / RIO CLARO
PRINCES TOWN
PRINCES TOWN
MAYARO / RIO CLARO
CANA-2
CANA-1
Canari Bay
Columbus Channel
Legend
Response Sites
Protection
Fishing
Divisions
Wetlands
Shoreline Type
2A: Shelving Bedrock Shores
5-Mixed Sand and Gravel Beaches
Trinidad Subregions
0 1 2 3 4 Miles
Copyright © TRG The Response Group, LLC
bing


250
250
900
800
PRINCES TOWN
CANA 1
Columbus Channel
Legend
Response Sites
Protection
Boom
Hard Boom
Trinidad Subregions
0
200
400
600 Feet
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bing

GRP Area Maintenance			GRP Area: CANA-1 - Moruga River	
Resources Required				
Area Of Operation	***Resource Kind***	***Description***	***Quantity***	***Size***
CANA-1 - Moruga River	Boom Accessories	Anchor Stakes	24 each	
CANA-1 - Moruga River	Boom	Hard Boom	2000 feet	18 inch (es)
CANA-1 - Moruga River	Boom Accessories	Boom Anchors	19 each	40 pound(s)
CANA-1 - Moruga River	Manpower: Responder	Responder	6 each	
CANA-1 - Moruga River	Manpower: Supervisor	Supervisor	2 each	
CANA-1 - Moruga River	Vessel	Work Boat	3 each	20 feet
CANA-1 - Moruga River	Manpower: Operator	Boat Operator	3 each	

Assignments

1.) Deploy (2) 250 ft section of hard boom to protect Moruga River.
2.) Deploy a total of 1,500 ft of hard boom to protect the shoreline at the mouth of Moruga River.

Location of Work

Latitude: 10° 5' 2.526" N
Longitude: 61° 15' 57.396" W

Special Environmental Considerations

Shoreline Type:
5: Mixed Sand and Gravel Beaches

EXAMPLE

GRP Area Maintenance

INCIDENT ACTION PLAN SOFTWARE™	Printed 10/28/2022 10:07	1 of 2	© TRG

10° 17' 20.677" N
Longitude:
60° 59' 54.923" W
Subregion: Mayaro / Rio Claro
Country: Trinidad
Population Density: Moderate
Land Use: Recreational, Residential,
Upstream Valve: N/A
Downstream Valve: N/A

Photo 1: Looking east towards protection site.

Access Information

Site Access:
Public
Access Type:
Road, ATV, Boat
Road Type: Light Duty
Road Surface Type: Paved
Road Condition: All Weather
Bridge Height: N/A

Waterway Information

Type of Waterway: Bay, River
Waterway Name:
Mayaro Bay, Mahaut River
Average Current Speed:
N/A
Waterway Width:
Low Water: 5 ft
High Water: 20 ft
Tidally Influenced: Yes
Shoreline Type: Sand, Palm Trees
Bank Slope: Slight
Bank Height: 2 ft

Response Information

Site Priority: A
Low Water: Booming
High Water: Booming

Recommended Staging Area: N/A

Nearest Boat Ramp & Dist.:
N/A

Existing Response Support Capabilities: N/A

Site Contact Information

Agency/ Organization/ Stakeholders:
N/A

Cellular Service: N/A

Site Description

Access Location Description: This site is located along the Plaisance South beach shoreline.

Obstructions / Limitations: Vegetation, debris

Considerations

Safety Considerations: Wear personal floatation device (PFD) anytime when working on a vessel or near water.

Environmental Considerations: Wildlife, nearby business, residents and Plaisance South beach.

Strategy Considerations: Monitor boom effectiveness and integrity as environmental conditions change.

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MAYB-1

Photo 2: Looking southeast towards the shoreline.

Photo 3:

Assignments

1.) Deploy 150 ft section of hard boom in a chevron configuration to protect the mouth of Mahaut River along Mayaro Bay.
2.) Deploy 250 ft section of shore seal boom protect the mouth of Mahaut River and shoreline.

Resources Required

Type	Description	Qty.	Size	Type	Description	Qty.	Size
Manpower: Responder	Responder	2 ea	N/A	Manpower: Supervisor	Supervisor	1 ea	N/A
Boom Accessories	Anchor Stakes	11 ea	N/A	Boom Accessories	Boom Anchors	1 ea	40 lbs
Boom	Hard Boom	150 ft	18 in	Boom	Shore Seal Boom	250 ft	24 in

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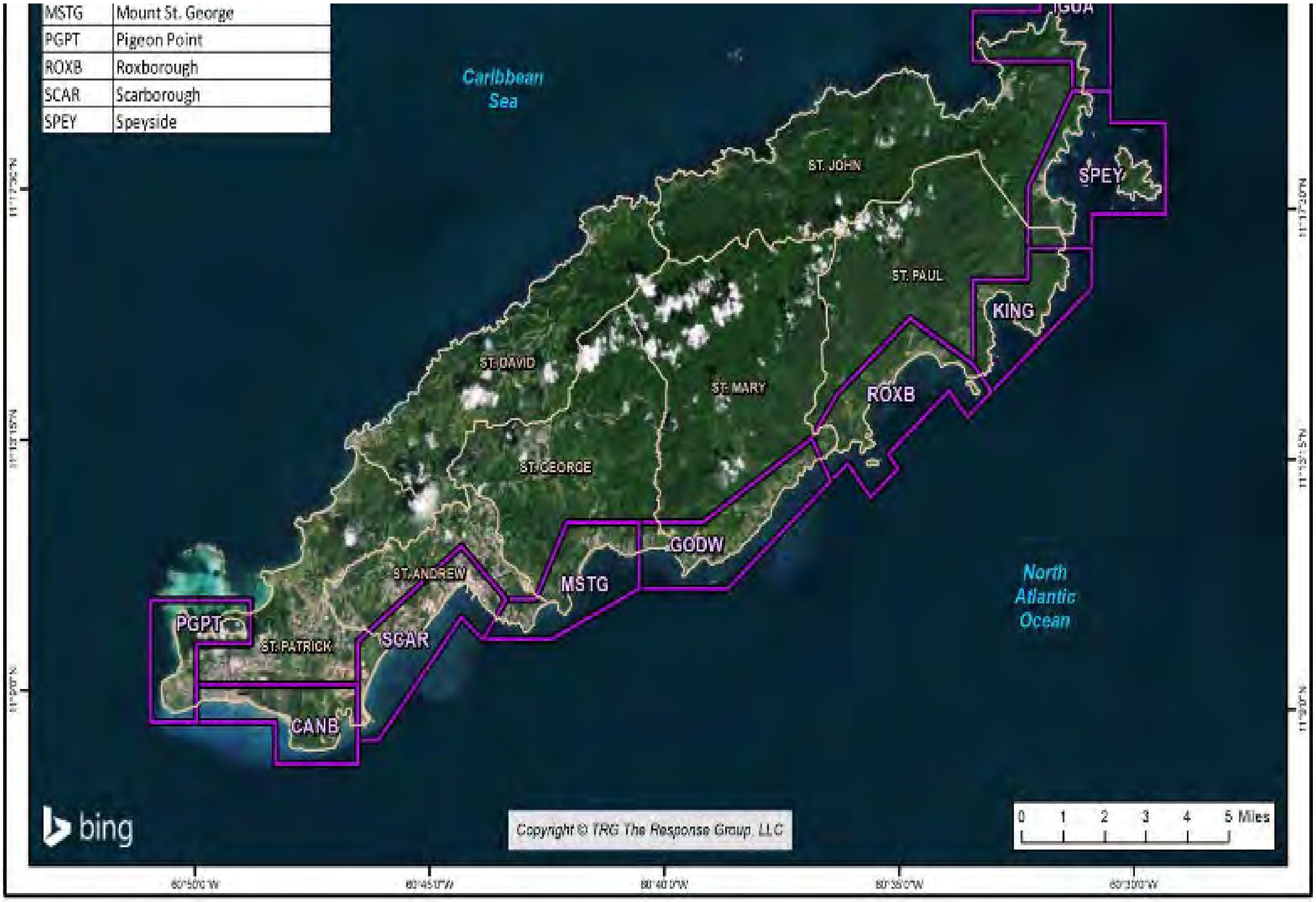
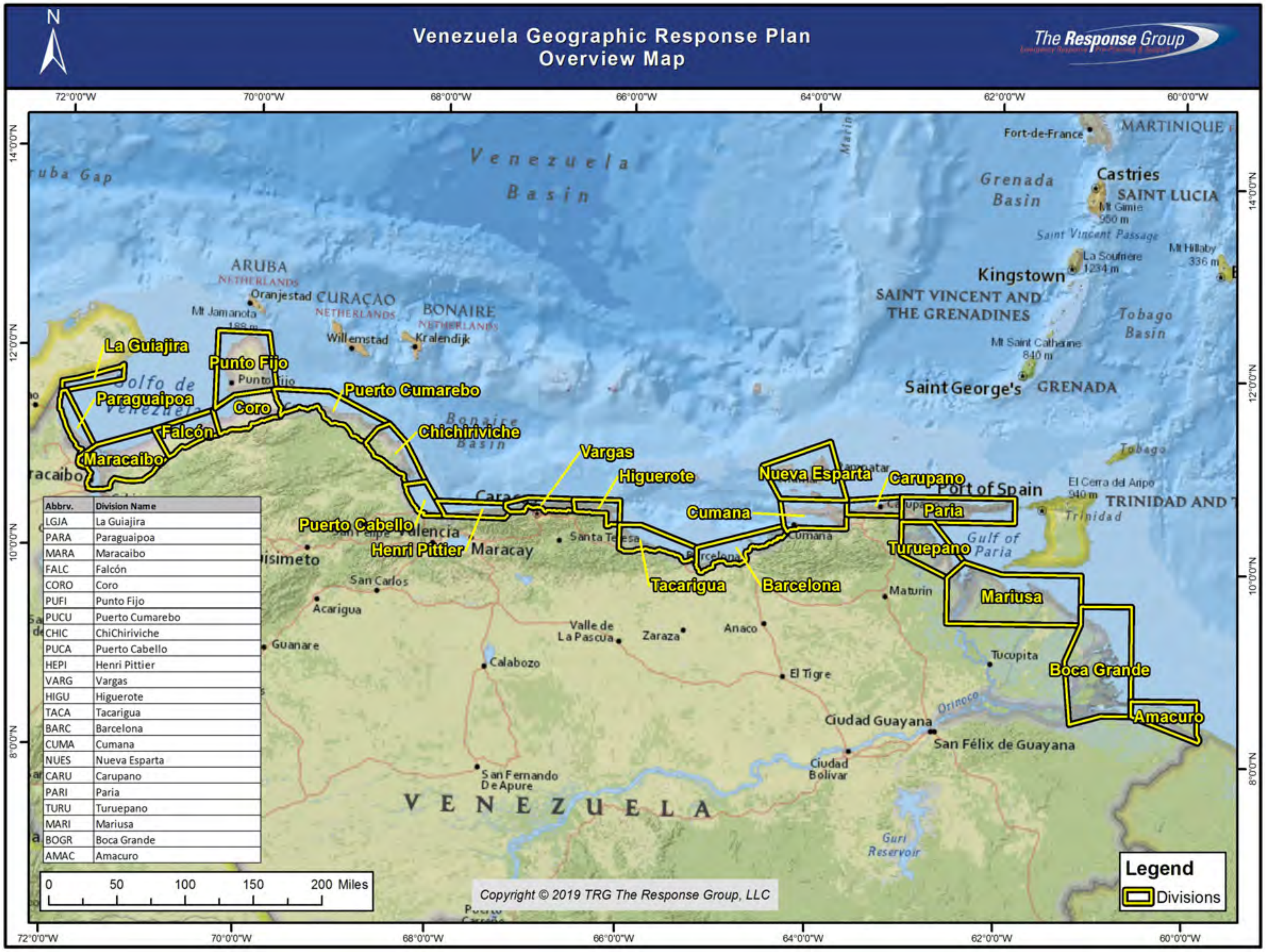
MAYB-1

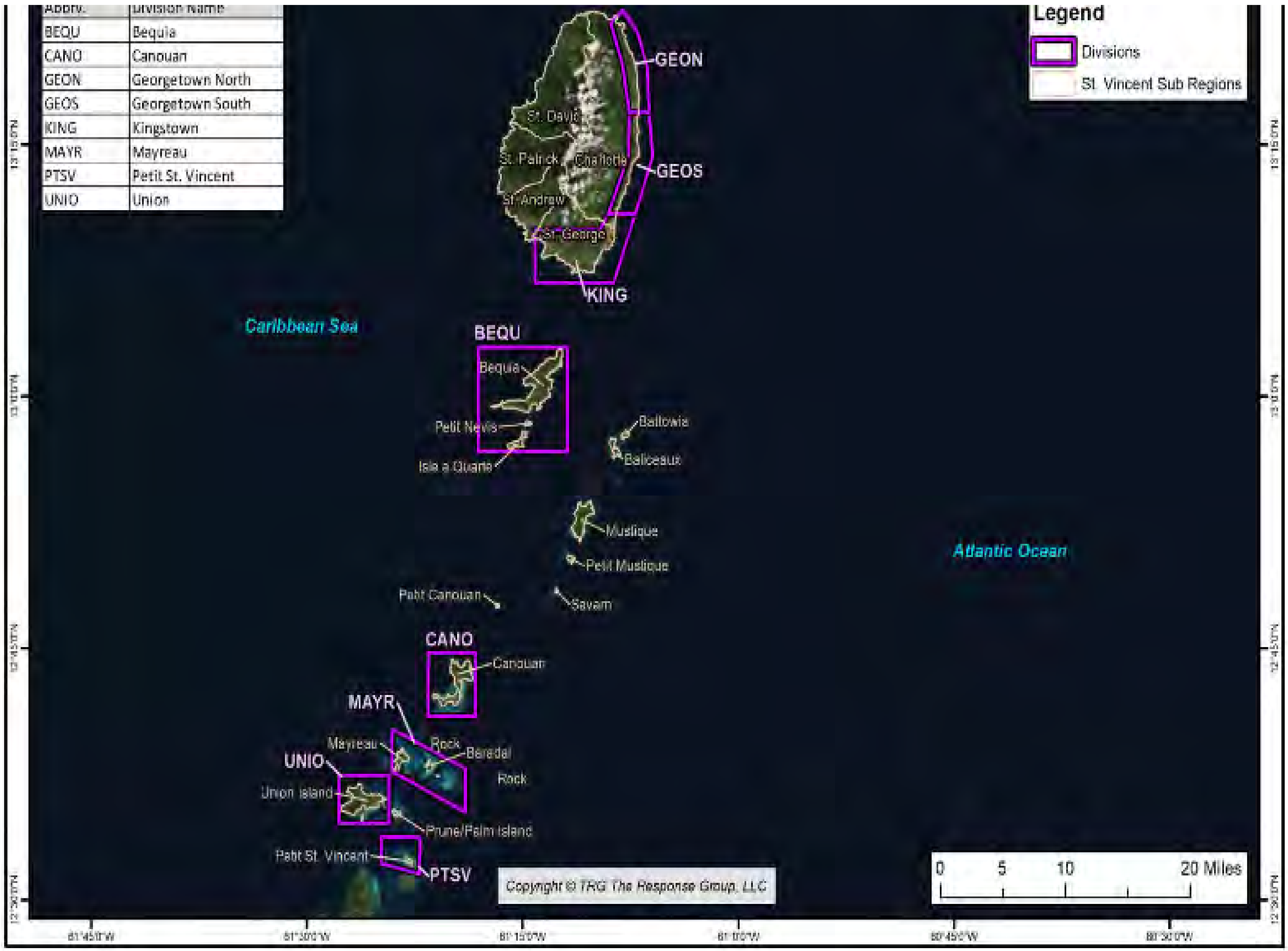

MSTG Mount St. George
PGPT Pigeon Point
ROXB Roxborough
SCAR Scarborough
SPEY Speyside
Caribbean Sea
North Atlantic Ocean
ST. JOHN
ST. PAUL
ST. DAVID
ST. MARY
ST. GEORGE
ST. ANDREW
ST. PATRICK
IGUA
SPEY
KING
ROXB
GODW
MSTG
SCAR
PGPT
CANB
bing
Copyright © TRG The Response Group, LLC
0 1 2 3 4 5 Miles

E.3. Example – Venezuela Geographical Response Plan Information (2018)



E.4. Example – Grenada Geographical Strategic Response Maps

E.5. Example – St. Vincent and the Grenadines Geographical Strategic Response Maps



APPENDIX F – WILDLIFE RESPONSE PLAN

F.1. Introduction

Prevention of oil spills remains the top priority for EMGL. In the unlikely event of a spill, it is important to minimise the duration and impact of any release. Beyond essential mitigation measures, it is important to have a robust spill response capability utilizing all appropriate tools. The proper selection and use of those tools should be based on minimizing potential harm to environmental and socioeconomic resources, including wildlife.

F.1.1. Objective

A critical aspect of protecting wildlife is to minimise the formation of floating slicks and, when they form, to prevent such slicks from coming ashore driven by wind/currents. Oiled wildlife response is a combination of the activities that aim to prevent oiling where possible and mitigate the effects on individuals when it has taken place. This Wildlife Response section is supplemental to the EMGL Oil Spill Response Plan (OSRP) for Guyana Operations and is intended to serve as general guidance for wildlife response efforts which include deterrence (hazing), capture, and rehabilitation measures. In the event of an actual event, an incident specific Wildlife Management Plan would be developed to guide the response. The principal objectives of Wildlife Operations during a response are:

- Provide protection of wildlife and habitats from contamination;
- Minimise injuries to wildlife and habitats from contamination;
- Minimise injuries to wildlife from the clean-up;
- Provide capture and care for injured wildlife;
- Document adverse effects that result from the spill and clean-up; and
- Prevent injuries to responders and the public.

In the event of potential wildlife impacts, EMGL personnel will initiate emergency response protocols which may include assistance / expertise from the ExxonMobil Regional Response Team (RRT), ExxonMobil Biomedical Sciences Inc. (EMBSI), Sea Alarm / Oil Spill Response Limited (OSRL) and the Global Oiled Wildlife Response System (GOWRS) network.

A list of notification numbers can be found in Table F-1.

F.1.2. Potential Oil Spill Impacts on Wildlife

Wildlife may be vulnerable to oiling depending on their behaviour, food preferences, and habitat requirements. They may encounter oil in near-shore and intertidal areas, and at sea. The number of individuals and species affected by an oil spill will depend on the spill size, chemistry of the petroleum product spilled, meteorological and oceanographic conditions, time of year, and the location of the spill.

Many important bird and turtle habitats are located in near-shore and intertidal areas. Some mammals may scavenge for food in intertidal areas and may encounter oiled carcasses. Foraging animals may encounter and ingest oil-contaminated vegetation or other oil-contaminated food sources in coastal areas.

Seabirds are highly vulnerable to oiling since they feed and rest on the water surface. Whales and dolphins have low vulnerability to oiling as these animals tend to avoid areas that are oiled. Turtles generally have a low vulnerability to oiling, but vulnerability may increase during nesting seasons.

Exposure to oil can occur from swimming or wading through oil. Ingestion of oil may occur if an animal attempts to clean its oiled feathers or fur. Another route of oil exposure is through the consumption of oil-contaminated food or water.

General effects of oil on wildlife can be separated into physical and toxicological effects. An example of a physical effect is loss of water repellence and insulating properties of feathers when birds become oiled. As a result, the ability to thermo-regulate may be impaired or lost.

Toxicological effects of oil on wildlife include irritation of the eyes, skin, mucous membranes, lungs, and digestive tract. Organ damage and disruption of immune responses may occur. Effects of oil on wildlife reproduction may include altered breeding behaviour, decreased hatching success, and decreased survival rates of the young.

F.1.3. Protected Species and Areas of Special Value

Protected species and associated habitats that are at risk of oiling should be given priority protection during an oil spill response. In oiled wildlife response planning, it is important to consider:

- Input from appropriate regulatory agencies;
- Seasonality of species occurrences (breeding, nesting, and migration periods);
- Habitats important for breeding, nesting, feeding, or resting;
- Areas of high-density occurrences; and
- Prioritization for protection of important habitats identified in the oil spill response plans.

Attachments F-1, F-2, F-3, and F-4 of this plan describe some of the habitats, birds, and marine reptile and mammal species at risk from oiling. In these appendices, information is provided for key sensitive periods (nesting, moulting, migration, breeding, rearing).

F.1.4. Scope of Wildlife Response Plan

An oiled wildlife response plan provides for pre-planning for the protection of sensitive habitats and species while considering seasonal effects and behaviours. The plan facilitates the identification of protocols, and resources (equipment and personnel) necessary to respond to an incident in a timely manner. Lastly, the plan identifies the needs and capabilities necessary to reduce or avoid impacts to sensitive habitats and species during an oil spill response.

F.1.5. Geographical Extent of Response

The geographic area of concern for response activities for wildlife is typically defined by the extent of the influence of the Project and its alternatives; however, wildlife response for wildlife impacted by an oil spill can be provided on a regional and/or international basis as needed.

F.2. Wildlife Branch Structure and Activities

A general overview of the Incident Command System (ICS) used for managing response efforts, with emphasis on wildlife response activities. The ICS is designed to provide a framework for a consistent, efficient, and effective means to train, activate, and implement EMGL's response resources. The ICS structure facilitates interaction with Contractors, Subcontractors, Guyana government agencies, and non-government organizations that could become involved during a response situation. An example of the structure of the Wildlife Branch during a response can be found below:

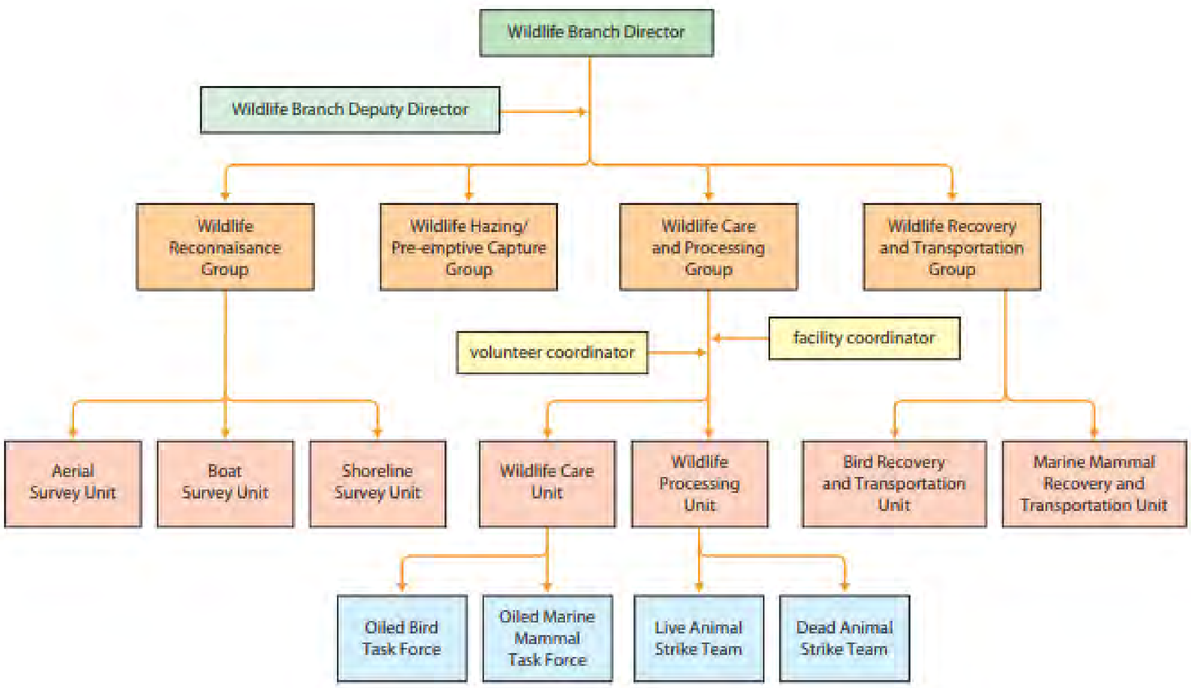
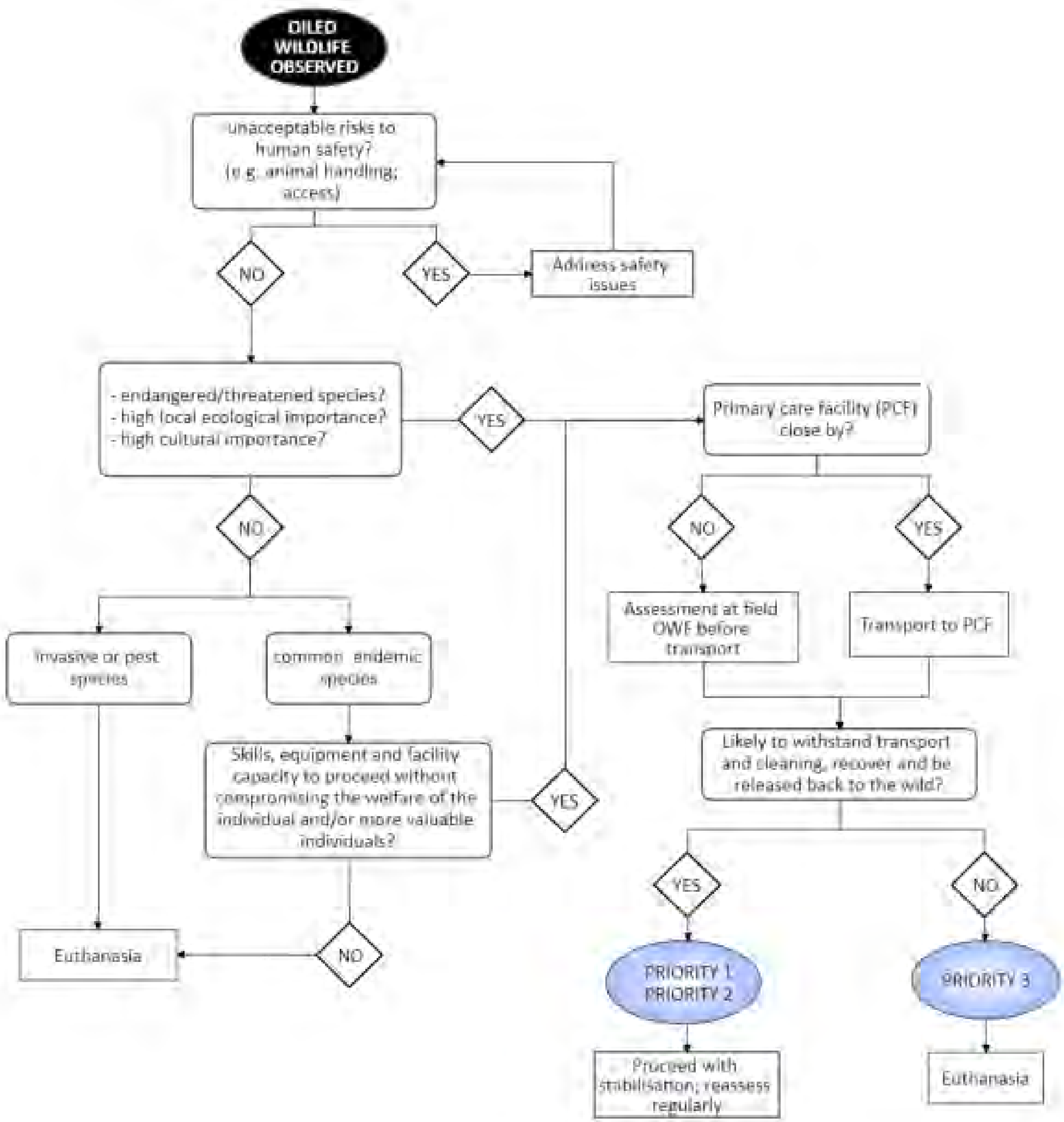


Figure F-1: Example of Wildlife Branch

The structure for the wildlife response organization is designed to fit within the ICS and allows for the integration of wildlife activities into the entire oil spill response plan.

Wildlife response is typically managed under the Wildlife Branch of the Operations Section of the ICS and coordinated through the Environmental Unit of the Planning Section. For example, the Planning Section identifies and characterizes environmentally sensitive areas and wildlife at risk. The Operations Section is responsible for wildlife deterrence, capture, rehabilitation, and shoreline protection.

See Attachment F-7 for initial response activities of the Wildlife Branch.



Response Steps (IPIECA)

1. **SURVEILLANCE/RECONNAISSANCE:** The goal of "reconnaissance" is to gather as much information as possible on what types of animals are in the region and where they are in relation to the spill or the projected area of impact. This information can be obtained by various methods, including by air (plane, helicopter, drone), by water (boat), or by land (walking or All-Terrain Vehicle). The information gathered is transmitted to the Wildlife Branch Director, who can then disperse this to the different response groups that would most benefit from this type of information, especially the Recovery and the Hazing groups.
2. **DETERRENCE/HAZING:** The best way to help wildlife during a spill is to keep them from getting oiled in the first place. There are a variety of factors that need to be considered before scaring animals away from an oil spill. For example, you don't want to scare an animal that is close to the oil spill into the spill itself. Knowing how the species is going to respond to the various hazing or deterrence methods, prior to trying to scare them, is important. Also, knowing where breeding colonies are and what stage of breeding they are in, is important for making sure that responders are not impacting additional animals.
3. **CAPTURE/RECOVERY:** When there is an oil spill, specially trained responders go out and collect oiled wildlife. They wear protective clothing that keeps the oil off of their skin. Once oiled animals are captured, they are then transported to a field stabilization location or a medical facility for care.
4. **FIELD STABILIZATION:** When a medical facility is far from where the animals are captured, an intermediate step is sometimes necessary in order to give the animals a head start in recovering from oiling. This step provides some initial medical care or "first aid" to help increase their chances of recovery.
5. **INTAKE & PROCESSING:** When the oiled animals arrive at the medical facility they go through the "intake & processing" procedures. This includes a full physical exam, just like people receive from doctor. Workers will check their body temperature, how much they weigh, whether they look healthy, and how much oil is on them (among other things). This is also when a medical record for each animal is generated, so that workers can keep track of how the animals are progressing. Workers will also collect information on each animal that comes into the facility, whether dead and live.
6. **PRE-WASH CARE:** The washing procedure can be stressful for animals, and a very weak animal may not survive. After the oiled animals have gone through intake, and before they are cleaned, they need to receive initial care to help make them strong enough for the cleaning process. During pre-wash care, the animals are warmed up and given food and water. You might be surprised to learn that the oiled animals are not washed right away. Responders wait at least 48 hours before they clean the oil off of animals. Working with mammals adds an additional complexity since most must be

anesthetized in order to make it safe and easy to clean. When an oiled animal comes into the medical facility, they are usually cold, hungry, thirsty, and weak.

7. **CLEANING:** Birds are washed in a series of tubs of warm soapy water. Sea otters and fur seals have warm soapy water poured on them and massaged into their thick hair coats. Other mammals and sea turtles usually have soap directly placed on the oiled areas and scrubbed. Then they are rinsed off. This step is very important, because all the soap needs to come off, or the animals' fur or feathers may not go back to normal and they may not be able to become waterproof. It takes a long time to clean an animal. Birds may take over an hour to wash and rinse, and marine mammals may take several hours.
8. **CONDITIONING:** A cleaned bird usually takes three-to-five days of conditioning to be a candidate for release. This process can take much longer if the animal has injuries. During conditioning, an animal is put in an outdoor pen or pool. Here they can spend time getting used to being in the water, and spend time preening or grooming, which is important for them to become waterproof. They are given food and water and watched carefully, so that they become strong and ready for release.
9. **RELEASE:** Once an animal is completely waterproof, healthy, and is acting and eating normally, then it can be released. The animals are always released to a safe and clean environment, where they won't become contaminated with oil again.

F.3. Response Personnel

Only trained and qualified personnel should haze, capture, transport, and rehabilitate oiled wildlife.

Experts from these organizations can be mobilized to Guyana within days by contacting OSRL or the GOWRS Duty Officer. Wildlife response experts and notification numbers are listed in Table F-1.

This Wildlife Response section will be implemented with the assistance of trained and qualified contractors and support groups. Upon notification, contractors and trained local experts (if applicable) will mobilize equipment and trained personnel to the spill site and begin wildlife response operations. Wildlife response equipment for the initial response is available through OSRL in Fort Lauderdale, Florida, USA. Additional equipment will be brought in as needed. Wildlife response standard operational protocols can be supplied by wildlife experts at the time of response or developed ahead of time.

Response-specific wildlife cleaning facilities will be setup in Guyana and/or the region based on response needs. These facilities are set up in response to a spill's trajectory and can be operational in approximately 3-5 days depending on the remoteness of the impacted area(s). There are no wildlife rehabilitators in Guyana with oiled wildlife experience. There are also no permanent facilities for oiled wildlife rehabilitation and few organized wildlife rehabilitation programs in the country. Local resources may be consulted to guide the Wildlife Branch and will be determined at the time of an incident.

Table F-1: Contact Information for Wildlife Experts and Responders

Contact	Contact Name	Contact Information	Comments
ExxonMobil Biomedical Sciences, Inc.	Duty Officer	+1 (908) 730-1111	Wildlife Response Issues
Sea Alarm Foundation	Duty Manager	(Office) +322 2788 744 (Mobile) +32 494900012 (Mobile) +32 499624772 secretariat@sea-alarm.org	Oiled Wildlife Response facilitator
Oil Spill Response Limited	Duty Manager	+1 (954) 983-9880 +44 (0)23 8033-1551 (UK)	Wildlife Response equipment
International Bird Rescue	Duty Officer		ExxonMobil has a contract in place with IBR
Tri-State Bird Rescue & Research, Inc., Delaware	On Call Manager	Main +1 (302) 737-9543 www.tristatebird.org	ExxonMobil has a contract in place with Tri-State

A veterinarian is integral to the oiled wildlife response organization. The veterinarian, using a decision tree, will confer with the appropriate Guyana authorities and fauna experts to decide which oiled animals should be rehabilitated and which animals should be euthanized. The ultimate decision to euthanize an animal based on health status should be made on the grounds that the animal is considered unlikely to be able to return to its 'normal status'.

A written Euthanasia Plan should be developed for each event and should follow established criteria in accordance with local legislation and authorities. The Plan should be discussed and agreed upon by the veterinary staff before rehabilitation operations commence.

- The Euthanasia Plan should be made available for responders, response planners and interested sections of the Incident Command Structure.
- The Plan will include relevant approvals and associated conditions, including the following:
- Details of authorised personnel (both to authorise as well as conduct euthanasia procedures).
- Legal requirements.
- Detailed criteria for decision making.
- Storage methods prior to disposal (based on ability and timeliness of necropsy/post-mortem).
- Methods/contacts for the appropriate disposal of carcasses in accordance with the waste management plan for the response.

For those animals rehabilitated, the veterinarian administers or supervises the appropriate treatment. According to the Guyana Agriculture Ministry, there are approximately 45 active veterinarians in Guyana. Contact can be made through the Guyana Veterinary Association.

Trained and qualified personnel are essential to an oiled wildlife response. The training each person receives will depend on the task the person will perform during the response. Personnel may conduct wildlife deterrence operations or search for and capture oiled animals. Other personnel may stabilize and transport oiled animals to a treatment area. Once oiled animals arrive at the treatment area, additional personnel maintain records on the animals, clean pens, and prepare food for the animals. Qualified personnel with additional training may perform tasks such as administering fluids to dehydrated animals, take blood samples from animals, and wash oiled animals.

F.4. Training and Health and Safety

Worker health and safety are a priority during oiled wildlife response operations. The following is a summary of safety precautions to be considered in the development of the Wildlife Health, Safety and Environmental Plan. Additional safety plans may need to be written for operation of specialized equipment (such as propane cannons, etc.).

- Be proficient with Safety Data Sheets;
- Recognize the most common hazards are slips, trips, and falls;
- Maintain necessary immunizations, including tetanus and hepatitis;
- Observe all industrial hygiene safety precautions stated in the Safety Plan;
- Ensure proper training regarding hazards of the work task, and the proper use of personal protective equipment (PPE);
- ALWAYS work in teams; never conduct wildlife rescue work alone;
- Don’t overwork;
- Keep animals at or below one’s waist level to protect the face and eyes from pokes, bites, and scratches;
- Wear approved PPE, and always remove PPE and wash hands and face with soap and water or approved cleaners before eating, drinking, or smoking;
- Never eat, drink, or smoke in wildlife handling areas;
- Minimise contact with contaminated materials and inhalation of vapours even when wearing PPE;
- Keep all oil, cleaning compounds, and contaminated materials away from face, eyes, and skin;
- Ensure work areas are clean and well ventilated;
- Report all injuries and illnesses to the supervisor and/or Command Centre medical staff;

- Do not work with oiled wildlife if you are ill, pregnant, have an immunosuppressive condition, or are taking medication that might affect your natural immunity.

Reference the ExxonMobil Oil Spill Response Field Manual, Section 13 Oiled Wildlife Response

F.4.1. Training for Wildlife Response Personnel

In addition to being trained in specific wildlife response tasks, wildlife response specialist personnel will be trained to recognize and prevent oil-related and physical hazards associated with wildlife response operations. Complete training will be given to a core group of specialists prior to participation in oiled wildlife response activities. Due to health and safety concerns associated with physically handling affected or injured wildlife, the majority of volunteers supporting wildlife response would be utilized in supportive roles not directly related to the cleaning of wildlife after receiving the required training, orientations, and deployment of Personal Protective Equipment (PPE).

F.4.2. Personal Protective Equipment (PPE)

To prevent exposure to oil and injury from wildlife, workers should wear approved PPE appropriate to their task. The following is a list of recommended PPE:

- Full eye protection (goggles or safety glasses) – eye protection is required when handling animals, especially birds. Birds will peck when under stress and should be considered dangerous as they will aim for eyes;
- Oil resistant rain gear or oil protective clothing (coated Tyvek, Saranex, etc.);
- Gloves (neoprene or nitrile rubber) that are oil resistant and waterproof and provide protection against beaks and claws;
- Non-skid shoes / boots, which are oil resistant and waterproof;
- Duct tape, used to tape rain jacket sleeves to gloves and rain pants to boots;
- Ear protection (muff or ear plug type) during deterrent operations, if appropriate;
- Respiratory protection, if appropriate.

In addition, the following PPE are recommended:

- Long-sleeved shirts;
- Hat (to provide shade in hot weather);
- Change of clothes (to rest or leave in);
- Clean towel / toiletries;
- No jewelry (birds will peck at bright, shiny objects).

Clothing and equipment to protect against bites and scratches should be worn underneath the oil protective equipment whenever necessary. Respiratory protection from organic vapor hazards may be required for some operations. If respirators are used, respirator training and fit testing are required. Workers will be trained in the proper use and limitations of all PPE prior to using the equipment.

F.4.3. Worker Safety

Worker safety is the primary consideration in wildlife handling. Handling and restraint techniques appropriate for specific species need to be applied by trained and experienced personnel.

Oiled wildlife response is often physically and emotionally stressful. Dehydration, exhaustion, and poor nutrition can affect a person's ability to assess and react to a dangerous situation. It is therefore important workers stay well hydrated and eat nutritionally sound meals. Rest is equally important. The safety of all depends on the alertness of each individual.

In addition to hazards from oil, numerous physical hazards may be associated with wildlife response activities. Workers should be aware of changing weather conditions, strong undertows in tidal areas, slick surfaces along shorelines. Personal flotation devices should be worn for all on-water and in-water operations.

F.4.4. Zoonosis

Wildlife may carry diseases that are transmissible to people. Diseases transmitted from animals to humans are called zoonoses; they may be viral, bacterial, fungal, or parasitic. **Individuals who have immunosuppressive conditions are more susceptible to contracting zoonotic diseases.**

Zoonoses can be transmitted to humans by:

- Inhalation of particles (spores, bacteria) in the air;
- Ingestion of feces (i.e., projectile feces, poor hygiene, etc.);
- Contact with the skin.

To reduce risk of contracting a zoonotic disease, wildlife handlers should always:

- Wash hands thoroughly with soap and water after handling wildlife;
- Wash hands well before and after eating or smoking;
- Smoke, drink, or eat in designated areas only and not near wildlife;
- Clean and treat all cuts and scratches;
- Use gloves as much as possible;
- Use surgical masks as appropriate.

In addition, there is a potential health risk to poultry, farm, and domestic animals (including pets) from clothing or equipment in contact with wildlife. Return used oil spill response equipment and supplies for proper decontamination or disposal. Thoroughly wash, and disinfect as appropriate, all personal items after completing wildlife response tasks for the day.

F.5. Wildlife Deterrence (Hazing)

F.5.1. Introduction

The primary strategy for wildlife protection is controlling the spread of spilled oil to prevent or reduce oil contamination of potentially affected species and habitats. Removal of oiled debris and contaminated food sources also protects wildlife. Another method of wildlife protection is deterrence or hazing. Hazing is the term used when a variety of deterrents are used to prevent wildlife from entering areas already oiled or areas that are in the projected pathway of the oil. Hazing should be carefully planned and executed, since hazed wildlife could move into other oiled areas.

Common hazing techniques include:

- Making noise with pyrotechnics, firearms, air horns, motorized equipment, or recorded bird alarm sounds;
- Using scare devices such as Mylar tape, helium-filled balloons, scarecrows, predator effigies in oiled areas;
- Herding wildlife using aircraft, boats, all-terrain vehicles, unmanned aerial vehicles (UAVs), or other vehicles; and
- Hazing by human presence.

Information necessary to help determine whether or not to begin hazing operations include time of year, availability of nearby uncontaminated habitat, proximity of nesting colonies and location of species in relation to the spill. The decision tree for hazing is presented in Figure F-1. Once the decision to haze is made, review the hazing plan with the Operations Section Chief, Incident Commander, and other appropriate authorities and obtain all necessary approvals, and permits (if required). Initiate deterrence activities as soon as possible. Whether or not a deterrent operation will be effective depends on the habitat, season, species, and their residency status and age. Deterrent effectiveness can decrease for birds occupying key habitat areas (established nesting colonies, important foraging areas) or during moulting season.

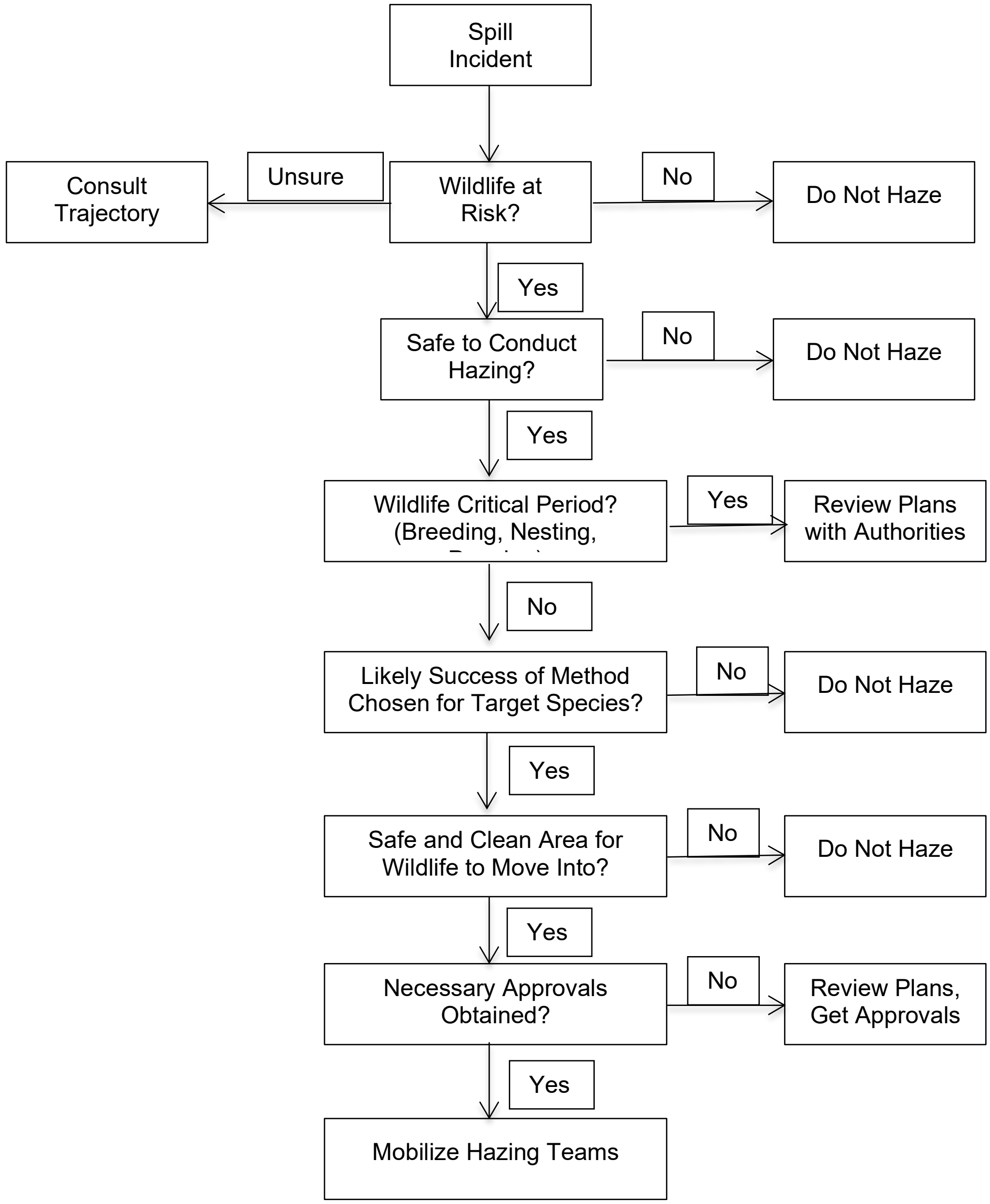


Figure F-2: Wildlife Deterrence Hazing Decision Tree

The potential effects of human activity and disturbance on sensitive habitats should be considered prior to starting a hazing operation. For example, take care not to trample fragile vegetation by foot traffic or off-road vehicles. If pyrotechnics or gas operated cannons are used, take care to prevent igniting vegetation. Wakes from boat operations should not push floating oil further into wetlands or mangroves. If in the nesting season, consider the potential effects of hazing on bird reproduction. Young birds are more susceptible to predation if they become separated from their parents.

Each spill situation will be unique and pre-planned deterrence activities are considered tentative. Consultation with local experts is advisable. Regulations should be followed regarding the purchase, possession, and discharge of firearms or explosives, including shotgun and pistol-launched pyrotechnics.

No attempt should be made to haze oiled wildlife. Depending on the extent of oiling, wildlife already oiled may need to be captured and cleaned. Hazing is most effective if the area of concern can be hazed as continuously as possible. Avoid hazing in areas with oiled habitat or adjacent to oiled habitats where hazed wildlife could become contaminated with oil.

Habituation is the gradual decrease in response to a deterrence method due to increased familiarity and acceptance. Habituation can be minimised by using a combination of hazing methods and frequently changing the type, timing, and location of the hazing devices. It is recommended that human patrols be incorporated in hazing operations. Moulting birds are not easily deterred and require a combination of different techniques.

Hazing is not generally recommended for marine mammals. Before hazing is being considered for marine mammals (whales, dolphins, seals, otters, manatees), consult the appropriate regulatory authorities and marine mammal experts. There are no established methods or data for hazing whales and dolphins.

F.5.2. Deterrence Methods and Equipment

Deterrent operations should include both visual and auditory techniques. Some petroleum products are highly flammable during the first few hours after a spill, due to high concentrations of volatile oil fractions. Techniques with potential to induce sparks should be avoided in these situations. The effects of sound emitting devices on humans, in terms or irritation and noise, especially at night, will influence whether or not some hazing methods will be acceptable. All appropriate approvals will be received prior to conducting any activities.

Gas-Operated Cannons

Gas-operated cannons should only be used by trained personnel. The cannons produce a loud shotgun-like noise when discharged. Blasts are emitted at adjustable time intervals from less than one minute to as much as 30 minutes. If multiple cannons are used in an area, stagger the firing intervals. Cannons should be elevated at a 45-degree angle and preferably aimed downwind to increase effectiveness. Propane cannons are more effective for migrating and hunted species that associate danger with loud noises.

Pyrotechnics

Pyrotechnic devices disturb wildlife by producing a whistling noise, explosion, and/or flash of light. Types include shotgun-launched projectiles (crackers), fireworks, and a variety of pistol-launched projectiles. Pyrotechnic devices are potentially dangerous and should only be used by trained personnel. Safety goggles and ear protection should be worn by operators. When using these devices, care must be taken not to ignite spilled oil or vegetation.

Aircraft

Aircraft are often effective for deterring birds and terrestrial mammals because of the combination of loud noise and rapid approach from above. Because of their maneuverability and noise, helicopters are probably more effective than fixed-wing aircraft.

Unmanned Aerial Vehicles

UAVs operate similarly to manned aircraft but may be able to operate at lower altitudes. Typically, they operate in conjunction with ground or boat-based personnel. UAVs can be used to scare off birds in flight. UAVs should be operated by trained personnel and must be approved by the Aviation Branch and appropriate government authorities.

Boats

Air boats or boats propelled by outboard motors can be used to haze wildlife and marine mammals. Small, noisy, shallow draft boats have been reported to be particularly effective. Boats can be used in combination with other hazing methods (i.e., UAVs, pyrotechnics).

All-Terrain Vehicles

All-terrain vehicles are moderately effective for hazing many species of wildlife. Human presence reinforces the effects of the noise and rapid movement of the vehicle.

Air Horns

Air horns can be used to deter wildlife. Since habituation may be rapid, it is recommended that air horns be used in combination with other deterrent methods or devices.

Electronic Sound Generators

Sound generators broadcast loud, intermittent electronically synthesized sounds. The units can be adjusted to the most effective range of sound patterns for the target species. Sound generators can be positioned on land, mounted on boats, or housed within floats in water. When a sound generator is deployed within a drifting slick, the potential of scaring birds directly into the oil-contaminated water is reduced.

Balloons

All-weather helium balloons are considered effective if frequently refilled and moved. They can be suspended from land or from floating objects in water (e.g., spill booms). They should not be located near trees or other objects that could cause puncturing.

Human Effigies and Predator Models

Human effigies (scarecrows) and raptor models may be effective if they appear lifelike, have motion, are moved frequently, and are used in combination with loud sounds or recorded distress calls.

Additional hazing techniques are available. The recommendation to haze will be guided by site-specific and species-specific factors present at the time of the spill, and availability of proven hazing techniques.

F.6. Capture and Transport of Oiled Wildlife

F.6.1. Objective

The sooner oiled wildlife can be captured and treated the better their chances for survival. It is helpful to plot and number oiled wildlife on maps and charts to identify search and recovery patterns. Reconnaissance surveys for oiled wildlife may occur in offshore and near-shore waters, shorelines in oiled areas, in addition to areas that could potentially be oiled. Reconnaissance surveys may also be conducted at nearby feeding and nesting areas to detect oiled wildlife that may have moved away from oiled areas. The objectives of a reconnaissance survey are to: (1) evaluate the number, species, and locations of wildlife potentially affected by an oil spill; and (2) determine the feasibility to rescue oiled wildlife.

Local experts can provide information regarding special site considerations (i.e., nesting grounds, cultural or historic sites) and oiled species prioritization for capture. An effort should be made to avoid capturing birds, or other animals, not impacted by the spill, unless otherwise authorised.

Wildlife capture operations should only be conducted when weather conditions permit. Captured wildlife may be aggressive and should be regarded as potentially dangerous. Only trained individuals should undertake the capture and treatment of oiled wildlife.

F.6.2. Capture

A capture team consists of two or more individuals wearing appropriate protective clothing. Capture strategies should be discussed before any attempt to capture oiled wildlife. Safety of individuals is not to be compromised for the objective of capture.

A variety of methods can be used to capture wildlife:

- Dip nets, throw nets, or mist nets can be used for small birds and mammals;
- Seine nets and net guns can be used for larger birds or turtles; and
- Capture poles can be used.

Oiled birds can be approached using boats, but it is best to allow them to reach the shore if possible. Oiled wildlife should be approached carefully so as not to further stress the animal.

Appropriate handling techniques are based on the size and species of the animal. Field personnel should be properly trained before attempting to handle oiled wildlife.

Dead wildlife should be collected to prevent other wildlife from becoming oiled as they attempt to eat the carcasses. Each carcass should be labelled, numbered, and documented on the appropriate form.

F.6.3. Transport

Oiled wildlife should be transported in well-ventilated containers of sufficient size for the species captured. Some species may be placed two or three to a container. Containers should be placed in an area separate from the operator of the transport vehicle to protect the operator from inhaling vapours. Temperature should be maintained at an adequate level to prevent hypothermia or overheating.

F.7. Stabilization, Rehabilitation, and Husbandry

F.7.1. Introduction

If an oiled animal is hypothermic, dehydrated, sick, or injured, it may not survive the stress of being washed. Stabilization increases an oiled animal's chances for a successful rehabilitation and release.

F.7.2. Stabilization

A stabilization centre will serve as a collection site for all oiled wildlife collected by the wildlife search teams. A field stabilization group will provide initial care in the field prior to transportation to the rehabilitation facility. Stabilization can include warming or cooling of oiled animals to stabilize body temperature, preliminary examinations and initial cleaning, and providing fluids and nutrition.

F.7.3. Rehabilitation

A suitable facility must have a large open space easily reconfigurable to accommodate the changing needs of the wildlife rehabilitation process. Contracted wildlife specialists and/or agency representatives should be consulted regarding facility requirements for optimum rehabilitation.

The following are equipment and facility considerations:

- Location with respect to location of spill;
- Anticipated number of animals;
- Types and numbers of species;
- Season / weather;
- Hot- and cold-water capacity;
- Electric and lighting;
- HVAC systems (good air handling necessary);
- Communications;
- Noise control;
- Waste management issues (collection and storage); and
- Appropriate holding pens (species dependent).

Each wildlife rehabilitation facility should have a Site Safety Plan in place prior to start-up. The Site Safety Plan should include checklists for measures to avoid physical, chemical, and biological hazards, safe animal handling procedures, and other emergency procedures and contact numbers.

Buildings of Opportunity

It may be possible to secure an appropriate building for oiled wildlife rehabilitation that is normally used for some other purpose but can be quickly transformed into a suitable facility. Examples may include warehouses, community centres, etc. To utilize this option will require considerable planning and contracts with building owners, suppliers and tradesmen to ensure that the facility can be up and running within hours when needed, and is able to provide the required space, water, heating and ventilation necessary to meet the goals of the wildlife plan (IPIECA 2014).

Mobile Facilities

Mobile facilities are comprised of modules (trailers, containers, tents, etc.) that can be easily transported and set up wherever they are needed. Infrastructure needs may vary, and potential settings could, for example, range from a large warehouse space with water and utilities to a level field or the deck of a barge or large ship. Such facilities may be used for field operations or all phases of rehabilitation. A wide variety of examples of mobile units exist that are intended for use as specific components or as a complete oiled wildlife rehabilitation facility (IPIECA 2014).

F.8. Wildlife Release Considerations

The goal in rehabilitating oiled wildlife is the release of healthy animals back into their natural environment. Release of rehabilitated wildlife requires planning in advance. Consultation with local wildlife experts, government agencies, and Incident Command is necessary to determine appropriate release sites and disposition of animals that cannot be released. Timely release is important to prevent or reduce occurrence of secondary problems associated with captivity. For wildlife that cannot be released, the options are euthanasia or placement in a long-term facility.

To be released, wildlife must exhibit:

- Normal behaviour;
- Normal body weight;
- Waterproof (particularly in seabirds);
- Normal blood values and physical exam; and
- Normal feeding.

Release sites should:

- Be free of oil contamination and not at risk of re-contamination;
- Same general geographic area or habitat of capture;
- Minimal human disturbance;

- Appropriate seasonal range for species (important for long rehabilitations); and
- Safe for response personnel.

If post-release monitoring is necessary, wildlife should be tagged or banded prior to release to aid visual observation.

F.9. Record Keeping

Record keeping is an important part of a wildlife rehabilitation program. Records are essential for evaluating the effectiveness of treatments and whether the rehabilitation efforts were successful. In addition, records are used to determine a spill's impact on wildlife. Records are usually divided into the following types:

- Field Survey and Wildlife Collection:
  - Document species collected, numbers, condition, location, etc.;
- Chain-of-Custody:

F.9.1. Used to track transport and transfer of all collected animals;

- Admission and Examination:
  - Record of admission to rehab centre, initial assessments, etc.;
- Treatment:
  - Tracks treatment of individual animals, feeding, behaviour, etc.;
- Necropsy:
  - For use by veterinarian for determining cause of death.

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Attachment F-1: Habitats

The following are designed to be a primer for those who are unfamiliar with the natural resources of Guyana and should serve as a guide only.

Coastal and Marine Habitats

Several habitat types are present in the network of plains and low hills that comprise Guyana's coast, including mangroves, salt to brackish lagoons, brackish herbaceous swamps, swamp woods and swamp forests. The swamps are an important source of freshwater to mangroves and other flora and fauna. The coastal mangroves are vital to Guyana's biodiversity, physical security, and economy. Guyana has relatively few beaches, but the Shell Beach Protected Area (SBPA) beaches are critically important nesting habitats for marine turtles.

Guyana's continental shelf occupies an area of 48,665 square kilometres. The average width of the continental shelf is 112.6 kilometres (NDS 1997). The shelf is widest near the Suriname and Venezuela borders, and slightly narrower near the centre, north of Georgetown. The entire continental shelf, continental slope, and the adjoining portion of the abyssal plain are part of the North Brazil Large Marine Ecosystem (LME). The North Brazil LME is an oceanic habitat unit that extends from the Caribbean Sea south to the Parnaiba River in Brazil. The seagrass and shallow coral reefs that are characteristic of coastal tropical Atlantic environments elsewhere do not occur in Guyana, mainly due to high turbidity along the coast, although some low encrusting coral species (so-called "deepwater" or "cold-water" corals) do occur further offshore (ERM 2016). The substrate is generally composed almost entirely of mud and silt deposited by the North Brazil Current.

Mangroves

Mangroves are important ecosystems to security of the biodiversity of the entire Guiana Shield region. They occupy over 81,000 hectares of Guyana's coast but the distribution of mangroves along the coast is highly dynamic, and subject to rapid change. Six of Guyana's ten geopolitical regions have mangroves but approximately 75 percent of the country's mangroves are concentrated in the Barima-Waini and Pomeroon-Supenaam regions.

There are currently three species of mangrove in Guyana: *Rhizophora mangle* (Red mangrove), *Avicennia germinans* (Black mangrove), and *Laguncularia racemosa* (White mangrove). Many invertebrates live either on or in close proximity to mangrove roots and substrate and include snails, barnacles, tunicates, mollusks, polychaete worms, oligochaete worms, small shrimps and crabs, sponges, jellyfishes, amphipods and isopods. These small organisms provide forage for birds, mammals, reptiles, amphibians, fish, and other larger crustaceans.

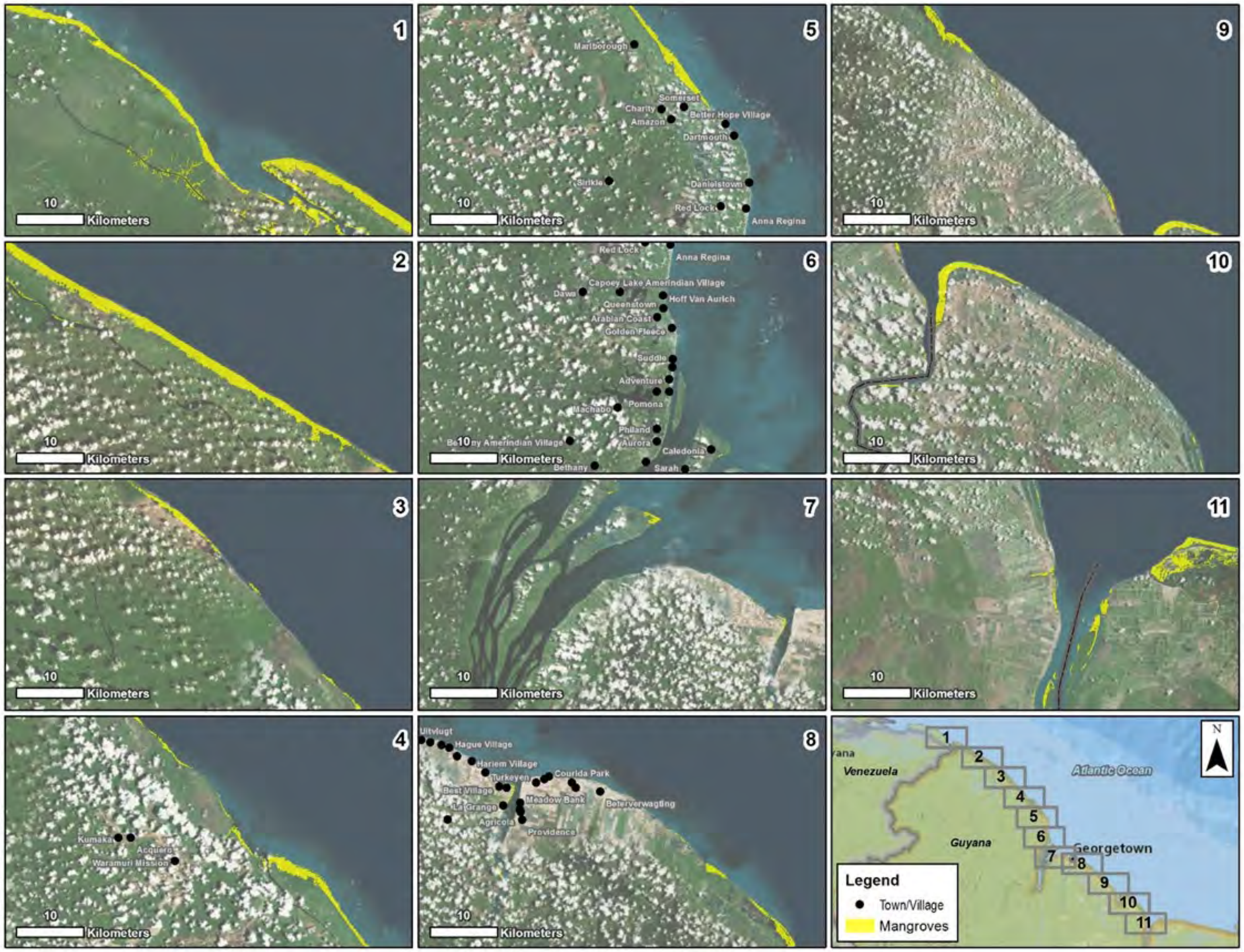


Figure F-1-1: Guyana's Coastal Mangrove Distribution

Mud Banks

The 1,500-kilometre -long coast of South America between the Amazon and Orinoco River mouths is the world's muddiest coastline. Mud banks extend approximately 20 to 460 kilometres offshore to an average thickness of 20 metres and are located seaward of the mangrove swamps that fringe much of the coastline. The mud banks are rich in invertebrate fauna, including plankton and micro-plankton assemblages, algae mats (diatoms), and benthic communities of Nematodes (worms), Tanaidacea (crustaceans), and Foraminifera (*amoeboid protists*). These small organisms provide habitat for fish species, post-larval and juvenile shrimps, and crabs, and numerous resident and migratory shore birds.

Shell Beach

SBPA is a protected area on Guyana's coast that could potentially be impacted by a marine oil spill. It accounts for 200,000 hectares or approximately 11 percent of Guyana's total protected areas. Figure F-1-2 provides a detailed map of SBPA and the surrounding area. It is located in northwestern Guyana and extends for almost 140 kilometres between the Waini, Baramani, and Moruka rivers and the Atlantic Ocean. Shell Beach is a dynamic area and constantly changes due to the competing effects of erosion and deposition along the shorefront. Seventy percent of the area is forested; the rest is made up of mostly swamp (28.8 percent), and sandy beaches (1.2 percent). Shell Beach supports numerous species of plants including coconut, papaya, and palm trees.

Shell Beach is not the only portion of Guyana's coast that contains mangroves; mangroves are a prominent feature along much of northwest Guyana's coastline. They are ecologically important and are a critical natural component of Guyana's coastal defence network, protecting the low-lying inland areas of the coast from sea-level rise and saltwater intrusion during storm events.

Shell Beach is best known as a marine turtle nesting site. The composition of the substrate at Shell Beach, its geographical location, and the low human impact makes it an ideal nesting site for marine turtles. Most nesting beaches in Guyana are used by only one or two species of sea turtle but four species of sea turtle (Leatherback, Hawksbill, Olive Ridley, and Green Turtle) found in Guyana nest at Shell Beach (Pritchard 2001).

In addition to the sea turtles there are also at least four other species of turtles present within the protected area including the yellow-footed tortoise (*Geochelone denticulate*), scorpion mud turtle (*Kinosternon scorpioides*), giant river turtle (*Podocnemis expansa*), and mata (*Chelus fimbriata*).

Shell Beach is also known for its diverse and abundant bird population. Two biodiversity surveys undertaken within SBPA over roughly the past decade documented over 200 bird species in the Shell Beach area, including many forest interior species that occur in the inland habitats of Shell Beach (Mendonca et al. 2006; EPA et al. 2004). Many of the over 200 species documented are migrants. The most abundant coastal species recorded at and around Shell Beach during the two surveys included Black-bellied Whistling-duck (*Dendrocyna autumnalis*), Laughing Gull (*Larus atricilla*), Least Tern (*Sterna antillarum*), Spotted Sandpiper (*Actitis macularius*), Lesser

Yellowlegs (*Tringa flavipes*), Scarlet Ibis (*Eudocimus ruber*), and Yellow-billed Tern (*Sterna superciliaris*) (Mendonca et al. 2006; EPA et al. 2004).

The Shell Beach area is also home to several species of mammals, including howler monkeys (*Alouatta* spp.), jaguars (*Panthera* spp.), and manatees (*Trichechus* sp.) (ERM 2016). Amerindian groups also inhabit the Shell Beach area and are concentrated along the areas of Almond Beach, Father's Beach, and Assakata (ERM 2016).

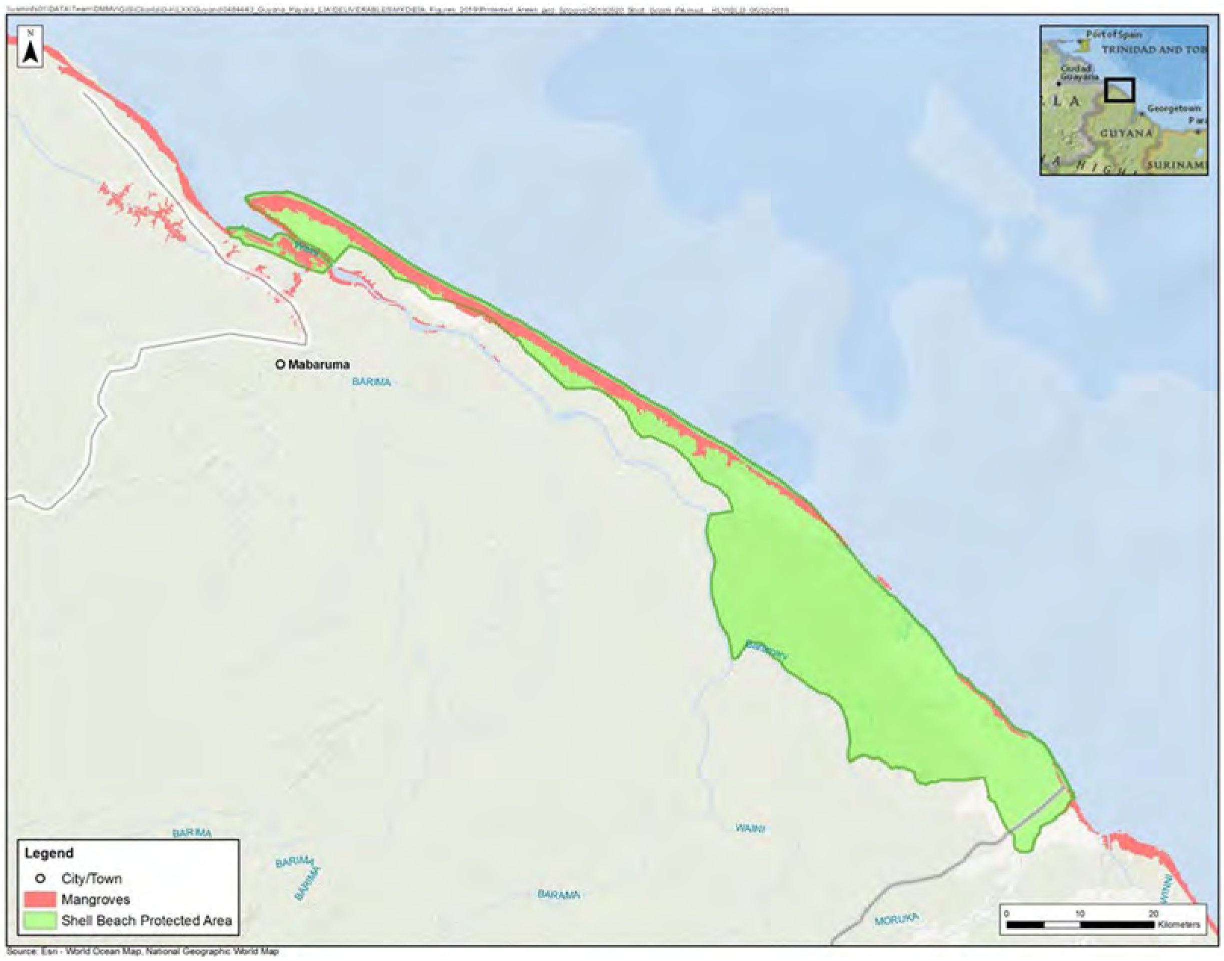


Figure F-1-2: Shell Beach Protected Area

Attachment F-2: Bird Species

Over 800 species of birds occur in Guyana, of which over 200 occur in coastal and/or offshore marine habitats for at least part of their life cycle. The bird groups most strongly affiliated with the coast are waterfowl, shorebirds, and colonial waterbirds.

- Waterfowl are species of birds that are ecologically dependent upon wetlands or waterbodies for their survival (e.g., ducks, geese, etc.).
- Shorebirds are found mainly on beaches and mudflats between the low and high-water marks and are typically migratory, utilizing Guyana's coastline during the course of their bi-annual migrations.
- Colonial waterbirds are birds that live near water and nest in colonies or groups (e.g., gulls, terns, ibis, herons, etc.).

Oceanic species (seabirds) such as frigatebirds and jaegers spend most of their time at sea and are less common along the coast. Thirty-five species of seabirds are known to occur in Guyana (see Table F-2-1).

Table F-2-1: Seabird Species Known to Occur in Guyana

Common Name	Scientific Name
Great Shearwater [a, b]	*Ardenna gravis*
Cory's Shearwater [a]	*Calonectris borealis*
Barolo Shearwater [c]	*Puffinus baroli*
Audubon's Shearwater [a, b]	*Puffinus lherminieri*
Wilson's Storm-Petrel [a, b]	*Oceanites oceanicus*
Leach's Storm-Petrel [a, b]	*Oceanodrama leucorhoa*
Brown Pelican [a, b]	*Pelecanus occidentalis*
Brown Booby [a, b, c]	*Sula leucogaster*
Masked Booby [c]	*Sula dactylatra*
Red-footed Booby [c]	*Sula sula*
Magnificent Frigatebird [a, b, c]	*Fregata magnificens*
White-tailed Tropicbird [c]	*Phaethon lepturus*
Parasitic Jaeger [b, c, d]	*Stercorarius parasiticus*
Pomarine Jaeger [a, b, c]	*Stercorarius pomarinus*
Great Skua [a, b]	*Stercorarius skua*
Lesser Black-backed Gull [c, d]	*Larus fuscus*
Laughing Gull [a, b, c]	*Leucophaeus atricilla*
Brown Noddy [a, c]	*Anous stolidus*
Black Tern [b, c, d]	*Chlidonias niger*

Common Name	Scientific Name
Gull-billed Tern [a, c]	*Gelochelidon nilotica*
Bridled Tern [c]	*Onychoprion anaethetus*
Sooty Tern [a]	*Onychoprion fuscatus*
Black Skimmer [a, c]	*Rynchops niger*
Roseate Tern [a, c]	*Sterna dougalli*
Common Tern [a, b, c]	*Sterna hirundo*
Royal Tern [a, b, c]	*Thalasseus maximus*
Arctic Tern [c]	*Sterna paradisaea*
Sandwich Tern [c, d]	*Thalasseus sandvicensis*
Bridled Tern[e]	*Onychoprion anaethetus*
Manx Shearwater[e]	*Puffinus puffinus*
Red-billed Tropicbird[e]	*Phaethon aethereus*
Bulwer's Petrel[e]	*Bulweria bulwerii*
Band-rumped Storm Petrel[e]	*Oceanodroma castro*
Long-tailed Jaeger[e]	*Stercorarius longicaudus*
Great Black-backed Gull[e]	*Larus marinus*

[a] Braun et al. 2007
[b] BirdLife International 2019a
[c] eBird 2019a
[d] Sight record only (Braun et al. 2007)
[e] Recorded during EMGL-commissioned marine bird surveys 2017-2019

Coastal habitats of Guyana provide ideal conditions for coastal birds, with mangrove forests providing shelter and nesting areas, mudflats providing important foraging sites, sandy beaches providing nesting habitat, and shallow water habitats providing foraging.

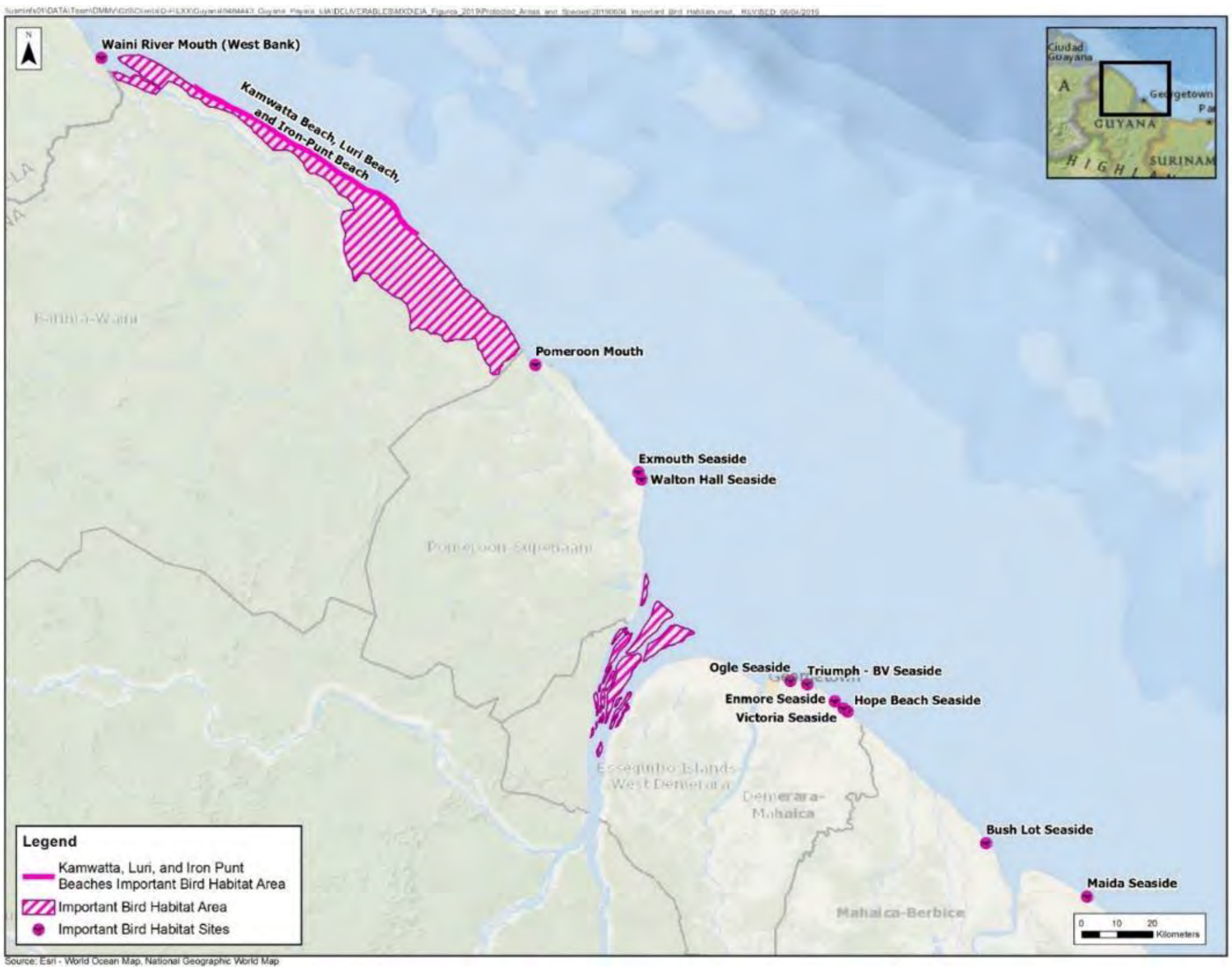
Many of Guyana's coastal bird species are migratory and so occur in Guyana on a seasonal basis, either spending the October–March (winter) season there or migrating through on their bi-annual northward and southward migrations. Guyana's coastal mangroves are noted for being wintering grounds for migratory birds including austral and Nearctic migratory species. Austral migrants breed in temperate South America during the Jun–Nov season but spend the remainder of the year away from their breeding grounds in the tropics. Nearctic migrants migrate in the other direction, breeding in North America during the Jun–Nov season and overwintering in tropical South America. There are many more Nearctic migrants than austral migrants (globally and in Guyana) but both groups spend the non-breeding/wintering season (spanning the months from October through March) in Guyana.

EMGL commissioned a series of seasonal coastal bird surveys along the Guyana coast (Regions 1 through 6) between 2017 and 2019. These surveys documented 230 species of birds along the coast, including 21 species of migratory shorebirds (*Charadriidae* and *Scolopacidae* families). The most common shorebirds observed were Semipalmated Sandpiper

(*Calidris pusilla*), White-rumped Sandpiper (*Calidris fuscicollis*), Lesser Yellowlegs, Sanderling (*Calidris alba*), and Greater Yellowlegs (*Tringa melanoleuca*). The most common colonial waterbirds were Snowy Egret (*Egretta thula*), Great Egret (*Ardea alba*), Little Blue Heron (*Egretta caerulea*), Scarlet Ibis, and Tricolored Heron (*Egretta tricolor*).

Important Bird Habitats – Coastal Sites

Fourteen coastal Important Bird Habitat (IBH) sites were identified within Regions 1 to 6 (Figure F-2-1). These IBH sites support one or more of the following: (1) predictable congregations of migratory shorebirds; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species or special status species.



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

Figure F-2-1: Locations of Important Bird Habitats – Regions 1-6

Important Bird Areas – Offshore Sites (outside of the Stabroek Area of Operation)

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 2019b). No Marine IBAs have been identified in Guyana, but five Marine IBAs of global or regional importance to seabirds have been designated in neighboring and nearby countries that have reasonable potential, based on documented species life histories and foraging distances, to support seabirds that transit the Stabroek Block during local and regional movements to and from their breeding sites or during offshore foraging trips. Table F-2-2 summarizes information on the five IBAs and Figure F-2-2 depicts the location of these IBAs relative to the Stabroek Block.

Table F-2-2: Marine IBAs with Importance to Seabirds that Transit the Stabroek Block

Important Bird Area Name	Country	IBA Attributes [a]
Little Tobago Island	Trinidad and Tobago	This IBA supports globally important breeding populations of Red-billed Tropicbird (*Phaethon aethereus*) and Laughing Gull (*Leucophaeus atricilla*), and regionally important breeding populations of Audubon's Shearwater (*Puffinus lherminieri*), Brown Booby (*Sula leucogaster*), Red-footed Booby (*Sula sula*), and Bridled Tern (*Onychoprion anaethetus*). Seabird population estimated at over 2,000 breeding pairs.
St. Giles Islands	Trinidad and Tobago	This IBA supports globally important breeding populations of Red-billed Tropicbird and regionally important breeding populations of Audubon's Shearwater, Magnificent Frigatebird (*Fregata magnificens*), Masked Booby (*Sula dactylatra*), and Red-footed Booby. Other seabird species including Brown Booby and Brown Noddy (*Anous stolidus*) also breed there. Total seabird population estimated at over 2,000 individuals.
All Awash Island	St. Vincent and the Grenadines	This IBA supports regionally significant breeding populations of several seabird species, most notably a large breeding population of Roseate Tern (*Sterna dougalli*) (~475 pairs). During the non-nesting period, hundreds to thousands of seabirds forage in surrounding waters and use the island for roosting.
Battowia Island	St. Vincent and the Grenadines	This IBA supports regionally significant populations of roosting and breeding seabirds (>5,000 pairs), including Magnificent Frigatebird, Red-footed Booby, Brown Booby, and Laughing Gull.
Petit Canouan Island	St. Vincent and the Grenadines	This IBA supports regionally significant populations of breeding seabirds (>2,200 pairs) including Sooty Tern (*Onychoprion fuscatus*), Brown Booby, Laughing Gull, Magnificent Frigatebird, Roseate Tern, Royal Tern (*Sterna maxima*), and Brown Noddy.

[a] Sources: BirdLife International 2019a, 2019b

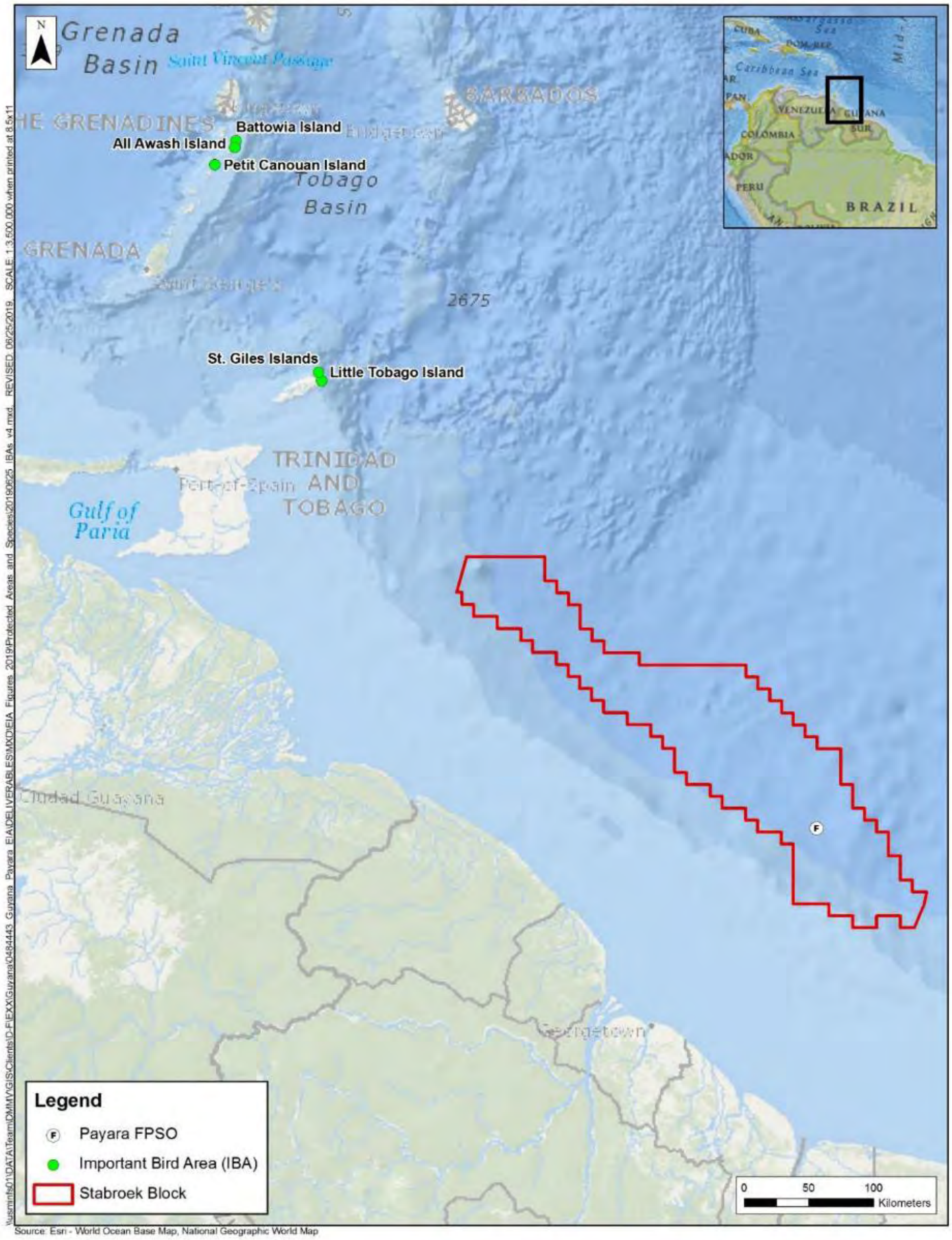


Figure F-2-2: IBAs with Importance to Seabirds Relative to Stabroek Block

Attachment F-3: Marine Mammals

The equatorial waters of Guyana are home to numerous species of marine mammals. The acoustic and visual monitoring that EMGL has conducted since 2015 represents the most robust dataset developed for marine mammals offshore Guyana, but regional studies and bycatch reports provide additional insight into the composition and distribution of the marine mammal community in the vicinity of the Project. There are 31 species of marine mammals, including coastal and offshore marine mammal species, whose distributions overlap with Guyana's Exclusive Economic Zone. Table F-3-1 lists these species and denotes whether they have been observed during EMGL survey activities conducted offshore Guyana and between the Guyana coast and the Stabroek Block since 2015.

Data collected during EMGL activities since 2015 document that dolphins are more common than large whales offshore. Sperm whales were the most common large whale species observed offshore Guyana, accounting for more than 25 percent of the total number of marine mammal detections that could be verified to the species level since 2015. Pantropical spotted dolphin (*Stenella attenuata*), common bottlenose dolphin (*Tursiops truncates)*, spinner dolphin (*Stenella longirostris*), clymene dolphin (*Stenella clymene),* and Bryde's whale (*Balaenoptera brydei*) are the other most common species verified to the species level and together they represent over 80 percent of the observations that produced a confirmed detection of a particular species. Consistent with the EMGL data, information published in 2015 from a survey carried out in 2012 in nearby Surinamese waters indicate that toothed whales (including dolphins, porpoises, pilot whales, and sperm whales) are more common offshore of Suriname than the baleen whales (including Bryde's and sei whales) (de Boer 2015).

Marine mammals are vulnerable to oil contamination in a variety of ways, including mortality. Marine mammals may be exposed to oil through inhalation, ingestion, and dermal pathways. Oil contamination can occur when a mammal surfaces to breathe or breach in an area with oil. Exposure to oil may harm their respiratory tissue and eyes and increase their susceptibility to infections. The risk to marine mammals would be greatest close to the spill location, where there is a higher proportion of volatile compounds still present in and around the surface slick.

Marine mammals not directly impacted from a spill may also be impacted indirectly through food-chain related impacts, as their food resources may also be impacted. Baleen whales and the smaller toothed whales (dolphins and porpoises) that feed on small prey near the surface may be disproportionately affected because their prey will presumably be less able to avoid the negative effects of spilled oil than other species. By comparison, the medium to large cephalopods that constitute a major portion of the medium- to large-toothed whales' diets will be more able to avoid affected areas; therefore, the effects on these species would be expected to be comparatively minor.

Table F-3-1: Marine Mammals with Ranges that include Guyana's Coastal and Offshore Marine Territorial Waters

Common Name	Scientific Name
Sei whale	*Balaenoptera borealis* (EN)
Bryde's whale *	*Balaenoptera brydei*
Blue whale	*Balaenoptera musculus* (EN)
Fin whale	*Balaenoptera physalu* (EN)
Short beaked common dolphin *	*Delphinus delphis* (LC)
Long-beaked common dolphin *	*Delphinus capensis*
Minke whale	*Balaenoptera acutorostrata* (LC)
North Atlantic right whale	*Eubalaena glacialis* (EN)
Pygmy killer whale *	*Feresa attenuate*
Short-finned pilot whale *	*Globicephala macrorhynchus*
Rissos dolphin *	*Grampus griseus* (LC)
Boto	*Inia geoffrensis*
Pygmy sperm whale	*Kogia breviceps*
Dwarf sperm whale	*Kogia simus*
Frasers dolphin *	*Lagenodelphis hosei* (LC)
Humpback whale	*Megaptera novaeangliae* (LC)
Blainvilles beaked whale	*Mesoplodon densirostris*
Gervais beaked whale	*Mesoplodon europaeus*
Trues beaked whale	*Mesoplodon mirus*
Melon-headed whale *	*Peponocephala electra* (LC)
Sperm whale *	*Physeter macrocephalus* (VU)
False killer whale	*Pseudorca crassidens*
Tucuxi	*Sotalia fluviatilis*
Pantropical spotted dolphin *	*Stenella attenuate* (LC)
Clymene dolphin *	*Stenella clymene*
Striped dolphin	*Stenella coeruleoalba* (LC)
Rough-toothed dolphin *	*Steno bredanensis* (LC)
Spinner dolphin *	*Stenella longirostris*
Atlantic spotted dolphin *	*Stenella frontalis*
West Indian manatee	*Trichechus manatus*
Common bottlenose dolphin *	*Tursiops truncatus*

EN = Endangered; LC = Least Concerned; VU = Vulnerable
Note: species marked with an asterisk (*) were confirmed sighted during EMGL activities

Attachment F-4: Marine Reptiles

Five marine turtle species are found in Guyana and the surrounding region. Four marine turtles (green turtle [*Chelonia mydas*], leatherback turtle [*Dermochelys coriacea*], hawksbill turtle [*Eretmochelys imbricata*], and olive ridley turtle [*Lepidochelys olivacea*]) nest on Guyana's beaches (Table F-4-1). A fifth species, loggerhead turtle (*Caretta caretta*), also occurs offshore Guyana, but rarely come ashore to nest in Guyana. In addition to relying on sandy beaches for egg-laying, marine turtles rely on healthy coral reef, seagrass, and hard-bottom habitats for food and refuge. Based on available information, post-hatchlings and juvenile green turtles are reported to feed on prey found within sargassum mats (USFWS 2018), while the other marine turtle life stages are associated with clearer offshore waters or coral reef environments where they prey on a variety of items (Piniak and Eckert 2011).

According to available information, the primary marine turtle nesting site in Guyana is Shell Beach (e.g., Alvarez-Varas 2016). The exact locations of secondary nesting sites in Guyana change each year with coastal erosion, which either creates or destroys nesting areas, but they are generally distributed along the northwest coast between the Pomeroon River and the Waini River estuaries.

Table F-4-1: Marine Reptiles with Ranges that include Waters Offshore Guyana

Common Name	Scientific Name	Primary Nesting Location in Guyana
Green turtle	*Chelonia mydas*	Shell Beach
Leatherback turtle	*Dermochelys coriacea*	Shell Beach
Hawksbill turtle	*Eretmochelys imbricata*	Almond Beach
Olive Ridley turtle	*Lepidochelys olivacea*	Shell Beach
Loggerhead turtle	*Caretta caretta*	Rare

Leatherback and green turtles commonly nest on Guyana's beaches followed by olive ridley and hawksbill turtles, which nest infrequently. According to the centre for Rural Empowerment and the Environment, the primary nesting season for the leatherback, green, hawksbill, and olive ridley turtles in Guyana (Shell Beach) is February to August; nesting occurs at night (PAC 2014).

When not nesting or in the immediate pre- or post-nesting periods, adult marine turtles are highly pelagic and migratory, inhabiting offshore environments over vast areas. During the nesting season, most turtles remain relatively close to nesting beaches (Shillinger et al. 2010; Bond and James 2017) because they often return to nesting beaches multiple times to lay additional eggs (multiple clutches). Available data on immediate post-nesting movements of adult marine turtles in Guyana from satellite tracking studies indicate that leatherback and green turtles remained offshore of Shell Beach and in Guyana's territorial waters for several weeks after nesting before moving offshore (Sea Turtle Conservancy 2012). After nesting, marine turtles are highly migratory, making extensive trips to and from foraging areas.

Several aspects of marine turtle biology place them at particular risk across all of their life stages. Marine turtles nest on sandy beaches. If such beaches were to become oiled, the laid eggs may be contaminated from oil entering the nest or adult turtles picking up oil and depositing it in the nest as they cross the beach. The eggs are susceptible to oil through absorption, which can inhibit their development. Besides oiling of nests, newly hatched turtles can be exposed to oil after emerging from their nests and crossing an oiled beach on their way to the water. All life stages of marine turtles (hatchlings, juvenile, sub-adults, and adults) can be exposed to oil through inhalation, ingestion, and dermal contact with varying effects (USFWS 1982; Mitchelmore et al. 2017).

Several aspects of marine turtle behaviour compound their biological susceptibility to oil:

- Lack of avoidance behaviour – there is no evidence that marine turtles will avoid areas of oil contamination (NOAA 2010);
- Indiscriminate feeding – marine turtles have a habit of ingesting floating objects (NOAA 2010; Schuyler et al. 2012), which can include 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 (NOAA 2010). This risk will be greatest in areas where fresh oil is present that has high levels of aromatic compounds and volatiles directly above the slick.

Attachment F-5: Marine Finfish

Guyana's marine fish community inhabits a large and ecologically diverse marine area consisting of shallow, turbid, coastal waters as well as the deep, clear, open ocean. Various life stages of finfish use different habitats at different periods during their life cycle, which shows the ecological connectivity among the various marine environments (e.g., mangroves, estuaries, and offshore zones). Several species that occur in the inshore and offshore zones as adults are dependent on coastal mangroves and estuaries as juveniles, particularly drums, croakers, marine catfishes, and snappers. Catfishes are found in mangroves, estuaries, and oceanic waters as adults. A few species may be found in the ocean, but prefer mangrove estuaries, such as snook and tarpon (MOA 2013). Further offshore, near the interface of the turbid North Brazil Current with oceanic water, the fish community is more complex, consisting of pelagic, highly migratory species (tuna, 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 generally found across the continental shelf, but a few species are highly migratory, such as the mako shark.

A total of 31 fish species were recorded during EMGL-commissioned fish surveys conducted offshore Guyana within the continental shelf and deepwater environments in 2017 through 2019 (Table F-5-1). The survey data indicate that compared to the shallower environments of the continental shelf, Guyana's deepwater environment appears to have low fish abundance and species diversity. The surveys also documented the importance of the continental shelf as a nursery area for sharks.

On the continental shelf, sea catfishes, including gillbacker catfish (*Sciades parkeri*), curass (*Sciades proops*), highwaterman catfish (*Hypophthalmus edentatus*), and several croakers/seatrouts, including bangamary (*Macrodon ancylodon*), white bashaw (*Cynoscion acoupa*), and sea trout (*Cynoscion virescens*), were all prevalent at depths of 10 to 15 metres (approximately 33 to 49 feet). The snappers and grunts, represented chiefly by banded grunt (*Conodon nobilis*), Caesar grunt (*Haemulon carbonarium*), mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), and southern red snapper, occurred deeper, primarily between 45 and 60 metres (approximately 148 to 197 feet).

Table F-5-1: Fish Species Observed in the Stabroek Block and between the Stabroek Block and the Guyana Shore during EMGL-Commissioned PSO Activities Since 2015

Common Name	Scientific Name	IUCN Status [a]
Atlantic bonito	*Sarda sarda*	LC
Atlantic flying fish	*Chellopogon melanurus*	LC
Atlantic tripletail	*Lobotes surinamensis*	LC
bar jack	*Caranx ruber*	LC
blackfin tuna	*Thunnus atlanticus*	LC
blackwing flying fish	*Hirundichthys rondeletii*	LC
blue marlin	*Makaira nigricans*	VU

Common Name	Scientific Name	IUCN Status [a]
clearwing flying fish	*Cypselurus comatus*	LC
Eelpout	*Lycodonus sp.*	–
four-wing flying fish	*Hirundichthys affinis*	LC
jack crevalle	*Caranx hippos*	LC
king mackerel	*Scomberomorus cavalla*	LC
largehead hairtail	*Trichiurus lepturus*	LC
little tunny	*Euthynnus alletteratus*	LC
dolphinfish/mahi-mahi	*Coryphaena hippurus*	LC
manta ray	*Mobula sp.*	–
margined flying fish	*Cheilopogon cyanopterus*	LC
ocean sunfish	*Mola mola*	VU
planehead filefish	*Stephanolepis hispidus*	LC
Porcupinefish	*Diodon hystrix*	LC
rainbow runner	*Elagatis bipinnulata*	LC
sailfish	*Istiophrous albicans*	LC
skipjack tuna	*Katsuwonus pelamis*	LC
smalleye smoothhound	*Mustelus higmani*	LC
southern red snapper	*Lutjanus purpureus*	–
swordfish	*Xiphiaa gladius*	LC
unidentified grenadiers	*Macrouridae*	–
unidentified skates and rays	*Rajiformes*	–
tiger shark	*Galeocerdo cuvier*	NT
tripodfish	*Bathypterois sp.*	DD-LC
yellowfin tuna	*Thunnus albacares*	NT

DD-LC = Data Deficient-Least Concern; LC = Lease Concern; NT = Near Threatened; VU = Vulnerable
[a] IUCN status is given as “ – ” for multi-species groups, or taxa for which a species-specific identification could not be made.

Potential impacts on marine fish from a marine oil spill are related to both water column concentrations of, and the duration of exposure to, dissolved hydrocarbons (primarily PAHs). Contamination in the water column changes rapidly in space and time, such that potentially harmful exposure levels are typically brief (i.e., typically measured in hours), except in the case of an ongoing release such as a loss-of-well-control event or slow leak from a vessel. Exposure to microscopic oil droplets may impact aquatic biota either mechanically (especially for filter feeders) or as a conduit for exposure to semi-soluble hydrocarbons (which might be taken up in the gills or digestive tract via dissolution from the micro-droplets).

Fish are generally only slightly impacted by oil spills because of their limited exposure to surface slicks and the dispersed oil being rapidly diluted to very low concentrations in open water environments. Fish may also actively avoid oil, as they can detect hydrocarbons in the water. Juvenile life stages of marine fish tend to be more susceptible to impacts from oil spills than adults.

Attachment F-6: 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 F-6-1 summarizes the characteristics of these fisheries.

Table F-6-1: 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 finfish and shrimp	Gillnets, seines, and others	0 – 18 m
Shark	Various	Trawls, gillnets, and hook and line	Throughout the continental shelf waters

Pelagic fisheries have traditionally been underexploited in Guyana, but tuna, such as yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*), have recently been identified as a potential oceanic target species of commercial interest. The seabob and shrimp fisheries operate the entire length of the Guyanese coast, but fishing operations associated with these sectors tend to be concentrated on the inner portion of the continental shelf (see Figure F-6-1).

Guyana's marine finfish 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 (ERM 2016). As a result, impacts in these areas may also have an impact on the fishery.

The Guyana Fisheries Department (a division of the Guyana Ministry of Agriculture) should be consulted on any potential impacts of an unplanned release.

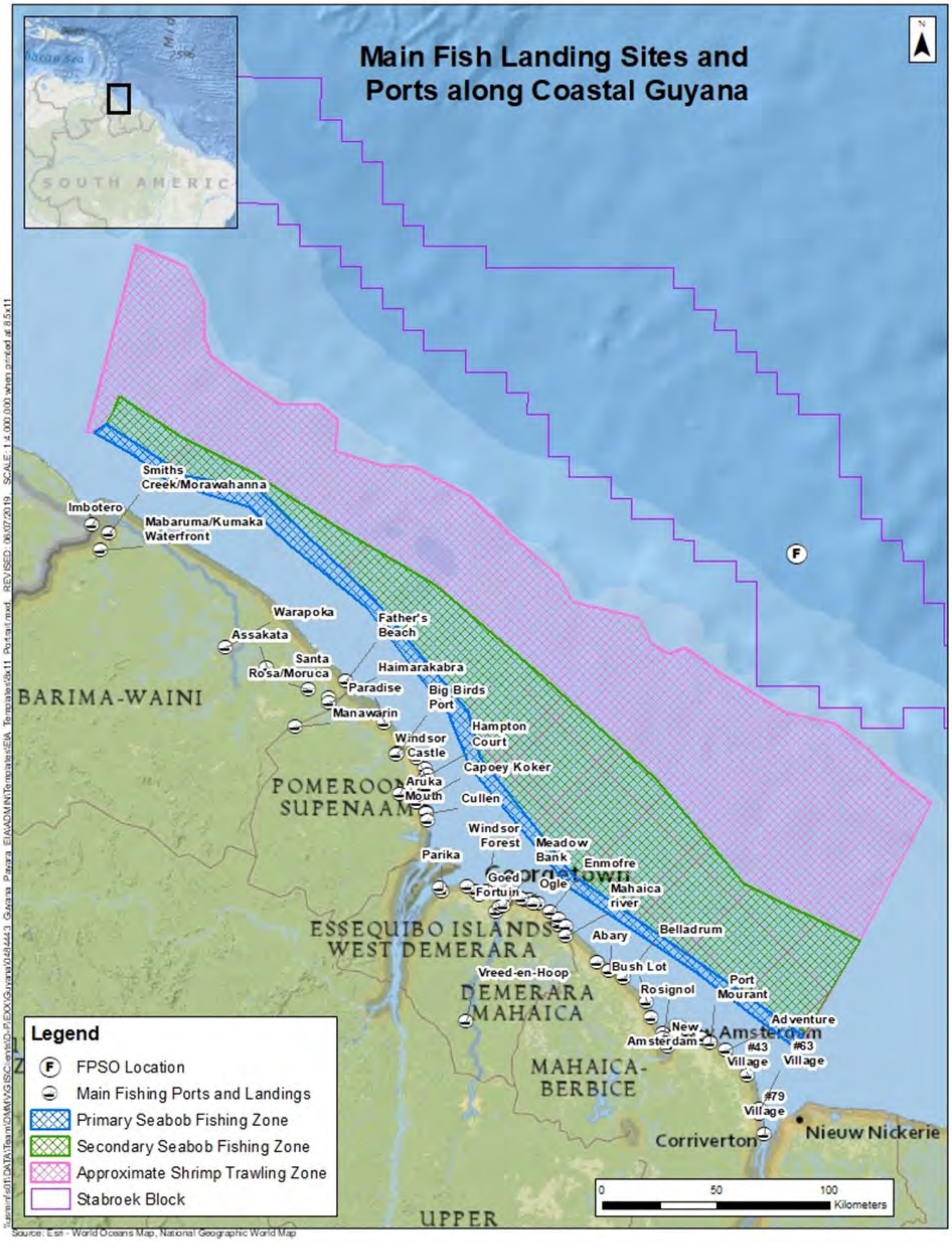


Figure F-6-1: Fishing Zones, Ports, and Landing Sites

Attachment F-7: Wildlife Branch Guidance

In the early hours of a spill response, it is important to quickly estimate the scale of the event (relative to potential animal impacts) as best as possible and order the equipment and personnel. Estimating size and ordering resources should be the first priority as it will take some time to mobilize and deploy resources.

- Wildlife Branch Objectives:
  - Develop a Wildlife Plan for inclusion in the Incident Action Plan (IAP);
  - Identify and mobilize equipment/facilities;
  - Identify and mobilize personnel and support;
  - Complete notifications: internal and external (phone list); and
  - Maintain communication: internal and external.
- Staffing/Positions (depending on response level):
  - Branch Director:
    - Leads Wildlife Branch, develops incident specific wildlife plan.
  - Deputy Branch Director:
    - Backup to the Director, compiles wildlife plan info, manages wildlife branch deadlines.
  - Wildlife Reconnaissance Group Supervisor:
    - Develops land, water, air reconnaissance plans;
    - Coordinates activities with Land, Water, and Air Operations.
  - Bird Recovery and Rehabilitation Group Supervisor:
    - Coordinates bird handling issues, protocols, and hazing activities.
  - Marine Mammal Recovery and Rehabilitation Group Supervisor:
    - Develops and coordinates capture, handling, and rehabilitation of marine mammals;
    - Develop and coordinate efforts for handling marine reptiles.
  - Wildlife Volunteer Coordinator:
    - If necessary, will coordinate training, use, and deployment of volunteers for wildlife collection and rehab activities.
  - Liaison:
    - Will coordinate communication between Environmental Unit in Planning, Joint Information centre (JIC), etc., and the Wildlife Branch in Operations;

    - Assist in maintaining communication with government agencies, non-governmental organizations, and other involved parties.
  - IAP software specialist:
    - Enter forms into the IAP;
    - Assist in getting maps and updating the Common Operating Picture.
  - Documentation tracker (for larger events).

Initial Steps (complete these in this order and on Day 1 when possible):

- Notify Command (as appropriate) that Wildlife Branch is up/running and making plans:
  - Notify Operations Section Chief;
  - Notify Environmental Unit;
  - Notify interested agencies, parties, or organizations.
- Begin Unit Log (ICS 214).
- Identify Branch staff and assignments. Use the list of positions and tasks above to identify tasks and who will be doing them. Remember, the number of personnel expands and contracts as appropriate to the event so it may be one person doing everything or there may be a full contingent of staff. (Provide an organization chart (ICS 207) and contact information to resources).
- Estimate equipment (facility) and personnel needed based on the estimated number and types of animals anticipated. Lean toward over-responding as it is easier to send resources back than not have resources when needed.
- Identify deployment locations for equipment and personnel. Equipment locations need to be available for a long enough time to handle entire (anticipated) response AND rehabilitation to avoid having to move during the process.
- Develop reconnaissance plan or “animal location” needs (on Day 1 this will be a very brief plan, if one at all). Coordinate with EU and Flight Operations, etc.
- Develop search and collection and transportation plans (Day 1 there may not be formal plans, Day 2 will). Identify search areas, number of crews, support needs, etc. (ICS 204 and ICS 204a).
- Develop a wildlife rehabilitation plan.
- Begin drafting the Wildlife Plan for inclusion in the IAP. Templates are on the RRT SharePoint page.
- Provide an Oiled Wildlife Statement to the JIC, listing phone numbers for reporting oiled wildlife and warning the public to stay away from oiled wildlife. A template is available on the RRT SharePoint page.

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APPENDIX G – SUMMARY OF SPILL PREVENTION, MITIGATION MEASURES AND EMBEDDED CONTROLS

The following table is considered a *representative list* of embedded controls and spill prevention measures utilized on a Floating Production, Storage, and Offloading (FPSO) Development Project, inclusive of drilling operations. These controls and measures are not necessarily applicable to every EMGL operation or asset.

Table G-1: Example Controls & Spill Prevention Measures

#	Embedded Control / Spill Prevention Measure
1	Monitoring and control of the FPSO production operations will be performed by an Integrated Control and Safety System (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	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.
3	The FPSO cargo tanks will be blanketed with inert gas. 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.
4	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.
5	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.

#	Embedded Control / Spill Prevention Measure
6	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.
7	With respect to prevention of spills of hydrocarbons and chemicals during the drilling stage: Change liquid hydrocarbon transfer hoses periodically; Utilize dry-break connections on liquid hydrocarbon bulk transfer hoses; Utilize a liquid hydrocarbon checklist before bulk transfers; Perform required inspections and testing of equipment prior to deployment/installation; Utilize certified Loss of well control Prevention (BOP) equipment; Regularly test certified BOP equipment and other spill prevention equipment; Utilize dynamically overbalanced drilling fluids to control wells while drilling; Perform operational training certification (including well control training) for drill ship supervisors and engineers; Regularly audit field operations on the drill ships, FPSO, and shorebase(s) to ensure application of designed safeguards; and Controls for mitigating a failure of the dynamic positioning system on the drill ships and maintain station keeping, which include: • 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.
8	Maintain marine safety exclusion zones with a 500-metre (m) (~1,640-foot [ft]) radius around drill ships and major installation vessels to prevent unauthorised vessels from entering areas with an elevated risk of collision.
9	Ensure offloading activities are supervised by a designated Mooring Master, according to the conditions of the sea. The conditions and characteristics of the export tankers will be assessed by the Mooring Master and reported to the Offshore Field Manager prior to commencing offloading operations.
10	Utilize support tugs to aid tankers in maintaining station during approach/departure from FPSO and during offloading operations.
11	Utilize breakaway couplers on offloading hose that would stop the flow of oil from FPSO during an emergency disconnect scenario.
12	Utilize a load monitoring system in the FPSO control room to support FPSO offloading.
13	Use leak detection controls during FPSO offloading (e.g., for breach of floating hose, instrumentation/procedures to perform volumetric checks).
14	Utilize marine safety exclusion zone of two nautical miles around the FPSO to prevent unauthorised vessels from entering areas with an elevated risk of collision.

G. Summary of Spill Prevention, Mitigation Measures and Embedded Controls

#	Embedded Control / Spill Prevention Measure
15	Regularly inspect and service shorebase cranes and construction equipment to mitigate the potential for spills and reduce air emissions to the extent reasonably practicable.
16	Utilize secondary containment for bulk fuel storage, drilling fluids, and hazardous materials, where practicable.
17	Regularly check pipes, storage tanks, and other equipment associated with storage or transfer of hydrocarbons/chemicals for leaks.
18	Perform regular audits of field operations on the drill ships, FPSO, and shorebases to ensure application of designed safeguards.
19	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.
20	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.
21	EMGL 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.
22	Adhere to the International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, which confirms the right of coastal member states to take specific actions when necessary to prevent pollution from oil following a maritime casualty. This convention would protect Guyana's rights to respond to an oil spill if such an event were to occur.
23	Adhere to the International Convention on Civil Liability for Oil Pollution Damage, which 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. This convention would not apply directly to EMGL's activities, but would apply to potential spills from tankers that had received oil from the FPSO.
24	Adhere to the International Convention on Oil Pollution Preparedness, Response and Cooperation, which establishes measures for dealing with marine oil pollution incidents. This convention requires ships to have a Shipboard Oil Pollution Emergency Plan (SOPEP).
25	The Company and its affiliates (including EMGL) are committed to conducting business in a manner that is compatible with the environmental and socioeconomic 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. EMGL's OIMS Framework 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, occupational safety, security, occupational 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 is consistent with the risks associated with the business activities being planned and performed.

G. Summary of Spill Prevention, Mitigation Measures and Embedded Controls

#	Embedded Control / Spill Prevention Measure
26	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.
27	Hydrocarbon releases under various nearshore spill scenarios would all be small and under control quickly, and would be managed with locally available spill control equipment.
28	A small Tier I offshore hydrocarbon release under various offshore scenarios would be quickly controlled and contained because of the relatively small volumes and the ready access to spill control equipment.
29	Oil spill modelling and coastal sensitivity mapping have been conducted to identify and characterize the resources/receptors with the potential to be exposed to oil.
30	Oil spill modelling was used to simulate spill events using the best available characterization of the wind and hydrodynamic (marine currents) forces that drive oil transport, and quantify the potential consequences from a spill, which can then be used to guide response planning and prioritize response asset deployment.
31	Coastal sensitivity mapping was conducted for the coastal area identified in the oil spill modelling as having the potential to be contacted by hydrocarbons as a result of any of the deterministic modelling of an unmitigated Tier III Marine Oil Spill. The mapping included characterization of the following resources and receptors: Environmental – protected areas, mangroves, shoreline types, seagrass beds, coral reefs, important coastal fish habitats, important coastal bird habitats, and other sensitive habitats; and Socioeconomic – coastal and/or indigenous peoples communities (e.g., locations, demographics, and socioeconomic characteristics), shoreline- and coastal-dependent commercial and artisanal activities (e.g., fishing, foraging, hunting, agriculture, and grazing), industrial activities and infrastructure (e.g., water intake facilities, ports), and traditional and cultural practices. This information enables EMGL to prioritize the mobilization of emergency response resources (manpower and equipment) to those areas most sensitive to a spill.
32	Regarding spill prevention controls associated with well control release, EMGL'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. EMGL 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 the influx of reservoir fluids entering the well during drilling, the use of physical barriers including BOPs, personnel training and proficiency drills for well control, and the use of dynamically overbalanced drilling fluids to control pressures within the well.

G. Summary of Spill Prevention, Mitigation Measures and Embedded Controls

#	Embedded Control / Spill Prevention Measure
33	Regarding spill prevention controls associated with FPSO offloading, the major spill prevention controls associated with FPSO offloading include: FPSO and tanker collision avoidance controls; use of a certified engineered floating double carcass hose system; use of emergency disconnect controls on the floating double carcass 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.
34	EMGL has a detailed Oil Spill Response Plan (OSRP) in place, which is included as part of the Project's Environmental and Socioeconomic Management Plan (ESMP), to ensure an effective response to an oil spill, if one were to occur. The OSRP: Describes the response measures appropriate to the magnitude and complexity of a spill incident; Clearly delineates the responsibilities of each entity that would take part in a response; Describes how EMGL 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; and Describes the EMGL process for notifying the government of Guyana with respect to mobilizing its resources.
35	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 minimise the risk of collision during the approach to the FPSO and during offloading, EMGL 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. 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.
36	A number of controls will be implemented to prevent collision near shore between a Project supply vessel and another (non-Project) vessel or structure (e.g., due to navigation error or temporary loss of power). EMGL has comprehensive contractor selection guidelines to ensure contractors are qualified and have robust safety, health, and environmental management systems. EMGL will provide active oversight over its contractors to verify they are complying with its requirements. Contractors are required to regularly inspect their vessels, which address marine safety and maintenance considerations and reduces the risk of a vessel losing power or steering capability. In addition, vessels operating within the Georgetown Harbour or other coastal areas will be adhering to speed restrictions and navigation aids.
37	EMGL will utilize a Simultaneous Operations procedure to safely manage Project marine vessels that are performing work in the same vicinity of each other, which will include considerations to avoid vessel collisions.
38	Marine vessels will have industry-proven station-keeping systems (e.g., FPSO mooring system, dynamic position systems on drill ships) to maintain station in the offshore environment.
39	A Wildlife Response Program would be established at the onset of an oil release from a large Marine Oil Spill to minimise impacts on ecological balance and ecosystems.

G. Summary of Spill Prevention, Mitigation Measures and Embedded Controls

#	Embedded Control / Spill Prevention Measure
40	The coastal sensitivity mapping that supports the OSRP includes mangroves as a sensitive coastal resource and in the unlikely event of an oil spill; EMGL will deploy emergency response equipment to protect these sensitive resources, as appropriate.
41	A claims process would be established at the onset of a large Marine Oil Spill incident to compensate for loss of sustenance and income (e.g., fisherfolk for loss of harvest due to regional fisheries closures) that were attributed to the oil spill.
42	Implementation of the OSRP would help minimise transboundary impacts just as it would minimise impacts within the Guyana Exclusive Economic Zone (EEZ). In response to a spill, EMGL 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 EMGL 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.
43	Implement an ESMP/ESMMP, which describes the measures EMGL will implement to manage the Project's potential environmental and socioeconomic risks and reduce impacts to the environment and communities.
44	EMGL will perform 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.
45	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.
46	The Project will augment ongoing stakeholder engagement process (along with relevant authorities) to identify commercial cargo, commercial fishing, and artisanal fishing vessel operators who might not ordinarily receive Notices to Mariners, and where possible, communicate with them regarding major vessel movements and marine safety exclusion zones.
47	Promptly remove damaged Project vessels (associated with any vessel incidents) to minimise impacts on marine use, transportation, and safety.

#	Embedded Control / Spill Prevention Measure
48	Implement the OSRP in the unlikely event of an oil spill, including: • Conducting air quality monitoring during emergency response; • Require use of appropriate PPE by response workers; • Implementing a Wildlife Oil Response Program, as needed; and • Implement a claims process for damage caused by an oil spill, as needed.
49	EMGL will proactively obtain additional support and resources to reduce the impact of a spill in the unlikely event it shows potential to exceed Tier I capabilities. The Emergency Response Team (ERT) will manage Tier I spill responses using the site-specific Emergency Response Plan (ERP) and resources located on vessels and in port facilities in Guyana and Trinidad. Such resources as well as dispersant application from vessels will also be used for larger Tier II spills until supplemental oil spill response resources arrive on-scene. For incidents that may exceed Tier I capabilities, EMGL would notify Oil Spill Response Limited (OSRL), to provide immediate incident management support as well as OSRL's global oil spill technical response teams and equipment.
50	Given the limited resources in-country, company will consider setting up a cooperative with a regional Oil Spill Response Organization to support Tier II+ oil spill response. Until the viability of a regional capability is determined, EMGL will rely on external world-class capabilities from Tier III centres located around the world.
51	The EMGL OSRP is supported by the EMGL ERP which provides a structured and systematic process for responding to incidents, and outlines plans and procedures for engagement between the incident site, EMGL, and ExxonMobil management and the relevant authorities in Guyana.
52	EMGL will initiate a systematic search with vessels and aircraft (weather permitting) to locate the spill and determine its coordinates. EMGL will estimate spill size and movement using coordinates, photographs, drawings, and other information received from vessels, aircraft and satellite imagery. Spotters will photograph the spill from aircraft as often as necessary for operational purposes, and determine its movement based on existing reference points, such as vessels and familiar shoreline features. Modelling of the oil release may be utilized to predict the oil slick's surface movement or trajectory. Modelling will help to identify shorelines that may be at risk from oil stranding, predict the probable timing of that stranding, and provide information regarding how the oil is changing with time.
53	In the event of a release, EMGL and ExxonMobil technical experts will complete a revised NEBA in real-time predicated on the current metocean conditions, location and nature of the release for review and discussion with the Guyana EPA and Civil Defense Commission (CDC) as soon as practical.
54	During EMGL's operations, the on-site ERT will endeavor to contain any spill at the source, whether it be onshore (shorebase or port) or onboard a vessel (i.e., PSV, FSV, installation, drill ship, tug, tanker or FPSO) and minimise any impacts to the environment, using the equipment available at the worksite. In the event of an on-water release, EMGL will ensure the required notifications are made, initial response actions are implemented and monitor the incident and consider all appropriate response strategies, including containment and recovery as well as dispersants to appropriately respond to the incident.

G. Summary of Spill Prevention, Mitigation Measures and Embedded Controls

#	Embedded Control / Spill Prevention Measure
55	If released oil is predicted to reach a shoreline, EMGL will continue to leverage all available resources to stop the release at the source, utilizing provided containment, mechanical recovery, open burning, surface and subsurface dispersant application. EMGL will also consider and evaluate shoreline protection measures (based on consultation with the appropriate government authorities) and outcomes from the NEBA to identify the combination of key response strategies that would be appropriate, given the specific situation, fate, and trajectory of the oil spill and weather conditions. Local regulatory approval and the ExxonMobil Oil Spill Dispersant Guidelines will govern the application of dispersants.
56	EMGL will use the NEBA process as a key input to the overall Incident Response Planning. NEBA compares the impacts of available response options, and selects the option or combination of options that minimises overall harm to environmental and socioeconomic resources. The use of NEBA will ensure that EMGL selects the most appropriate response techniques available to minimise overall environmental impact based on the conditions and sensitivities of an actual incident.
57	EMGL will respond to a release as far offshore as possible, using all appropriate tools and tactics to minimise shoreline impact. In consultation with the Guyana EPA, EMGL will develop Incident Response Plans that could respond with aerially applied dispersants, which can be quickly deployed and treat large surface areas rapidly and efficiently.
58	The safety of responders also needs to be considered in the evaluation of response strategies. Response tactics depend upon a variety of environmental conditions: • Implement subsea dispersant application as soon as possible, if warranted, to treat most if not all oil spilled at the source before it encounters surface water resources; • Deploy in situ burning equipment to burn thick oil near the source; • Continue to use aerially applied dispersant as an initial, and in some cases, primary response tool for oil further from the source where mechanical recovery/in situ burn operations are less effective; • Utilize aerial dispersant application during calm seas on emulsified oil; and • Outfit vessels of opportunity (VOO) with dispersant delivery and mechanical containment and recovery systems to provide a fleet of vessels that can be a line of defense against surface oil approaching shorelines. • Shoreline protection and clean-up may be potentially needed for some scenarios, in which case, sensitive shorelines will receive prioritization for protective booming.
58	Utilize surveillance and monitoring teams, which can fulfill the following response objectives in the waters offshore Guyana and as needed beyond the Guyana EEZ if required by the scale of the incident: • Verify oil spill scale and location; • Monitor effectiveness of applied response strategies; • Visually quantify spill volume; • Direct operations – dispersant application, containment and recovery, shoreline assessment, in situ burning; and • Monitor wildlife.
59	At a minimum, surveillance and monitoring personnel will take visual observations, and vessel owners/operators will implement their Emergency Response/Shipboard Oil Pollution Emergency Plan (SOPEP), deploying the Tier I response equipment they have onboard.

G. Summary of Spill Prevention, Mitigation Measures and Embedded Controls

#	Embedded Control / Spill Prevention Measure
60	For Tier II or Tier III incidents, EMGL will scale up to a full surveillance plan using helicopters, fixed wing aircraft and satellite imagery.
61	The Incident Management Team (IMT) will assign an Air Operations Branch as part of the Operations Section for large or complex incidents. The Air Operations Branch will coordinate aerial support according to operational needs and document operational assignments in an ICS-220 Air Operations Summary form, which will be included in the Incident Action Plan.
62	To assist the natural dispersion process techniques such as prop washing or water hoses can be implemented to introduce energy and agitate the hydrocarbons, thereby assisting with the break up of a surface slick and promoting biodegradation.
63	For operational spills: Shorebases in Guyana and Trinidad have site-specific ERPs and are equipped with Tier I spill response kits; Vessels maintain a SOPEP and associated equipment onboard the vessel.
64	EMGL will use harbour containment and recovery should a PSV or FSV release hydrocarbons in Port. The harbour response team will employ a strategy that considers tides, currents, wind, vessel traffic, and local infrastructure and stakeholder input. EMGL will deploy equipment available on site and in the Port (such as or similar to the equipment and trained personnel at the Guyana Fuel Terminals and resources held by NRC for Trinidad) immediately following a release.
65	EMGL will implement a shoreline response if released hydrocarbons show the potential to affect a shoreline, prioritizing environmentally or socio-economically sensitive areas. This will consist of using vessel dispersant application to prevent approaching slicks from impacting socio-economically sensitive areas and using shoreline booming to protect sensitive areas and provide collection points for hydrocarbon recovery.
66	EMGL will only apply dispersants if there is a direct advantage to protecting environmental or socio-economical sensitivities (determined using NEBA) and they have obtained regulatory approval per the protocols described in the OSRP.
67	Vessel mounted systems will be used to apply dispersant in small-scale incidents and aircraft will apply dispersant on large oil slicks. Dispersant (and associated vessel spray equipment) will be kept at the shorebase or other easily accessible location where it can be easily loaded on vessels for application. OSRL will conduct aerial dispersant application and will likely base the operation out of the Georgetown airport. In the unlikely event of a loss-of-well-control, dispersant is injected subsea at the wellhead location on the seafloor using specialized equipment and remote operated vehicles (ROVs).
68	EMGL will use the Dispersant Spraying Considerations Flowchart as a guide for whether to use dispersants. Dispersant will be applied according to manufacturers' guidelines and the operating procedures of the spray applicators. Dispersant use will reguire Guyana EPA approval prior to application. EMGL will work with the EPA to develop a dispersant application, monitoring and evaluation strategy. Safety Data Sheets for the dispersants that might be utilized are available in Appendix D.
69	EMGL will source VOOs to provide platforms for the containment and recovery systems.

#	Embedded Control / Spill Prevention Measure
70	A Wildlife Response Plan specific to Guyana has been developed to allow for a timely, coordinated and effective protection, rescue, and rehabilitation of wildlife to minimise any negative impacts of a spill. Should a wildlife response be required, EMGL will call upon the Sea Alarm Foundation via OSRL to provide specialist advice and assistance with carrying out a response.
71	EMGL may use in situ burning for large-scale Tier III incidents. OSRL will provide the resources required.
72	EMGL will manage hazardous waste resulting from clean-up activities and ensure appropriate disposal.
73	The Tanker Owner/Operator will implement an ERP should any spill occur during tanker offloading and the FPSO ERP will have similar details on the surface and subsea response for a spill from either the FPSO, during tanker offloading or SURF equipment during production operations.
74	If a Tier III loss-of-well control event occurs involving the release of wellbore fluids into the sea, EMGL will perform a site survey, conduct debris removal operations (as required), evaluate and execute well intervention options, install subsea dispersant application hardware, and mobilize and install a capping device/auxiliary equipment as required. If a relief well is required, it will be drilled to intersect the original well and address specific issues encountered in the original wellbore.
75	EMGL will utilize OSRL's Subsea Well Intervention Service (SWIS), which provides access to a Subsea Incident Response Toolkit (SIRT), Global Dispersant Stockpile (GDS) and multiple CSSs. The CSS and SIRT includes equipment that can be mobilized directly to the well site: • Survey & debris clearance equipment; • Intervention equipment; • Dispersant hardware application system*; and • CSSs and auxiliary equipment.
76	In the event of a spill, an incident-specific Decontamination Plan will be developed by EMGL relevant to the nature and extent of the spill, to prevent further oiling through secondary contamination.
77	The Tier I equipment held at EMGL's onshore and offshore operations, including shorebases, fueling terminal, support vessels, drill ship, tankers and FPSO will be available for rapid deployment in the event of an incident.
78	Equipment and trained personnel are available through the terminals and shorebases to initiate an onshore/nearshore response to a Tier II incident. Vessel dispersant spray operations will be initiated from the PSVs and supported from the shorebases or other accessible locations as needed to supplement other Tier II response actions.
79	The Regional Response Team (RRT) can be partially or fully activated, and includes trained individuals and specialists, with assigned roles and responsibilities, who can be deployed at short notice to address a broad range of emergency situations.
80	EMGL is a Participant member with OSRL, and therefore has immediate access to technical advice, resources and expertise 365 days a year on a 24-hour basis.
81	EMGL has access to the Global Dispersant Stockpile (GDS), which is an additional 5,000 cubic metres (m^3) of dispersant located across the OSRL bases and in France.

#	Embedded Control / Spill Prevention Measure
82	EMGL has access to the Boots & Coots 15 PSI Subsea Well Capping Stack located in Houston, TX, USA. Should EMGL require a capping stack, Boots & Coots would be EMGL's primary provider.
83	EMGL also has access to the OSRL SWIS, Oceaneering, Wild Well Control, and Trendsetter Engineering for subsea well response. SWIS holds and maintains four CSSs and two SIRTS globally: • 15k PSI Subsea Well Capping Stack – Norway and Brazil; • 10k PSI Subsea Well Capping Stack – South Africa and Singapore; • SIRT – Norway and Brazil.
84	EMGL conducts oil spill training courses and exercises (desktop and in-field) for operations. The training, drills, and exercises familiarize response personnel with their duties and responsibilities in an oil spill response.
85	EMGL ERT and IMT members, which includes the RRT, will receive oil spill response training listed in the OSRP based on their response position.
86	ERT and IMT members will receive appropriate Incident Command System (ICS) Training listed in OSRP based on their roles and responsibilities.
87	EMGL will conduct oil spill response exercises to test incident response personnel function and responsibilities, in line with OSRP.
88	EMGL will implement a Wildlife Response Plan as a supplement to the OSRP to serve as general guidance for wildlife deterrence (hazing), capture, and rehabilitation during an oil spill response.

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APPENDIX H – SPILL IMPACT MITIGATION ANALYSIS FOR SELECTION OF RESPONSE TECHNOLOGIES

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EXXONMOBIL GUYANA UARU DEVELOPMENT PROJECT SPILL IMPACT MITIGATION ASSESSMENT 22-P-218059

Quantitative Spill Impact Mitigation Assessment (SIMA) using a Comparative Risk Assessment (CRA) Approach

Spill Impact Mitigation Assessment
ExxonMobil Guyana Uaru
22-P-218059

December 19, 2022

REPORT

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Executive Summary

Esso Exploration & Production Guyana Ltd. contracted RPS Ocean Science to perform a Spill Impact Mitigation Assessment (SIMA) to evaluate potential emergency response mitigation strategies for discharges of oil resulting from loss of well control events occurring at a well site (Uaru) within the Stabroek Block, offshore Guyana. A quantitative SIMA was performed using a Comparative Risk Assessment (CRA) approach that uses 3D transport and fate modeling to calculate exposure indices, which are used as inputs to a relative risk calculation comparing potential effects on, and risks to, ecological receptors residing within the model domain (defined as Valued Ecological Components or VECs). Valued Ecological Components (VECs) are important ecological receptors, which are either important habitats or species have been grouped taxonomically and by behavior type (e.g., planktonic, pelagic fish, demersal). The CRA approach applied here was initially developed for hypothetical subsea loss of well control events in the Gulf of Mexico and for a Deepwater Horizon counter-historical study (French-McCay et al., 2018, 2021a; Bock et al., 2018, 2021a; Walker et al.,, 2018; French-McCay, et al., 2022), and is the same as that described in recent publications by the National Academies of Sciences, Engineering, and Medicine (NASEM, 2020; NASEM, 2022).

The oil transport and fate modeling used in the CRA was conducted using RPS' OILMAPDeep and SIMAP (Spill Impact Model Application Package) modeling systems, based on inputs and environmental conditions described in the Oil Spill Modeling Report (22-P-218059). The scenarios modeled were hypothetical oil and gas discharges at the wellhead involving a medium crude oil. The SIMA analysis was based on an individual spill event representing a Most Credible Worst-Case Discharge (WCD) with a 95th percentile fastest time to shoreline oiling. After 5.5 days, it was assumed that a capping stack would be placed and stop the flow of oil and gas from the wellhead, while the oil remaining in the environment at that time was further tracked for a total simulation length of 45 days. The loss of well control scenario was simulated unmitigated (i.e., capping only, without any other emergency response) and with six different combinations of mitigation activities, including mechanical removal (e.g., skimming), *in situ* burning (ISB), surface application of dispersants applied aerially and by boat, and subsea dispersant injection (SSDI), whereby dispersants are applied at the wellhead. This suite of scenarios allowed for comparison of the value provided by different response mitigation options and the relative risks posed to important ecological receptors (i.e., VECs in different Environmental Compartments, or ECs). Environmental compartments (ECs) are zones of the marine environment based on water depth, i.e., coastal (<10 m), shelf (10 – 200 m), and offshore (>200 m) waters, divided vertically in each zone as upper epipelagic (0-20 m), lower epipelagic (20-200 m), and deepwater (>200 m).

The OILMAPDeep model was used to determine the buoyant discharge plume geometry and define the size of the oil droplets released into the water column, as well as the effect that SSDI had on the droplet sizes. Oil droplet size determines the oil fate and environmental exposures, as smaller

droplets rise more slowly to the sea surface, allowing more weathering and dispersion into the sea. The droplet size distribution (with or without SSDI) was used as in input to modeling the far-field transport and fate of the oil in SIMAP. Quantitative outputs from the far-field modeling were first used to calculate exposure metrics, representing the area or volume of ECs exposed to surface oil or dissolved hydrocarbons in the water column above relevant ecological effects thresholds. These exposure metrics were also used to calculate relative risk scores (or CRA scores), which provided the basis for a quantitative SIMA for the Uaru scenarios.

Dispersants applied at the wellhead (SSDI) were effective in reducing the size of the oil droplets, leading to greater dispersion in the water column compared to the unmitigated (“Cap Only”) case. Response measures resulted in reductions of shoreline oiling and oil contamination at the water surface. Slight differences in trajectory can result from different applications of response strategy, including the effects of prioritization of response (e.g., ISB versus mechanical recovery), which can affect which areas are oiled in a specific scenario. However, net reductions were generally seen for increasing levels of response application, particularly including SSDI.

The potential environmental effects of an oil spill on the coastline of Guyana were compared by evaluating the different exposure metrics and CRA scores associated with different response strategies. Overall, the exposures and relative risks across the ecosystem were substantially reduced with response application and particularly SSDI. The scenarios that included SSDI were predicted to have sea surface exposures up to 60-88% lower than the Cap Only scenario. These scenarios were also predicted to have shoreline exposures that were 25-30% lower than the Cap Only scenario. In the scenarios including SSDI, the surface and shoreline oiling resulted primarily from oil released before SSDI began (which was 3.5 days after the spill start). Once SSDI was initiated, further surface and shoreline oiling was largely prevented. Water column exposures were predicted to be greatest near the sea surface where oil was able to be entrained by wind-induced waves into the water column. SSDI reduced the amount of oil surfacing and the thickness of that oil, which correspondingly reduced the amount of oil available to be entrained. In contrast, the smaller droplets caused by SSDI remained longer in the deep water (200+ m depth); however, they were also dispersed more widely into a greater volume of water, such that deep water column exposures were not much different than without SSDI.

The CRA scoring further showed that response application resulted in substantially lower relative risk to the environment as a whole, taking into account the locations in which the VECs reside and their ability to recover after exposures to oil. The relative risk scores were reduced with increasing application of response. The degree of reduction primarily depended on the type of response strategy and its effectiveness at reducing the surface and shoreline exposures. Mechanical recovery and ISB therefore had the least effect on reducing overall risk. Risks were reduced with surface dispersant application, and were lowest for the scenarios that included SSDI. Any tradeoffs due to dispersion of the oil into the water column from dispersants were outweighed by the benefits to reduced oiling on the surface and shorelines.

Another important feature of SSDI was not only that it kept some oil from surfacing entirely, but also that it dispersed oil into smaller droplets that rose more slowly allowing oil to weather (dissolve and biodegrade) before surfacing. This weathering reduced volatile organic compound (VOC) emissions by approximately 40% (in combination with other response options), which would provide benefit and improve safety for responders working near the wellhead and in areas proximate to the surfacing oil. Because of the slower rise times, oil would also be captured longer in subsea currents and surface farther away from the wellhead than without SSDI. The more distant surfacing would further reduce VOC exposures to responders near the wellhead, such as those installing the capping stack.

1 Contents

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1 Introduction

Esso Exploration & Production Guyana Ltd. contracted RPS Ocean Science to perform a Spill Impact Mitigation Assessment (SIMA) to evaluate potential emergency response mitigation strategies for discharges of oil resulting from blowout events occurring at a well site (Uaru) within the Stabroek Block, offshore Guyana. A quantitative SIMA was performed using a Comparative Risk Assessment (CRA) approach that uses 3D oil transport and fate modeling to calculate exposure indices used as inputs to a relative risk calculation comparing potential effects on, and risks to, Valued Ecological Components (VECs) residing within the model domain.

The oil transport and fate modeling used in the CRA was conducted using RPS' OILMAPDeep and SIMAP (Spill Impact Model Application Package) modeling systems, based on inputs and environmental conditions described in the Oil Spill Modeling Report (22-P-218059). Wind and current data relevant to the studied area were taken from a combination of models, including NOGAPS, NAVGEM, SAT-OCEAN, and U.S. Navy HYCOM (described in the Oil Spill Modeling Report). The scenarios modeled were hypothetical oil and gas discharges at the wellhead involving a medium crude oil. The SIMA analysis was based on an individual spill event representing a Most Credible WCD with a 95th percentile fastest time to shoreline oiling. This simulated event started on July 1st, 2006. After 5.5 days, it was assumed that a capping stack would be placed and stop the flow of oil and gas from the wellhead, while the oil remaining in the environment at that time was further tracked for a total simulation length of 45 days. The loss of well control scenario was simulated unmitigated (i.e., capping only, without any other emergency response) and with six different combinations of mitigation activities, including mechanical removal (e.g., skimming), *in situ* burning (ISB), surface application of dispersants applied aerially and by boat, and subsea dispersant injection (SSDI), whereby dispersants are applied at the wellhead.

The OILMAPDeep model was used to determine the buoyant discharge plume geometry and define the size of the oil droplets released into the water column, as well as the effect that SSDI had on the droplet size. Oil droplet size determines the oil fate and environmental exposures, as smaller droplets rise more slowly to the sea surface, allowing more weathering and dispersion into the sea. The droplet size distribution (with or without SSDI) was used as input for modeling the far-field transport and fate of the oil in SIMAP. Quantitative outputs from the far-field modeling were first used to calculate exposure metrics, representing the area or volume of ECs exposed to surface oil or dissolved hydrocarbons in the water column above relevant ecological effects thresholds. These exposure metrics were also used to calculate relative risk scores (or CRA scores), which provided the basis for a quantitative SIMA for the Uaru scenarios.

This report presents a quantitative SIMA conducted for a set of scenarios with different mitigation options, for comparison to the Cap Only scenario at the Uaru well site. The methodology and model scenarios are described in Section 2. Section 3 provides a summary of the oil spill modeling and the results of the exposure analysis and CRA that were used for the SIMA. A summary of the SIMA is included in Section 4.

2 Methodology & Scenarios

2.1 Oil Spill Modeling

Modeling of the fate and transport of oil was conducted using RPS's integrated plume model (OILMAPDeep) and farfield model (SIMAP). OILMAPDeep calculations included developing representative droplet size distributions (DSDs) released into the farfield environment. SIMAP modeling tracked 18 pseudo-components of oil as they were subject to differing fate processes, importantly including dispersion and dissolution in the water column during the ~1.7 km ascent to the sea surface. One site within the Uaru Prospect in the Stabroek Block (UA3-P Drill center or "Uaru wellhead") was used for all spill scenarios in this study. The site is located offshore from Guyana, roughly 200 km from the coastline (Figure 2-1).

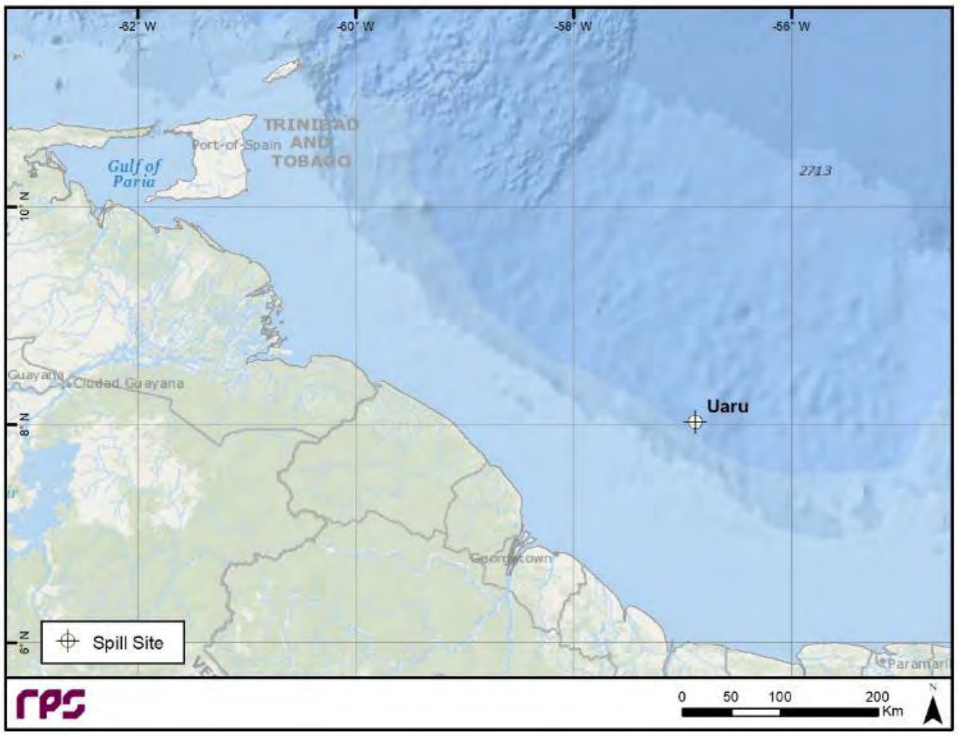


Figure 2-1. Location of the Uaru site in the Stabroek Block used in the modeling.

A suite of seven scenarios were modeled, including a release with only a capping stack (i.e., no active response) and six combinations of spill response options (Table B-7). The overall spill volumes and release rates of oil and gas were provided by the client to RPS based on anticipated reservoir characteristics. The plume exit velocity was calculated from the total volumetric release rate and local gas to oil ratio (based on pressure and temperature conditions at the release point) considering reservoir properties, release depth, and the cross-sectional area of the release opening (see Oil Spill Modeling Report).

Table 2-1. Spill scenarios modeled in the Uaru prospect (Stabroek Block), offshore Guyana.

Scenario ID	Spill Location	Spill Response	Description	Spill Duration	Spill Rate	Model Duration
1		**Cap Only**	Monitor and observe with B&C capping stack placed at 5.5 days; no other response actions	5.5 day		
2		**Mech**	Mechanical (Mech) only	5.5 day		
3		**Mech + ISB**	Mechanical + *in situ* burning (ISB)	5.5 day		
4	Uaru Wellhead	**Mech + SD**	Mech + surface dispersant applications (SD)		Most Credible WCD (88,364 bbl/day)	45 day
5		**Mech + ISB + SD**	Mech + ISB + SD	5.5 day		
6		**Mech + SD + SSDI**	Mech + SurfDisp + SubSea Dispersant Injection (SSDI)	5.5 day		
7		**Mech + ISB + SD + SSDI**	Mech + ISB + SD + SSDI	5.5 day		

Environmental conditions for wind and currents were modeled based on data described in the Oil Spill Modeling Report. Wind data used in the SIMAP oil spill model simulations were taken from two US-government global meteorological models, NOGAPS and NAVGEM, to define wind speed and direction time series over the region. Wind data from the two models cover the same 10-year period as the current data from the hydrodynamic model (2005-2014). Currents in the upper water column off the Guyana coast are strong and flow towards the northwest along the coast of South America over the entire year. The Guiana Current is part of the regional flow between South America, Africa and the Caribbean Sea, extending from Guyana to the Caribbean. Current data produced by the SAT-OCEAN model (provided by ExxonMobil Upstream Research Company) covering the area around the Stabroek Block were used in combination with currents extracted from the U.S. Navy HYCOM global hindcast model as inputs to the SIMAP spill simulations.

The farfield modeling for this study was conducted using RPS' SIMAP (Spill Impact Model Application Package) oil spill modeling system. The SIMAP three-dimensional physical fates model calculates the distribution (as mass and concentrations) of whole oil and oil components on the water surface, on shorelines, in the water column, and in sediments. Oil fate processes included are oil spreading (gravitational and by shearing), evaporation, transport, randomized dispersion, emulsification, entrainment (natural and facilitated by dispersant), dissolution, volatilization of dissolved hydrocarbons from the surface water, adherence of oil droplets to suspended sediments, adsorption of soluble and sparingly-soluble aromatics to suspended sediments, sedimentation, and degradation. Description of the physical fates models can be found in a previous report for the

Payara Prospect in this region (Rowe et al. 2018). French-McCay et al. (2021b,c,d) describe the SIMAP oil fate model in detail, and its validation for the Deepwater Horizon oil spill.

The loss of well control events were simulated for a release of medium crude oil, assuming a capping stack stops the flow of oil and gas at 5.5 days after the start of the spill. The scenarios modeled included different combinations of response, listed in Table B-7. Specific spill response capabilities, assumptions, and timing used to model the various applications were based on the capabilities documented in the EMGL Oil Spill Response Plan for Guyana Operations. However, the response capabilities were further refined in this assessment to enable relative comparisons of different response options using real-world effectiveness and capacity information that are likely to be available during the specific event modeled (i.e., the “modeled response”). This refinement led to applying rates of oil removal, burning, and dispersion that were customized to these capacities and the environmental conditions modeled herein. Thus, the modeled response was site-specific, to represent what would occur during a real response. Notably, SSDI was modeled assuming 24/7 treatment, beginning 3.5 days after the release started and ending at the cessation of discharge with the capping stack placement after 5.5 days. SSDI was modeled assuming a Dispersant to Oil Ratio (DOR) of 1:70 and that 100% of discharged oil was effectively treated (i.e., full contact with dispersant). The capacities for mechanical recovery, ISB, and surface dispersant were further limited from the Oil Spill Modeling Report by using the specific modeled oil weathering, as well as rates realistically achieved during the Deepwater Horizon spill response and only in daylight hours. These limitations included: 1) assuming similar percent water in skimmed material as Deepwater Horizon, 2) that ISB would be limited by increased viscosity with weathering and end after approximately 6.5 to 8.5 days (when oil remaining on the surface would likely be too weathered to burn), 3) and that four airborne dispersant sorties would be conducted per day (two per day per plane) with a 50% likelihood of contacting oil. Application of surface dispersants was also restricted in waters less than 10 meters deep and south of 10°N (i.e., south of Trinidad). Vessels applying surface dispersants, which would have lesser travel capabilities, were limited to south of 8°N.

2.2 CRA Approach

The CRA approach applied here was initially developed for hypothetical subsea loss of well control events in the Gulf of Mexico and for a Deepwater Horizon counter-historical study (French-McCay et al., 2018, 2021a; Bock et al., 2018, 2021; Walker et al., 2018; French-McCay, et al., 2022). Recent publications by the National Academies have described it as “a new, computationally advanced approach to the comparison of response techniques and their potential effects” (NASEM, 2022), which “in many ways…can be considered an evolutionary step of NEBA, one that takes advantage of recent advances in biological modeling technology to remove some of the subjectivity out of preceding frameworks” (NASEM, 2020). By analyzing a suite of different scenarios using an integrated model that simulates both the fates and effects of a spill, the CRA enables comparison of the value provided by different response mitigation options and the relative risks posed to VECs in different ECs.

The CRA methodology is particularly suited to evaluating SSDI because of the complexity of modeling SSDI's effect on oil droplet size and the need to calculate how oil fate and resulting exposures would affect VECs in a variety of depth zones and shore proximities within the large model domain. For this CRA, relative exposure metrics or indices (representing the portion of each EC exposed above a threshold of concern) were calculated for each unique VEC: EC combination, then multiplied by a relative population index and a relative recovery index to estimate the fraction of the VEC population exposed and its recovery potential. Ecological risks are calculated and compared for a variety of depth zones and shore proximities (i.e., ECs), such that changes in the oil fate model results for different response options and varying droplet sizes can impact the CRA scoring among compartments.

The predicted effects of a release are highly dependent on the ecological sensitivity of the exposed organisms to oil exposure. For this reason, two sets of exposure thresholds were analyzed in the CRA to represent the variable species sensitivity across each VEC type, providing a range of interpretation for the modeled scenarios. For VECs residing on or interacting with oil on the water surface, two exposure thresholds were selected to assess the potential for greater sensitivity (10 g/m^2) and lower sensitivity (100 g/m^2) upon exposure. Thresholds for VECs in shoreline habitats include those for greater sensitivity (10 g/m^2 for invertebrates and 100 g/m^2 for vegetation) and lower sensitivity (100 g/m^2 for invertebrates and 1000 g/m^2 for vegetation). Upper and lower thresholds of 10 μg/L and 100 μg/L polynuclear aromatic compounds (PACs) were selected to assess most VECs in the water column. Plankton exposures at depths of less than 20 meters were compared to lower thresholds (1 μg/L and 10 μg/L) due to their higher sensitivity and the phototoxic effects of UV light. All exposure metrics were calculated as a time-weighted area (as km^2-days) or time-weighted volume (as m^3-days), over which aquatic biota moving through the spill environment were exposed to doses above the threshold.

Ecological populations and communities of interest for the CRA evaluation were categorized as VECs present in different portions of the environment (i.e., ECs) that they inhabit. Thirteen VECs were selected to represent the species or taxa present within the model domain (Table 2-2). Thirteen ECs were identified within which those VECs reside, delineated by proximity to shore (e.g., shoreline, coastal, shelf, and offshore) and by depth zone within these (i.e., surface; depth ranges in the water column; sea floor;

Table **2-3**). Together, the combination of a VEC, such as Marine Mammals, and an EC, such as Offshore: Sea Surface, represents a single VEC:EC grouping (i.e., Marine Mammals in the Offshore: Sea Surface) that was assigned a CRA score and evaluated for the overall CRA.

Table 2-2. Valued Ecosystem Components (VECs) evaluated with example organism groups.

VEC	Representative Species and Taxa
Zooplankton	Amphipods, copepods, deep-sea shrimp, gelatinous spp.
Ichthyoplankton	Fish eggs and larvae
Small Pelagic Fishes	Snapper, anchovies, flying fishes, myctophids
Large Pelagic Fishes	Mahi mahi, sharks, tuna, billfish
Macrobenthos	Crabs, mollusks, other invertebrates exposure to bottom water contamination
Sargassum Communities	Associated fish and invertebrates
Birds	Sea birds (e.g., gulls, pelicans), waterfowl, waders, shorebirds
Marine Mammals	Dolphins, whales, manatees
Sea Turtles	Six species found in Caribbean, offshore Guyana
Coral Reef Communities	Deep-sea and shallow water corals
Demersal Fishes	Flatfish, grouper, catfishes, skates and rays
Shoreline Invertebrates	Barnacles and other crustaceans, mollusks, worms
Shoreline Vegetation	Mangroves, Spartina spp., seagrasses, macroalgae

Table 2-3. Environmental Compartments (ECs) evaluated.

Region	EC
Shoreline	N/A
Coastal/Nearshore	Sea Surface
Coastal/Nearshore	Water Column (<10 m)
Coastal/Nearshore	Sea Floor
Shelf	Sea Surface
Shelf	Upper Epipelagic (<20 m)
Shelf	Lower Epipelagic (20-200 m)
Shelf	Sea Floor
Offshore	Sea Surface
Offshore	Upper Epipelagic (<20 m)
Offshore	Lower Epipelagic (20-200 m)
Offshore	Deepwater (>200 m)
Offshore	Sea Floor

In the present work, the maximum potential exposure areas and volumes were defined in a model domain comprising the Caribbean Sea north of South America, extending east to the boundary with French Guiana. Data for the population densities and recovery potentials of the VECs were largely based on those derived for the Gulf of Mexico (French-McCay et al., 2018, 2021a, 2022; Bock et al., 2018, 2021). The population density of coral reef communities was derived from data on deep sea coral habitat suitability (Kinlan, et al., 2013), because it is not feasible to survey deep coral reef communities over an entire sea or model domain. These data presented the best available of this type and were assumed typical of similar offshore deepwater environments. The suitability data indicated that approximately 5% of the Gulf of Mexico seafloor had a greater likelihood (i.e., more than 50% chance) of reefs and related habitats being present. For the purposes of this assessment, the same 5% assumption was applied for the model domain in Guyana in efforts to provide a conservative look in the absence of seafloor data outside EMGL operated blocks. Also updated for this assessment, shoreline habitats were considered separately from subtidal soft-bottom benthic communities, whereas in French-McCay et al. (2022), invertebrates in both habitats were considered together. For shoreline invertebrate and vegetation VECs, production rates used to calculate relative population densities and recovery times were based on data for the Caribbean Islands in French et al. (1996) and French-McCay (2009), respectively.

Computationally, oil trajectory and fate results from the spill modeling were used to calculate time-weighted exposures metrics, reported in units of either km^2-days (on the sea surface and shorelines) or m^3-days (in the water column). The exposure metrics represent the exposed area or volume exposed above a threshold of concern for the duration that hydrocarbons are present in the model simulation. CRA scores are calculated from these metrics by determining the portion of each EC exposed (compared to the Maximum Possible Exposure over the whole domain), then multiplying first by the fraction of the total VEC population present in each EC (i.e., a population index) and multiplying again by a relative index of recovery time (Equation 1). The resulting VEC:EC combination scores can be readily compared to other VECs and ECs in the model.

$$\begin{array}{c}\text{VEC : EC}\\ \text{Score}\end{array} = \left(\begin{array}{c}\text{VEC : EC}\\ \text{Exposure Index}\end{array}\right) \times \left(\begin{array}{c}\text{VEC : EC}\\ \text{Population Index}\end{array}\right) \times \left(\begin{array}{c}\text{VEC : EC}\\ \text{Recovery Index}\end{array}\right) \qquad \textbf{(1)}$$

Using the above-described methodology, exposure metrics and CRA scores were calculated for each VEC:EC combination to assess the relative exposures and risks for each of the examined response scenarios. These results are presented as a series of comparative graphs in Section 3.2, which provides exposure metrics predicted on the surface, shoreline, water column, and sea floor; and Section 3.3, which provides the full CRA scores calculated and compared for each scenario. Risk reductions (from reduced exposures at the surface and shoreline) and risk tradeoffs (from greater exposures of the deep water column and benthos) can therefore be assessed and compared for a quantitative SIMA.

In addition to the overall CRA conducted for the full model domain, location-specific ecological data were incorporated into separate geographic assessments of exposure. Three Geographic Groupings were spatially identified within the model domain (Table 2-4, Figure 2-2). Separate exposure metrics were calculated for each of these geographic groupings to allow comparative assessment by geographical area. In other words, individual assessments were conducted within the spatial areas defined by each Geographic Grouping, in order to compare how exposures in those areas would be affected by different response options.

Table 2-4. Geographic Groupings used in the CRA.

Geographic Grouping	Description
Manatee Area	Any waters falling within an identified Manatee Area in the model domain.
Sea Turtle Protection	Waters falling within an identified Sea Turtle Protection area in the model domain.
Guyana	Waters along the coast of Guyana and within the country's Exclusive Economic Zone

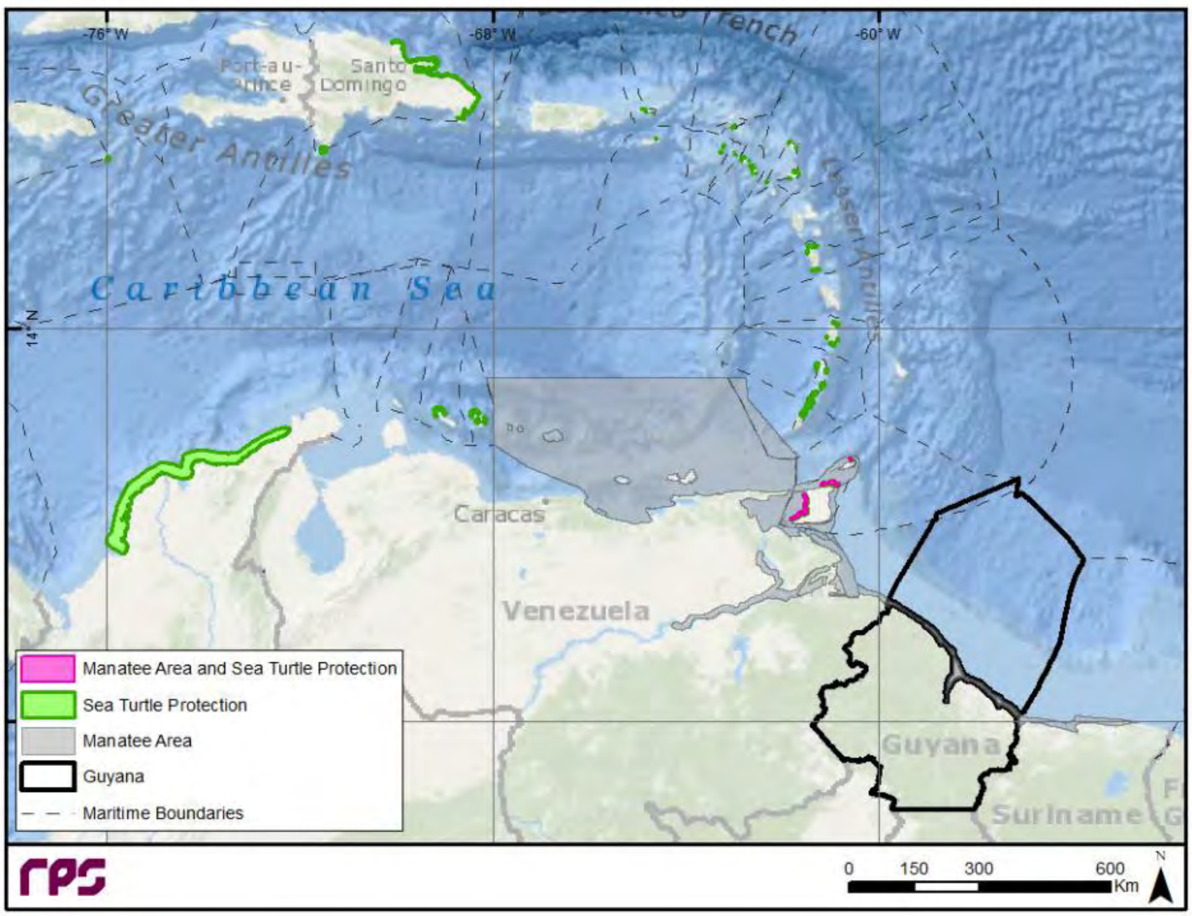


Figure 2-2. Map of Geographic Grouping locations used in the CRA. Separate exposure metrics were calculated within each Geographic Grouping's spatial area.

3 Results

3.1 Oil Spill Modeling Results

The near-field modeling using OILMAPDeep predicted the behavior of the rising plume in the event of a loss of well control at the wellhead. Under the conditions simulated at the Uaru site, droplet sizes were predicted to range from approximately 150 to 1,100 µm (microns). The resulting droplet size distribution was used in the Cap Only scenario and the four mitigated scenarios without SSDI. With SSDI, droplet sizes were predicted to range from approximately 75 to 550 µm (microns). These droplets would rise more slowly to the surface, and most are sufficiently small to remain at depth, without surfacing.

3.1.1 Mass Balance Results

The far-field modeling in SIMAP predicted the trajectory and fate of the oil as the droplets in the plume exited the near-field and either rose to the surface or stayed in the subsea (depending on droplet size), from there transporting through the model domain with winds and currents. A summary of the mass balance at the end of the 45-day simulations, in percent of released mass, is provided in Table B-2: . For each scenario, spill trajectories for both surface oil and dissolved components were individually modeled to allow for development of exposure metrics and for use as inputs to the CRA.

Table 3-1. Representative worst-case scenario mass balance at the end of the 45-day simulation, as percent (%) of the total column of oil released.

Scenario	Surface	Water Column	Ashore	Evaporated	Degradation	Sediment	Removed (via burning or mechanical recovery)
Cap Only	11.9	24.2	4.6	20.5	38.9	<0.1	0
Mech	9.9	23.8	4.6	20.4	38.2	<0.1	3.2
Mech + ISB	9.8	23.7	4.3	20.3	37.9	<0.1	3.9
Mech + SD	8.3	23.8	3.5	19.6	41.6	<0.1	3.2
Mech + ISB + SD	5.4	26.2	3.5	19.4	41.5	<0.1	3.9
Mech + SD + SSDI	2.9	26.5	1.7	12.4	53.3	<0.1	3.3
Mech + ISB + SD + SSDI	2.4	26.4	1.8	12.2	53.6	<0.1	3.5

The predicted mass balances over time for three of the simulations are provided in Figure 3-1 to Figure 3-3. The overall effects of applying a combination of mechanical recovery, ISB, and surface dispersants can be seen by comparing the Cap Only scenario (Figure 3-1) to the Mech + ISB + SD scenario (Figure 3-2). These response activities slightly reduced the amount of oil on the surface over the course of the simulation (red lines), while response activities continued to remove and disperse any floating oil that remained amenable to recovery and response.

The effects of applying SSDI can be seen by comparing the Mech + ISB + SD scenario (Figure 3-2) to the same scenario plus SSDI (Figure 3-3). The addition of SSDI was predicted to cause a marked decrease in VOC emissions to the atmosphere (black lines). This reduction started 3.5 days after the release began and primarily occurred over the next few days, while oil continued to surface. After the capping stack was applied (day 5.5), evaporation was predicted to dramatically slow in all scenarios, even without SSDI, due to the reduction in fresh surfacing oil. SSDI also significantly reduced the amount of oil on the surface (red lines), due to the dispersal of smaller droplets into the water column. This reduction is most notable after approximately July 6th (after 5 days), when the SSDI that started on day 3.5 began to have an effect on the amount of surfacing oil. SSDI also significantly increased biodegradation rates, such that the total mass degraded was considerably higher with SSDI as opposed to without SSDI.

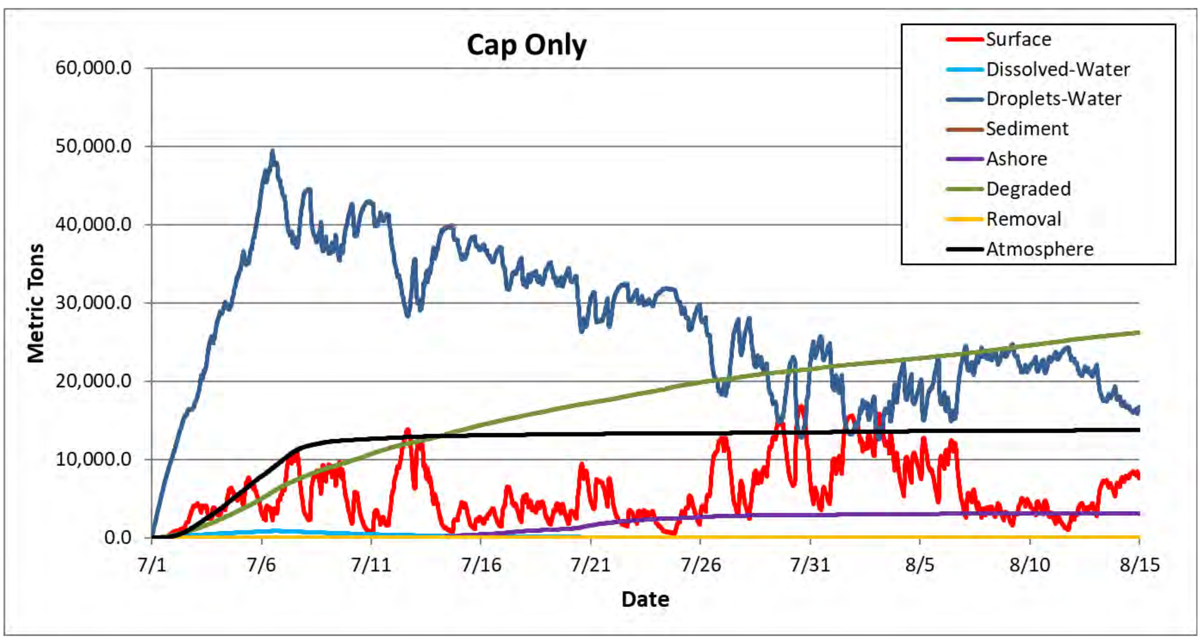


Figure 3-1. Mass balance over time for the scenario with only a capping stack applied (Cap Only).

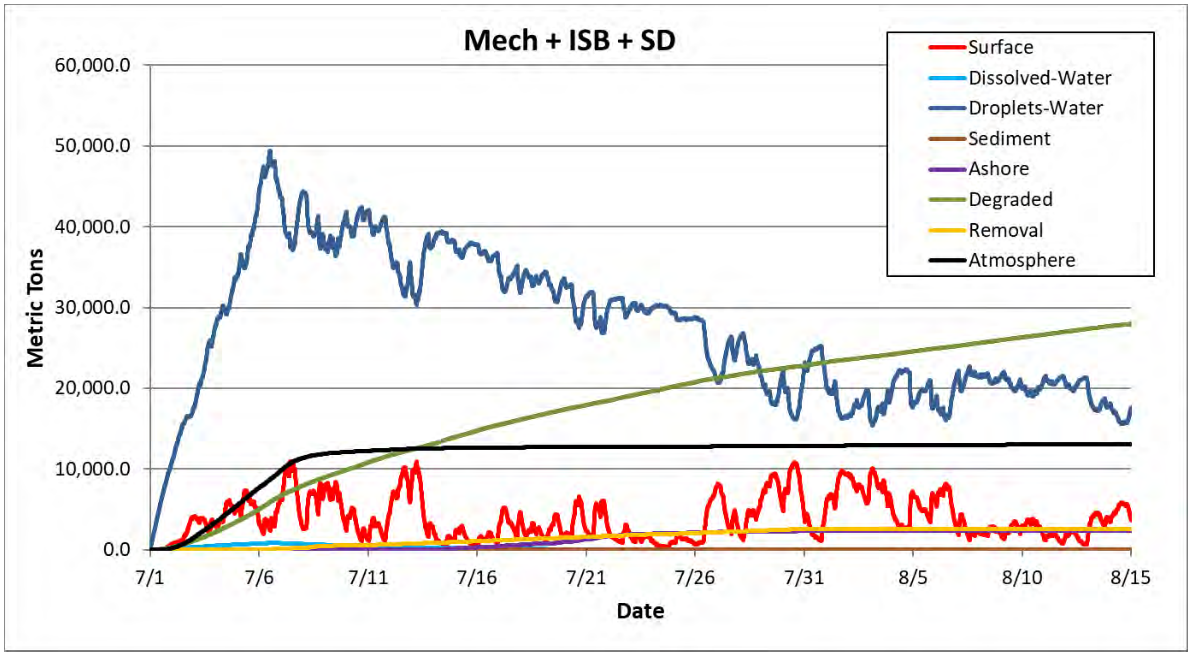


Figure 3-2. Mass balance over time for the scenario with a capping stack applied, mechanical removal, *in situ* burning, and surface dispersants (Mech + ISB + SD).

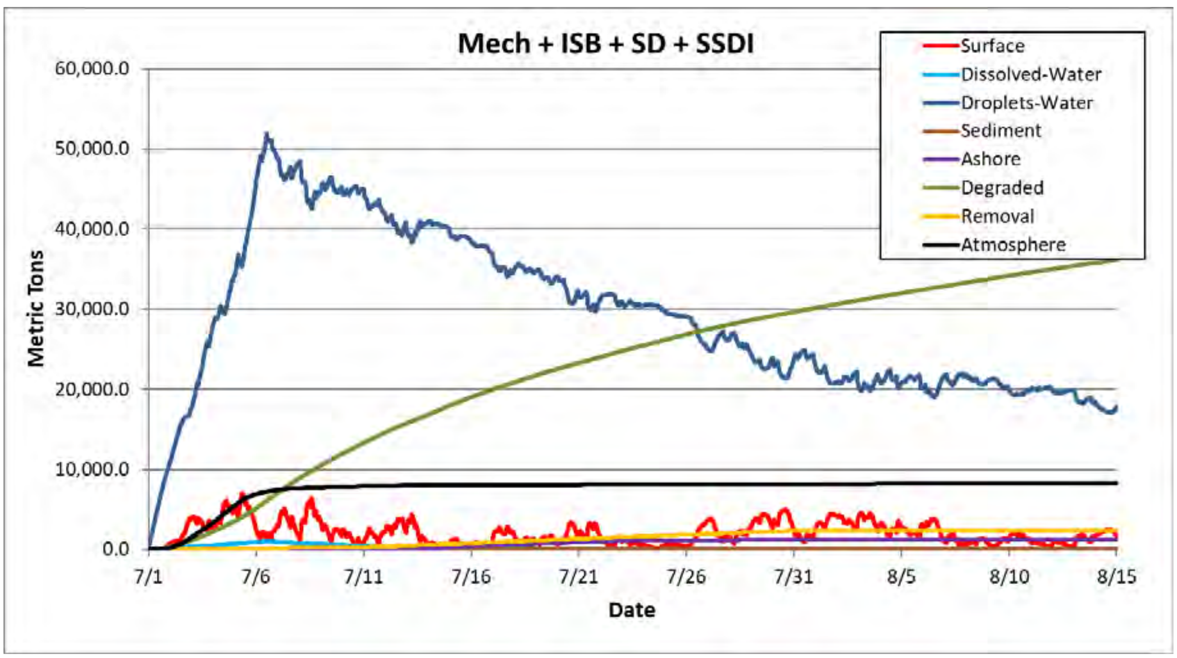


Figure 3-3. Mass balance over time for the scenario with a capping stack applied, mechanical removal, *in situ* burning, surface dispersants, and SSDI (Mech + ISB + SD + SSDI).

3.1.2 Volatile Emissions

The total volatile emissions to the atmosphere occurring by the end of the simulation are provided in Table 3-2 for each modeled scenario. Emissions are predicted to be slightly reduced with the application of various surface response strategies that remove the oil from the surface, preventing its further evaporation. Emissions are substantially reduced with the further application of SSDI, by approximately 40% in combination with other response options. SSDI slows the rise time of oil and allows for greater dissolution in the water column, preventing later evaporation on the surface. Some oil is also prevented from surfacing at all, which correspondingly restricts any volatile emissions from occurring from that oil. As noted in Section 3.1.1, the VOC reduction is predicted to occur after SSDI begins, with the >40% reduction overall occurring on the days during and immediately following the SSDI application. The mass balance shows that total VOC mass emitted to the atmosphere levels off on July 6 (Figure 3-3), as opposed to continuing to increase on subsequent days, as it did for the Cap Only scenario (Figure 3-1) and the Mech + ISB + SD scenario (Figure 3-2).

Note that because of the slower rise times, oil would also be captured longer in subsea currents and therefore surface farther away from the wellhead than without SSDI. The more distant surfacing would further reduce VOC exposures to responders near the wellhead, such as those installing the capping stack. Greater VOC reductions than those summarized in Table 3-2 could occur in the close vicinity of the wellhead, where larger droplets would otherwise surface to form thick slicks without SSDI.

Table 3-2. Total volatile emissions by the end of the simulations (metric tons, MT).

Scenario	Total Volatile Emissions (MT)
Cap Only	13,743
Mech	13,748
Mech + ISB	13,692
Mech + SD	13,185
Mech + ISB + SD	13,060
Mech + SD + SSDI	8,318
Mech + ISB + SD + SSDI	8,222

3.1.3 Shoreline Oiling

The length of shoreline oiled by shoreline type or category is provided in Table 3-3 for each modeled scenario. Slight differences in trajectory can result from different applications of response strategy, including the effects that prioritization of response (e.g., ISB versus mechanical recovery) can have on which areas are oiled in a specific scenario. However, net reductions are generally seen for increasing levels of response application, particularly including SSDI. Oiling primarily occurs on rocky shores and sand beaches, with smaller amounts of wetland and artificial shorelines oiled.

Table 3-3. Total shoreline length oiled above 0.01 mm threshold by the end of the simulations (km).

Scenario	Rocky Shore	Sand Beach	Wetland	Intertidal Artificial
Cap Only	218	56	3	6
Mech	214	55	3	6
Mech + ISB	201	55	3	5
Mech + SD	194	59	4	5
Mech + ISB + SD	196	53	3	7
Mech + SD + SSDI	153	37	3	4
Mech + ISB + SD + SSDI	144	42	2	4

3.2 Quantified Exposure Metrics

Three exposure metrics were assessed to quantify oil fate in a context that is meaningful for evaluating exposures during an oil spill. These metrics do not incorporate information on population density or potential recovery after exposure, as with CRA. They allow for direct comparison of relative differences in overall exposure potential within the model domain.

Figure 3-4 shows the predicted floating oil exposure on the surface (in km^2-days) for each modeled scenario, above lower and upper thresholds of exposure. Figure 3-5 shows the predicted shoreline exposure (in km^2-days) for each modeled scenario, above lower and upper thresholds. Figure 3-6 shows the predicted water column exposure (in m^3-days) for each modeled scenario, above lower and upper thresholds assumed for the exposure of fish. Plankton exposures were calculated in a similar way, but were compared to different thresholds (one order of magnitude lower) due to their higher sensitivity and the phototoxic effects of UV light.

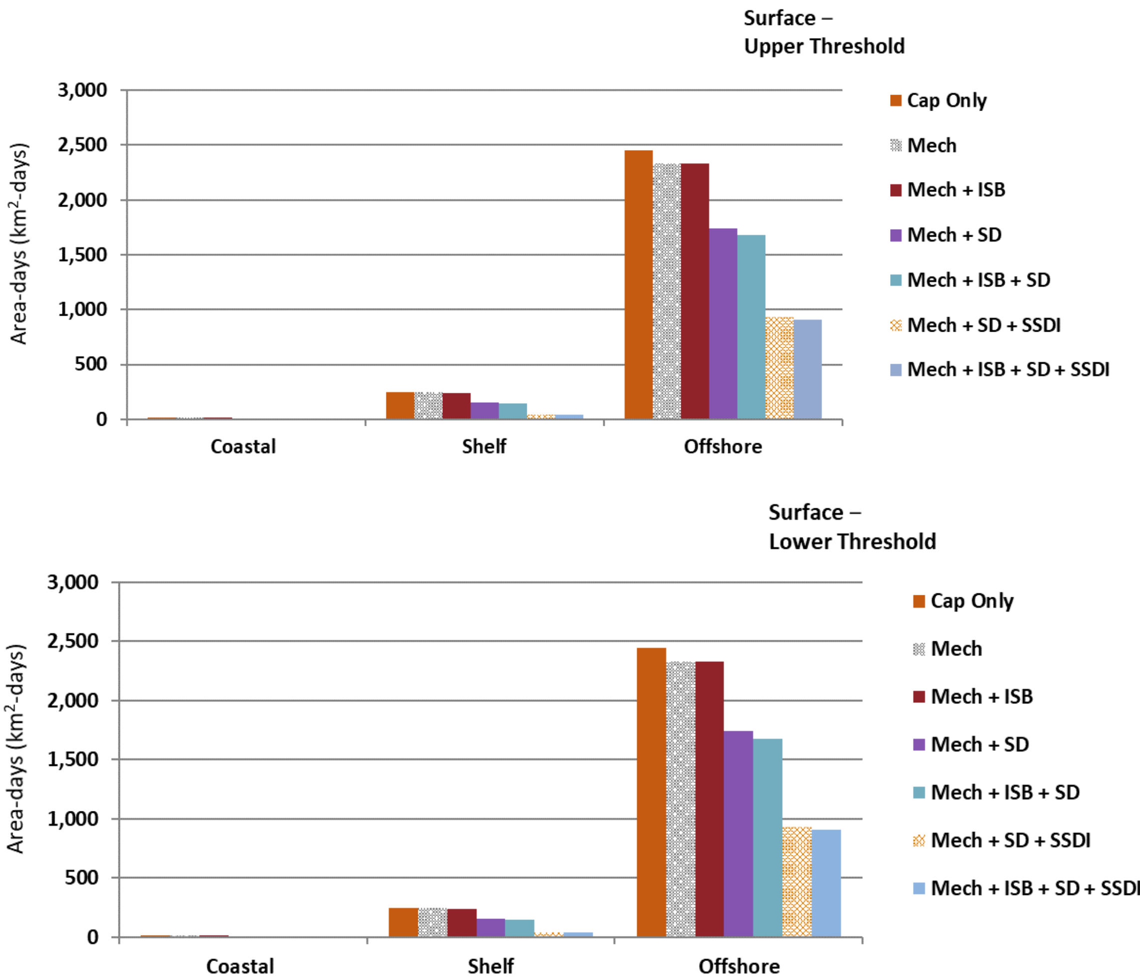
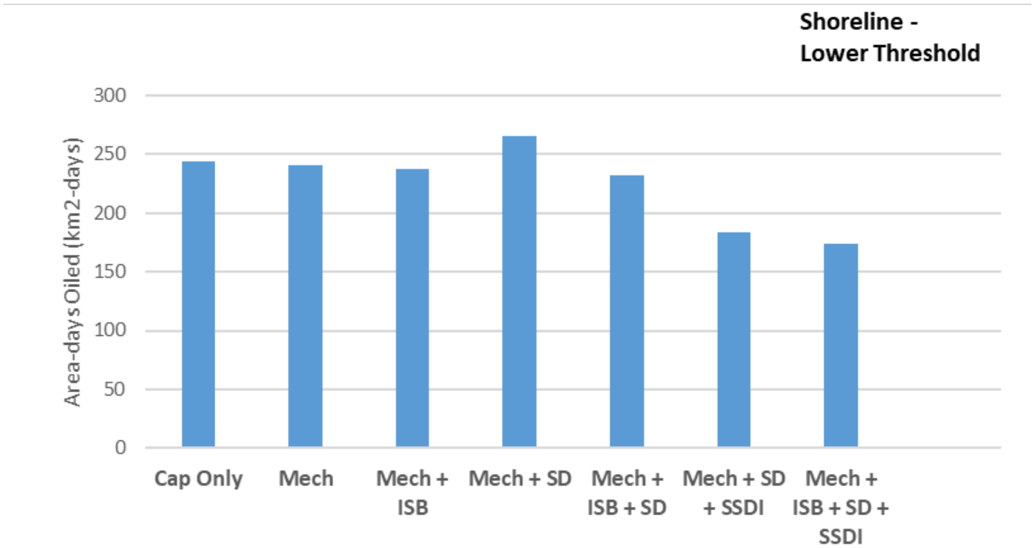


Figure 3-4. Modeled floating oil exposure (km^2-days) exceeding a lower threshold (top) and upper threshold (bottom).



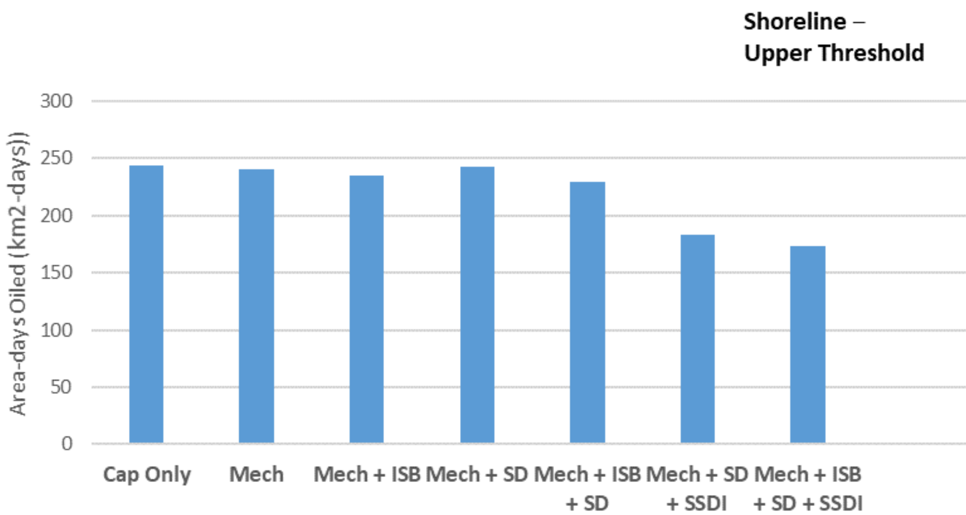


Figure 3-5. Modeled shoreline exposure (km^2-days) exceeding a lower threshold (top) and upper threshold (bottom).

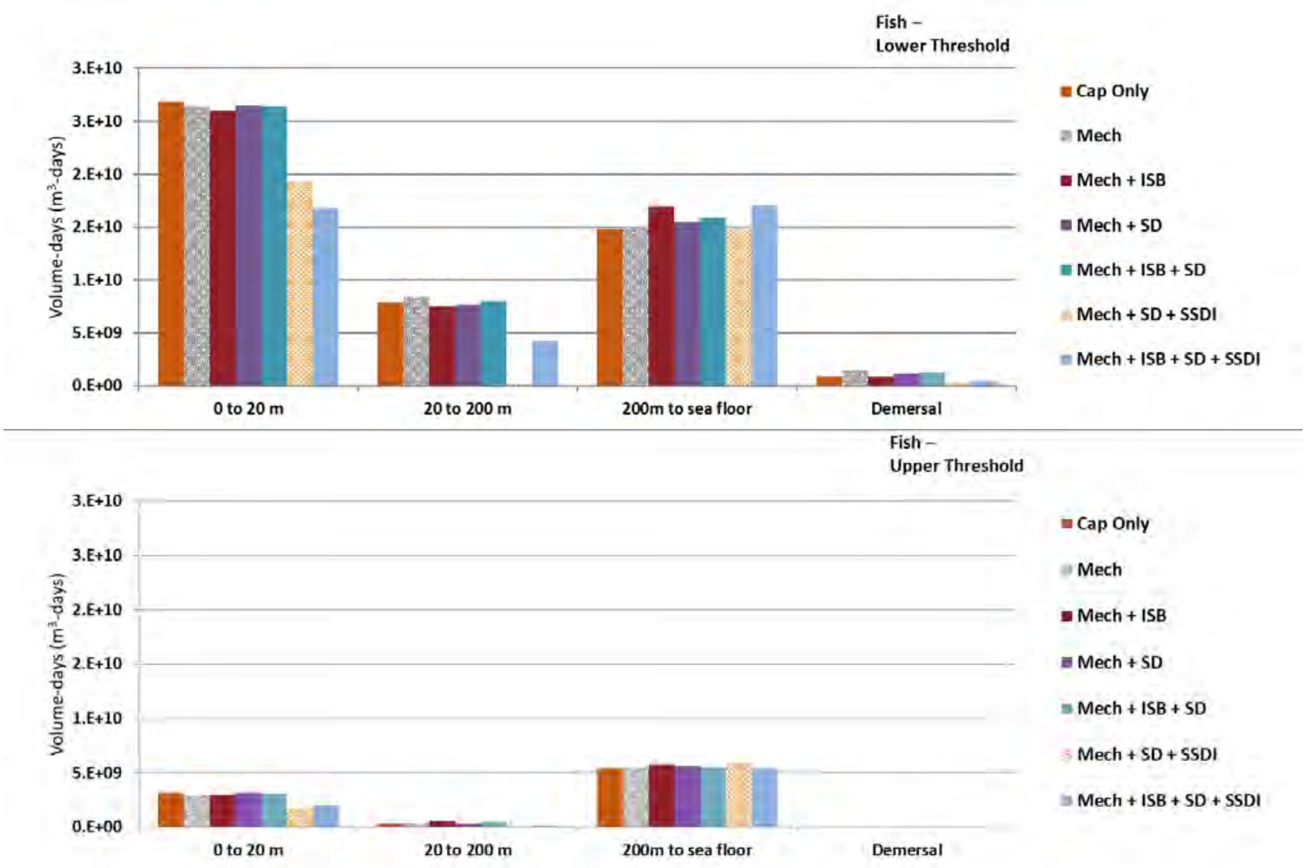


Figure 3-6. Modeled water column exposures (m^3-days) exceeding a lower threshold (top) and upper threshold (bottom).

The exposures to floating oil on the surface (Figure 3-4) occur primarily offshore, with some exposures in shelf waters and minimal coastal oiling in the areas adjacent to where the oil comes ashore. These exposures are slightly reduced with the activation of response technologies that directly remove surface oil (i.e., mechanical recovery and ISB) and are further reduced with surface dispersant application. The response scenarios including application of SSDI have the lowest surface exposures, due to reduced droplet sizes that rise more slowly and widely, limiting the formation of thicker slicks on the sea surface.

The exposures to shoreline oil (Figure 3-5) are generally reduced with the application of increasing response activities. Although the greatest lengths of shoreline oiling are predicted for rocky shores and sand beach (Table 3-3), shoreline exposures (per unit area) are greatest for wetlands because they have the largest shore width and greatest holding capacity of oil. Thus, slight differences in oil trajectory and fate result in different types of shoreline being exposed and some variation in predicted exposure (particularly for the Mech + SD scenario that has the longest wetland length oiled). The scenarios with SSDI have the shortest lengths of oiling overall and the lowest shoreline exposures as well.

The water column exposures to oil (Figure 3-6) are greatest near the sea surface (<20 m depth), where oil that initially surfaces is entrained by wind-induced waves into the water column. The vast majority of these exposures occur in the offshore and shelf environments. In these near-surface waters, surface dispersant application causes slightly higher exposures because it increases the dispersion of oil back into the water column. SSDI reduces the amount of oil surfacing and the thickness of that oil, which correspondingly reduces the amount of oil available to be entrained (i.e., smaller exposures near the sea surface). In contrast, the smaller droplets caused by SSDI remain longer in the deep water (200+ m depth); however, they are also dispersed more widely into a greater volume of water, such that deep water column exposures above the thresholds are not much different than without SSDI. Exposures near the seafloor at the bottom of the water column (where demersal fish and shoreline macrobenthos could be exposed to oil components) are lower than the other water depths for all scenarios.

3.3 CRA Results

Based on the exposure metrics for the one Cap Only scenario and six alternative response scenarios, CRA scores were calculated for each VEC:EC combination. Those scores, unweighted, are compared in Figure 3-7 for the 12 affected VECs (shoreline vegetation being exposed only to highly weathered oil residuals), summed across the ECs in which they reside, and in Figure 3-8 for the 13 ECs, summed across the VECs within them. Results are shown using both the lower and upper thresholds selected for CRA evaluation.

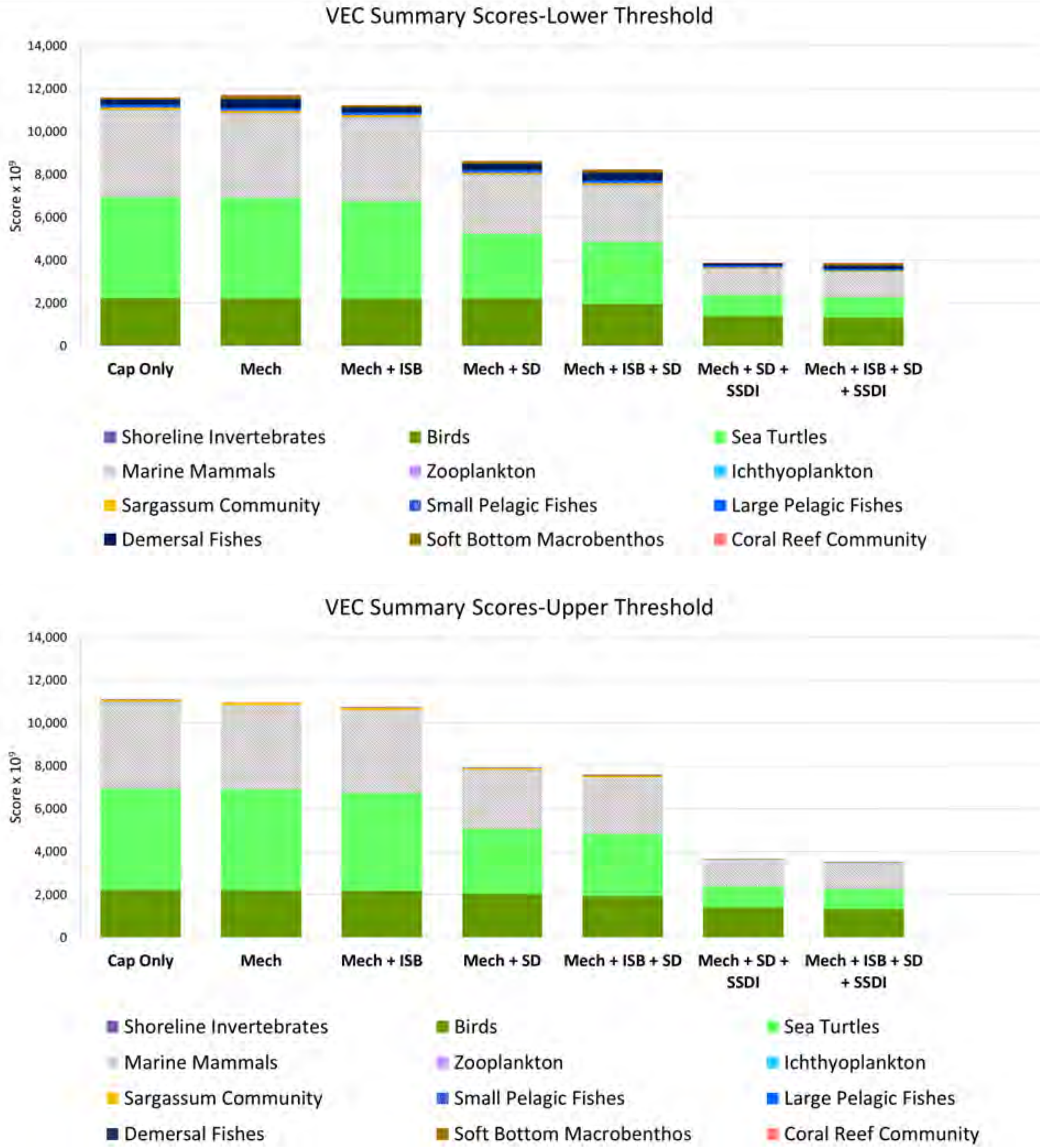


Figure 3-7. CRA Scores totaled for Valued Ecosystem Components (VECs), applying lower thresholds (top) and upper thresholds (bottom) for ecological effects.

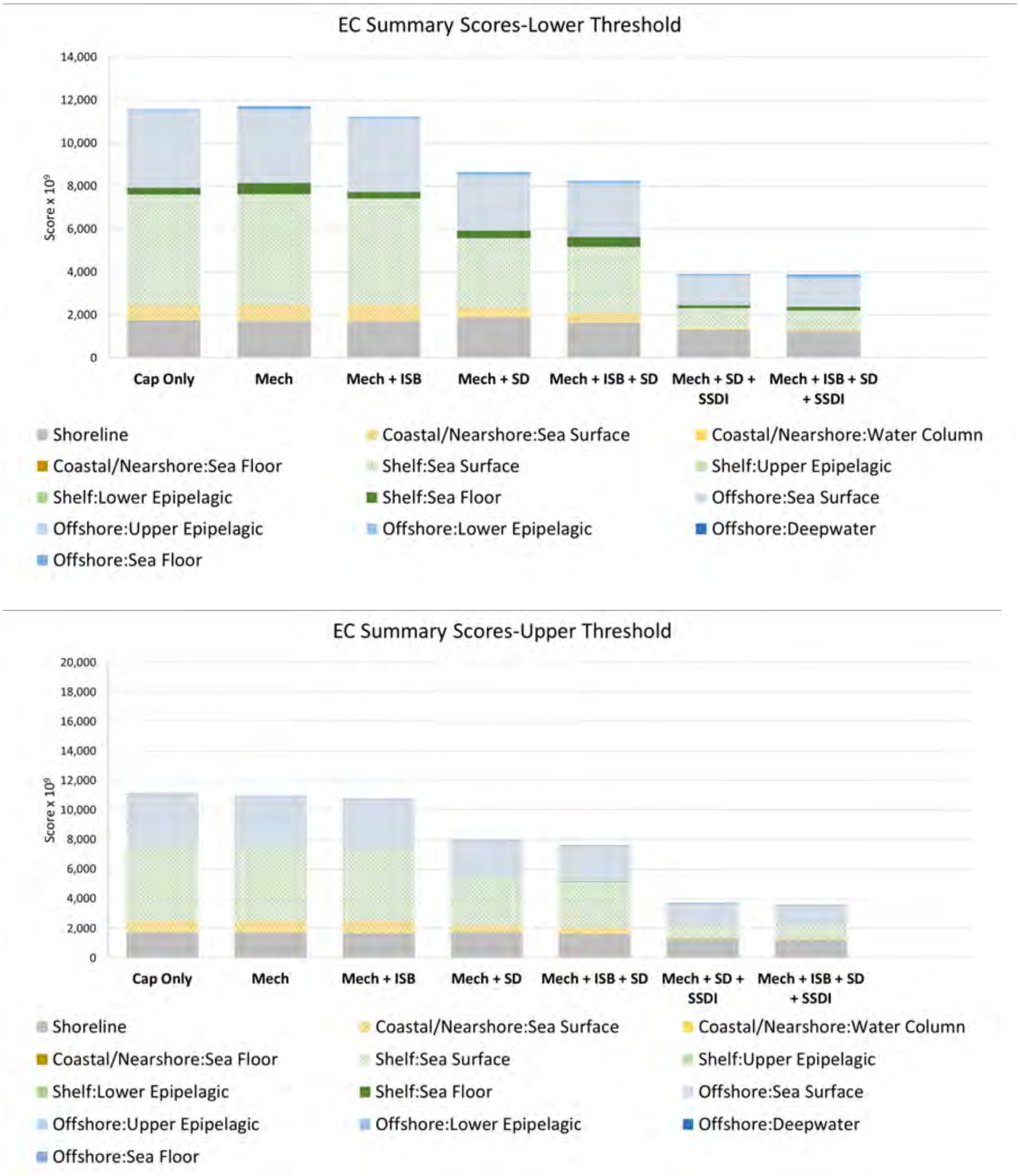


Figure 3-8. CRA Scores totaled for Environmental Compartments (ECs), applying lower thresholds (top) and upper thresholds (bottom) for ecological effects.

Viewed cumulatively, the CRA scores summed for the VECs (Figure 3-7) depict the importance of the relative population index (i.e., the opportunity to be exposed to oil) and the relative recovery index to predicting the overall relative risk to the VECs under different exposure scenarios. Scores are greatest for marine mammals, birds, and sea turtles, all of which spend time on the sea surface and/or shorelines and take longer periods to recover. The small fraction of surface oil removal that occurs with application of mechanical recovery and ISB (3.2 to 3.9%, Table B-2:) is not predicted to substantially reduce the relative risk for these scenarios. Relative risks are, however, reduced with surface dispersant application, and further with SSDI. In the modeled scenarios, any tradeoffs due to dispersion of the oil into the water column from dispersants are outweighed by the benefits to reduced oiling on the surface and shorelines. In net, the combined response scenarios result in substantially lower relative risk to the environment, taking into account the locations in which the VECs reside and their ability to recover after exposures to oil.

Similarly, the CRA scores summed for the ECs (Figure 3-8) show a similar reduction in relative risk with surface dispersant application, and further with SSDI. Risk scores are highest for the sea surface ECs on the shelf and offshore, followed by the shoreline. For these scenarios, lower risks are also associated with the water column in coastal waters (where greater densities of VECs reside) and the sea floor in shelf and offshore areas (where dissolved oil components may contact demersal species near the water bottom). Viewed cumulatively, the scores for other ECs are not contributing notably to the overall risk for any scenario, even without response.

The primary sources of uncertainty in the CRA are gaps in knowledge on the distribution and recovery of VECs. The VECs represent multiple species or groups of species that are generally treated as one group with similar characteristics. In reality, they can have varying habitat utilization, varying ecological importance (e.g., certain species have protected status), and may exhibit different behaviors affecting their exposure to oil, such as migratory behavior, life stage distributions, etc. One benefit of the CRA tool is that these inputs can be changed with better information, without rerunning the oil spill and exposure modeling.

To address this uncertainty, three Geographic Groupings were separately evaluated to determine the potential exposures to key ecological habitats in the model domain. The surface areas or volumes of water exposed over time within certain areas (i.e., Manatee Areas, Sea Turtle Protection areas, and the waters of Guyana) were calculated for these Geographic Groupings (Table 3-4, Table 3-5). Similar patterns in exposure are seen within each Geographic Grouping as with the model domain as a whole. However, there is some variation in the level of exposure predicted with different response combinations, such as scenarios where the addition of ISB does not cause a reduction in exposure within a certain Geographic Grouping. This variation results from slight differences in oil trajectory that were predicted to occur under different response scenarios, either moving oil into or out of areas categorized in a Geographic Grouping. The results are affected by the prioritization of response resources and the model’s ability to identify oil amenable to dispersant or removal (via mechanical recovery of ISB) at different timepoints in the simulation.

Table 3-4. Modeled floating oil exposure (km^2-days) exceeding the lower threshold for wildlife, by Geographic Grouping.

Scenario	Guyana	Manatee Area	Sea Turtle Protection
Cap Only	668	359	127
Mech	675	338	132
Mech + ISB	676	330	130
Mech + SD	571	190	90
Mech + ISB + SD	552	186	87
Mech + SD + SSDI	291	6	0
Mech + ISB + SD + SSDI	308	134	9

Table 3-5. Modeled water column exposures (m^3-days) exceeding the lower threshold for fish, by Geographic Grouping.

Scenario	Guyana	Manatee Area	Sea Turtle Protection
Cap Only	3.54E+10	2.32E+04	1.17E+08
Mech	3.54E+10	2.12E+03	4.96E+08
Mech + ISB	3.69E+10	7.55E+03	2.47E+08
Mech + SD	3.62E+10	1.64E+05	2.54E+08
Mech + ISB + SD	3.69E+10	2.63E+04	2.33E+08
Mech + SD + SSDI	2.19E+10	3.30E+03	0.00E+00
Mech + ISB + SD + SSDI	3.08E+10	2.37E+03	1.38E+08

4 Spill Impact Mitigation Assessment (SIMA)

A SIMA was conducted to help responders make the best choices to minimize impacts of potential oil spills on people and the environment. This SIMA utilized an oil spill scenario involving a Most Credible WCD crude oil release from loss of well control at the Uaru location. The SIMA results provide a representative analysis for the Most Credible WCD release that would also be applicable to smaller spills. The assessment involved oil spill modeling of different response options and a relative risk analysis using the CRA approach to quantitatively compare those options. The results of the CRA helped identify the option or combination of options that minimized overall harm.

Similar to previous studies performed by RPS in this area, the trajectory and fate of a loss of well control event simulated at the Uaru wellhead was driven largely by the strong northwestward flowing currents running parallel to the South American coast. Without any response action (other than the capping stack), surface oil was predicted to travel towards the northwest and reach shorelines along parts of Trinidad, Tobago, and the Lesser Antilles. With increasing levels of response action, the extent and degree of surface oiling was reduced, as was the resulting shoreline oiling. In the scenarios including SSDI, the surface and shoreline oiling primarily resulted from oil released before SSDI began (which was 3.5 days after the spill start). Once SSDI was initiated, further surface and shoreline oiling was largely prevented.

The potential environmental effects of an oil spill on the coastline of Guyana were compared by evaluating the different exposure metrics and CRA scores associated with different response strategies. Overall, the exposures and relative risks across the ecosystem were substantially reduced with response application and particularly SSDI. The scenarios that included SSDI were predicted to have sea surface exposures up to 60-88% lower than the Cap Only scenario. These scenarios were also predicted to have shoreline exposures that were 25-30% lower than the Cap Only scenario. Water column exposures were predicted to be greatest near the sea surface where oil was able to be entrained by wind-induced waves into the water column. SSDI reduced the amount of oil surfacing and the thickness of that oil, which correspondingly reduced the amount of oil available to be entrained. In contrast, the smaller droplets caused by SSDI remained longer in the deep water (200+ m depth); however, they were also dispersed more widely into a greater volume of water, such that deep water column exposures were not much different than without SSDI.

The CRA scoring further showed that response application resulted in substantially lower relative risk to the environment as a whole, taking into account the locations in which the VECs reside and their ability to recover after exposures to oil. The relative risk scores totalled for both VECs and ECs were reduced with increasing application of response. The degree of reduction primarily depended on the type of response strategy and its effectiveness at reducing the surface and shoreline exposures. Mechanical recovery and ISB therefore had the least effect on reducing overall risk. Risks were reduced with surface dispersant application and were lowest for the scenarios that included SSDI. Any tradeoffs due to dispersion of the oil into the water column from dispersants were outweighed by the benefits to reduced oiling on the surface and shorelines.

Another important feature of SSDI was not only that it kept some oil from surfacing entirely, but also that it dispersed oil into smaller droplets that rose more slowly allowing oil to weather (dissolve and biodegrade), reducing VOC emissions by approximately 40% (in combination with other response options). This would provide benefit and improve safety for responders working near the wellhead and in areas proximate to the surfacing oil.

5 References

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APPENDIX I – FORMS

I.1. Incident Notification Form for Spills in Offshore Operations

Environmental Protection Agency

Incident Notification Form for Spills in Offshore Operations

General Information

Scope of document use and application: The document shall be applicable to all spills amounting to **five (5) Imperial gallons or more**; however, any other spills, unwanted or accidental discharges shall be recorded and reported to the EPA on a monthly basis. The Agency shall reserve the right to request further information and investigations into incidents highlighted in the monthly reports as it deems necessary.

An initial incident notification form must be forwarded to the Environmental Protection Agency within **forty-eight (48) hours** of spill incident. Copies of the Original Forms must be emailed to kparsram@epaguyana.org, jgravesande@epaguyana.org, and epa@epaguyana.org. Printed copies can be sent via mail to Environmental Protection Agency, Ganges Street, Sophia, Georgetown, Guyana. A follow-up incident notification form must be submitted within **seventy-two (72) hours** of the submission of the initial notification form (a total of five days after the spill incident).

Note: The EPA reserves the right to request additional documentation as deemed necessary

Type of Notification: (Initial or Follow-up)			
Name of Project:		Permit Reference No.	
Permit Holder:		Contractor:	
Type of activity being undertaken: *For example: installation, exploration or developmental drilling, etc.*		Project Location: *(include GPS coordinates)*	
		Worksite: *(include GPS coordinates)* *For example: Vessel Name*	
Work area where incident occurred:		Equipment involved in the incident:	
Date of incident:		Date reported to EPA:	
Time incident started/discovered		Time incident Ended/contained	
Environmental Conditions at the time of Incident			
Weather	☐ Cloudy ☐ Sunny	☐ Windy ☐ Rainy	
Wind speed and direction			
Swell height			
Sea conditions	☐ Calm ☐ Slight	☐ Moderate ☐ Rough	☐ Very Rough ☐ High
Light	☐ Good ☐ Fair	☐ Poor ☐ Natural	☐ Artificial
Situation Report			
Description of event *(Give details of spill location, discharge point, apparent source and cause)*			

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Environmental Protection Agency

Incident Notification Form for Spills in Offshore Operations

Note: Where equipment is involved as a potential cause of the spill, attach the operator's maintenance schedule, manufacturer's maintenance requirements and most recent maintenance report.			
Description of spilled substance *(Include SDS as an attachment)*			
Quantity spilled	Litres	Gallons	Barrels
Description of Environmental Impact(s)			

Immediate Response Actions Taken		
Time action was taken	**Action taken**	**Person(s) that took action** *(include name, designation, department employed, and employer)*

Root Cause Analysis *(To be completed as part of the follow-up submission)*	
Direct Cause	**Root Cause(s) for each direct cause**

Preventative actions to be implemented *(To be completed as part of the follow-up submission)*		
Time Period for Implementation	**Preventative action to be implemented (for each root cause mentioned)**	**Designated person(s) to oversee the implementation of preventative action** *(include designation, department employed, and employer)*

Other Observations/Comments
1.
2.
3.

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Environmental Protection Agency

Incident Notification Form for Spills in Offshore Operations

Limitations
1.
2.

List of Attachments	
For Example: Photos, Maintenance Records, Schematics, SDS', Signed Witness Statements, etc.	1.
	2.
	3.

Witnesses (if any): (as part of follow-up notification)	Name in print: 1. 2.	Designation and employer of each witness: 1. 2.

Signatures			
I hereby certify that the information contained herein and attached is true and correct to the best of my knowledge, information and belief, and fully acknowledge and accept that any false or misleading information provided hereunder shall render me liable to penalties under the Environmental Protection Act, Cap. 20:05.			
Completed By (Name in print):	Signature:	Date (dd/mm/yyyy):	Designation and Employer:
Verified By (Name in print):	Signature:	Date (dd/mm/yyyy):	Designation and Employer:
Approved By (Name in print):	Signature:	Date (dd/mm/yyyy):	Designation and Employer:

Page 3 of 3

I.2. Dispersant Use Planning Form – Initial Incident Information

Incident Sheet for Dispersant Use Concurrence Requests				
Name of Incident: **Initial Time of Spill:** **Date**______/______/______ Time: ____:______ ______ Month Day Year 24 Hour Clock Time Zone				
Air Monitoring Data: (Maximum reported in Source Control area of operations)				
VOC:	Percent LEL:			
Incident Location:				
Distance (miles/km) and Direction to nearest land:	Lat: N/S Long: E/W			
Block Name: Block Number: Water Depth:				
Brief Description of Incident:				
Incident: Pipeline___ Transfer Operations___ Explosion___ Collision___ loss-of-well-control ___ Facility Release___ Other________________________________ Type of Release: Instantaneous (___) Continuous Flow (___) Did the source burn? Yes (___) No (___) Is the source still burning? Yes (___) No (___) Estimated water surface covered (square miles/square km) ________________				
Event Chronology:				
Oil Characteristics:				
Name:	API Gravity:	GOR:	Pour Point:	Viscosity at release
Is the oil dispersible into the water column: Yes/No (circle one)				

I. Forms

Spill Description:	
Estimated Flow Rate (bpd): ________________ Estimated Spill Volume:____________________ Product easily emulsified? Yes (___) No (___) Product already emulsified? No (___)	
Method used for estimate:	
Current On Site Weather Conditions	
Sea state – wave height:	Beaufort Scale:
Wind direction and velocity (knots):	
Ceiling:	Visibility:
Five day forecast: Forecasted wind speed / direction (24 hours): ______knots from the ______ (direction) Forecasted wind speed / direction (48 hours): ______knots from the ______ (direction) Temperature: Air ___°F/C Water ___°F/C Dominant Current, net drifts (towards): Speed ___ knots; Direction ____ Water Depth (fathoms ___ Feet ___ Metres_____) 0-3 (___) 4-10 (___) 11-30 (___) 31-99 (___) >100 (___) Other considerations: Low Visibility (___) Rip Tides (___) Whirlpools (___) Eddies (___)	
Additional Data that could affect operations: (e.g., subsea currents speed and direction, oil seeps)	
Surface Slick/Subsurface Plume Modelling	
2-D/ 3-D Model(s) used:	
Expected slick/plume trajectory and behaviour:	

I.3. Dispersant Use Planning Form – Application Tactics

Description

Reason(s) for requesting dispersant use:

____

____

Location of area to be treated relative to the following, as shown on attached chart:
Slick/Trajectory
Dispersant Zone
Nearest Land
Wellhead/Release Point

Dispersant Operations

Name of dispersant proposed for use:	Application platform(s): Aerial______ Vessel______ Subsea______

Safety Plan for applicable platform(s) in place? Yes (__) No (__)

Planned time of dispersant application (as applicable):
Sortie 1: Start ________________ Finish________________
Sortie 2: Start ________________ Finish________________
Sortie 3: Start ________________ Finish________________
Sortie 4: Start ________________ Finish________________
Estimate percentage of surface spill area to be treated (if known)
1-5% (___) 6-20% (___) 21-40% (___) 41-70% (___) 71-99% (___) 100% (___)
Estimate percentage of subsea volume treated (if known):
1-5% (___) 6-20% (___) 21-40% (___) 41-70% (___) 71-99% (___) 100% (___)

Dispersant Dosage Goals

Ratio of dispersant-to-oil (DOR): ______________
Gallons per acre: ______________

Dispersant Decision

Responsible Party Incident Commander________ Approve/Concur Signature: ________________
Regulatory Agency Coordinator ________________ Approve/Concur Signature: ________________
Regulatory Agency Coordinator ________________ Approve/Concur Signature: ________________

Additional consultation or concurrence, if needed

Agency/Contact	Concurrence/Consultation Method (verbal/written)		Time/Date
______________	______________	______________	______________
______________	______________	______________	______________

Points of Contact

	Name	Position	Telephone
Regulatory Agency	________________	________________	(_____)_____-___________
Regulatory Agency	________________	________________	(_____)_____-___________
Responsible Party	________________	________________	(_____)_____-___________
Other	________________	________________	(_____)_____-___________
Other	________________	________________	(_____)_____-___________

I.4. Oil Spill Response Limited (OSRL) Notification Form

OSRL NOTIFICATION FORM

WARNING! Ensure telephone contact has been established with OSRL's Duty Manager before using e-mail and fax communications.

To	Duty Manager		
Southampton Emergency Fax	+44 (0)23 8072 4314	Fort Lauderdale Emergency Fax	+1 954 987 3001
Southampton Telephone	+44 (0)23 8033 1551	Fort Lauderdale Telephone	+1 954 983 9880
Email	dutymanagers@oilspillresponse.com		
Section 1	**Obligatory Information Required-Please Complete All Details**		
Name of person in charge			
Position			
Company			
Contact telephone number			
Contact Mobile number			
Contact fax number			
E-mail address			
Section 2	**Spill Details**		
Location of spill			
Description of slick (size, direction, appearance)			
Latitude / longitude			
Situation (cross box)	❑ Land ❑ River ❑ Estuary ❑ Coastal ❑ Offshore ❑ Port		
Date & time of spill	❑ GMT ❑ Local		
Source of spill			
Quantity (if known)	❑ Cross box if estimate		
Spill status (cross box)	❑ On-going ❑ Controlled ❑ Unknown		
Action taken so far			
Product name			
Viscosity			
API / SG			
Pour point			
Asphaltene			
Section 3	**Weather**		
Wind speed & direction			
Sea state			
Sea temperature			
Tides			
Forecast			

Section 4	**Additional Information Required – Please Complete Details if Known**
Resources at risk	
Clean-up resources	
On-site / Ordered	
Nearest airport (if known)	
Runway length	
Handling facilities	
Customs	
Handling agent	
Section 5	**Vessel Availability**
Equipment deployed	
Recovered oil storage	
Section 6	**Equipment Logistics**
Transport	
Secure storage	
Port of embarkation	
Location of command centre	
Other designated contacts	
Section 7	**Special Requirements of Country**
Security	
Visa	
Medical advice	
Vaccinations	
Others (specify)	
Section 8	**Climate Information**
Section 9	**Other Information**

I.5.. Oil Spill Response Limited (OSRL) Mobilization Form

OSRL MOBILIZATION FORM

WARNING! Ensure telephone contact has been established with OSRL's Duty Manager before using e-mail and fax communications.

To	Duty Manager
Southampton Emergency Fax	+44 (0)23 8072 4314
Southampton Telephone	+44 (0)23 8033 1551
Email	dutymanagers@oilspillresponse.com

Authorizer's Details	
Subject	Mobilization of OSRL
Date	
Name	
Company	
Position	
Contact Telephone Number	
Contact Mobile Number	
Contact Email Address	
Incident Name	
Invoice Address	
I, authorize the activation of Oil Spill Response Limited and its resources in connection with the above incident under the terms of the Agreement in place between above stated Company and Oil Spill Response Limited.	
Signature:	

If OSRL personnel are to work under another party's direction please complete details below:

Additional Details	
Name	
Company	
Position	
Contact Telephone Number	
Contact Mobile Number	
Contact Email Address	

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APPENDIX J – SUMMARY OF EMGL TRAINING 2021– 2023

J.1. Summary of EMGL Training, Simulations, Exercises, Mobilizations and Oil Spill Response Drills 2021 - 2023

Year	Training	Exercise		
		Emergency Call-Outs and Test Notifications	High Consequence Process Safety Simulated Tabletop Exercises	Oil Spill Equipment Mobilization Exercises
2021	• **WebIAP Software Training** geared towards Users to enhance capability in the use of IAP Software, forms, and data entry during an emergency response. Participants included IMT members, SCB and SBM. • **Emergency Response equipment demonstration** for ERT at GYSBI. Participants included EMGL ERT. • **ICS 300 Training and workshop** was completed in 2Q and 3Q 2021, focusing on building the capacity of personnel on the IMT. These training were completed over a three-day period, each.	• **ESG Callout** - Quarterly notification exercise EMGL ESG • **Callout** - MIR 3 notification exercise. All employees and contractors • Established a structured preventative maintenance (PM) program for in-country Tier I oil spill response equipment	• Destiny LOPC on production riser resulting in oil on water EMGL ESG • **First Response Toolkit** (FRT) equipment walk-through with EPA EMGL ESG/ IMT Members, EPA • **Equipment walk-through** of EMGL first response toolkit (FRT) for government agencies GWT, EMGL, GoG agencies • Following the arrival of Liza Unity FPSO, a HC **process safety joint tabletop exercise** was conducted between SBM LECC and EMGL IMT. This exercise test SBM and EMGL joint tactical ability to manage a Tier II event on the Liza Unity FPSO. A similar exercise using the same scenario was done for Liza Destiny FPSO • **4Q21**- A Joint IMT/SCB tabletop exercise with the ARRT was completed.	• **Liza Unity FPSO** dedicated Tier I OSR Equipment preventative maintenance and deployment by Vikoma OEM and ERT Personnel on open water - EMGL IMT, SBM, Marine Logistics, MARAD • Supported the GoG and CDC to plan, design and observe 2021 Tradewinds exercise which featured an **oil spill scenario in the Demerara River**. This exercise involved agencies and members from the NOSCP in the Command Post and tactical plans including on water deployment of Tier I equipment.

J. Summary of EMGL Training 2021 - 2023

Year	Training	Exercise		
		Emergency Call-Outs and Test Notifications	High Consequence Process Safety Simulated Tabletop Exercises	Oil Spill Equipment Mobilization Exercises
2022	• **Tier 1 equipment maintenance, mobilization execution and on-water deployment -** OEM Tier I response equipment hands on training to build local skill set on preventative maintenance for in-country response resource. Training was also completed offshore with marine vessel teams to use and deploy Tier I equipment. This training was done at anchorage, offshore Guyana. Participants included EMGL Operations Maintenance team, Logistics, SBM and marine vessel crew.	• ESG Callout - Quarterly EMGL ESG • IMT Callout - Quarterly EMGL IMT • Emergency Alerts Callout - Quarterly Notification All	• **3Q22** - An advanced tabletop exercise with process safety HC scenario that exceeds "preventative escalation" safeguards - FPSO abandonment was completed with SBM LECC and EMGL IMT. This exercise demonstrated process safety safeguards, test safety critical devices, confirmed response teams roles and responsibilities, test notification procedures between difference organizations etc. • **4Q22** - EMGL completed a full-scale tabletop Tier III source control exercise with IMT, SCB, ARRT, GoG agencies who form part of the NOSCP committee and third-party Tier III contractors. Exercise test activation protocols for local and global response resources, reinforced understanding of tactical response plans, develop team proficiency and leadership capacity and leverage GoG interface.	• **Demerara River Spill at GYSBI Quayside-** Mobilization and on water deployment exercise of Tier I shoreline equipment at GYSBI. Equipment was deployed in the Demerara river - 1Q22. • **1Q22** - **Tier I Offshore equipment deployment exercise** completed with equipment OEM, EMGL, SBM, Marine Vessels and logistics. Exercise was conducted at anchorage, 10 miles offshore Guyana. Location was identified as it was similar to offshore sea conditions. This exercise also tested the dispersant application devices and disc skimmer.

J. Summary of EMGL Training 2021 - 2023

Year	Training	Exercise		
		Emergency Call-Outs and Test Notifications	High Consequence Process Safety Simulated Tabletop Exercises	Oil Spill Equipment Mobilization Exercises
2022 (cont.)	• **ICS 100/200/300 and WebIAP Software Training** - Training was completed twice in 2022 targeting IMT, SCB and SBM personnel. In August 2022, EMGL IMT and SBM LECC members participated in a refresher ICS and WebIAP one day training. In November 2022, to support a full-scale source control response exercise, another refresher session of WebIAP and ICS training was completed with the IMT and SCB. Following two days of SCB management and IMT refresher of ICS, including a review of WebIAP software, IMT roles and responsibilities, use of preloads, templates, forms, and checklists. • **University of Spill Management** (incl ICS 300) in Louisiana + Exercise			

J. Summary of EMGL Training 2021 - 2023

Year	• Training	• Exercise		
		• Emergency Call-Outs and Test Notifications	• High Consequence Process Safety Simulated Tabletop Exercises	• Oil Spill Equipment Mobilization Exercises
2023	• Oil Spill Response OEM hands on training on Tier 1 in-country equipment preventative maintenance for local workforce • ICS100/200/300 capacity building training for Tradewinds23 • ICS 300 training for EMGL and SBM team forming part of the Guyana Enterprise and 4WD transformation • Incident Command training and onboarding for Payara Asset Manager and Deputy • UoSM training for team members in Paradis, Louisiana	• ESG Callout - quarterly EMGL ESG • IMT Callout - quarterly EMGL IMT • ESG / IMT On - Call Duty Roster – Weekly • Emergency Alerts Callout - quarterly Notification All EMGL Employees	• ESG workshop bridging the gap and difference between ESG Strategic response vs IMT Tactical response- Refresher EMGL ESG • **EMGL** BCP exercise- Security overview for LT, ESG and BL Managers • 3Q23- Prosperity SBM LECC / IMT basic joint tabletop HC Tier 2 exercise a part of start-up commissioning. This exercise test and confirmed SBM and EMGL joint tactical IC roles and responsibilities and response interface, communications, tactical plans. etc. • 4Q23 – EMGL and SBM joint table top exercise with Liza Asset team to test response readiness to a HC Tier 2 event • 4Q23 – SCER tabletop high consequence Wells exercise, testing IMT and SCB response efforts, confirm Tier 3- and third-party contractor interface, agencies notification, tactical plans etc. • Provided SME support for Tradewinds23 HADR exercise. • EMGL / OMNI tabletop aviation simulated exercise completed to confirm new operator notification processes, operator's ERP, MERP, response time etc.	• Monthly, quarterly, bi-annual, and annual equipment maintenance for Tier 1 in country surface response equipment continued in 2023. • Following the arrival of Prosperity FPSO, an on-water deployment exercise was completed offshore Guyana. This exercise was done jointly with EMGL, SBM, equipment manufacturer – Vikoma, in collaboration with the Guyana EPA and Guyana Coast Guard to familiarize vessel crew with boom operations underway, in open water, mobilization and offshore deployment of boom and skimmers, confirm function and familiarize crews with operation of dispersant application devices

APPENDIX K – OPERATIONAL & SCIENTIFIC MONITORING PLAN FRAMEWORK

9. 1 Introduction

7.1 Purpose

An Operational & Scientific Monitoring Plan (OSMP) is a component of the environmental management framework for the EMGL Oil Spill Response Plan for Guyana Operations.

An OSMP outlines environmental monitoring that may be implemented in the event of a hydrocarbon spill to the marine or coastal environment. Information from operational monitoring provides situational awareness enabling the Incident Management Team (IMT) to make informed decisions regarding response options. Oil spill monitoring modules are the tools for determining the extent, severity and persistence of environmental impacts from a hydrocarbon spill and associated response and/or remediation activities.

Note, this plan focuses on oil spill monitoring of a hydrocarbon spill event only.

It is important to note that the following are not a prescriptive set of procedures that must strictly be followed but are intended to provide EMGL and their monitoring providers with sufficient information to efficiently finalise a monitoring design of an appropriate nature and scale in the event of a hydrocarbon spill. It is expected that individual monitoring plans and operating procedures would only be finalised once a spill event has occurred. This is essential to ensure the finalised monitoring plan/s are fit for purpose and tailored to the specific location, hydrocarbon type, environmental sensitivities, and the nature and scale of the individual spill.

7.2 Objectives

The objectives of an OSMP are:

- Identify and describe the oil spill monitoring that may be implemented in the event of a hydrocarbon spill to the marine or coastal environment;
- Demonstrate an appropriate degree of readiness to implement this monitoring in the event of a hydrocarbon spill to the marine or coastal environment.

7.3 Scope

7.3.1 Activity Type

This OSMP is relevant to all EMGL petroleum activities within Guyana. The OSMP modules provide for the rapid assessment of the extent of spread of oil from a Tier 2 or 3 spill and effects on the environment both as a result of the spilt hydrocarbons and any oil spill response activities that may be used in the clean-up of the oil or any monitoring activities that may occur in response to the spill.

7.3.2 Hydrocarbon types and states

The petroleum resources within Guyana include both crude oil and natural gas; and petroleum activity related vessels typically use marine diesel oils. The OSMP is relevant to all hydrocarbon types and states (i.e., fresh and weathered); and all distributions throughout the environment (i.e., surface, entrained, dissolved and shoreline).

7.3.3 Geographical extent

The OSMP is relevant and applicable to all marine and coastal areas that are potentially at risk of exposure to hydrocarbons in the event of a spill resulting from petroleum activities. The spatial boundaries of an individual monitoring study will depend primarily on the actual or potential exposed area affected by the spill. Spatial boundaries will be sufficient to meet monitoring objectives, usually by determining impacted areas and the level of effects, linking effects to the spill source, and supporting decisions on clean-up strategies. Monitoring may also be undertaken outside the boundaries of a spill where monitoring programs require un-impacted reference sites. The spatial extent of a monitoring study would only be finalised once a spill event has occurred.

8 OSMP Framework

8.1 Operational Monitoring

The following sections outline the individual operational monitoring modules that may be implemented in the event of a hydrocarbon spill to the marine or coastal environment. The tables describe the key aims, initiation and termination criteria, implementation times, and provide a high-level description of monitoring, reporting and resources. The studies are presented separately below; however, in practice they may be undertaken simultaneously.

These overviews are supported by internal implementation guides for each of the operational monitoring modules. The implementation guides have been prepared to provide Esso and their monitoring providers' sufficient information to efficiently finalise a monitoring design of an appropriate nature and scale in the event of a hydrocarbon spill.

Six operational monitoring modules have been identified:

- O1: Oil Spill Surveillance;
- O2: Water and Oil Sampling;
- O3: Shoreline Assessment;
- O4: Fauna Observations;
- O5: Air Quality;
- O6: Sediment Sampling.

8.2 O1: Oil Spill Surveillance

8.2.1 Purpose

The development and implementation of effective responses to oil spills depends critically on the knowledge of the extent and likely fate and behaviour of oil once exposed to ambient weather and sea state conditions. The purpose of this module is to:

- Track the location, extent, and thickness of the surface oil slick to gain situational awareness of the incident and validate and inform forecasting;
- Collect and collate relevant weather and sea state conditions to inform modeling and response actions;
- Predict sensitivities at risk and fate/behaviour of the spill to inform response actions and scientific monitoring;
- Provide location of slick to O2 (water and oil sampling) monitoring team;
- Provide feedback on the extent, location, appearance and thickness of a dispersed slick (applicable only if dispersants used).

8.3 O2: Water and Oil Sampling

8.3.1 Purpose

The purpose of this module is to provide quantitative measures of water quality and oil (hydrocarbon) characteristics to:

- Determine the physical and chemical characteristics of the spilled oil to validate trajectory forecasts or models;
- Obtain samples of spilled oil for retention or additional analysis;
- Establish background concentrations of total petroleum hydrocarbon (TPH) and polyaromatic hydrocarbons (PAH), and non-hydrocarbon constituents in sea water;
- Determine concentrations of TPH and PAH within the spill plume;
- Determine the concentrations of non-hydrocarbon constituents (e.g. heavy metals) within the spill plume;
- Determine the effectiveness of dispersants in reducing concentrations of oil in the water column (applicable only if dispersants used);
- To inform scientific monitoring.

8.4 O3: Shoreline Assessment

8.4.1 Purpose

The purpose of this module is to:

- Determine the physical, biological and dynamic properties of shorelines at risk, in order to:
  - Predict the oil behaviour and distribution;
  - Determine the most appropriate clean-up methods;
  - Identify sensitive or vulnerable areas or resources;
  - Determine whether any pre-impact actions are warranted;
- Determine the characteristics and distribution of oil on the shoreline in order to predict the potential for oil persistence and / or natural removal;
- Determine the effectiveness of shoreline response strategies and provide feedback to the IMT.

8.5 O4: Fauna observations

8.5.1 Purpose

This module is designed to inform responses to spills where there is the potential for exposure to fauna either onshore (e.g., birds on the shoreline) or offshore (e.g., marine mammals or birds either in/on the water). The purpose of this module is to:

- Identify the presence of onshore and offshore fauna, including marine mammals and seabirds, in the response area (i.e., near the oil slick, response vessels or aircraft) in order to implement mitigation strategies, such as reduce vessel speeds, halt operations, move vessels or aircraft from the area, increase flight altitude or consider “hazing” strategies;
- Locate potentially oiled fauna for recovery.

8.6 O5: Air Quality

8.6.1 Purpose

In the event of a hydrocarbon spill, people will need to be deployed on site for monitoring and/or response and clean-up operations. Monitoring of air quality is necessary to ensure the protection and safety of human health. The purpose of this module is to:

- Establish a safe perimeter prior to any response operations being conducted where personnel may be exposed to hazards of airborne gases and vapours
- Identify any hazards from airborne gases and vapours;

- Determine the need for respiratory protection for environmental monitoring and clean-up workers; and
- Comply with occupational health regulatory requirements.

8.7 O6: Sediment Sampling

8.7.1 Purpose

The purpose of this module is to provide quantitative measures of sediment quality to:

- Establish background concentrations of TPH and PAH, and non-hydrocarbon constituents in sediment;
- Determine concentrations of TPH, PAH and non-hydrocarbon constituents within exposed sediments to inform response strategies;
- Determine the effectiveness of clean-up operations;
- To inform scientific monitoring.

9 Scientific Monitoring

9.1 Purpose

Implementation of monitoring and sampling activities begin immediately after a spill occurs to:

- Facilitate decision-making;
- Identify resources at risk;
- Provide baseline data to be compared with data obtained throughout the response time frame.

Guidance on approaches for scientific monitoring (e.g. use of baseline data in 'before versus after' analyses, and alternative approaches such as 'control versus impact' and 'gradient approach') and implementation of programmes may be modelled following international good practices. Documents that have been developed to guide implementation can be found in References below.

10 References

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