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15.0 ACCIDENTAL EVENTS

BP uses a systematic, risk-based approach to identify and manage potential accidental events that could occur during its project activities. This chapter presents potential accidental events that could arise during Project operations, with a focus on those that could result in a release of hydrocarbons to the marine environment. An assessment of potential environmental effects of accidental spills is presented, which has been informed, in part, by oil spill fate and behaviour modelling that has been undertaken for the Project (refer to Section 15.5 and Appendix D). The assessment is also undertaken in consideration of BP's approach to crisis and continuity management (including spill response and planning) and lessons learned following the 2010 Deepwater Horizon incident and other industry incidents.

Detailed information about reasonably foreseeable events that could impact worker safety will be presented in BP's Safety Plan and Incident Management Plan (IMP) (and associated Spill Response Plan [SRP]). An emergency response plan (ERP) for the MODU will be prepared by the MODU operator. Environmental management measures will be described in the Environmental Protection Plan (EPP). BP's Safety Plan, IMP, SRP, and EPP will be submitted to the C-NLOPB as part of the Operations Authorization (OA) process.

15.1 Risk Management

A risk is the measure of the likelihood of occurrence of an undesirable event (i.e., an incident) and of the potentially adverse consequences that this event may have upon people, the environment, or economic resources (IAGC-OGP 1999). BP manages, monitors, and reports on the principal risks and uncertainties that could potentially arise during their global activities, to ensure safe, compliant, and reliable operations. BP uses management systems, organizational structures, processes, standards, behaviours, and its code of conduct to form a system of internal controls to govern the way in which BP operates and manages its risks.

15.1.1 Risk Barrier Philosophy

One of the key tools that BP uses to manage risk is the risk barrier philosophy. Multiple preventative and response barriers are put in place to manage the risk of an incident arising, as well as mitigation and response to incidents should they occur. This barrier philosophy is illustrated in Figure 15.1.

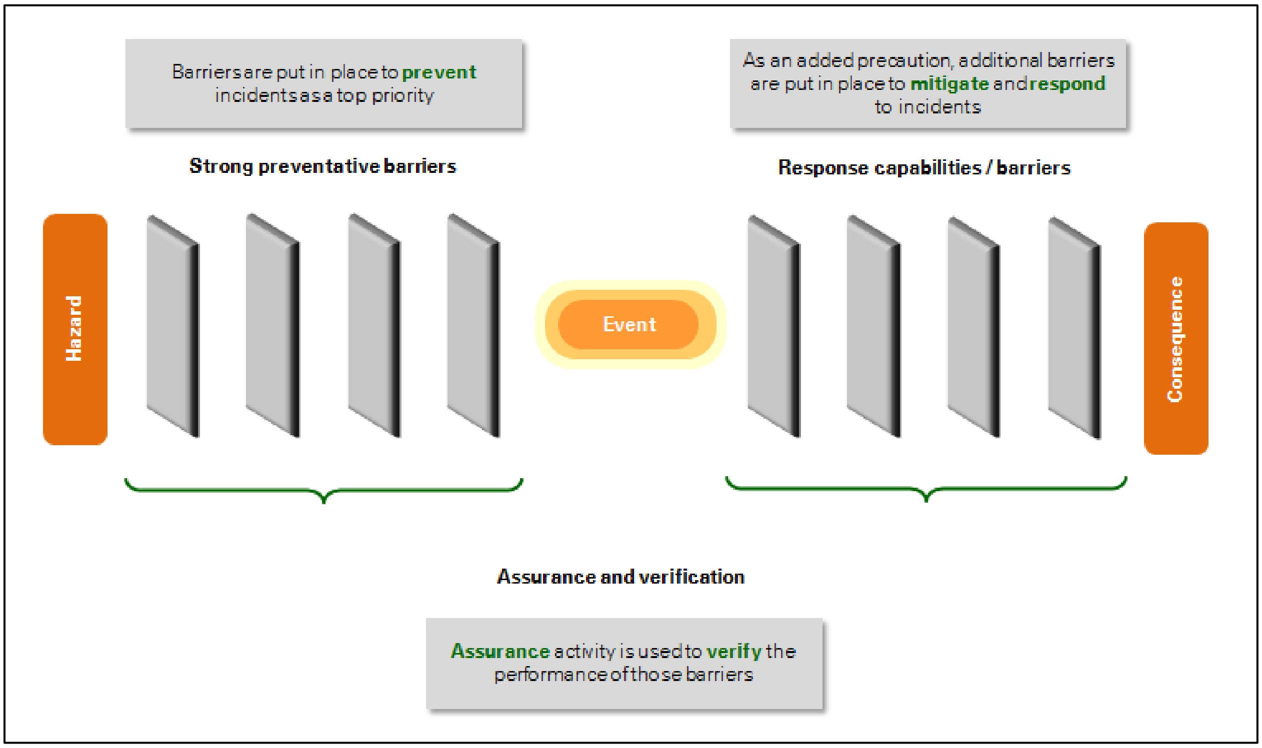


Figure 15.1 Risk Barrier Philosophy

As an example, pressure within a wellbore (the hazard) could give rise to a loss of well control (undesirable event). The barrier philosophy for risk management uses a combination of equipment, processes, and procedures carried out by competent personnel as barriers to prevent conditions from arising that could allow a hazard to become an undesirable event. If an undesirable event does occur, further barriers, such as response plans and equipment, are implemented to mitigate and reduce the negative consequences associated with the event.

BP has assessed the risks associated with the Project and has identified effective and robust barriers that will be in place to prevent and mitigate the identified risks. The performance of the barriers will be monitored and tested through self-verification, assurance, and audit.

BP has worked, along with industry partners, to improve the strength of the barriers used in deep-water drilling risk prevention and management. These improvements are built on the lessons learned as a result of the Deepwater Horizon incident and response in the Gulf of Mexico in 2010 (refer to Appendix E). Standardized global requirements for well design and construction are used by BP to reduce the risk of a major accident. Additional and strengthened preventative and response barriers to manage risk have been embedded in the key areas as described in the following sections.

15.1.1.1 People

BP has a single, centralized Global Wells Organization that is responsible for embedding standardization and a consistent approach to the delivery of well-related activity across the company.

BP processes verify that individuals and teams have the competencies to deliver safe operations. Only highly trained and competent personnel are authorized to supervise operations. BP uses industry and company training for wells personnel examination and accreditation and conducts specific competency assessments for Well Superintendents and Well Site Leaders. BP emphasizes the development and management of key competencies within the company, particularly around cementing, well control, and blowout preventer (BOP) reliability. Personnel undergo ongoing, consistent, and structured well control training to assure competency in key capability areas. BP's training facilities have received accreditation by the International Association of Drilling Contractors and the International Well Control Forum to teach, test, and provide certification to those attending its drilling well control courses.

BP uses well simulators to bring together well crews, to train and practice using scenarios from actual wells that they will drill. This includes BP, rig contractor, and well service company employees.

BP also works closely with contractors to deliver safe, compliant, and reliable performance. Bridging documents align BP and contractor requirements during operations. Additionally, BP conducts formal oversight of performance against the contractor's safety and environmental management systems. Since 2012, BP has held annual safety workshops and quarterly check-ins with senior executives from drilling contractors and service providers to continuously improve safety performance across its operations worldwide.

BP also uses a Stop Work Authority program which grants all personnel the responsibility and authority, without fear of reprisal, to stop work or decline to perform an assigned task that is perceived to be creating imminent risk or danger to personnel, equipment, or the environment.

15.1.1.2 Procedures

There is a continual focus on procedural discipline and on self-verification, assurance, and audit. All drilling activity is carried out in line with a well operations program, which includes measures to prevent loss of well control. Additionally, contactor procedures are in place to prevent and mitigate potential effects from bulk, operational, and maintenance spills.

BP uses its global wells engineering practices and procedures, which embed standardization and consistent implementation of well design and planning. These practices and procedures include current industry standards.

Leadership, including well site leaders and supervisors, conduct regular safety inspections. BP uses a standardized tool with checklists on tablet computers to support leaders across its global drilling operations to self-verify safety standards and preventative well barriers.

15.1.1.3 Process and Equipment

BP carries out several equipment and process checks during drilling operations. This includes regular checks on the BOP and well control equipment before and during drilling operations. The MODU that will be used for drilling operations will be subject to a comprehensive rig intake process, which involves obtaining a Certificate of Fitness from an independent third-party Certifying Authority. The rig intake process provides the means to identify and effectively manage risks for rig start-ups and verify that contracted rigs conform to specified BP requirements and industry standards.

Technological innovation has further enabled safe and reliable operations. BP uses advanced technology to remotely monitor conditions in their wells, enhance operational safety, and improve drilling efficiency. For its exploration wells offshore Newfoundland, BP will use a real-time monitoring centre in Houston to provide an additional level of monitoring to identify potential well control situations. This acts as an additional resource to manage well integrity, reducing both the occurrence and likely severity of potential well control events.

BP shares expertise with industry peers and works to promote common standards across the industry. For example, in 2015 BP worked with the Center for Offshore Safety, Oil and Gas UK and the International Association of Oil & Gas Producers (IOGP) to publish global definitions of well control incidents, providing a common way to report and share lessons learned. BP also works with the American Petroleum Institute (API) to develop and update industry standards.

15.1.2 Risk Assurance Process

There are a number of tiers to BP’s risk management philosophy to provide a holistic approach to risk management across the company:

- **Day-to-day risk management**
  Management and staff at individual facilities and assets identify and manage risk, promoting safe, compliant, and reliable operations. The operating management system (OMS) integrates BP requirements on health, safety, security, environment, social responsibility, regulatory compliance, operational reliability, and related issues. BP also leverages risk management processes of their contractors through bridging documentation.

- **Business and strategic risk management**
  BP’s businesses and functions integrate risk into key business processes such as strategy, planning, performance management, and resource and capital allocation. This is done using a standard process for collating risk data, assessing risk management activities, making further improvements, and planning new activities.

- **Oversight and governance**
  Functional leadership, the executive team, the board of directors, and relevant committees provide oversight to identify, understand, and endorse management of substantive risks to BP. They also put in place systems of risk management, compliance, and control to mitigate these risks. Executive committees set policies and procedures and oversee the management of important risks, and dedicated board committees review and monitor certain risks throughout the year.

BP has dedicated expertise within the company to provide a consistent approach to risk management, to support individual assets and teams in the identification and management of risk, and to manage the checks and controls around risk management to provide assurance regarding the assessment and delivery of risk management strategies within the company.

- The operating functions, including Global Wells Organization, identify and manage the risks, as described above in day-to-day risk management. They are also required to carry out self-verification and contractor oversight and are subject to independent scrutiny and assurance.
- BP's Safety & Operational Risk organization works alongside operating functions to set clear requirements, maintain an independent view of operating risk, perform assurance reviews to examine how risks are being assessed, prioritized and managed, and intervene when appropriate to bring about corrective action.
- Members of BP's Group audit team periodically visit sites across the globe to evaluate how the operating functions are managing risks.

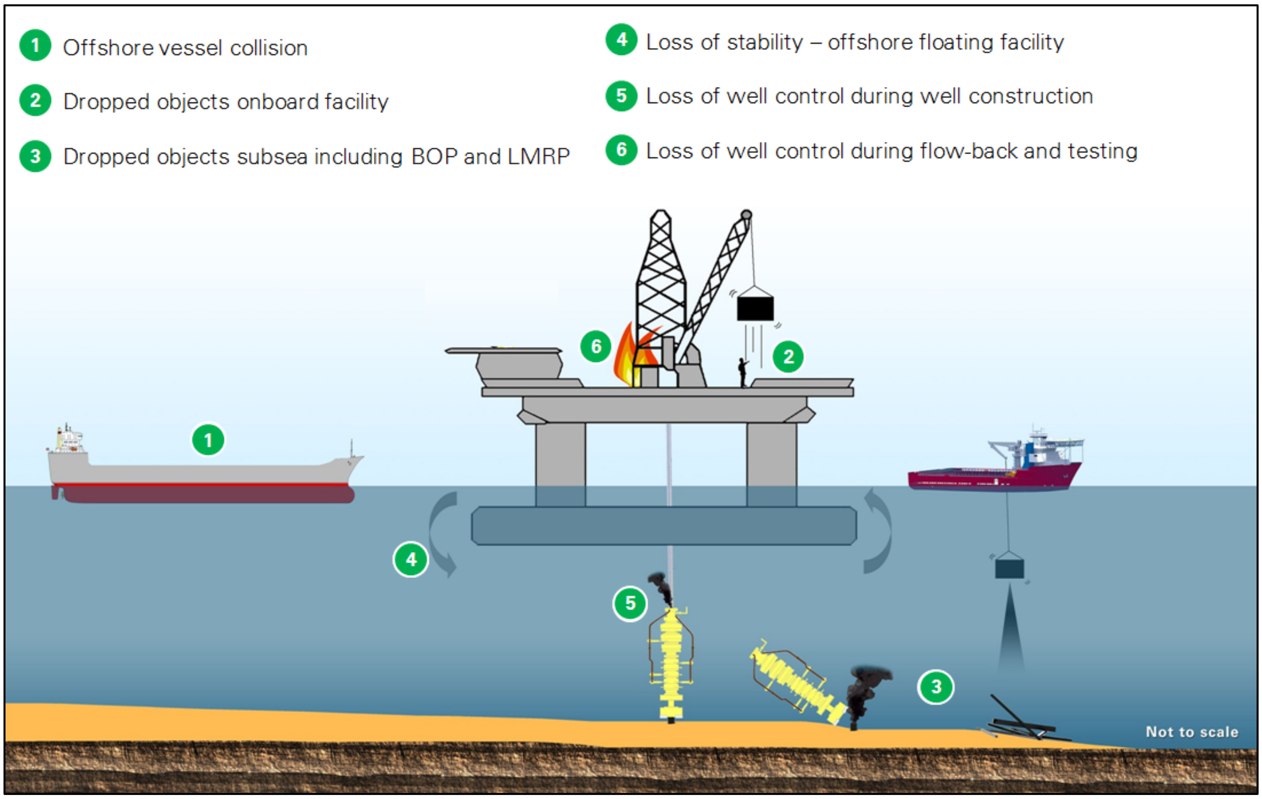
15.1.3 C-NLOPB Special Oversight Measures

In response to the Deepwater Horizon incident and heightened public concern over drilling operations in the Newfoundland and Labrador Offshore Area, the C-NLOPB identified the need to establish special oversight measures for deep-water wells so that lessons learned from the accident could be used to prevent similar occurrences from happening. This initiative was first announced by the C-NLOPB in 2010 in relation to Chevron's Orphan Basin Lona O-55 exploration drilling program (C-NLOPB 2018). Since that time, the C-NLOPB has expanded its special oversight role to include any "critical well", which includes any deepwater well, any high pressure-high temperature well, or any other well where there may be higher concerns of a well control incident (C-NLOPB 2018). Special oversight measures are focused on well control protocols, equipment and contingencies, blowout prevention, and oil spill contingency plans. Special oversight measures include: establishment of a dedicated Special Oversight Team; bi-weekly oversight meetings with the operator; increased monitoring, reporting, and frequency of offshore audits and inspections; program change reviews; and lessons learned from review sessions (C-NLOPB 2016a). Operators are notified of the C-NLOPB's decision to exercise special regulatory oversight on a case-by-case basis (C-NLOPB 2018).

15.2 Potential Accidental Event Scenarios

The accidental risk events that have been identified for the Project and described here have been identified by specialist safety and operational risk personnel within BP. They have been assessed based on historic industry trends and events and the proposed drilling program described in detail in Chapter 2 of this EIS. It is possible that additional accidental risk scenarios other than those presented below could occur. Risk management is a dynamic process. The risk events are regularly evaluated, and BP continually seeks to refine its understanding of the preventative and response barriers to ensure a robust risk management strategy.

Accidental risk events with potential environmental consequences that could occur during Project operations are illustrated in Figure 15.2. The accidental events are further described in Section 15.2.1 including their potential causes and consequences, and the barriers that are in place to help manage these risks. Further information about accidental risks that could occur during Project operations, including risks with higher health and safety consequences (e.g., helicopter ditching), will be described in the Safety Plan, which will be submitted for regulatory approval as part of the OA process.



Note: BOP = blowout preventer; LMRP = lower marine riser package

Figure 15.2 Exploration Drilling Accidental Risks

For a discussion on how the environment (e.g., meteorological or oceanographic conditions) could have an effect on the Project and potentially results in accidental events, refer to Chapter 16.

15.2.1 Potential Environmental Accidental Risks

15.2.1.1 Vessel Collision

As described in Section 7.3.2.1 and depicted in Figure 7.38, several established shipping routes are used for international and domestic commercial shipping in Canadian waters. PSVs will be used to support the drilling operations. One of the PSVs will remain on standby in the event that operational assistance or emergency response support is required. Other PSVs will be used to deliver equipment and supplies to the MODU and collect waste for return to shore.

It is possible that there could be a collision between the MODU and one of the vessels encountered in the Project Area (i.e., one of the Project PSVs or one of the other domestic or international vessels passing through the Project Area). A collision could also arise if the MODU moves from its designated position or in the event of extreme weather, such as an intense storm, which may cause either a vessel or the MODU to lose position. There is also the possibility of a collision between a PSV and another non-Project vessel in the nearshore or offshore during transit between the MODU and the onshore supply base.

The probability of any of these vessel collision scenarios occurring during the proposed drilling program is very low. PSVs have been operating in and out of the Port of St. John's, supporting oil and gas exploration and development activities in the Newfoundland offshore area for over 30 years and complying with applicable regulatory requirements, including applicable vessel pilotage requirements.

The C-NLOPB has publicly disclosed preliminary information about 110 incidents that were reported by oil and gas operators in the offshore area of Newfoundland and Labrador during the period of December 2010 to April 2018; of these, only four have involved PSVs (C-NLOPB 2018). One was related to a fire on the PSV during transit (approximately 100 km from St. John's) (C-NLOPB 2013a) and the other three incidents occurred while "in-field" at a drilling or production installation. One of these incidents included contact between a supply vessel and drilling installation, although there were no reported injuries or pollution (C-NLOPB 2011). The other two in-field incidents involved a non-occupational medevac (C-NLOPB 2013b) and the loss of an empty container overboard as it was being offloaded from a PSV (C-NLOPB 2016b).

A review of marine transportation occurrence (accident and incidents) datasets from January 1995 to February 2018 revealed 19 records of vessel collisions in the Newfoundland and Labrador region. Three additional incidents were recorded as "near collision" or "allision" (striking a stationary object). The majority of these incidents involved fishing vessels and/or Canadian Coast Guard vessels (Transportation Safety Board of Canada 2018).

As detailed in Section 2.4.1, a 500-m safety zone is maintained at all times around the MODU, within which non-Project vessels are excluded. The safety zone will be monitored by the MODU and the standby vessel. The boundaries of the safety zone will be communicated formally through a Notice to Mariners and a Notice to Shipping.

Positioning systems and certified watch-keepers on the MODU and PSVs, navigation aids, weather radars, and alarms will be used to keep the rig and vessels on position and to highlight the presence of other vessels and changing weather conditions (including sea ice and icebergs). The strength of these preventative barriers will be tested as part of the rig and vessel inspection processes, such as the rig intake process, and marine assurance reviews described in Chapter 2 of this EIS. Vessel and MODU operator procedures will be used, defining a process for collision avoidance, communication protocols, and procedures for the use of navigation equipment and alarms, which will be used by competent personnel. Weather and natural hazard preparedness processes to monitor for and respond to extreme weather events will identify conditions when precautionary riser unlatching or rig evacuations are required.

Consequences of a marine collision could include personnel injury or fatalities, or a loss of primary containment of hydrocarbons, which could result in adverse effects to the receiving environment. A marine collision could cause other accident risk events, such as a loss of stability of the MODU, or a loss of well control. Response barriers in place to reduce the consequences associated with such an incident include MODU design, fire and explosion suppression and protection systems, evacuation and escape protocols, and emergency unlatching protocols. Emergency response containment and recovery operations will reduce adverse consequences resulting from a spill event.

15.2.1.2 Dropped Objects

Dropped objects refers to items accidentally falling either onboard the MODU structure (i.e., from a crane onto the decking below) or subsea (i.e., from a PSV or MODU on to the seafloor or subsea infrastructure). These are both illustrated in Figure 15.2. Subsea infrastructure could refer to non-Project equipment, such as third-party subsea cables, or Project equipment, such as the BOP and the lower part of the riser that connects to the BOP, often referred to as the lower marine riser package (LMRP).

Large objects dropped from height could result in personnel injury or fatality and/or damage the MODU. Damage to the MODU could result in the loss of primary containment and the release of hydrocarbons into marine waters. This section is focused on those incidents that could cause damage to the MODU and potential subsequent release of hydrocarbons. Personnel injury risks and mitigations will be addressed in the Safety Plan.

An object could be dropped as a result of a failure of the PSV or MODU lifting equipment (e.g., cranes, winches, lines or connections). This risk is managed through the use of tested and certified lifting equipment and ropes, clear specifications for equipment limits, and the use of agreed and controlled lifting plans. An object could fall from the MODU during extreme weather events. As described in Sections 2.3.1.1 and 16.1, potential meteorological conditions are considered during the MODU selection process to confirm that the MODU is capable of operating in harsh, deep-water environments. The Project will use weather forecasting to monitor and prepare for a response to extreme weather.

Between 2010 and April 30, 2018, there were 12 incidents reported by the C-NLOPB that involved dropped objects. All but one of these incidents involved objects dropping to the deck of the MODU, the exception being an empty container sinking to the seafloor (C-NLOPB 2017).

On March 5, 2016, Shell Canada Limited advised the CNSOPB that it had successfully disconnected the rig drilling its Cheshire exploration well 225 km offshore Nova Scotia from the well in advance of severe weather. It also reported that "*shortly after the rig moved away from the well location, high waves and heave caused the riser tensioner system to release, resulting in the riser and lower marine riser package, which connect the rig to the well during drilling, to fall to the seabed*". There were no injuries and no drilling fluid was released during the incident (CNSOPB 2016). BP has reviewed the lessons learned from the incident and will work with regulators to apply them appropriately for the MODU selected for this operation.

There is a low potential for preventative barriers to fail, resulting in a release of hydrocarbons and adverse effects to the receiving environment. Released hydrocarbons present a fire or explosion risk, particularly in the presence of a source of ignition, and a fire or explosion on the rig could cause injuries and/or fatalities. A number of response barriers are in place to mitigate harmful consequences. These include active and passive fire and explosion prevention and suppression equipment and systems and procedures to prevent ignition of any released hydrocarbons. Evacuation and escape procedures would be used to move the workforce to safe areas. Response barriers to mitigate adverse environmental effects associated with released hydrocarbons include source control contingency provisions (e.g., capping and containment plan) and oil spill response plan. Further information about spill response is provided in Section 15.3.

15.2.1.3 Loss of MODU Stability or Structural Integrity

As described in Section 2.3.1, the Project will use a semi-submersible drilling rig or a drillship as the MODU for the Project. MODU stability is managed by controlling the distribution of weight both across the rig, as well as below and above the waterline. One way this is managed is by using ballast. A loss of stability or structural integrity could cause the MODU to list, capsize, or even sink. A loss of stability could also result in personnel injury, fatalities, or a loss of primary containment on the MODU, which could result in adverse environmental consequences. There is also a possibility that a loss of MODU stability could cause a loss of well control.

A loss of stability or structural integrity could be caused by a design or operation error of the MODU, specifically its ballast system, or by an extreme weather event. Other accidental risk events could result in the loss of the MODU's stability or integrity, (e.g., a vessel collision, or a fire or explosion during a loss of well control event).

Some of the key barriers that are in place to prevent a loss of stability or structural integrity include the use of positioning and control systems, alarms, and operator interventions to operate the MODU correctly, including careful control of variable deck load by competent personnel. MODU design, including the use of inherently safe design systems and watertight compartments, is tested through the rig intake and marine assurance process. Maintenance and inspection processes are designed to test and regularly check equipment. As identified in Section 15.1, competent personnel are of primary importance in the correct implementation of procedures. The Project will use weather and natural hazard preparedness processes, such as weather forecasting tools as discussed in Chapter 16. If the rig loses position, an emergency disconnect protocol is in place that will allow the well to be shut in and the MODU to safely move off location.

15.2.1.4 Loss of Well Control

A number of well control measures are put in place as part of drilling operations to maintain control of wellbore fluid pressures. Should multiple well control barriers fail, there could be an uncontrolled flow of formation fluids, which could result in a blowout incident. This could occur during any phase of the well, including the type of activity planned for the Project, such as well construction (i.e., drilling operations), and well testing, (which is not planned for the first well(s) associated with the program).

An influx of hydrocarbons into the wellbore could occur during the drilling program. Blowout incidents are prevented in the first instance using primary well control measures. This includes the design of the well and installation of casing strings, predicting and monitoring the formation pressure, and controlling the density of the drilling fluid accordingly. During the drilling of the well, the drilling crew will use equipment and procedures to maintain hydrostatic overbalance (i.e., a wellbore pressure that is greater than the formation fluid pressure) to prevent an influx of hydrocarbons into the wellbore. Drilling and geologic properties are monitored during operations and the density of the drilling fluid is increased or decreased accordingly to maintain an overbalance, which keeps the wellbore stable.

BP has a number of processes in place to assure that personnel undergo consistent and structured competency training and assessment for well control. In addition to the requirement that key personnel have industry-accredited well control training certification, well control is practiced on simulators in the scenario-based enhanced crew competency development programs. Agreed shut-in procedures define what the rig crew must do in the event of a “kick” (i.e., a sudden influx of formation fluids into the wellbore). The crew on the rig will be supported with an additional level of monitoring for well control situations from BP’s monitoring centre in Houston.

BP uses standardized planning and design procedures and all drilling operations are carried out in accordance with a well operations program. Engineering procedures are designed to deliver consistent implementation of well design and planning. These procedures include current industry practices and standards. BP works with experienced, qualified drilling contractors and uses assurance processes, such as the rig intake process, to confirm that the equipment is fit for purpose and satisfies BP, contractor, and regulatory standards. The verification and oversight program provides BP with assurance that contractors are delivering against their management systems.

There could be a loss of well control in the event that a shallow gas pocket is encountered during initial drilling. As explained in Section 2.2, the well location will have been selected to avoid potential shallow gas pockets following the outcome of the geohazard review, carried out using processed seismic data and offset wells. The well operations program will highlight if there are any areas in which shallow gas could be encountered and will detail responsibilities for crew members in the event that shallow gas is encountered to enable a swift and effective response.

The MODU will be equipped with secondary well control equipment in the unlikely event that the primary well control measures fail. The secondary well control equipment enables an emergency shut-down that would allow the well to be shut in. An API Standard 53-compliant 15,000 pounds per square inch (psi) working pressure BOP will be used, equipped with hydraulically-operated valves and sealing mechanisms including multiple blind shear rams. Further information about the BOPs that will be used is included in Section 2.5.

An unmitigated loss of well control, followed by a gas or fluid release, could result in fatalities and environmental damage. Procedures and equipment will be in place to manage the release of any hydrocarbons if it were to occur. This includes systems to keep personnel safe, such as ignition prevention, fire suppression, explosion protection, and hydrogen sulphide monitoring equipment. Evacuation and escape procedures for personnel will be in place. ERPs will be in place that will define emergency response procedures and measures for the containment, recovery, and control of released hydrocarbons.

Further information about well control is provided Section 2.5. Information about spills associated with a loss of well control, specifically a blowout incident, is provided in Section 15.2.2. Response measures to a blowout incident are detailed in Section 15.3.

15.2.2 Potential Spill Scenarios

As described in Section 15.2.1, some accidental events could potentially result in releases to the marine environment. This section focuses on accidental events that could result in spills to the marine environment, including operational spills that could potentially occur on the MODU or PSVs and a loss of well control that could result in a blowout event.

15.2.2.1 Operational Spills

Operational spills include leaks from pipes, hoses, connections, flanges, or valves and can occur during routine operations including loading, discharging, and bunkering operations. Small operational spills tend to be higher frequency events with less severe consequences. Such spills are most likely to occur on board drilling rigs or vessels, where they may be more easily contained and have a lower probability of reaching the marine environment.

Batch spills, which can also occur on the MODU or PSVs, involve the accidental release of different types of hydrocarbons, including diesel, aviation fuel, and drilling fluids such as SBM.

Further to the information on potential accidental risk scenarios provided in Section 15.2.1, a number of potential batch spill accidental risk scenarios have been identified. These scenarios include a tank rupture as a result of a vessel collision, and a riser unlatching as a result of a loss of position through dynamic positioning (DP) failure or severe weather before fluids are removed. A hose or tank failure during bunkering operations on the PSV or MODU could also result in a release of hydrocarbons.

Batch spills refer to a range of spill events; consequently, the preventative and response measures employed to reduce the probability and consequences of such a spill are broad ranging. Competent personnel, well maintained and well-designed equipment and processes, and procedures are all used to reduce the probability and potential severity of a bulk spill incident. Oil spill response kits will be available in relevant locations around the MODU and PSVs and will be used in the event of diesel, utility oil or SBM spills on board these vessels.

Bunkering transfer procedures will be used to define roles and responsibilities for personnel involved in transfer operations. Transfers will not be undertaken without completing a risk assessment process through control of work processes. Dry-break hose couplings will be used to reduce the risk of a spill and hose floats will be used so that hose leaks are quickly and easily identifiable. Transfer hoses will be regularly inspected.

As described in Section 15.2.1, the risk of vessel collisions will be reduced by maintaining a 500-m safety (exclusion) zone around the MODU. The MODU and vessels will use weather forecasting tools and radar to plan operations to avoid or prepare for extreme weather events. Navigation and communication equipment, and the implementation of vessel operator procedures will help to reduce the risk of a vessel collision and potential spill.

The riser used in drilling, which will circulate drilling fluid and cuttings between the MODU and the wellbore, will be designed to withstand the meteorological and oceanographic (metocean) conditions likely to be encountered in the area. In the approach of an extreme weather event, the riser may be unlatched to prevent damaging the MODU, the BOP or the riser, and to avoid risk of uncontrolled loss of cuttings or fluid. The riser would be emptied prior to unlatching. Procedures will be in place to reduce the risk of an unintentional unlatching (refer to Section 15.2.1.2 for a discussion of dropped objects and the recent riser incident during the Shelburne Basin Venture Exploration Drilling Project, where no drilling fluid loss occurred).

Secondary containment systems are used where bulk or drummed chemicals and hydrocarbon-based products are stored. Oil spill response kits will be available in relevant locations around the MODU and PSVs. These oil spill response kits will be used in the event of diesel, utility oil or SBM spills onboard the MODU or PSVs. The MODU will be equipped with labelled drainage systems for both hazardous and non-hazardous materials so that all surface and drainage water is disposed of in accordance with the *Offshore Waste Treatment Guidelines* (OWTG). Personnel will be trained in chemical handling procedures and the use of spill kits to reduce the probability and consequence of operational and maintenance spills.

As indicated by a review of spill statistics from 1997 to 2017 published by the C-NLOPB, the majority of spills that occur during exploraPtion drilling, as well as during development drilling and production, are small operational spills (refer to Table 15.1).

With a total of 60 spills reported during exploration activities between 1997 and 2017, approximately 82% of spills were hydrocarbon spills and 18% of spills were attributed to SBM spills. However, in terms of spill volumes, SBM spills accounted for approximately 96% of total volume spilled, with an average volume of 70.55 barrels (bbls) per spill. The average volume of each hydrocarbon spill occurring during exploration within this timeframe was approximately 0.72 bbls (see Table 15.1).

The probability of a medium (i.e., 50 to 999 bbl) to large (>1,000 bbl) batch spill occurring is lower than a small (i.e., less than 50 bbl) spill. Taking into account large and medium spill data from exploration drilling on the US Outer Continental Shelf (1980 to 2011) and small and very small spill data based on Newfoundland and Labrador exploration, delineation and production drilling (2000-2016), SL Ross (2017) calculated the probability of a small batch spill of petroleum occurring as 1.45 x 10-2 on a per well basis (i.e., 1 spill per 69 wells). The calculated probability of a very small batch spill was considerably higher at 1.50 (i.e., 1 spill per 0.67 wells) (SL Ross 2017). The probability of an SBM spill occurring was calculated to be higher, based on Newfoundland and Labrador exploration, delineation and production drilling statistics (1997 to 2016) at 8.33 x 10-2 for spills less than 50 bbl and 2.33 x 10-2 for SBM spills between 50 and 999 bbl (SL Ross 2017).

Table 15.1 Annual Summary of Spills from Petroleum Exploration and Development Activities in the Newfoundland and Labrador Offshore Area (1997-2017)

Year	Exploration Drilling						Development Drilling and Production						Total					
	Number of Spills			Volume (bbl)			Number of Spills			Volume (bbl)			Number of Spills			Volume (bbl)		
	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All	HC	SBM	All
1997	1	0	1	0.25	0.00	0.25	10	0	10	10.64	0.00	10.64	11	0	11	10.89	0.00	10.89
1998	4	0	4	20.10	0.00	20.10	22	2	24	3.70	12.63	16.33	26	2	28	23.80	12.63	36.43
1999	11	0	11	10.74	0.00	10.74	28	8	36	7.29	46.37	53.66	39	8	47	18.03	46.37	64.40
2000	1	0	1	1.01	0.00	1.01	4	5	9	0.40	29.56	29.96	5	5	10	1.40	29.56	30.97
2001	0	0	0	0.00	0.00	0.00	15	2	17	0.82	35.22	36.04	15	2	17	0.82	35.22	36.04
2002	0	0	0	0.00	0.00	0.00	24	2	26	0.19	77.05	77.24	24	2	26	0.19	77.05	77.24
2003	1	1	2	0.63	27.68	28.30	19	4	23	1.81	167.48	169.29	20	5	25	2.44	195.15	197.60
2004	0	0	0	0.00	0.00	0.00	50	5	55	1,043.49	679.95	1723.44	50	5	55	1043.49	679.95	,723.44
2005	0	0	0	0.00	0.00	0.00	40	1	41	1.21	25.35	26.56	40	1	41	1.21	25.35	26.56
2006	3	1	4	0.10	3.77	3.87	31	3	34	3.88	19.06	22.93	34	4	38	3.98	22.83	26.81
2007	0	1	1	0.00	465.45	465.45	37	1	38	0.61	6.85	7.46	37	2	39	0.61	472.30	472.91
2008	0	0	0	0.00	0.00	0.00	35	1	36	30.25	0.63	30.88	35	1	36	30.25	0.63	30.88
2009	4	0	4	0.06	0.01	0.07	37	0	37	1.80	0.00	1.80	41	0	41	1.86	0.01	1.87
2010	3	0	3	0.02	0.00	0.02	16	0	16	1.16	0.00	1.16	19	0	19	1.19	0.00	1.19
2011	2	5	7	0.28	180.78	181.06	36	2	38	3.51	28.94	32.45	38	7	45	3.78	209.72	213.50
2012	0	0	0	0.00	0.00	0.00	7	0	7	0.07	0.00	0.07	7	0	7	0.07	0.00	0.07
2013	0	0	0	0.00	0.00	0.00	11	2	13	39.33	1.40	40.73	11	2	13	39.33	1.40	40.73
2014	0	1	1	0.00	5.41	5.41	11	3	14	1.44	6.94	8.38	11	4	15	1.44	12.35	13.79
2015	1	1	2	0.00	92.93	92.93	1	1	2	0.02	0.90	0.92	2	2	4	0.02	93.83	93.85
2016	1	0	1	0.00	0.02	0.02	3	0	3	0.01	<0.01	0.01	4	0	4	0.01	0.00	0.01
2017	0	0	0	0.00	0.00	0.00	5	1	6	0.01	0.02	0.03	5	1	6	0.01	0.02	0.02
Total	49	11	60	35.10	776.07	811.17	415	51	466	1149.62	1138.18	2287.80	464	62	526	1184.72	1914.26	3098.98

SBM = synthetic based mud; HC = other hydrocarbons
Source: Adapted from Statoil 2017 and C-NLOPB 2018

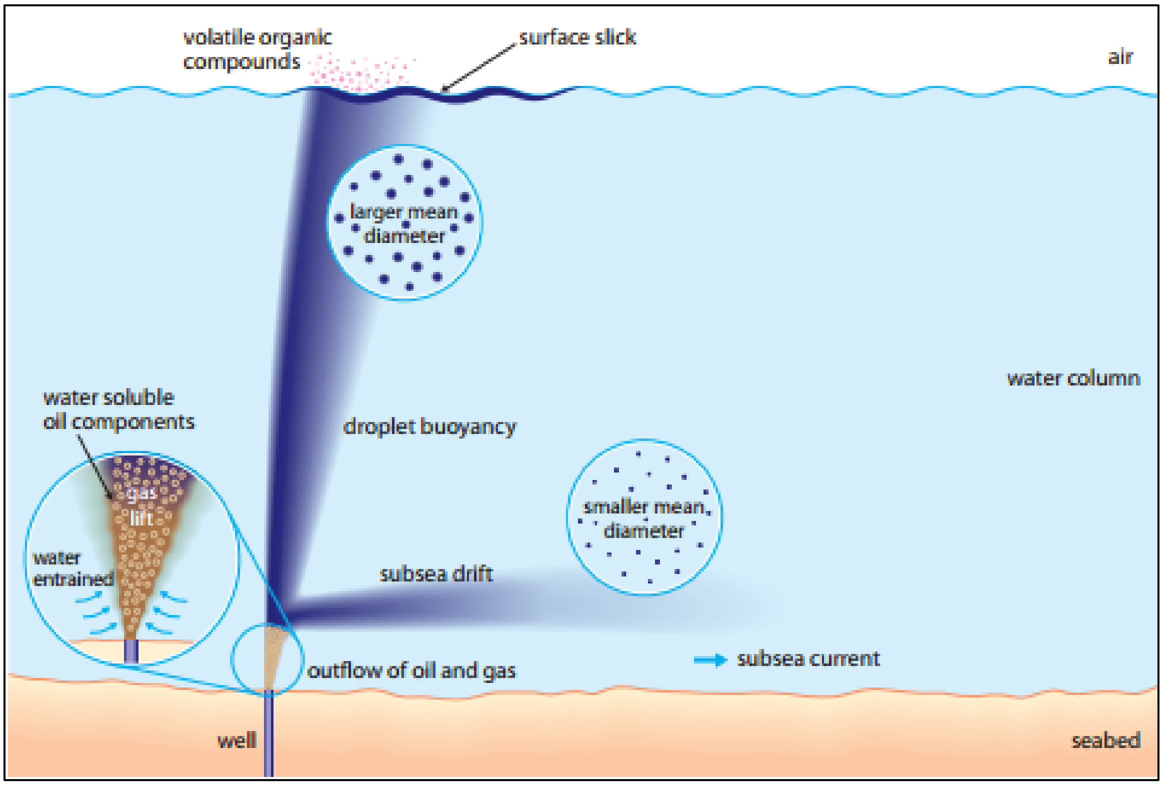
On June 22, 2018, during routine drilling operations on the Scotian Basin Exploration Project offshore Nova Scotia, BP detected a release of SBM in the drilling fluid system. Drilling operations were suspended and the loss of drilling fluid was stopped. It is estimated that approximately 136 m^3 (855 bbl) of SBM was released during the incident. An incident investigation was launched in cooperation with the CNSOPB. As of August 31, 2018, the investigation remains ongoing, although it has been determined that the release was from a connection in the mud boost line (the mud boost line routes drilling mud into the bottom of the riser above the BOP to provide additional lift to remove drill cuttings from the well through the large diameter marine riser back to the MODU for processing). Following identification and implementation of several responsive actions to prevent a reoccurrence of this type of failure (including repairs and integrity testing as well as improved inspection and monitoring procedures), BP received authorization from the CNSOPB to recommence drilling operations on the Scotian Basin Exploration Project. BP is participating in an ongoing investigation that will continue to assess potential environmental effects associated with this accidental event. BP will use learnings from this incident to help prevent similar incidents from occurring on other current and future drilling programs, including the Newfoundland Orphan Basin Exploration Drilling Program.

Bulk spill scenarios of 10 bbl (1,590 L; representing a hose failure) and 100 bbl (15,899 L; representing a tank failure) of diesel at the wellsite have been modelled for this effects assessment (see Appendix D). A summary of modelling results is provided in Section 15.4. The effects of a diesel release from a PSV and an SBM release (e.g., full riser release of SBM fluid) have been assessed qualitatively in the effects assessment in Section 15.5.

15.2.2.2 Well Blowout Incident

A blowout incident is an uncontrolled release from the wellbore that can occur following a loss of well control. Formation fluids that can be released during a blowout include salt water, gas, and oil. A blowout incident occurs when the formation pressure exceeds the pressure exerted from the drilling fluid, and well control measures fail. When the pressure encountered in the formation increases rapidly and becomes higher than the pressure exerted by the mud column, it is referred to as a ‘kick’. The severity of the kick depends on the reaction time of the drill crew and the permeability of the formation (i.e., how it allows fluid to flow through it), and the difference between the formation pressure and the hydrostatic pressure of the drilling fluid. Information about primary and secondary well control measures, which are employed to prevent a well blowout incident, is included in Section 15.3.3.1.

In the extremely unlikely event where primary and secondary well control measures have failed, hydrocarbons would be released from the well into the marine environment. A subsea well blowout incident is illustrated in Figure 15.3 (International Petroleum Industry Environmental Conservation Association [IPIECA]-IOGP 2015).



Source: IPIECA-IOGP 2015

Figure 15.3 Blowout Incident Schematic

A subsea well blowout incident includes the following (IPIECA-IOGP 2015):

- High-velocity jets of oil and gas released subsea in deep water will be broken up by the intense turbulence of the release conditions into small oil droplets and gas bubbles. This is often referred to as “mechanically” dispersed oil to distinguish it from oil dispersed by chemical dispersant use.
- The plume of small oil droplets, gas bubbles, and entrained water will initially rise rapidly in the form of a buoyant plume, with the gas providing the dominant source of lift and buoyancy. Close to the point of release, this plume will behave like a single-phase plume.
- As the plume of oil droplets and gas bubbles rise through the deep water (where water depths are greater than 500 m), the methane gas will dissolve into the ocean (due to its solubility at high pressure); this reduces the buoyancy of the plume, thereby slowing its ascent through the water.
- Stratification in the water column and currents will then separate the oil droplets and gas bubbles (if not already dissolved) from the plume of entrained water.
- The larger oil droplets will then continue to rise slowly to the sea surface under their own buoyancy, which is a function of size, while the smaller oil droplets will be carried horizontally under the influence of ocean currents and remain suspended in the water column as they dilute and biodegrade.

A surface blowout refers to a situation in which hydrocarbons are released at or near the ocean surface, from either the drill string or through the riser. In both of these scenarios, BOP intervention would be used to attempt to shut in the well and to stop the release. A surface blowout is more likely to be rapidly contained, resulting in lower spill volumes. If the well cannot be shut in, the MODU would activate the emergency disconnect system to move the MODU off location and the surface blowout would ultimately degrade to a subsea well blowout. A subsea blowout is therefore used as a credible worst-case scenario and so has been selected for assessment in this EIS.

There have been no loss of well control incidents offshore Newfoundland since the first well was drilled in 1966. Two loss of well control incidents have occurred in offshore Nova Scotia, with only one unmitigated case that resulted in a blowout incident and release of hydrocarbons to the environment. The Uniacke G-72 loss of well control incident occurred on February 22, 1984 and resulted in a blowout incident. The incident occurred at a gas well that was being drilled 150 nautical miles (278 km) from Halifax by the semi-submersible drilling vessel, *Vinland*, under contract to Shell Canada Resources. The initial flow rate of gas and condensate was estimated to be approximately 300 bbl per day. The incident lasted for 10 days with approximately 1,500 bbl of gas condensate and between 1.11 to 1.83 million m^3/day of natural gas released in total. The well was declared static after 10 days once a team of specialists boarded the *Vinland* and pumped mud down the choke line (Gill et al. 1985).

The second loss of well control occurred in 1985 at N-91, a Mobil exploratory gas well in West Venture at a water depth of 38 m. The BOP was activated at the N-91 incident and no fluids or hydrocarbons were released into the marine environment or atmosphere as a result of the loss of well control; hydrocarbons were contained within the subsurface formations. The loss of well control arose as a consequence of a casing failure in the wellbore that allowed natural gas to escape from one subsurface formation to another. A relief well was drilled to kill the well (Angus and Mitchell 2010).

Historical data indicate that the probability of a blowout incident is extremely low. Between 1980 and 2011, there were 12,429 exploration wells drilled in the United States Federal Outer Continental Shelf (OCS) region; there were 45 blowouts from exploration drilling in this same period. The blowout frequency is therefore calculated to be 3.62×10^{-3} or one blowout for every 276 wells drilled (SL Ross 2017). As of June 2018, there have been 382 exploration wells drilled offshore Nova Scotia and Newfoundland and Labrador since drilling began in 1968. Based on the one well blowout incident (*Uniacke* G-72) offshore Nova Scotia in 1984, the historic frequency of blowouts for Atlantic Canada is calculated to be 2.6×10^{-3}.

These data for the US OCS and Atlantic Canada are relevant to a period prior to the implementation of additional controls and mitigation measures that will be used for well control. The following controls and mitigation measures are based on industry advancements and the lessons learned following the Macondo well blowout (Deepwater Horizon incident):

- enhanced industry and BP training and competency assessment for individuals and crews with accountability for well control and other wells operations
- additional shear rams on the BOP – BP uses three shear rams on the BOP. In addition, there are a minimum of two pipe rams
- third-party verification of BOP testing and maintenance
- onshore remote monitoring to support well operations
- enhanced monitoring processes and procedures

More information on lessons learned and advancements since the Macondo well blowout incident is contained in Appendix E. Detailed information on emergency preparedness and response is presented in Section 15.3.

Spill fate and behaviour modelling has been conducted for a well blowout incident at two potential locations within the ELs. Assumptions and background information about the modelling work including specific scenarios that were modelled and a summary of modelling results are provided in Section 15.4; refer to Appendix D for a detailed account of the spill modelling. Section 15.5 presents the effects assessment for blowout events.

15.3 Contingency Planning and Emergency Response

BP prioritizes activities and takes measures to reduce the probability of incidents, including oil spills, from occurring through the use of prevention barriers. As a precaution, BP prepares response barriers to mitigate adverse consequences should an incident occur.

Response barriers used by BP include standardized practices for the preparation and response to crises and emergency events that have the potential to cause harm to BP employees, contractors or the public, the environment, company assets, or interruption to business operations. These practices form the foundation of the response management strategy for the Project, which will be based upon the principles of preparedness, response, and recovery. Response management strategies incorporate lessons learned from within BP and the wider industry.

This section provides detail about the emergency response measures that will be used by BP as part of the exploration program, with specific focus on spill management.

15.3.1 Incident Management Plan and Spill Response Plan

A Project-specific IMP will be developed that outlines the emergency response processes to be implemented during actual or potential emergency incidents, regardless of size, complexity or type. It will describe the facilities, notification and reporting procedures, response organization, and specific roles and responsibilities to ensure a comprehensive, efficient and timely response. It will also contain checklists and guidance for initial actions for specific response scenarios, including potential spill or well control events.

The IMP is designed to serve as a high-level, over-arching umbrella plan under which the functional and tactical-level ERPs bridge, including the SRP. The Project IMP and associated plans will be aligned with applicable regulations, industry practice and BP standards. These plans will be submitted to C-NLOPB prior to the start of any drilling activity as part of the OA process. The SRP will be finalized in consultation with applicable regulatory authorities.

The SRP will satisfy BP’s planning requirements and will be designed to fulfil the information required as part of the OA process. The SRP will identify potential spill scenarios based on the risks associated with the Project (see Section 15.2.1). For these scenarios, the Plan will outline a response strategy, identifying the timing and location for implementing the response tactics that would be employed. This includes information about how to monitor and predict spill movement to facilitate an effective response. The development of response strategies will be informed by the results of a Project Spill Impact Mitigation Assessment (SIMA – also known as Net Environmental Benefit Analysis or NEBA) (see IPIECA-IOPG-API 2017). The SRP will identify the location, mobilization, and deployment of the equipment and personnel necessary to implement the various strategies, ensuring the capabilities are present in the times and quantities required. It will also include details on the spill response organization structure, roles and responsibilities, and the procedures for notification and reporting specific to oil spill response. Information about environmental and socio-economic sensitivities and potentially affected Indigenous groups and stakeholders will also be included in the plan.

BP will include tactical response measures within the SRP, which will contain details on procedures, equipment, and applicability for each of the specific response tactics that might be employed. These will include information about how oiled wildlife and recovered oil waste will be managed and how a sampling and monitoring program will be established, if necessary.

Information about source control will be presented in a series of related plans under the umbrella of the IMP, describing how resources will be deployed to respond to a loss of well control incident (see Section 15.3.2).

Emergency response exercises and drills will be conducted to test the various plans and personnel readiness. The number and scope of exercises, as well as associated training, will meet internal BP and C-NLOPB requirements and will be outlined within the IMP and/or SRP.

Bridging documents will be prepared to link the safety management systems of BP and the contractors that it works with, which will include the IMP and SRP (or equivalent documents as defined by the contractor).

The Project will adopt a tiered approach for spill response and preparedness, as per IPIECA guidelines, for planning the response to oil spills. The tiered response definitions are provided in Table 15.2.

Table 15.2 Tiered Level Response Description

Response Tier	Description
Tier 1	**Resources necessary to handle a local spill and/or provide an initial response** Tier 1 has been conventionally defined by the response capability required to deal immediately with operational spills. However, it is important to recognize that all spills, regardless of cause or consequence, have a Tier 1 component. Tier 1 is therefore the foundation of preparedness and response for all spills, which may or may not ultimately escalate beyond the scope of Tier 1 initial actions and capabilities.
Tier 2	**Shared resources necessary to supplement a Tier 1 response** Tier 2 capability includes a wider selection of equipment suited to a range of strategic response options. More importantly, Tier 2 delivers more people, and a greater range of specialism. While Tier 1 responders may be appropriately trained and knowledgeable, their response duties are invariably subordinate to their operational role. Tier 2 service providers come with appropriate professional training and have knowledge of national legislation and domestic practices in the countries/regions in which they work. In the context of the wider incident, Tier 2 contractors can also provide access to expertise for specific elements of spill response (e.g., aircraft, communication systems, marine logistics and other emergency-related services), the absence of which may delay or hinder a response.
Tier 3	**Global resources necessary for spills that require a substantial external response due to incident scale, complexity and/or consequence potential** Tier 3 capability tends to be predetermined, with well-established industry-controlled equipment stockpiles and response personnel at key strategic locations and with defined geographical remits. It is through contracts and agreements that industry and governments can have access to the cooperatively held resources therein. Physical response times to any given risk location can be ascertained, and agreements are in place which guarantee specified response services and time frames to provide added security.
Source: from IPIECA 2015	

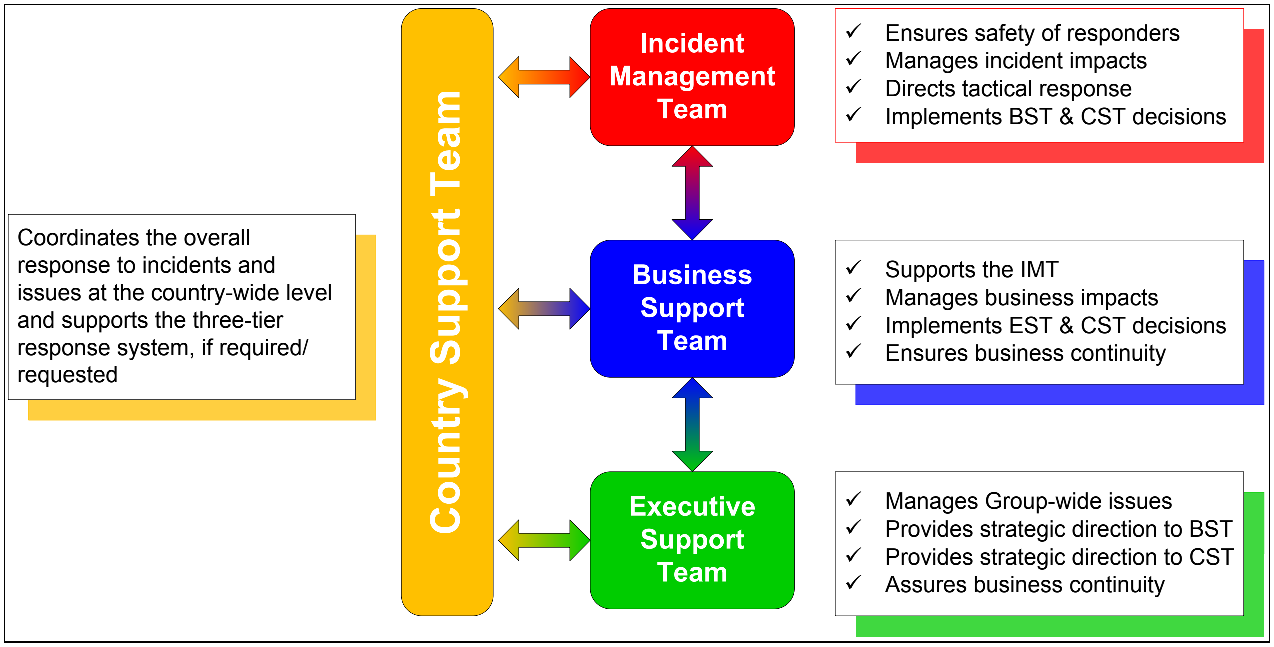
The tiered response approach provides a full range of response tools and strategies that can be mobilized and demobilized and implemented efficiently and appropriately. The tiered response approach will be adhered to in BP's IMP, SRP, and the well control plan described above.

The selection of appropriate response methods and equipment will be determined by the specific nature of the incident and the environmental conditions at the time of the incident; however, indicative strategies that may be applied during response to an oil spill are described in Section 15.3.3.

15.3.2 Response Coordination and Management

BP's incident management organization is based upon a scalable system illustrated in Figure 15.4. This structure is designed to co-ordinate an efficient, timely and effective response with the Incident

Management Team in St. John's supported, as needed, by the Business Support Team and Country Support Team in Calgary, and the Executive Support Team in London. Additional support and subject matter expertise is available through BP's global Mutual Response Team, as well as specialized well control support teams in Houston, US and Sunbury, UK. BP has adopted the Incident Command System (ICS) as the foundation for the response management system across its global operations. The ICS structure will be described in the IMP and SRP. ICS is a standardized emergency response system that provides a systematic response capability and an integrated organization structure that provides clear lines of communication and defined roles and responsibilities. It is a scalable, all-hazards system that can be deployed in any emergency response scenario.



Note: BST=Business Support Team; CST = Country Support Team; IMT = Incident Management Team; EST = Executive Support Team

Figure 15.4 BP 3-Tiered Incident Management Structure

BP will work with applicable local and federal government bodies in the event of a spill event. Agencies that would be notified of a spill event, engaged to support response efforts and provide regulatory oversight, as required, include the C-NLOPB, the Canadian Coast Guard, the Joint Rescue Coordination Centre, Transport Canada, DFO, ECCC (Environmental Emergencies), and the Government of Newfoundland and Labrador.

BP has access to support organizations and agencies that can provide resources to support a spill response effort. Different organizations and resources are in place within the region and may be mobilized depending on the extent and scale of a spill to support a response. These organizations may include, but not be limited to, Eastern Canada Response Corporation (ECRC) and Oil Spill Response Limited (OSRL).

ECRC is a local marine response organization with which BP currently has a Standing Agreement in Nova Scotia and plans to execute one for Newfoundland and Labrador. This agreement allows BP to access ECRC's equipment and trained personnel for purposes of oil spill response, training, exercises, as well as maintenance of BP-owned equipment. ECRC maintains a response centre in St. John's, with the ability to cascade additional personnel and resources from throughout eastern Canada.

OSRL is an international, industry-owned organization that provides resources and expertise for oil spill response and clean-up. BP is a member of OSRL and, as such, is able to access and use specialist equipment and call on and deploy specialist incident management experts and technical advisors. OSRL's expertise and resources are strategically located across the world to facilitate effective and efficient response to oil spill incidents.

OSRL has a dedicated subsea division, the Subsea Well Intervention Services (SWIS), which provides OSRL members with the opportunity to access subsea intervention capabilities, including subsea dispersant equipment, and capping and containment equipment. This complements the response services described above that OSRL membership provides for oil spill response. BP is a signatory to SWIS and worked as part of the Subsea Well Response Project to create the SWIS. OSRL will be notified of upcoming wells drilled as part of the Project to cover drilling activities under the SWIS and other OSRL services. Specific information about the capping stack equipment, which BP can access as part of SWIS, is presented in Section 15.3.3.2.3.

15.3.3 Response Strategies

A response strategy refers to the collection of individual response tactics that would be employed during a response, including the timing and location of their implementation. The specific strategy employed for a spill will vary depending on the spill scenario and incident-specific conditions. However, general response strategies for each identified spill scenario will be defined in the SRP described above.

The most critical spill event, in terms of potential adverse effects on VCs, which could occur during Project activities, is a major release of formation fluids from a loss of well control (i.e., a blowout) event. The majority of this section therefore refers to response tactics that would be implemented following a major release of formation fluids.

The IMP and SRP will include information about well control response strategies to set out measures to stop the flow of oil, and spill response tactics to manage any released oil.

15.3.3.1 Well Control Response Strategies

In the event that all of the preventative measures described in earlier sections have failed and an uncontrolled well event has occurred, BP will have plans in place to launch multiple simultaneous activities to respond to and stop the flow of hydrocarbons.

A suite of response measures (see Figure 15.5) will be activated in response to any uncontrolled well control event as soon as practicable and when safe to do so. Many of these measures will be deployed simultaneously to provide a comprehensive response. This approach also provides a level of contingency so that if initial response measures are unsuccessful, additional measures will be available to be deployed as back-up.

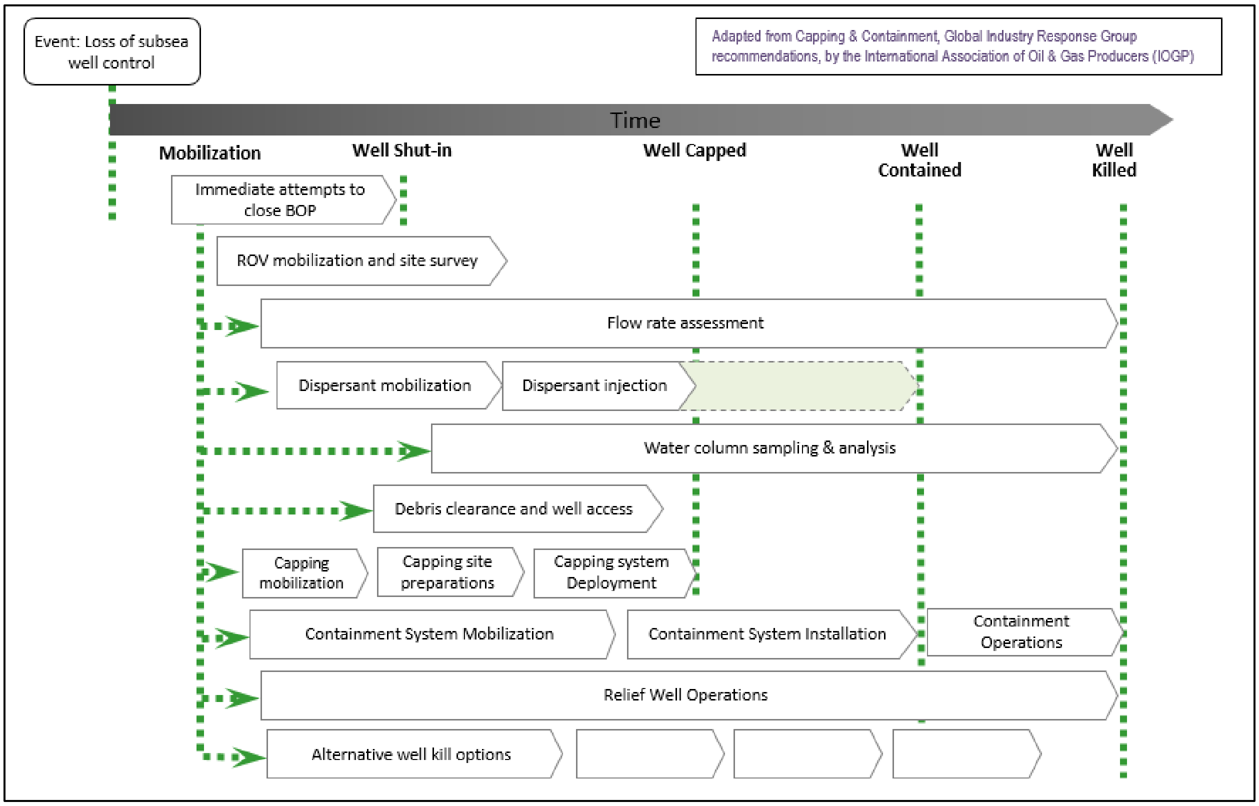


Figure 15.5 Generic Sequence of Response for Source Control

Well control response effort will comprise well intervention (i.e., source control) strategies, including direct BOP intervention, mobilization and installation of a capping stack, and drilling of a relief well if required. Additional spill response options, including containment and recovery of oil and in-situ burning, may be implemented, as appropriate. Dispersant application may be considered to help reduce surface or shoreline oiling, depending on the outcome of the Project and incident-specific SIMAs and pending regulatory approval (refer to Section 15.3.3.3 for information on BP's plan for dispersant use).

The Incident Management Team will assess the situation as it evolves throughout any response effort to adjust the response strategy so that it is appropriate for the specific, changing conditions.

Figure 15.5 illustrates the relative timing of BOP intervention and capping and containment measures that would be implemented to stop the flow of hydrocarbons in the event of a loss of well control and subsequent blowout incident. Note that additional spill response efforts would be ongoing to manage, contain, and recover spilled hydrocarbons.

15.3.3.2 Well Intervention Response

BOP Intervention

In the event that the primary BOP procedures are ineffective (see Section 2.5 of the EIS), BP's first response would be to attempt direct intervention measures intended to close in the original BOP. The BOP will be equipped with multiple shear rams to provide additional options to close the BOP.

BP will maintain equipment and capability to perform external intervention on the BOP within the Newfoundland and Labrador region. This will include specialist equipment and ROVs that can be deployed from a PSV or the MODU to provide hydraulic power to the BOP in order to close the rams directly.

A BOP intervention response is estimated to take between two and five days.

ROV Mobilization, Site Survey and Debris Clearance

In parallel with the attempted BOP intervention activities, an ROV-based site survey will be carried out to assess the extent of debris on the seafloor following the blowout incident. Debris on the seafloor, potentially including formation debris blown out of the wellbore, can impede additional response efforts. If large debris that could limit access for response equipment is detected, subsea cranes and ROVs with debris removal tools will be used to clear the area around the wellsite.

Well Capping

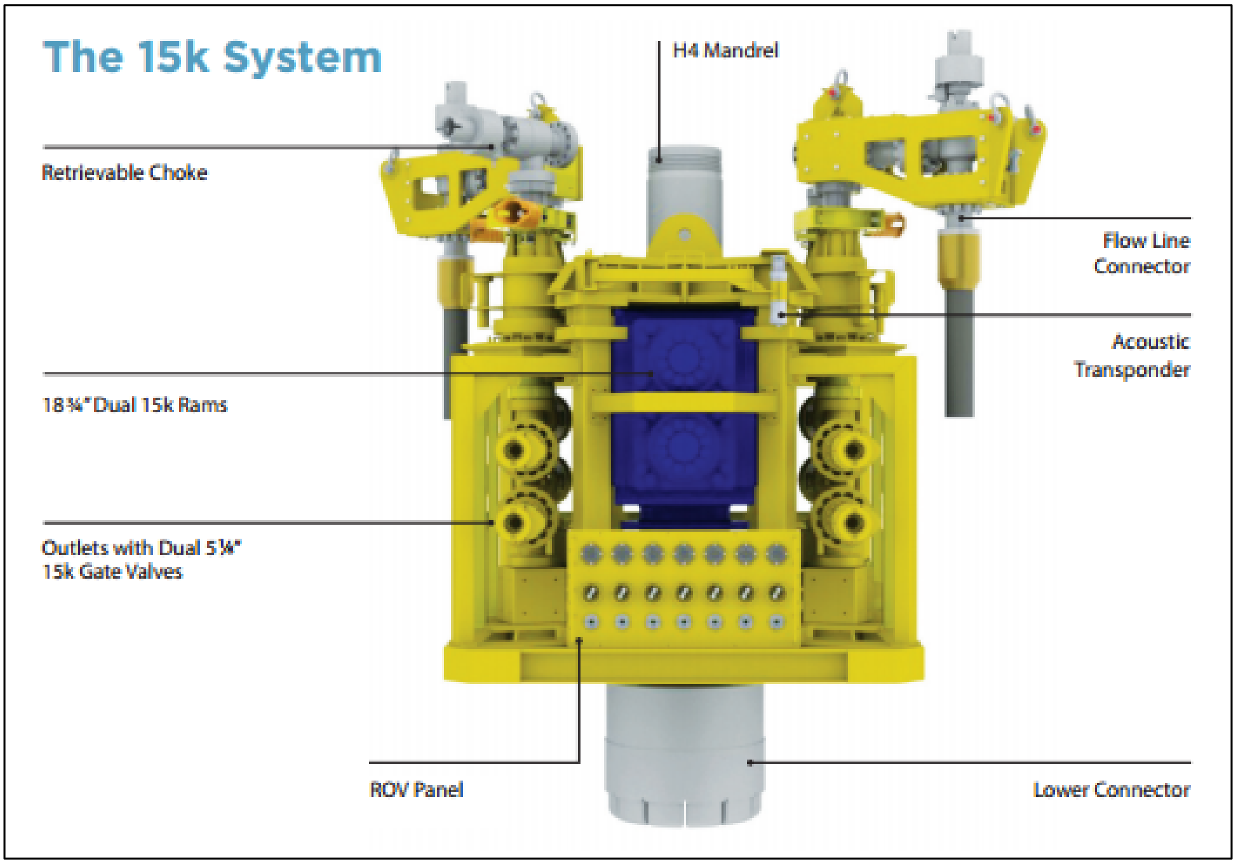
A subsea well capping stack is a specialized piece of equipment used to "cap" (i.e., stop or redirect) the well flow while work to permanently kill the well is undertaken. Capping stacks are designed to withstand the maximum anticipated wellhead pressure generated by the well.

BP has contributed to the provision of industry capping stacks, and along with other operators in industry, continues to refine and enhance the deployment of capping stacks being developed today.

A number of capping stacks are staged in strategic locations across the globe, including Brazil, Norway, Singapore, and South Africa. Capping equipment is stored ready for immediate use and onward transportation by sea or air in the event of an incident.

For this drilling program, BP's current primary plan is to access the capping stack stored in Stavanger, Norway, which is a capping stack capable of managing up to 15,000 psi. A diagram of the 15,000-psi capping stack that would be used is shown in Figure 15.6.

OSRL, in collaboration with its members (including BP) have recently established a single unit air-freightable capping stack in response to industry demand for improved response times. This advanced capping stack allows it to be transported, fully assembled in one single unit, by air, in an Antonov AN-124.



Source: OSRL 2014

Figure 15.6 18.3/4” 15,000 psi Capping Device

If a blowout incident were to occur, BP would immediately assess the most expedient route for capping the well. This would involve the assessment of aircraft and deployment vessel locations and availability. One option is to commence the mobilization of the air-freightable capping stack from Stavanger, Norway (available July 2018) to the St. John’s International Airport using an Antonov AN-124 aircraft. The Antonov aircraft comes with its own loading / offloading system and once on the ground, the capping stack would be offloaded from the aircraft for road transport to the shorebase. In parallel with the cap air freight, a suitable PSV would be secured to receive the cap and transport to the wellsite for deployment. The most likely timing for mobilization and installation of the air-freightable capping stack is calculated to be nine days (P50, median value).

Another option is to secure a deployment vessel in Stavanger and mobilize the capping stack direct from Stavanger via marine transport to the incident site. The most likely timing for mobilization and installation by sea on a subsea construction vessel from Stavanger is calculated to be 13 days (summer) to 17 days (winter) (P50, median value).

Sailing times from Stavanger to the Project Area are dependent on vessel cruising speeds, which are in turn dependent on metocean conditions. Metocean conditions, and therefore sailing times, are likely to differ between summer and winter. And, while it is preferred that the cap is transported directly to the wellsite on-board a vessel with suitable deployment capabilities, it may become necessary to make a port call in St. John's. If this were to become necessary, the required customs clearances, functional checks, cargo transfers, could add several days to the overall transit time.

During the cap transit, the necessary engineering analysis, technical review, debris clearance, and site preparations will have been underway such that cap installation can begin upon arrival of the cap at the wellsite.

Precise durations for cap installation and closure would be highly dependent on local conditions specific to the incident. A straightforward installation and closure under good conditions would take approximately 24 hours. A more complicated installation, with potential weather-related downtime, could take longer.

Allowing for these uncertainties, BP estimates that a well could be capped between 9 and 17 days after an incident based on P50 timings.

Relief Well Drilling

Depending on the circumstances where well control cannot be re-established, a relief well may be drilled to kill the well. BP has master service agreements in place for specialist assistance to help with engineering and operational support for a relief well.

The relief well would be drilled using a similar execution plan to a standard well. A relief well is typically drilled as a vertical hole down to a planned deviation ("kick-off") point, where it is turned toward the target well using directional drilling technology and tools.

Once the target well is intersected, dynamic kill well control commences by pumping drilling fluid down the relief well and into the incident well to kill the flow. Concrete may follow to seal the original well bore.

A MODU would be mobilized to Newfoundland offshore waters should a relief well be required. The duration of mobilization and drilling a relief well has been based on a conservative (P90) time forecast and includes a 50% non-productive time assumption, resulting in an estimate of 120 days to kill the well.

Wellheads, running tools, connectors, and tubulars will be transported by air and sea as appropriate such that equipment required in the top-hole sections of the relief well construction would be available prior to spud.

15.3.3.3 Oil Spill Tactical Response Methods

BP's SRP will contain specific details of response methods that can be used in the event of an oil spill. A toolkit of different tactical response methods will be available to be used depending on the specific conditions of a spill event. The effectiveness of some of the methods described below will be affected by specific environmental conditions (e.g., wave height and visibility), and it is possible that some of the options may not be feasible at the time of a spill. Specific details about the tactical response methods will be further defined in the SRP, including a description of how different tactics will be selected for different scenarios and locations.

Tactical response methods that will be considered following a spill incident include, but are not limited to, those described in the following sections. The actual strategy / tactics employed during a response will depend on the specific circumstances and conditions at the time of the incident and will be informed by an incident-specific, expedited SIMA process. Stakeholder and Indigenous input, including traditional knowledge and input on ecological and socio-economic priorities for response, would be coordinated through the ICS process.

Surveillance and Tracking

Surveillance and tracking of an oil spill is necessary to determine its extent, behaviour, and trajectory to determine the most appropriate response options.

Surveillance of an oil spill is accomplished using a variety of platforms, potentially including boats, piloted aircrafts, unpiloted aerial vehicles, and satellites, as well as using a variety of sensors and trained and experienced personnel. Surveillance is used to inform the response about the location, condition, and movement of oil to maximize the effectiveness of tactical response, assist in trajectory modelling, and help determine strategic response options.

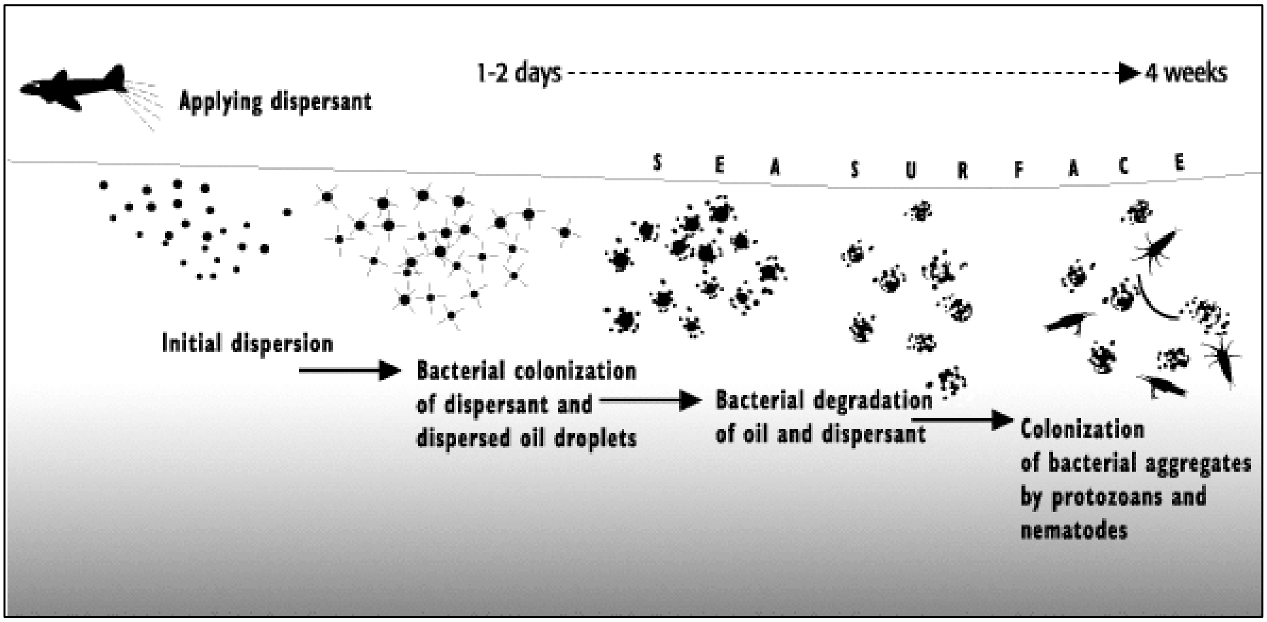
Offshore Containment and Recovery

Offshore containment and recovery of oil includes booming and skimming operations. Booms are floating physical barriers that can be used in a variety of ways to contain, deflect, and control the movement of surface oil. Booms can be used to contain oil in a defined area, which increases the effectiveness of oil recovery equipment (e.g., that of skimmers and vacuums). Booms can also be used to divert oil away from sensitive receptors (e.g., rafting bird assemblages or shorelines) to reduce the likelihood or magnitude of adverse environmental effects.

Dispersant Planning and Application

Dispersant products are formulations of chemicals that, when applied to spilled oil, reduce the interfacial tension between the oil and water, allowing the oil to be broken down into smaller droplets, thus substantially enhancing the natural dispersion and subsequent biodegradation of the oil droplets. The commercial dispersant products are made up of two primary component groups - surfactants and emulsifiers. These surfactants and emulsifiers are commonly found in a wide variety of household products, including skin creams, mouthwash, food emulsifiers, baby bath, cosmetics, and cleaning agents (Word et al. 2014).

Dispersants do not reduce the total volume of oil in the marine environment; however, dispersants increase the surface area of oil exposed to the environment, which helps to accelerate oil biodegradation, and typically reduce the extent of oil slicks on the sea surface and shoreline oiling. Once dispersants have been applied, dispersed oil moves down into the water column and eventually, dispersed oil droplets degrade into naturally occurring substances, as shown in Figure 15.7. There is evidence that dispersed oil degrades more quickly than oil that has not been dispersed (Lee et al. 2013; Brakstad et al. 2015).



Source: NOAA 2016

Figure 15.7 Degradation of Oil Following Dispersant Application

Chemical dispersant may be applied at the sea surface, or subsea in the event of a subsurface release such as a blowout incident. A number of factors determine which application method is appropriate in any spill scenario, some of which are discussed below.

Surface application is often used in conjunction with other spill response tactics, including those described in this Chapter. Surface application involves spraying the dispersant aerially from deployed aircraft or from available vessels. Weather conditions (e.g., wind, wave height, and visibility) are key factors that dictate effectiveness and method of surface dispersant application and would be taken into account by spill responders when analyzing the situation for a dispersant plan. To increase the chances that an application will be effective, spill responders monitor and analyze the situation to determine the best combination of dispersant droplet size, concentration, and rate and method of application.

Surface application by aircraft allows for quick transit to the spill site and covering of large areas in a short period of time; however, this method can be limited by poor visibility and weather, which can affect the safe operation of aircraft and the accurate application of the dispersant. Surface application by vessels can result in a more focused application of the dispersant and application in some areas where aircraft cannot operate; however, the amount of oil that can be treated by dispersants applied from vessels is limited due to the speed of the vessels and width of the spray.

As the oil weathers, primarily through dilution, evaporation and emulsification, the effectiveness of dispersants is reduced. This resulting “window of opportunity” needs to be considered and monitored when considering dispersant use.

In the event of a subsea blowout incident, the water depth at which dispersed oil droplets separate from the plume of entrained water is a function of the release conditions. Thereafter, the dispersed oil droplets rise very slowly through the water column and are transported laterally from the release site via subsea cross currents, with the extent and direction of drift determined by the prevailing speed and direction of currents in the water column. Dispersant can also be injected subsea, close to the point of release at the wellhead. Subsea dispersant injection (SSDI) was used as one of the response measures deployed in response to the Deepwater Horizon incident in 2010.

In SSDI, dispersant is injected directly at, or near, the source of the release. The resulting reduction in oil droplet size makes the droplets more accessible to oil-biodegrading microbes after they separate from the plume. All of the world's oceans have natural hydrocarbon seeps (Kvenvolden and Cooper 2003), and oil degrading microbes are found in all marine environments – even cold, dark environments – having evolved to degrade petroleum from these seeps (Hazen et al. 2016). SSDI increases the "encounter rate" of the dispersant with the oil, allowing for a higher dispersant-to-oil ratio - less dispersant used per volume of oil. As with surface application, the dispersant use results in a reduction in the size of oil droplets and an associated enhancement and acceleration of in-water-column microbial degradation of hydrocarbons.

The primary reason for any dispersant use is to prevent, or reduce, the amount of oil on the ocean surface that may subsequently impact shallow coastal waters and the shoreline, where it could cause considerable damage to sensitive environmental resources on the surface and shoreline, such as seabirds and marine mammals, and disrupt socio-economic activities. A key additional safety-related benefit of SSDI is that it reduces the amount of liquid oil and volatile organic compounds (VOCs) that reach the surface of the ocean, therefore reducing potential health and safety impacts to response workers at the surface, especially in the context of exposure to the VOCs. Additional benefits of SSDI include:

- increasing the "encounter rate" of the dispersant with the oil, therefore reducing the amount of dispersant required compared to surface application
- facilitating a continuous response, being able to be maintained day and night, and in adverse weather and sea conditions that often preclude use of other response techniques
- the high temperature of the oil released from a blowout, where the dispersant is injected, means that oil weathering and viscosity issues are not a factor for effectiveness of dispersion, such as they would be for surface application of dispersants

Potential trade-offs include increased water column and benthic resource exposures to oil at depth. Dispersants will not be used by BP without prior regulatory approval.

In May 2016, the *Regulations Establishing a List of Spill-treating Agents* under the *Canada Oil and Gas Operations Act* came into force, listing spill-treating agents (dispersants) Corexit© EC9500A and Corexit© EC9580A as acceptable for use in Canada's offshore. While this does not imply pre-authorization for use, these regulations, along with provisions in the *Energy Safety and Security Act*, lifts legal prohibitions that would otherwise prevent the use of spill-treating agents if, among other stipulations, the C-NLOPB's Chief Conservation Officer determines that its use is likely to achieve a net environmental benefit in the particular circumstances of the spill and approves the use of the spill-treating agent.

If dispersant use is advisable in the event of an oil spill, BP will seek approval from the C-NLOPB Chief Conservation Officer. BP will undertake a SIMA as part of the preparation of the SRP to evaluate the benefits associated with different spill response strategies including dispersant application. SIMA is a tool that aids in the design of response planning through consideration of the best available information about the relative impacts of spilled oil and the probable capabilities and consequences of response options in the area of concern. A SIMA will be used to assess and compare the feasibility and environmental and socio-economic impacts of employing different oil spill response techniques (including but not limited to dispersant application) to prevent or reduce contact of the oil with resources most likely to be affected. The baseline case for the SIMA for the Project will be one of “no action” (i.e., the use of no tactical response methods) to assess the relative merits of each potential oil spill response option. Before any dispersant use is requested, an incident-specific SIMA will be conducted, taking into consideration the specific conditions present at the time and location of the spill. Only if the SIMA shows that dispersant use would be feasible, effective, and result in a net benefit, would its use be requested. Operational considerations in evaluating the role of various spill response strategies (including use of dispersants) will consider: the feasibility of the response technique in prevailing conditions; capability of the response technique to substantially affect the outcome; and the availability of equipment and personnel to deploy the response technique. In addition to these operational considerations, other factors may influence response effectiveness. The rapid evaporation of very light oils or the rapid formation of emulsified oil can change the amounts and nature of floating oil on the surface, shoreline oiling, or the amount of oil that can be effectively dispersed and diluted in the water column. Spills that occur near sensitive ecological areas may not allow sufficient time to mobilize slower responding vessel equipment, making aerial dispersant application the optimal way to intercept the oil before it reaches shore. Alternatively, wind or water currents may alter the course of an oil slick, which may influence the time to landfall, therefore influencing the potential window to apply dispersants to reduce the extent of shoreline oiling.

The plan to use dispersants as part of any response plans will consider the operational requirements and prevailing conditions. Should dispersants be approved for application, an incident-specific monitoring and sampling plan would be developed to evaluate the effectiveness and potential impacts of dispersant application. Further information about the potential ways in which dispersants may be used as part of the Project will be included in the SRP.

Dispersant Effects

Use of dispersants can alter the relative importance of exposure pathways to oil for wildlife (BP 2014). In many cases, risk of adverse environmental effects is lessened due to the reduction in floating oil on the sea surface. Subsea dispersant injection may therefore greatly reduce potential for interaction of crude oil with marine birds, mammals and sea turtles that need clean air to breathe, and environmentally sensitive shoreline habitats. Oil on the water surface can pose an inhalation and ingestion risk as well as an external exposure risk through skin and eye irritation to certain marine and coastal species. Oil floating on the sea surface can also smother some small species and some early life stages of fish or invertebrates (eggs, larvae), and coat feathers and fur, reducing birds' and mammals' ability to maintain their body temperatures (refer to Section 15.5 for more information on the effects of hydrocarbons on the marine environment). However, dispersants application (as is the case with any spill response measure) may also result in adverse environmental effects.

Treatments of spilled oil with dispersants can temporarily increase exposure of small subsurface marine organisms (which cannot quickly swim away) to small oil droplets that remain in the water column due to natural turbulent mixing. With respect to surface application of dispersants, concentrations of dispersed oil components can potentially increase (generally within the top 10 m of the upper water column) to acutely toxic levels to sensitive life stages of small fish and invertebrates - especially their larvae and eggs (embryos). Although the intent of dispersion of the oil is to rapidly reduce the formation of oil slicks floating on the sea surface and to dilute oil concentrations in the water column, the dispersed oil can therefore sometimes reach toxic concentrations for short time periods for those very sensitive life stages of organisms that are part of the nekton (endpoint is mortality).

There have been many reports and publications examining the toxicity and effectiveness of dispersant products (including toxicity of dispersed oil) from laboratory experiments, field studies and actual spill response activities and the results were used for regulatory approval of dispersant applications in many countries, including Canada. The toxic response of an organism to dispersants and dispersed oil is dependent primarily on the extent of exposure (chemical form, concentration, duration) of the organism. Different species or life stages of the same species may exhibit different degrees of response to similar exposure conditions and species sensitivity distributions are derived to establish thresholds for environmental effects (BP 2014).

Corexit 9500A, the primary dispersant used during the Deepwater Horizon incident spill response effort, meets the rigid US Environmental Protection Agency (USEPA) criteria established for the US National Oil and Hazardous Substances Pollution Contingency Plan listing, as well as subsequent testing conducted by USEPA laboratories to validate test results obtained during the listing process (USEPA 1994, 2017). Environment Canada (2016) testing further confirmed low toxicity of Corexit 9500A to marine organisms and approved its use in Canada’s offshore. Corexit 9500A, among other dispersant products, is composed of surfactant components similar to those used in common household products, and their toxicity to aquatic species when they are free in solution is low. Word et al. (2014) put dispersant toxicity in context by commissioning two independent accredited laboratories to conduct parallel studies that compared the acute toxicity of Corexit 9500A to common household cleaning agents. These studies revealed that the commercially available dispersant products are less toxic than crude oil or oil mixed with dispersants. The review by the Royal Society of Canada confirmed that dispersant products themselves do not cause synergistic toxicity, nor increase the solubility of toxic constituents of the oil but rather, increase the concentration of small oil droplets to which organisms are exposed to (Lee et al. 2015). A paired model and mesocosm study examining Atlantic cod (*Gadus morhua)* larval response to dispersant water-soluble fraction (WSF) treatments versus WSF + oil droplet treatments concluded no additional toxicity effects were attributable to the oil droplet component (Nordtug et al. 2011).

Bioaccumulation occurs in the food web when a substance in the tissue of a food item is at a higher concentration than the concentration in the organism’s surrounding environment such that the substance is persistent and accumulates from the consumer’s diet faster than it is lost due to excretion or metabolism (Lee et al. 2015). Invertebrates do not metabolize or excrete petroleum hydrocarbons quickly, and as a result can contribute to the dietary exposure of predators feeding on them. However, petroleum hydrocarbons typically do not biomagnify in food webs. This is likely due to the fact that most hydrocarbons can be readily metabolized by vertebrates including fish, birds, and marine mammals, and bioaccumulation is not thought of as an issue for these species (Lee et al. 2015). Monitoring by federal and state agencies for PAHs and the dispersant components in >8,000 seafood specimens (whole fish or groups of individual small shellfish) collected in federal waters of the Gulf of Mexico in response to the 2010 Deepwater Horizon oil spill concluded concentrations were below the limits of quantitation or, when detected, were at least two orders of magnitude lower than the US Food and Drug Administration human level of concern for each compound (Ylitalo et al. 2012). There have also been studies that demonstrate that turtles can bioaccumulate persistent organic pollutants and develop dose-dependent deformities. However, evidence for similar effects due to petroleum hydrocarbons, particularly PAHs, on turtles is less evident (Lee et al. 2015).

Fish are typically at risk from acute oil exposure in a 24- to 48-hour period following an oil spill. As a result of this, mortality to fish – mainly early life stages (larvae, eggs if present if a spill happens during spawning season) are typically brief and localized due to the loss of the acutely toxic water-soluble low molecular weight aromatic components of oil due to dilution and weathering (Lee et al. 2015). The primary toxicity concern regarding dispersant use is therefore the acute (short-term) exposure of small water column organisms to potentially toxic concentrations of these lower molecular weight compounds. Additional concerns include the potential sub-lethal effects from the persistent components that remain bioavailable in the different environmental matrices. But those mortalities to fish larvae or eggs wouldn’t be expected to produce effects at population- or community-levels (e.g., population of fish stocks). The magnitude of potential effects would also depend on the habitat where local species spawn or have nurseries and the time of the year.

Although acute mortality to early life stages of fish could be extensive in the event of a well blowout directly in the area of a continuous oil release and dispersants use would likely increase the chance of fish species to come into contact with oil, any substantial impact on fish populations is not expected. When dynamic, rapidly decreasing concentrations of dispersed oil are present, short-term exposures above laboratory-derived toxicity thresholds are usually limited in duration and occur only in the upper layers of the water column for treated surface slicks. For sub-sea injection of dispersants at well control incidents, concentrations exceeding mortality thresholds are limited to areas near the dispersant injection site.

Chronic toxicity thresholds are often derived from acute toxicity test data. However, Lee et al. (2015) has suggested that ‘‘models of chronic toxicity must be developed from results of chronic toxicity tests and not from acute toxicity tests via application factors’’. Unfortunately, chronic toxicity data for oil and associated polycyclic aromatic hydrocarbons are limited (Lee et al. 2015). A few studies have examined potential chronic effects on growth, including studies of cardiac toxicity (Brette et al. 2014; Incardona et al. 2014), mutagenicity (Paul et al. 2013), and developmental deformities (Barron 2012; Dubansky et al. 2013; Incardona et al. 2013). However, those studies generally used novel test procedures that have not been shown to yield reliable results, and do not show that the test results can be reproduced if the test is repeated.

For this EIS, we looked at chronic toxicity studies that used the type of accepted standard aquatic toxicity test procedures typically used by regulatory authorities to make decisions in environmental, health, and safety assessments, since those methods provide greater assurance of data quality and greater ability to reproduce tests results for oil exposures.

Echols et al. (2016) studied the chronic toxicity of fresh and weathered oil using two standard test species (mysids and inland silversides), and standardized / approved aquatic test guideline methods for Whole-Effluent Toxicity testing (USEPA 2002). These species were exposed for 21 to 28 days to oil loading rates up to 1 g/L of fresh or weathered oil collected from the Deepwater Horizon spill. The highest exposure levels contained an average total polycyclic aromatic hydrocarbons (TPAH) concentration of 165 µg/L for fresh source oil, and 5 to 18 µg/L for weathered oil, which is similar to the highest concentrations of TPAHs in water column samples collected during the Deepwater Horizon incident, although these concentrations were uncommon (Boehm et al. 2016). Lower exposure levels of 0.1 g/L of oil were used to study the oil concentrations that are more commonly found in the upper surface water layer after oil has been treated with chemical dispersants (Neff 1999).

Echols et al. (2016) found that fresh oil had some effect on the survival and growth of mysid shrimp and inland silversides at approximately 132 µg/L TPAH (lowest observed effect concentration), which approaches the higher concentrations of fresh oil and TPAH seen near the site of the oil release in the Deepwater Horizon spill. As the concentration of TPAH increased, mortality also increased, and growth decreased. Weathered oil also had some effect on silverside survival at a lower concentration of approximately 5 to 8 µg/L TPAH, and on growth at approximately <2 to <8 µg/L TPAH (lowest observed effect concentration). However, weathered oil had no effect on the survival and growth of mysid shrimp, even at the highest levels tested, at 1 g/L oil of weathered oil (approximately 5 to 18 µg/L TPAH). These data were used to estimate the potential for chronic toxicity in the well blowout model.

Marine mammals are susceptible to floating oil due to the fact they need to surface at regular intervals to breathe; as a result, dispersing oil may be beneficial for mammals by reducing the probability of contacting concentrated floating oil. However, the dispersion of oil may expose swimming or feeding mammals to skin or fur contamination, the consumption of contaminated plankton, and potentially the clogging of baleen (Lee et al. 2015). Hydrocarbons consumed by marine mammals through contaminated diets can be metabolized and excreted, although Engelhardt (1983) hypothesized hydrocarbons might be stored in blubber and other fat deposits. These stored hydrocarbons have the potential to be released into circulation during periods of physiological stress (low prey availability, migration, or lactation). These circulating hydrocarbons may be bioavailable and toxic to a fetus or newborn (Engelhardt 1983).

Several mesocosm and open ocean field trial experiments have demonstrated that the rates of mixing and dilution in open waters that are 5.5 km (3 nautical miles) or more offshore and are 10 m in depth or greater are sufficient to reduce the potential toxic effects of oil dispersed at the surface. At these depths and distances from shore, NEBA / SIMA demonstrates that transient aquatic toxicological impacts in the water column are much less than the risks to birds, mammals, and coastal and shoreline communities by allowing oil slicks to persist on the water surface and eventually become stranded on the shoreline (Lewis and Aurand 1997). The net environmental benefits of subsea dispersant injection could be more pronounced since the depths and distance from shore are likely to be greater for Newfoundland and Labrador.

Laboratory studies on embryos and larvae of corals exposed to dispersed oil caused greater toxicity than to oil alone (Lee et al. 2015); direct contact with oil may also cause mortality and/or sublethal effects (i.e., reduced growth or reproduction) to adult corals (depending on the concentration and exposure duration to toxic components. Those exposures are rapidly mitigated by the effects of dilution and microbial degradation of the dispersed oil. While corals can exist in the deep-water environment at this site, they will likely be present in sporadic aggregations or mounds at the seafloor. Past SINTEF Oil Spill Contingency and Response (OSCAR) modelling suggested that the deep-water dispersed oil will be localized to the area of the wellhead (one to several kilometres) and the vertical modelling results indicated that risks to corals are low based on the predictions of low water column concentrations in the deeper and colder waters at the sea bottom. The use of dispersants to manage the discharge of oil from the wellhead during the Deepwater Horizon oil spill indicated that deep-water organisms were at risk for exposure to chemically-dispersed oil, mainly due to the depth of the well and the presence of a chemocline at 1,100 m, which was a strong, vertical chemistry gradient within that location of the Gulf of Mexico that acted as a barrier to vertical oil migration.

Due to the dynamic nature of the marine environment, exposure conditions are rarely constant. Environmental exposures from dispersants and dispersed oil are dynamic events of oil spills in open waters, with concentrations diminishing rapidly over time in offshore waters following dispersant application to surface oiling (BP 2014). Use of SSDI for prolonged oil releases at well control events can generate more consistent exposure conditions at points near the sources. These dynamic exposure conditions must be considered in order to more accurately characterize the potential toxicity from dispersed oil exposure in the environment (BP 2014). It is possible that SSDI results in a temporary, localized increase in risk of adverse environmental effects to invertebrates and plankton in the water column near the dispersant application area (i.e., wellhead) (HDR Inc. 2015). However, few marine species (e.g., invertebrates, plankton) would be exposed to dispersant concentrations greater than their laboratory LC_{50} values (mortality), and those concentrations are unlikely to be sustained long enough to elicit a toxic effect. For continuous SSDI at well control events, concentrations of dispersants not associated with the oil would be low during application and would diminish quickly due to dilution as currents move the dispersant away from the treatment site. This would lead to very localized potential areas of effect from dispersant alone (BP 2014).

In general, dispersed oil is believed to result in reduced adverse environmental effects on marine mammals and birds due to the reduction of exposure to floating oil on the sea surface. However, dispersant use in close proximity to various species may reduce surface tension at the feather / fur-water interface, thereby reducing the capacity of insulation provided by feathers or fur. The magnitude of these effects depends on the proximity of wildlife during dispersant application as well as the effectiveness of the dispersant on the surface oil (NRC 2005). As discussed in Section 8.5.3, exposure to oil will also affect thermal regulation.

Although studies indicate that dispersants have relatively low toxicity to fish species, dispersant use may increase public concern over seafood safety, thereby potentially prolonging effects on commercial and Indigenous fisheries (HDR Inc. 2015).

The SIMA will weigh the potential biophysical and socio-economic risks of dispersant application in comparison with risks of not dispersing surface oil, including the risk to marine life associated with surface slicks and shoreline contamination. In particular, the SIMA will analyze the trade-off between the toxic effects of the dispersed oil in the water column relative to the advantages of removing floating oil from the surface and preventing shoreline impacts.

In-Situ Burning

Controlled in-situ burning can be used to quickly and efficiently reduce the volume of oil on the water surface that could otherwise reach shorelines and nearshore sensitive receptors. In-situ burning involves containment and ignition of oil within oil-resistant booms. Typically, the oil is contained within a boom and ignited using a hand-held igniter or an igniter suspended from a helicopter. The burn will continue only as long as the oil is thick enough - usually approximately 2 to 3 mm (1/10 of an inch).

Under favourable conditions, in-situ burning is a fast, efficient, and relatively simple way of removing spilled oil from the water. Furthermore, it greatly reduces the need for storage and disposal of the collected oil and the waste it generates. This response tactic is most effective for fresh oil and spill locations away from populated areas and can only be conducted under certain meteorological conditions (i.e., calm seas and light winds).

The SIMA will consider potential effects of various spill response tactics including but not limited to in situ burning. Environmental effects associated with in-situ burning include the generation of atmospheric emissions and burn residue and a temporary localized effect on the surface microlayer.

Studies of the emissions from in-situ burning have shown fairly consistent results. Approximately 85% to 95% of the burned oil becomes carbon dioxide and water, 5% to 15% of the oil is not burned efficiently and is converted to particulates, mostly soot, and the remaining 1% to 3% is comprised of nitrogen dioxide, sulphur dioxide, carbon monoxide, PAHs, ketones, aldehydes, and other combustion by-products (Ferek et al. 1997). The burning of oil on water seems to be similar to burning the oil in a furnace or a car, with the exception that the burn is oxygen-starved and not very efficient, so that it generates black soot particulates that absorb sunlight and create black smoke.

Generally, the composition of burn residue is similar to that of the original oil. Burn residues generally have less volatile hydrocarbons and are more viscous and denser than unburned oil. Burn residues may either float or sink. For example, in a controlled test burn during the *Exxon Valdez* spill, an estimated 15,000 to 30,000 gallons of Prudhoe Bay crude oil were burned. Following this burn, about 300 gallons of "stiff, taffy-like burn residue that could be picked up easily" remained on the sea surface (Allen 1990). However, during the 1991 Haven tanker incident near Genoa, Italy, the remaining burn residues sank. Reliable estimates of the amount of oil actually burned were not possible, but the tanker was laden with 141,000 tons of Iranian heavy crude, and very little remained in the wreck after the incident. Several 1991 surveys confirmed that there was sunken oil offshore and along the coast (Moller 1992). In some other cases, the residues stay afloat while warm, but sink as they cool. In a series of test burns in Prudhoe Bay, Alaska using Alaska North Slope crude, it was found that, as the residues cooled, some of it sank (Buist 1995). The sunken residues formed a brittle solid, while the residues that stayed afloat were semi-solid tar. It seems, therefore, that prompt collection of the residues can at least in some cases prevent the residues from sinking.

Observations during large-scale burns using towed containment boom did not indicate a temperature impact on surface waters. Thermocouple probes in the water during a Newfoundland test burn showed no increase in water temperatures during the burn (Fingas et al. 1994). It appears that the burning layer may not remain over a given water surface long enough to change the temperature because the ambient temperature seawater is continually being supplied below the oil layer as the boom is towed.

Environment Canada coordinated a series of studies to determine whether in-situ burning caused water-column toxicity beyond that attributable to allowing the slick to remain on the surface of the water. While these studies centered on the Newfoundland in-situ burn field trials conducted in August 1993, they also included laboratory tests to investigate potential effects in a more controlled environment (Daykin et al.1994). Results from the laboratory and field studies indicated that, although toxicity increased in water samples collected beneath oil burning on water, this increase was generally no greater than that caused by the presence of an unburned oil slick on water. Chemical analyses performed along with the biological tests reflected low hydrocarbon levels in the water samples.

The surface of the water represents a unique ecological niche called the “surface microlayer,” which has been the subject of many recent biological and chemical studies. The microlayer, often considered to be the upper millimetre or less of the water surface, is habitat for many sensitive life stages of marine organisms, including eggs and larval stages of fish and crustaceans, and reproductive stages of other plants and animals. It is known that cod, sole, flounder, hake, anchovy, crab, and lobster have egg or larval stages that develop in this layer. There is little doubt that in-situ burning would kill the organism in the area of the burn. However, when considering the small area affected by in-situ burning, the rare nature of this event, and the rapid renewal of the surface microlayer from adjacent areas, the long-term biomass loss is negligent (Shigenaka and Barnea 1993).

Shoreline Protection

Shoreline protection involves deploying barriers, including boom and berms, to deflect and protect coastal environmental sensitivities from the surface oil. A range of equipment can be used for shoreline protection, including deflection booming, which is used to divert oil to a suitable collection point on the shoreline or at sea, and protection booming, which is used to hold oil back from environmental or socio-economic sensitivities. Sand, sand bags, and earth barriers can be used to prevent the ingress of oil to specific areas. Selection of equipment and strategies is dependent on local conditions and the outcome of spill trajectory modelling.

Shoreline Clean Up

In the event that oil threatens or reaches the shoreline, a shoreline response program will be initiated. Shoreline Clean-up Assessment Technique (SCAT) teams will be mobilized to perform systematic surveys to document the location, degree, and type of shoreline oiling. This information will be used establish shoreline treatment recommendations appropriate for each area, or shoreline segment. There are a range of treatment measures including, but not limited to, low-pressure flushing, mechanical collection, manual cleaning, plowing, soil washing, and natural attenuation. Stakeholders and rights-holders are engaged to build consensus on clean-up endpoints, based on net environmental benefit. SCAT teams will also be used to monitor and evaluate the effectiveness of the clean-up operations.

Oiled Wildlife Response

Oiled wildlife response may be required for fauna encountered at sea and on the shorelines of islands and the mainland. An Oiled Wildlife Response Plan will be developed in conjunction with the OSRP.

Where it is required, BP will draw upon the expertise and equipment of specialist contractors to support the oiled wildlife response effort. Oiled wildlife response typically is based on a three-tier approach:

1. Primary response: surveillance to determine the location and extent of wildlife injuries and death; and deflecting oil away from areas of high sensitivity where practicable.
2. Secondary response: deterring fauna from affected or potentially affected areas; and pre-emptive capture and exclusion activities.
3. Tertiary response: capture and stabilization of oiled wildlife (using boats, or on the shoreline); transport to treatment facilities and treatment of affected fauna.

15.4 Fate and Behaviour of Potential Spills

Spill fate modelling has been undertaken to evaluate the effects of potential spill scenarios that could arise as part of the Project. The fate and behaviour of spilled oil depends on a number of factors at the point of release, and the effects on any VC are contingent on how the VC and oil interact. Spill fate modelling will also be used to inform the response strategies selected as part of the SRP.

This section sets out the methods and assumptions used for the modelling work. The spill modelling report is included as Appendix D.

15.4.1 Spill Fate Modelling Approach

As discussed in Section 15.2, a number of potential spill scenarios could occur during Project activities as a result of an accidental event.

BP has modelled a number of these scenarios to inform the assessment of potential environmental effects associated with spills that could occur during exploration drilling activity. The primary objective of spill modelling carried out for the Project was to assess transport, fates and effects of oil associated with each scenario. Modelling was carried out using BP's preferred model, the SINTEF Oil Spill Contingency and Response (OSCAR) model. Prior to modelling, BP consulted with technical experts from applicable regulatory agencies (e.g., C-NLOPB, DFO, ECCC, NRCan) to discuss the proposed modelling approach including the use of OSCAR, data inputs (e.g., metocean and oil characteristics), modelling scenarios, and modelling thresholds. BP also reviewed recent spill modelling and EA reports prepared for other exploration drilling projects in the Newfoundland and Labrador offshore area as well as regulatory review comments associated with these reports in an effort to incorporate lessons learned.

The scope of the modelling included several aspects:

- a prediction of the movement and weathering of the oil originating from release sites using spatial wind data, current data, sea ice data, and specific hydrocarbon properties
- stochastic modelling to predict the probability and areal extent of oiling above threshold levels at the sea surface, on shorelines, and in the water column for each scenario
- deterministic modelling to show the single spill trajectory with the highest amount of oil reaching the shore for each scenario
- a calculation of the maximum amount of oil that could contact the shoreline

Scenarios were modelled to represent both a low probability, large-scale event (i.e., a subsea blowout incident) and an instantaneous, small-scale spill scenario (i.e., a surface release of diesel). The scenarios were modelled at two possible drilling locations in the Project Area to evaluate the potential impact of water depth and proximity to sensitive receptors in and around the Project Area. For all scenarios, modelling was conducted for both “summer” and “winter” seasons, and the models were run without mitigation (i.e., without any oil spill tactical response methods such as those presented in Section 15.3.3.3) until the amount of oil in the system fell below the significance thresholds described in 15.4.6.

15.4.2 Spill Model

BP carried out the modelling work using its preferred model for oil spill trajectory modelling, SINTEF’s OSCAR model. OSCAR is a sophisticated 3-dimensional model that calculates and records the distribution (as mass and concentrations) of oil on the water surface, on the shorelines, and in the water column. The model computes surface spreading, slick transport, entrainment into the water column, evaporation, biodegradation, emulsification, and shoreline interactions to determine oil drift and fate at the surface. In the water column, horizontal and vertical transport by currents, dissolution, adsorption, settling, and degradation are simulated.

There are two types of model simulations that can be generated: stochastic simulations; and deterministic simulations. Both simulation types are used in different ways during the modelling process to inform the various stages of assessing the risk posed by the scenarios. Together, the two model types provide an indication of both likelihood and magnitude of any potential effects.

15.4.2.1 Stochastic Modelling Simulations

Stochastic modelling is used to predict the probability of sea surface, shoreline or water column oil contact that may occur following a spill event. This type of modelling accounts for the variability of metocean conditions in the modeling domain over the anticipated operational period to provide insight into the probable behaviour of the potential spills.

Stochastic modelling involves running numerous individual spill trajectory simulations using a range of prevailing wind and current conditions that are historically representative of the season and location of where the spill event may occur. The trajectory results are then combined to produce statistical outputs that include the probability of where oil might travel and the time taken for the oil to reach a given shoreline. The stochastic model output does not represent the extent of any one oil spill event (which would be substantially smaller) but rather provides a summary of the total individual simulations for a given scenario or oil type. Stochastic models are used for emergency response planning purposes.

15.4.2.2 Deterministic Modelling Simulations

Deterministic modelling (or single spill trajectory analysis) is used to predict the fate (transport and weathering behaviour) of spilled oil over time under predefined hydrodynamic and meteorological conditions.

When carrying out deterministic modelling, BP typically selects the conditions that give rise to the simulation with the greatest shoreline oiling from the stochastic modelling.

15.4.3 Model Scenarios

Further to the information presented about potential scenarios that could arise during the Project in Section 15.2, two categories of scenarios were modelled as part of the EIS. Two locations representing likely drilling targets were selected on the basis of preliminary seismic data processing and interpretation (Table 15.3; Figure 15.8). Both locations represent viable drilling prospects for the Project and represent different geographical areas and water depths in the Project Area.

Table 15.3 Spill Release Modelling Locations

Location	EL	Water Depth (m)	UTM Easting	UTM Northing
Site 1 (West Orphan Basin)	EL 1145	1360	168454.17	5,608,064
Site 2 (East Orphan Basin)	EL 1149	2785	352,231	5,471,024

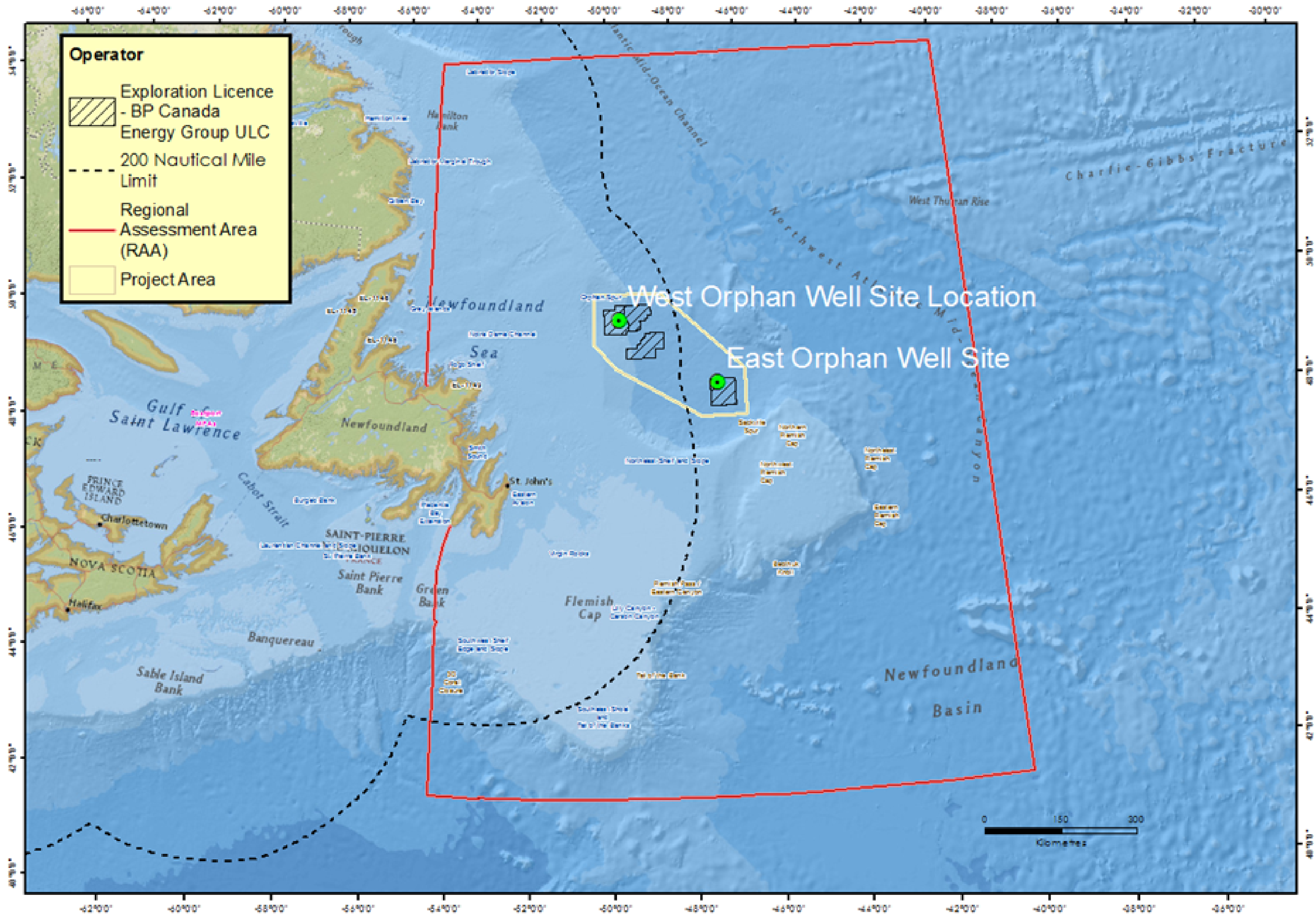


Figure 15.8 Modelled Release Locations

The scenarios that were modelled are described below and summarized in Table 15.4.

1. **A subsea blowout of crude oil**

   Two subsea blowout scenarios have been modelled at different locations within the Project Area. Release volumes varied between the two locations. The West Orphan Basin site assumes an initial oil release rate of 128,000 barrels per day (bpd). The East Orphan Basin site assumes an initial oil release rate of 39,000 bpd (see Table 15.4). Steady state uncontrolled well discharge modelling has been undertaken to assess the potential worst-case credible discharge that could occur as a result of a blowout incident at the two potential locations. The well discharge model and analysis was prepared by BP subject matter experts against internal standards and has been peer reviewed internally.

   For modelling purposes, conservative estimates of 120 days (to simulate a relief well scenario) and 30 days (to simulate a capping stack response scenario) are used; however, as indicated in Section 15.3.3, anticipated response time is significantly less.

2. **A surface release of diesel**

   Two surface diesel release scenarios have been modelled to represent a loss of containment at the MODU. This scenario represents the most likely spill scenario that could occur on the MODU.

   The spill volumes modelled included 10 bbl, to represent a hose failure (i.e., an operational and maintenance spill), and 100 bbl, to represent a tank failure (i.e., a bulk spill). These scenarios were modelled from both spill modelling locations (refer to Table 15.4).

All modelled scenarios were run unmitigated (i.e., without any oil spill tactical response methods such as those presented in Section 15.3.3.3) with the use of a relief well or capping stack for the blowout incident scenarios. In reality, spill mitigation measures such as oil spill containment, recovery, and shoreline protection measures would be implemented in the event of a spill to reduce adverse effects to marine and coastal resources, thereby mitigating the full impact of a spill.

Stochastic and deterministic modelling were carried out for each scenario. Separate stochastic simulations were carried out to represent the following weather seasons:

- winter season (November to April)
- summer season (May to October)

Ice cover in the region is present in specific regions from November through April, while May through October is mostly ice-free. The simulations were run at varying start times to cover each six-month season using data for winds, currents and ice from January 2006 through December 2010, thus ensuring that the predicted transport and oil weathering for each oil spill simulation is subjected to a range of prevailing wind current and ice conditions that is historically representative of the time period in question. Although each simulation has the same release information, they have differing trajectory paths, due to the varying start times and associated conditions.

Table 15.4 Modelled Spill Scenarios

Oil Spill Scenario				Initial Release Rate (Day 1)		Final Release Rate (Date 30/120)		GOR (scf/bbl)	Cumulative Volume of Oil Released		Release Duration
No.	**Description**	**Wellsite Location**	**Type of Hydrocarbon Release**	**Oil (bpd)**	**Water (bpd)**	**Oil (bpd)**	**Water (bpd)**		**Oil (bpd)**	**Water (bpd)**	
1	Well blowout – relief well	WOB	Crude Oil	128,000	118,000	Day 120; 47,000	Day 120; 25,000	1,800	9.88	7.33	120 days
2	Well blowout – capping stack	WOB	Crude Oil	128,000	118,000	Day 30; 101,000	Day 30; 81,000	1,800	3.44	2.98	30 days
3	Well blowout – relief well	EOB	Crude Oil	39,000	216,000	Day 120; 12,000	Day 120; 1,000	260	3.27	4.49	120 days
4	Well blowout – capping stack	EOB	Crude Oil	39,000	216,000	Day 30; 38,000	Day 30; 30,00	260	1.15	3.68	30 days
5	Batch spill – hose failure	WOB	Marine Diesel	--	--	--	--	n/a	100	--	6 hours
6	Batch spill – tank failure	WOB	Marine Diesel	--	--	--	--	n/a	10	--	1 hour
7	Batch spill – hose failure	EOB	Marine Diesel	--	--	--	--	n/a	100	--	6 hours
8	Batch spill – tank failure	EOB	Marine Diesel	--	--	--	--	n/a	10	--	1 hour

WOB = West Orphan Basin
EOB = East Orphan Basin
bpd = barrels per day
GOR = Gas to oil ratio
scf/bbl = standard cubic feet/barrel

15.4.4 Predicted Fluid Characteristics

The oil types modelled include marine diesel and crude oil.

Oil and chemical databases supply chemical and toxicological parameters required by the OSCAR model. A unique strength of the model is its foundation on an observational database of oil weathering properties. The laboratory and field methods developed at SINTEF for weathering of crude oils and petroleum products are described in Daling et al. (1990, 1997). Numerous field tests have verified the reliability of weathering predictions based on this methodology, in order to avoid unrealistic results.

The oil database contains complete weathering information for more than 50 crude oils and petroleum products. It also contains crude assay data for approximately 150 other crude oils. These latter data are derived from the Hydrocarbon Processing Industry database (Hydrocarbon Processing Industry 1987). Since no empirical observations of weathering are available for these oils, model estimates of oil weathering are less reliable than for oil for which oil weathering studies have been carried out.

SINTEF (Aamo et al. [1993]; Daling et al. [1997]) use a multivariate approach to group oil types based on a limited data set available from crude oil assays (wax / asphaltene content, viscosity, density, pour point, and the true boiling point curve). This approach can be used to match new oil types to oils where their weathering properties are already mapped or characterized to select analogue oils for OSCAR modelling.

15.4.4.1 Crude Oil

Given that the wells to be drilled for this Project are exploratory, the exact nature of the well hydrocarbon fluids that may be encountered is unknown. The crude oil characteristics were selected to align with the expected reservoir characteristics. Petroleum fluid properties in exploration areas can be predicted using a bottom-up petroleum system analysis approach. Specific properties of the petroleum fluid will depend on the richness, quality, and thermal maturity of the source rocks. Where available, top-down observations on petroleum fluid analogues from offset wells or nearby areas can be used to further constrain expected fluid properties.

Tables 15.5 and 15.6 summarize the predicted fluid properties for the West Orphan and East Orphan Basin prospects as well as the analogue oils using the multivariate analysis best fit approach developed by SINTEF that provided the best overall match of oil properties to those predicted for these prospects. YME (IKU), a light crude with low viscosity, was the best oil analogue match for the West Orphan prospect. In contrast the fluid associated with the East Orphan (Jurassic) prospect is expected to be slightly heavier and similar to Bay du Nord (BdN) crude oil. VARG 2004 was the analogue oil selected and matches well on specific gravity and volatiles when compared to BdN.

Table 15.5 Reservoir Fluid Properties – West Orphan

Fluid Properties:	Estimated Fluid Properties	Analogue: YME	Units
API gravity	38	38.4	
Specific gravity	0.835	0.833	
Pour point	0 ±10	6	°C
Wax content	8±2	6	wt%
Asphaltene content	<4	0.3	wt%
Dead oil viscosity at reference (surface) temperature	2.95	4	cP
Reference (surface) temperature	13	13	°C

Table 15.6 Reservoir Fluid Properties – East Orphan

Fluid Properties:	Estimated Fluid Properties	Analogue: VARG 2004	Units
API gravity	34	35.6	
Specific gravity	0.856	0.847	
Pour point	0 ±10	9	°C
Wax content	8±2	5.6	wt%
Asphaltene content	<6	1.5	wt%
Dead oil viscosity at reference (surface) temperature	4.63	36	cP
Reference (surface) temperature	13	13	°C

15.4.4.2 Marine Diesel

Marine diesel is a standard diesel used widely in offshore activity including shipping and oil and gas activity. It has a low viscosity and high aromatic content. Its characteristics are well known and tested. Characteristics of marine diesel were derived from the SINTEF database. Marine diesel fluid properties are listed in Table 15.7.

Table 15.7 Diesel Fluid Properties

Parameter	Value
API gravity	36.4
Specific gravity	0.843
Pour point	-36˚C
Dead oil viscosity at reference (surface) temperature	3 cP
Reference temperature	13 ˚C

15.4.5 Metocean Model Information

Currents, winds, sea ice and other metocean factors are critical parameters that can influence the fate and behaviour of oil following a spill. Metocean data are available from a number of sources and can be formatted to work in the OSCAR model. More information on environmental (hydrodynamic, wind, sea ice, hydrographical and bathymetry) data used in the modelling can be found in Section 5.3 of Appendix D.

The hydrodynamic dataset used in OSCAR modelling comprised of 3-hourly HYCOM current speeds with Bedford Institute Tides linearly superimposed. Table 15.8 presents the metocean data parameter inputs used in the spill model (OSCAR).

Table 15.8 Metocean Data Parameter Inputs

Parameter	Input Data	Temporal Resolution	Reference
Bathymetry	GEBCO-1 minute	n/a	http://www.gebco.net/
Current velocity	HYCOM	3 hourly	https://hycom.org/
Temperature	World Ocean Atlas	Monthly	https://www.nodc.noaa.gov/OC5/woa13/
Salinity	World Ocean Atlas	Monthly	https://www.nodc.noaa.gov/OC5/woa13/
Tides	Bedford Institute Tides	3 hourly	http://www.bio.gc.ca/
Winds	NCAR /NCEP (CFSR)	3 hourly	http://rda.ucar.edu/pub/cfsr.html
Atmospheric forcing	NCAR/NCEP (CFSR)	3 hourly	http://rda.ucar.edu/pub/cfsr.html
Sea ice	National Snow and Ice Data Centre	daily	http://nsidc.org/
Wave heights	Calculated in OSCAR	n/a	n/a
Wind induced current	Calculated in OSCAR	n/a	n/a

15.4.6 Modelling Thresholds

Following a spill, it is expected that oil will spread over the water surface and disperse throughout the water column. To assess the probability or likelihood of potential effects of a spill, specific thresholds for surface oil thickness, shoreline oiling, and in water concentration have been used. The chosen hydrocarbon thresholds for probability of exposure at the sea surface, entrained and dissolved in the water column, and stranded on shorelines and the justification for their use is presented in Table 15.9.

Table 15.9 Thresholds Used in Spill Modelling

Selected Threshold	Rationale
Surface Oil Thickness	
0.04 μm	Visible sheens on the water surface can have a socio-economic effect as commercial resources can be affected. For example, fisheries are typically closed when a visible sheen is detected. A visible sheen can be detected from 0.04 μm oil thickness. The Bonn Agreement Oil Appearance Code (BAOAC) is a series of five categories that relate the appearance of oil on the sea surface to the thickness of the oil layer. Between 0.04 μm and 0.30 μm oil thickness, a silvery grey sheen may be visible. A rainbow sheen is visible between 0.30 μm and 5.0 μm, a metallic sheen is visible between 5.0 to 50 μm, a discontinuous true oil colour is visible between 50 and 200 μm, and a continuous true oil colour is visible at 200 μm oil layer thickness. The minimum thickness of oil that may result in harm to seabirds through ingestion from preening of contaminated feathers, or loss of thermal protection from their feathers, has been estimated by different researchers to range between 10 to 25 μm (10 to 25 g/m²) (French-McCay 2009). A conservative surface thickness threshold of 0.04 μm was used in the modelling in recognition of potential socio-economic effects (e.g., fisheries closure) in the presence of a barely visible or silver sheen on the water surface.
Shoreline Mass	
1.0 g/m²	Oil on the shoreline can have an effect on environmental and socio-economic receptors. French-McCay (2011) quotes shoreline impact lethal thresholds of 1 kg/m² (1 mm) for vegetation growing along flat shorelines with soft sediments and 100 g/m² (0.1 mm) for epifaunal invertebrates (e.g., mussels, crabs, starfish). However, a conservative stranded oil threshold of 1.0 g/m² was used in the stochastic modelling as that amount of oil would conservatively trigger the need for shoreline clean-up. This is equivalent to a density of 2.5 cm (1 inch) diameter tarballs at 0.12 to 0.14 tarballs per m² of shoreline.
In-Water Concentration (dissolved and entrained, top 100 m)	
58 ppb total hydrocarbons	Carls et al. (2008) found that the acute toxicity of water-soluble fraction of oil (lethal concentration at which 50% death may occur) for fish embryos varies from 200 to 5,000 ppb total hydrocarbons. Based on extensive toxicity tests of crude oils and oil components on marine organisms, the OLF (the Norwegian Oil Industry Association) *Guideline for risk assessment of effects on fish from acute oil pollution* (2008) concluded that threshold concentration for an expected "no observed effect concentration" (NOEC) for acute exposure for total hydrocarbons ranges from 50 to 300 ppb. Work undertaken by Neilson et al. (2005, as reported in OLF 2008) proposed a value for acute exposure to dispersed oil of 58 ppb, based on the toxicity of chemically dispersed oil to various aquatic species, which showed the 5% effect level is 58 ppb.

15.4.7 Well Blowout Scenario Modelling Results

15.4.7.1 Stochastic Modelling Results

Stochastic modelling outputs illustrate the probabilistic locations of surface oiling, water column dispersed and dissolved oil concentrations, and shoreline oiling for spills based on seasonal metocean conditions. Associated minimum arrival times for threshold exceedances are also provided in the stochastic modelling outputs. The stochastic model output does not represent the extent of any one oil spill event (which would be substantially smaller) but rather provides a summary of the total individual simulations for a given scenario or oil type. Stochastic models are used for emergency response planning purposes.

Stochastic trajectories for the West Orphan blowout scenarios were predicted to drift in all directions, but extended out much more towards the east from the release location. For example, for the relief well scenario (unmitigated crude oil release for 120 days) the extent of the sea surface area with greater than

5% probability of sea surface oil contact exceeding the 0.04 µm (Bonn Agreement Oil Appearance Code (BAOAC) “Sheen”) thickness threshold extended 270 km westward from the release location but 1,350 km to the east. This is attributable to the predominantly westerly winds throughout the year. However, there was a notable seasonal variation in the movement of oil, with a higher potential for surface oil contamination to the south and east of Newfoundland and east of Nova Scotia during winter months. This was especially true for the Avalon Peninsula where the probability of sea surface oil contact exceeding the 0.04 µm “Sheen” BAOAC threshold in near coastal waters was 0% during the summer season but increased to 5% in the winter months. The west to northwesterly winds and higher frequency and strength of surface currents towards the south and south southeast during the winter months transports the oil further south during the winter season, whereas the predominant southwesterly winds transport the oil away from the Avalon coastline in the summer months. In the event that surface oil was to enter the nearshore area of Newfoundland during the winter season, it would take a minimum of 50 days to arrive. The stronger winds and currents during the winter months transported the surface oil further away from the release site, resulting in a larger trajectory footprint. For example, the predicted cumulative footprint of locations where there is a >50% probability of surface oil thicknesses exceeding the 0.04 µm BAOAC “Sheen” threshold was 1,173,820 km² for the winter season compared to 721,520 km² for the summer season.

The same trajectory and seasonal trends were observed for the capping stack scenarios (30-day unmitigated crude oil release); however, the footprints were considerably smaller due to the smaller release volumes. For example, the predicted cumulative footprint of locations where there is a greater than 50% probability of surface oil thicknesses exceeding the 0.04 µm BAOAC “Sheen” threshold was 296,910 km² for the winter season and 228,590 km² for the summer season.

The duration of surface exposure for nearshore waters of Newfoundland was 0 to 1 day. The low surface exposure times suggests that the complex coastal circulation patterns and the turbulent nature of the sea in the region are continually mixing any surface oil into the upper water column reducing exposure time on surface. Exposure times increase on approaching the release site. For example, in the worst exposure scenario (relief well, winter season) the area where oil might be present on the surface for greater than 20 days measures 615 km by 320 km in the respective northwest to southeast and southwest to northeast directions at its maximum extent. The higher wind speeds and associated waves in winter result in significantly more entrainment, reducing the spatial extent of thick oil (BAOAC Dark (or True) colour) on the sea surface.

The smaller volume release at the East Orphan Basin modelling site and the more south-easterly release location resulted in predicted oil trajectories to the north and east, attributable to the easterly bias in surface currents at the East Orphan location. In addition, as a result of the deeper well location, oil travels further in the water column and is dispersed more widely before surfacing. Hence, the footprint around the East Orphan release location (relief well scenario) of “high” probability surface oiling occurrences (>50%) exceeding the 0.04 micron BAOAC “Sheen” threshold was larger than that predicted for the West Orphan location (1,296,256 km² for the winter season and 1,056,102 km² for the summer season compared to 1,173,823 km² and 721,520 km² for the equivalent West Orphan scenarios). Similarly, the area where oil might be present on the surface for greater than 20 days was also larger, typically measuring approximately 1,100 km by 800 km in the respective northwest to southeast and southwest to northeast directions at its maximum extent.

The resulting surface oil slick was also predicted to be thinner for the East Orphan scenarios with no thick oil (BAOAC Dark (or True) colour) occurrences on the sea surface. The same seasonal variation in the movement of oil was predicted, with a higher potential for surface oil contamination to the south during winter months. In addition, as the East Orphan modelling location is further offshore, the probability of sea surface oil contact exceeding the 0.04 µm BAOAC "Sheen" threshold only exceeded 1% at distances greater than 225 km from the coast for the relief well scenario during the summer season (compared to 40 km for the equivalent West Orphan case). However, there was a 1% probability of surface oil being present in the near-coastal waters of the Avalon Peninsula during the winter months and it would take a minimum of 70 days to arrive. The duration of surface exposure was less than 1 day.

The stochastic results also demonstrated the potential locations for spill effects exceeding threshold levels beyond the RAA boundary, and in some cases, beyond Canadian jurisdiction (Saint-Pierre and Miquelon - France, Greenland and the Azores. See Section 7.3 and Annex D of Appendix D). However, average probabilities are low (<10%) and arrival times are greater than 50 days.

The in-water dispersed and dissolved oil threshold exceedance of 58 ppb for total hydrocarbons (THC) is expected to remain in offshore waters with a much smaller areal extent than for surface oil. The modelling results indicate that the in-water oil exceedance will not reach the nearshore waters of mainland Newfoundland. The only exception was the West Orphan relief well, winter season scenario where some localised THC concentrations above the 58-ppb threshold occurred, albeit at probabilities <5%. For West Orphan scenarios, the in-water dispersed and dissolved oil trajectories extend predominantly towards the south and south-southeast, whereas for the East Orphan scenarios it is predominantly towards the east, indicating that transport is controlled by the dominant surface current flow direction at both locations.

Concentrations of dissolved and total hydrocarbons are predicted to be highest around the release site and dissipate as the oil moves away and disperses within the water column. While the highest concentrations of THC are predicted near the release site at the plume trap height, the majority of the predicted THC concentrations are within tens of meters of the surface. This is due to the majority of the predicted THC being the result of entrained oil from wind-induced surface breaking waves.

Analysis of vertical cross sections through the water column at the West Orphan and East Orphan modelling sites show that the subsea probability of oil exceeding the 58 ppb THC threshold is limited to a maximum radius from the wellsite of circa 70 km for probabilities greater than 1%. The West Orphan scenarios have higher THC concentrations and larger cumulative footprints than for the corresponding East Orphan scenarios due to the larger release volume. In addition, the plume trap height occurs at much greater water depth than for the East Orphan well blowout scenarios, therefore the oil is dispersed and diluted more readily to concentrations below the threshold level, reducing the footprint. This is evident in the exposure time footprints. For example, for the unmitigated relief well scenarios, the predicted distance from the wellsite where exposure to in-water concentrations of oil >58 ppb may exceed 14 days ranges extends up to 600 km away from the wellsite for the West Orphan scenarios, compared to 240 km for the East Orphan scenarios.

Shoreline contact is unlikely from releases at either the West Orphan or East Orphan sites. The highest shoreline contact probabilities occurred for the West Orphan relief well scenario during the winter months, with 31 km of coastline potentially at risk from contact probabilities of 5% to 7%. The predicted maximum amount of oil accumulating on the shoreline was circa 400 tonnes with peak oiling occurring between 90 and 120 days. This amount of oil represents 0.04% of the total amount of oil released. However, there was a wide range in the maximum amount of oil accumulated on the shoreline, with no stranded oil occurring in 72% of the simulations and <1 tonne beaching in 85% of the cases during the winter season. The maximum length of coastline potentially at risk from stranded oil exceeding the minimum film or sheen thickness threshold of 1 micron (1 g/m²) was 270 km.

No shore contacts were predicted for the West Orphan and East Orphan capping stack scenarios during the summer seasons with maximum probabilities of 1% to 2% for the capping stack winter scenarios and the West Orphan relief well summer scenarios.

The East Orphan relief well, winter scenario gave rise to the second highest amount of accumulated oil on the shoreline (270 tonnes) with potentially 205 km of coastline at risk from stranded oil film or sheen thicknesses >1 micron (1 g/m²). Peak oiling occurred between 30 and 60 days, but with no stranded oil occurring in 86% of the simulations and <1 tonne beaching in 88% of the cases. This scenario also produced the earliest arrival time of oil to shore (27 days) of all the scenarios modelled. The earliest arrival times for shoreline oiling ranged from 27 to 145 days for the scenarios where beaching of oil occurred.

Tables 15.10 and 15.11 summarize predicted intersection of surface oiling with special areas from a subsurface release in winter and summer in the West Orphan Basin and East Orphan Basin, respectively, Information on stranded oil contact with special areas along the shoreline in winter (there is no shoreline contact in summer in the West Orphan Basin and East Orphan Basin) are provided in Tables 15.12 and 15.13, respectively. Information on intersection of water column dispersed and dissolved oil with special areas from a subsurface release in winter and summer in the West Orphan Basin and East Orphan Basin are provided in Tables 15.14 and 15.15, respectively. All of these results represent a relief well (120-day unmitigated well blowout) scenario. Refer to Appendix D for data and figures pertaining to the capping stack (30-day unmitigated well blowout) scenarios.

Surface oil probability exceeding a threshold of 0.04 µm, minimum arrival time to reach that threshold, maximum exposure time, and average emulsion thickness from a subsurface release in summer and winter in the West Orphan Basin is illustrated in Figures 15.9 to 15.12. This same information for the East Orphan Basin modelling site is illustrated in Figures 15.13 to 15.16. Shoreline contact probability and minimum time to shoreline contact from a subsurface release in summer and winter in the West Orphan Basin are illustrated in Figures 15.17 and 15.18. Shoreline contact probability exceeding a threshold of 1.0 g/m² and minimum time to shoreline contact from a subsurface release in summer and winter in the East Orphan Basin are illustrated in Figures 15.19 and 15.20. Water column dispersion probability exceeding a threshold of 55 ppb total hydrocarbons, minimum arrival time, maximum exposure time, and maximum dissolved oil concentration from a subsurface release in summer and winter in the West Orphan Basin is illustrated in Figures 15.21 to 15.24. Water column dispersion probability exceeding a threshold of 58 ppb total hydrocarbons, minimum arrival time, maximum exposure time, and maximum dissolved oil concentration from a subsurface release in summer and winter in the East Orphan Basin is illustrated in Figures 15.25 to 15.28.

Table 15.10 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) - Surface Oiling Intersects with Specials Areas in Summer and Winter

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface Area Contacted by Emulsified Oil >0.04 µm Thickness	Average of Probability (%)	Average of Min. Arrival Time (days)	Average of Maximum Exposure Time (days)	Time-Averaged Bonn Thickness
Summer								
Sackville Spur	NAFO VME	992	993	100%	99.9	20	18	Rainbow
Northern Flemish Cap	NAFO VME	486	487	100%	99.2	23	17	Rainbow
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	2.0	29	15	Rainbow
Northwest Flemish Cap	NAFO VME	412	413	100%	98.8	20	15	Rainbow
Orphan Knoll	NAFO VME	15,817	15,849	100%	95.2	21	19	Rainbow
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	88.1	36	11	Rainbow
Flemish Pass / Eastern Canyon	NAFO VME	5,418	5,428	100%	87.8	25	10	Rainbow
Northeast Newfoundland Slope	Marine Refuge	55,251	55,283	100%	77.8	17	19	Metallic
Beothuk Knoll	NAFO VME	648	649	100%	76.6	40	8	Rainbow
Tail of the Bank	NAFO VME	144	144	100%	67.4	25	8	Rainbow
Orphan Spur	EBSA	21,569	21,473	100%	61.2	15	13	Metallic
Northeast Shelf and Slope	EBSA	13,885	13,912	100%	61.0	16	8	Metallic
Lilly Canyon - Carson Canyon	EBSA	120	120	100%	49.4	31	6	Rainbow
Bonavista Cod Box	Experimental Closure	9,830	9,848	100%	49.0	15	10	Metallic
Newfoundland Seamounts	NAFO VME	15,491	15,522	100%	26.0	58	4	Rainbow
3O Coral Closure	NAFO VME	14,057	14,083	100%	22.3	68	4	Rainbow
Division 3O Coral	Marine Refuge	10,336	10,356	100%	20.1	73	4	Rainbow
Southwest Shelf Edge and Slope	EBSA	16,644	16,677	100%	15.9	71	3	Rainbow
Southeast Shoal and Tail of the Banks	EBSA	30,935	19,369	63%	10.0	74	3	Sheen

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface Area Contacted by Emulsified Oil >0.04 µm Thickness	Average of Probability (%)	Average of Min. Arrival Time (days)	Average of Maximum Exposure Time (days)	Time-Averaged Bonn Thickness
Fogo Seamounts 1	NAFO VME	4,522	4,532	100%	9.4	96	3	Rainbow
Funk Island Deep	Marine Refuge	7,272	5,732	79%	4.3	83	3	Rainbow
Notre Dame Channel	EBSA	6,222	5,752	92%	4.1	84	3	Rainbow
Fogo Seamounts 2	NAFO VME	4,616	3,333	72%	2.0	134	1	Sheen
Laurentian Channel	AOI	16,564	8,093	49%	1.7	98	1	Sheen
Laurentian Channel and Slope	EBSA	17,140	7,996	47%	1.7	99	1	Sheen
Corner Seamounts	NAFO VME	40,251	10,278	26%	1.2	143	1	Sheen
St. Pierre Bank	EBSA	5,482	2,530	46%	1.1	113	1	Sheen
Virgin Rocks	EBSA	6,843	252	4%	0.9	138	1	Sheen
New England Seamounts	NAFO VME	178,306	11,447	6%	0.9	144	1	Sheen
Burgeo Bank	EBSA	1,952	467	24%	0.9	150	1	Sheen
Labrador Slope	EBSA	29,746	1,320	4%	0.9	132	2	Sheen
Gully Marine Protected Area	MPA	2,385	2,390	100%	2.4	107	1	Sheen
Winter								
Sackville Spur	NAFO VME	992	993	100%	100.0	18	22	Rainbow
Northwest Flemish Cap	NAFO VME	412	413	100%	100.0	19	22	Rainbow
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	100.0	27	21	Rainbow
Northern Flemish Cap	NAFO VME	486	487	100%	99.9	23	22	Rainbow
Orphan Knoll	NAFO VME	15,817	15,849	100%	98.7	23	23	Rainbow
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	98.1	35	15	Rainbow
Flemish Pass / Eastern Canyon	NAFO VME	5,418	5,428	100%	97.6	22	15	Rainbow
Beothuk Knoll	NAFO VME	648	649	100%	95.1	33	11	Rainbow
Tail of the Bank	NAFO VME	144	144	100%	93.9	32	11	Rainbow

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface Area Contacted by Emulsified Oil >0.04 µm Thickness	Average of Probability (%)	Average of Min. Arrival Time (days)	Average of Maximum Exposure Time (days)	Time-Averaged Bonn Thickness
Northeast Shelf and Slope	EBSA	13,885	13,912	100%	86.7	15	15	Metallic
Lilly Canyon - Carson Canyon	EBSA	120	120	100%	81.4	25	11	Rainbow
Orphan Spur	EBSA	21,569	21,609	100%	78.6	12	18	Metallic
Northeast Newfoundland Slope	Marine Refuge	55,251	55,360	100%	78.4	18	20	Metallic
Bonavista Cod Box	Experimental Closure	9,830	9,848	100%	78.3	13	17	Metallic
Newfoundland Seamounts	NAFO VME	15,491	15,522	100%	63.5	53	6	Rainbow
3O Coral Closure	NAFO VME	14,057	14,083	100%	40.5	52	6	Rainbow
Division 3O Coral	Marine Refuge	10,336	10,356	100%	36.8	56	6	Rainbow
Southwest Shelf Edge and Slope	EBSA	16,644	16,677	100%	30.0	60	5	Rainbow
Fogo Seamounts 1	NAFO VME	4,522	4,532	100%	26.8	56	5	Sheen
Notre Dame Channel	EBSA	6,222	6,234	100%	18.4	40	5	Rainbow
Southeast Shoal and Tail of the Banks	EBSA	30,935	29,916	97%	18.4	74	4	Rainbow
Funk Island Deep	Marine Refuge	7,272	7,282	100%	17.8	42	5	Rainbow
Virgin Rocks	EBSA	6,843	6,857	100%	14.5	52	5	Sheen
Fogo Seamounts 2	NAFO VME	4,616	4,626	100%	10.5	79	3	Sheen
Funk Island Ecological Reserve	Ecological Reserve	5	5	100%	2.2	73	1	Metallic
Funk Island	IBA	135	135	100%	1.9	94	1	Rainbow
Corner Seamounts	NAFO VME	40,251	38,522	96%	1.9	125	2	Sheen
Fogo Shelf	EBSA	9,403	2,217	24%	1.8	85	1	Metallic
Laurentian Channel	AOI	16,564	9,848	59%	1.5	136	1	Sheen
Laurentian Channel and Slope	EBSA	17,140	9,514	56%	1.5	136	1	Sheen
Placentia Bay Extension	EBSA	7,693	2,201	29%	1.3	119	1	Rainbow

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface Area Contacted by Emulsified Oil >0.04 µm Thickness	Average of Probability (%)	Average of Min. Arrival Time (days)	Average of Maximum Exposure Time (days)	Time-Averaged Bonn Thickness
Placentia Bay	IBA	1,399	415	30%	1.1	129	1	Rainbow
St. Pierre Bank	EBSA	5,482	2,631	48%	1.1	145	2	Sheen
Hawke Channel	Marine Refuge	8,839	159	2%	1.0	82	2	Sheen
Burgeo Bank	EBSA	1,952	1,180	60%	0.9	150	1	Sheen
Cape St. Mary's	IBA	330	169	51%	0.9	135	1	Sheen
Cape Freels Coastline and Cabot Island	IBA	334	13	4%	0.9	50	1	Discontinuous true oil colour (DTOC)
Eastern Avalon	EBSA	36	0	1%	0.9	91	1	Metallic
Wadham Islands and adjacent Marine Area	IBA	159	7	5%	0.9	51	1	DTOC
Cape St. Mary's Ecological Reserve	Ecological Reserve	54	16	30%	0.9	138	1	Sheen
New England Seamounts	NAFO VME	178,306	6,985	4%	0.9	123	2	Sheen
Labrador Slope	EBSA	29,746	1,561	5%	0.9	153	1	Sheen
Gully Marine Protected Area	MPA	2,385	2,390	100%	5.1	96	3	Sheen
Sable Island**	National Park reserve	33	5	14%	0.9	140	1	Sheen
Sable Island Migratory Bird Sanctuary**	Migratory Bird Sanctuary	31	8	24%	0.9	139	1	Sheen
Sable Island National Park Reserve**	National Park reserve	30	8	25%	0.9	139	1	Sheen

* Probability of sea surface emulsified oil thicknesses exceeding the 0.04 µm (BAOAC “Sheen”) thickness threshold.

** Outside RAA

Table 15.11 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) - Surface Oiling Intersects with Special Areas in Summer and Winter

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface area of SA contacted by emulsified oil >0.04 µm thickness	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Average Time-Averaged Bonn Thickness
Summer								
Orphan Knoll	NAFO VME	15,817	15,849	100%	99.8	6	38	Rainbow
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	90.7	10	24	Rainbow
Sackville Spur	NAFO VME	992	993	100%	70.3	6	16	Rainbow
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	69.8	18	17	Sheen
Northern Flemish Cap	NAFO VME	486	487	100%	63.7	8	16	Rainbow
Northwest Flemish Cap	NAFO VME	412	413	100%	33.2	12	13	Rainbow
Northeast Newfoundland Slope	Marine Refuge	55,251	55,219	100%	29.6	25	9	Rainbow
Beothuk Knoll	NAFO VME	648	649	100%	25.2	34	7	Sheen
Flemish Pass / Eastern Canyon	NAFO VME	5,418	5,428	100%	11.0	31	4	Sheen
Tail of the Bank	NAFO VME	144	144	100%	6.5	55	2	Sheen
Orphan Spur	EBSA	21,569	20,694	96%	5.3	61	2	Sheen
Newfoundland Seamounts	NAFO VME	15,491	15,514	100%	4.7	67	2	Sheen
Northeast Shelf and Slope	EBSA	13,885	12,693	91%	4.6	40	2	Rainbow
Lilly Canyon - Carson Canyon	EBSA	120	116	97%	2.5	51	1	Sheen
Labrador Slope	EBSA	29,746	7,405	25%	1.7	107	1	Sheen
Bonavista Cod Box	Experimental Closure	9,830	3,415	35%	1.7	94	1	Sheen
3O Coral Closure	NAFO VME	14,057	7,883	56%	1.4	91	1	Sheen
Southeast Shoal and Tail of the Banks	EBSA	30,935	10,168	33%	1.3	81	1	Sheen
Division 3O Coral	Marine Refuge	10,336	4,853	47%	1.1	95	1	Sheen

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface area of SA contacted by emulsified oil >0.04 µm thickness	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Average Time-Averaged Bonn Thickness
Southwest Shelf Edge and Slope	EBSA	16,644	6,857	41%	1.1	87	1	Sheen
Corner Seamounts	NAFO VME	40,251	2,139	5%	1.1	148	1	Sheen
Fogo Seamounts 1	NAFO VME	4,522	1,513	33%	1.0	129	1	Sheen
Labrador Marginal Trough	EBSA	16,952	1,195	7%	1.0	137	1	Sheen
Hawke Channel	Marine Refuge	8,839	1,260	14%	1.0	136	1	Sheen
St. Pierre Bank	EBSA	5,482	191	3%	0.9	98	1	Sheen
Funk Island Deep	Marine Refuge	7,272	170	2%	0.9	156	1	Sheen
Fogo Seamounts 2	NAFO VME	4,616	248	5%	0.9	154	1	Sheen
Grey Islands	EBSA	11,301	198	2%	0.9	152	1	Sheen
Laurentian Channel and Slope	EBSA	17,140	276	2%	0.9	102	1	Sheen
Notre Dame Channel	EBSA	6,222	314	5%	0.9	156	1	Sheen
Laurentian Channel	AOI	16,564	358	2%	0.9	102	1	Sheen
Gully Marine Protected Area**	MPA	2,385	217	9%	0.9	117	1	Sheen
Winter								
Orphan Knoll	NAFO VME	15,817	15,849	100%	100.0	6	47	Rainbow
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	99.7	8	37	Rainbow
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	96.8	16	33	Sheen
Northern Flemish Cap	NAFO VME	486	487	100%	96.8	7	38	Rainbow
Sackville Spur	NAFO VME	992	993	100%	95.5	6	30	Rainbow
Northwest Flemish Cap	NAFO VME	412	413	100%	79.9	10	24	Rainbow
Beothuk Knoll	NAFO VME	648	649	100%	66.1	25	21	Sheen
Northeast Newfoundland Slope	Marine Refuge	55,251	55,362	100%	58.1	16	22	Rainbow

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface area of SA contacted by emulsified oil >0.04 µm thickness	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Average Time-Averaged Bonn Thickness
Flemish Pass / Eastern Canyon	NAFO VME	5,418	5,428	100%	51.5	21	15	Sheen
Tail of the Bank	NAFO VME	144	144	100%	37.3	25	10	Sheen
Northeast Shelf and Slope	EBSA	13,885	13,912	100%	32.7	13	10	Rainbow
Lilly Canyon - Carson Canyon	EBSA	120	120	100%	29.9	25	6	Sheen
Orphan Spur	EBSA	21,569	21,609	100%	24.3	29	7	Sheen
Newfoundland Seamounts	NAFO VME	15,491	15,522	100%	20.9	43	4	Sheen
Bonavista Cod Box	Experimental Closure	9,830	9,839	100%	10.1	31	4	Rainbow
3O Coral Closure	NAFO VME	14,057	13,898	99%	6.7	63	3	Sheen
Southeast Shoal and Tail of the Banks	EBSA	30,935	29,161	94%	6.1	64	2	Sheen
Division 3O Coral	Marine Refuge	10,336	10,170	98%	5.4	70	3	Sheen
Southwest Shelf Edge and Slope	EBSA	16,644	14,762	89%	5.0	75	2	Sheen
Virgin Rocks	EBSA	6,843	6,857	100%	4.4	39	7	Sheen
Fogo Seamounts 1	NAFO VME	4,522	4,532	100%	4.3	70	3	Sheen
Labrador Slope	EBSA	29,746	11,338	38%	3.7	64	2	Sheen
Fogo Seamounts 2	NAFO VME	4,616	2,330	50%	1.6	100	1	Sheen
Notre Dame Channel	EBSA	6,222	3,090	50%	1.1	76	1	Sheen
Labrador Marginal Trough	EBSA	16,952	1,956	12%	1.0	117	1	Sheen
Funk Island Deep	Marine Refuge	7,272	3,161	43%	1.0	78	1	Sheen
Placentia Bay Extension	EBSA	7,693	1,079	14%	1.0	97	1	Sheen
Cape St. Mary's	IBA	330	144	44%	1.0	127	1	Sheen
Fogo Shelf	EBSA	9,403	1,490	16%	1.0	77	1	Sheen
Hawke Channel	Marine Refuge	8,839	1,234	14%	1.0	122	1	Sheen

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface area of SA contacted by emulsified oil >0.04 µm thickness	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Average Time-Averaged Bonn Thickness
Corner Seamounts	NAFO VME	40,251	7,709	19%	0.9	135	1	Sheen
New England Seamounts	NAFO VME	178,306	1,005	1%	0.9	157	2	Sheen
Laurentian Channel and Slope	EBSA	17,140	95	1%	0.9	79	1	Sheen
Grey Islands	EBSA	11,301	122	1%	0.9	51	1	Sheen
Funk Island	IBA	135	73	54%	0.9	102	1	Sheen
Eastern Avalon	EBSA	36	4	12%	0.9	76	1	Sheen
Funk Island Ecological Reserve	Ecological Reserve	5	5	94%	0.9	102	1	Sheen
Hopedale Saddle	Marine Refuge	15,450	56	0.4%	0.9	131	1	Sheen
Mistaken Point	IBA	103	7	7%	0.9	156	1	Sheen
Placentia Bay	IBA	1,399	0.02	0.001%	0.9	90	1	Sheen
St. Pierre Bank	EBSA	5,482	11	0.2%	0.9	79	1	Sheen
Wadham Islands and adjacent Marine Area	IBA	159	2	1%	0.9	67	1	Sheen
Laurentian Channel	AOI	16,564	142	1%	0.9	79	1	Sheen
Cape St. Mary's Ecological Reserve	Ecological Reserve	54	16	30%	0.9	139	1	Sheen
Gully Marine Protected Area**	MPA	2,385	259	11%	1.0	148	1	Sheen

* Probability of sea surface emulsified oil thicknesses exceeding the 0.04-µm (BAOAC “Sheen”) thickness threshold.

** Outside RAA

Table 15.12 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) – Stranded Oil Shoreline Contact with Special Areas in Winter

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Protected SA contacted by emulsified oil >1 µm thickness	Average of Probability (%)	Average of Min Arrival Time (days)	Average Degree of Oiling
The Cape Pine and St. Shotts Barren	IBA	57.40	7.56	13.2%	3.4	73	Light
Placentia Bay Extension	EBSA	7,693.17	103.30	1.3%	2.6	104	Light
Mistaken Point	IBA	102.75	10.41	10.1%	2.4	81	Moderate
Fogo Shelf	EBSA	9,403.09	43.83	0.5%	2.2	50	Heavy
Witless Bay Ecological Reserve	Ecological Reserve	29.03	3.82	13.2%	2.2	101	Light
Witless Bay Islands	IBA	62.05	11.09	17.9%	1.9	106	Light
Cape St. Mary's	IBA	329.61	36.95	11.2%	1.5	100	Light
Placentia Bay	IBA	1,398.93	21.11	1.5%	1.5	133	Moderate
Eastern Avalon	EBSA	35.60	1.40	3.9%	1.1	110	Moderate
Cape Freels Coastline and Cabot Island	IBA	334.49	65.10	19.5%	0.9	117	Moderate
Baccalieu Island	IBA	45.21	2.82	6.2%	0.9	107	Light
Baccalieu Island Ecological Reserve	Ecological Reserve	17.50	0.69	4.0%	0.9	107	Light
Grates Point	IBA	66.53	10.80	16.2%	0.9	88	Heavy
Quidi Vidi Lake	IBA	7.00	0.05	0.7%	0.9	132	Stain/Film
St. Pierre et Miquelon**	France	234.21	9.08	3.9%	0.9	124	Light
Cape St. Mary's Ecological Reserve	Ecological Reserve	53.66	5.26	9.8%	0.9	100	Light

* Probability of stranded oil emulsion mass exceeding the 0.0019 tonnes/km (or 0.001 L/m² = 1 µm), minimum threshold for “Stain / Film” oiling.

** Included as recognition of potential transboundary (international) effect.

Table 15.13 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario)– Stranded Oil Shoreline Contact with Special Areas in Winter

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Protected SA contacted by emulsified oil >1 µm thickness	Average of Probability (%)	Average of Min Arrival Time (days)	Average Degree of Oiling
Mistaken Point	IBA	102.75	10.51	10.2%	2.6	71	Light
Cape St. Mary's	IBA	329.61	29.34	8.9%	2.0	94	Light
Placentia Bay Extension	EBSA	7,693.17	43.49	0.6%	1.9	92	Light
Cape St. Mary's Ecological Reserve	Ecological Reserve	53.66	1.39	2.6%	1.7	95	Stain/Film
Placentia Bay	IBA	1,398.93	11.34	0.8%	1.5	92	Light
Eastern Avalon	EBSA	35.60	0.78	2.2%	1.3	32	Moderate
The Cape Pine and St. Shotts Barren	IBA	57.40	22.75	39.6%	1.3	78	Light
St. Pierre et Miquelon**	France	234.21	6.29	2.7%	1.1	121	Light
Cape Freels Coastline and Cabot Island	IBA	334.49	17.89	5.3%	0.9	104	Light
Cape St. Francis	IBA	70.18	3.06	4.4%	0.9	34	Heavy
Fogo Shelf	EBSA	9,403.09	4.87	0.1%	0.9	104	Light

* Probability of stranded oil emulsion mass exceeding the 0.0019 tonnes/km (or 0.001 L/m² = 1 µm), minimum threshold for “Stain / Film” oiling.

** Included as recognition of potential transboundary (international) effect

Table 15.14 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario)- Water Column Dispersed and Dissolved Oil in Special Areas in Summer and Winter

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Sensitive Area contacted by THC >58 ppb	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Maximum Time-Averaged Dissolved Oil Concentration (ppb)
Summer								
Sackville Spur	NAFO VME	992	993	100%	99.91	19	24	0
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	82.49	32	12	0
Northeast Newfoundland Slope	Marine Refuge	55,251	50,247	91%	78.81	11	34	20
Northern Flemish Cap	NAFO VME	486	487	100%	76.97	27	17	0
Northwest Flemish Cap	NAFO VME	412	413	100%	73.65	20	16	0
Orphan Spur	EBSA	21,569	20,080	93%	56.79	10	23	9
Orphan Knoll	NAFO VME	15,817	15,849	100%	45.99	21	19	0
Northeast Shelf and Slope	EBSA	13,885	13,911	100%	43.93	14	9	1
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	35.80	48	6	0
Bonavista Cod Box	Experimental Closure	9,830	9,485	96%	31.98	15	18	1
Flemish Pass / Eastern Canyon	NAFO VME	5,418	5,428	100%	26.10	27	9	0
Tail of the Bank	NAFO VME	144	144	100%	11.27	27	5	0
Lilly Canyon - Carson Canyon	EBSA	120	120	100%	4.31	35	2	0
3O Coral Closure	NAFO VME	14,057	2,696	19%	1.89	61	1	0
Southeast Shoal and Tail of the Banks	EBSA	30,935	1,808	6%	1.35	70	1	0
Notre Dame Channel	EBSA	6,222	764	12%	1.15	59	1	0

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Sensitive Area contacted by THC >58 ppb	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Maximum Time-Averaged Dissolved Oil Concentration (ppb)
Funk Island Deep	Marine Refuge	7,272	763	10%	1.13	63	1	0
Southwest Shelf Edge and Slope	EBSA	16,644	1,753	11%	0.99	66	1	0
Beothuk Knoll	NAFO VME	648	573	88%	0.98	93	1	0
Newfoundland Seamounts	NAFO VME	15,491	3,902	25%	0.97	74	1	0
Division 3O Coral	Marine Refuge	10,336	1,041	10%	0.92	69	1	0
Fogo Seamounts 1	NAFO VME	4,522	82	2%	0.89	93	1	0
Winter								
Sackville Spur	NAFO VME	992	993	100%	99.98	19	30	0
Northwest Flemish Cap	NAFO VME	412	413	100%	99.21	22	27	0
Northern Flemish Cap	NAFO VME	486	487	100%	91.70	28	23	0
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	87.41	31	15	0
Northeast Newfoundland Slope	Marine Refuge	55,251	49,307	89%	81.98	12	37	14
Orphan Spur	EBSA	21,569	20,155	93%	79.21	8	37	6
Northeast Shelf and Slope	EBSA	13,885	13,912	100%	72.29	14	17	1
Bonavista Cod Box	Experimental Closure	9,830	9,848	100%	62.30	14	28	1
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	53.65	42	9	0
Flemish Pass / Eastern Canyon	NAFO VME	5,418	5,428	100%	49.53	25	12	0
Orphan Knoll	NAFO VME	15,817	15,849	100%	42.79	28	20	0
Tail of the Bank	NAFO VME	144	144	100%	16.76	31	5	0

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Sensitive Area contacted by THC >58 ppb	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Maximum Time-Averaged Dissolved Oil Concentration (ppb)
Lilly Canyon - Carson Canyon	EBSA	120	117	97%	5.16	33	2	0
Beothuk Knoll	NAFO VME	648	649	100%	3.39	69	2	0
Funk Island Deep	Marine Refuge	7,272	6,352	87%	2.53	41	2	0
Notre Dame Channel	EBSA	6,222	5,636	91%	2.46	40	2	0
Cape Freels Coastline and Cabot Island	IBA	334	53	16%	1.25	47	1	0
Southeast Shoal and Tail of the Banks	EBSA	30,935	3,293	11%	1.25	72	1	0
Fogo Shelf	EBSA	9,403	1,868	20%	1.25	64	1	0
3O Coral Closure	NAFO VME	14,057	4,281	30%	1.19	71	1	0
Newfoundland Seamounts	NAFO VME	15,491	4,078	26%	0.99	72	1	0
Southwest Shelf Edge and Slope	EBSA	16,644	1,980	12%	0.94	78	1	0
Funk Island	IBA	135	80	59%	0.94	75	1	0
Division 3O Coral	Marine Refuge	10,336	2,100	20%	0.90	80	1	0
Virgin Rocks	EBSA	6,843	343	5%	0.86	73	1	0
Fogo Seamounts 2	NAFO VME	4,616	91	2%	0.86	72	1	0
Eastern Avalon	EBSA	36	2	4%	0.86	103	1	0
Funk Island Ecological Reserve	Ecological Reserve	5	4	86%	0.86	89	1	0
Fogo Seamounts 1	NAFO VME	4,522	293	6%	0.86	82	1	0

* Probability of THC (Dispersed and dissolved oil) in the water column exceeding the 58-ppb concentration threshold.

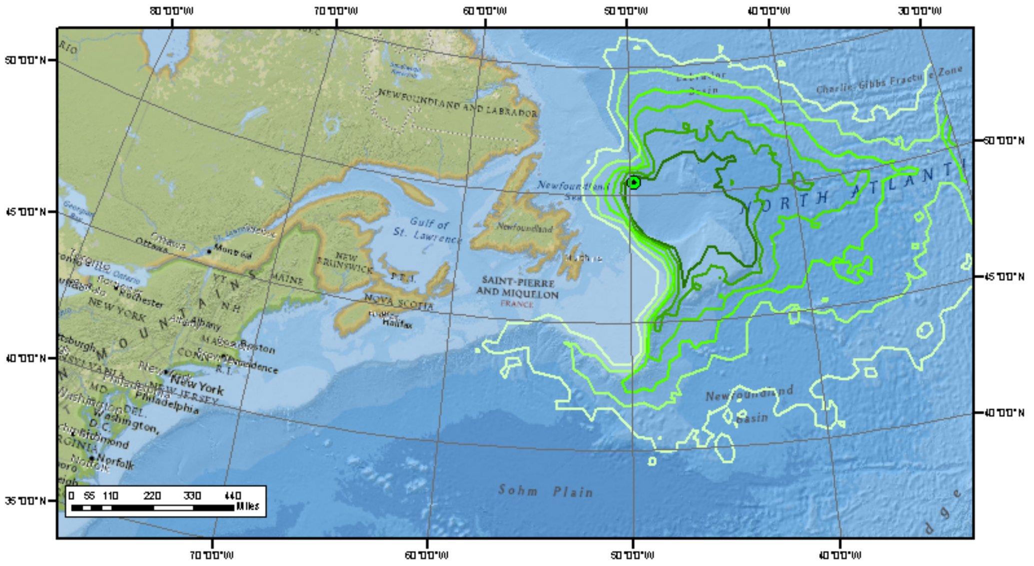
Table 15.15 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario)- Water Column Dispersed and Dissolved Oil in Special Areas in Summer and Winter

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface EBSA Area contacted by THC >58 ppb	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Maximum Time-Averaged Dissolved Oil Concentration (ppb)
Summer								
Orphan Knoll	NAFO VME	15,817	15,849	100%	54.73	8	9	1.4
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	25.87	13	6	0.5
Sackville Spur	NAFO VME	992	993	100%	19.43	8	4	0.8
Northern Flemish Cap	NAFO VME	486	487	100%	9.11	11	3	0.2
Northeast Newfoundland Slope	Marine Refuge	55,251	24,622	45%	5.90	20	3	0.5
Northwest Flemish Cap	NAFO VME	412	413	100%	4.10	15	2	0.2
Eastern Flemish Cap	NAFO VME	1,609	1,578	98%	3.20	32	2	0.0
Northeast Shelf and Slope	EBSA	13,885	1,799	13%	1.04	29	1	0.0
Flemish Pass / Eastern Canyon	NAFO VME	5,418	335	6%	1.02	30	1	0.0
Orphan Spur	EBSA	21,569	401	2%	0.92	43	1	0.0
Beothuk Knoll	NAFO VME	648	16	2%	0.89	51	1	0.0
Winter								
Orphan Knoll	NAFO VME	15,817	15,849	100%	40.45	7	9	2
Sackville Spur	NAFO VME	992	993	100%	34.49	7	6	2
Northeast Flemish Cap	NAFO VME	2,898	2,904	100%	30.01	9	6	2
Northern Flemish Cap	NAFO VME	486	487	100%	22.90	8	6	1
Northwest Flemish Cap	NAFO VME	412	413	100%	10.51	13	3	1
Northeast Newfoundland Slope	Marine Refuge	55,251	37,961	69%	9.98	15	4	1
Eastern Flemish Cap	NAFO VME	1,609	1,611	100%	5.05	29	3	1

Name	Special Area Type	Area (km²)	Sum of Intersect Area (km²)	% Surface EBSA Area contacted by THC >58 ppb	Average of Probability (%)	Average of Min Arrival Time (days)	Average of Maximum Exposure Time (days)	Average of Maximum Time-Averaged Dissolved Oil Concentration (ppb)
Northeast Shelf and Slope	EBSA	13,885	13,185	95%	4.96	17	2	0.5
Orphan Spur	EBSA	21,569	4,807	22%	2.80	22	1	0.2
Flemish Pass / Eastern Canyon	NAFO VME	5,418	4,128	76%	1.83	31	1	0.1
Beothuk Knoll	NAFO VME	648	504	78%	1.81	37	1	0.1
Bonavista Cod Box	Experimental Closure	9,830	3,682	37%	1.66	23	1	0.1
Virgin Rocks	EBSA	6,843	1,070	16%	0.91	43	1	0.0
3O Coral Closure	NAFO VME	14,057	4	0%	0.86	87	1	0.0
Eastern Avalon	EBSA	36	2	5%	0.86	36	1	0.0
Lilly Canyon - Carson Canyon	EBSA	120	13	11%	0.86	32	1	0.0
Southeast Shoal and Tail of the Banks	EBSA	30,935	15	0%	0.86	85	1	0.0
Tail of the Bank	NAFO VME	144	5	4%	0.86	53	1	0.0
Newfoundland Seamounts	NAFO VME	15,491	136	1%	0.86	57	1	0.0

* Probability of THC (Dispersed and dissolved oil) in the water column exceeding the 58-ppb concentration threshold.

Summer Season (May - October)



Winter Season (November - April)

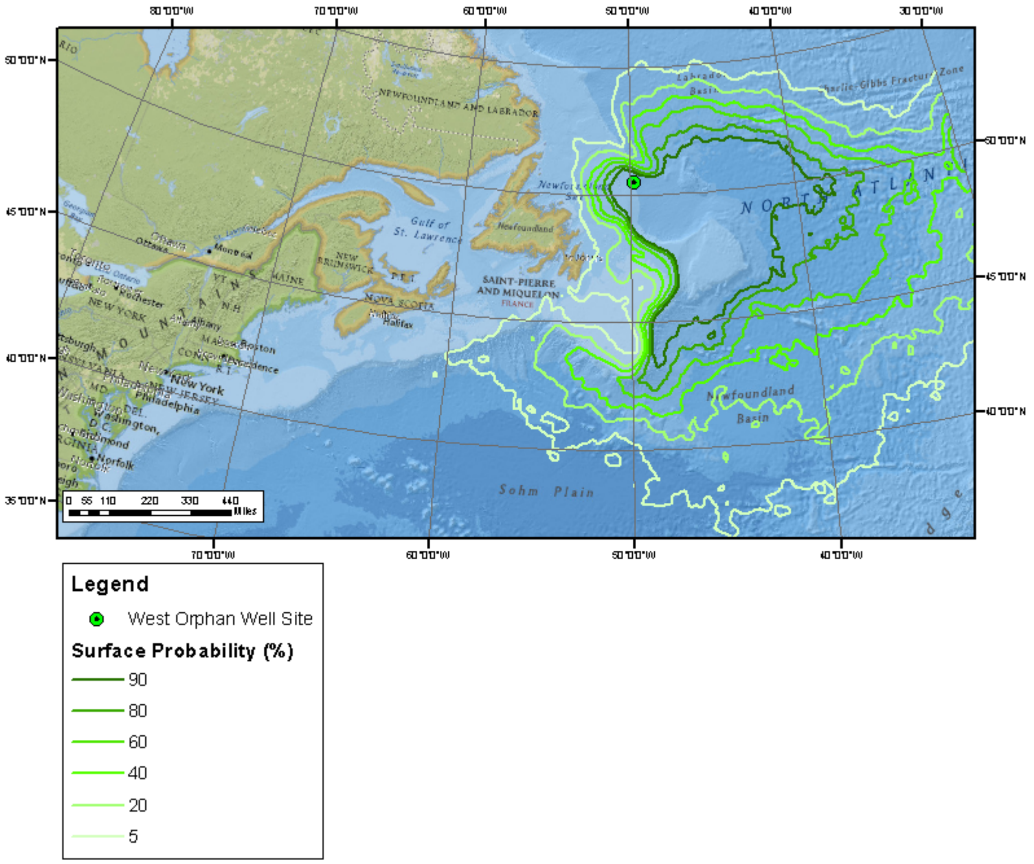
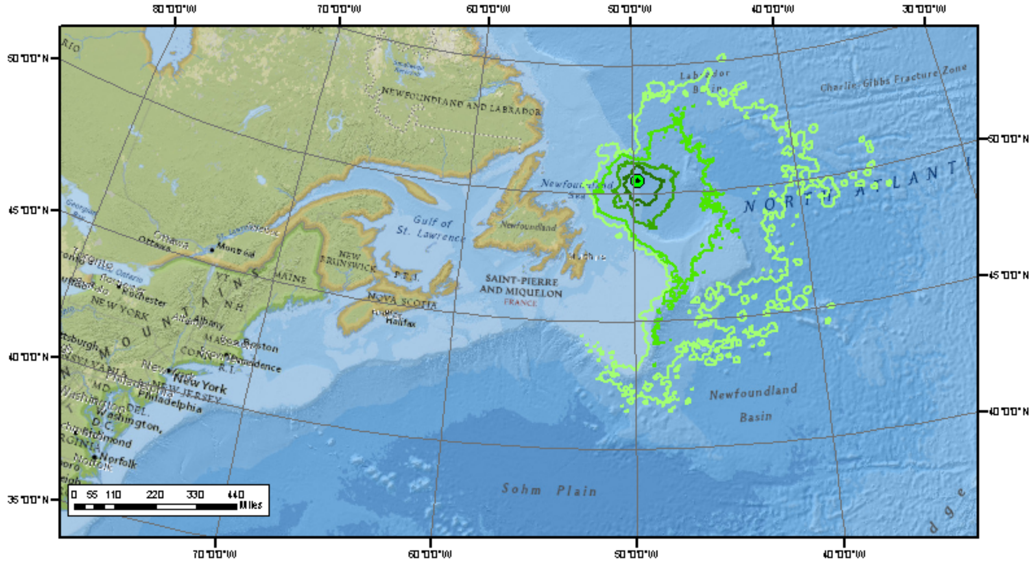


Figure 15.9 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oiling Exceeding 0.04 µm Probability

Summer Season (May - October)



Winter Season (November - April)

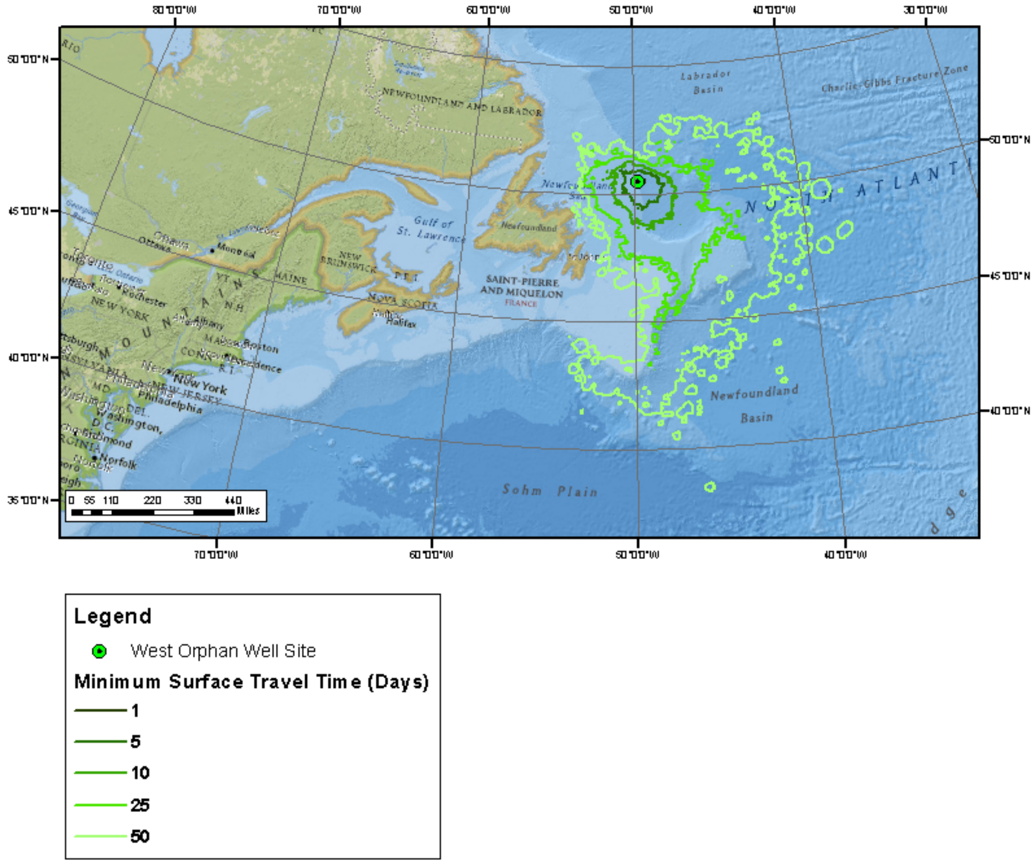
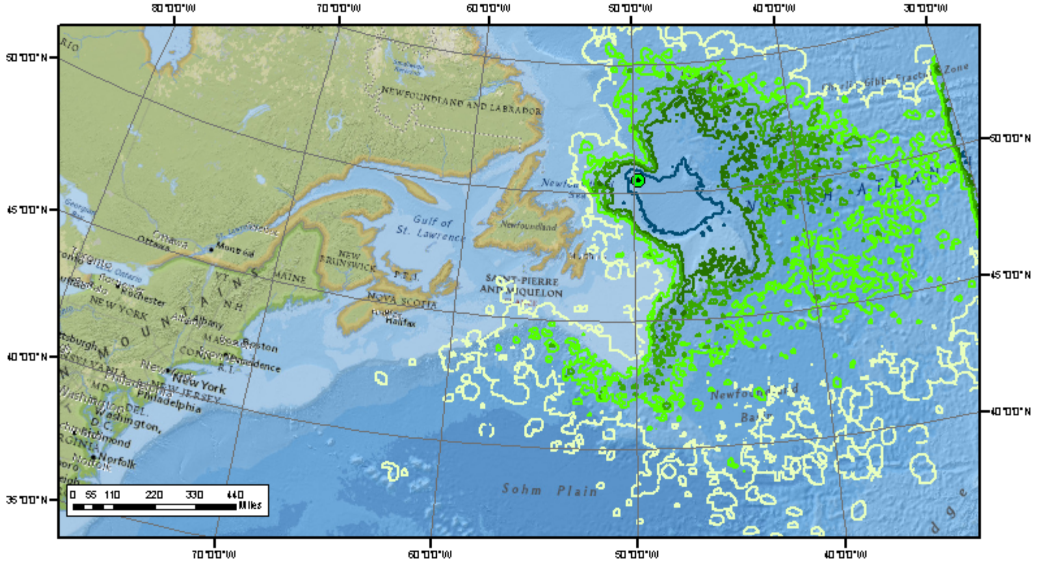
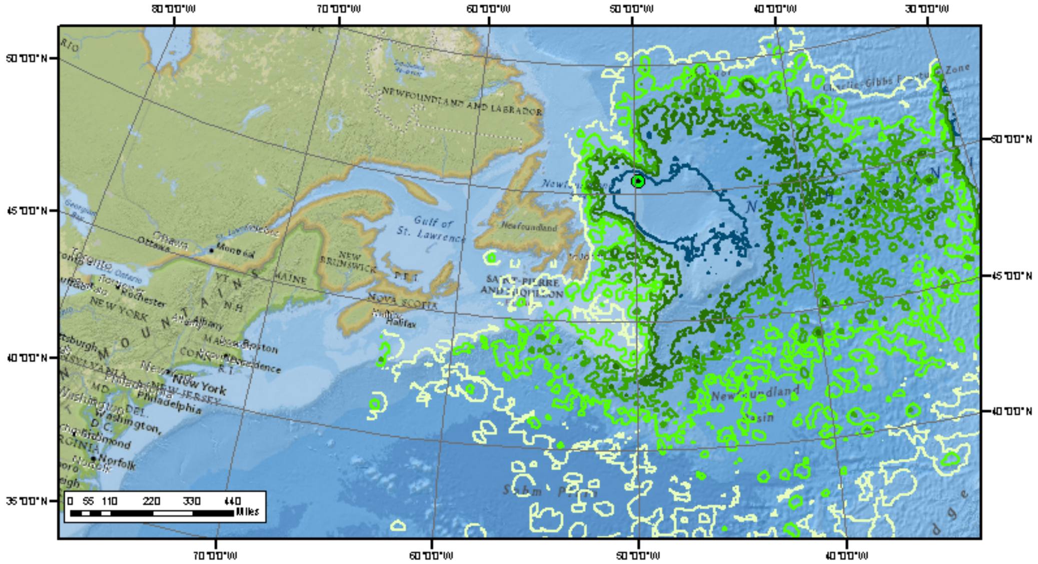


Figure 15.10 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oil Exceeding 0.04 µm - Minimum Travel Time

Summer Season (May - October)



Winter Season (November - April)



Legend

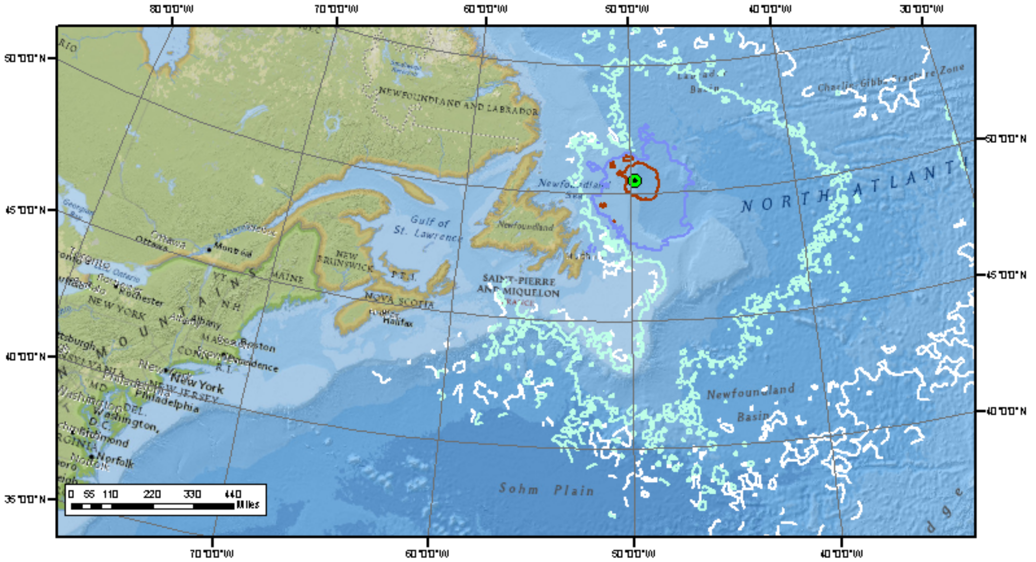
● West Orphan Well Site

Maximum Surface Exposure Time (Days)

- 1
- 4
- 7
- 10
- 20

Figure 15.11 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oil Exceeding 0.04 µm - Maximum Exposure Time

Summer Season (May - October)



Winter Season (November - April)

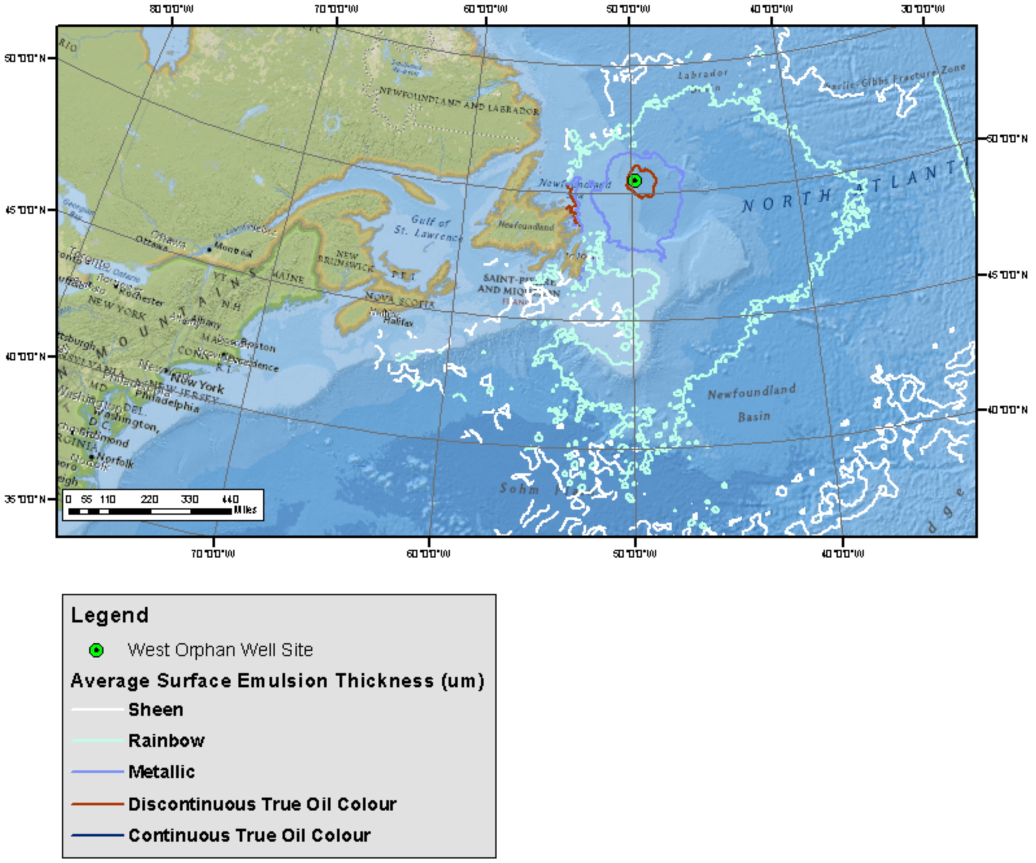
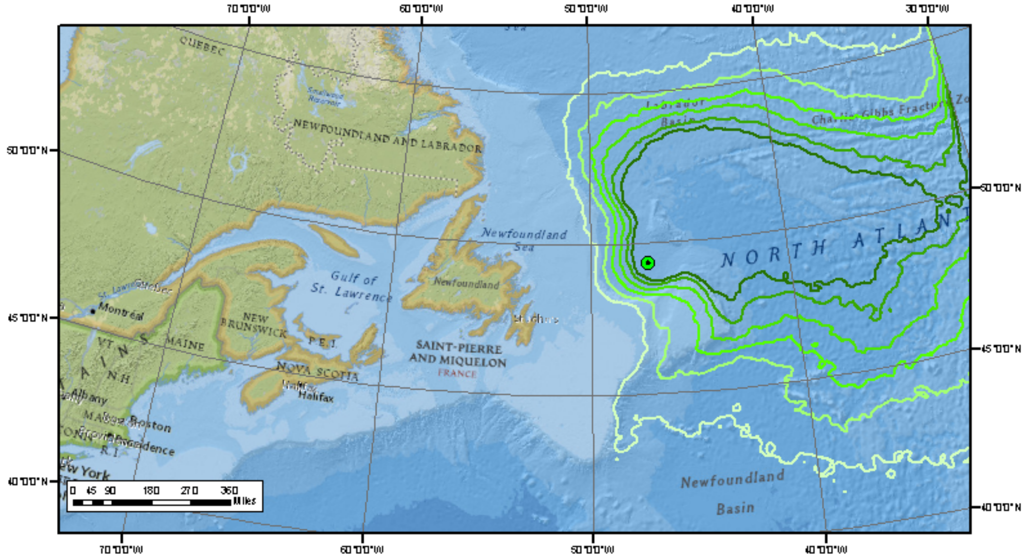


Figure 15.12 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oil Exceeding 0.04 µm - Average Emulsion Thickness

Summer Season (May - October)



Winter Season (November - April)

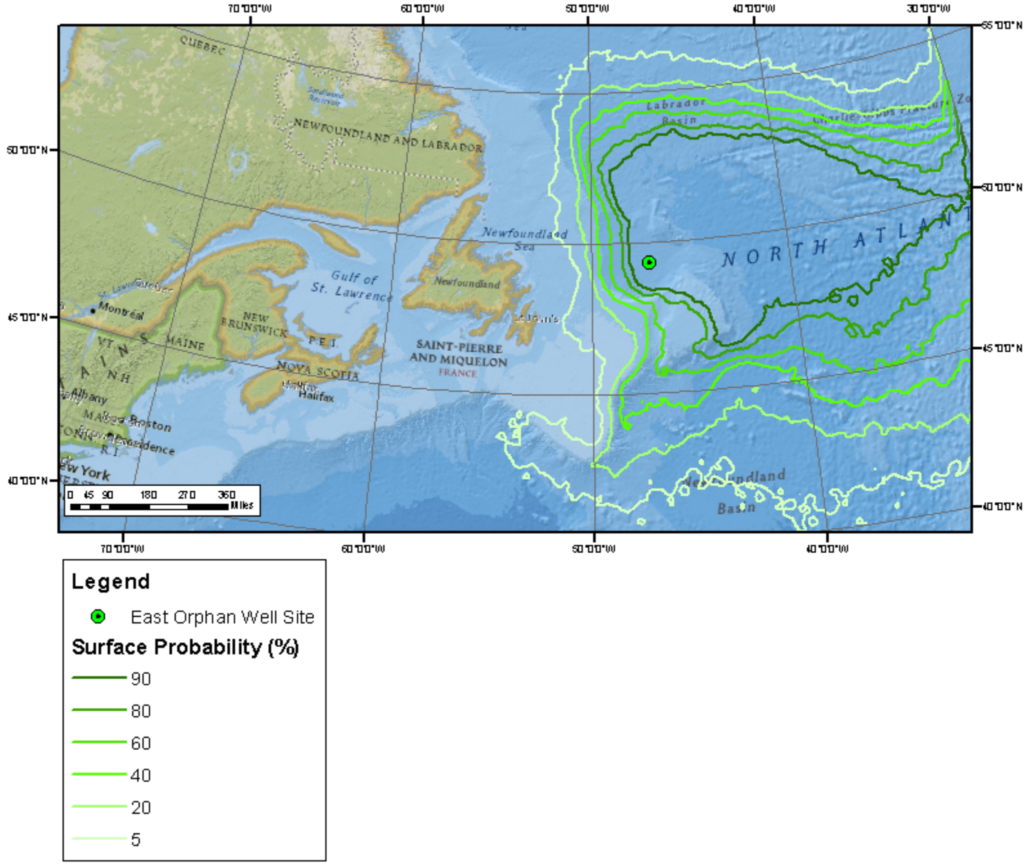


Figure 15.13 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oil Probability Exceeding 0.04 µm

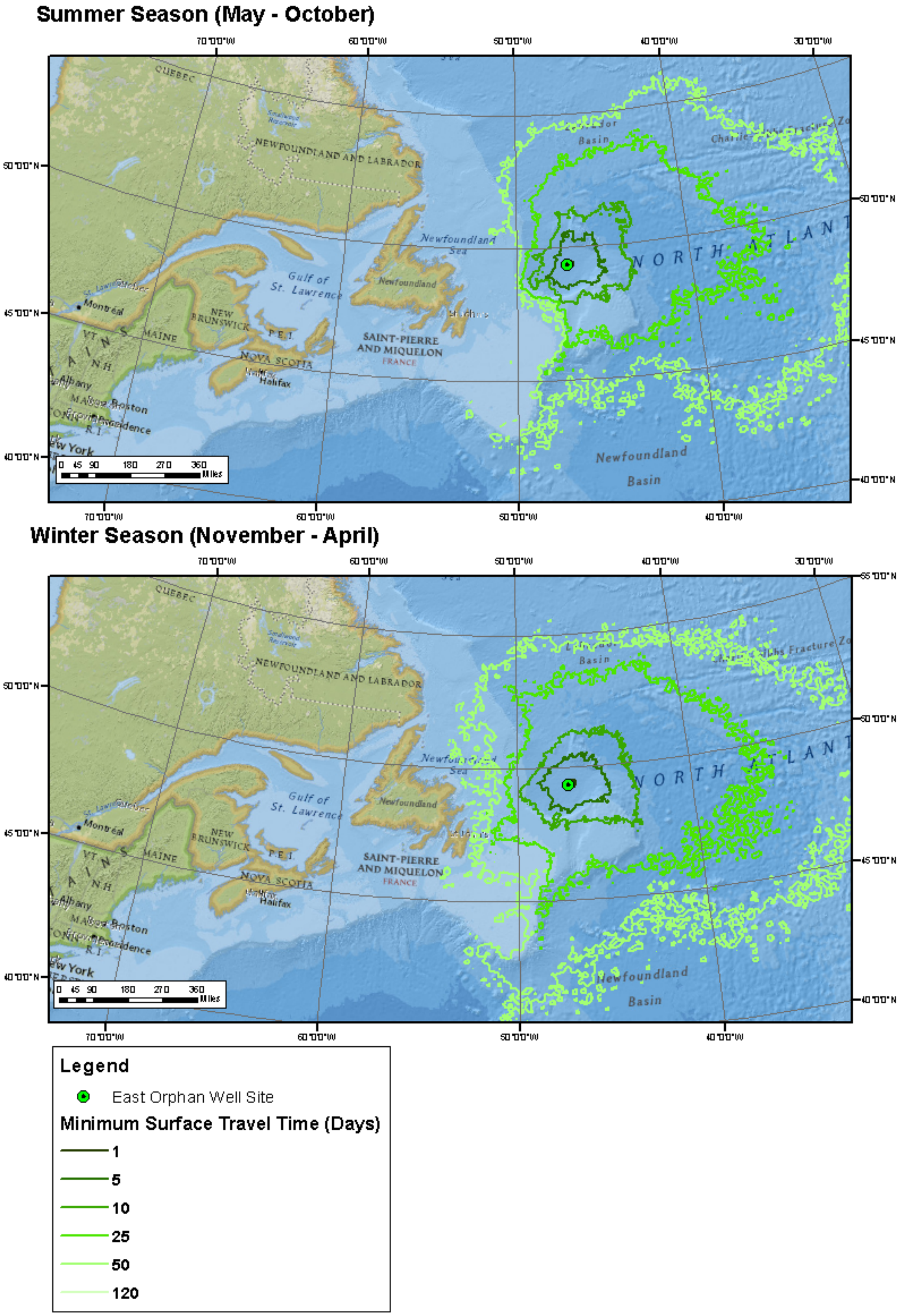
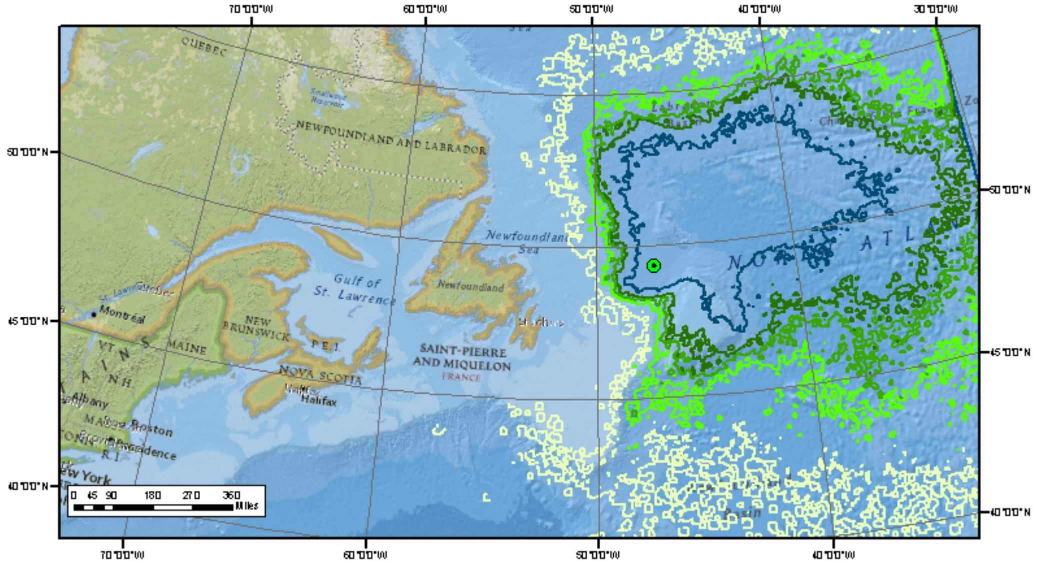
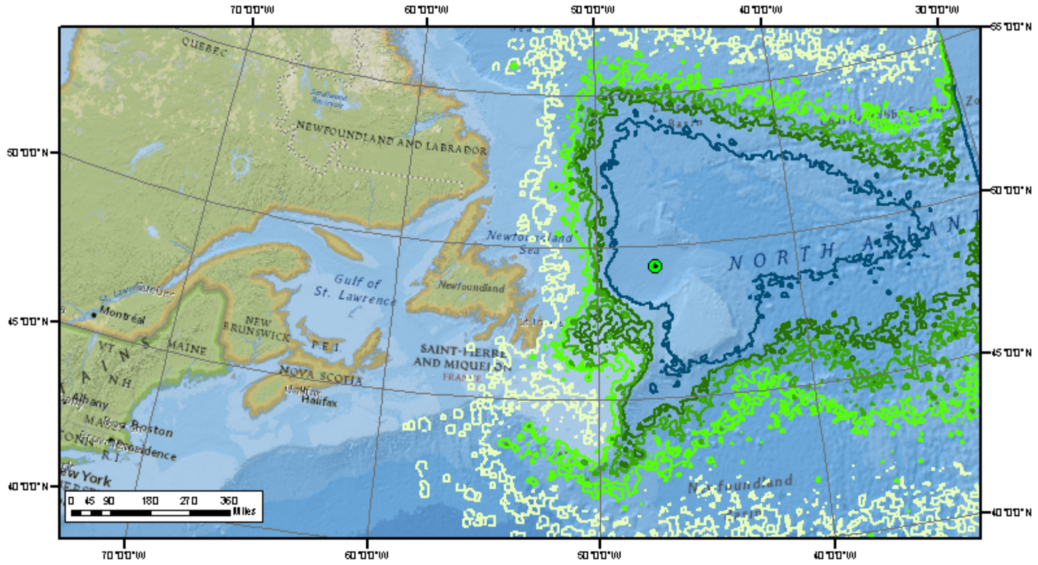


Figure 15.14 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) - Surface Oil Exceeding 0.04 µm Minimum Travel Time

Summer Season (May - October)



Winter Season (November - April)



Legend

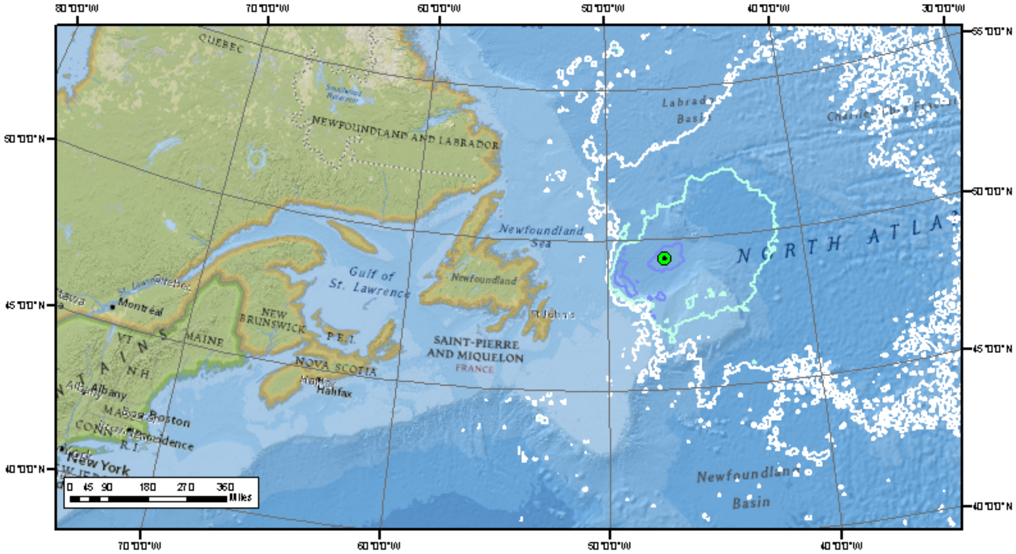
● East Orphan Well Site

Maximum Surface Exposure Time (Days)

— 1
— 4
— 7
— 10
— 20

Figure 15.15 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oil Exceeding 0.04 µm - Maximum Exposure Time

Summer Season (May - October)



Winter Season (November - April)

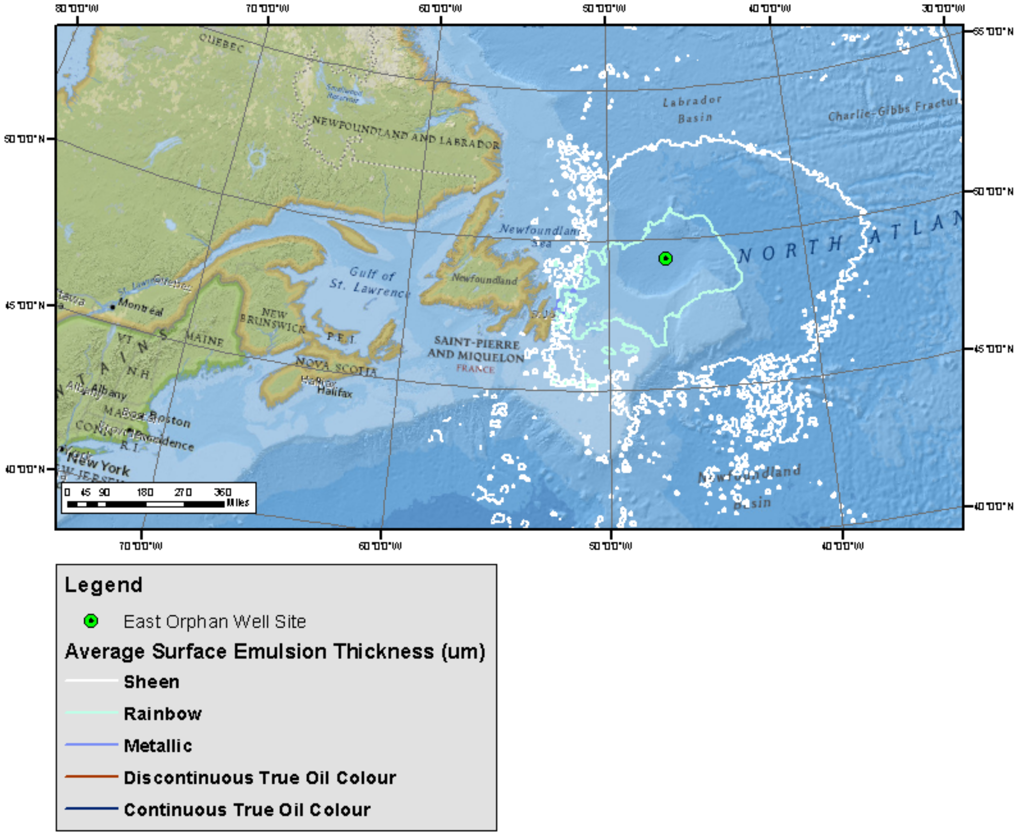


Figure 15.16 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Surface Oil Exceeding 0.04 µm - Average Emulsion Thickness

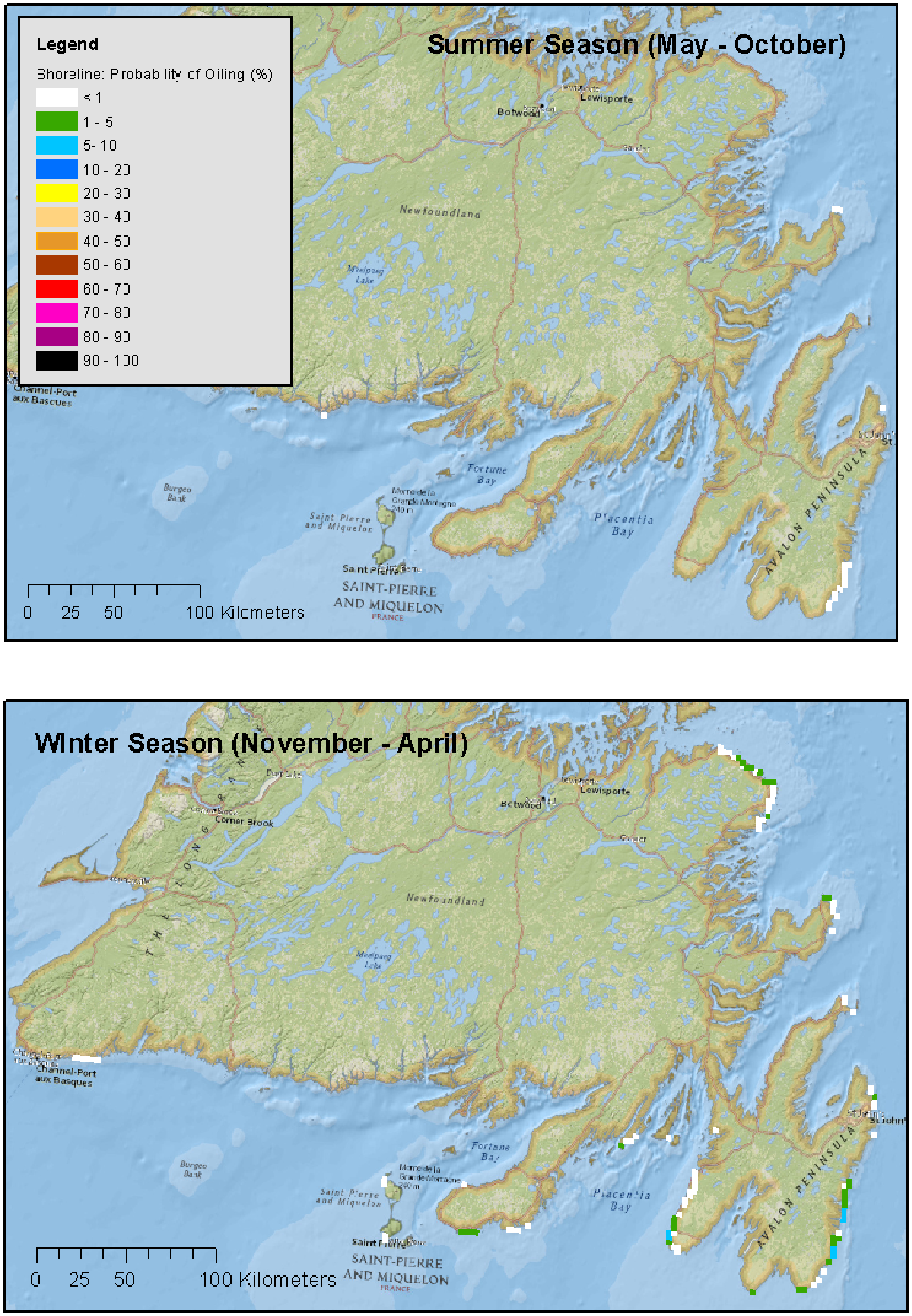


Figure 15.17 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Shoreline Contact Exceeding 1.0 g/m² Probability

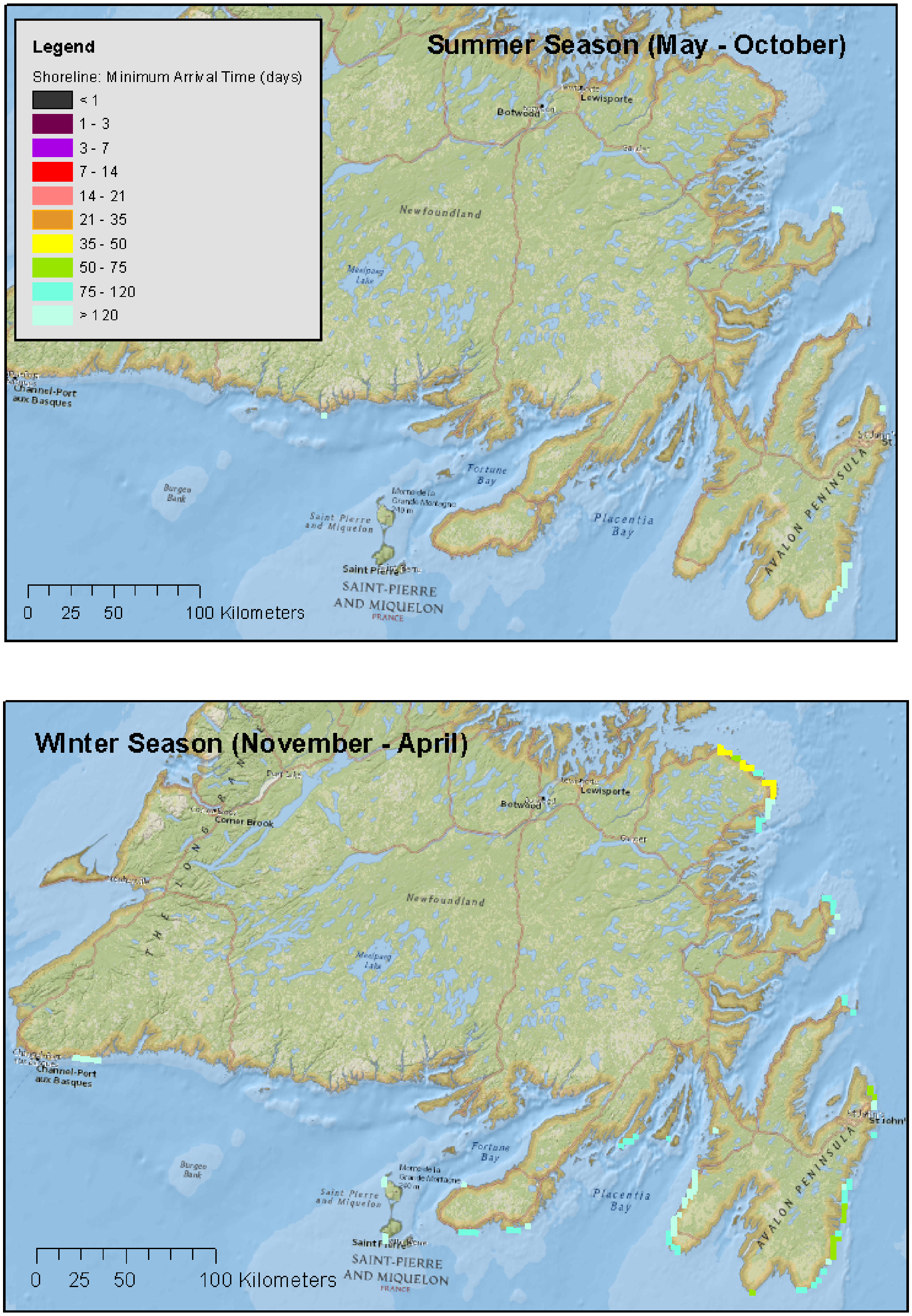


Figure 15.18 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Shoreline Contact Exceeding 1.0 g/m² - Minimum Arrival Time

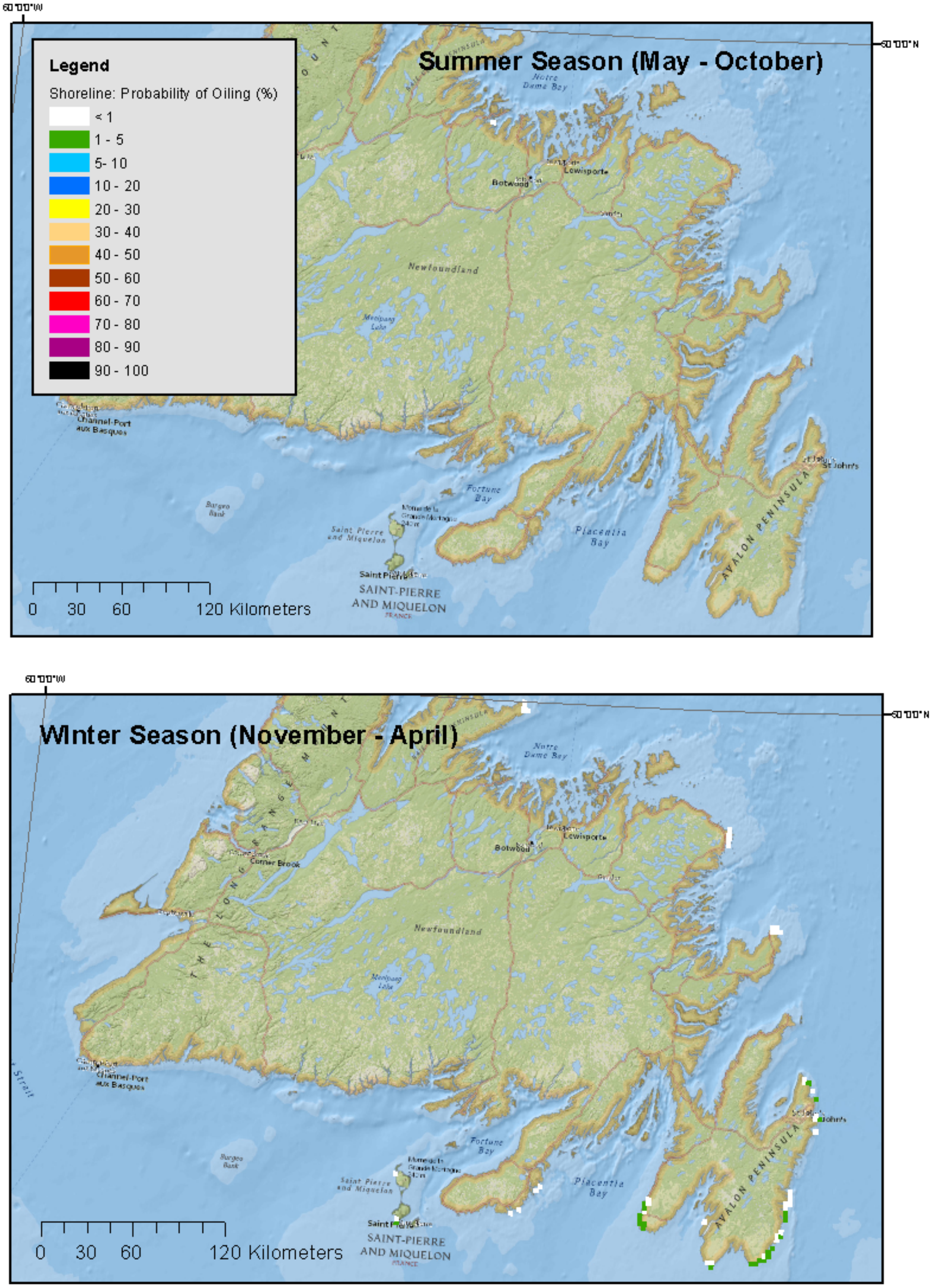


Figure 15.19 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Shoreline Contact Exceeding 1.0 g/m² Probability

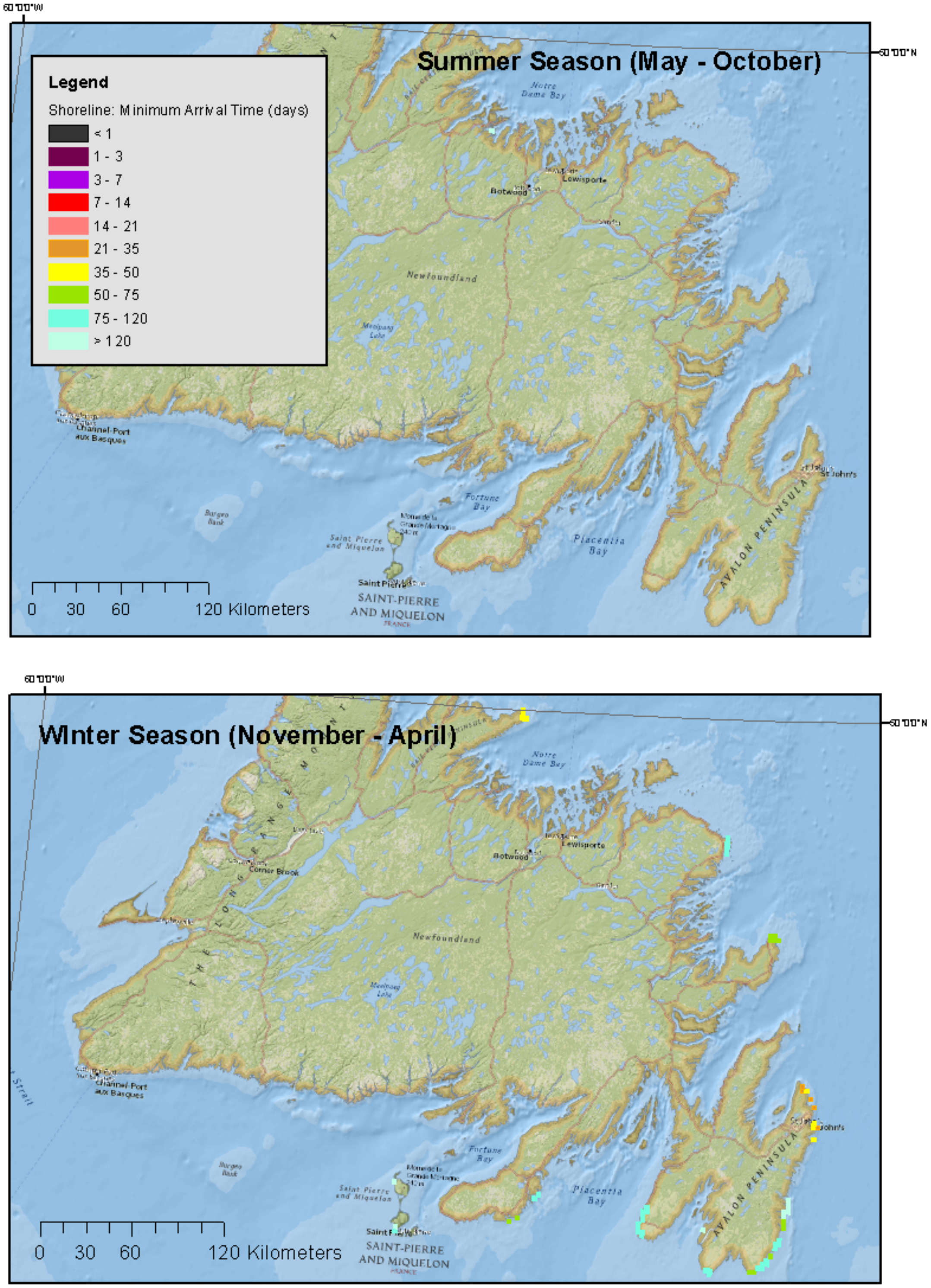
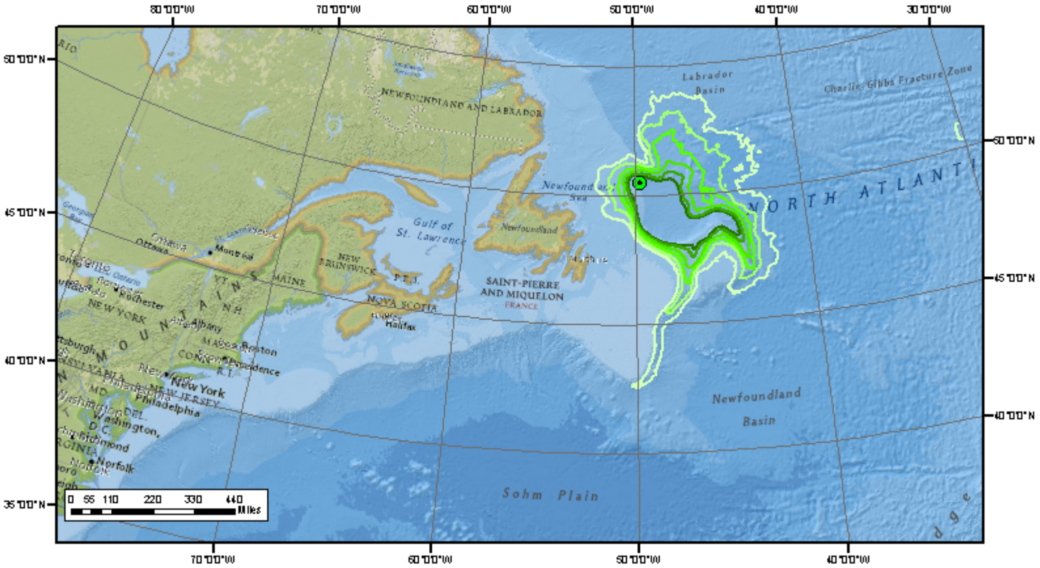


Figure 15.20 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Shoreline Contact Exceeding 1.0 g/m² - Minimum Arrival Time

Summer Season (May - October)



Winter Season (November - April)

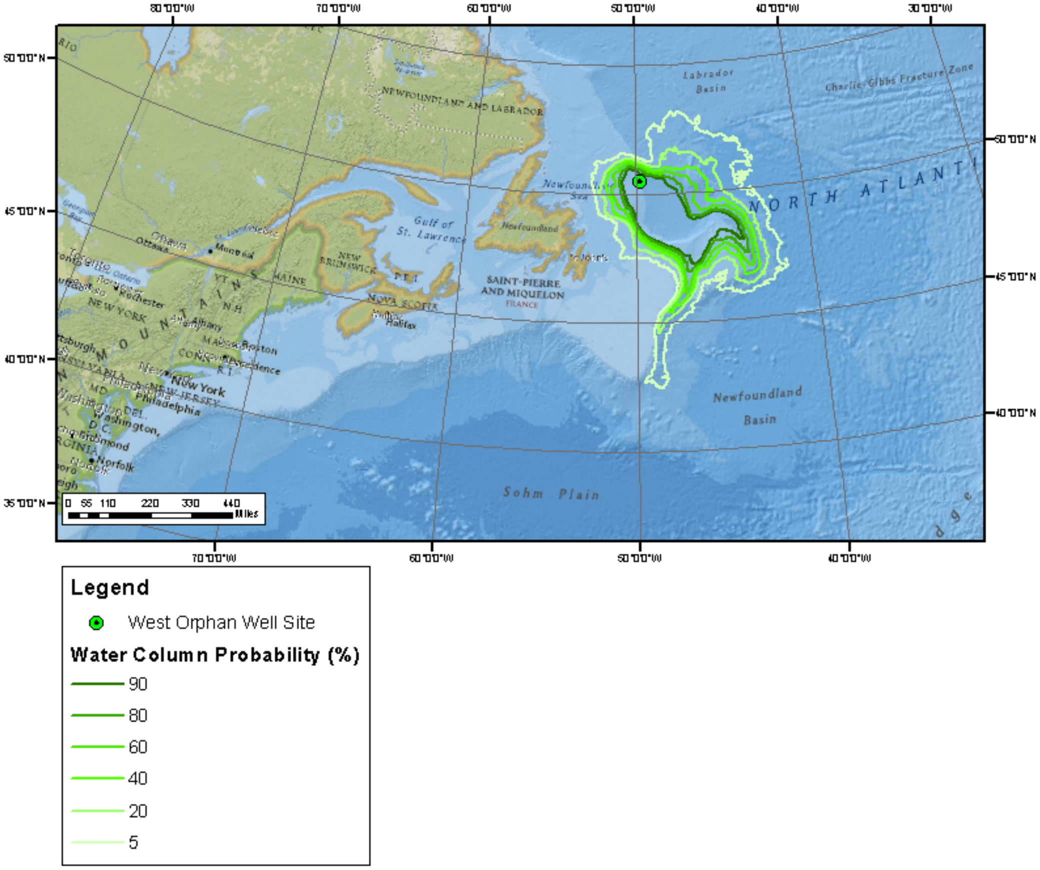
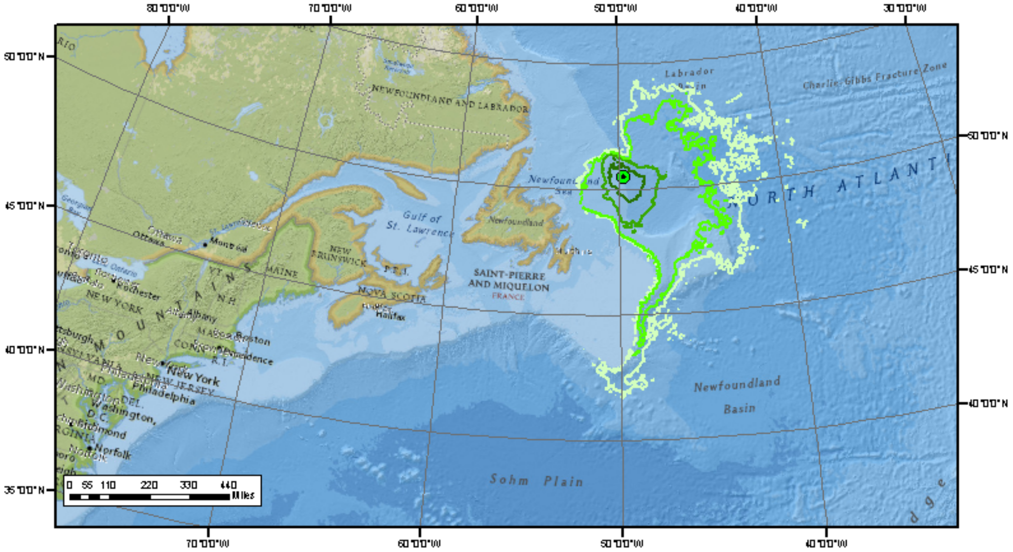


Figure 15.21 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Exceeding 58 ppb Total Hydrocarbons Probability

Summer Season (May - October)



Winter Season (November - April)

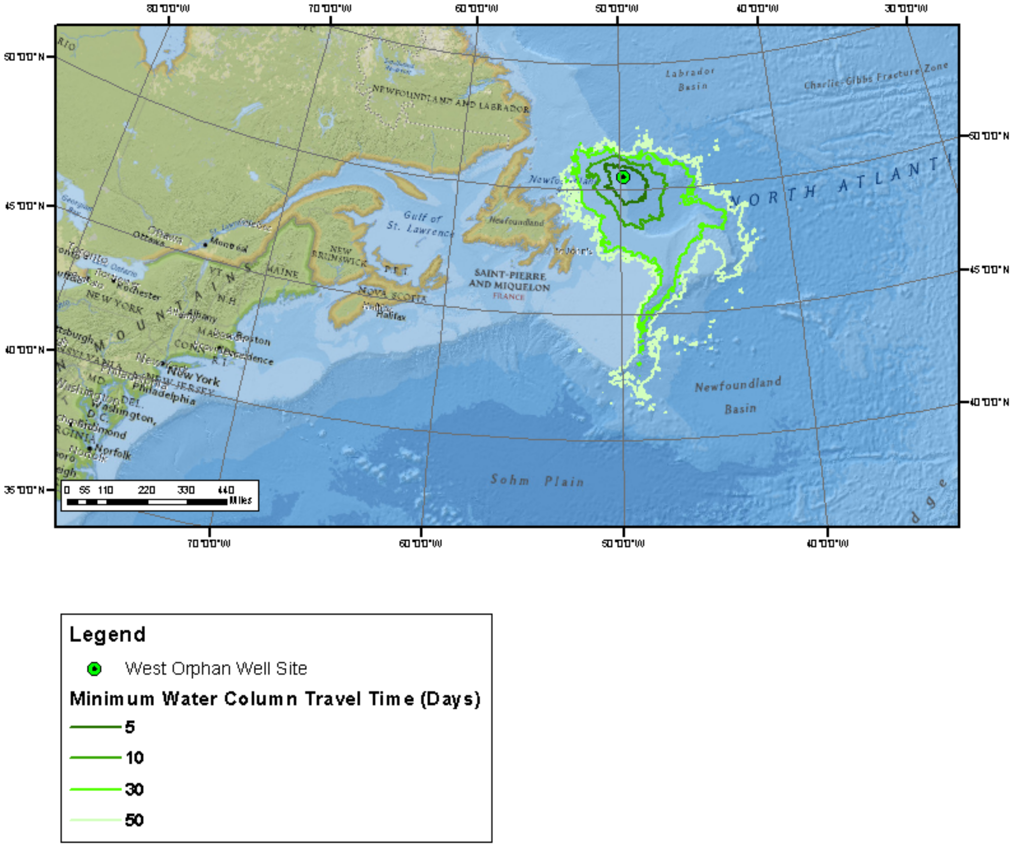
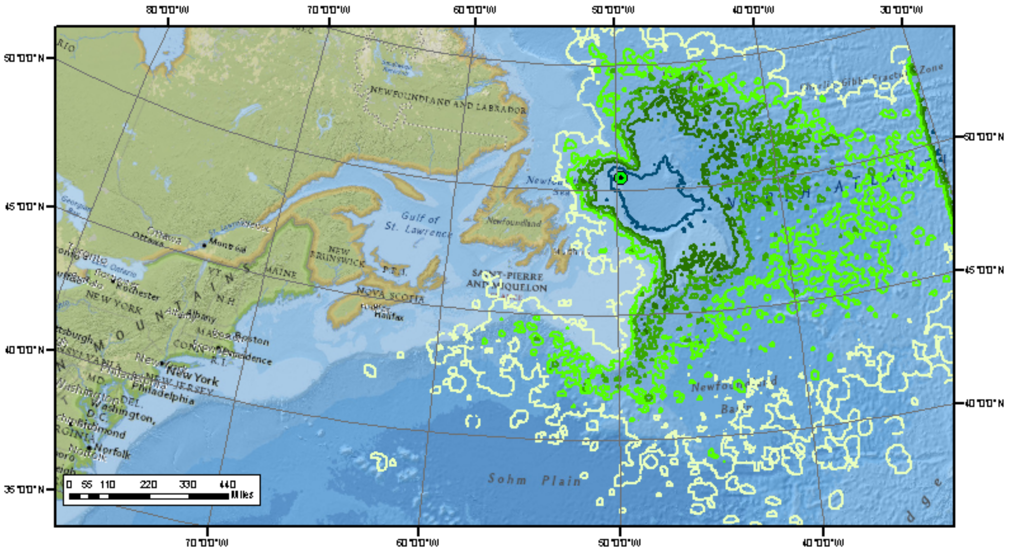


Figure 15.22 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Exceeding 58 ppb Total Hydrocarbons - Minimum Travel Time

Summer Season (May - October)



Winter Season (November - April)

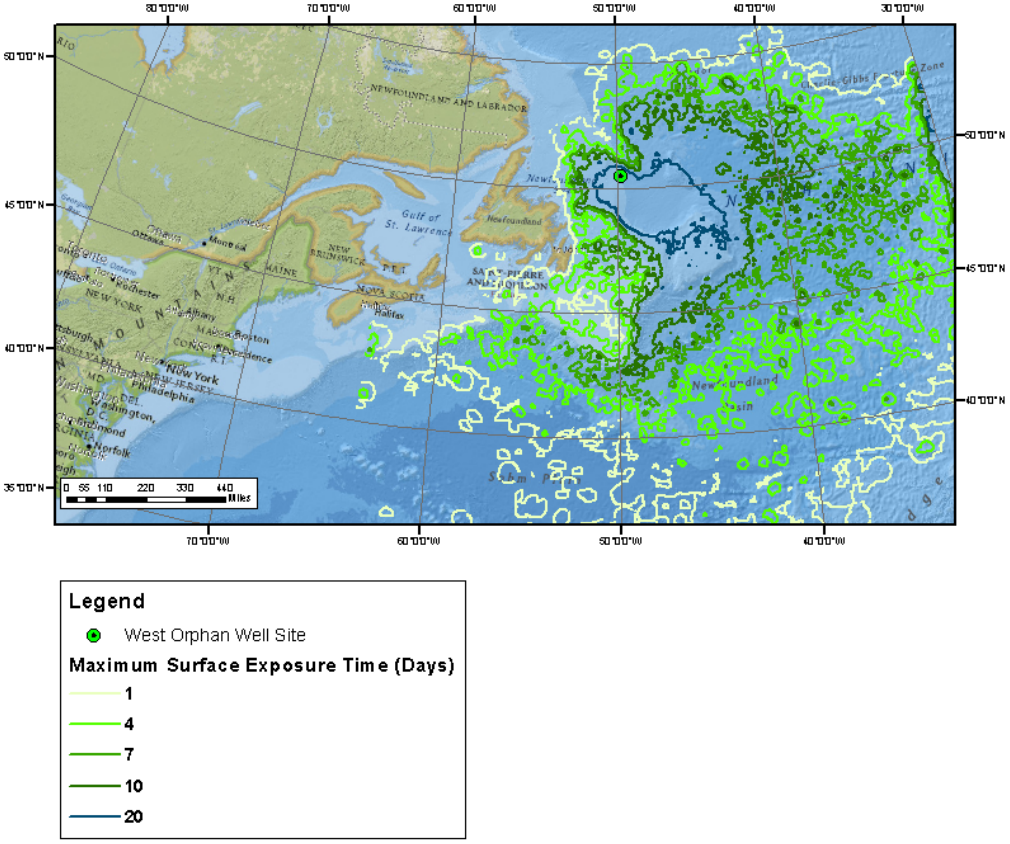


Figure 15.23 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Exceeding 58 ppb Total Hydrocarbons - Maximum Exposure Time

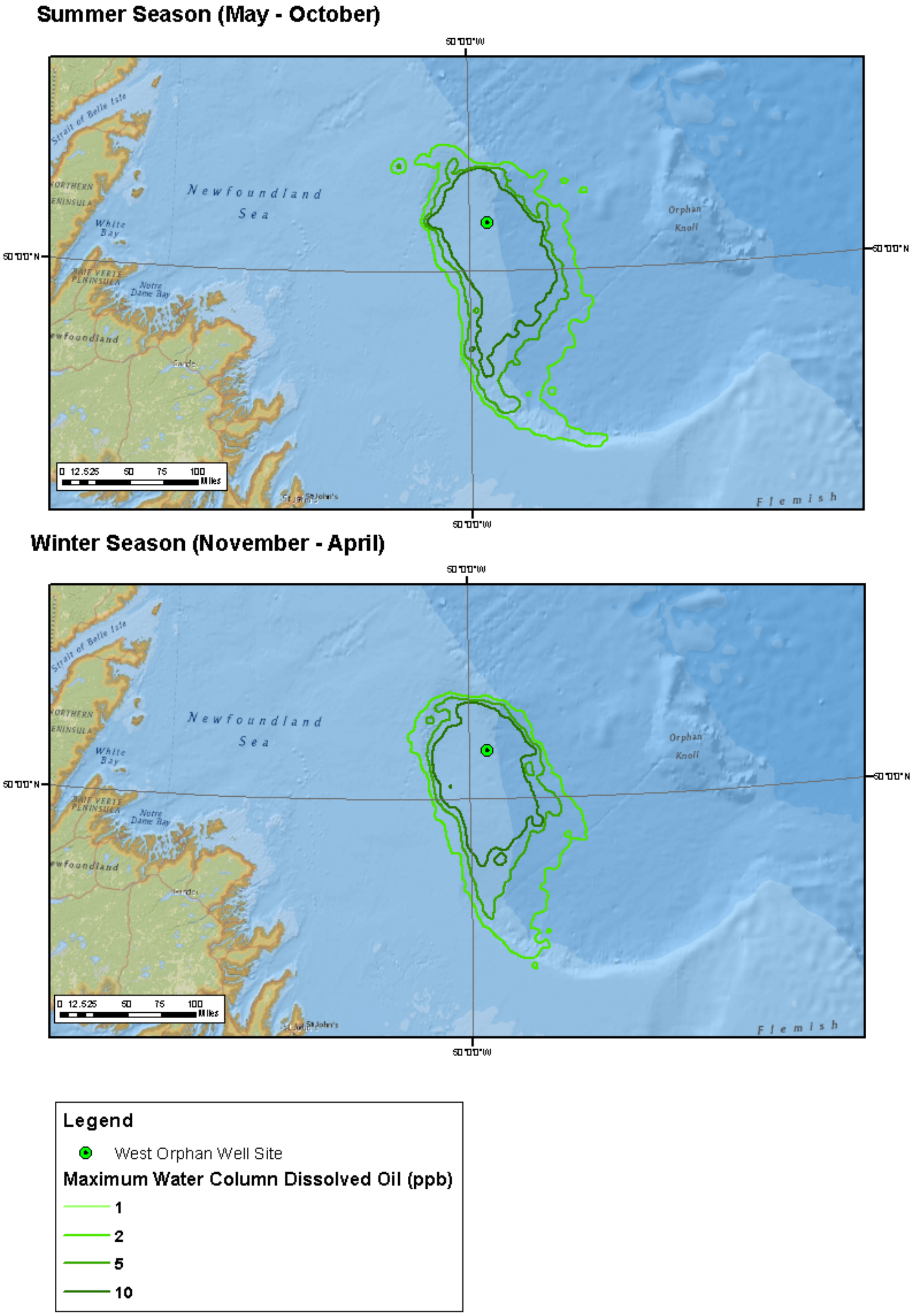
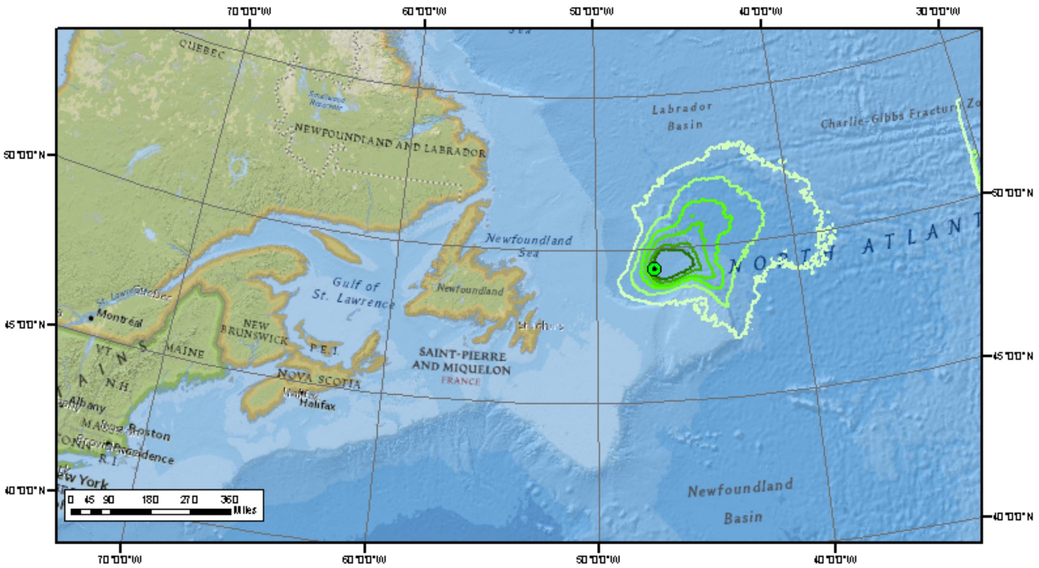


Figure 15.24 West Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Maximum Dissolved Oil Concentration Exceeding 58 ppb Total Hydrocarbons

Summer Season (May - October)



Winter Season (November - April)

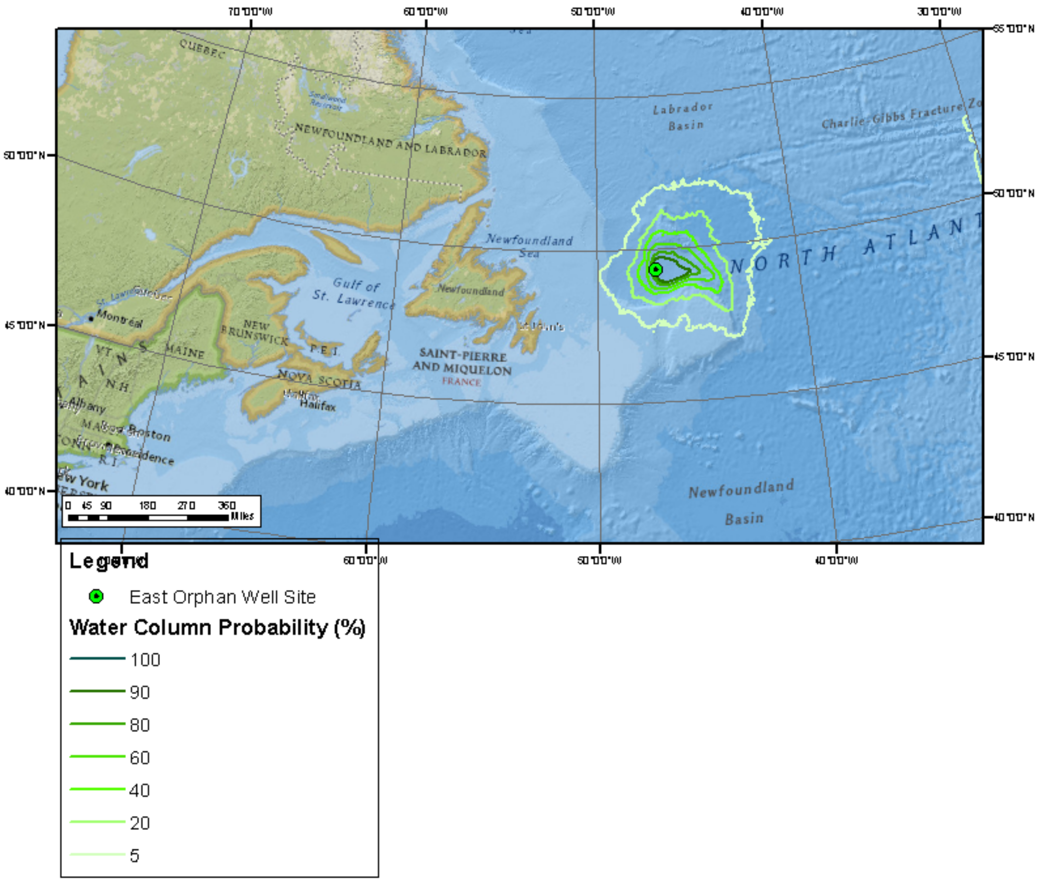
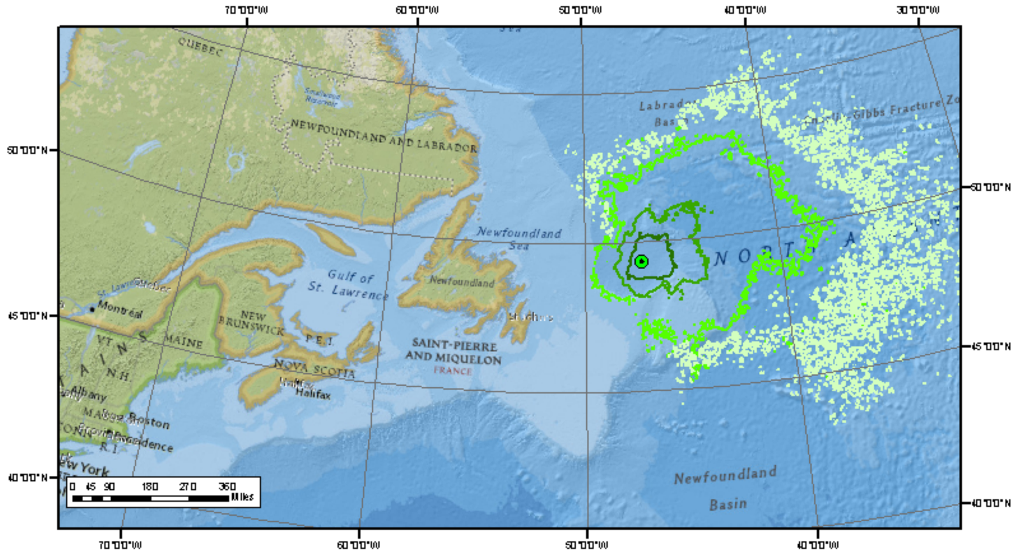


Figure 15.25 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Exceeding 58 ppb Total Hydrocarbons Probability

Summer Season (May - October)



Winter Season (November - April)

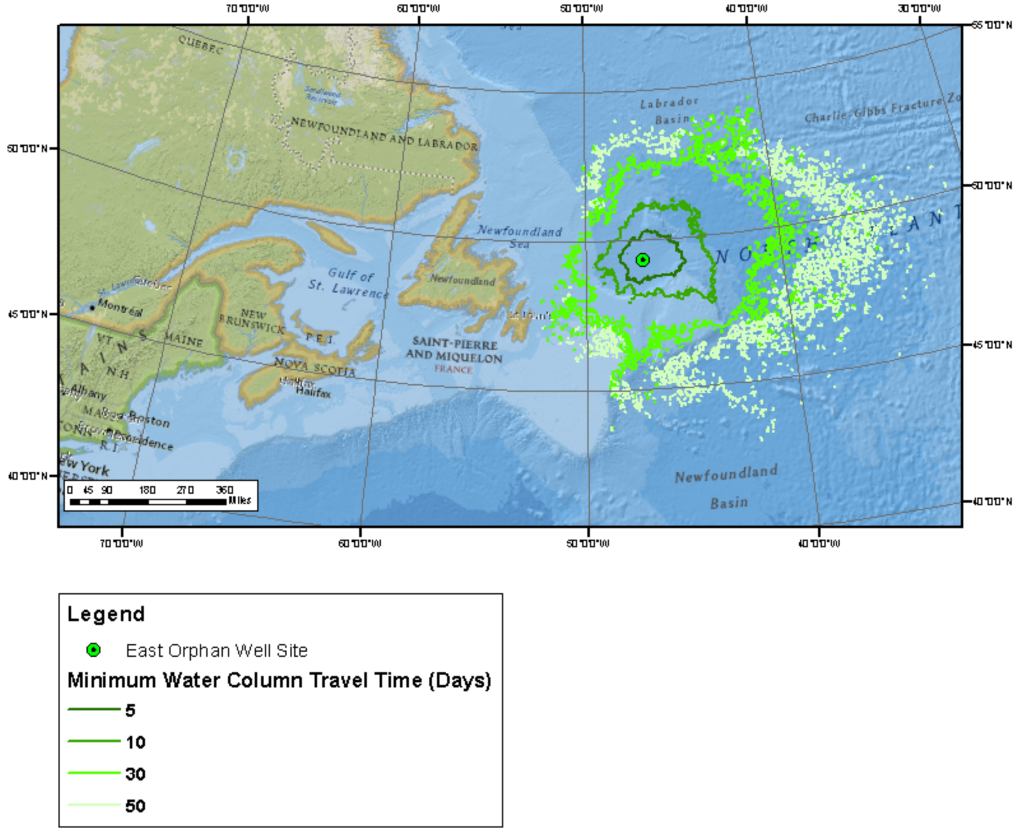
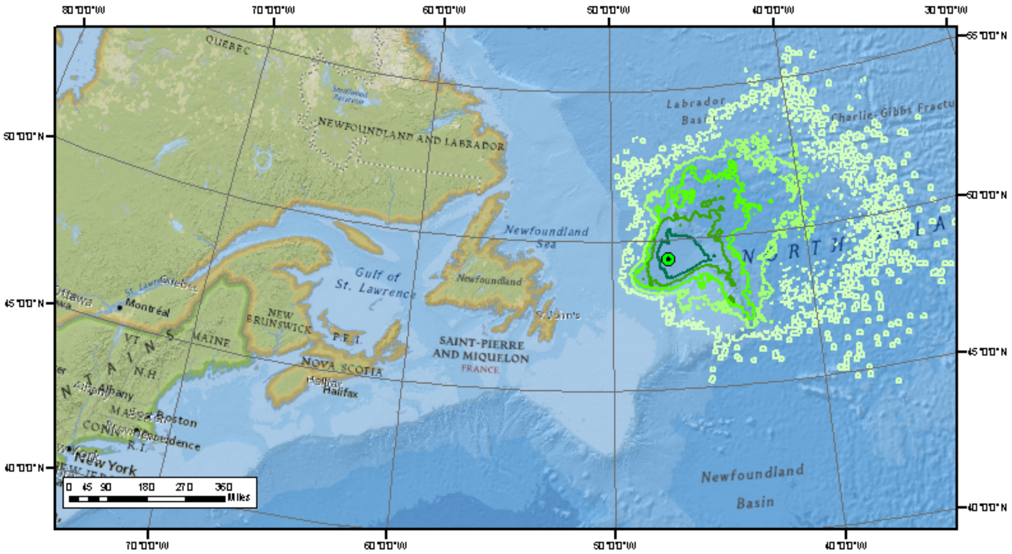


Figure 15.26 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Exceeding 58 ppb Total Hydrocarbons - Minimum Travel Time

Summer Season (May - October)



Winter Season (November - April)

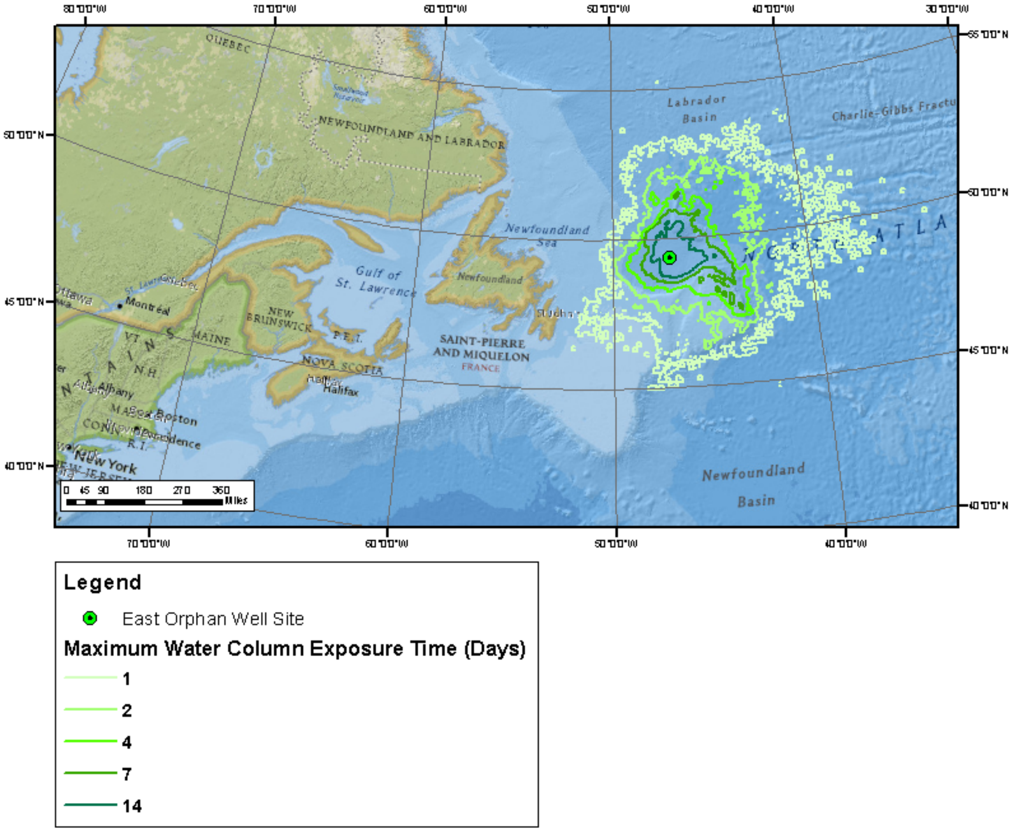
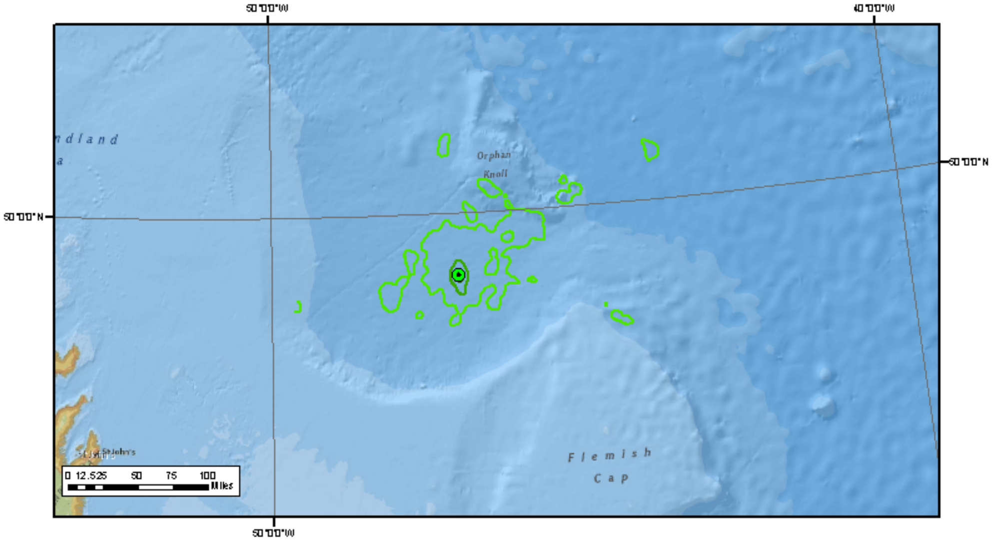


Figure 15.27 East Orphan Basin Water Column Well Blowout (Unmitigated 120-Day Relief Well Scenario) Exceeding 58 ppb Total Hydrocarbons - Maximum Exposure Time

Summer Season (May - October)



Winter Season (November - April)

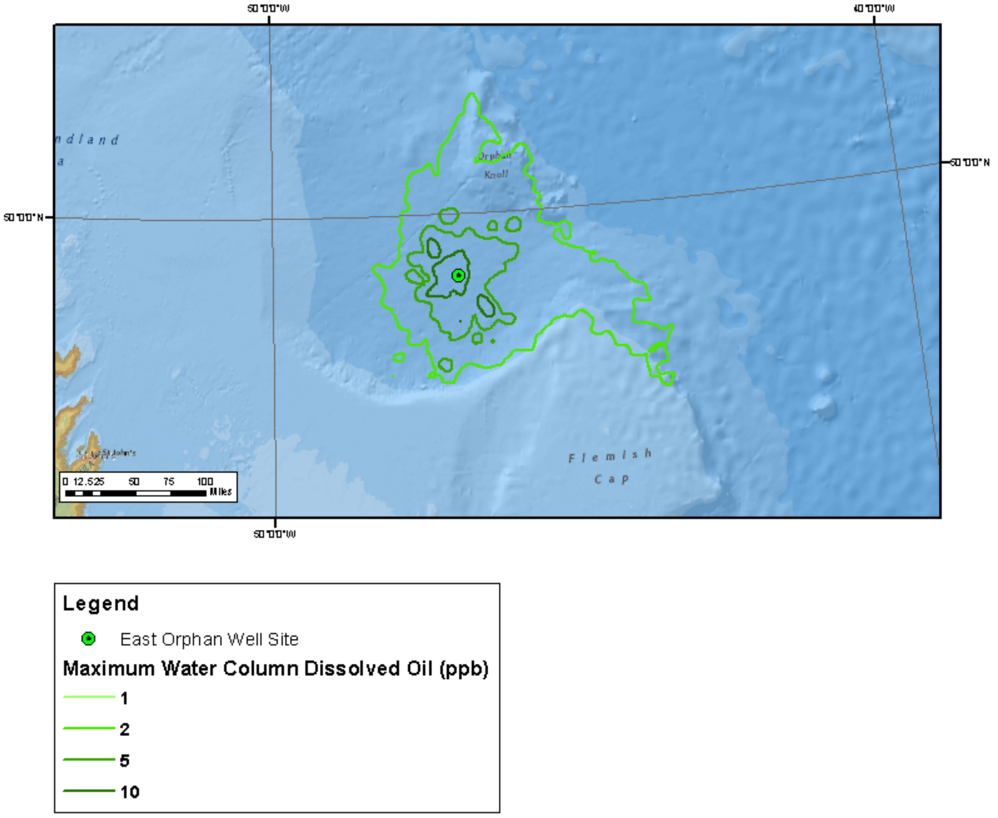


Figure 15.28 East Orphan Basin Well Blowout (Unmitigated 120-Day Relief Well Scenario) Water Column Maximum Dissolved Oil Concentration Exceeding 58 ppb Total Hydrocarbons

15.4.7.2 Deterministic Modelling Results

Individual or "deterministic" trajectories were identified and selected from the stochastic results that represented the maximum shoreline oiling for each wellsite and season. These representative worst credible case scenarios were then rerun deterministically to establish near-field and far-field fate and transport. The deterministic simulations provide insight to the individual trajectories, oil weathering behaviour, the mass of oil in each environmental compartment (air, water, surface, land and sediment) and other information (area of oil slick, length of shoreline oiled) related to each single spill at a given location and time which cannot be assessed using stochastic models.

Near-field deterministic simulations of the West Orphan blowout event using the 3-D plume model in OSCAR indicate that the high exit velocity cause the plume to rise rapidly before it terminates after about 10 minutes at a water depth of 535 m. The oil droplet size model in OSCAR predicts an initial d95 droplet size of 4.3 mm and d50 (median) droplet size of 2.0 mm for the West Orphan release. The model predicts it will take the largest oil droplets (4.1 mm) another 2 hours to rise to the surface, with 50% having arrived after 4 hours.

In contrast, the outlet velocity of the East Orphan release is three times less than that of the release at West Orphan. Although the oil droplet sizes are larger in the East Orphan release due to the smaller release rate, the decrease in outlet velocity means that plume does not rise as rapidly at East Orphan and terminates at a much deeper water depth (2,435 m below sea-level). Consequently, the oil droplets on leaving the plume take far longer to reach the sea surface, are dispersed more by cross currents as they rise, resulting in much thinner oil slick at the sea surface than was the case for the West Orphan blowout scenarios.

The oil droplet size model in OSCAR predicts an initial d95 droplet size of 9.8 mm and d50 (median) droplet size of 4.6 mm for the East Orphan release. The model predicts it will take the largest oil droplets (9.8 mm) 8 hours to rise to the surface, with 50% having arrived after 23 hours.

Far-field deterministic modelling results for the West Orphan "worst" shoreline oiling simulation for the winter season, indicated that at the end of the simulation (after 160 days), 36% of the oil released is biodegraded, 27% evaporated, 0.19% is reported on the surface and 34% in the water column; with that remaining in the water column dispersed to negligible concentrations (<58 ppb THC dispersed oil). Shoreline oiling exceeding the 1.0 g/m² threshold level is expected to be limited to the Avalon Peninsula with occurrences of moderate, light and stain oiling. The maximum length of shoreline impacted would occur after 119 days with 20 km of coastline being affected. The maximum mass of oil on the shoreline occurs slightly earlier (after 107 days) and is associated with 403 tonnes of oil accumulated on the shoreline.

Far-field deterministic modelling results for the East Orphan "worst" shoreline oiling simulation for the winter season, indicated that at the end of the simulation (after 160 days), 46% of the oil released is biodegraded, 37% evaporated, 0.65% is reported on the surface and 25% in the water column; with that remaining in the water column dispersed to negligible concentrations (<58 ppb THC dispersed oil). Shoreline oiling exceeding the 0.04 µm threshold level is also expected to be limited to the Avalon

Peninsula with occurrences of light oiling and staining. The maximum length of shoreline impacted would occur after 132 days with 27 km of coastline being affected. The maximum mass of oil on the shoreline occurs slightly earlier (after 98 days) and is associated with 271 tonnes of oil accumulated on the shoreline.

15.4.8 Diesel Spill Scenario Modelling Results

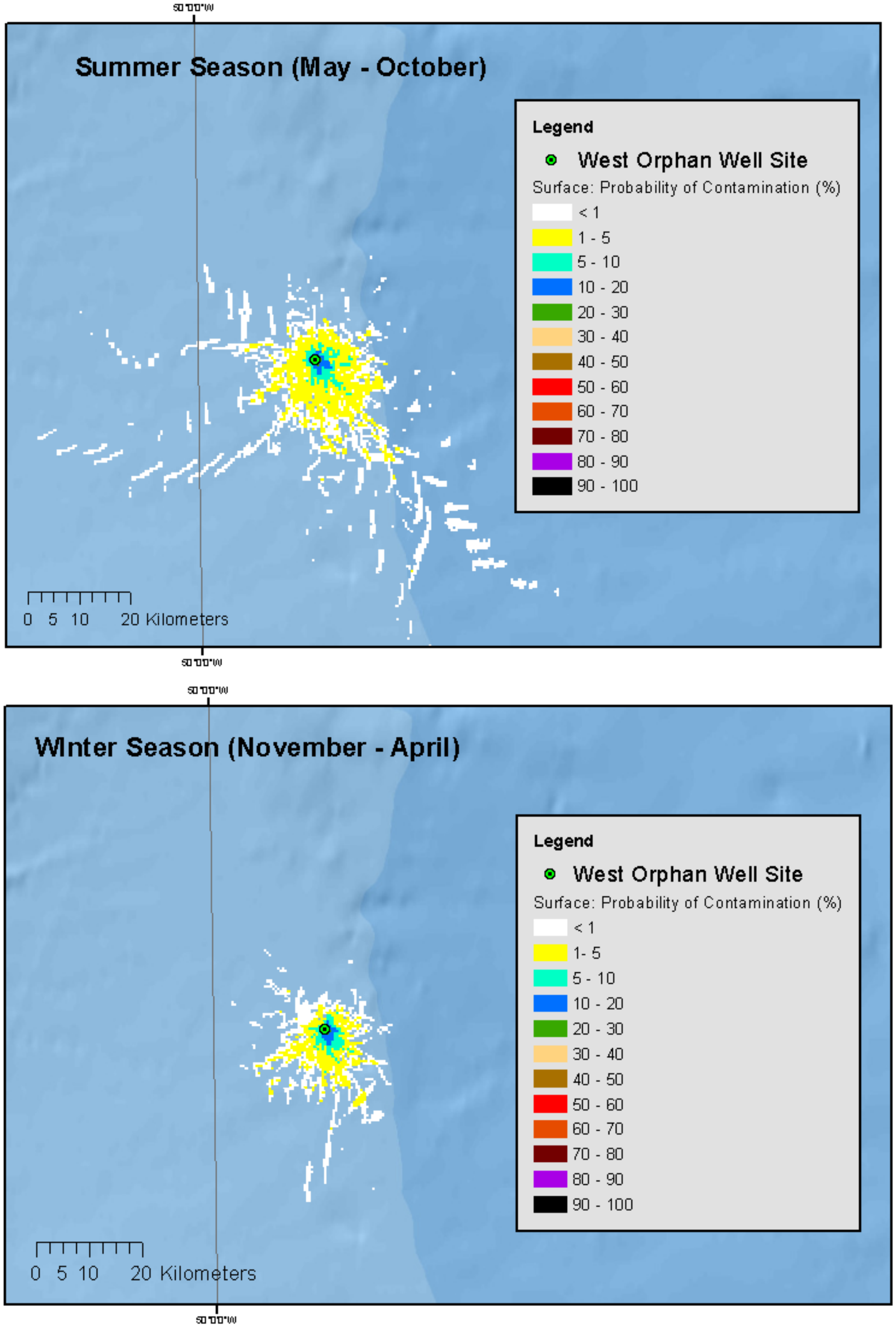
To simulate an accidental discharge from Project vessels, two batch spills of diesel were modelled as a surface release using stochastic and deterministic methods. Modelling for the batch release of diesel was undertaken for unmitigated incidents involving a hose failure (a 10-bbl surface release over 1 hour) and a tank failure (a 100-bbl surface batch release over 6 hours). Simulations were run over 15-day and 50-day periods for the 10-bbl and 100-bbl spills, respectively, for both summer (May to October) and winter (November to April) seasons for both wellsite locations.

Figures 15.29 to 15.32 depict the probability of sea surface emulsified oil thickness exceeding the 0.04 µm sheen thickness threshold. The results show that the location of threshold exceedances for surface effects are expected to occur over a greater area if a spill occurs during the summer season compared to the winter months. For a 100 bbl spill, there is a less than 1% probability of surface oiling in excess of the BAOAC sheen (0.04 µm thickness) threshold extending >25 km from either release location in the summer season and >15 km in the winter months. The cumulative footprint of locations where there is a >1% probability of exceeding this threshold ranged between 209 to 238 km² for the summer season compared to 121 to 133 km² for the winter season.

Figures 15.33 to 15.36 depict the probability of THC concentration (dispersed and dissolved oil) in the water column exceeding the 58-ppb threshold concentration level. The predicted THC concentrations and dissolved oil concentrations were within tens of meters of the surface, as they are the result of entrained oil from wind-induced surface breaking waves within the surface mixed layer. The duration of exposure to either surface oil or oil in the water column that exceeded thickness or oil in water concentration threshold levels was <6 hours for the 10-bbl releases and for the 100-bbl releases ranged from 12 to 18 hours in the immediate vicinity of the release location to <6 hours at the majority of locations further away.

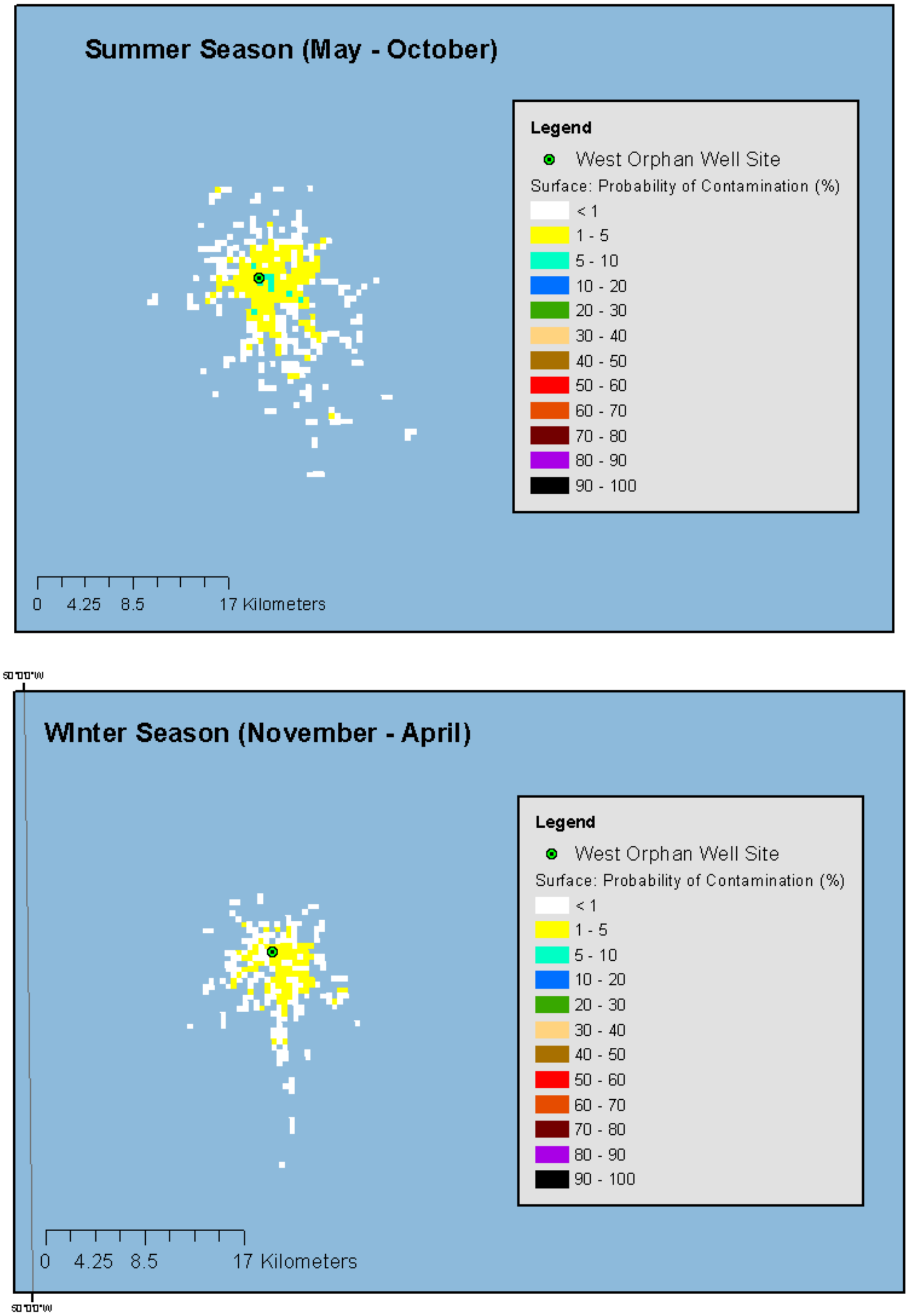
Deterministic modelling was conducted for a 100-bbl and 10 bbl-spill during the summer season, at the time of lowest ambient surface currents to capture a scenario of maximum surface oiling. Modelling showed that surface oil would rapidly evaporate and disperse into the water column following a release. In the 100-bbl batch spill scenario, approximately 60% of the spill evaporates from the surface within three days following the release, with remaining proportions dispersing or biodegrading within the same period. Results were similar for both West and East Orphan Basin modelling sites.

Additional details on the modeling of diesel batch spills can be found in Section 8 of Appendix D.



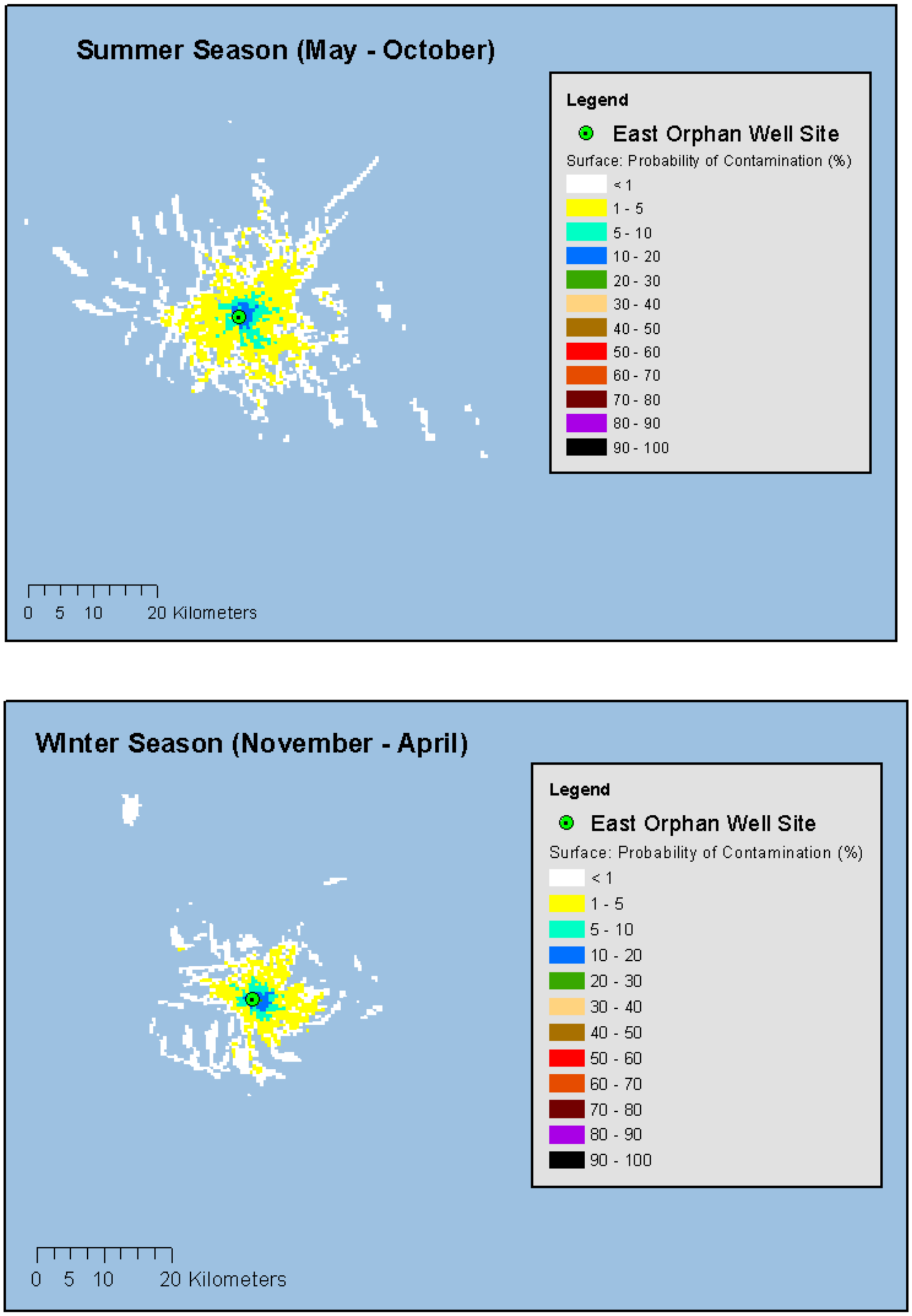
Statistical maps showing the probability of sea surface emulsified oil thicknesses exceeding the 0.04-μm thickness threshold.

Figure 15.29 West Orphan 100 bbl Surface Batch Release of Diesel



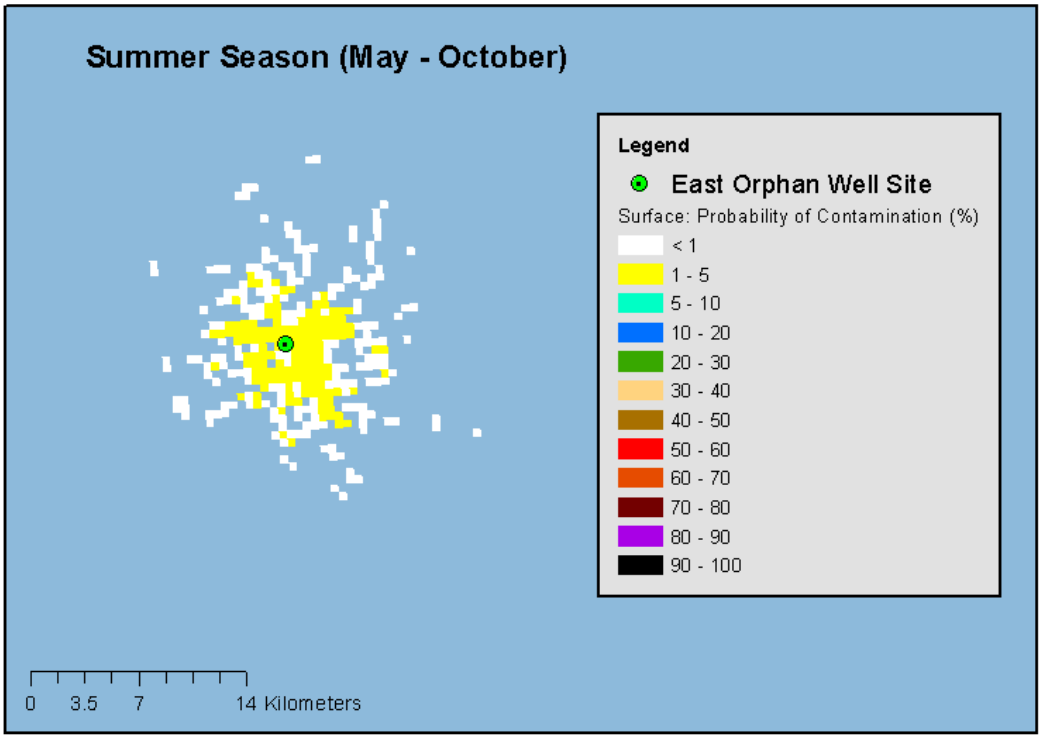
Statistical maps showing the probability of sea surface emulsified oil thicknesses exceeding the 0.04-µm thickness threshold.

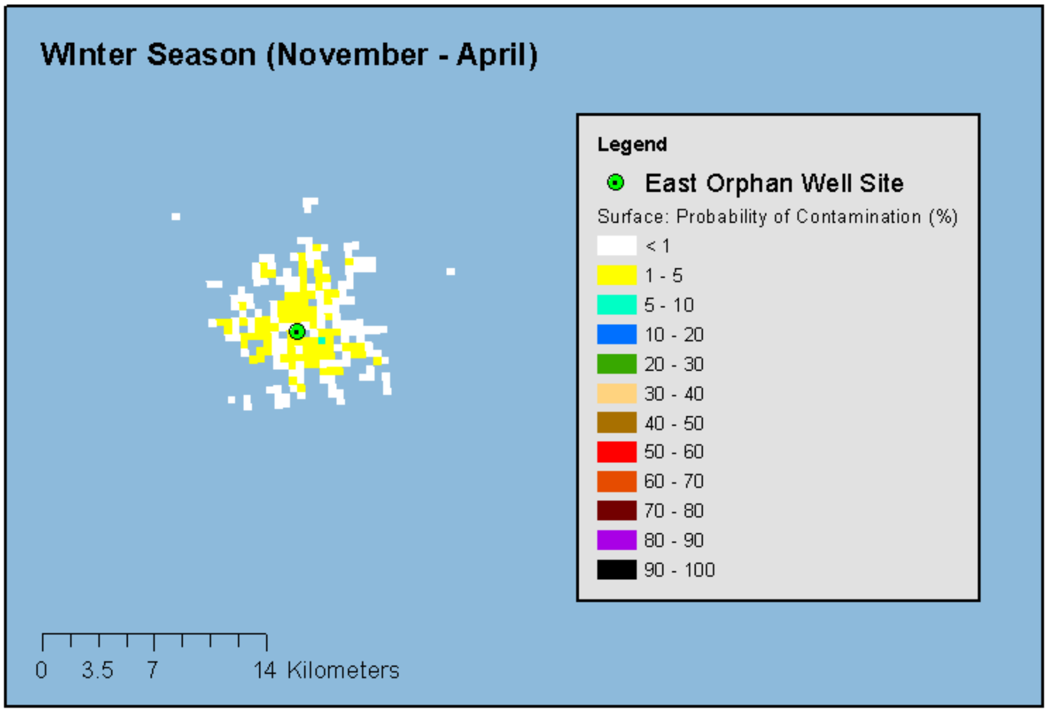
Figure 15.30 West Orphan 10 bbl Surface Batch Release of Diesel



Statistical maps showing the probability of sea surface emulsified oil thicknesses exceeding the 0.04-µm (BAOAC “Sheen”) thickness threshold.

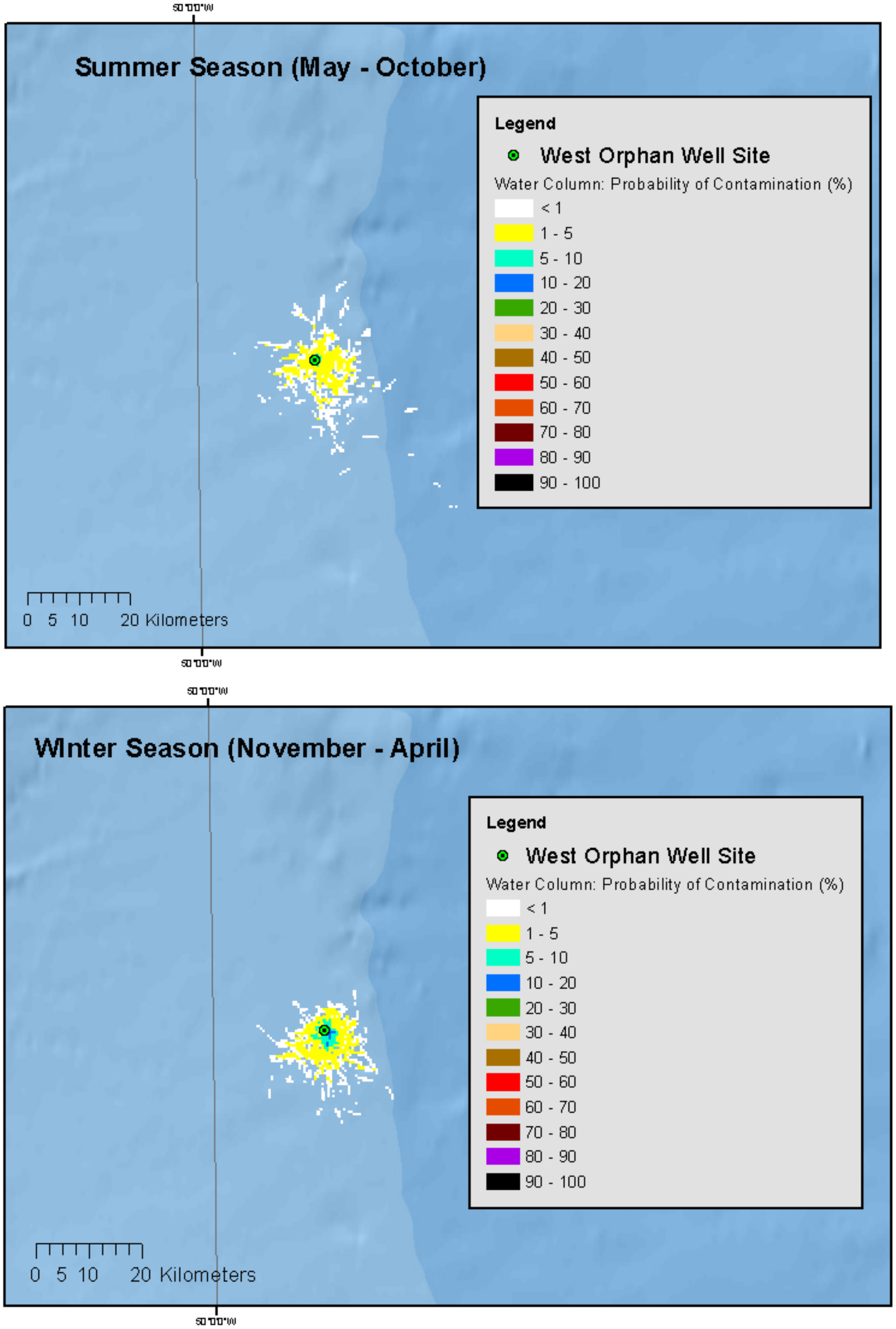
Figure 15.31 East Orphan 100 bbl Surface Batch Release of Diesel





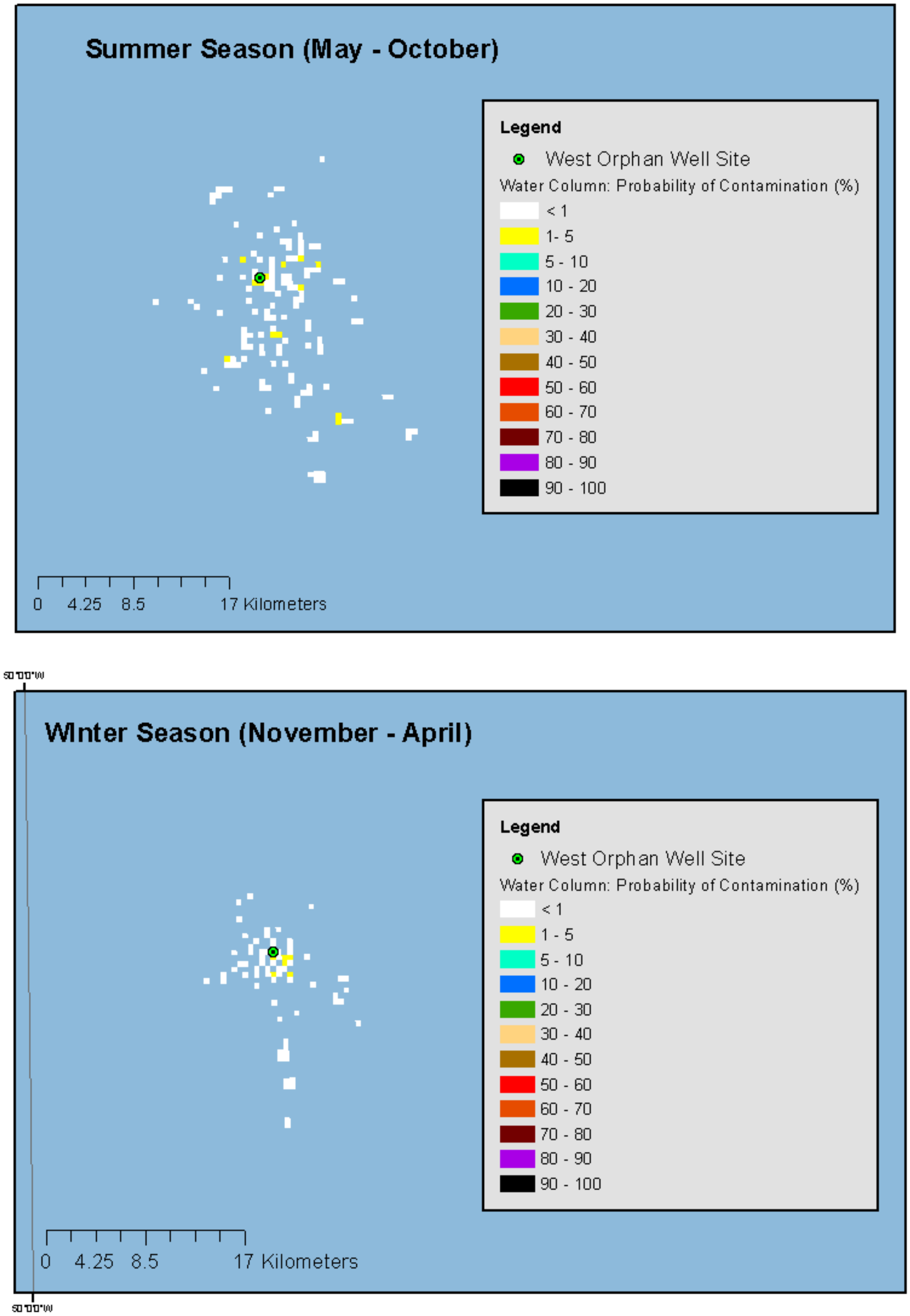
Statistical maps showing the probability of sea surface emulsified oil thicknesses exceeding the 0.04-µm (BAOAC “Sheen”) thickness threshold.

Figure 15.32 East Orphan 10 bbl Surface Batch Release of Diesel



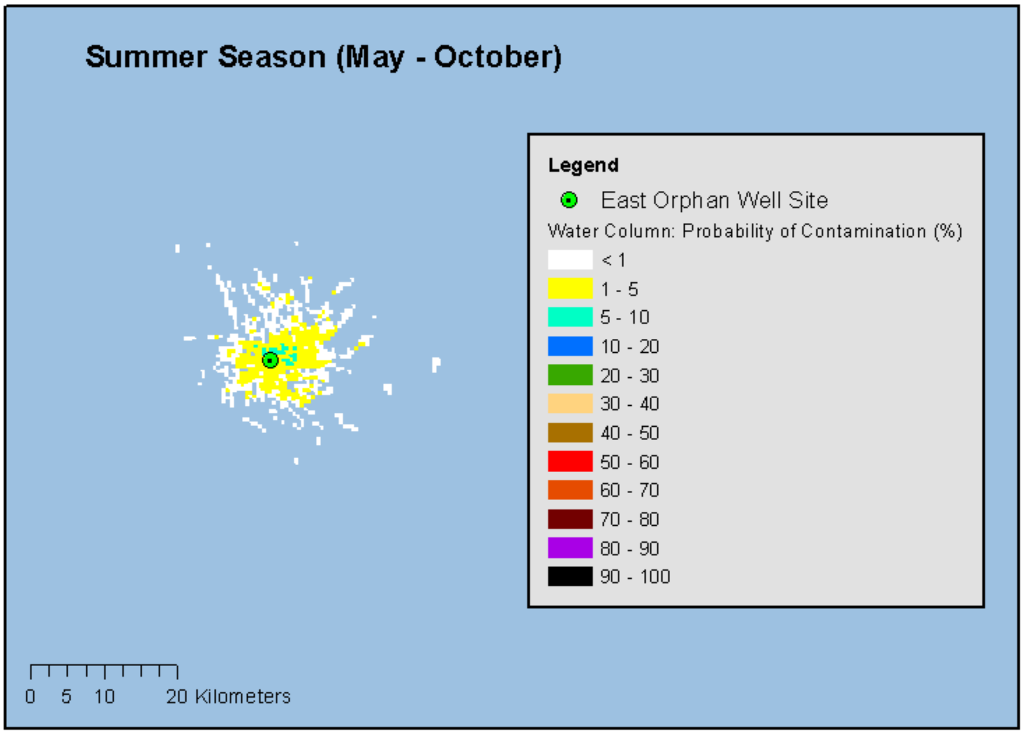
Statistical maps showing the probability of the total hydrocarbon concentration (dispersed and dissolved oil) in the water column exceeding the 58-ppb threshold concentration level for any grid cell in the top 100 m of water column.

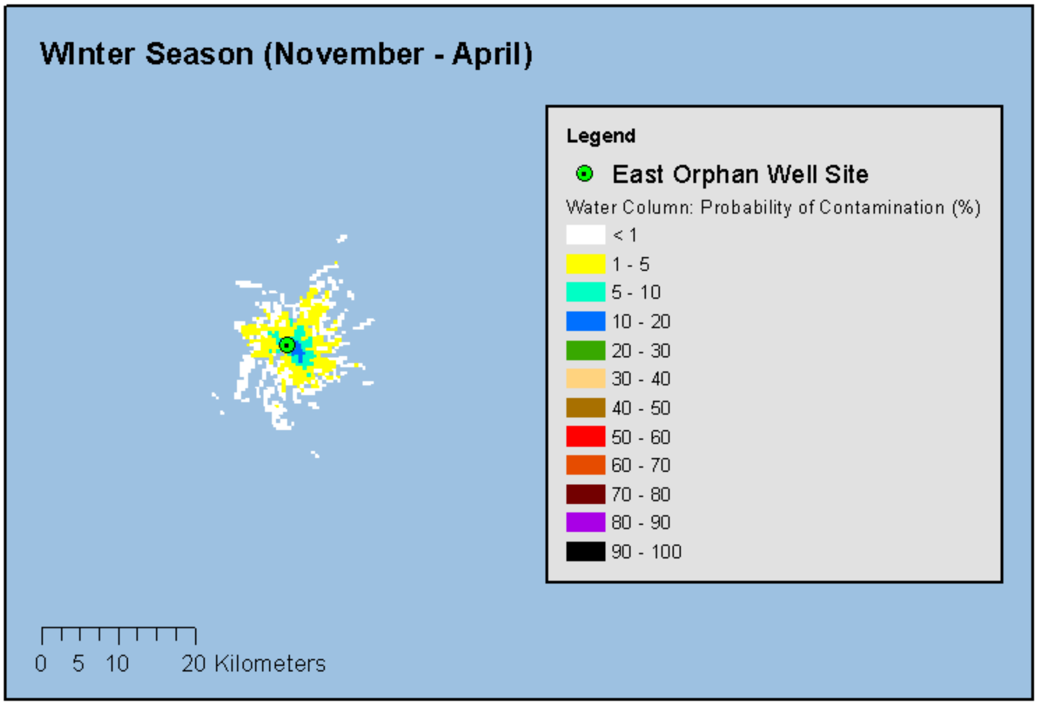
Figure 15.33 West Orphan 100 bbl Surface Batch Release of Diesel



Statistical maps showing the probability of the total hydrocarbon concentration (dispersed and dissolved oil) in the water column exceeding the 58-ppb threshold concentration level for any grid cell in the top 100 m of water column.

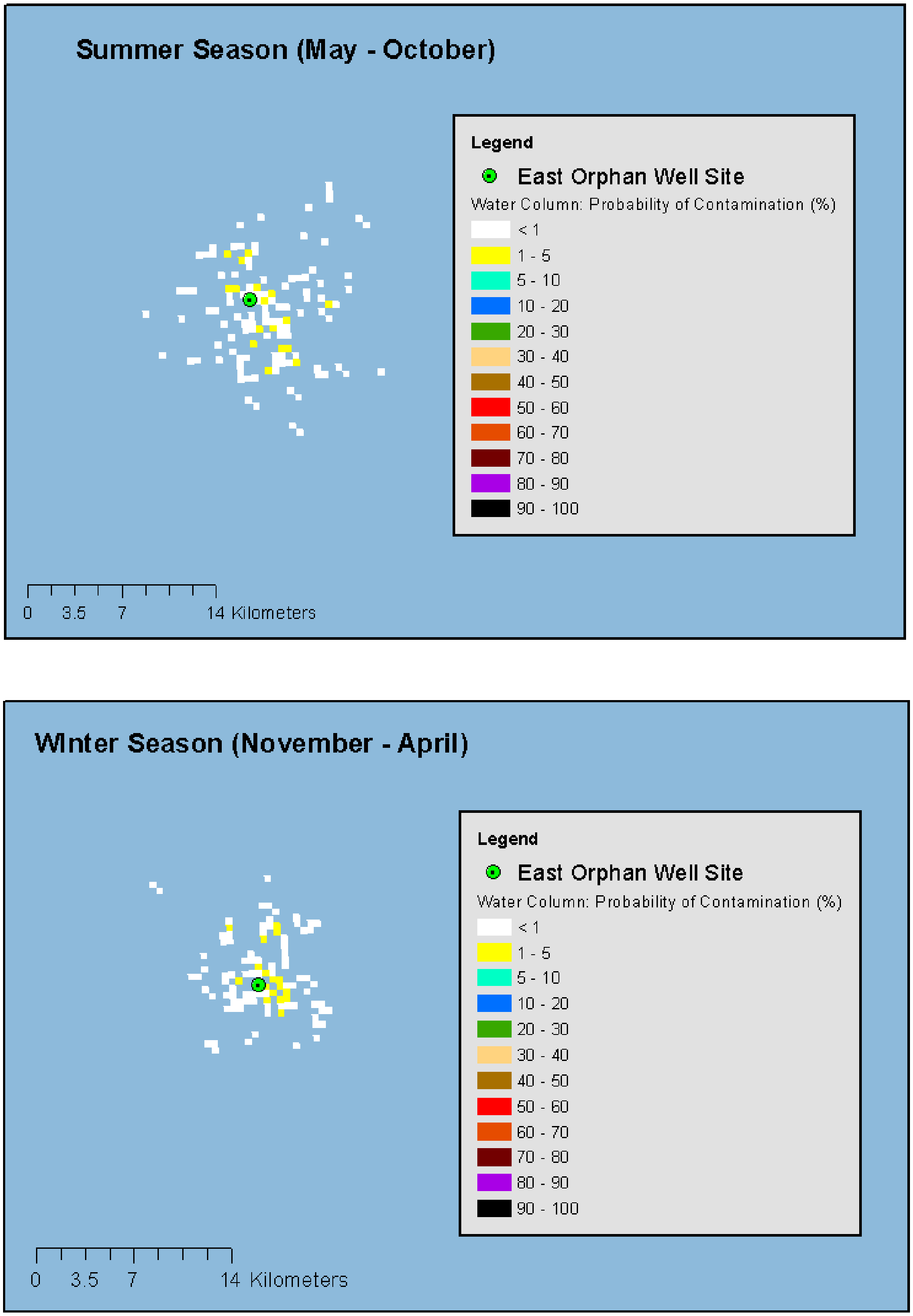
Figure 15.34 West Orphan 10 bbl Surface Batch Release of Diesel





Statistical maps showing the probability of the total hydrocarbon concentration (dispersed and dissolved oil) in the water column exceeding the 58-ppb threshold concentration level for any grid cell in the top 100 m of water column.

Figure 15.35 East Orphan 100 bbl Surface Batch Release of Diesel



Statistical maps showing the probability of the total hydrocarbon concentration (dispersed and dissolved oil) in the water column exceeding the 58-ppb threshold concentration level for any grid cell in the top 100 m of water column.

Figure 15.36 East Orphan 10 bbl Surface Batch Release of Diesel

15.5 Effects Assessment

The environmental assessment for accidental events considers the following accidental spill scenarios:

- subsea well blowout
  - Continuous 30-day (capping stack scenario) and 120-day (relief well scenario) well blowout at representative wellsites in the West Orphan Basin and East Orphan Basin
- marine diesel spill
  - Instantaneous spill of marine diesel from the MODU including 10 bbl (e.g., hose failure) and 100 bbl (e.g., tank failure) scenarios
  - spill from a PSV in transit to or from the MODU
- SBM spill from the MODU and the marine riser

As detailed in Section 15.4 and Appendix D, stochastic and deterministic modelling was conducted for subsea blowout and marine diesel spill scenarios at the MODU (refer to Table 15.2). This modelling included an assumption that no oil spill tactical response was undertaken, and that flow rates for the well blowout scenarios were based on the worst credible case discharge rates at each of the two potential locations. For the purpose of this environmental assessment and associated spill modelling, it is conservatively estimated that the mobilization and drilling of a relief well could take approximately 120 days. However, the actual time to plan and execute a relief well would be considerably less. Although a continuous 30-day well blowout scenario was also modelled for the Project, and the anticipated response time for the capping stack scenario is similarly significantly less than this conservative modelling assumption, this assessment focuses primarily on the 120-day well blowout scenario due to the relatively higher spatial extent, magnitude, and duration of associated potential environmental effects. Section 15.3.3 of the EIS provides more information on well control and well intervention response strategies.

Project-specific modelling was not conducted for a marine diesel spill from a PSV in transit or SBM spill scenarios. Modelling conducted for Nexen Energy's Flemish Pass Exploration Drilling Project (2018-2028) (Nexen Energy 2018) was used to generally inform this effects assessment to allow for a qualitative assessment of environmental effects from these spill scenarios. Nexen Energy's project area is approximately 110 km southeast of BP's Project Area in ELs 1144 and 1150. Nexen Energy's assessment of a marine diesel spill from a PSV in transit was based on a hypothetical release of 750,000 L (6,391 bbl) over 30 days at a location between St. John's and Nexen Energy's project area, which was modelled by RPS (2017). The assessment of a potential SBM spill relies on SBM spill modelling that was conducted by Amec Foster Wheeler (Amec) in support of Nexen Energy's project. Their SBM spill modelling considered a wellsite location in EL 1144 that is at a water depth (1,137 m; Amec 2017) similar to the West Orphan Basin wellsite (1,360 m); it is therefore a reasonable approximation of the potential properties and behaviour of a Project-related SBM spill. Amec (2017) modelled the following worst-case accidental SBM release scenarios:

- inadvertent surface release of the entire volume (64 m^3) of the active mud system, over a period of one to two hours
- subsurface SBM release from the marine riser and associated transport lines, during an emergency BOP disconnect event (255 m^3 at EL 1144), over a period of approximately 2 hours

These scenarios are consistent with those identified in Section 15.2 as credible spill event scenarios for the Project. Accidental spills, which result in an unplanned release of hydrocarbons (i.e., marine diesel or crude oil) to the marine environment, are collectively referred to as “oil spills” in this section, focusing on interactions between hydrocarbon material and the VCs being assessed. The chemical composition of a hydrocarbon will affect the physical properties of the oil (e.g., how heavy or thick it is), its behaviour in the environment (e.g., how it spreads, disperses, or sinks), its toxicity to receptors, and its susceptibility to degradation by weathering (Lee et al. 2015). SBM spills are not considered to be “oil spills” and are addressed separately.

In identifying interactions between each VC and each potential accident scenario, a credible worst-case event was assumed as described in Section 15.4.3. As part of the assessment methods, environmental effects pathways are identified and discussed, including a review of available research and scientific data on these effect pathways. The potential environmental effects, effect pathways, and measurable parameters identified for each VC in Chapters 8 to 13 with respect to routine Project activities remain valid for the assessment of potential environmental effects from an accidental event. VC-specific mitigation has been identified where appropriate, although for all VCs the focus is on emergency response and spill management as outlined in Section 15.3. Spill modelling results presented in Appendix D are assumed to be unmitigated events (i.e., no emergency response measures to contain or recover oil), which adds another element of conservatism to the effects assessment. Residual effects are characterized in residual effect summary tables. The significance of residual effects is determined using the same VC-specific thresholds for determining the significance of residual environmental effects used for routine Project activities (refer to Sections 8 to 13).

The descriptions of existing conditions for each VC provided in Chapters 6 and 7 generally focus on offshore receptors that may interact with the Project during routine activities. In recognition of concern for potential interactions between nearshore receptors and oil released from an accidental event (e.g., a marine diesel spill from a PSV operating in a nearshore area or a large-scale subsea blowout from an offshore well), the subsections below provide overviews of existing conditions for each VC with a focus on the nearshore environment. For the purposes of this assessment, the term “offshore” refers to the zone beyond the nearshore zone where sediment motion induced by waves alone effectively ceases and where the influence of the seabed on wave action is small in comparison with the effect of wind. “Nearshore” is defined as the zone extending from the low tide mark to the offshore, typically reaching water depths of the order of 20 to 30 m (DFO 1996; Voigt 1998).

15.5.1 Marine Fish and Fish Habitat

The Orphan Basin and surrounding areas provide habitat for a variety of groundfish, pelagic fish, and invertebrate species, including four fish SAR and 20 fish SOCC (identified in Section 6.1.8) that may be present in the Project Area and/or RAA at various times of the year. Of these, three species (northern wolffish, spotted wolffish, and white shark [Atlantic population]) are formally protected under Schedule 1 of SARA and one species (American eel) is formally protected under the NL ESA. Although the potential for occurrence of some of these SAR in the Project Area is believed to be migratory / transient (American eel) or low (white shark), based on known habitat preferences, distribution mapping, and catch data (where available), spotted and northern wolffish are considered moderately likely and highly likely to occur in the Project Area, respectively. However, an accidental release of oil or SBM could extend outside of the Project Area to affect SAR, SOCC, and secure species in the larger RAA.

At least 45 species of fish have been identified as early life stages in the ichthyoplankton of the Grand Banks and nearshore waters of Newfoundland, with the most frequently reported being: Atlantic herring, capelin, Atlantic cod, sand lance, redfish, seasnail, witch flounder, American plaice, and yellowtail flounder (Petro-Canada 1996, in Templeman 2010).

Some fish species spend their whole lives in nearshore areas, while others spend only certain life stages in the nearshore, enter the nearshore only to feed, or are seasonal migrants in the nearshore. Coastal and estuarine areas offer suitable cover for use as spawning and nursery grounds. Species that are likely to spawn in nearshore areas of the RAA include Atlantic herring, haddock, pollock, witch flounder, and yellowtail flounder.

The demersal juvenile stage is the most habitat-dependent period in the life-cycle of Atlantic cod (DFO 2012). Juvenile cod (up to the age of four years [COSEWIC 2010] or 4-35 cm long [DFO 2012]) prefer habitats that provide protection and cover, such as nearshore waters with eelgrass (COSEWIC 2010). In both nearshore and offshore areas off eastern Newfoundland, pebble-gravel and rock-boulder substrates within patchy marine landscapes are significant habitats for demersal juveniles (DFO 2012).

Groundfish that have potential to occur in nearshore areas of eastern Newfoundland include American plaice, Atlantic cod, skates, winter flounder, pollock, haddock, winter flounder, and yellowtail flounder. Large pelagic species observed in the nearshore include bluefin tuna, swordfish, and several shark species (porbeagle shark, spiny dogfish, blue shark, and shortfin mako). Small pelagics that may occur in the nearshore include Atlantic herring, Atlantic mackerel, and capelin.

All native fish species inhabiting fresh water in eastern Newfoundland are diadromous (Scott and Crossman 1973, in Catto et al. 2003), meaning that they require both salt and freshwater environments to complete their lifecycles. As the interface between salt and freshwater environments, the nearshore area is particularly important to diadromous species. Diadromous species may be either anadromous (i.e., fish that spend most of their lives in the marine environment but migrate to the freshwater environment to spawn) or catadromous (i.e., fish that spend most of their lives in the freshwater environment but migrate to the marine environment to spawn). Anadromous species found in the nearshore region of Newfoundland include: American shad, Arctic char, Atlantic salmon, Atlantic sturgeon, Atlantic tomcod, brown trout, rainbow smelt, rainbow / steelhead trout, and sea lamprey. The American eel is a catadromous species that has potential to occur in the RAA.

Many invertebrates spend their entire life in the nearshore region (e.g., lobster, green crab, rock crab, sea urchins, and blue mussels) (Bundy et al. 2014). Other invertebrate species that can be found in nearshore waters include jellyfish, scallops, shrimp, squid, whelks, numerous crab species, periwinkles, sea cucumbers, sea stars, and sand dollars. The invertebrates found in the nearshore tend to be sessile or have limited mobility and the nearshore area provides a variety of food sources to support their life cycle. Many of these species support commercial fisheries. As described in Section 6.1.6, there is a high abundance and diversity of structure-forming benthic invertebrate species in the Orphan Basin and surrounding areas, including soft corals, scleractinians (stony corals), antipatharians (black corals), gorgonians, and sea pens. Portions of the Project Area in the West Orphan Basin have been identified as a significant benthic area for sea pens.

Sections 6.1.10 and 6.4 describe several special areas of importance to marine fish that are found within the RAA, including nearshore and offshore areas. Additional details regarding existing conditions for marine fish and fish habitat are provided in Section 6.1.

15.5.1.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine fish and fish habitat. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume worst-case credible discharge rates and no implementation of mitigation measures).

Potential Effects of an Oil Spill on Marine Fish and Fish Habitat

Potential effects pathways for a change in risk of mortality or physical injury and/or change in habitat quality and use for marine fish and fish habitat due to an oil spill include: reduction of water and/or sediment quality; reduced primary productivity due to a reduction in air-water gas exchange and light penetration; and lethal and sub-lethal effects from acute or chronic exposure to water-soluble fractions of hydrocarbons.

The risk of exposure of fish and invertebrates to an oil spill depends on the type of oil and volume released, but also on the habitat these species occupy, their behaviour, the time of year, their life history, and the general health of the stock at the time of the spill. Fish kills are typically brief and localized following a discrete spill event due to the rapid loss of the acutely lethal low-molecular weight components of oil due to dilution and weathering (Lee et al. 2015), the ability of motile species to detect and avoid impacted areas, and the ability of phytoplankton, zooplankton, and adult fish to metabolize hydrocarbons (Wolfe et al. 1996; Graham et al*.* 2010).

In general, adult pelagic and benthic fish occurring in relatively deep waters have lower exposure risk because they are highly mobile and able to avoid oiled areas (Irwin 1997; Law et al. 1997). Larval and juvenile pelagic and benthic fish species are at a greater risk of exposure as they are often less motile than adults (Yender et al. 2002) and have shown higher sensitivity to lower concentrations of hydrocarbons, since they may not have yet developed detoxification systems allowing them to metabolize hydrocarbons (Rice 1985; Carls et al. 1999; Incardona et al. 2013; Lee et al. 2015). Fish that spawn or occur in nearshore intertidal and subtidal zones and in shallow reef zones are at higher risk of exposure where there is shoreline oiling or contamination of sediments, thereby potentially increasing the risk for chronic exposure (Yender et al. 2002; Lee et al. 2015). Benthic invertebrates have a moderate to high risk of exposure, depending on their motility and use of contaminated sediments (Yender et al. 2002; Lee et al. 2015).

Potential effects on phytoplankton and zooplankton vary by species, with mortality more dependent on exposure time (some zooplankton have been shown to avoid spills) than hydrocarbon concentration (Seuront 2010; Abbriano et al. 2011). Reduction of air-water gas exchange and light penetration following a spill generally results in reduced productivity and growth and ultimately a change in community composition (Teal and Howarth 1984; Abbriano et al. 2011; Gilde and Pinckney 2012).

Post-spill studies on phytoplankton conducted using crude oil obtained from the Deepwater Horizon oil spill and a mixture of Texas crude samples found that total phytoplankton biomass declined with increasing concentration of oil, and that the phytoplankton community was modified. Diatoms, cyanobacteria, euglenophytes, and chlorophytes were found to be relatively resistant to contamination, while cryptophytes were found to be vulnerable (Gilde and Pinckney 2012).

Zooplankton have also been shown to be sensitive to hydrocarbons, with increased mortality, decreased feeding and decreased reproduction (Suchanek 1993; Seuront 2011). Zooplankton with the ability to sense and avoid spills (e.g., copepods) can reduce contact and mortality risk (Seuront 2010). At sub-lethal levels, hydrocarbons accumulated in zooplankton after a spill can be depurated within days of moving to clean water (Trudel et al. 1985). Recovery of zooplankton communities are likely to occur soon after a spill due to their short generation time, high fecundity, and the ability of some zooplankton to actively avoid spill sites (Seuront 2011). When there is a spill of crude oil or hydrocarbons, the bacteria capable of degrading the substance proliferate and multiply quickly (ASM 2011). The local community of microbes in an area is adapted to the background supply of hydrocarbons. When a spill occurs, there is a lag time during which the microbes replicate and increase their populations in response to the influx of a new energy source. During an oil spill, the volume of oil released into the environment initially out paces the ability of bacteria to degrade the substance until the community catches up in numbers in response to the increased availability of a hydrocarbon source. In coordination with other physical processes including evaporation, dissolution, dispersion, and photo-oxidation, bacteria will eventually clean up the spill by consuming the hydrocarbon compounds which are biodegradable (ASM 2011). Studies have shown that bacterial respiration, through biodegradation of hydrocarbons, has the potential to cause oxygen depletion, eventually leading to hypoxia in areas near oil spills (Adcroft et al. 2010).

Various experimental studies have shown sub-lethal toxic effects of hydrocarbons on early life stages of pelagic fish (Marty et al. 1997; Peterson and Kristensen 1998; Carls et al. 1999; Heintz et al. 1999; Couillard 2002; Pollino and Holdway 2002; Colavecchi et al. 2004; Incardona et al. 2004; Hendon et al. 2008; Incardona et al. 2014).

After the Deepwater Horizon oil spill, early life stages of coastal fishes using seagrass habitat in the northern Gulf of Mexico were investigated. The studies concluded that immediate, catastrophic losses of 2010 cohorts were largely avoided, and that no shifts in species composition occurred following the spill. However, it was pointed out that this did not preclude potential long-term effects experienced by fish from chronic exposure and delayed indirect effects (Fodrie and Heck 2011). In another study, commercial fish and shellfish (crab, shrimp, oyster) species were collected after the Deepwater Horizon oil spill from closed fishing grounds along the Mississippi coast. Higher levels of PAHs were detected in all four taxa (fish, crab, shrimp, oyster) during the early sampling. When compared with later months, and after one year, PAH levels in the collected samples were similar to those reported in commonly consumed processed foods and below regulated levels (Xia et al. 2012).

Effects of hydrocarbon spills are most realistically examined using the water-soluble fractions of oil or light hydrocarbon products since natural weathering of the oil, including dispersion and dissolution, cause the water-soluble hydrocarbons to move into the water column. The OLF Guideline for risk assessment of effects on fish from acute oil pollution (2008) concluded that threshold concentration for no observed effect from acute exposure to total hydrocarbons ranges from 50 to 300 ppb. Neilson et al. (2005, as reported in OLF 2008) proposed a value for acute exposure to dispersed oil of 58 ppb, based on the toxicity of dispersed oil to various aquatic species, which showed the 5% effect level is 58 ppb. This threshold was used as a modelling reference for this assessment and is used to predict environmental effects of hydrocarbon spills (well blowout incident, diesel spills) on marine fish.

Potential Effects of an SBM Spill of Marine Fish and Fish Habitat

In the event of an accidental batch spill of SBM, the pathways for effects would be similar to those assessed for routine drilling discharges (refer to Chapter 8). Potential effects pathways for a change in risk of mortality or physical injury and/or change in habitat quality and use for marine fish and fish habitat due to an accidental SBM release include: smothering of sessile or slow-moving individuals and food sources for fish and shellfish; sedimentation; and potential for contamination.

SBM is a heavy, dense fluid which sinks rapidly in the water column when released (refer to Section 2.8.2 for information on SBM constituents). SBM constituents will be selected according to the OCSG so that low-toxicity chemicals are used wherever practicable. Therefore, environmental effects are mostly restricted to smothering of sessile or slow-moving individuals and sedimentation. Elevated TSS levels can have detrimental effects on fish, including physiological stresses, reduced growth, and adverse effects on survival, with the severity of these effects dependent on various factors including life-history stage and risk of exposure (e.g., ability of fish to avoid undesirable conditions). It is expected that increases in TSS levels from an SBM spill would be transient. An accidental spill of SBM would also have the potential to result in a small, thin surface sheen (more likely if the SBM spill occurred at the surface) with effects similar to those discussed above for hydrocarbon spills, but more limited in nature.

15.5.1.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. Refer to Section 15.1 for information on BP’s approach to risk management, Section 2.5 for specific information on well control and blowout prevention, and Section 15.3 for a description of BP’s contingency planning and emergency response measures.

As noted in Section 15.3.1, the Project will operate under an IMP that will include contingency plans for responding to specific emergency events, including potential spill or well control events. The IMP and supporting specific contingency plans, such as a SRP, will be submitted to the C-NLOPB prior to the start of any drilling activity as part of the OA process. The SRP will specify tactical response methods, procedures, and strategies for safely responding to different spill scenarios. Tactical response methods that will be considered following a spill incident include, but are not limited to: offshore containment and recovery; surveillance and tracking; dispersant application (surface and subsea injection); in-situ burning; shoreline protection; shoreline clean-up; and oiled wildlife response. Refer to Section 15.3 for details regarding incident management and spill response.

BP will undertake a SIMA / NEBA as part of the OA process with the C-NLOPB. The SIMA is a structured process that will qualitatively evaluate the risks and trade-offs of all feasible and effective response options, when compared to no action. The SIMA process will inform the selection of an overall spill response strategy for the Project. If identified as a preferred response option, use of chemical dispersants would not occur without first obtaining regulatory approval.

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

15.5.1.3 Characterization of Residual Project-Related Environmental Effects

Subsea Blowout

A subsea blowout scenario has the greatest potential for causing environmental effects. The actual effects of a blowout incident would depend in large part upon the duration and volume of the spill, as well as the environmental conditions at the time of the spill.

In the event of a blowout scenario, there is a risk of mortality of phytoplankton and zooplankton (food sources) present in the mixed surface layer of the water column. Although zooplankton communities may be able to avoid exposure, there will be a temporary decline in the abundance of phytoplankton in the immediate area of the spill. Zooplankton that cannot avoid exposure and experience sub-lethal effects will depurate once the spill has subsided due to response actions (e.g., containment and/or recovery) and natural weathering processes.

Lethal and sub-lethal effects could occur if the spill encompasses areas where fish eggs, larvae, or juveniles are located, including those in spawning and nursery areas. Most fish species in the RAA spawn in a variety of large areas, over long time-scales, and a spill is not predicted to encompass all these areas or time-scales to such a degree that natural recruitment of juvenile organisms may not re-establish the population(s) to their original level within one generation. In the event of a large blowout incident, the area affected is unlikely to encompass all of the spawning locations for any one species. The few species that spawn in a limited geographic area have potential to spawn over many months or the entire year. Therefore, with mitigation (e.g., containment and/or recovery), their spawning window will not be completely affected by a blowout incident. Because most species spawn in multiple locations within the RAA or over long time-scales, it is not likely that an entire year class would be lost due to the toxic effects of oil from a large blowout on early life stages of fish species.

It is anticipated that most adult finfish would be able to avoid exposure via temporary migration. Effects on slow-moving or sedentary species would be similar to those on phytoplankton, zooplankton, and larval and juvenile fish species.

The likelihood, magnitude, geographic extent, and duration of potential effects will depend on how the spill trajectory and fish and fish habitat overlap in both space and in time. Stochastic oil release modelling was undertaken for blowout scenarios at two representative well locations (West Orphan Basin and East Orphan Basin). Subsea oil releases were modelled over a 160-day period at each wellsite location based on worst-case credible discharges and a scenario in which the oil is released continuously and without mitigation for 120 days. These assumptions result in very conservative (i.e., highest potential) effects assessments. Separate stochastic simulations were carried out to represent summer (May to October) and winter (November to April) seasonal weather conditions. For the purposes of the spill modelling, a 58-ppb in-water total hydrocarbon concentration (THC) of oil that is dispersed, dissolved, and entrained in the water column was selected as the threshold for acute exposure of aquatic species. This is the THC at which it is conservatively estimated in this assessment that a change in habitat quality and use may occur for marine fish (Neilson et al. 2005; refer to Table 15.9). This assessment also conservatively assumes that a THC of 200 ppb is the threshold for a change in risk of mortality or physical injury for marine fish (Carls et al. 2008; refer to Table 15.9).

Following a continuous, 120-day unmitigated blowout from a wellsite in the West Orphan Basin or the East Orphan Basin, stochastic modelling results indicate that the geographic extent of a residual change in habitat quality and use for marine fish (using the 58-ppb THC [dispersed and dissolved oil] as an effect threshold) could spread beyond the RAA. Environmental effects related to in-water THC concentrations above 58 ppb would be anticipated to occur over the greatest potential area in the event of a blowout during the winter months in the West Orphan Basin, followed by (in descending order of spatial extents for potential areas of threshold exceedance) a blowout during the summer months in the West Orphan Basin, a blowout during the summer months in the East Orphan Basin, and a blowout during the winter months in the East Orphan Basin (refer to Table 7.1 in Appendix D).

Based on stochastic modelling for a continuous, 120-day unmitigated blowout in the West Orphan Basin, there is less than a 5% probability of concentration of THCs in the water column exceeding 58 ppb outside of the RAA. Stochastic modelling for a continuous, 120-day unmitigated blowout in the East Orphan Basin, shows a high probability of this threshold being reached outside the RAA in the summer (20% probability) but similar (5% probability) in the winter.

Although the areas of potential effects delineated by the modelling results are relatively large, substantial portions of these areas would have low probabilities of occurrence if the release is allowed to continue unmitigated for 120 days. As indicated by the modelling, exceedances of the 58-ppb threshold for in-water dispersed and dissolved THCs are generally expected to remain in offshore waters and have a much smaller areal extent than for surface oil (Appendix D). The only exception is the West Orphan Basin winter season scenario, where there is a less than 5% probability that some localized THCs above 58 ppb could occur in the nearshore after at least 50 days of continuous, unmitigated release (refer to Figure 15.22). However, the maximum water column exposure time before the oil in the nearshore environment is dispersed and diluted to concentrations below the threshold level is expected to be limited to one or two days (refer to Figure 5.23).

The implementation of mitigation measures would further reduce the already relatively low probabilities of oil extending beyond the RAA or reaching nearshore areas. In the unlikely event of an actual subsea blowout, mitigation (including emergency response measures such as containment [e.g., capping stack] and recovery operations) would be implemented well before 120 days elapse, thereby likely reducing the magnitude, duration, and geographic extent of the spill and associated residual environmental effects.

Concentrations of dissolved and total hydrocarbons are predicted to be highest around the release site and dissipate as the oil moves away and disperses within the water column (Appendix D). THCs above 58 ppb are most likely to be encountered in the Orphan Basin for all modelled scenarios (refer to Figures 15.21 and 15.25), extending south to the Jeanne d'Arc Basin and southeast to the Flemish Pass and Flemish Cap for the West Orphan Basin scenario (refer to Figure 15.21). Information on intersection of water column naturally dispersed and dissolved oil with special areas from a subsurface release in winter and summer in the West Orphan Basin and East Orphan Basin (based on a relief well [120-day unmitigated well blowout] scenario) are provided in Tables 15.14 and 15.15, respectively. Refer to Appendix D for data and figures pertaining to the capping stack (30-day unmitigated well blowout) scenarios. The probabilities of oil intersecting with special areas are lower for the unmitigated capping stack scenario than for the unmitigated relief well scenario. Stochastic modelling results for the relief well scenario indicate average probabilities of 50% or more that exceed the 58-ppb in-water THC threshold will reach the following special areas of importance to marine fish as a result of an unmitigated blowout from the West Orphan Basin (refer to Tables 15.14):

- Sackville Spur NAFO VME (up to 99.98% average probability of contact [in winter])
- Northwest Flemish Cap NAFO VME (up to 99.21% average probability of contact [in winter])
- Northern Flemish Cap NAFO VME (up to 91.70% average probability of contact [in winter])
- Northeast Flemish Cap NAFO VME (up to 87.41% average probability of contact [in winter])
- Northeast Newfoundland Slope marine refuge (up to 81.98% average probability of contact [in winter])
- Orphan Spur EBSA (up to 79.21% average probability of contact [in winter])
- Northeast Shelf and Slope EBSA (up to 72.29% average probability of contact [in winter])
- Bonavista Cod Box experimental closure (up to 62.3% average probability of contact [in winter])
- Eastern Flemish Cap NAFO VME (up to 53.65% average probability of contact [in winter])

For these special areas, the average minimum arrival times range from 8 to 42 days, the average maximum exposure times range from 9 to 37 days, and the average of maximum time-averaged[1] dissolved oil concentrations range from 0 to 20 ppb.

It should be noted that the approach for identifying marine special areas potentially at risk from contact with oil entrained in the upper water column is conservative. Some of the special areas may be designated for seabed features (such as pockmarks, trenches, corals etc.) and will therefore not be

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[1] As described in Appendix D, time-averaged statistics are used to produce an average value for a variable. For each simulation, OSCAR monitors each grid cell and records its value unless it has no impact (e.g., no total concentration or no surface oil). At the end of the simulation, these values are averaged to produce the time-average. Whenever thresholds are applied pre-processing, the time-average will also exclude values below these specified thresholds. Maximum time-averaged values can be presented as maps (such as the maximum time-averaged value total concentration). This means that for each grid cell, the value from the simulation with the largest time-average is selected and reported.

directly impacted by oil entrained in the upper water column. Of the special areas identified above, in-water concentrations of total hydrocarbons are an issue of relatively greater concern for those special areas that were designated primarily to protect marine fish (i.e., Orphan Spur EBSA, Northeast Shelf and Slope EBSA, Bonavista Cod Box) and an issue of relatively lower concern for those special areas that were designated primarily to protect benthic habitat (i.e., Sackville Spur NAFO VME, Northwest Flemish Cap NAFO VME, Northern Flemish Cap NAFO VME, Northeast Newfoundland Slope marine refuge, and Eastern Flemish Cap NAFO VME). However, the intersection routines used in the GIS analysis (Appendix D) show all locations where surface oil and oil in the water outputs from oil spill modelling spatially overlap with special areas (designated by latitude and longitude), even when the oil spill outputs are vertically separated from the special area.

For a 120-day unmitigated blowout from the East Orphan Basin, the modelling results indicate that the only special area that would be contacted by in-water THC levels greater than 58 ppb at an average probability of >50% is the Orphan Knoll NAFO VME (54.73%) and this would only occur during the summer. The average minimum arrival time would be 8 days, the average maximum exposure time would be 9 days, and the average of maximum time-averaged dissolved oil concentrations would be 1.4 ppb (refer to Table 15.15).

Models were not run to specifically identify the 200 ppb THC threshold for a change in risk of mortality or physical injury for marine fish; however, Figures 7.28 and 7.39 in Appendix D illustrate the maximum time-averaged concentration of total hydrocarbons (58-ppb concentration threshold applied) based on stochastic models run for West Orphan Basin and East Orphan Basin, respectively. The extent of the 200 ppb contours approximate the areas in which the 200-ppb threshold concentration may be exceeded.

The modelled minimum time for in-water oil concentrations exceeding 58 ppb to arrive at the maximum distance in any direction from the well is between 30 and 50 days (refer to Figures 15.22 and 15.26). As noted in Section 15.3.3, in the event of a well blowout, BP would attempt direct intervention measures to close in the original BOP and, if unsuccessful with BOP intervention, deploy a capping stack. The timing of these intervention measures would reduce the magnitude, duration, and geographic extent of the spill. These activities were not factored into modelling in order to demonstrate the worst-case scenarios of an unmitigated blowout in the West Orphan Basin and in the East Orphan Basin. Exposure time to oil concentrations above 58 ppb is also contingent on spill response time. The predicted durations of exposure to in-water concentrations of oil exceeding 58 ppb around the wellsite are >14 days for all scenarios, while in-water exposure time of one day or less may be expected at the outer extent of the predicted threshold exceedance area (refer to Figures 15.23 and 15.27).

Marine Diesel Spill

Project-specific stochastic modelling for the batch release of diesel was undertaken for unmitigated incidents involving a hose failure (10 bbl surface batch release of diesel) and tank failure (100 bbl surface batch release of diesel). Modelling was conducted for both summer (May to October) and winter (November to April) seasons for both representative wellsite locations (West Orphan Basin and East Orphan Basin). The same effects thresholds that were used for the subsea blowout modelling and assessment are also applicable for the marine diesel spill modelling and assessment.

Stochastic modelling results indicate that diesel spills from the MODU or PSV are likely to result in biological and habitat effects on marine fish over a much smaller area relative to a well blowout scenario. For the 100-bbl surface release scenario, environmental effects related to in-water THC concentrations above 58 ppb would be anticipated to occur over the greatest potential area in the event of a spill during the winter months in the West Orphan Basin, followed by (in descending order of spatial extents for potential areas of threshold exceedance) a spill during the winter months in the East Orphan Basin, a spill during the summer months in the East Orphan Basin, and a spill during the summer months in the West Orphan Basin (refer to Table 8.1 in Appendix D). However, the probabilities of THC exceeding 58 ppb within the top 100 m of the water column are low (<1-5% for the 10-bbl spill scenario and <1-20% for the 100-bbl spill scenario) (refer to Figures 15.33 to 15.36 in Section 15.4.8 and Table 8.1 in Appendix D). The highest probabilities (10% probability contour) of in-water THC exceeding 58 ppb would occur during the winter season, within 2 km^2 of the West Orphan Basin release site or within 4 km^2 of the East Orphan Basin.

Figures 8.17, 8.18, 8.23, and 8.24 in Appendix D show the spatial extents of the maximum time-averaged concentrations of total hydrocarbons (dispersed and dissolved oil) in the top 100 m of water column for the 100-bbl and 10-bbl diesel spill scenarios in the West Orphan Basin and the East Orphan Basin. Only concentration values exceeding the 58 ppb THC threshold were included in the time-average calculations. The time-averaged concentrations do not exceed 0.5 ppb for any scenario or season.

For the 100-bbl spill scenarios in both West Orphan Basin and East Orphan Basin, stochastic modelling results indicate that the duration of exposure to oil in the water column exceeding the 58 ppb THC threshold ranges from 12 to 18 hours in the immediate vicinity of the release location to less than 6 hours at most locations further away (refer to Figures 8.15 and Figure 8.21 in Appendix D).

Based on the Project-specific spill modelling results provided in Appendix D and discussed above, diesel spills from the MODU or a PSV are not likely to result in biological effects on fish over a large area. With respect to a change in habitat quality and use, it is expected that most diesel from a spill from either the MODU or PSV would evaporate and disperse within the first one or two days following the release (refer to Appendix D). This will create a temporary and reversible degradation in habitat quality. Depending on the location and extent of the spill, nearshore spawning and nursery areas could potentially be affected. Diesel is known to have immediate toxic effects on many intertidal (e.g., molluscs, amphipods) and benthic organisms (Stirling 1977; Simpson et al. 1995; Cripps and Shears 1997), with sessile and early life stages (eggs, larvae) the most at risk as they are unable to actively avoid the diesel and/or are during sensitive life-stage development periods. Benthic invertebrates, including commercial species, have experienced sub-lethal effects resulting from low-level exposure to hydrocarbons, with crustaceans being the most sensitive taxa (Sanders et al. 1980; Jewett et al. 1999). However, given the small-scale and short-term nature of the spill, effects on nearshore areas are expected to be limited to a scenario in which marine diesel is spilled from a PSV transiting close to the shore. Oil spill containment and recovery operations will further reduce residual effects on fish and fish habitat associated with total dissolved hydrocarbons.

With respect to a change in risk of mortality or physical injury, although there is a risk of mortality of phytoplankton and zooplankton (food sources), and sub-lethal and lethal effects to larval and juvenile fish species present in the mixed surface layer of the water column, these residual effects will likely be restricted to a localized area. The potential for these effects would also be temporary and reversible. Adult fish species in surface waters will largely be unaffected due to avoidance mechanisms; demersal (bottom dwelling) species are unlikely to be exposed to harmful concentrations of dissolved total hydrocarbons. Residual effects following a nearshore diesel spill from the PSV could include localized mortality and sub-lethal effects to fish eggs, larvae, and juveniles.

The results of deterministic modelling conducted by RPS (2017) in support of Nexen Energy's Flemish Pass Exploration Drilling Project, for a hypothetical release of 750,000 L (6,391 bbl) of diesel from a PSV over 30 days at a location between St. John's and Nexen Energy's project area, indicate that the maximum concentrations of total hydrocarbons at any depth in the water column would exceed 500 ppb within a localized area immediately surrounding the PSV release site (i.e., extending up to approximately 10 km to the south from the release site). Maximum THC levels would decrease to 50-500 ppb within the adjacent surrounding area, extending up to approximately 100 km to the southeast from the release site, and would decrease to less than 50 ppb at distances extending over 300 km to the south and east of the release site. The approximate subsurface volume of THCs exceeding 1 ppb was predicted to be 100 km^3 (RPS 2017). At the end of the 30-day simulation, modelling results indicated that 8-14% of the released volume would remain entrained in the water column, ≤0.01% would adhere to suspended sediment, 63-76% would evaporate into the atmosphere, and 16-45% would degrade (RPS 2017). In the unlikely event of such a spill scenario occurring as a result of a collision involving a Project PSV, response measures (e.g., containment and/or recovery operations) would be initiated in less than 30 days, likely reducing the spatial extent of the spill and associated environmental effects on marine fish and fish habitat.

SBM Spill from the MODU and the Marine Riser

Based on the SBM modelling conducted in EL 1144 for Nexen Energy's Flemish Pass Exploration Drilling Project (Amec 2017), an accidental surface release of SBM would reach the seafloor within a maximum of one kilometer from the drilling site. The maximum spill distance from the drilling site would range from 264 m (in the summer) to 982 m (in the fall), and the maximum spatial extent (footprint) of SBM deposition on the seafloor would range from 7,200 m^2 to 9,000 m^2. The maximum modelled deposition thickness of 7.1 cm, and the average modelled deposition thicknesses ranging from 1.7 cm to 2.2 cm, exceed the 6 mm thickness likely to cause smothering of benthic organisms. The SBM originating from a potential BOP disconnect scenario could contact the seafloor within approximately 40-60 m of the drilling site, resulting in smaller initial footprint, but potentially larger initial SBM layer thicknesses of approximately 23 to 28 cm (Amec 2017).

In consideration of these modelling results, it is conservatively estimated for the Project that a change in risk of mortality or physical injury in the case of an unintended bulk release of SBM would likely be restricted to smothering effects on immotile individuals and benthic prey species within up to approximately 1 km from the spill site.

With respect to a change in habitat quality and use following an SBM spill, it is conservatively predicted that there would likely be a temporary and reversible degradation in habitat quality within up to approximately 1 km from the spill site. As discussed in Section 8.3.3, the acute toxicity of SBM is considered relatively low and would not result in adverse effects from contamination of marine biota or habitats.

Benthic recovery following discharges of drill muds and cuttings in relatively shallow waters has been documented as occurring within as few as approximately one to four years (Bakke et al. 1986, Neff et al. 2000, Hurley and Ellis 2004, Renaud et al. 2008, Bakke et al. 2011, Lee et al. 2011). Although little is known about the timeline for recolonization by benthic communities in deepwater environments, benthic recovery is generally expected to take longer at greater depths and in colder waters due to lower rates of metabolism and growth (Gates and Jones 2012). For slow-growing and long-lived species of large benthic organisms, such as sponges, corals, and crinoids, Clark et al. (2016) estimate that it may take centuries or millennia for benthic communities to recover following large-scale removal of attached epifauna from hard substrates in deepwater environments (e.g., with bottom-contact fishing gear). However, benthic recovery following an accidental spill of SBM is anticipated to take much less time since a spill would not entail the removal of large swathes of attached epifauna. Neff et al. (2000) also note that complete recovery of deepwater benthic animals requires many years because they reproduce and grow slowly, but that this recovery is likely to be initiated shortly after completion of cuttings discharges and is expected to be well advanced within three to five years once the synthetic material has degraded to low concentrations. This is anticipated to also be the case following the deposition of spilled SBM.

Summary

Table 15.16 provides a summary of predicted residual environmental effects of accidental events on marine fish and fish habitat.

Table 15.16 Summary of Residual Project-Related Environmental Effects on Marine Fish and Fish Habitat – Accidental Events

Residual Effect	Residual Environmental Effects Characterization						
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological and Socio-economic Context**
Change in Risk of Mortality or Physical Injury/Change in Habitat Quality and Use							
Well Blowout Incident	A	M-H	RAA*	ST-MT	S	R	D
10 bbl Diesel Spill	A	L	LAA	ST	S	R	D
100 bbl Diesel Spill	A	M	RAA	ST	S	R	D
PSV Diesel Spill	A	M	RAA	ST-MT	S	R	D
SBM Spill	A	L	LAA	ST-LT	S	R	D

KEY:
See Table 8.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High
Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"
Duration:
ST: Short-term
MT: Medium-term
LT: Long-term
Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

15.5.1.4 Determination of Significance

Based on information presented above and a consideration of the significance criteria identified in Section 8.1.5, the predicted residual adverse environmental effects from any of the accidental event scenarios on marine fish and fish habitat is predicted to be not significant. This determination takes into account the conservatism of the spill modelling and assumptions, the use of mitigation measures to prevent and reduce effects from a spill, and the nature of the adverse effects as described in the literature summarized above. This conclusion is made with a high level of confidence for the 10-bbl diesel spill and SBM spill scenarios based on the low magnitude and geographic extent of likely effects. A medium level of confidence is assigned to the 100-bbl diesel spill, PSV diesel spill, and well blowout scenarios given the potential for oil to reach special areas and spawning areas in the Orphan Basin and/or nearshore. However, as noted above, the majority of fish species in the Orphan Basin spawn in a variety of large areas, over long time-scales, and a spill is not predicted to encompass all of these areas or time scales within the RAA to such a degree that natural recruitment of juvenile organisms may not re-establish the population(s) to their original level within one generation. None of the spill scenarios are expected to result in permanent alteration or irreversible loss of critical habitat as defined in a recovery plan or an action strategy.

15.5.2 Marine and Migratory Birds

An estimated 30 million seabirds frequent Atlantic Canadian waters each year, including breeding marine birds and migrating birds from the southern hemisphere and northeastern Atlantic (Fifield et al. 2009). Significant numbers of overwintering birds, including alcids, gulls, and northern fulmars can be found in Atlantic Canadian waters during the fall and winter (Brown 1986, in Fifield et al. 2009). However, the combination of northern hemisphere and southern hemisphere birds results in peak diversity during spring and summer months (Fifield et al. 2009). During summer, seabirds in the RAA are largely concentrated in coastal areas (Fifield et al. 2009) at nesting colonies in globally important numbers of Atlantic puffin, common murre, Leach's storm-petrel, and northern gannet; in continentally important numbers of black-legged kittiwake; and in smaller numbers of other species. Most of these birds forage close to their colonies on pelagic fish that have migrated to shallow waters to spawn. The exception is Leach's storm-petrel, which traverses the continental shelf to forage for its nestlings in deep waters off the shelf. Forage areas for this species include the Orphan Basin, which is the nearest deep-water area to the largest Leach's storm-petrel nesting colony in the world at Baccalieu Island.

There are approximately 19 species of pelagic seabirds, 17 species of neritic seabirds, 24 species of waterfowl, loons, and grebes, and 26 species of shorebirds that regularly occur in the waters of eastern Newfoundland. Neritic seabirds typically feed in shallow coastal waters, returning to land to rest at night, and are therefore infrequent visitors of the offshore Project Area. The presence of these species is highest in summer because some, such as terns, migrate to more southern areas for the winter. Landbirds may occur in the marine environment during migration and can occur in coastal areas at any time of the year.

A total of nine bird SAR / SOCC have the potential to occur in the Project Area and/or RAA (refer to Table 6.12). These species consist of two coastal waterfowl species (harlequin duck and piping plover), three shorebird species (Barrow's goldeneye, red knot, and buff-breasted sandpiper), one phalarope species (red-necked phalarope), two gull species (ivory gull and Ross's gull), and one raptor species (peregrine falcon). Most of these species are protected federally under Schedule 1 of SARA and/or provincially under the NL ESA and are therefore considered SAR. However, buff-breasted sandpiper and red-necked phalarope are considered SOCC.

Many coastal areas in eastern Newfoundland support colonies of breeding seabirds and some bays provide important overwintering and migration habitat. Many of the seabird colonies are located on islands, but some species nest on inaccessible mainland cliffs or on sandy beaches and peninsulas. Some species arrive at the colonies as early as February (black-legged kittiwakes) and March (northern gannet), and egg-laying commences in mid- to late-May and into June. The young of most species depart the colonies by July to August, and as late as November for northern gannets (Amec 2014). Seabirds occurring in the region are generally long-lived with low fecundity, delayed recruitment, and low rates of population growth (Amec 2014). Approximately 3.5 million pairs of marine birds nest at the following seven major colonies in the RAA: Wadham Islands, Funk Island, Cape Freels / Cabot Island, Bonavista Peninsula, Baccalieu Island, Witless Bay Islands, and Mistaken Point (refer to Table 6.9). These colonies are known to support black-legged kittiwakes, herring gulls, great black-backed gulls, ring-billed gulls, Arctic and common terns, common murres, thick-billed murres, razorbills, black guillemots, Atlantic puffins, northern fulmars, Leach's storm-petrels, northern gannets, and great and double-crested cormorants. Leach's storm-petrel is the most numerous breeding seabird in the RAA, with almost 2 million breeding pairs recorded on Baccalieu Island alone (refer to Table 6.9).

Based on the results of an ESRF study conducted in the waters off the coast of eastern Canada between 2006 and 2009, Fifield et al. (2009) identified various "hotspots" as being notably important to one or more species / groups in one or more seasons. The following hotspots overlap all or part of the RAA: the Grand Banks; the Flemish Cap and Pass; the Orphan Basin and Sackville Spur; and the Northeast Newfoundland Shelf. Of these, the hotspot in closest proximity to the nearshore is the coastline along the Northeast Newfoundland Shelf, where some of the largest seabird colonies in the world can be found (e.g., Funk Island and Baccalieu Island). These colonies are associated with large numbers of black-legged kittiwake, gulls, northern gannets, murres, and other alcids that are present on the shelf during the spring and summer. During the winter, this coastline is a hotspot for black-legged kittiwakes, dovekies, gulls, and murres (Fifield et al. 2009). Overall, the Grand Banks was identified as the most important hotspot for seabirds in the ESRF study area, particularly the northeast and southeast portions (including the Nose and Tail of the bank), where high concentrations of a variety of species were found during all seasons (Fifield et al. 2009).

Sections 6.2.5 and 6.4 describe several special areas of importance to marine and migratory birds that are found within the RAA, including 10 coastal IBAs. These IBAs are scattered throughout the nearshore portion of the RAA and have been designated as IBAs for a variety of reasons, including the presence of congregatory species, colonial waterbirds / seabird concentrations, waterfowl concentrations, restricted range species, and threatened species. Seven of the 10 IBAs (Funk Island, Cape Freels Coastline and Cabot Island, Baccalieu Island, Witless Bay Islands, Mistaken Point, Cape Pine and St. Shotts Barren, and Cape St. Mary's) are considered to be globally significant (refer to Section 6.2.5). Based on stochastic modelling results for the well blowout scenarios, it is possible that environmental effects could extend beyond the RAA and affect one additional IBA not listed in Section 6.2.5: Quidi Vidi Lake (NF022). This IBA is located within the city limits of St. John's, Newfoundland. The eastern end of the lake connects to the ocean at the Quidi Vidi Gut. It is globally significant for congregatory species (great black-backed gull and Iceland gull) and nationally significant for colonial waterbird / seabird concentrations (ivory gull and red crossbill) (IBA Canada n.d.).

As described in Section 6.4, several Migratory Bird Sanctuaries, ecological reserves, and EBSAs of importance to marine and migratory birds have also been identified within nearshore and offshore portions of the RAA (refer to Tables 6.15, 6.23, and 6.27). The criteria for selection and ranking of EBSAs includes importance to seabird biodiversity, density, reproduction, and survival (Statoil Canada Ltd. 2017).

Additional details regarding existing conditions for marine and migratory birds are provided in Section 6.2.

15.5.2.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine and migratory birds. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in space and time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

Potential Effects of an Oil Spill on Marine and Migratory Birds

Birds are among the most vulnerable and visible species to be affected by oil spills. Based on available literature, the probability of mortality once oiled is assumed to be 100% for birds. A change in risk of mortality or physical injury for marine and migratory birds exposed to hydrocarbons can occur through three main pathways: external exposure to oil (resulting in coating of oil on feathers); inhalation of particulate oil and volatile hydrocarbons; and ingestion of oil.

External exposure to oil occurs when flying birds land in oil slicks, diving birds surface from beneath oil slicks, and swimming birds swim into slicks. Reported effects vary with species, type of oil, weather conditions, time of year, volume of the spill, and duration of the spill (Gorsline et al. 1981).

Physical alteration of feathers through oiling leads to thermal and buoyancy deficiencies that typically result in death from a combination of heat loss, starvation, and drowning (Leighton 1993). Oiling of feathers can also affect flight, also increasing risk of drowning and starvation (Lee et al. 2015). Issues of thermoregulation are particularly acute if birds are oiled during winter months or during spring or fall migration (Lee et al. 2015).

Diving species, such as black guillemot, murres, Atlantic puffin, dovekie, eiders, long-tailed duck, scoters, mergansers, loons, and grebes, are considered to be the most susceptible to the immediate effects of surface slicks (Leighton et al. 1985; Chardine 1995; Wiese and Ryan 1999; Irons et al. 2000). Other birds, such as northern fulmar, shearwaters, storm-petrels, gulls, phalaropes, and terns, are also vulnerable to contact with oil because they feed over wide areas and make frequent contact with the water's surface, in addition to being vulnerable to the disturbance and habitat damage associated with oil spill clean-up (Lock et al. 1994). Shorebirds and phalaropes may be more affected by oil spills than has been suggested by carcass counts (Larsen and Richardson 1990). This may be due to the higher mobility of oiled shorebirds.

Ingestion of oil as a result of preening or consumption of contaminated food or drinking water can also result in physiological and pathological issues. These long-term physiological changes may eventually result in death (Ainley et al. 1981; Williams 1985; Frink and White 1990; Fry 1990) or decrease long-term survival (Esler et al. 2002). However, the extent of bioaccumulation of the chemical components of oil in birds is limited because vertebrate species are capable of metabolizing them at rates that minimize bioaccumulation (Neff 1985, in Hartung 1995). Assuming the birds are healthy enough after a spill to continue to feed properly, they have the ability to excrete much of the hydrocarbons within a short time period (McEwan and Whitehead 1980).

Nesting seabirds that have survived oil contamination generally exhibit decreased reproductive success (see Hartung 1965; Holmes et al. 1978; Szaro et al. 1978; Vangilder and Peterle 1980; Ainley et al. 1981; Stubblefield et al. 1995). When oiled birds return to nests, they risk exposing eggs to oil and causing high mortality of embryos. Mortality and developmental defects in avian embryos exposed to even small quantities of oil (i.e., 1 to 20 µL) have been documented (Leighton 1993; Lee et al. 2015). Other contributing factors affecting mortality of young include change in prey availability (Velando et al. 2005), and changes in normal parental behaviour (Eppley and Rubega 1990), including abandonment of nests (Butler et al. 1988).

Following the *Exxon Valdez* spill, nearly 30,000 birds were collected, with total mortality estimates ranging from 100,000 to 650,000 birds (reviewed by Day et al. 1997). Almost 10,000 carcasses were collected following the sinking of the tanker *Prestige* off the coast of Spain in 2002, with common murre, Atlantic puffin, and razorbill being most affected (Oropesa et al. 2007). The 1984 blowout incident at the Uniacke G-72 well (near Sable Island) resulted in a spill of 240 m^3 (1,510 bbl) of condensate. A survey of an extensive area around the well after the well was capped (11 days after the blowout incident) observed a total of seven oiled marine birds (three dovekies and four murres), with no obvious oiling of gulls, kittiwakes, or fulmars (Martec Ltd. 1984, in Hurley and Ellis 2004).

The scientific literature is divided with respect to long-term population effects on migratory birds from oil spills. Several studies suggest that oil pollution is unlikely to have major long-term effects on bird productivity or population dynamics (Butler et al. 1988; Boersma et al. 1995; Erikson 1995; Stubblefield et al. 1995; White et al. 1995; Wiens 1995, 1996; Seiser et al. 2000). Conversely, others (Leighton 1993) do show long-term effects of oil pollution on birds (e.g., birds having ingested oil no longer contribute to the reproductive output of a species). These differences can be explained, in part, by varying circumstances of the spill event (acute or chronic exposure, location of spill, time of year) and health of bird populations (Burger 1993; Wiese and Robertson 2004).

An assessment of environmental effects of oil spills in Greenland (Mosbech 2002) concluded that while major oil spills have the potential to deplete bird populations or cause single seabird colonies to be deserted, reports from several spills demonstrate the resiliency of seabird populations to single catastrophic events. It was also concluded that an oil spill can play more of a role where other factors hamper the recovery of the population (e.g., hunting), and the population is small or has a restricted distribution (Mosbech 2002). Similarly, it has been found that population effects are more likely to be realized where spill events involve ongoing exposure (Wiese et al. 2004). For example, and for additional context, it is conservatively estimated that approximately 300,000 seabirds are killed each winter in the waters of Atlantic Canada by chronic operational discharges of oil at sea (e.g., bilge dumping) (Wiese 2002). This estimate was derived based on data collected in 1998-1999 and 2000-2001 which suggested that between 180,000 and 250,000 thick-billed murres, between 25,000 and 40,000 common murres, and between 60,000 and 80,000 dovekies may have been killed each winter by oil in waters off southeastern Newfoundland during that period (Wiese 2002). The annual number of seabirds killed by chronic operational discharges of oil at sea may actually be higher than 300,000, as the estimate only includes the winter months, even though oil pollution also occurs in the summer when small numbers of oiled birds are found on beaches, and the estimate only includes murres and dovekeys, even though other seabird species are also found oiled on beaches (Wiese 2002).

Murphy and Mabee (1999) assessed the effects of the *Exxon Valdez* on the black oystercatcher (*Haematopus bachmani*) population in Prince William Sound almost a decade after the spill. Authors reported that, while sub-lethal effects to the breeding population were evident in post-spill assessments conducted between 1989 and 1993, results from 1998 indicated no oiling effects on nesting effort, breeding phenology, egg volumes, chick growth rates, or chick survival at either a regional or territorial scale. In contrast, Trust et al. (2000) considered the recovery of harlequin duck populations in Prince William Sound from 1995 to 1997 and concluded that chronic exposure to oil and resulting biochemical and physiological changes in individuals were hindering the population recovery of some sea duck species in Prince William Sound. Esler et al. (2002) further concluded that recovery of harlequin duck populations continued to be hindered as many as nine years after the oil spill, postulating that life history characteristics of this species and their benthic, nearshore feeding habits make them susceptible to both initial and long-term oil spill effects.

The use of dispersants during oil spills has been promoted as a means of reducing effects to birds. Dispersants can result in less exposure of marine birds to spilled oil because the major oiling of birds occurs at the surface and the amount of oil that is likely to be taken up by birds while moving through the water column while diving for food is considered small (Peakall et al. 1987). Dispersed oil is less likely to reach nearshore and coastal areas (Kildrufff and Lopez 2012) where birds may congregate (e.g., near breeding colonies) and the use of dispersants has potential to provide an important means of protection where large numbers of over-wintering birds are present and response strategies are limited by ice or other factors (Chapman et al. 2007). Although the use of dispersants has potential to reduce exposure of marine birds to spilled oil, it may cause a short-term increase in exposure to dispersed oil to organisms in the water column, such as corals and shellfish.

There are few studies on the effects of chemically-treated oil on the thermal balance of birds and differing opinions on whether they should be employed to reduce effects on seabirds. However, a review of the effects of oil pollution, chemically treated oil, and cleaning on the thermal balance of birds indicated that the effects of contamination by oil-dispersant mixtures may be similar to that of the oil alone, with results of one study indicating that oil treated with dispersants may be more harmful to birds than untreated oil (Jenssen 1994 and references therein). Dispersant-oil mixtures have been found to reduce the water repellency of plumage and result in water absorption and to increase heat loss and metabolic rate (Lambert et al. 1982; Jenssen and Ekker 1991). For example, Jenssen and Ekker (1991) reported that a much smaller volume of chemically treated crude oil was required to cause adverse effects on plumage insulation and thermoregulation in eiders than crude oil itself. Another study found that ducks exposed to dispersant in water were less buoyant and stayed wet longer than control birds or oil-exposed birds (Lambert et al. 1982). The low tolerance for chemically treated oil may be a result of the surfactants in the dispersants more easily adhering to feathers (possibly by binding to the hydrophobic waxes in the plumage), reducing the surface tension at the feather-water interface and enhancing the effects of contamination on their insulating properties (Jenssen 1994). Dispersants and dispersed oil have also been shown to have toxic effects on bird eggs that are similar or worse than from untreated oil (Jenssen 1994 and references therein).

Hydrocarbon spills can also result in a change in habitat quality and use for marine and migratory birds. Day et al. (1997) examined the effects of the *Exxon Valdez* oil spill on marine bird habitat use, determining that while initial effects were severe, most of the habitat use for most bird species recovered within 2.5 years of the spill. While initial effects to bird habitat were severe, this rate of recovery was attributed to high-latitude seabird populations, which appear to be fairly resilient to environmental perturbations, as well as Prince William Sound being a high wave energy and a largely rocky substrate environment where oil does not persist as long as other settings (Day et al. 1997).

Potential Effects of an SBM Spill on Marine and Migratory Birds

SBM is considered to be of low toxicity (IOGP 2016) and environmental effects are mostly restricted to physical smothering effects on the sea floor. A release of SBM would result in elevated levels of TSS in the water column and possibly a small thin sheen on the surface, with effects potentially similar to those discussed above for hydrocarbon spills, but more limited in magnitude given the comparative volume and physical property of the SBM. O’Hara and Morandin (2010) investigated the effects of thin oil sheens associated with both crude oil and synthetic-based drilling fluids on the feathers of pelagic seabirds (common murre and dovekie) and found that feather weight and microstructure changed substantially for both species after exposure to thin sheens of both hydrocarbons, concluding a plausible link between even operational discharges of hydrocarbons and increased seabird mortality.

15.5.2.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. Refer to Section 15.1 for information on BP’s approach to risk management, Section 2.5 for specific information on well control and blowout prevention, and Section 15.3 for a description of BP’s contingency planning and emergency response measures.

As noted in Section 15.3.1, the Project will operate under an IMP which will include contingency plans for responding to specific emergency events, including potential spill or well control events. The IMP and supporting specific contingency plans, such as a SRP, will be submitted to the C-NLOPB prior to the start of any drilling activity as part of the OA process. The SRP will specify tactical response methods, procedures and strategies for safely responding to different spill scenarios. Tactical response methods that will be considered following a spill incident include, but are not limited to: offshore containment and recovery; surveillance and tracking; dispersant application (surface and subsea injection); in-situ burning; shoreline protection; shoreline clean-up; and oiled wildlife response. Refer to Section 15.3 for details regarding incident management and spill response.

BP will undertake a SIMA / NEBA as part of the OA process with the C-NLOPB. The SIMA is a structured process that will qualitatively evaluate the risks and trade-offs of all feasible and effective response options, when compared to no action. The SIMA process will inform the selection of an overall spill response strategy for the Project. If identified as a preferred response option, use of chemical dispersants would not occur without first obtaining regulatory approval.

Of particular relevance to marine and migratory birds are the commitments related to shoreline protection and clean-up, and oiled wildlife response (refer to Sections 15.3.3.3.5 to 15.3.3.3.7). In the event that oil threatens or reaches the shoreline, shoreline protection measures, including deflection from sensitive areas, will be implemented as practical. SCAT teams will be mobilized to the affected areas to conduct shoreline surveys to document the type and degree of any shoreline oiling and inform shoreline clean-up and remediation as applicable. SCAT teams will also be used to monitor and evaluate the effectiveness of the clean-up operations.

BP will develop a Wildlife Response Plan and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed (refer to Section 15.3.3.3 for BP's oiled wildlife response approach).

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

15.5.2.3 Characterization of Residual Project-Related Environmental Effects

Subsea Blowout

A subsea blowout has potential to result in a change in risk of mortality or physical injury and change in habitat quality and use for marine and migratory birds. Two thresholds were established to assess the effects to migratory birds. These thresholds are based on the predominant habitats of seabirds (open water) and shorebirds (shorelines). Although potential for direct effects on nesting habitat is possible, there is greater potential for direct effects on foraging habitat at sea. A threshold concentration for lethal effects to seabirds is the open water area covered by an oil plume greater than 10 µm thick (>10 g/m^2) (French et al. 1996; French-McCay and Rowe 2004; French-McCay 2009). For shorebirds (and other wildlife) on or along the shore, an exposure index is length of shoreline oiled by 100 µm thick (>100 g/m^2) emulsion (French-McCay 2009). Emulsion thickness of 100 µm thickness would be characterized as "light oiling". However, a more conservative threshold of 0.04 µm emulsion thickness (visible sheen) was used in the modelling in recognition of potential socio-economic effects on fisheries (refer to Table 15.9). A surface oil thickness of 0.04 µm is also conservatively used in this assessment as the threshold for a change in habitat quality and use for marine and migratory birds.

With respect to a change in risk of mortality or physical injury, exposure to hydrocarbons frequently leads to hypothermia and deaths of affected marine birds. Although some may survive these immediate effects, long-term physiological changes may eventually result in lower reproductive rates or premature death. Sub-lethal effects of hydrocarbons ingested by marine birds may affect their reproductive rates or survival rates (Fingas 2015). Sub-lethal effects may persist for a number of years, depending upon generation times of affected species and the persistence of any spilled hydrocarbons. Most marine birds are relatively long-lived. Adult marine birds foraging offshore to provision their young may become oiled and bring hydrocarbons on their plumage back to the nest to contaminate their eggs or nestlings, causing embryo or nestling mortality. It is generally agreed that the survival rate for oiled birds is very low, regardless of rescue and cleaning attempts (French-McCay 2009). The probability of lethal effects to birds is therefore primarily dependent on the probability of exposure, which is influenced by behaviour, including the percentage of the time an animal spends on the water or shoreline as well as any oil avoidance behaviour (French-McCay 2009). Table 15.17 indicates the combined probabilities of oiling and mortality once oiled for various generic behaviour categories.

Table 15.17 Combined Probability of Encounter with Oil and Mortality Once Oiled for Generic Behaviour Categories (If Present in the Habitats Listed and Area Swept by Oil Exceeding Threshold Thickness)[1]

Wildlife Group	Probability	Habitats[2]
Surface birds in seaward habitats only	99%	All seaward intertidal and subtidal
Surface diving birds in seaward habitats only	35%	All seaward intertidal and subtidal
Aerial divers in seaward habitats only	5%	All seaward intertidal and subtidal
Surface birds in landward habitats only	99%	All landward intertidal and waters
Surface diving birds in landward habitats only	35%	All landward intertidal and waters
Aerial divers in landward habitats only	5%	All landward intertidal and waters
Surface diving birds in water habitats only	35%	All waters
Aerial divers in water only	5%	All waters

Source: Modified from French-McCay 2009

Note:

[1] If diameter of the spill is less than 230 m in diameter a thickness of 100 μm is assumed as threshold thickness for oiling mortality of wildlife. If the spill is less than 230 m in diameter 10 μm is assumed as a threshold thickness for oiling mortality.

[2] Intertidal includes all between-tide or terrestrial areas flooded by tides or by storm surges; seaward and landward designations are operationally defined for the area modelled.

With respect to a change in habitat quality and use for migratory birds, hydrocarbon spills are not likely to permanently alter the quality of marine bird habitat. Prey availability may be reduced or migratory birds may avoid affected habitat. However, spill cleanup and natural weathering processes are likely to result in the eventual recovery of such habitat. Following the 1989 *Exxon Valdez* oil spill, in Prince William Sound, recovery of marine bird abundance and use of oiled shorelines sites back to estimated (naturally variable) baseline levels, was reported to occur for all species surveyed within 12 years (Wiens et al. 2004). On oiled rocky and open coast soft-sediment shorelines, the recovery of sessile, mobile, and infaunal invertebrate species, which provide an important food source for marine birds, is expected to occur within five to ten years following shoreline oiling (Moore 2006). The recovery rate for sand beaches is variable, depending on conditions and initial disturbance during spill response, but is estimated to occur within three years (French-McCay 2009).

Following a continuous, 120-day unmitigated blowout from a representative wellsite in the West Orphan Basin or the East Orphan Basin, stochastic modelling results indicate that the geographic extent of a residual change in habitat quality and use for marine and migratory birds (using surface oiling with an emulsified oil thickness of 0.04 μm as an effect threshold) could spread beyond the RAA. Environmental effects related to surface oiling at thicknesses above 0.04 μm would be anticipated to occur over the greatest potential area in the event of a blowout during the winter season in the West Orphan Basin, followed by (in descending order of spatial extents for potential areas of threshold exceedance), a blowout during the winter season in the East Orphan Basin, a blowout during the summer season in the West Orphan Basin, and a blowout during the summer in the East Orphan Basin (refer to Table 7.1 in Appendix D).

Seabird colonies, IBAs, Migratory Bird Sanctuaries, EBSAs, and ecological reserves of importance to marine and migratory birds along the coast (including small coastal islands) could potentially be affected by nearshore surface oiling and/or shoreline stranding of oil from an unmitigated well blowout.

The stochastic modelling results for West Orphan Basin indicate a higher potential for surface oil contamination to the south and east of Newfoundland and east of Nova Scotia during winter months (Figure 15.9). As noted in Section 15.4.7.1 and Appendix D, the probability of sea surface oil contact exceeding the 0.04 µm thickness threshold in nearshore waters of the Avalon Peninsula would be 0% during the summer season but would increase to 5% in the winter months. In the event that surface oil enters the nearshore area of Newfoundland during the winter season, it would take a minimum of 50 days to arrive. The duration of surface exposure for nearshore waters of Newfoundland would be 0 to 1 day. Exposure times increase on approaching the West Orphan Basin release site. For East Orphan Basin, the stochastic modelling results for the worst exposure scenario indicate a 1% probability of surface oil being present in the near-coastal waters of the Avalon Peninsula during the winter months. It would take a minimum of 70 days to arrive and the duration of surface exposure would be less than one day.

As indicated on Figures 15.17 to 15.20, there are several coastline areas (including those outside of the RAA) that could potentially be exposed to shoreline oiling above the 1 g/m^2 threshold. However, as described in Section 15.4.7.1, shoreline contact is unlikely from releases at either the West Orphan Basin or East Orphan Basin sites (refer to Figures 15.17 and 15.19). The highest shoreline contact probabilities occurred for the West Orphan relief well scenario during the winter months, with 31 km of coastline potentially at risk from contact probabilities of 5% to 7% (refer to Figure 15.17). The predicted maximum amount of oil accumulating on the shoreline was approximately 400 tonnes with peak oiling occurring between 90 and 120 days. This amount of oil represents 0.04% of the total amount of oil released. However, there was a wide range in the maximum amount of oil accumulated on the shoreline, with no stranded oil occurring in 72% of the simulations and less than 1 tonne beaching in 85% of the cases during the winter season. The maximum length of coastline potentially at risk from stranded oil exceeding the minimum film or sheen thickness threshold of 1 µm (1 g/m^2) was 270 km (refer to Table 7.1 in Appendix D).

Given that the earliest arrival times for shoreline oiling (i.e., arrival of stranded oil exceeding the minimum film or sheen thickness threshold of 1 µm [1 g/m^2]) ranged from 27 to 145 days for the West Orphan Basin and East Orphan Basin relief well scenarios where beaching of oil occurred (refer to Figures 15.18 and 15.20), the length of time required for oil to potentially reach these areas would allow for response measures and containment equipment to be placed in advance to avoid or mitigate adverse effects. As noted above, a threshold of 100 µm is used as an exposure index for mortality of shorebirds on the shore; therefore, this would provide additional response time to intervene prior to shoreline emulsion reaching levels predicted to result in shorebird mortality. However, response measures could potentially result in disruption of nesting birds and reproductive failure.

Tables 15.10 and 15.11 summarize predicted intersection of surface oiling with special areas from a subsurface release in winter and summer in the West Orphan Basin and East Orphan Basin, respectively, Information on stranded oil contact with special areas along the shoreline in winter (there is no shoreline contact in summer in the West Orphan Basin and East Orphan Basin) are provided in Tables 15.12 and

15.13, respectively. All of these results represent a relief well (120-day unmitigated well blowout) scenario. Refer to Appendix D for data and figures pertaining to the capping stack (30-day unmitigated well blowout) scenarios.

Stochastic modelling results for the relief well scenario indicate that the highest average probability of surface oil thicknesses of 0.04 µm or more reaching special areas of importance for marine and migratory birds as a result of an unmitigated blowout from either wellsite is 30% (from the West Orphan Basin). This 30% probability is applicable for surface oiling of the Southwest Shelf Edge and Slope EBSA, which is critical to a wide variety of seabirds and supports the highest density of pelagic seabird feeding within the PB / GB IMA (refer to Table 6.25). For surface oil to intersect with this special area, the average minimum arrival time would be 60 days, the average maximum exposure time would be 5 days, and the average time-averaged BAOAC thickness would be "rainbow" (refer to Table 15.10).

With respect to shoreline oiling, stochastic modelling indicates that the highest average probability that emulsified oil with thicknesses exceeding 1 µm could intersect the shoreline of special area of importance for marine and migratory birds from an unmitigated blowout from either wellsite is 3.4% (from the West Orphan Basin during the winter). This 3.4% probability is applicable for shoreline of the Cape Pine and St. Shotts Barren IBA, which is considered globally significant for congregatory species. For shoreline oiling to intersect with this special area, the average minimum arrival time would be 73 days and the average degree of oiling would be light (refer to Table 15.12). This probability is quite low; however, in the unlikely event of such a blowout, the minimum arrival time would be long enough to allow BP to implement mitigation (including emergency response measures such as containment and recovery operations) to reduce potential residual effects.

The probabilities of oil intersecting with special areas are lower for the unmitigated capping stack scenario than for the unmitigated relief well scenario. No shoreline contact was predicted for the West Orphan and East Orphan capping stack scenarios during the summer seasons with maximum probabilities of 1% to 2% for the capping stack winter scenarios and the West Orphan relief well summer scenarios.

The East Orphan relief well, winter scenario gave rise to the second highest amount of accumulated oil on the shoreline (270 tonnes) with potentially 205 km of coastline at risk from stranded oil film or sheen thicknesses greater than 1 µm (1 g/m²). Peak oiling occurred between 30 and 60 days, but with no stranded oil occurring in 86% of the simulations and less than 1 tonne beaching in 88% of the cases. This scenario also produced the earliest arrival time of oil to shore (27 days) of all the scenarios modelled.

Deterministic models were not run to specifically identify the 10 µm threshold thickness for lethal effects to marine and migratory birds at sea; however, Figures 7.7 and 7.17 in Appendix D illustrate the maximum time-averaged emulsified oil thicknesses on the sea surface (0.04 µm BAOAC "sheen" thickness threshold applied) based on stochastic models run for West Orphan Basin and East Orphan Basin, respectively. The extents of the 5 to 50 µm BAOAC "metallic" thickness contours approximate the areas in which the 10 µm threshold coverage may be exceeded.

As described in Section 15.4.7.2, far-field deterministic modelling results for the West Orphan "worst" shoreline oiling simulation, for the winter season, indicated that at the end of the simulation (after 160 days), 36% of the oil released is biodegraded, 27% is evaporated, 0.19% is on the surface, and 34% is in the water column and dispersed to negligible concentrations (<58 ppb THC). Shoreline oiling exceeding the 1.0 g/m² threshold level is expected to be limited to the Avalon Peninsula, where there would be occurrences of moderate oiling (1-10 mm [or 1,000-10,000 μm]), light oiling (0.1-1 mm [or 100-1,000 μm]), and stain oiling (0.01-0.1 mm [or 10-100 μm]) of the shoreline. The maximum length of shoreline to be affected would be 20 km, and this would occur after 119 days. The maximum mass of oil on the shoreline would occur slightly earlier (after 107 days) and be associated with the accumulation of 403 tonnes of oil on the shoreline.

Far-field deterministic modelling results for the East Orphan “worst” shoreline oiling simulation, for the winter season, indicated that at the end of the simulation (after 160 days), 46% of the oil released is biodegraded 37% evaporated, 0.65% is reported on the surface and 25% in the water column; with that remaining in the water column dispersed to negligible concentrations (<58 ppb THC dispersed oil). Shoreline oiling exceeding the 0.04 μm threshold level is also expected to be limited to the Avalon Peninsula with occurrences of light and stain oiling. The maximum length of shoreline impacted would occur after 132 days with 27 km of coastline being affected. The maximum mass of oil on the shoreline occurs slightly earlier (after 98 days) and is associated with 271 tonnes of oil accumulated on the shoreline.

The implementation of mitigation measures would reduce the probabilities of oil extending beyond the RAA or reaching nearshore areas, shorelines, or special areas. In the unlikely event of an actual subsea blowout, mitigation (including emergency response measures such as containment and recovery operations) would be implemented well before 120 days elapse. As noted in Section 15.3.3, in the event of a well blowout, BP would attempt direct intervention measures to close the original BOP and, if unsuccessful with BOP intervention, deploy a capping stack. The timing of these intervention measures would reduce the magnitude, duration, and geographic extent of the spill and associated residual environmental effects.

Marine Diesel Spill

A batch diesel spill or vessel spill has the potential to result in a change in risk of mortality or physical injury and change in habitat quality and use for marine and migratory birds. As noted above, two thresholds were established to assess the effects to migratory birds. A threshold concentration for lethal effects to seabirds is the open water area covered by an oil plume greater than 10 μm thick (>10 g/m^2). For shorebirds (and other wildlife) on or along the shore, an exposure index is length of shoreline oiled by 100 μm thick (>100 g/m^2) emulsion.

Stochastic modelling for the batch release of diesel was undertaken for unmitigated incidents involving a hose failure (10 bbl surface batch release of diesel) and tank failure (100 bbl surface batch release of diesel). Modelling was conducted for both summer (May to October) and winter (November to April) seasons for both wellsite locations (West Orphan Basin and East Orphan Basin). The same 0.04 μm surface emulsion thickness threshold that was used for the subsea blowout modelling is also applicable for the marine diesel spill modelling.

Stochastic modelling results indicate that diesel spills from the MODU or PSV are likely to result in biological and habitat effects on marine and migratory birds over a much smaller area relative to a well blowout scenario. For the 100-bbl surface release scenario, environmental effects related to emulsified oil thickness on the sea surface exceeding 0.04 µm would be anticipated to occur over the greatest area in the event of a spill during the summer months in the West Orphan Basin, followed by (in descending order of spatial extents for potential areas of threshold exceedance) a spill during the summer months in the East Orphan Basin, a spill during the winter months in the West Orphan Basin, and a spill during the winter months in the East Orphan Basin. However, the probabilities of emulsified oil thicknesses exceeding 0.04 µm on the sea surface are low (<1-10% for the 10-bbl spill scenario and <1-20% for the 100-bbl spill scenario) (refer to Figures 15.29 to 15.32 in Section 15.4.8 and Table 8.1 in Appendix D).

Figures 8.5, 8.6, 8.11, and 8.12 in Appendix D show the spatial extents of the maximum time-averaged emulsified oil thicknesses on the sea surface for the 100-bbl and 10-bbl diesel spill scenarios in the West Orphan Basin and the East Orphan Basin. Only oil thicknesses exceeding the 0.04 µm threshold were included in the time-average calculations. The time-averaged thicknesses are primarily 5 µm (BAOAC "rainbow" thickness) or less, but reach as high 50 µm (BAOAC "metallic" thickness) in some areas. The extents of the metallic thickness contours approximate the areas in which the 10 µm threshold coverage may be exceeded.

For the 100-bbl spill scenarios in both West Orphan Basin and East Orphan Basin, modelling results indicate that the duration of exposure to surface oil exceeding 0.04 µm in thickness ranges from 12 to 18 hours in the immediate vicinity of the release location to less than 6 hours at the majority of locations further away (refer to Figures 8.3 and Figure 8.9 in Appendix D). Deterministic simulations indicate that approximately 60% of the spill evaporates from the surface within three days following the release, with remaining proportions dispersing or biodegrading within the same period. Deterministic modelling results for the West Orphan Basin also indicate an initial transient surface oil coverage of 27 km^2 (for a 100-bbl diesel spill) and 1.5 km^2 (for a 10-bbl diesel spill) which thereafter decreases rapidly as the diesel evaporates and biodegrades. Similar trends were observed for the East Orphan Basin scenarios. A diesel spill from a PSV operating in the nearshore would be expected to behave similarly.

With respect to a change in habitat quality and use, the majority of diesel from a spill from either the MODU or PSV will evaporate and disperse within the first three days following the release (refer to Appendix D). The maximum exposure time for oil on the surface with a thickness greater than 0.04 µm is less than one day. As a result, this will create a temporary and reversible degradation in habitat quality. Depending on the location and extent of the spill, it could directly and indirectly reduce the amount of habitat available to marine and migratory birds at sea. In the event of a vessel spill in the nearshore area, there is the potential for shoreline to be affected by a diesel spill. When diesel spills interact with the shoreline, it tends to penetrate porous sediments quickly and washes off quickly by waves and tidal flushing (NOAA 2016). These effects would be short-term in duration until the slick disperses and the diesel content in the area reaches background levels. A batch spill of diesel is not expected to create permanent or irreversible changes to habitat quality and use.

With respect to change in risk of mortality or physical injury for marine and migratory birds, the accidental release of diesel fuel has the potential to affect migratory birds through direct contact, although it is predicted that the number of birds affected would be limited due to the short time and small area where the diesel would be on the water's surface. Mortality can be caused by ingestion during preening as well as through hypothermia due to matted feathers (NOAA 2016). Some birds may survive the immediate effects of contact with diesel, although there is the potential for long-term physiological changes resulting in lower reproductive rates or premature death. Migratory birds foraging at sea have the potential to become oiled and bring hydrocarbons back to their nest, contaminating their eggs or nestlings, thereby causing embryo or nesting mortality.

The results of deterministic modelling conducted in support of Nexen Energy's Flemish Pass Exploration Drilling Project, for a hypothetical release of 750,000 L (6,391 bbl) of diesel from a PSV over 30 days at a location between St. John's and Nexen Energy's project area, indicate that the release would be predicted to result in patchy and discontinuous surface sheens, although the large release volume would likely result in a rainbow sheen for approximately 40 km before transitioning to a colourless and silver sheen (RPS 2017). The predicted exposure area for surface oil from the vessel collision was 925 km^2 for the lower 0.04 μm threshold for a change in habitat quality and use and 13 km^2 for the higher 10 μm threshold for a change in risk of mortality or physical injury for seabirds in open water areas (Nexen Energy 2018). The 750,000-L spill was predicted to result in more extensive surface oiling and a smaller percentage of oil evaporation in comparison with the smaller (100-L and 1,000-L) batch spills that were modelled for the Nexen project (Nexen Energy 2018). At the end of the 30-day simulation, only <0.1% of the released volume was predicted to remain floating on the water surface and 0% was predicted to contact the shore. For the remaining released volume, modelling results indicated that 63-76% would evaporate into the atmosphere, 8-14% would remain entrained in the water column, ≤0.01% would adhere to suspended sediment, and 16-45% would degrade (RPS 2017). In the unlikely event of such a spill scenario occurring as a result of a collision involving a Project PSV, response measures (e.g., containment and/or recovery operations) would be initiated in less than 30 days, likely reducing the spatial extent of the spill and associated environmental effects on marine and migratory birds.

SBM Spill from the MODU and the Marine Riser

Although unlikely. there is potential for a SBM spill to result in a surface sheen which in turn could potentially cause a change in risk of mortality or physical injury and change in habitat quality and use for seabirds present in the immediate area. If the wind and wave conditions were such that a sheen formed, it would be temporary and limited in size, such that only birds in the immediate area of the spill would likely be affected. Given the low surface oil thickness required to result in a sheen (0.04 μm), it is expected that effects would be minor and unlikely to result in seabird mortality.

Summary

Table 15.18 provides a summary of predicted residual environmental effects of accidental events on migratory birds.

Table 15.18 Summary of Residual Project-Related Environmental Effects on Migratory Birds – Accidental Events

Residual Effect	Residual Environmental Effects Characterization						
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Risk of Mortality or Physical Injury and Habitat Quality and Use							
Well Blowout Incident	A	H	RAA*	ST-MT	S	R	D
10 bbl Diesel Spill	A	L	LAA	ST	S	R	D
100 bbl Diesel Spill	A	M	RAA	ST	S	R	D
PSV Diesel Spill	A	M	RAA	ST-MT	S	R	D
SBM Spill	A	L	LAA	ST	S	R	D

KEY:
See Table 9.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"
Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

15.5.2.4 Determination of Significance

Based on the characterization of residual effects above, a precautionary conclusion is drawn that the residual adverse environmental effect of a blowout incident, large batch spill, or vessel spill is predicted to be significant for marine and migratory birds, but not likely to occur. Infrequent small spills, as well as a SBM release, would be not significant.

Although hydrocarbon spills could result in some mortality at the individual level, these residual adverse environmental effects are predicted to be reversible at the population level. However, these environmental effects could be significant if the consequences carried over more than one generation according to the significance threshold used in this environmental assessment or self-sustaining population objectives or recovery goals for listed species are jeopardized. Again, this is considered unlikely given the low probability of a large spill event to occur and the response that would be in place to reduce the consequences of such an event.

A medium level of confidence is assigned to the significance determination for all accident scenarios, with the exception of a blowout incident (which is made with high confidence), as the significance is based on a worst-case credible scenario, with the actual significance influenced by a number of factors such as volume spilled, duration, location, season, presence of birds, and effectiveness of mitigation.

15.5.3 Marine Mammals and Sea Turtles

There are six species of mysticetes (baleen whales), 13 species of odontocetes (toothed whales), five species of phocids (seals), and four species of sea turtles that could potentially be present in the Project Area and/or surrounding RAA. These include five marine mammal SAR (North Atlantic right whale, blue whale [Atlantic population], and northern bottlenose whale [Scotian Shelf population], fin whale, and Sowerby's beaked whale), two sea turtle SAR (leatherback sea turtle and loggerhead sea turtle), and three marine mammal SOCC (humpback whale, killer whale, and habour porpoise) (refer to Tables 6.16 and 6.18). The potential occurrence of these marine mammal and sea turtle SAR in the Project Area is considered rare to uncommon. However, an accidental release of oil or SBM could extend outside of the Project Area to affect SAR, SOCC, and secure species in the larger RAA.

Many of the marine mammal and sea turtle species that could occur in the RAA have potential to be present year-round but are most likely to occur from late spring or summer through fall, which is also the period when most migratory marine mammal and sea turtle species frequent the area. Exceptions to this include harp seal and hooded seal, which may be present year-round but mostly from winter to spring; ringed seal, which are seasonally present from winter to spring; and leatherback sea turtle, which are seasonally present from April to December.

The species of marine mammals and sea turtles most likely to be found in coastal habitats within the RAA are: North Atlantic right whale, humpback whale, minke whale, blue whale, Atlantic white-sided dolphin, common bottlenose dolphin, killer whale, harbour porpoise, grey seal, ringed seal, and bearded seal.

Sections 6.1.10 and 6.4 describe several special areas of importance to marine mammals and sea turtles that are found within the RAA, including nearshore and offshore areas. Additional details regarding existing conditions for marine mammals and sea turtles are provided in Section 6.3.

15.5.3.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in risk of mortality or physical injury and/or a change in habitat quality and use for marine mammals and sea turtles. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

Potential Effects of an Oil Spill on Marine Mammals

The effects of oil on marine mammals and sea turtles depend on the extent of exposure to toxic components of oil. Exposure may be derived from external coatings of oil (e.g., interaction with surface slicks when animals surface for air, clogging of baleen plates), inhalation of aerosols of particulate oil and hydrocarbons, and ingestion of contaminated prey (Lee et al. 2015). French–McCay (2009) describes biological effects associated with oil spills. Wildlife individuals that move through the area swept by floating oil (e.g., slicks, emulsions, or other floating forms such as tar balls) are assumed to be oiled based on probability of encounter and those oiled above a threshold dose are assumed to die. Based on available scientific data, a combined probability of oil encounter and mortality once oiled assumed for species groups, if present in the area swept by oil exceeding a threshold thickness of 10 µm (for spills larger than 230 m in diameter), was 0.1% for cetaceans and 75% for fur-bearing marine mammals (e.g., seals).

Several studies have demonstrated varying results on the ability of marine mammals to detect and/or avoid oil-contaminated waters (Engelhardt 1983; St. Aubin et al. 1985; Smultea and Würsig 1995; Ackleh et al. 2012). Several species of cetaceans and seals have been documented behaving normally in the presence of oil (St. Aubin 1990; Harvey and Dahlheim 1994; Matkin et al. 1994). It is possible that cetaceans swim through oil because of an overriding behavioural motivation (e.g., feeding). Some evidence exists that dolphins attempt to minimize contact with surface oil by decreasing their respiration rate and increasing dive duration (Smultea and Würsig 1995).

Other studies document examples of individuals avoiding surface slicks. Aerial surveys conducted offshore Atlantic Canada between 1979 and 1982 monitored the presence of individuals near small oil slicks, noting some individuals swimming near surface oil but rarely within surface slicks (Sorensen et al. 1984).

In some cases, marine mammals may avoid an affected area beyond the detected slick. Based on a comparison of sperm whale acoustic activity from pre-spill (2007) and post-spill (2010 Deepwater Horizon oil spill) conditions, Ackleh et al. (2012) noted that sperm whales may have relocated out of the areas with a high concentration of oil and pollutants (possible shortages of food) and increased boat traffic (and therefore increased anthropogenic noise).

Humpback whales may have shown temporary avoidance during the 1989 *Exxon Valdez* spill in Prince William Sound, Alaska (von Ziegesar et al. 1994), although another study noted that killer whales were observed swimming through surface oil within 24 hours of the spill (Matkin et al. 2008).

Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982). Species like the humpback whale, right whale, beluga, and harbour porpoise that feed in restricted areas may be at greater risk of ingesting oil (Würsig 1990). Hydrocarbons consumed through eating contaminated prey can be metabolized and readily excreted, but some is stored in blubber and other fat deposits (Lee et al. 2015). Absorbed oil can cause toxic effects such as minor kidney, liver, and brain lesions (Geraci and Smith 1976; Geraci 1990; Spraker et al. 1994). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982).

In baleen whales, crude oil could coat the baleen plates and reduce filtration efficiency, but these effects are considered reversible (Geraci 1990). Geraci (1990) noted that adverse effects on cetaceans, such as sickness, stranding or mortality, tended to be associated with crude or bunker C oil. Most marine mammals can withstand some oiling without toxic or hypothermic effects. Whales and seals use blubber to maintain core body temperature, which is not affected by a covering of oil. Hypothermia is possible, such as if a young seal pup is covered in oil because it takes several months to build up a blubber layer sufficient to maintain body heat.

Direct contact with oil can cause fouling in fur-bearing marine mammals such as seals, reducing thermoregulation abilities (Kooyman et al. 1977) and potentially causing similar effects as those associated with thermoregulatory failure in birds (Lee et al. 2015) (refer to Section 15.5.2). Following the *Exxon Valdez* spill, harbour seals were observed swimming through and surfacing in floating oil while feeding and moving to and from haul-out sites (Lowry et al. 1994). Oil fouling might affect seal locomotion, with heavy oiling causing flippers to stick to the body. Contact with oil also reduces the insulative value of hair, but in healthy seals this is not likely to be a major problem since they rely primarily on blubber for insulation; thus, the risk of hypothermia may be offset somewhat by thick layers of blubber (Lee et al. 2015). Seals became cleaner over time if they were not repeatedly exposed to oil. Various types of skin lesions in harbour seals were probably caused by crude oil. Examination of dead, oiled seals suggested lesions may have been related to inhalation of toxic fumes and mortality could have resulted from behavioural disorientation, lethargy and stress response (Ott et al. 2001).

Monitoring studies of marine mammals following oil spill events in different parts of the world have demonstrated evidence implicating oil spills with the mortality of cetaceans. Sea otters, harbour seals, Stellar sea lions, killer whales, and humpback whales were most affected by the *Exxon Valdez* oil spill (Lee et al. 2015). Continued monitoring over 16 years after the spill indicates a measurable decrease and lack of recovery in the population size of a fish-eating killer whale pod using the area affected by the spill (Dahlheim and Matkin 1994; Matkin et al. 2008). Continued monitoring over 16 years indicates that the killer whale pod had still not returned to its pre-spill population abundance, and the population's rate of increase was substantially less than other fish-eating pods in the area (Matkin et al. 2008). More recently, Matkin's conclusion that the killer whale deaths could be attributed to the *Exxon Valdez* spill has been challenged by Fraker (2013), who argues that there is not a clear and plausible connection given other factors (including frequency of bullet wounds) that might have factored into the documented mortalities.

Also following the *Exxon Valdez* spill, five harbour porpoises were found dead in Prince William Sound. While three autopsied animals showed elevated levels of hydrocarbons in blubber and liver tissues, the levels of assimilated oil were not high enough to determine with certainty that the animals died from exposure to crude oil (Dalheim and Matkin 1994). The deaths might have been the result of a combination of factors, including acute toxicity of crude oil, starvation due to chronic respiratory damage, increased energy expenditure from epidermal fouling, reduced prey abundance and increased susceptibility to parasitism or disease (Albers and Loughlin 2003; Lee et al. 2015).

Following the Deepwater Horizon oil spill in the Gulf, a total of 171 dolphins and whales were collected from April 30, 2010 to February 15, 2011, either from stranding or directed capture in the open water (NOAA 2014a). Of these, 153 were collected dead, with almost 90% of individuals being bottlenose dolphins. Of the 109 marine mammals collected as of November 10, 2010, only six individuals were visibly oiled (NOAA 2010). The low estimated carcass recovery rates of cetaceans (as low as 2%) after the Deepwater Horizon oil spill (Williams et al. 2011) limits the statistical validity of proposed cause-effect relationships. This is one example of why it has historically been challenging to link oil exposure to acute and chronic effects in marine mammals (Lee et al. 2015).

Potential Effects of an Oil Spill on Sea Turtles

It is unknown if sea turtles are able to detect oil spills, but evidence suggests that they do not avoid oil at sea (Milton et al. 2010). Gramentz (1988) reported that sea turtles did not avoid oil at sea, and sea turtles experimentally exposed to oil showed a limited ability to avoid oil (Vargo et al. 1986) or petroleum fumes (Milton et al. 2010). Exposure pathways for effects on sea turtles are similar to those of marine mammals: external coatings of oil (e.g., interaction with surface slicks when animals surface for air); inhalation of aerosols of particulate oil and hydrocarbons; and ingestion of contaminated prey.

French-McCay (2009) assumes a combined probability of oil encounter and mortality once oiled of 5% for juvenile and adult sea turtles and 50% for hatchling sea turtles. This is based on a moderate to high short-term survival rate if oiling occurs as indicated by the literature (Vargo et al. 1986), but also taking into consideration that there are few definitive data regarding the long-term effects of oil on reptiles. Hatchlings are particularly vulnerable since they spend most of their in-water time at the surface, and their size and anatomy (and weaker mobility) increases their susceptibility to passing oil and suffocating as a result of this exposure. Once oiled, hatchlings may not be able to swim as well, thereby increasing their predation risk. French-McCay (2009) acknowledges that the likely range of probability for oiling and dying of hatchlings is 10 to 100%, but uses 50% as a best estimate. Compared to hatchlings, juveniles and adults spend less time at the sea surface, which may reduce their exposure to smaller oil slicks. The data on hatchlings is provided for context, although is less relevant in this case given the absence of sea turtle hatchlings in Atlantic Canada waters.

In addition to surface oiling, sea turtles are particularly vulnerable to prolonged exposure to petroleum vapours as a consequence of their diving behaviour, which requires rapidly inhaling large volumes of air prior to diving and continually resurfacing (Milton et al. 2010).

Even if sea turtles avoid direct contact with oil slicks, they can still be directly affected through ingestion of oil or contaminated prey. As turtles consume anything that appears to be the same size as their preferred prey (e.g., jellyfish), ingestion of tarballs is an issue for turtles of all ages. Ingested oil can be retained within a turtle’s digestive tract for several days thereby increasing likelihood of absorption of toxic compounds and risk of gut impaction (Milton et al. 2010). Sea turtle exposure to oil has been shown to result in histologic lesions (Bossart et al. 1995) as well as a reduction in lung diffusion capacity, decrease in oxygen consumption or digestion efficiency, and/or damage to nasal and eyelid tissue (Lutz et al. 1989). Hall et al. (1983) observed seven live and three dead sea turtles following the Ixtoc 1 oil well blowout incident in 1979; two of the carcasses had oil in the gut but no lesions, and there was no evidence of aspirated oil in the lungs. However, hydrocarbon residues were found in kidney, liver, and muscle tissue of all three dead turtles, and prolonged exposure to oil may have disrupted feeding behaviour and weakened the turtles.

Following the Deepwater Horizon oil spill in the Gulf, a total of 1,146 turtles were collected from April 30, 2010, to February 15, 2011, either from stranding or capture in the open water (NOAA 2014b). Of these, 537 were collected alive (456 of which were visibly oiled) and 609 were dead (18 of which were confirmed to have visible oiling) (NOAA 2010); 70% percent of those captured were Kemp's ridley sea turtles. The NOAA fisheries national sea turtle coordinator reported that of the 461 live sea turtles collected between

May and September 2010, approximately 420 were rehabilitated and returned to the wild, with the longer-term, less visible effects of the oil on sea turtles remaining undetermined (NOAA 2014c). Of significance, NOAA reports thousands of sea turtle strandings every year along the Gulf of Mexico and US east coast even prior to this spill and continues to investigate possible reasons for these events (NOAA 2010).

For this Project, it is assumed that any turtles occurring within the zone of influence of an accidental event scenario have the potential to be exposed to oil and experience related health effects, as described above. As the turtles occurring in the RAA would be juveniles and adults, the potential for mortality from oil exposure would be lower than for hatchlings. Turtles would also experience a short-term reduction in habitat quality, during which they have the potential to ingest oil or oiled prey.

Potential Effects of an SBM Spill on Marine Mammals and Sea Turtles

SBM is a heavy, dense fluid which sinks rapidly in the water column when released. SBM constituents selection is controlled by the OCSG so that low toxicity chemicals are used wherever practicable. Therefore, SBMs are of low toxicity and environmental effects are mostly restricted to physical smothering effects on the sea floor (C-NLOPB 2011). Any interaction between an SBM whole mud spill and marine mammals and sea turtles would be limited given the scale of effects in the water column and low toxicity of the material, resulting in a temporary reduction in habitat quality. Any risk of physical injury would be limited to individuals in the immediate vicinity of the spill. A subsea release of SBM at the wellsite would have no expected effects on sea turtles given the water depth.

15.5.3.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. Refer to Section 15.1 for information on BP’s approach to risk management, Section 2.5 for specific information on well control and blowout prevention, and Section 15.3 for a description of BP’s contingency planning and emergency response measures.

As noted in Section 15.3.1, the Project will operate under an IMP which will include contingency plans for responding to specific emergency events, including potential spill or well control events. The IMP and supporting specific contingency plans, such as a SRP, will be submitted to the C-NLOPB prior to the start of any drilling activity as part of the OA process. The SRP will specify tactical response methods, procedures and strategies for safely responding to different spill scenarios. Tactical response methods that will be considered following a spill incident include, but are not limited to: offshore containment and recovery; surveillance and tracking; dispersant application (surface and subsea injection); in-situ burning; shoreline protection; shoreline clean-up; and oiled wildlife response. Refer to Section 15.3 for details on incident management and spill response.

BP will undertake a SIMA / NEBA as part of the OA process with the C-NLOPB. The SIMA is a structured process that will qualitatively evaluate the risks and trade-offs of all feasible and effective response options, when compared to no action. The SIMA process will inform the selection of an overall spill response strategy for the Project. If identified as a preferred response option, use of chemical dispersants would not occur without first obtaining regulatory approval.

BP will develop a Wildlife Response Plan and, for incidents where wildlife is threatened, engage specialized expertise to implement the Plan, including the recovery and rehabilitation of wildlife species as needed (refer to Section 15.3.3.3 for BP's oiled wildlife response approach).

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

15.5.3.3 Characterization of Residual Project-Related Environmental Effects

Subsea Blowout

A well blowout has the potential to result in a change in risk of mortality or physical injury and change in habitat quality and use for marine mammals and sea turtles. The extent of the potential effects will depend on how the spill trajectory and marine mammals and sea turtles overlap in both space and in time.

A threshold concentration for lethal effects to marine mammals and sea turtles was identified as a 10 µm thick layer of on-water oil (French et al. 1996; French-McCay and Rowe 2004; French McCay 2009). For the purposes of this assessment, a surface oil thickness of 10 µm is the threshold at which it is assumed that a change in risk of mortality or physical injury may occur for marine mammals and sea turtles. However, a more conservative threshold of 0.04 µm (visible sheen) was used in the modelling in recognition of potential socio-economic effects on fisheries (refer to Table 15.9). A surface oil thickness of 0.04 µm is also conservatively used in this assessment as the threshold for a change in habitat quality and use for marine mammals and sea turtles. For wildlife on or along the shore (e.g., seals and otters), an exposure index is length of shoreline oiled by 100 µm thick (>100 g/m^2). This emulsion thickness would be characterized as "light oiling".

Marine mammals can congregate in high numbers, but except for species at risk, the number of individuals likely to be present in an area of oiling at the time of a spill is unlikely to represent a high proportion of any marine mammal population. In a worst-case scenario, where a group of non-fur-bearing individuals (e.g., cetaceans) contacted surface oil, the risk of mortality is considered low.

Deterministic models were not run to specifically identify the 10 µm threshold thickness for lethal effects to marine mammals and sea turtles; however, Figures 7.7 and 7.17 in Appendix D illustrate the maximum time-averaged emulsified oil thicknesses on the sea surface (0.04 µm BAOAC "sheen" thickness threshold applied) based on stochastic models run for West Orphan Basin and East Orphan Basin, respectively. The extents of the 5 to 50 µm BAOAC "metallic" thickness contours approximate the areas in which the 10 µm threshold coverage may be exceeded. Potential effects in these areas could include physiological effects associated with direct oiling or ingestion of prey and/or indirect effects associated with a change in behaviour (including habitat use). A change in risk of mortality or physical injury as well as a change in habitat quality and use for marine mammals and sea turtles is therefore predicted to occur from a well blowout scenario.

Tables 15.10 and 15.11 summarize predicted intersection of surface oiling with special areas from a subsurface release in winter and summer in the West Orphan Basin and East Orphan Basin, respectively, Information on stranded oil contact with special areas along the shoreline in winter (there is no shoreline contact in summer in the West Orphan Basin and East Orphan Basin) are provided in Tables 15.12 and 15.13, respectively. These results represent a relief well (120-day unmitigated well blowout) scenario. Refer to Appendix D for data and figures pertaining to the capping stack (30-day unmitigated well blowout) scenarios.

As noted in Section 6.3.8, several EBSAs in the RAA provide important habitat for ecological functions (e.g., overwintering, refuge, feeding) for marine mammals and sea turtles, including the Northeast Shelf and Slope, Notre Dame Channel, Fogo Shelf, Labrador Marginal Trough, Eastern Avalon, Placentia Bay Extension, Lilly Canyon-Carson Canyon, Southeast Shoal and Tail of the Banks, Southwest Shelf Edge and Slope (Table 6.16). The highest average probabilities that surface oiling at thicknesses above 0.04 μm (refer to Tables 15.10 and 15.11) could occur in these special areas are applicable to the Northeast Shelf and Slope EBSA (86.7%), Lilly Canyon-Carson Canyon (81.4%), and the Southwest Shelf Edge and Slope EBSA (30%). The remaining probabilities are below 20%. For these special areas, the average minimum arrival times range from 15 to 60 days, the average maximum exposure times range from 5 to 15 days, and the average of average time-averaged dissolved oil concentrations ranges from rainbow to metallic (refer to Table 15.10).

With respect to shoreline oiling, stochastic modelling indicates that the highest average probability that emulsified oil with thicknesses exceeding 1 μm could intersect the shoreline of a special area of importance for marine mammals and sea turtles from an unmitigated blowout from either wellsite is 2.6% (from the West Orphan Basin during the winter). This 2.6% probability is applicable for Placentia Bay Extension EBSA, which supports high aggregation of cetaceans and leatherback sea turtles in the spring and summer. Otters and harbour seals use the area year-round and it is an important feeding area from spring to fall for many cetaceans (especially humpbacks and porpoises), as well as an important area for reproduction of harbour seals and otters (refer to Table 6.25). Additional details regarding potential shoreline oiling of Placentia Bay Extension EBSA are provided below in the discussion of potential effects on seals.

Because the occurrence of harp and hooded seals is common in the Project Area (refer to Section 6.3.5), where the West Orphan Basin and East Orphan Basin representative wellsites are located, the likelihood of these species of fur-bearing marine mammals contacting oil in the event of a blowout is high. Other species of seals that can be reasonably expected to occur in the RAA but are uncommon in the Project Area, and more likely to be found in coastal areas or on landfast ice, include grey seal, ringed seal, and bearded seal. As described in Section 15.5.2.3, although there are several coastline areas (including those outside of the RAA) that could potentially be exposed to shoreline oiling above the 1 g/m^2 threshold, shoreline contact is unlikely from releases at either the West Orphan Basin or East Orphan Basin sites. The highest shoreline contact probabilities occurred for the West Orphan relief well scenario during the winter months, with 31 km of coastline potentially at risk from contact probabilities of 5% to 7% (refer to Figure 15.17). The predicted maximum amount of oil accumulating on the shoreline was approximately 400 tonnes with peak oiling occurring between 90 and 120 days. However, there was a wide range in the maximum amount of oil accumulated on the shoreline, with no stranded oil occurring in 72% of the simulations and <1 tonne beaching in 85% of the cases during the winter season.

The probabilities of oil intersecting with special areas are lower for the unmitigated capping stack scenario than for the unmitigated relief well scenario. No shoreline contact was predicted for the West Orphan and East Orphan capping stack scenarios during the summer seasons with maximum probabilities of 1% to 2% for the capping stack winter scenarios and the West Orphan relief well summer scenarios.

Based on the results of far-field deterministic modelling, shoreline oiling exceeding the 0.04 μm threshold level is expected to be limited to the Avalon Peninsula, where there would be occurrences of moderate oiling (1-10 mm [or 1,000-10,000 μm]), light oiling (0.1-1 mm [or 100-1,000 μm]), and stain oiling (0.01-0.1 mm [or 10-100 μm]). These accumulated surface oil emulsion thicknesses are high enough to cause a change in risk of mortality or physical injury for marine mammals that may be present onshore (e.g., seals and otters). The maximum length of shoreline to be affected would be 20 km, and this would occur after 119 days. The maximum mass of oil on the shoreline would occur slightly earlier (after 107 days) and be associated with the accumulation of 403 tonnes of oil on the shoreline.

Stochastic modelling results for unmitigated blowouts originating in the West Orphan Basin and East Orphan Basin during the winter (refer to Tables 15.12 and 15.13, respectively) indicate 1.1-1.3% average probabilities of moderate oiling for Eastern Avalon EBSA, a coastal area in which seals are known to feed from spring to fall (refer to Table 6.25). These probabilities are quite low; however, in the unlikely event of such a blowout, the minimum arrival time to reach 1 μm thickness threshold at these special areas ranges from 32 to 110 days, which would allow time for BP to implement of mitigation (including emergency response measures such as containment and recovery operations) to reduce potential residual effects. Tables 15.12 and 15.13 also indicate 1.9-2.6% average probabilities of light oiling for the Placentia Bay Extension EBSA, which is used by otters and seals year-round and provides important habitat for their reproduction. The average minimum arrival times range from 92 to 104 days, which would allow time for the implementation of mitigation in the unlikely event of such a blowout.

Marine Diesel Spill

Maximum time-averaged emulsified oil thickness on the sea surface (stochastic results) can be seen in Figures 8.5, 8.6, 8.11, and 8.12 in Appendix D. Modelling results indicate that diesel spills from the MODU or PSV are not likely to result in biological effects on marine mammals over a large area. The extent of the 5 to 50 μm thickness in Figures 8.4.22 and 8.4.23 approximates the location in which the 10 μm threshold may be exceeded.

With respect to a change in habitat quality and use for marine mammals and sea turtles, the majority of diesel from a spill from either the MODU or PSV will evaporate and disperse within the first three days following the release, based on deterministic modelling results (refer to Appendix D). This will create a temporary and reversible degradation in habitat quality. Depending on the location and extent of the spill, it could directly and indirectly reduce the amount of habitat available to marine mammals and sea turtles for foraging and other life history activities. These effects would be short-term in duration until the slick disperses and hydrocarbon content in the area reaches background levels. A batch spill of diesel is not expected to create permanent or irreversible changes to habitat quality and use.

As indicated in Section 15.5.2.3, the hypothetical (and unlikely) 750,000 L spill from a PSV collision that was deterministically modelled in support of Nexen Energy's Flemish Pass Exploration Drilling Project was predicted to result in more extensive surface oiling and a smaller percentage of oil evaporation in comparison with the smaller (100-L and 1,000-L) batch spills that were modelled for that project (Nexen Energy 2018). At the end of the 30-day simulation, only <0.1% of the released volume was predicted to remain floating on the water surface and 0% was predicted to contact the shore. For the remaining released volume, modelling results indicated that 63-76% would evaporate into the atmosphere, 8-14% would remain entrained in the water column, ≤0.01% would adhere to suspended sediment, and 16-45% would degrade (RPS 2017).

With respect to change in risk of mortality or physical injury, the accidental release of diesel fuel has the potential to affect various physical and internal functions of marine mammals and sea turtles. As noted above, the behaviour of species influences the likelihood of their being oiled with probabilities of lethal effects on exposure varied among species groups. Fur-bearing marine mammals are the most susceptible to contact with hydrocarbons. Direct contact with hydrocarbons can cause fouling in fur-bearing marine mammals such as seals, reducing thermoregulation abilities. Hydrocarbons can be inhaled or ingested, leading to behavioural changes, inflammation of mucous membranes, pneumonia and neurological damage (Geraci and St. Aubin 1990). Diesel fuel would disperse faster than crude oil, limiting the potential for surface exposure, although there would be increased toxicity associated with this spill and risk of inhalation of toxic fumes is present for either type of spill (crude oil or diesel).

Marine mammals and sea turtles are not considered to be at high risk from a diesel spill, because it is probable that only a small proportion of a species population would be within the area affected by the spill which is expected to be limited in size. It is also expected that most marine mammals would avoid surfacing in areas of harmful hydrocarbon concentrations.

SBM Spill from the MODU and the Marine Riser

There is potential for a SBM spill to result in a surface sheen which in turn could potentially cause a change in risk of mortality or physical injury for marine mammals and sea turtles present in the immediate area. If the wind and wave conditions were such that a sheen formed, it would be temporary and limited in size, such that only individuals in the immediate area of the spill would likely be affected. Furthermore, given the low surface oil thickness required to result in a sheen (0.04 µm), it is expected that effects would be minor and unlikely to result in marine mammal or sea turtle mortality.

An accidental release of SBM whole mud would also likely result in elevated levels of TSS in the water column. A SBM whole mud spill could therefore cause a temporary reduction in habitat quality for marine mammals and sea turtles due to increased levels in TSS and the potential for a thin sheen associated with the spill. This reduction in habitat quality and use would be temporary, reversible and localized.

Summary

Table 15.19 provides a summary of predicted residual environmental effects of accidental events on marine mammals and sea turtles.

Table 15.19 Summary of Residual Project-Related Environmental Effects on Marine Mammals and Sea Turtles – Accidental Events

Residual Effect	Residual Environmental Effects Characterization						
	Direction	**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological and Socio-economic Context**
Change in Risk of Mortality or Physical Injury and Habitat Quality and Use							
Well Blowout Incident	A	H	RAA*	ST-MT	S	R	D
10 bbl Diesel Spill	A	L	LAA	ST	S	R	D
100 bbl Diesel Spill	A	M	LAA	ST	S	R	D
PSV Diesel Spill	A	M	LAA	ST-MT	S	R	D
SBM Spill	A	L	LAA	ST	S	R	D

KEY:
See Table 10.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"
Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

15.5.3.4 Determination of Significance

Based on information presented above and a consideration of the significance criteria identified in Section 10.1.5, the predicted residual adverse environmental effects from any of the accidental event scenarios on marine mammals and sea turtles is predicted to be not significant. This determination is made in consideration of the conservatism of the spill modelling (results show an unmitigated release), the use of mitigation measures to prevent and reduce effects from a spill, and the nature of the adverse effects as described in the literature summarized above. This conclusion is made with a high level of confidence for the diesel and SBM spill scenarios based on the low magnitude and geographic extent of likely effects. A medium level of confidence is assigned to the well blowout scenarios given the marine mammal and sea turtle species at risk inhabiting the affected area.

15.5.4 Special Areas

The following special areas are partially located within the Project Area:

- The Project Area overlaps approximately 44% of the Northeast Newfoundland Slope Closure marine refuge, which is closed to bottom-contact fishing activities in consideration of its high density of corals and sponges and high biodiversity.
- The Project Area overlaps approximately 22% the Orphan Spur EBSA, which was designated in consideration of its high concentration of corals and its densities of sharks as well as SAR and SOCC (e.g., northern, spotted, and striped wolffish; skates; roundnose grenadier; American plaice; redfish).
- The Project Area overlaps approximately 2% of the Bonavista Cod Box, which is experimentally closed to all fishing activity (except snow crab trapping) in consideration of its importance as a spawning and migration area for Atlantic cod, American plaice, and redfish.
- The Project Area overlaps <0.5% of the Orphan Knoll Seamount Closure, which is closed to bottom-fishing to protect deep-water corals.

Collectively, these special areas comprise approximately 59% of the Project Area. Potential vessel transit routes intersect one additional special area, the Northeast Shelf and Slope EBSA, which is known to support aggregations of groundfish, marine mammals, and corals.

There are several other special areas located within the RAA, most of which could potentially interact with a Project-related accidental spill. Of particular interest for this assessment are special areas within the RAA that (Table 15.20):

- are protected by federal or provincial legislation
- are known to provide important habitat for, or support aggregations of, SAR or SOCC and/or
- are known to provide important habitat for, or support aggregations of, marine or migratory birds, since birds are particularly vulnerable to oil spills; and/or meet one or more of the criteria above and are located within 30 km of the coastline, and therefore have potential to be affected by a spill originating in the nearshore (e.g., a marine diesel spill from a PSV operating in a nearshore area) or a spill originating in the Project Area but extending to the nearshore (e.g., a large-scale subsea blowout from an offshore well)

Table 15.20 Special Areas within the RAA that are of Particular Interest for the Assessment of Accidental Events

Special Areas	Type of Special Area	Protected under Federal Legislation	Protected under Provincial Legislation	SAR or SOCC Habitat	Marine or Migratory Bird Habitat	Within 30 km of Coastline
Baccalieu Island	Ecological Reserve		✓		✓	✓
Baccalieu Island (NF003)	IBA				✓	✓
Beothuk Knoll	NAFO VME			✓		
Cape Freels Coastline and Cabot Island (NF025)	IBA				✓	✓
Cape St. Francis (NF021)	IBA				✓	✓
Cape St. Mary's	Ecological Reserve		✓		✓	✓
Cape St. Mary's (NF001)	IBA			✓ *	✓	✓
Division 3O Coral	Marine Refuge	✓		✓		
Division 3O Coral Closure	NAFO VME			✓		
Eastern Avalon	EBSA				✓	
Eastport (Duck Islands and Round Island)	MPA	✓				✓
Flemish Cap East	NAFO VME			✓		
Fogo Shelf	EBSA				✓	✓
Funk Island	Ecological Reserve		✓		✓	✓
Funk Island (NF004)	IBA				✓	✓
Funk Island Deep	Marine Refuge	✓		✓		✓
Gander Bay	Marine Refuge / Lobster Area Closure	✓				✓
Goose Island	Marine Refuge / Lobster Area Closure	✓				✓
Grates Point (NF019)	IBA				✓	✓
Grey Islands	EBSA			✓	✓	✓
Hawke's Channel	Marine Refuge	✓		✓		
Labrador Marginal Trough	EBSA			✓	✓	✓
Labrador Slope	EBSA			✓		
Mistaken Point (NF024)	IBA				✓	✓

Special Areas	Type of Special Area	Protected under Federal Legislation	Protected under Provincial Legislation	SAR or SOCC Habitat	Marine or Migratory Bird Habitat	Within 30 km of Coastline
Northeast Newfoundland Slope Closure	Marine Refuge	✓				
Northeast Shelf and Slope	EBSA			✓		
Northern Flemish Cap	NAFO VME			✓		
Notre Dame Channel	EBSA				✓	✓
Orphan Spur	EBSA			✓		
Placentia Bay Extension	EBSA			✓	✓	✓
Quidi Vidi Lake (NF022)	IBA				✓	✓
South East Shoal and Adjacent Shelf Edge / Canyons	NAFO VME			✓		
Southern Flemish Pass to Eastern Canyons	NAFO VME			✓		
Terra Nova	Migratory Bird Sanctuary	✓			✓	✓
Terra Nova National Park (NF017)	IBA				✓	✓
The Cape Pine and St. Shotts Barren (NF015)	IBA				✓	✓
Virgin Rocks	EBSA				✓	
Wadham Islands and Adjacent Marine Area (NF013)	IBA				✓	✓
Witless Bay	Ecological Reserve		✓		✓	✓
Witless Bay Islands (NF002)	IBA				✓	✓

NOTE:

* Cape St. Mary's IBA (NF001) is the only IBA within the RAA that meets the IBA criterion for nationally significant threatened species (i.e., harlequin duck and piping plover). For an IBA to meet this criterion, it must be known, or thought to, regularly hold significant numbers of a bird species, subspecies, or otherwise distinct population that is considered by COSEWIC to be endangered, threatened, or of special concern in Canada (Moore and Couturier). However, several other IBAs in and around the RAA are frequented by various marine and migratory bird SAR and/or SOCC in smaller numbers.

Additional details regarding existing conditions for special areas are provided in Section 6.4.

15.5.4.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in habitat quality for special areas. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

Special areas provide important habitat and may be comparatively more vulnerable to environmental effects, including effects from accidental events, than other areas. Adverse effects on special areas could degrade the ecological integrity of the special area such that it is not capable of providing the same ecological function for which it was designated (e.g., protection of sensitive or commercially important species). The assessment of special areas is therefore closely linked to all of the other VCs considered in this assessment. This consideration is particularly true for accidental events where the physical effects on the biological resources found in these areas represent the potential effects of greatest concern. These potential effects are discussed in Sections 15.5.1 to 15.5.3 for marine fish an fish habitat, marine and migratory birds, and marine mammals and sea turtles, and are not repeated in this section. The assessment of effects on special areas therefore focuses on a change in habitat quality.

15.5.4.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. Refer to Section 15.1 for information on BP's approach to risk management, Section 2.5 for specific information on well control and blowout prevention, and Section 15.3 for a description of BP's contingency planning and emergency response measures.

As noted in Section 15.3.1, the Project will operate under an IMP which will include contingency plans for responding to specific emergency events, including potential spill or well control events. The IMP and supporting specific contingency plans, such as a SRP, will be submitted to the C-NLOPB prior to the start of any drilling activity as part of the OA process. The SRP will specify tactical response methods, procedures and strategies for safely responding to different spill scenarios. Tactical response methods that will be considered following a spill incident include, but are not limited to: offshore containment and recovery; surveillance and tracking; dispersant application (surface and subsea injection); in-situ burning; shoreline protection; shoreline clean-up; and oiled wildlife response. These tactical response methods will be used as applicable to mitigate potential environmental effects of oil on special areas. Refer to Section 15.3 for details on incident management and spill response.

BP will undertake a SIMA / NEBA as part of the OA process with the C-NLOPB. The SIMA is a structured process that will qualitatively evaluate the risks and trade-offs of all feasible and effective response options, when compared to no action. The SIMA process will inform the selection of an overall spill response strategy for the Project. If identified as a preferred response option, use of chemical dispersants would not occur without first obtaining regulatory approval.

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with applicable regulatory agencies.

15.5.4.3 Characterization of Residual Project-Related Environmental Effects

Subsea Blowout

A well blowout represents the accidental event with the potential for the most widespread effects. Following a blowout incident, for each designated protected area in the RAA, Tables 15.10 and 15.11 provide the probabilities from stochastic modelling results of surface oiling exceeding 0.04 µm and the associated exposure time for surface oiling associated with subsea blowouts from wells in the West Orphan Basin and East Orphan Basin, respectively. The 0.04 µm threshold applied corresponds to a visible oil sheen on the surface, and the threshold is conservatively lower than the 10 µm threshold above which the quality of habitat of the special areas would be compromised such that harm to marine mammals, sea turtles and seabirds may be expected. Tables 15.14 and 15.15 provide probabilities from stochastic modelling results of water column dispersed and dissolved oil with THC exceeding 58 ppb. The probabilities of the areas reaching the surface oil threshold (0.04 µm) or in-water THC threshold (58 ppb) represent results modelling a continuous, 120-day unmitigated blowout scenario. An unmitigated release is highly unlikely as it precludes consideration of oil containment and recovery measures, which would be implemented following an actual release.

It should be noted that the approach for identifying marine special areas potentially at risk from contact with oil on the sea surface is conservative. Some of the special areas may be designated for seabed features (such as pockmarks, trenches, corals etc.) and will therefore not be directly impacted by surface oil. However, the intersection routines used in the GIS analysis (Appendix D) show all locations where surface oil outputs from oil spill modelling spatially overlap with special areas (designated by latitude and longitude), even when the oil spill outputs are vertically separated from the special area.

As shown in Tables 15.10 and 15.14, a blowout occurring in the West Orphan Basin in the winter has the greatest potential to interact with the most designated special areas. The Sackville Spur, Northwest Flemish Cap, Northern Flemish Cap, Northeast Flemish Cap, Orphan Knoll, and Northeast Newfoundland Slope Closure have the highest probabilities of reaching the surface oil or in-water THC thresholds. However, these special areas are primarily designated to protect corals and sponges and the potential for sponges and corals on the seafloor to be exposed to surface or in-water oil, particularly at these water depths is considered low. There are lower probabilities (generally less than 2%) for surface oiling exceeding 0.04 µm in coastal special areas.

The Bonavista Cod Box, an experimental fishery closure area, is an importance spawning area Atlantic cod, American plaice, and redfish. Sub-lethal and lethal effects to eggs and larvae that drift in the mixed surface layer of the water column may result in this special area following exposure to in-water oil above the 58 ppb and 200 ppb in-water concentrations, respectively. As indicated in Table 15.14, the average probability of exposure of this special area to in-water THCs greater than 58 ppb is up to approximately 62%.

Stranded oil is of primary relevance to special areas with shorelines. Tables 15.12 and 15.13 present probabilities and the average degrees of shoreline oiling in winter, above the 1 µm (1g/m^2) threshold, at designated special areas with shoreline habitat. The Cape Pine and St. Shotts Barren IBA has the highest probability (3.4%) of being subject to stranded oil exceeding the threshold; all other probabilities of stranded oil shoreline contact with special areas in winter are 2.6% or less. Stochastic modelling results for unmitigated blowouts originating in the West Orphan Basin and East Orphan Basin during the winter (refer to Tables 15.12 and 15.13, respectively) indicate 0.9-2% average probabilities of heavy oiling (>10 mm thickness [or 10,000 μm] of emulsified oil) for the Fogo Shelf EBSA, Grates Point IBA, and Cape St. Francis IBA. These probabilities are quite low; however, in the unlikely event of such a blowout, the minimum arrival time to reach 1 μm thickness threshold at these special areas ranges from 34 to 80 days, which would allow time for BP to implement of mitigation (including emergency response measures such as containment and recovery operations) to reduce potential residual effects.

Marine Diesel Spill

Based on the results of Project-specific modelling of 100-bbl and 10-bbl batch spills (Appendix D), it is expected that in-water THCs and surface oil thicknesses would be highest in the immediate vicinity of the spill and that the spill would be limited in terms of its overall magnitude, extent, and duration, and thus its potential adverse environmental effects on habitat quality in special areas. Given that such a spill could conceivably occur at any location within the Project Area or along the associated vessel and aircraft traffic routes, it is possible that it could overlap with, and to a degree affect, the special areas that are located within these boundaries. The Project Area and PSV transit routes overlap directly with the Northeast Newfoundland Slope Closure marine refuge, the Orphan Spur EBSA, the Bonavista Cod Box, the Orphan Knoll Seamount Closure, and the Northeast Shelf and Slope EBSA (refer to Section 15.5.4).

Dissolved hydrocarbons from spilled diesel are expected limited to the surface and mixed layer of the water column. The potential for exposure of deep-water sponges and corals in special areas is therefore considered low.

The Bonavista Cod Box is an importance spawning area Atlantic cod, American plaice, and redfish. Sub-lethal and lethal effects can result for eggs and larvae present in the mixed surface layer of the water column. The relatively limited zone of influence of a vessel spill would prevent any wider spread and potentially significant adverse effects from occurring, and adverse effects would be considered temporary and reversible.

The durations of exposure to either surface oil exceeding the 0.04 μm thickness threshold or oil in the water column exceeding the 58-ppb threshold for THC levels was less than 6 hours for the 10-bbl releases. For the 100-bbl releases, the durations of exposure ranged from 12 to 18 hours (in the immediate vicinity of the release location) to less 6 hours (at the majority of locations further away). Any effects on special areas are anticipated to be short-term and reversible.

Refer to Appendix D for data and figures pertaining to the capping stack (30-day unmitigated well blowout) scenarios. The probabilities of oil intersecting with special areas are lower for the unmitigated capping stack scenario than for the unmitigated relief well scenario.

Refer to Sections 15.5.1.3 and 15.5.2.3 for consideration of the results of deterministic modelling conducted by RPS in support of Nexen Energy's Flemish Pass Exploration Drilling Project for a hypothetical release of 750,000 L of diesel from a PSV over 30 days at a location between St. John's and Nexen Energy's project area.

SBM Spill from the MODU and the Marine Riser

The potential changes in habitat quality described for marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles in Sections 15.5.1, 15.5.2, and 15.5.3 could also affect habitat quality within the following special areas that are located within 1 km of BP ELs in the Project Area: the Northeast Newfoundland Slope Closure marine refuge and the Orphan Spur EBSA.

Summary

Table 15.21 provides a summary of predicted residual environmental effects of accidental events on special areas.

Table 15.21 Summary of Residual Project-Related Environmental Effects on Special Areas – Accidental Events

Residual Effect	Residual Environmental Effects Characterization						
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Habitat Quality							
Well Blowout Incident	A	H	RAA*	ST-MT	S	R	D
10 bbl Diesel Spill	A	L	LAA	ST	S	R	D
100 bbl Diesel Spill	A	M	LAA	ST	S	R	D
PSV Diesel Spill	A	L-M	LAA	ST-MT	S	R	D
SBM Spill	A	L	LAA	ST-LT	S	R	D

KEY:
See Table 11.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"
Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

15.5.4.4 Determination of Significance

Based on information presented above and a consideration of the significance criteria identified in Section 11.1.5, the predicted residual adverse environmental effects from any of the accidental event scenarios on special areas is predicted to be not significant. This determination is made in consideration of the conservatism of the spill modelling (results show an unmitigated release), the use of mitigation measures to prevent and reduce effects from a spill, and the nature of the adverse effects as described in the literature summarized above. This conclusion is made with a high level of confidence for the diesel and SBM spill scenarios based on the low magnitude and geographic extent of likely effects. A high level of confidence is also assigned to the well blowout scenarios given the low modelled probabilities of oiling in most special areas in the unlikely event of a blowout, the fairly long modelled minimum arrival times for oil in most special areas, and the relatively low exposure times in most special areas.

15.5.5 Indigenous Peoples and Community Values

Several Indigenous groups reside in Atlantic Canada, including in communities in Newfoundland and Labrador, the Maritime Provinces, and Quebec. Many of these groups have asserted and/or established Aboriginal and/or Treaty rights including the right to hunt, fish or gather resources which could potentially be affected by the Project under certain circumstances as a result of an accidental event. Many Indigenous groups hold commercial communal and/or FSC licenses in the RAA or for species that may migrate through the RAA. Species harvested for commercial communal purposes in the RAA include capelin, groundfish, herring, mackerel, seal, shrimp, snow crab, swordfish, tuna, and whelk. There is no known FSC harvesting occurring in the Project Area.

Additional details regarding existing conditions for Indigenous peoples and community values are provided in Section 7.3.

15.5.5.1 Project Pathways for Effects

Accidental spill scenarios have potential to affect fisheries resources (direct or indirect effects on fished species affecting fisheries success) and/or fishing activity (displacement from fishing areas, gear loss or damage) in such a way that results in a change in commercial communal fisheries and/or a change in current use of lands and resources for traditional purposes, as well as associated socio-economic impacts to the Indigenous communities. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

Although FSC fisheries were not currently identified to occur in the vicinity of the Project Area, in the event of a spill, there could be effects on FSC species that could be migrating through or otherwise using the affected area. An effect on species fished for traditional (e.g., communal gathering of fish for feasts) or commercial purposes, a change in habitat traditionally fished by Indigenous peoples, and/or area closures could affect traditional use of marine waters and resources. These effects could also potentially affect the social, spiritual, and cultural value of the fishery to the Indigenous communities, including asserted or established traditional territories and resources, and other components of the health (physical or social), heritage (physical or cultural) and other socioeconomic conditions of an Indigenous group.

Biophysical effects resulting from an accidental event on marine fish and fish habitat, marine and migratory birds, and marine mammals and sea turtles that are used for traditional purposes can potentially affect the physical health of persons harvesting or consuming contaminated resources. Discussion on potential effects to harvested species is not repeated in this Section. Refer to Section 15.5.1 for potential effects to marine fish and fish habitat, Section 15.5.2 for marine and migratory birds, and Section 15.5.3 for marine mammals and sea turtles. This section therefore focuses on effects related to the current use of these resources for traditional purposes, and in turn, the overall quality of life and well-being of an Indigenous community.

As discussed in Section 7.4, there are two commercial communal species (swordfish and bluefin tuna) and two species harvested for FSC purposes (Atlantic salmon and American eel) that were identified through engagement as having particular importance to the Indigenous communities that could be affected by Project-related activities. Additional information on these species is provided below. It is conservatively assumed that any Indigenous organization that has a licence to fish in the RAA could be exercising that right at any time of year and theoretically could potentially interact with the Project.

Swordfish

In the event of a spill event, adult finfish, including swordfish, will likely avoid exposure through temporary migration from affected areas. The biomagnification of petroleum hydrocarbons typically does not occur in food webs. This is because vertebrates, including swordfish, can readily metabolize petroleum hydrocarbons. If swordfish are exposed to hydrocarbons via respiration, direct contact, or through diet, these hydrocarbons will be metabolized and generally will not pose a risk through bioaccumulation. As noted in Section 7.4.7, swordfish are a migratory species that are widely distributed throughout the Atlantic Ocean. Given their overall ranges and migration patterns, it is unlikely that they would be present within the affected area in large concentrations during an accidental event, and the highly motile nature of this species would likely allow individuals to avoid affected areas.

Bluefin Tuna

Although chronic effects of hydrocarbons on juvenile and spawning adult bluefin tuna are not well understood (Hazen et al. 2016), the exposure of adult finfish (including bluefin tuna) may be reduced through temporary migration away from affected areas in the event of a blowout incident. However, acute oil exposure has been predicted to cause defects in heart development which may result in mortality of bluefin eggs and larvae (Incardona et al. 2014). Similar to swordfish, tuna are a highly migratory species, and they have been found in the offshore waters of Newfoundland and Labrador. Given their overall ranges and migration patterns, it is unlikely that they would be present within the affected area in large concentrations during an accidental event, and the highly motile nature of this species would likely allow individuals to avoid affected areas.

Atlantic Salmon

Atlantic salmon breed and spend the early part of their life cycle in freshwater systems throughout Atlantic Canada, eastern Québec, and the northeastern seaboard of the United States. They have potential to occur in both the Project Area and RAA, although most likely as a transient presence during migration. As discussed in the Section 15.5.1, adult fish, including salmon, occurring in relatively deep waters have lower exposure risk because they are highly motile and able to avoid oiled areas (Irwin 1997; Law et al. 1997). There have been few studies on the avoidance behaviour of returning adult salmon to hydrocarbons in water under natural conditions (Nexen 2018). A behavioural study on adult Pacific salmon (*Oncorhynchus* sp.) was conducted where hydrocarbons that closely approximated the water-soluble fraction of Prudhoe Bay crude oil were added in one of two fishways as salmon were migrating upriver (Weber et al. 1981). Results found that migrating salmon substantially avoided (i.e., when 50 percent of fish which were expected to ascend a fishway avoided it) hydrocarbons in the water at concentrations of 3,200 µg/L. Concentrations used in the study ranged from 300 to 6,100 µg/L (Nexen 2018).

American Eel

American eel has a broad distribution throughout the northwest Atlantic Ocean, stretching from Venezuela to Greenland and Iceland (COSEWIC 2012). The most recent DFO research vessel surveys for 2016 / 2017 found that American eel occurs within the Project Area between March and November, but the potential for occurrence within the Project Area was considered low (see Section 6.1.7); it is generally considered a migratory / transient species within the RAA. There is little information available on specific migration patterns of American eel, and if American eel were to occur within the Project Area, it is likely that they would be carried by currents on their way either to Greenland, Iceland, or to Newfoundland and Labrador. American eel, like other fish, when exposed to oil have been shown to induce oil degrading enzymes (Schlezinger and Stegeman 2000) with a 5 mg/kg dose response, a sensitivity that is less than that of other fish (Nexen 2018). It has been speculated that this is because of the species' life history, where they spend a portion of their life in estuaries with increased chance of exposure to contaminants and therefore less sensitivity (Schlezinger and Stegeman 2000).

15.5.5.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. Refer to Section 15.1 for information on BP's approach to risk management, Section 2.5 for specific information on well control and blowout prevention, and Section 15.3 for a description of BP's contingency planning and emergency response measures.

BP will undertake a SIMA / NEBA as part of the OA process with the C-NLOPB. The SIMA is a structured process that will qualitatively evaluate the risks and trade-offs of all feasible and effective response options, when compared to no action. The SIMA process will inform the selection of an overall spill response strategy for the Project. If identified as a preferred response option, use of chemical dispersants would not occur without first obtaining regulatory approval.

Mitigation to reduce effects from an accidental spill on Indigenous peoples and community values includes measures which are also intended to mitigate potential effects on commercial fisheries including:

- Implementation of an Indigenous Fisheries Communication Plan which would include procedures for informing Indigenous groups of an accidental event and appropriate response. Emphasis is on timely communication, thereby providing fishers with the opportunity to haul out gear from affected areas, reducing potential for fouling of fishing gear

- Compensation for damage to gear in accordance with *Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity* (C-NLOPB and CNSOPB 2017).

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with regulatory agencies, Indigenous groups, and fisheries stakeholders, as applicable.

15.5.5.3 Characterization of Residual Project-Related Environmental Effects

Subsea Blowout

In the event of a subsea blowout, there is potential for adverse effects to a change in commercial communal fisheries. A blowout incident could result in effects on availability of fisheries resources (e.g., effects on fisheries species), access to fisheries resources (e.g., fisheries closure, interruption of fishing rights), and/or fouling of fishing or cultivation gear. In the event of a blowout there may also be effects to socio-economic aspects in the Indigenous communities.

Although the Project is not located within an area of high harvesting activity by Indigenous fisheries, Figures 15.9 and 15.13 show that in the unlikely event a blowout incident, hydrocarbons would reach active commercial communal fishing areas where harvesting activity is more likely to occur. Figures 15.9 and 15.13 show the probability of surface oiling exceeding 0.04 μm across the RAA following unmitigated (i.e., no emergency response measures to contain or recover oil) 120-day, blowout incident. While the modelling demonstrates a potentially large affected area, it is important to note that many of the areas delineated through the modelling have low probabilities of occurrence and that results are based on an unmitigated release. In an actual incident, emergency response measures are likely to have some effect on limiting the magnitude and duration of the spill thereby limiting the geographic extent and potential environmental effects. Stochastic modelling results for a continuous, 120-day unmitigated blowout from a wellsite in the West Orphan Basin or the East Orphan Basin indicate that the geographic extent of a residual change in habitat quality and use for marine fish (using the 58-ppb THC [dispersed and dissolved oil] as an effect threshold) could spread beyond the RAA. Environmental effects related to in-water THC concentrations above 58 ppb would be anticipated to occur over the greatest potential area in the event of a blowout during the winter months in the West Orphan Basin, followed by (in descending order of spatial extents for potential areas of threshold exceedance) a blowout during the summer months in the West Orphan Basin, a blowout during the summer months in the East Orphan Basin, and a blowout during the winter months in the East Orphan Basin (refer to Table 7.1 in Appendix D). These levels are not likely to cause acutely toxic effects to adult fish such as swordfish and bluefin tuna, which have the potential to be present in the RAA.

In the event of a spill, surface oiling would have a short-term effect on commercial communal fisheries due to the exclusion of fishing in areas where oil exceeds a thickness of 0.04 µm (a visible sheen). Affected areas would be closed to commercial and Indigenous fishing to prevent human contact with spilled oil and consumption of potentially contaminated food sources. Closures typically remain in place until: an area is free of oil and oil sheen on the surface; there is low risk of future exposure based on predicted trajectory modelling; and seafood has passed sensory sampling (smell and taste) for oil exposure (taint) and chemical analysis for oil concentration (toxicity).

As discussed in Section 15.5.2, the presence of hydrocarbons may temporarily affect habitat quality and risk of mortality for migratory birds. Of the migratory bird species hunted by Indigenous communities, the murre is the only species hunted by Indigenous people that is known to occur in the RAA and potentially affected by an accidental event. A change in risk of mortality or physical injury for migratory birds exposed to hydrocarbons can occur through three main pathways: external exposure to oil (resulting in coating of oil on feathers); inhalation of particulate oil and volatile hydrocarbons; and ingestion of oil. Migratory birds are the most visible and among the first species impacted by oil spills, with diving species (such as murres) the most susceptible to the immediate effects of surface slicks (Leighton et al. 1985; Chardine 1995; Wiese and Ryan 1999; Irons et al. 2000). Dispersed oil; however, is unlikely to reach nearshore and coastal areas where birds may congregate (e.g., near breeding colonies) and the use of dispersants has potential to provide an important means of protection where large numbers of over-wintering birds are present and response strategies are limited by ice or other factors (Chapman et al. 2007).

A blowout incident has the potential to result in a change in risk of mortality or physical injury and change in habitat quality and use for seals. The extent of the potential effects will depend on the spill trajectory and overlap with individual seal. Seals are not considered to be at high risk from the effects of oil exposure, but harp seal pups may succumb to exposure if oiled during the spring. Adult harp seals are only present during the winter. With a population estimate of 7 to 9 million, there is little chance of a population level effect on harp seals.

In the event of a subsea blowout there is also potential for adverse effects to a change in current Indigenous use of lands and resources for traditional purposes. Similar to the effects described above for commercial communal fisheries, a blowout could result in adverse effects to FSC fishing. Although there are no known FSC fishing activities occurring in the Project Area, species harvested for FSC purposes have the potential to migrate through the area. In particular, Atlantic salmon and American eel were identified as harvested species of importance. There is also a potential for adverse effects on socio-economic conditions for the Indigenous communities. The importance of the FSC fishery has been emphasized by the communities as being culturally important. For example, although traditional food may currently be a small portion of the community's diet, it is very important considering that some community members face food insecurity. Communities maintain a general perception that a spill would result in a negative effect to the FSC fishery with impacts to the quality of life within the communities.

Because the coastline of Newfoundland is known to contain resources of historical, archaeological, paleontological, or architectural significance (refer to Section 7.4), shoreline oiling from a subsea blowout could adversely affect the physical and cultural heritage of one or more Indigenous groups in Newfoundland.

Marine Diesel Spill

Project-specific modelling results indicate that marine diesel spills from the MODU or a PSV (10 bbl and 100 bbl) are not likely to result in effects on fish over a large area (Figures 15.29 to 15.32). Accidental discharges of marine diesel resulted in limited modelled effects. Around 60% of the spill evaporated within three days, with the maximum exposure time for emulsified oil thickness on the sea surface exceeding 0.04 µm being one day. Deterministic modelling results indicate that the surface area covered by oil in excess of 0.04 µm will equate to 1.5 km^2 for the 10 bbl spill scenario and 27 km^2 for the 100 bbl spill scenario. If a fisheries closure was implemented due to the spill, this could result in a temporary loss of access to Indigenous fishers for commercial communal or FSC purposes; however, a small spill offshore is unlikely to measurably affect fisheries occurring outside the MODU operational safety zone. Associated socio-economic effects due to a marine diesel spill are therefore likely to be low in magnitude as effects to the resource are predicted to be short term and localized to the Project Area.

Refer to Sections 15.5.1.3 and 15.5.2.3 for consideration of the results of deterministic modelling conducted by RPS in support of Nexen Energy’s Flemish Pass Exploration Drilling Project for a hypothetical release of 750,000 L of diesel from a PSV over 30 days at a location between St. John’s and Nexen Energy’s project area.

The Project Area and LAA are not known to contain resources of historical, archaeological, paleontological, or architectural significance, therefore given the localized nature of a marine diesel spill, it is predicted that a marine diesel spill would not adversely affect the physical and cultural heritage of any Indigenous group.

As discussed in Sections 15.5.1 to 15.5.3, in the event of a marine diesel spill, significant adverse effects are not predicted for marine fish or marine mammals, including species known to be harvested for traditional purposes. Significant effects could occur to marine and migratory birds in the unlikely event of a 100-bbl diesel spill or PSV diesel spill however, it is predicted that the number of birds affected would be limited due to the short time and small area where the diesel would be on the water’s surface. Mitigation measures identified within the respective sections will be implemented to reduce any associated environmental effects on the harvested species. There is limited potential for the biophysical effects of the Project to have an adverse effect on the presence, abundance, distribution or quality the overall availability for harvesting activities by Indigenous groups within their traditional harvesting areas which would therefore have limited effects on quality or cultural value of these traditional activities by any Indigenous group. Similarly, any such effects are unlikely to extend to or affect the physical (through, for example, ingestion of toxic materials) or social health and well-being of any Indigenous persons or communities.

SBM Spill from the MODU and the Marine Riser

All substances that comprise drilling muds are screened through a chemical management system in consideration of the OCSG (NEB et al. 2009). Previous studies have shown little or no risk of drilling base chemicals to bioaccumulate to potentially harmful concentrations in tissues of benthic animals or to be transferred through marine food webs to fishery species (Neff et al. 2000). The predicted affected area would be limited to within the LAA, any measurable effect on water quality would be temporary, and the product is considered to be of low toxicity. A fisheries closure would not likely be necessary, and fouling of gear would be unlikely given the relatively small spatial and temporal footprint of the spill event and limited harvested activity within the LAA. Associated social, cultural, and economic effects would also therefore be limited. Adverse effects of a drill fluid spill on Indigenous peoples are therefore anticipated to be negligible to low in magnitude.

Summary

Table 15.22 summarizes predicted residual environmental effects on Indigenous peoples and community values from various accidental event scenarios.

Table 15.22 Summary of Residual Project-Related Environmental Effects on Indigenous People and Community Values – Accidental Events

Residual Effect	Residual Environmental Effects Characterization						
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Commercial Communal Fisheries and Change in Current Indigenous Use of Lands and Resources for Traditional Purposes							
Well Blowout Incident	A	H	RAA	LT	S	R	D
10 bbl Diesel Spill	A	N-L	LAA	ST	S	R	D
100 bbl Diesel Spill	A	M	RAA	MT	S	R	D
PSV Diesel Spill	A	M	RAA	MT	S	R	D
SBM Spill	A	N-L	LAA	ST	S	R	D

KEY:
See Table 12.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area
Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

15.5.5.4 Determination of Significance

The significance of spill-related adverse effects depends on the magnitude, location and timing of a spill. A small spill offshore is unlikely to measurably affect fisheries occurring outside the MODU operational safety (exclusion) zone and therefore would not result in a significant adverse environmental effect on Indigenous people and community values. A spill of the same material and volume occurring in the nearshore environment could have potential effects on nearshore fisheries, potentially displacing

Aboriginal fishers from traditional fishing grounds for all or most of a fishing season, depending on the volume, location and timing of the spill.

Because of the widespread nature of the worst-case, unmitigated blowout incident, a significant effect is conservatively predicted for Indigenous peoples and community values for this scenario. The likelihood of this significant effect occurring is considered low, given the potential for a blowout incident to occur and given the response measures that would be in place to mitigate potential effects. In addition, while a blowout incident could potentially affect nearshore fishing and resource use along the coastline, the likelihood of oil reaching the coast is very low and the time required for oil to reach the shore would give BP and fishers time to implement mitigation against oiling of cultivation gear.

In the event of a 10 bbl diesel spill, adverse environmental effects are predicted to be not significant for Indigenous peoples and community values. This effects prediction is made with a high level of confidence based on the predictive modelling results indicating a limited spatial and temporal exposure of spilled diesel to Aboriginal fisheries and resource use in the RAA.

In recognition of variances of magnitude depending on the time of year, volume, and location of a PSV spill, a 100-bbl diesel spill scenario is also conservatively predicted to potentially result in a significant adverse environmental effect on Indigenous peoples and community values.

A medium level of confidence is assigned to the significance determination for a blowout incident, PSV spill, and 100-bbl batch spill in recognition of the variables which could cause the actual significance to be less than predicted (e.g., proximity to fishing area, timing of spill, effectiveness of response and VC-specific mitigation). None of these significant effects is considered likely to occur.

Given the predicted affected area, temporary period of measurable effect on water quality, and the low toxicity of the product, effects of a SBM spill are predicted to be not significant on Indigenous people and community values. This determination is made with a high level of confidence. A fisheries closure would not likely be necessary, and fouling of gear would be unlikely given the relatively small spatial and temporal footprint of the spill event and limited harvested activity within the LAA.

15.5.6 Commercial Fisheries and Other Ocean Users

The Project Area is located within NAFO Divisions 3KLM, while the RAA overlaps portions of NAFO Divisions 2J and 3KLMNO. Fishing effort in the RAA is generally concentrated along the continental shelf, including the slopes along the Orphan Basin, as well as on the Grand Banks and Labrador Shelf. As illustrated on Figure 7.5 (Section 7.1.4), there is a limited amount of commercial fishing effort currently ongoing within the Project Area, including within BP's ELs. Most of the commercial fishing activity in offshore Newfoundland and Labrador takes place during the summer months, typically from April to September. This timeline overlaps with the beginning of important seasonal fisheries, such as the snow crab fishery.

Domestic commercial fishing activity within the Project Area and RAA appears to be focused primarily on groundfish species, along with northern shrimp and snow crab. Between 2012 and 2016 Greenland halibut was the species with the largest landings by total weight within the Project Area, followed by northern shrimp. Between 2012 and 2016, northern shrimp was the species with the highest amount of weight landed within the RAA, followed by snow crab. Redfish and other groundfish species also comprise a large majority of commercial fish species harvested in the RAA. The RAA also contains commercial fisheries for pelagic species such as capelin, mackerel, herring, and larger fish such as shark, swordfish, and tuna. Swordfish and tuna are species that have also been highlighted as important to Indigenous groups that hold licences to fish these species (see Section 15.5.5.1).

Species harvested by international commercial fisheries outside the Canadian EEZ (potentially in areas that overlap with portions of the Project Area and RAA) include northern shrimp, snow crab, redfish, and Greenland halibut.

A variety of fishing gear and equipment is used to harvest specific species of fish within the offshore waters of Newfoundland and Labrador, including fixed gear such as pots for snow crab; mobile gear such as modified otter trawls used in the shrimp fishery; the combination of stern trawls, gillnets (which can be fixed or mobile), and longlines used in groundfish fisheries; the longlines, seines, and nets used in pelagic fisheries; and the dredges are used to harvest species such as deep-sea clams.

Species fished recreationally in the inland and coastal waters of Newfoundland and Labrador include Atlantic cod, smelt, Atlantic salmon, and trout. Coastal aquaculture operations in eastern Newfoundland include farms for blue mussels, Atlantic cod, trout, and oysters, as well as a tilapia farm on the Avalon Peninsula.

In addition to commercial and recreational fishing activity and aquaculture, other human-related activities that take place within offshore Newfoundland and Labrador (including in areas that overlap with the Project Area and RAA) include marine research, marine transportation, other offshore oil and gas activity, military operations, and subsea infrastructure, as described in Section 7.2.

Additional details regarding existing conditions for commercial fisheries and other ocean users are provided in Section 7.1 and 7.2.

15.5.6.1 Project Pathways for Effects

Accidental spill scenarios have potential to result in a change in availability of resources for commercial fisheries and other ocean users. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. The assessment is conservative (i.e., geographic and temporal overlap are assumed to occur, and modelling results assume no implementation of mitigation measures).

Potential Effects of an Oil Spill on Commercial Fisheries and Other Ocean Users

An accidental subsea blowout or marine diesel spill could interact with commercial fisheries and other ocean users by potentially impeding the ability of fishers to harvest fish, affecting the biological health of commercial fish species, reducing the marketability of commercial fish products, and interfering with marine research activities or offshore military exercises.

An accidental event could result in effects on availability of resources, access to fisheries resources, and/or fouling of fishing or cultivation gear. Although the Project is not located within an area of high harvesting activity, hydrocarbons could reach nearby areas on the continental shelf, including the slopes along the Orphan Basin, or the Grand Banks, where harvesting activity is more concentrated. Under some circumstances (e.g., nearshore PSV spill, well blowout incident), oil could reach coastal locations, potentially interacting with nearshore fisheries and aquaculture operations. As indicated in Section 15.5.1, adult free-swimming fish rarely suffer long-term damage from oil spills, primarily due to rapid dispersion and dissolution. Sedentary species, such as edible seaweeds and shellfish, are particularly sensitive to oiling (ITOPF 2011).

Section 15.5.1 evaluates the potential effects of accidental events on marine fish and fish habitat and concludes that associated residual effects are predicted to be not significant. However, adverse effects could still be realized by fishers in the event of an offshore or nearshore spill, from reduced access to fishing grounds (e.g., fisheries exclusion), reduced catches, and/or reduced marketability of fish products. Fishing gear or aquaculture cultivation gear may be lost or damaged as a result of an accidental event. The significance of the potential adverse effects depends on the nature, magnitude, location, and timing of a spill. Similarly, effects on fisheries resources can vary depending on the nature, magnitude, location and timing of a spill, and how much oil reaches the fisheries resource. Changes can also arise from other factors (e.g., natural fluctuations in species levels, variation in fishing effort, climatic effects, or contamination from other sources), making it difficult to assess implications of an oil spill itself (ITOPF 2011).

Physical and chemical characteristics of oil products, along with environmental and biological factors influence the degree to which seafood may become contaminated (Yender et al. 2002). The uptake of oil and PAHs by exposed fish poses a potential threat to human consumers and affects the marketability of catches. However, market perceptions of poor product quality (e.g., tainting) can persist even when results demonstrate safe exposure levels for consumption, thereby prolonging effects for fishers.

According to ITOPF (2011), the presence of taint, which is recognized as when a food product has an unusual odour or flavour (e.g., petroleum taste or smell), can be influenced by the type of oil, species affected, extent and duration of exposure, hydrographical conditions, and water temperature. The hydrocarbon concentrations at which tainting can occur are very low (no reliable chemical threshold has been established) with the presence of taint determined by sensory testing. If seafood is taint-free, it is considered safe to eat since contaminant levels detected during sensory testing are so low (ITOPF 2011).

Reduced demand for seafood that is perceived to be tainted can also lead to depressed market prices. As demonstrated in the Gulf of Mexico following the Deepwater Horizon oil spill, lack of consumer confidence in seafood quality and in the validity of government testing methods can have effects that persist beyond the period of actual effects. Even after federal and state testing showed Gulf seafood to be safe to eat, sales remained depressed due to lack of consumer confidence (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

Physical contamination of boats, fishing gear, and aquaculture facilities can also occur, with flotation equipment (e.g., buoys, nets, fixed traps) and shoreline cultivation facilities at higher risk. In some cases, fouling of gear can result in oil being transferred to the catch or product (ITOPF 2011).

Fishery closures may be imposed after a spill to prevent gear from being contaminated and to protect or reassure seafood consumers while the spill is being remediated. Fishery closures are usually implemented in areas (including a buffer) where: a visible sheen exists on the ocean surface, which occurs at a surface oil thickness of 0.04 µm or more; in areas (including a buffer) with detectable levels of subsurface oil; and, as a precautionary measure, in areas where surface oil is predicted to occur based on trajectory modelling (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011).

Closures typically remain in place until: an area is free of oil and oil sheen on the surface; there is low risk of future exposure based on predicted trajectory modelling; and seafood has passed sensory sampling (smell and taste) for oil exposure (taint) and chemical analysis for oil concentration (toxicity) (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling 2011). The implementation of a fishery closure would prevent localized or area-specific harvesting of fish, and potentially alleviate concerns about marketing of tainted product, but it also represents a material concern for fishers.

With respect to other ocean users, the quality of marine research could be affected through closure of survey areas, fouling of research gear, or contaminated research results due to the presence of hydrocarbons on surface water or in the water column. Offshore training exercises such as military training activities could also be affected if areas are closed due to a spill.

Indirect effects from the use of dispersants can also affect commercial fisheries and other ocean users such as researchers. If targeted fish species for research become tainted due to absorption of hydrocarbons that may be present in the water column, then it may negatively influence the research results. After the Deepwater Horizon spill, the US Food and Drug Administration conducted laboratory tests on the effects of a commonly used dispersant on eastern oyster, blue crab, and red snapper and found little to no bioaccumulation; the dispersant was depurated from the organisms' tissues with 24 to 72 hours (Tjeerdema et al. 2013). Seafood species collected during the Deepwater Horizon spill detected dioctylsulfosuccinate sodium salt, a highly water-soluble component of dispersants, in 4 of 299 tissue samples and determined that it was unlikely to pose a risk to aquatic receptors due to low tissue concentrations, low bioaccumulation, and rapid depuration (Tjeerdema et al. 2013).

Previous studies have shown little or no risk of drilling base chemicals to bioaccumulate to potentially harmful concentrations in tissues of benthic animals or to be transferred through marine food webs to fishery species (Neff et al. 2000).

15.5.6.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. Refer to Section 15.1 for information on BP's approach to risk management, Section 2.5 for specific information on well control and blowout prevention, and Section 15.3 for a description of BP's contingency planning and emergency response measures.

BP will undertake a SIMA / NEBA as part of the OA process with the C-NLOPB. The SIMA is a structured process that will qualitatively evaluate the risks and trade-offs of all feasible and effective response options, when compared to no action. The SIMA process will inform the selection of an overall spill response strategy for the Project. If identified as a preferred response option, use of chemical dispersants would not occur without first obtaining regulatory approval.

Specific mitigation to reduce effects from an accidental spill on fisheries also includes compensation for gear loss or damage caused by the spill. Specific measures to be implemented by BP to mitigate adverse environmental effects on commercial fisheries and other ocean users include the following:

- Implementation of a Fisheries Communication Plan which would include procedures for informing fishers of an accidental event and appropriate response. Emphasis is on timely communication, thereby providing fishers with the opportunity to haul out gear from affected areas, reducing potential for fouling of fishing gear.

- Compensation for damage to gear in accordance with *Compensation Guidelines Respecting Damages Relating to Offshore Petroleum Activity* (C-NLOPB and CNSOPB 2017).

In the unlikely event of a spill, specific monitoring (e.g., environmental effects monitoring) and follow-up programs may be required and will be developed in consultation with regulatory agencies, Indigenous groups, and fisheries stakeholders as applicable.

15.5.6.3 Characterization of Residual Project-Related Environmental Effects

Subsea Blowout

A well blowout has the potential to result in a change in availability of resources for commercial fisheries and other ocean users. The extent of the potential effects will depend on how the spill trajectory and the activities and resources of commercial fisheries and other ocean users overlap in both space and in time.

The threshold of 0.04 μm (visible sheen threshold) was used for spill trajectory modelling of surface oiling in recognition of the possibility of a fisheries closure occurring at this threshold (refer to Table 15.9); 0.04 μm is therefore a threshold for a change in availability of resources in this assessment. A threshold is also needed to account for the possibility that dissolved concentrations of oil in the water column could cause real or perceived contamination or tainting of commercial fisheries resources. As noted in Section 15.5.6.1, the hydrocarbon concentrations at which tainting can occur are very low (no reliable chemical threshold has been established) with the presence of taint determined by sensory testing (ITOPF 2011). For the purpose of this assessment, it is assumed that the 58-ppb in-water THC threshold for acute exposure of aquatic species that was established in Section 15.5.1 is a reasonable threshold for potential taint of commercial fisheries resources, although it is acknowledged that the perceived taint of commercial fisheries resources (and the associated potential reduction in the marketability of commercial fish products) could potentially occur at variable concentrations and depending on the commercial species. Refer to Section 15.5.1 for discussion of potential environmental effects on marine fish (including marine fish of commercial importance) related to in-water THC concentrations above 58 ppb, as well as the potential spatial extent of those effects as indicated by Project-specific modelling results.

Stochastic modelling results for a continuous, 120-day unmitigated blowout from a wellsite in the West Orphan Basin or the East Orphan Basin indicate that the geographic extent of a residual change in availability of resources for commercial fisheries and other ocean users (using surface oiling with an emulsified oil thickness of 0.04 µm as an effect threshold) could spread beyond the RAA. Environmental effects related to surface oiling at thicknesses above 0.04 µm would be anticipated to occur over the greatest potential area in the event of a blowout during the winter season in the West Orphan Basin, followed by (in descending order of spatial extents for potential areas of threshold exceedance), a blowout during the winter season in the East Orphan Basin, a blowout during the summer season in the West Orphan Basin, and a blowout during the summer in the East Orphan Basin (refer to Table 7.1 in Appendix D).

Some seasonal variation in the movement of oil following a release is expected. The stochastic modelling results reflect that west to northwesterly winds and higher frequency and strength of surface currents towards the south and south southeast during the winter months would transport oil released from the representative West Orphan Basin wellsite further south during the winter season, while the predominant southwesterly winds would transport the oil away from the Avalon coastline in the summer months. The same seasonal variation in the movement of oil was predicted for a blowout from the East Orphan Basin, with a higher potential for surface oil contamination to the south during winter months. The spatial extent of the heaviest maximum surface emulsion thickness around each wellsite (i.e., BAOAC “continuous true oil colour” [thickness of 200 µm or more]) on the sea surface would be greater in the summer, as a result of decreased wind and wave action and an associated decrease in the dispersal and entrainment of oil in the water column (refer to Figures 7.7 and 7.17 in Appendix D). As indicated in Section 7.2.4, the majority of commercial fishing activity in offshore Newfoundland and Labrador takes place during the summer months, typically from April to September.

As shown on Figures 15.9 and 15.13, there is a very high probability of surface oiling (in excess of 0.04 µm) from an unmitigated blowout leaving the Project Area and reaching nearby offshore areas where commercial fishing effort is considerably more concentrated (such as those shown on Figure 7.5). Stochastic modelling indicates that the minimum length of time for oil to reach threshold concentrations (0.04 µm for surface oiling) in these offshore areas is approximately one to five days (refer to Figures 5.10 and 15.4), which may not allow sufficient time to notify commercial fishers of the spill and prevent the setting or hauling of gear in the affected area. Fouling of gear and/or catch of contaminated resources could therefore occur.

Surface oiling from a subsea blowout scenario or a diesel spill from a PSV could adversely affect nearshore commercial fisheries as well as coastal aquaculture sites, particularly those on the Avalon Peninsula (refer to Figure 7.35). As previously noted, stochastic modelling for continuous, 120-day unmitigated blowout in the West Orphan Basin predicts the probability of sea surface oil contact exceeding the 0.04 µm thickness threshold in nearshore waters of the Avalon Peninsula would be 0% during the summer season but would increase to 5% in the winter months. In the event that this surface oil enters the nearshore area of Newfoundland during the winter season, it would take a minimum of 50 days to arrive. The duration of surface exposure for nearshore waters of Newfoundland would be 0 to 1 day. For East Orphan Basin, the stochastic modelling results for the worst exposure scenario indicate a 1% probability of surface oil being present in the near-coastal waters of the Avalon Peninsula during the winter months. It would take a minimum of 70 days to arrive and the duration of surface exposure would be less than one day. These minimum arrival times would provide an opportunity to notify fishers of the spill and prevent the setting or hauling of gear in the affected area. Fouling of gear and/or catch of contaminated resources would therefore be reduced or avoided.

While the effects of oil on aquaculture are similar to other commercial fisheries (i.e., potential for fouling of cultivation gear, tainting of fish, and temporary shutdown of operations), aquaculture operations are unique in the type and variety of mitigation that can be used to limit effects of spills if operators are notified in a timely manner. This can include moving floating facilities to avoid slicks and the transfer of stock to areas unlikely to be affected; however, these mitigation measures can be technically, logistically or financially challenging (ITOPF 2004). Other options include temporary suspension of water intakes for shore tanks, ponds or hatcheries to isolate stock from potential oil contamination and suspension of feeding (ITOPF 2004). A SIMA / NEBA would conducted by BP which would consider proximity to aquaculture operations that may be adversely affected by oil concentrations in water and the effects of any response tactics, including dispersant use, on those operations.

Depending on the duration and volume of the release following a blowout incident and the effectiveness of mitigation measures, closure areas may not be widespread and fishers may also be able to fish in alternative areas.

Marine Diesel Spill

Stochastic modelling results indicate that batch spills from the MODU (10 bbl and 100 bbl) are not likely to result in effects over a large area (Figures 15.29 to 15.32). Accidental discharges of marine diesel resulted in limited modelled effects. However, the spatial extent of 0.04 µm threshold exceedances for surface effects are expected to occur over a greater area if a spill occurs during the summer season compared to the winter months. As noted above, the majority of commercial fishing activity in offshore Newfoundland and Labrador takes place during the summer months, typically from April to September.

For the 100-bbl spill scenarios in both West Orphan Basin and East Orphan Basin, modelling results indicate that the duration of exposure to surface oil exceeding 0.04 µm in thickness ranges from 12 to 18 hours in the immediate vicinity of the release location to less than 6 hours at the majority of locations further away (refer to Figures 8.3 and Figure 8.9 in Appendix D). Deterministic simulations indicate that approximately 60% of the spill evaporates from the surface within three days following the release, with remaining proportions dispersing or biodegrading within the same period. A nearshore vessel diesel spill would be expected to behave similarly.

Refer to Sections 15.5.1.3 and 15.5.2.3 for consideration of the results of deterministic modelling conducted by RPS in support of Nexen Energy’s Flemish Pass Exploration Drilling Project for a hypothetical release of 750,000 L of diesel from a PSV over 30 days at a location between St. John’s and Nexen Energy’s project area.

Diesel fuel is considered to result in a moderate to high risk of seafood contamination because of the relatively high content of water-soluble aromatic hydrocarbons, which are semi-volatile and evaporate slowly (Yender et al. 2002). The risk of interference with marine research activities or offshore military exercises would be low.

SBM Spill from the MODU and the Marine Riser

All substances that comprise drilling muds are screened through a chemical management system in consideration of the OCSG (NEB et al. 2009). Previous studies have shown little or no risk of drilling base chemicals to bioaccumulate to potentially harmful concentrations in tissues of benthic animals or to be transferred through marine food webs to fishery species (Neff et al. 2000). The predicted affected area would be limited to within the LAA, any measurable effect on water quality would be temporary, and the product is considered to be of low toxicity. A fisheries closure would not likely be necessary, and fouling of gear would be unlikely given the relatively small spatial and temporal footprint of the spill event and limited harvested activity within the LAA.

Summary

Table 15.23 summarizes predicted residual environmental effects on commercial fisheries and other ocean users from various accidental event scenarios.

Table 15.23 Summary of Residual Project-Related Environmental Effects on Commercial Fisheries and Other Ocean Users – Accidental Events

Residual Effect	Residual Environmental Effects Characterization						
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Change in Availability of Resources							
Well Blowout Incident	A	H	RAA*	LT	S	R	D
10 bbl Diesel Spill	A	L	LAA	ST	S	R	D
100 bbl Diesel Spill	A	M	RAA	MT	S	R	D
PSV Diesel Spill	A	M	RAA	MT	S	R	D
SBM Spill	A	L	LAA	ST	S	R	D

KEY:
See Table 13.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
Magnitude:
N: Negligible
L: Low
M: Moderate
H: High

Geographic Extent:
PA: Project Area
LAA: Local Assessment Area
RAA: Regional Assessment Area; in certain scenarios, effects may extend beyond the RAA as indicated by an "*"
Duration:
ST: Short-term
MT: Medium-term
LT: Long-term

Frequency:
S: Single event
IR: Irregular event
R: Regular event
C: Continuous
Reversibility:
R: Reversible
I: Irreversible
Ecological/Socio-Economic Context:
D: Disturbed
U: Undisturbed

15.5.6.4 Determination of Significance

The significance of spill-related adverse effects depends on the magnitude, location and timing of a spill. A small spill offshore is unlikely to measurably affect fisheries and other ocean uses occurring outside the MODU operational safety zone and therefore would not result in a significant adverse environmental effect on commercial fisheries and other ocean users. A spill of the same material and volume occurring in the nearshore environment could have potential effects on nearshore fisheries, potentially displacing commercial fishers from their customary fishing grounds for all or most of a fishing season, depending on the volume, location and timing of the spill.

Because of the widespread nature of the worst-case, unmitigated blowout incident, a significant effect is conservatively predicted for commercial fisheries and other ocean users for this scenario. The likelihood of this significant effect occurring is considered low, given the potential for a blowout incident to occur and given the response measures that would be in place to mitigate potential effects. In addition, while a blowout incident could potentially affect nearshore fishing and other ocean uses along the coastline, the likelihood of oil reaching the coast is very low and the time required for oil to reach the shore would give BP and fishers or aquaculture operators time to implement mitigation against oiling of cultivation gear.

In the event of a 10-bbl diesel spill, adverse environmental effects are predicted to be not significant for commercial fisheries and other ocean users. This effects prediction is made with a high level of confidence based on the predictive modelling results indicating a limited spatial and temporal exposure of spilled diesel to commercial fisheries and other ocean uses in the RAA.

In recognition of variances of magnitude depending on the time of year, volume, and location of a PSV spill, a 100-bbl diesel spill scenario is also conservatively predicted to potentially result in a significant adverse environmental effect on commercial fisheries and other ocean users.

A medium level of confidence is assigned to the significance determination for a blowout incident, PSV spill, and 100-bbl batch spill in recognition of the variables which could cause the actual significance to be less than predicted (e.g., proximity to fishing area, timing of spill, effectiveness of response and VC-specific mitigation). None of these significant effects is considered likely to occur.

Given the predicted affected area, temporary period of measurable effect on water quality, and the low toxicity of the product, effects of a SBM spill are predicted to be not significant on commercial fisheries and other ocean users. This determination is made with a high level of confidence. A fisheries closure would not likely be necessary, and fouling of gear would be unlikely given the relatively small spatial and temporal footprint of the spill event and limited harvested activity within the LAA.

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