8.0 ACCIDENTAL EVENTS

BP uses a systematic process 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 behavior modelling that has been undertaken for the Project (refer to Section 8.4 and Appendix H). 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 (DWH) incident and other industry incidents.

Detailed information about reasonably foreseeable events which could impact worker safety will be presented in the Safety Plan and Incident Management Plan (IMP) (and associated Spill Response Plan (SRP)). Additionally, an emergency response plan for the MODU will be provided. Details about environmental management measures which will be put in place will be submitted in the Environmental Protection Plan (EPP). The Safety Plan, IMP, SRP and EPP will be submitted to the CNSOPB as part of the Operations Authorization (OA) process.

8.1 POTENTIAL ACCIDENTAL EVENTS

8.1.1 Risk Management within BP

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 control to govern the way in which BP operates and manages its risks.

There are a number of tiers to BP's risk management philosophy to ensure 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.

- **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 and relevant committees provide oversight to identify, understand and endorse management of significant 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 significant risks, and dedicated board committees review and monitor certain risks throughout the year.

BP has dedicated organizations within the company to ensure 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 businesses identify and manage the risks, as described above in day-to-day risk management. They are also required to carry out self-verification, and are subject to independent scrutiny and assurance.

- BP's safety and operational risk (S&OR) team works alongside operating businesses to set clear requirements; maintain an independent view of operating risk; 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 visit sites across the globe to evaluate how they are managing risks.

8.1.2 Barrier Philosophy

One of the key tools that BP uses to manage risk is the barrier philosophy, illustrated in Figure 8.1.1.

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). An undesirable event can occur as a consequence of a hazard, which is a situation with the potential to cause adverse effects. An example of a hazard includes pressure within the wellbore, which can give rise to a loss of well control. 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 will be put in place to mitigate and minimize the negative consequences associated with the event.

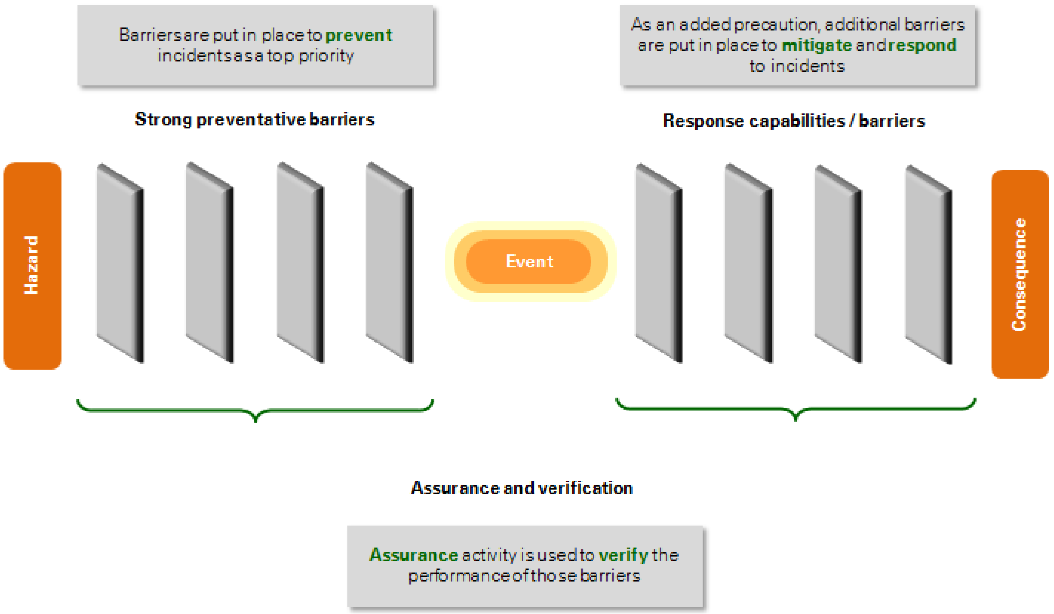


Figure 8.1.1 Risk Barrier Philosophy

Multiple preventative and response barriers are put in place to manage the risk, both in terms of the incident arising in the first place, and to mitigate and respond to incidents to manage the potential consequences. This is illustrated in Figure 8.1.1.

BP has assessed the risks associated with the Project and has identified barriers that will be in place to prevent and mitigate the identified risks. In order to be effective, each of these barriers needs to be robust. 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 deepwater drilling risk prevention and management. These improvements are built on the lessons learned as a result of the Deepwater Horizon (DWH) incident and response in 2010. Standardized global requirements for well design and construction are used by BP to reduce risk of a major accident. Additional and strengthened preventative and response barriers to manage risk have been embedded in the following key areas as described below.

People

BP has a single, centralized global wells organization (GWO) which is responsible for embedding standardization and a consistent approach to the delivery of wells-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 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 consistent and structured well control competency training to assure competency in key capability areas. BP's training facilities have received accreditation by the International Association of Drilling Contractors (IADC) and the International Well Control Forum (IWCF) to teach, test and provide certification to those attending its drilling well control courses.

BP also works closely with contractors to deliver safe, compliant and reliable performance. 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.

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.

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, rig contactor procedures are in place to prevent and mitigate potential effects from bulk, operational and maintenance spills.

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

Process and Equipment

BP carries out a number of equipment and process checks for equipment used during drilling operations. This includes regular checks on the BOP and well control equipment before and during drilling operations. Additionally, the mobile offshore drilling unit (MODU) that will be used for drilling operations will be subject to a rig intake process. 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 practices 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 in offshore Nova Scotia, BP will use a real-time monitoring center 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 to develop industry standards.

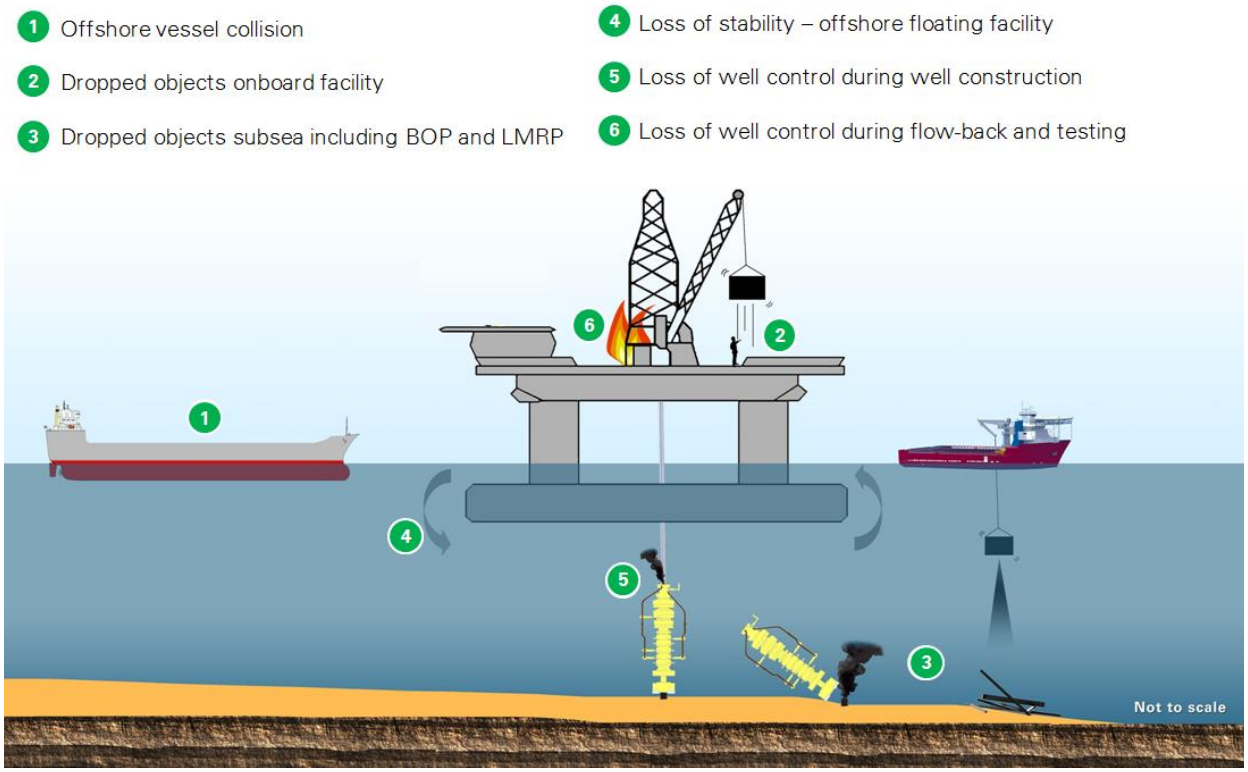
8.1.3 Potential Accidental Risk Scenarios

A number of potential accidental risk events that could occur during drilling activity have been identified. A summary of these events and the associated preventative and response barriers is presented below. 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.

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 which is described in detail in the Project Description, Section 2.

Accidental risk events that could occur during Project operations are illustrated in Figure 8.1.2. The accidental events are further described below in terms of 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 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 8.1.2 Exploration Drilling Accidental Risks

8.1.3.1 Offshore Vessel Collision

As described in Section 5.2.3.2, several established shipping routes are used for international and domestic commercial shipping in Canadian waters. Additionally, platform supply vessels (PSVs) will be used to support the drilling operations. One of the PSVs will remain on standby outside the MODU's 500-m safety (exclusion) zone at all times in the event that operational assistance or emergency response support is required, while the 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.

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

Additionally, robust 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. 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 the Project Description, Section 2. Robust vessel and MODU operator procedures will be used, defining a process for collision assessment, communication protocols and procedures for the use of navigation equipment and alarms, which will be used by competent personnel.

The Project will use weather and natural hazard preparedness processes to monitor for and respond to extreme weather events. These processes will identify conditions when precautionary riser unlatching or rig evacuations are required.

Some 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. Additionally, 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 are in place to reduce the possibility of these consequences arising, such as fire and explosion suppression and protection systems, evacuation and escape protocols, and emergency unlatching protocols. Additionally, emergency response containment and recovery operations will reduce adverse consequences resulting from a spill event.

8.1.3.2 Dropped Objects

Dropped objects refers to items accidentally falling either onboard the MODU structure, (*i.e.*, from a crane on to 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 8.1.2 above. Subsea infrastructure could refer to non-Project equipment, such as third party pipelines, or project equipment, such as the BOP and the lower part of the riser which connects to the BOP, often referred to as the lower marine riser package (LMRP). There is no third-party subsea infrastructure, including pipelines, in the exploration licences (ELs) as illustrated in Section 5.3.4.

Large objects dropped from height pose a health and safety risk as personnel could be injured or killed, and there is also potential for dropped objects to damage the MODU. Damage to the MODU could result in the loss of primary containment and the release of hydrocarbons into marine waters.

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 Section 2.3.1.1 and 9.2, potential meteorological conditions are considered during the MODU selection process to confirm that the MODU is capable of operating in harsh, deepwater environments. The Project will use weather forecasting to monitor and prepare for a response to extreme weather.

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). When results of the investigation are available, BP will work with regulators to apply lessons learned from the incident.

There is a low potential for response 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 prevent harmful consequences from arising. These include active and passive fire and explosion prevention and suppression equipment and systems and procedures to prevent ignition of any released hydrocarbons. Additionally, 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 emergency response containment and recovery operations and well intervention plans. Further information about these response barriers is provided below.

8.1.3.3 Loss of MODU Stability or Structural Integrity

As described in Section 2.3.1, the Project is likely to 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 in which 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 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 also 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 ensure that the MODU is operated correctly, including careful control of variable deck load by competent personnel. Robust MODU design, including the use of inherently safe design systems, is tested through the rig intake and marine assurance process. Maintenance and inspection processes are designed to test and regularly check equipment to confirm that it is still operating. As identified in Section 8.1.2, competent personnel are of primary importance in the correct implementation of procedures. As stated previously, the Project will use weather and natural hazard preparedness processes, such as weather forecasting tools as defined in Section 9. If the rig loses position, an emergency disconnect protocol is in place that will allow the well to be shut in and the rig to move off location.

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.

8.1.3.4 Loss of Well Control during Well Construction and Well Testing

A number of well control measures are put in place as part of drilling operations to maintain control of wellbore fluid pressures. Should 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 two wells 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 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. The density (*i.e.,* weight per given volume) of the drilling fluid is controlled to maintain an overbalance of pressure against the formation, which keeps the wellbore stable. 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.

As described previously, only highly trained and competent personnel are authorized to supervise operations, and BP has a number of programs 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 center in Houston.

BP uses standardized planning and design procedures and all drilling operations are carried out in line 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. Additionally, 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. BP uses bridging documents to define roles and responsibilities for personnel and 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 reprocessed seismic data from the BP Tangier 3D WATS survey, geotechnical cores 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 American Petroleum Institute (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 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 and explosion protection and H_2S monitoring equipment. Evacuation and escape procedures for personnel will be in place. Additionally, emergency response plans 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 8.2.3. Additionally, response measures to a blowout incident are detailed in Section 8.3.

8.2 POTENTIAL SPILL SCENARIOS

Some of the potential accidental risk events described above could result in a release of hydrocarbons, chemicals or emissions, resulting in adverse environmental effects. Additionally, there are some potential operational spill events that could result from anywhere that hydrocarbons or chemicals are stored or transferred on the MODU or PSVs.

Key categories of potential spill events that could occur on the MODU and/or PSVs are described in Sections 8.2.1 to 8.2.3.

In addition to the potential spills from oil and gas activity, offshore oil spills could occur from a number of anthropogenic sources in the region. For example, tankers transport 82 million tonnes of petroleum products in and out of 23 ports in Atlantic Canada, and there are approximately 3,890 tanker movements along the east coast per year (Transport Canada 2015). Significant tanker spills have occurred in waters in and near Nova Scotia, including the *SS Arrow* which ran aground in February 1970 releasing over 10,000 tonnes of oil. Additionally, urban run-off and onshore industrial facilities can contribute to spilled hydrocarbons. Furthermore, natural seeps of hydrocarbons from the sea floor are present in the region; however, there is no quantification of volumes that are released into waters around Nova Scotia.

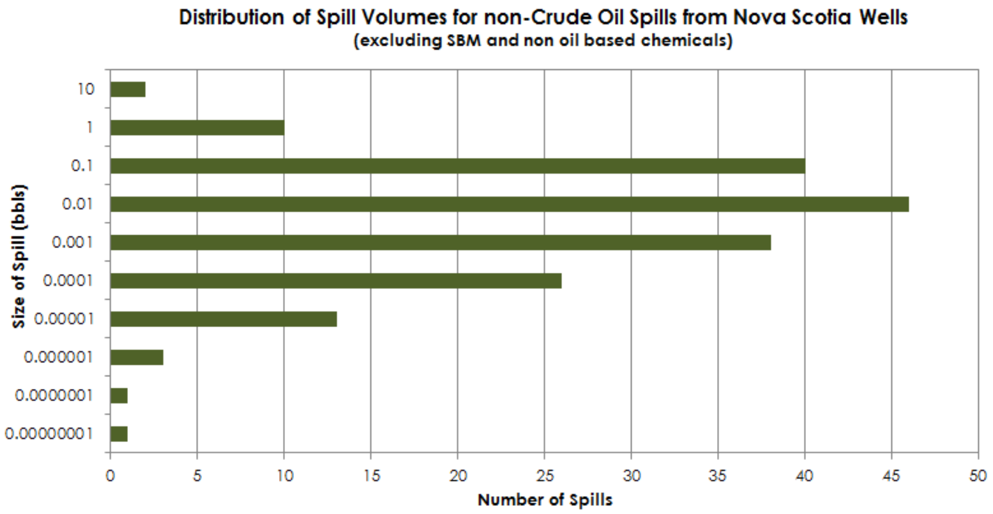
Historic industry data, including data from the CNSOPB, has been used to provide information about trends of accidental spill events from oil and gas activity in Nova Scotia and other regions. Analysis shows that the probability of a well blowout incident or other release is very low. Well-related spills occur infrequently during offshore operations. Of the spills that do occur, most spills involve releases of less than 100 barrels (bbl) over the course of less than one day. Large-scale exploratory well blowout incidents are very rare events (ERC 2014; Appendix F of Stantec 2014a).

Credible spill event scenarios considered in this effects assessment are described below. Further information is provided in Sections 8.4 and 8.5.

8.2.1 Spills during Operations and Maintenance

Spills which could occur during operations and maintenance activity are likely to be small volume, instantaneous release events which could arise where hydrocarbons, such as diesel, lubricants, or drilling fluids are spilled during handling, storage or transfers.

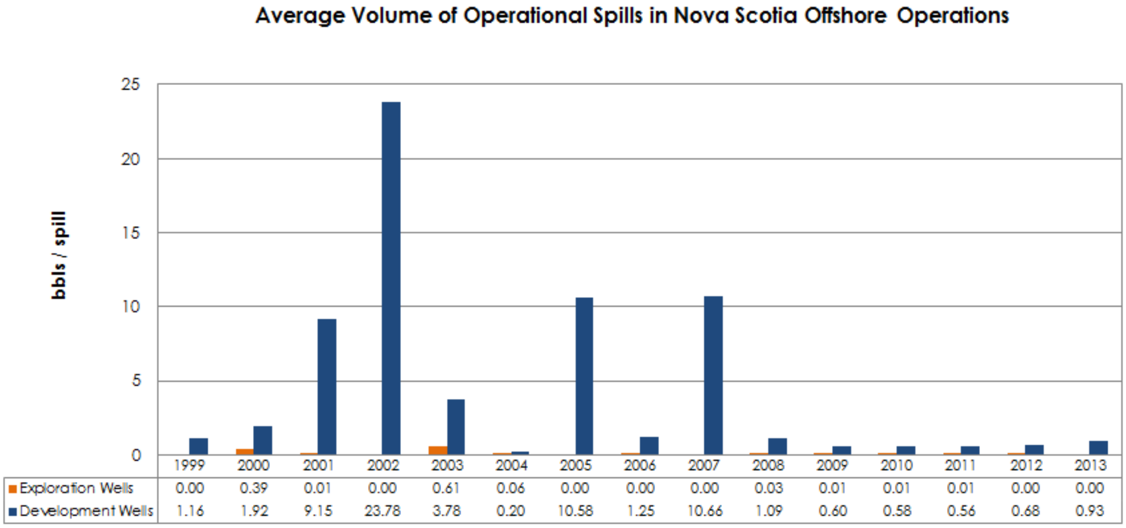
Small operational and maintenance spills are the most probable spill events that could occur during drilling operations. Historical data for spills of this type at wells in Nova Scotia (sourced from CNSOPB for the period 1999 to 2010) are provided in Figure 8.2.1. During this time, 53 exploration and development wells were drilled. The vast majority of non-crude, oil based chemicals (*e.g.*, diesel or kerosene) spills that have occurred in Nova Scotia, and have been reported to CNSOPB are less than 1 bbl in volume. Very small spills (*i.e.*, those under 20 ml) may not have been detected; consequently, spills of this magnitude may be underreported in this data.



Source: Modified from ERC 2014

Figure 8.2.1 Distribution of Non-Crude Spill Volumes for Nova Scotia

Figure 8.2.2 shows the frequency and average volume of small to medium spills from both exploration and development wells drilled in Nova Scotia between 1999 and 2013. These data do not show crude spills or synthetic-based mud (SBM) spills. Over this time, a total of 88 bbl of refined products were spilled over 189 different spill events. The data show that on average, non-crude and non-SBM spills between 1999 and 2013 were small in nature; the average spill volume was 0.4 bbl.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
■ Exploration Wells	0.00	0.39	0.01	0.00	0.61	0.06	0.00	0.00	0.00	0.03	0.01	0.01	0.01	0.00	0.00
■ Development Wells	1.16	1.92	9.15	23.78	3.78	0.20	10.58	1.25	10.66	1.09	0.60	0.58	0.56	0.68	0.93

Source: Modified from ERC 2014

Figure 8.2.2 Average Volume of Operational Spills in Offshore Nova Scotia

Possible causes of these small to medium non-crude oil spills include leaks from pipes, hoses, connections, flanges or valves. These spills could occur during loading, discharging and bunkering operations and tend to be higher frequency events with less severe consequences. Such spills are most likely to occur onboard drilling rigs or vessels, where they may be more easily contained and have a lower probability of reaching the marine environment.

Secondary containment systems are used where bulk or drummed chemicals and hydrocarbon based products are stored. Additionally, 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.

An operational diesel spill of 10 bbl from the MODU has been modelled as part of the spill fate and behaviour modelling work, further described in Section 8.4.3. A summary of results is provided in Section 8.4.9, and effects of this spill scenario are assessed in Section 8.5.

8.2.2 Bulk Spills

Bulk spills, which can 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. The bulk spill category includes a number of small to medium size releases from a variety of potential incidents.

Further to the information on potential accidental risk scenarios provided in Section 8.1.3, a number of potential bulk 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 bad weather before which fluids are removed. Additionally, a hose or tank failure during bunkering operations on the PSV or MODU could result in a release of hydrocarbons.

Bulk spills refer to a range of spill events and 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 robustly designed equipment and process, 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.

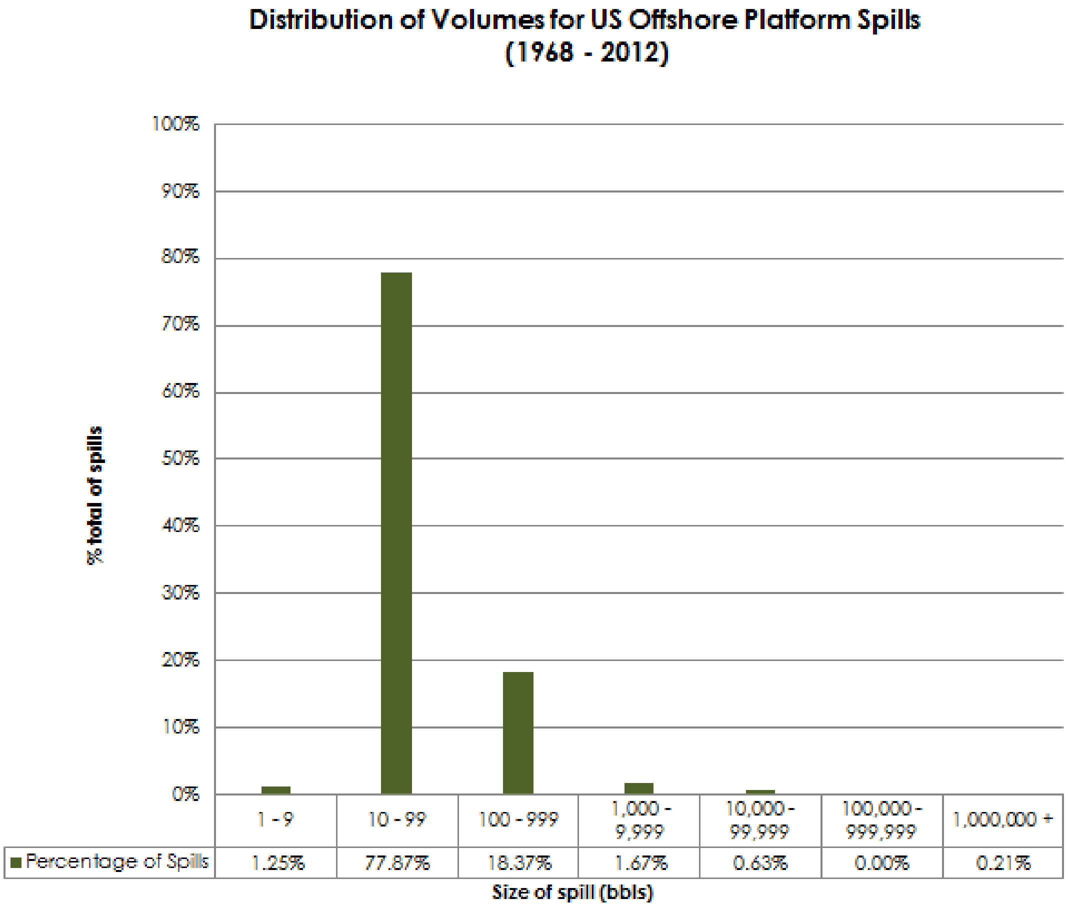
Bunkering transfer procedures will be used to define roles and responsibilities for personnel involved in transfer operations. Transfers will not be undertaken without completing a risk assessment process through the permit to work process. Dry-break hose couplings will be used to minimize the risk of 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 8.1.3.1, 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.

The riser used in drilling, that will circulate drilling fluid and cuttings between the MODU and the wellbore, will be confirmed to have been 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 as part of the unlatching process. Procedures will be in place to minimize the risk of an unintentional unlatching (refer to Section 8.1.3.2 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).

Bulk spills have occurred historically in Nova Scotia. For example, in 2004, a 2,226 bbl spill of SBM drilling fluid occurred as a result of an equipment failure at an exploration well (CNSOPB 2004). SBM is a heavy, dense fluid used during drilling operations to lubricate the drill pipe and balance formation pressure. SBM could be accidentally released from a surface tank discharge, riser flex joint failure or a BOP disconnect.

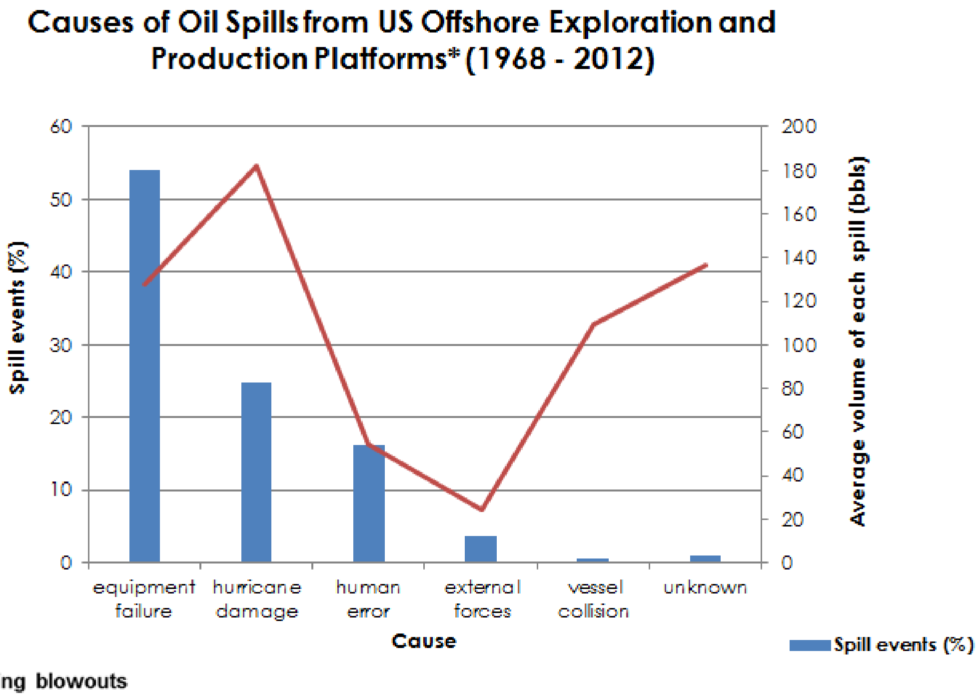
Industry trends show that bulk spills are less frequent than small operational and maintenance spills. Figure 8.2.3 illustrates the higher prevalence of medium size spills (10 to 99 bbl and 100 to 999 bbl) relative to other sizes of spills from offshore exploration and production platforms in the United States (US) over 45 years from 1968 to 2012.



Source: Modified from ERC 2014

Figure 8.2.3 Distribution of Volumes of Spills from US Offshore Platforms

The same data set, taken from offshore exploration and production facilities in the US between 1968 and 2012, shows the majority of spills are caused by equipment failure. Extreme weather events also play a substantial contributing role, accounting for nearly 25% of all spill events. Much of the data available for US offshore platform would have been derived from platforms in the Gulf of Mexico. The Gulf of Mexico is a hurricane prone area; therefore, these data are likely to include a higher percentage of hurricane related spills than may be expected in other regions, such as the North Atlantic.



* excluding blowouts

Source: Modified from ERC 2014

Figure 8.2.4 Causes of Oil Spills from US Offshore Exploration and Production Platforms (1968-2012)

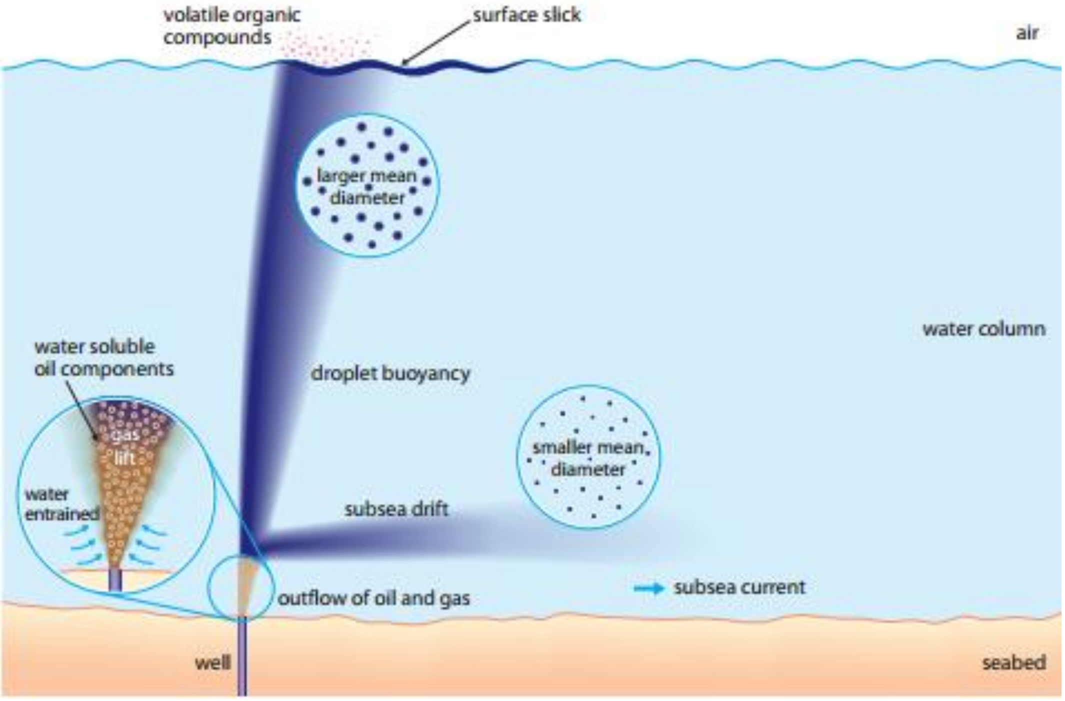
A bulk spill of 100 bbl of diesel from the MODU has been modelled as part of the spill fate and behaviour modelling work as explained in Section 8.4.3. A summary of results is provided in Section 8.4.9; effects are assessed in Section 8.5. Additionally, the effects of a bulk diesel release from a PSV (*e.g.*, 10 bbls in the nearshore environment) have been considered in the effects assessment in Section 8.5.

Project-specific modelling was not conducted for a SBM spill scenario. Instead, modelling conducted for the Shelburne Basin Venture Exploration Drilling Project EIS was consulted to inform the assessment (refer to Appendix C in Stantec 2014a). A summary of SBM spill modelling results is provided in Section 8.4.10; effects are assessed in Section 8.5.

8.2.3 Well Blowout Incident

As previously described in Section 8.1.3.4, 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 brine, water, gas or 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, it is referred to as a kick. The severity of the kick depends on the reaction time of the drill crew, the porosity 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 8.1.3.4.

In the extremely unlikely event where primary and secondary well control measures have failed, hydrocarbons would be released from the BOP into the ocean. A subsea well blowout incident is described below and illustrated in Figure 8.2.5 (IPIECA-OGP 2015).



Source: IPIECA-OGP 2015

Figure 8.2.5 Blowout Incident Schematic

- High-velocity jets of oil and methane 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 in depth), 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 blowout incident has occurred in offshore Nova Scotia. The Uniacke G-72 incident occurred on February 22, 1984. The incident occurred at a gas well that was being drilled 150 nautical miles from Halifax by the semisubmersible 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 and approximately 1,500 bbl of gas condensate was released in total. Between 1.11 to 1.83 million m^3 / day of natural gas was released. The well was declared static 10 days after the initial release after a team of specialists boarded the Vinland and pumped mud down the choke line (Gill *et al.* 1985).

Historical data indicates that the probability of a blowout incident is extremely low. It is estimated that for wells with a subsea BOP installed, including shear rams and following the two-barrier principle, the frequency of a blowout incident is 3.1×10^{-4} (0.00031, or 0.031%) per exploration well drilled (OGP 2010 and DNV 2011). This probability estimate is based on data from the Gulf of Mexico, United Kingdom (UK) and Norway between 1980 and 2004. These data 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 DWH 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 two variable pipe rams and one fixed diameter ram;
- regular system and pressure testing of BOP;
- third-party verification of BOP testing and maintenance; and
- onshore remote monitoring to support well operations.

Detailed information on emergency preparedness and response is presented in Section 8.3, including specific lessons learned following the DWH incident.

Spill fate and behaviour modelling has been conducted for a well blowout incident in two potential locations within the ELs. Assumptions and background information about the modelling work are provided in Section 8.4; effects are assessed in Section 8.5.

8.3 EMERGENCY RESPONSE AND SPILL MANAGEMENT

BP prioritizes activities and takes measures to reduce the probability of incidents, including oil spills, from occurring through the use of prevention barriers. Additionally, 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 and contractors, the environment, company assets and neighbouring communities, environmental damage and 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 will 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.

8.3.1 Incident Management Plan and Spill Response Plan

The Project will operate under an IMP to define the response to incidents. The IMP will be a comprehensive document including practices and procedures for responding to an emergency event. The IMP will include, or reference, a number of specific contingency plans for responding to specific emergency events, including potential spill or well control events.

The IMP and supporting specific contingency plans, such as the SRP will be aligned with applicable regulations, industry practice and BP standards and will include response scenarios, strategies and capabilities. These plans will be submitted to CNSOPB 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.

To ensure readiness, emergency exercises and drills will be conducted to test the plans. 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 IMP will describe the overarching response measures to respond to an emergency event, irrespective of the size, complexity or type of incident. Specifically, it will define the response organization and roles and responsibilities, and will include notification and reporting procedures. It will be designed to ensure an efficient and timely response.

As part of the IMP, BP will prepare an SRP. The SRP will satisfy BP's planning requirements and will be designed to fulfil all of the information required as part of the OA process. The SRP will include a risk assessment and detailed description of how BP's preventative measures reduce the likelihood of spills occurring. It will also include response information for a variety of potential spill scenarios, the response organization structure, roles and responsibilities, and the procedures for notification and reporting. The SRP will describe the mobilization and deployment of equipment and personnel and will include information about how to monitor and predict spill movement to facilitate an effective response. Information about source control will be included as part of the IMP and SRP documentation, describing how resources will be deployed to respond to a loss of well control incident. Information about environmental and socio-economic sensitivities and potentially affected Aboriginal groups and stakeholders will also be included in the plans.

BP will include tactical response measures within the SRP to clarify procedures and strategies for safely responding to different spill scenarios. The plan 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.

The Project will adopt a tiered approach for spill response and preparedness, as per International Petroleum Industry Environmental Conservation Association (IPIECA) guidelines, for planning the response to oil spills. The tiered response definitions are as below in Table 8.3.1.

Table 8.3.1 Tiered Level Response Description (from IPIECA 2015)

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.

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.

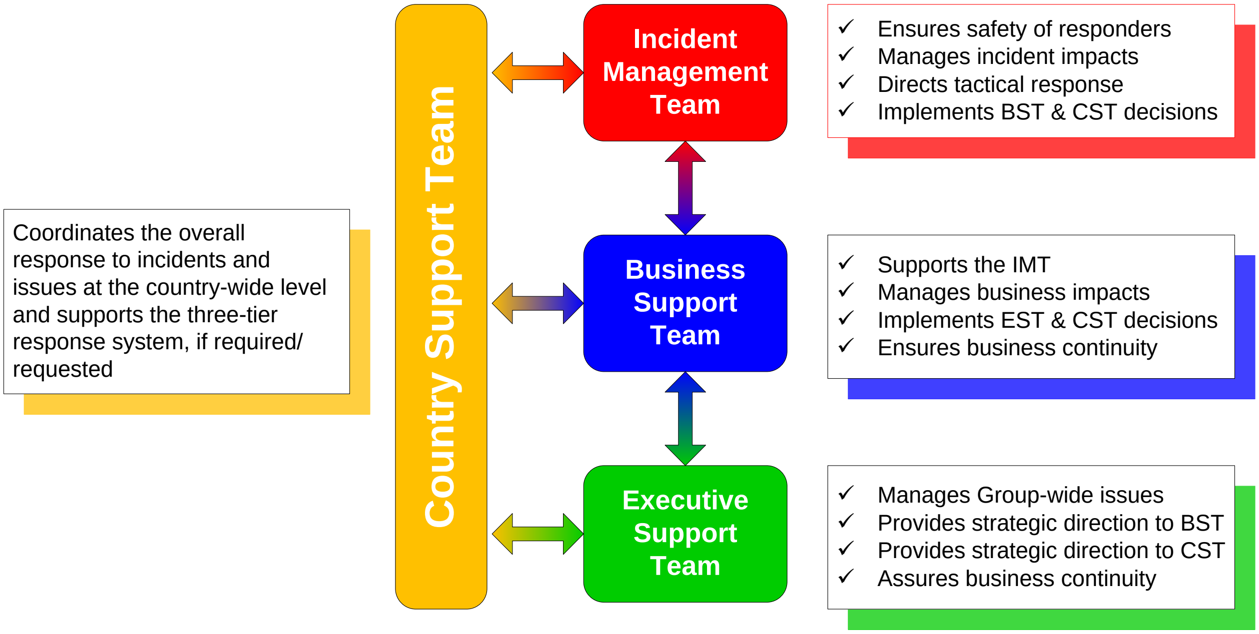
The selection of appropriate response methods and equipment will be determined by the specific nature of the incident and the environmental conditions at the time of the incident; however, indicative strategies that may be applied during response to an oil spill are described in Section 8.3.3 below.

8.3.2 Response Co-ordination and Management

BP's incident management organization is based upon a scalable system illustrated in Figure 8.3.1. This structure is designed to co-ordinate an efficient, timely and effective response using teams based at the worksite, BP Canada offices in Halifax and Calgary, and BP head offices in Houston and London where appropriate. The Incident Management Team has access to a global network of expertise to support response efforts.

Throughout BP's incident management organization, BP adopts the incident command system (ICS) as the foundation for the response management system. 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 system that can be deployed in any emergency scenario.

BP will have personnel in their Halifax office who will co-ordinate the incident management team. Additional personnel will be called from supporting offices, as required, to provide technical or specialist support.



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

Figure 8.3.1 BP Incident Management Organization

BP will work with a number of 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 CNSOPB, the Canadian Coast Guard (CCG), the Joint Rescue Coordination Centre (JRCC), the Nova Scotia Emergency Management Office (NSEMO), DFO, and Environment and Climate Change Canada (ECCC).

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. Further information about these organizations will be provided in the SRP.

One of these organizations is Oil Spill Response Limited (OSRL). 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, 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. 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 ensure that they are covered 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 8.3.3.

8.3.3 Response Strategies

Response strategies to a spill will vary depending on the spill scenario and will be defined by the IMP and SRP described above.

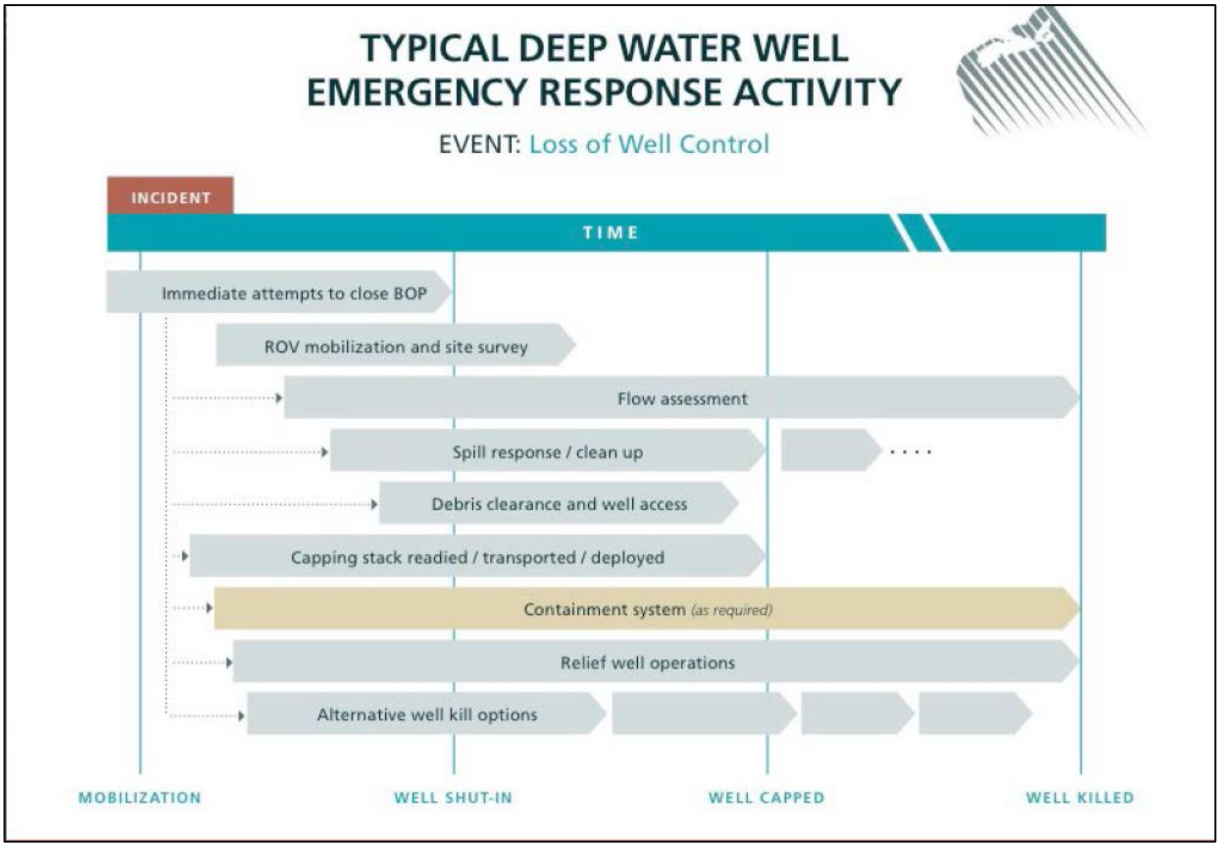
The most significant spill event, in terms of potential adverse effects on Valued Components (VCs), which could occur during Project activities, is a major release of formation fluids from a loss of well control (*i.e.*, a blowout) event. The majority of this section therefore refers to response strategies 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.

8.3.3.1 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 stop the flow of hydrocarbons.

Figure 8.3.2 outlines the typical sequence of events that will be implemented in the event of a loss of well control and subsequent blowout incident. The figure illustrates the BOP intervention, and capping and containment measures that would be conducted to stop the flow of hydrocarbons, and indicates the timing of spill response efforts to manage, contain and recover spilled hydrocarbons.



Source: CNSOPB n.d. (c).

Figure 8.3.2 Well Control Response Strategies

A suite of response measures 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.

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. Dispersants may be mobilized, depending on the outcome of BP's net environmental benefit analysis (NEBA) and regulatory approval to help reduce surface or shoreline oiling (refer to Section 8.3.3.3 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 ensure that the response strategy is appropriate for the specific conditions.

8.3.3.2 Well Intervention Response

BOP Intervention

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 Nova Scotia region. This will include specialist equipment and ROVs which 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 2 and 5 days.

ROV Mobilisation, 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 well site.

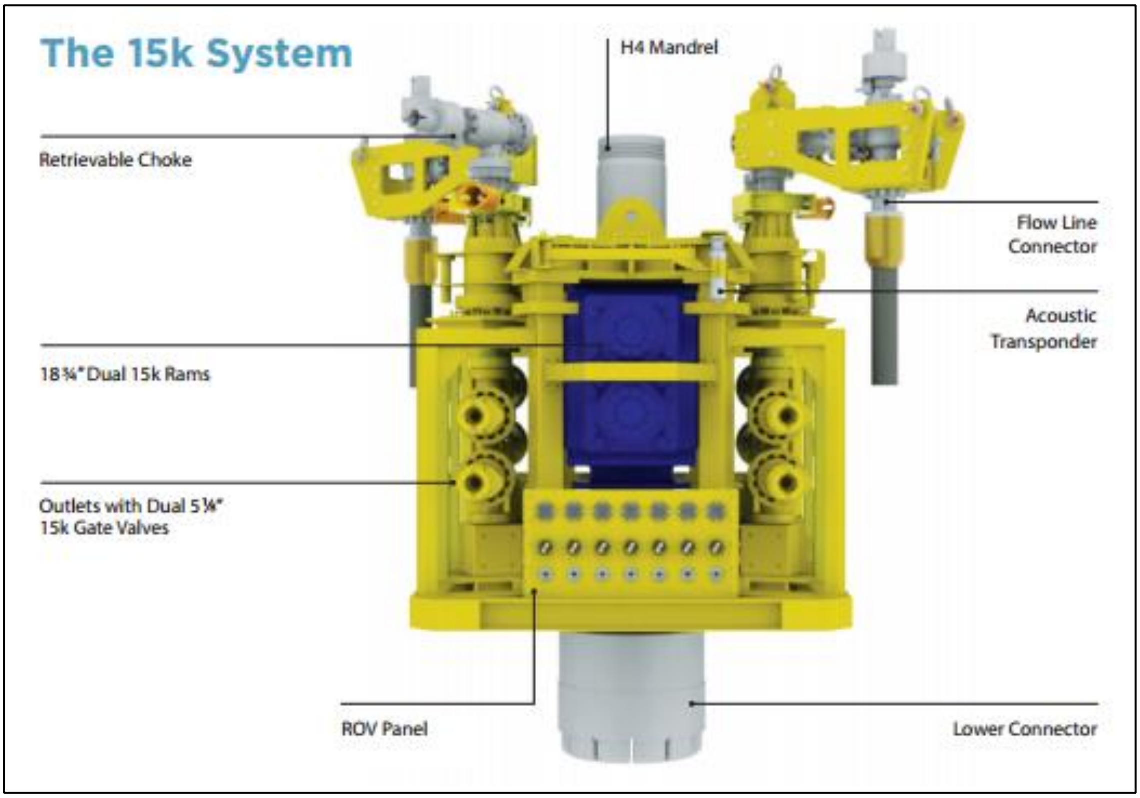
Well Capping

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 (rated at up to 15,000-psi).

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 stored in strategic locations across the globe in 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 Scotian Basin wells, 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 8.3.3.



Source: OSRL 2014

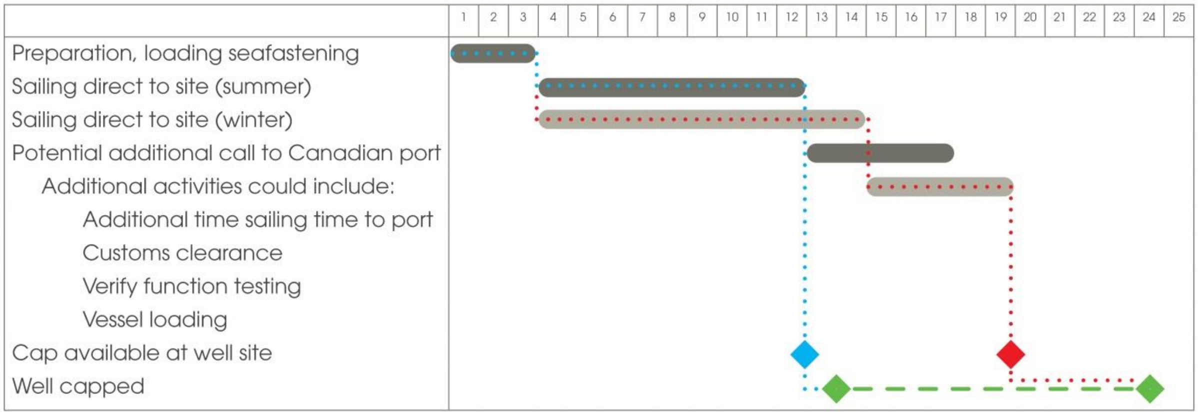
Figure 8.3.3 18.$^{3}/_{4}$" 15,000psi Capping Device

If a blowout incident were to occur, BP would immediately commence the mobilization of the primary capping stack from Stavanger. The capping stack would be transferred from Stavanger on a vessel. Prior to departure, the capping stack would be prepared, tested and then transferred on to the vessel.

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.

Estimated sailing times from Stavanger to the ELs have been calculated and are presented in Figure 8.3.4 below. While it is preferred that the cap is transported directly to the well site on-board a vessel with suitable deployment capabilities, it may become necessary to make an intermediate port call in St. John's (Newfoundland and Labrador) or Halifax. If this were to become necessary, the required customs clearances, functional checks, cargo transfers, *etc.*, could add several days to the overall transit time. These potential additional durations are shown in Figure 8.3.4 below.

Mobilization of subsea capping equipment to the wellsite is estimated to take 12 to 19 days dependent on weather conditions and vessel availability.



Note:
Blue represents predicted cap mobilization during the summer months
Red represents cap mobilization during the winter months
Green represents anticipated capping window

Figure 8.3.4 Cap Mobilization Sequence and Durations

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 well site.

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 13 and 25 days after an incident.

Relief Well Drilling

Depending on the circumstances where well control cannot be reestablished, 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 Nova Scotia 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 165 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.

8.3.3.3 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 below 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 below.

Surveillance and Tracking

Surveillance and tracking of an oil spill, using trained and experienced personnel, is necessary to determine the extent, behaviour and trajectory of a spill in order to determine the most appropriate response options.

Surveillance of an oil spill is accomplished using a variety of platforms, potentially including boats, manned aircrafts, unmanned aerial vehicles, and satellites, as well as utilizing a variety of sensors. Surveillance is used to inform the response with the respect to the location, condition and movement of oil so as to maximize the effectiveness of tactical response, assist in trajectory modelling, and help determine strategic response options.

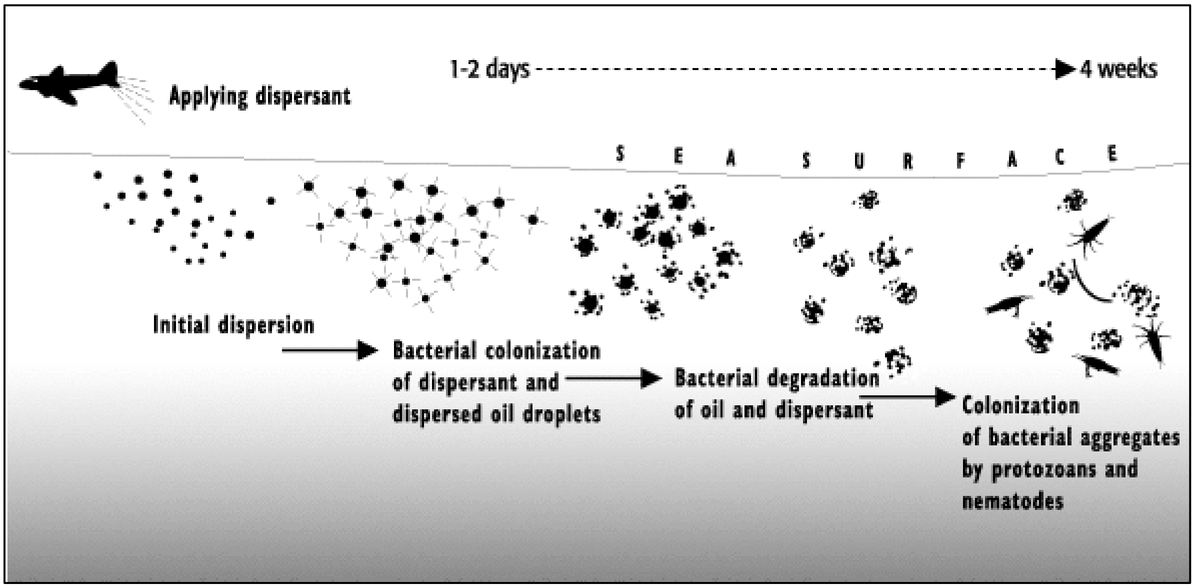
Offshore Containment and Recovery

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

Dispersants are chemicals that, when applied to 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. Dispersants are made up of two primary components – a surfactant and emulsifier. 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.

Dispersants do not reduce the total volume of oil in the 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 surface and onshore 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 8.3.5. There is evidence that dispersed oil degrades more quickly than oil that has not been dispersed (Lee *et al.* 2013).



Source: NOAA 2016a

Figure 8.3.5 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 provided below.

Surface application is often used in conjunction with other spill response tactics, including those listed within this Section of the EIS. 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 which 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 that 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.

It should be noted that as the oil weathers, primarily through 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 blowout incident, 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 DWH incident in 2010. In subsea dispersant injection, dispersant is injected directly at, or near, the source of the release.

This increases the "encounter rate" of the dispersant with the oil, resulting in a reduction in the size of oil droplets and an associated enhancement and acceleration of in-water-column microbial degradation of hydrocarbons.

Dispersed oil droplets rise very slowly through the water column, or become neutrally buoyant. This results in the dispersed hydrocarbons being transported from the release site via subsea drift, quickly reducing concentration and making oil droplets more accessible to oil-degrading microbes. 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. This is also true for Nova Scotia, where a BP-funded microbiology study revealed that oil serves as a significant energy/nutrient source for the indigenous field-collected microbes (Yergeau *et al.* 2014). The water depth at which a submerged plume of dispersed oil is formed and the direction in which the plume drifts will be a function of the prevailing conditions and currents in the water.

The primary reason for any dispersant use, including SSDI, is to prevent, or minimize, the amount of oil that may subsequently impact shallow coastal waters and the shore, where it could cause considerable damage to sensitive environmental resources on the surface and shoreline, such as seabirds and mammals, and disrupt socio-economic activities. Additional benefits of SSDI include:

- reducing 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;
- 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; and
- 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.

Dispersants will not be used by BP without prior regulatory approval.

In May 2016, 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 CNSOPB'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.

Authorization for the use of dispersants as part of emergency response measures is currently being reviewed by the CNSOPB as part of the Accord Act. If dispersant use is advisable, BP will seek approval from the CNSOPB Chief Conservation Officer. BP will undertake a NEBA as part of the preparation of the SRP to evaluate the benefits associated with different spill response strategies including dispersant application.

NEBA 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 NEBA 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 NEBA 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 approach.

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 significantly 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 minimize the extent of shoreline oiling.

The plan to use dispersants as part of any response plans will take into account the operational considerations and prevailing conditions. 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, sea turtles and shoreline habitats (*e.g.*, Sable Island). 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. Surface oil can also smother some small species and some life stages of fish or invertebrates, and coat feathers and fur, reducing birds' and mammals' ability to maintain their body temperatures (refer to Section 8.5 for more information on the effects of hydrocarbons on the marine environment). However, the use of dispersants (as is the case with any spill response measure) may also result in adverse environmental effects. With the objective of attaining a net environmental benefit, the NEBA evaluates “trade-off” situations whereby the acceptance of certain adverse effects (*e.g.*, those associated with dispersant use) may be necessary to avoid other, more significant adverse environmental effects on habitats and receptors (*e.g.*, oiling of marine birds and shoreline habitats) (Stantec 2012c).

There have been many reports and publications examining the toxicity and effectiveness of dispersant products (including toxicity of dispersed oil) including 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) to the substance. 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 2014b).

Due to the dynamic nature of the marine environment, exposure conditions are rarely constant. Exposures to dispersants and dispersed oil are dynamic events for oil spills in open waters, with concentrations diminishing over time in offshore waters following treatment of surface oiling (BP 2014). Use of subsea dispersant treatments for prolonged releases at well control events can generate more consistent exposure conditions at points near the sources. These dynamic exposure conditions must be taken into account in order to more accurately characterize the potential environmental toxicity of dispersed oil in the environment (BP 2014b). Subsea injection of dispersants could result in a temporary, localized increase in risk of adverse environmental effects to invertebrates and plankton in the water column in the vicinity of the application (*i.e.*, wellhead) (HDR Inc. 2015). However, few species (*e.g.*, invertebrates, plankton) would be exposed to dispersant concentrations greater than their laboratory LC50 value, and those concentrations are unlikely to be sustained long enough to elicit a toxic effect. For continuous, subsea injection of dispersants at well control events, concentrations of dispersants not associated with the oil would be low at the source of treatment, 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 2014b).

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 2005b). As discussed in Section 8.5.3, exposure to oil will also affect thermal regulation.

Given the relative distance of most Special Areas from the Project Area, predicted effects of dispersant use with respect to the protection of Special Areas are generally positive, related to the reduction of risk of exposure to surface oil or stranded oil on shorelines (*e.g.*, Sable Island; mainland Nova Scotia). Dilution of dispersants in the water column as currents move the dispersant away from the treatment site will reduce likelihood of toxicity effects on the Haddock Box and sponge conservation areas.

From a socio-economic perspective, 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 Aboriginal fisheries (HDR Inc. 2015).

In a NEBA framework, potential biophysical and socio-economic risks would be weighed against risks of not dispersing surface oil, including the risk to marine life associated with surface slicks and shoreline (*e.g.*, Sable Island) contamination. The NEBA 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 can only take place when oil has been contained within fire resistant booms and when meteorological conditions are suitable (*i.e.*, calm seas and light winds). In-situ burning will not be used by BP without prior regulatory approval.

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. Additionally, 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. Treatment measures can include a range of options including, but not limited to, low-pressure flushing, mechanical collection, manual cleaning, plowing, soil washing, and natural attenuation. Stakeholders 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. 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.

8.3.4 Lessons from the Deepwater Horizon Incident

On April 20, 2010, a well control event allowed hydrocarbons to escape from the Macondo well in the Gulf of Mexico onto the Transocean DWH MODU, resulting in explosion and fire on the MODU and the loss of 11 lives. BP Exploration and Production Inc. was the lease operator of the well. Hydrocarbons flowed from the reservoir through the wellbore and the BOP for 87 days, causing a spill of national significance. In January 2015, the United States District Court for the Eastern District of Louisiana found that 3.19 million barrels of oil were discharged into the Gulf of Mexico.

A BP priority is to prevent any similar oil spill from taking place. BP's 2010 internal investigation into the DWH incident, known as the Bly Report, concluded that no single cause was responsible for the incident. A complex, inter-linked series of mechanical failures, human judgments, engineering design, operational implementation and team interfaces (involving several companies including BP), contributed to the incident.

BP's internal investigation, which culminated in the Bly Report, involved a team of over 50 internal and external specialists from a variety of fields, including safety, operations, subsea, drilling, well control, cementing, well flow dynamic modelling, BOP systems, and process hazard analysis. Eight key findings relating to the causal chain of events were made, with 26 associated recommendations to enable the prevention of a similar accident and aimed at further reducing risk across BP's global drilling activities.

Table 8.3.2 outlines the eight key findings related to the cause of the DWH incident, as outlined in the Bly Report (BP 2010). It also addresses how these lessons are applied to this Project in order to prevent a reoccurrence of the DWH incident.

Table 8.3.2 Key Findings from the Macondo Well Blowout Incident and Application to the Scotian Basin Exploration Drilling Project

Finding	Summary Description	Investigation Conclusion	Application to this Project
Critical factor: Well integrity was not established, or failed			
1. The annulus cement barrier did not isolate the hydrocarbons.	The day before the accident, cement had been pumped down the production casing and up into the wellbore annulus to prevent hydrocarbons from entering the wellbore from the reservoir. The annulus cement that was placed across the main hydrocarbon zone was light, nitrified foam cement slurry. This annulus cement did not isolate the wellbore annulus from the hydrocarbon zone.	There were weaknesses in the cement design and testing, quality assurance and risk assessment.	BP's Zonal Isolation Practice was updated and clarified, establishing clear requirements for annular cement well barrier elements and verification of these barriers during well construction, temporary abandonment and permanent abandonment. BPs zonal isolation objectives, within the Practice, are designed to prevent unintended movement of fluids between distinct permeable zones (DPZ), flow to surface or seabed, development of sustained casing pressure (SCP) during well operations due to communications between a DPZ and the surface or seabed, and contamination of potable-water aquifers. BP's established a comprehensive set of cementing documents to provide clear engineering guidance to BP Engineers when designing cement jobs to achieve zonal isolation requirements. BP established a global Cementing Engineering Team to enhance cementing discipline capability, to provide increased assurance of cement designs and to fulfill the cement job design review requirements outlined in the Zonal Isolation Practice. BP conducted a review of the quality of the services provided by all cementing service providers working with BP globally and new providers are reviewed before their services are contracted. BP provided leadership for a Work Group within the American Petroleum Institute (API) that updated the industry recommended practice for the preparation and testing of foamed cement slurries.

Table 8.3.2 Key Findings from the Macondo Well Blowout Incident and Application to the Scotian Basin Exploration Drilling Project

Finding	Summary Description	Investigation Conclusion	Application to this Project
2. The shoe track barriers did not isolate the hydrocarbons.	Having entered the wellbore annulus, hydrocarbons passed down the wellbore and entered the 9 ⅞" x 7" production casing through the shoe track, installed in the bottom of the casing. Flow entered into the casing rather than the casing annulus. For this to happen, both barriers in the shoe track must have failed to prevent hydrocarbon entry into the production casing. The first barrier was the cement in the shoe track, and the second was the float collar, a device at the top of the shoe track designed to prevent fluid ingress into the casing.	Hydrocarbon ingress was through the shoe track, rather than through a failure in the production casing itself or up the wellbore annulus and through the casing hanger seal assembly. Potential failure modes were identified that could explain how the shore track cement and the float collar allowed hydrocarbon ingress into the production casing.	BP's updated Well Barrier Practice provides the requirements for the design, selection, installation, maintenance, monitoring and management of well barriers and well barrier elements throughout the full life cycle of the well. Per the practice, well barriers are generally required to isolate energy sources within the earth from each other, the surface environment, and people. Dual well barriers (primary and a secondary) are required between energy sources and the surface. This BP practice applies to all wells regardless of where they are in their life cycle, including those wells under construction, actively in service, temporarily abandoned or permanently abandoned. Well barrier elements are verified to acceptance criteria in BP's Well Barrier Practice. For a cemented shoe track to be used as a well barrier element, it must have two independent floats for redundancy to prevent backflow of cement; have cement verified with a length and compressive strength required in BP's zonal isolation practice; and have successfully passed both a positive test and a negative test as outlined in BP's pressure testing practice.
Critical factor: Hydrocarbons entered the well undetected and well control was lost			
3. The negative-pressure test was accepted although well integrity had not been established.	Prior to temporarily abandoning the well, a negative pressure test was conducted to verify the integrity of the mechanical barriers (the shoe track, production casing and casing hanger seal assembly). The test involved replacing heavy drilling mud with lighter seawater	The Transocean MODU crew and BP well site leaders reached the incorrect view that the test was successful and that well integrity had been established.	BP's practices address both the positive and negative pressure testing requirements for wells. This updated practice requires prior approval of the engineering procedures for negative testing, and also specifies the minimum criteria to be met for a successful test. The Well Site Leader interprets the results of the test

Table 8.3.2 Key Findings from the Macondo Well Blowout Incident and Application to the Scotian Basin Exploration Drilling Project

Finding	Summary Description	Investigation Conclusion	Application to this Project
	to place the well in a controlled underbalanced condition. In retrospect, pressure readings and volume bled at the time of the negative pressure test were indications of flow-path communication with the reservoir, signifying that the integrity of these barriers had not been achieved.		against the engineered acceptance criteria. The Well Superintendent, who has an off-site supervisory role, then approves the negative pressure test. Both staff positions are classified as critical roles that undergo mandatory competency assessments. With the aim of building and maintaining competency of its staff, BP delivers in-house industry-accredited well control training with staff instructors and full-size drilling simulators in its own facilities in Houston, Sunbury, and, from 2016, in Baku. In addition, building on its Applied Deep Water Well Control course that BP developed and delivered in recent years to its entire deep water rig fleet, BP has an agreement with Maersk Training to use its state-of-the-art immersive simulation training facilities and instructors to provide an enhanced development program for rig teams. The integrated rig teams -- including individuals from BP, drilling contractors and service companies -- work through simulator-based scenarios to practice procedures, roles and responsibilities in challenging drilling and completion situations before they potentially encounter those situations in actual operations.
4. Influx was not recognized until hydrocarbons were in the riser.	With the negative pressure test having been accepted, the well was returned to an overbalanced condition, preventing further influx into the wellbore. Later, as part of normal operations to temporarily abandon the well, heavy drilling mud was again replaced with seawater, under-balancing the well. Over time, this allowed hydrocarbons to flow up through the production casing and past	The rig crew did not recognize the influx and did not act to control the well until hydrocarbons had passed through the BOP and into the riser.	BP's well monitoring practice lists the responsibilities and requirements for verifying and documenting that well monitoring has been properly implemented. The requirements include alarm setting and actions to be taken, fluid volume and density monitoring, flow checking, and actions to verify conformance with the practice. The BP practice requires a tailored regional wellbore monitoring procedure that is communicated to

Table 8.3.2 Key Findings from the Macondo Well Blowout Incident and Application to the Scotian Basin Exploration Drilling Project

Finding	Summary Description	Investigation Conclusion	Application to this Project
	the BOP. Indications of influx with an increase in drill pipe pressure are discernible in real-time data from approximately 40 minutes before the rig crew took action to control the well. The rig crew's first apparent well control actions occurred after hydrocarbons were rapidly flowing to the surface.		personnel with responsibilities for well monitoring, including the rig contractor and mud logger. The Well Site Leader, through BP's self-verification and oversight process, helps assure that the crew's actions conform to the wellbore monitoring procedure. As described in item 3, BP well site leaders and superintendents undergo competency assessments for their role. Relevant BP, rig contractor and well services company staff are required to receive industry-recognized well control certification. Also, BP provides enhanced, scenario-based training for rig crews.
5. Well control response actions failed to regain control of the well.	The first well control actions were to close the BOP and diverter, routing the fluids exiting the riser to the DWH mud gas separator (MGS) rather than to the overboard diverter line.	If fluids had been diverted overboard, rather than to the MGS, there may have been more time to respond, and the consequences of the accident may have been reduced.	BP's practices provide requirements and options for well control risk mitigation, response, and remediation on all BP operated activity throughout the lifecycle of a well. These practices incorporate enhanced industry standards that BP and others developed to advance capabilities across the industry following industry incidents. As described in item 3, BP well site leaders and superintendents are required to undergo competency assessments for their role. BP, rig contractor and well services company staff are required to receive industry-recognized well control certification. Also, BP provides enhanced, scenario-based training for rig crews.
Critical factor: Hydrocarbons ignited on Deepwater Horizon			
6. Diversion to the mud gas separator resulted in gas venting onto the	Once diverted to the MGS, hydrocarbons were vented directly onto the rig through the 12" goosenecked vent exiting the MGS, and other flowlines	The design of the MGS system allowed diversion of the riser contents to the MGS vessel although the well was in a	BP's practices outline the methods and tools to achieve design safety through management of hazards. Managing hazards involves eliminating or minimizing major accident hazards (MAHs) at source

Table 8.3.2 Key Findings from the Macondo Well Blowout Incident and Application to the Scotian Basin Exploration Drilling Project

Finding	**Summary Description**	**Investigation Conclusion**	**Application to this Project**
rig.	also directed gas onto the rig. This increased the potential for the gas to reach an ignition source.	high flow condition. This overwhelmed the MGS system.	and preventing those that remain from becoming major accidents. This may include equipment and design modification before the MODU begins a drilling program. For example, BP design requirements for mud gas separators have been changed in order to divert gas overboard and not near equipment or personnel. In addition, BP conducts hazard and operability reviews (HAZOPs) of surface gas and fluid systems for all BP-owned and BP-contracted drilling rigs, which include a review of hydrocarbon vent locations and design. For additional assurance, BP's Rig Engineering team inspects new MODUs before well operations begin and all MODUS on a periodic basis.
7. The fire and gas system did not prevent hydrocarbon ignition.	Hydrocarbons migrated beyond areas on DWH that were electrically classified to areas where the potential for ignition was higher.	The heating, venting and air conditioning (HVAC) system probably transferred a gas-rich mixture into the engine rooms, causing at least one engine to overspeed, creating a potential source of ignition.	
Critical factor: The blowout preventer did not seal the well			
8. The BOP emergency mode did not seal the well.	Three methods for operating the BOP in the emergency mode were unsuccessful in sealing the well. • The explosions and fire very likely disabled the emergency disconnect sequence, the primary emergency method available to the rig personnel, which was designed to seal the wellbore and disconnect the marine riser from the well. • The condition of critical components in the yellow and blue control pods on the BOP very likely prevented activation of another emergency method of well control, the automatic mode function, which was	There were indications of potential weaknesses in the testing regime and maintenance management system for the BOP.	BP's Well Control Practice specifies that: • all dynamically positioned (DP) rigs be equipped with subsea BOPs that have two blind shear rams and a casing shear ram; • before beginning drilling new wells, a remotely operating vehicle (ROV) demonstrates the ability to access the subsea BOP control panel to pressurize and activate the shear rams; • a third party will certify that; o the BOP has been inspected and its design reviewed in accordance with the original equipment manufacturer (OEM) specifications, o modifications to the BOP, if any, have not compromised its design or function,

Table 8.3.2 Key Findings from the Macondo Well Blowout Incident and Application to the Scotian Basin Exploration Drilling Project

Finding	Summary Description	Investigation Conclusion	Application to this Project
	designed to seal the well without rig personnel intervention upon loss of hydraulic pressure, electric power and communications from the rig to the BOP control pods. An examination of the BOP control pods following the accident revealed that there was a fault in a critical solenoid valve in the yellow control pod and that the blue control pod AMF batteries had insufficient charge; these faults likely existed at the time of the accident. • Remotely operated vehicle intervention to initiate the autoshear function, another emergency method of operating the BOP, likely resulted in closing the BOP's blind shear ram (BSR) 33 hours after the explosions, but the BSR failed to seal the well.		o testing and maintenance of BOPs are performed in accordance with OEM guidelines and API Standard 53. This practice also requires confirmation by a shear specialist that the BOP has the ability to shear drill pipe under maximum anticipated surface pressure (MASP) conditions. Also, BP maintains dedicated subsea BOP reliability personnel with a global remit to support all offshore BP drilling activities and can be called upon to assist with BOP related issues. BP's subsea BOP reliability personnel work with its drilling contractors and their original equipment manufacturers (OEMs) to monitor BOP performance and further enhance BOP system reliability through oversight of maintenance and testing. Also, BP and others in industry have advanced industry standards for BOP equipment through the American Petroleum Institute (API). In addition, efforts through API, the International Association of Oil and Gas Producers (IOGP), the International Association of Drilling Contractors (IADC) and other industry groups is focused on sharing information on BOP performance.

8.3.5 Incorporating Lessons Learned

Every official investigation report released to date, including those from the Presidential Commission, the US Coast Guard, the Bureau of Ocean Energy Management (Regulation and Enforcement), and the National Academy of Engineering/National Research Council, reinforces the Bly Report's core conclusion that this was a complex accident with multiple causes involving multiple parties.

The Bly Report recommended a number of measures to strengthen BP's operational practices, and these are being addressed through the implementation of enhanced drilling requirements. Key requirements that have been captured in guidance documents and engineering technical practices are described below.

- **Cementing or zonal isolation**

  BP issued revised mandatory zonal isolation requirements and nine associated engineering guidance documents covering key cementing activities. BP established a global Cementing Engineering team to increase cementing discipline capability and provide increased technical and operational assurance for cementing operations.

- **Integrating process safety concepts into the management of wells**

  BP produced a technical practice specifying minimum requirements for well barrier management to manage the movement of fluids and gas during the life cycle of the well.

- **Well casing design**

  BP updated its design manual for well casing and tubing to include new requirements for pressure tests and revised technical practices. BOP stacks – BP issued a revised technical practice on well control, defining and documenting requirements for subsea BOP configurations. BP requires two sets of BSR and a casing shear ram for all subsea BOPs used on deepwater DP MODUs. BP also requires that third-party verification be carried out on the testing and maintenance of subsea BOPs in accordance with recommended industry practice, and that ROVs capable of operating these BOPs be available in an emergency.

- **Rig audit and verification**

  BP continued the MODU audit process that was enhanced in 2011. BP has conducted detailed hazard and operability reviews for key fluid handling systems on all offshore MODUs contracted to BP. New MODUs contracted to BP are subject to a full independent S&OR Rig Verification assessment and 'readiness to operate' is verified with a detailed go/no-go process assured by S&OR. This verification process includes a checklist, which among other things, assists in assessing that the MODU conforms to applicable BP practices and industry standards and has the right technical specification, and that all actions required for start-up are completed. All MODUs are also subject to subsequent periodic Rig Verification assessments.

In addition to these technical requirements, BP has focused on enhancement of capability and competency; verification, assurance and audit; and process safety performance management.

8.3.6 Progress on Recommendations of the Bly Report

Progress on implementing the recommendations from the Bly Report, BP's investigation into the Deepwater Horizon accident, from an independent expert appointed to provide an objective assessment of this progress, concluded in February 2016 that all 26 Bly Report recommendations had been closed out to his satisfaction. Further information is provided in the BP 2015 Sustainability Report (http://www.bp.com/en/global/corporate/sustainability/reporting.html). Table 8.3.3 outlines progress against the Bly Report recommendations.

Table 8.3.3 Progress Against the Bly Report Recommendations

No.	Finding	Progress (at end 2015)
1	Update and clarify cementing practice and guidelines.	Complete
2	Update requirements for subsea BOP configuration.	Complete
3	Update recommendations for negative pressure tests and lock-down rings.	Complete
4	Update practice on working with pressure, including contingency and testing procedures.	Complete
5	Strengthen incident reporting standards for well control and well integrity.	Complete
6	Proposal of recommended practice for design and testing of foamed cement slurries to API.	Complete
7	Assess risk management and Management of Change (MoC) processes for life cycle global wells activities.	Complete
8	Strengthen the technical authority's role in cementing and zonal isolation.	Complete
9	Enhance drilling and completions competency programs for key operations and leadership positions.	Complete
10	Develop advanced deepwater well control training.	Complete
11	Establish BP in-house expertise for subsea BOP and BOP control systems.	Complete
12	Request the IADC to develop subsea engineering certification.	Complete
13	Strengthen BP's rig audit process to improve closure and verification of audit findings across the rigs BP owns and contracts.	Complete
14	Establish key performance indicators (KPIs) for well integrity, well control, and rig safety-critical equipment.	Complete
15	Require drilling contractors to implement auditable integrity monitoring system.	Complete
16	Assess cementing service provider capabilities.	Complete

Table 8.3.3 Progress Against the Bly Report Recommendations

No.	Finding	Progress (at end 2015)
17	Confirm well control and monitoring practices are defined and applied.	Complete
18	Require hazard and operability reviews for surface gas and drilling fluid systems.	Complete
19	Include study of all drilling rig surface system hydrocarbon vents in all hazardous operations (HAZOPS).	Complete
20	Establish minimum levels of redundancy and reliability for BOP systems.	Complete
21	Strengthen BP's requirements for BOP testing by drilling contractors, including emergency systems.	Complete
22	Strengthen BP's requirements for BOP maintenance management systems by drilling contractors.	Complete
23	Set minimum standards for drilling contractors' MoC for subsea BOPs.	Complete
24	Develop a clear plan for ROV intervention for each subsea BOP.	Complete
25	Require contractors to verify BSR performance capability.	Complete
26	Include testing and verification of revised BOP standards in MODU audit.	Complete

8.4 SPILL FATE AND BEHAVIOUR

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 is dependent 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 methodology and assumptions used for the modelling work, and a summary of the modelling outputs is provided to describe spill fate and behaviour. The spill modelling report is included as Appendix H.

8.4.1 Spill Fate Modelling Approach

As discussed in Section 8.2, 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). Prior to modelling, BP consulted with technical experts from applicable regulatory agencies (*e.g.*, CNSOPB, DFO, Environment

Canada) to discuss the proposed modelling approach including the use of OSCAR, data inputs (*e.g.*, metocean and oil characteristics), modelling scenarios and modelling thresholds.

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 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; and
- 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 potential drilling locations in the ELs to evaluate the potential impact of water depth and proximity to sensitive receptors in and around the ELs. For all scenarios, the models were run without mitigation until the amount of oil in the system fell below the significance thresholds described in 8.4.6.

Results from a 10 bbl diesel spill at the MODU were used to inform an assessment of a nearshore PSV diesel spill. Additionally, SBM modelling conducted for the Shelburne Basin Venture Exploration Drilling Project (RPS ASA 2014, included as Appendix C in Stantec 2014a) has been referenced as appropriate to inform the assessment of a SBM spill (refer to Section 8.4.10).

8.4.2 Spill Model

BP carried out the modelling work using its preferred model for oil spill trajectory modelling, SINTEF's (1) 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, 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

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(1) For more information on SINTEF see www.sintef.no.

two model types provide an indication of both likelihood and magnitude of any potential effects.

Stochastic Modelling Simulations

Stochastic modelling is used to predict the probability of sea surface, shoreline or water column oiling that may occur following a spill event. This type of modelling accounts for the variability of metocean conditions in the study area 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.

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.

8.4.3 Model Scenarios

Further to the information presented about potential scenarios that could arise during the Project in Section 8.2, two categories of scenarios were modelled as part of the EIS. Two tentative locations were selected on the basis of preliminary seismic data processing and interpretation. These are located in different water depths and at varying distances to sensitive receptors within and around the ELs (shown in Figure 8.4.1). Both locations represent viable drilling prospects in the Scotian Basin.

Table 8.4.1 Release Locations

Location	Block	Water Depth	Longitude	Latitude	Distance from Sable Island
Site 1	EL 2434	2104 m*	60.434610	43.046428	105 km
Site 2	EL 2432	2652 m	61.229314	42.692076	170 km

* Referred to as shallow site given relative water depth within BP's Project Area and prospective drilling prospects.

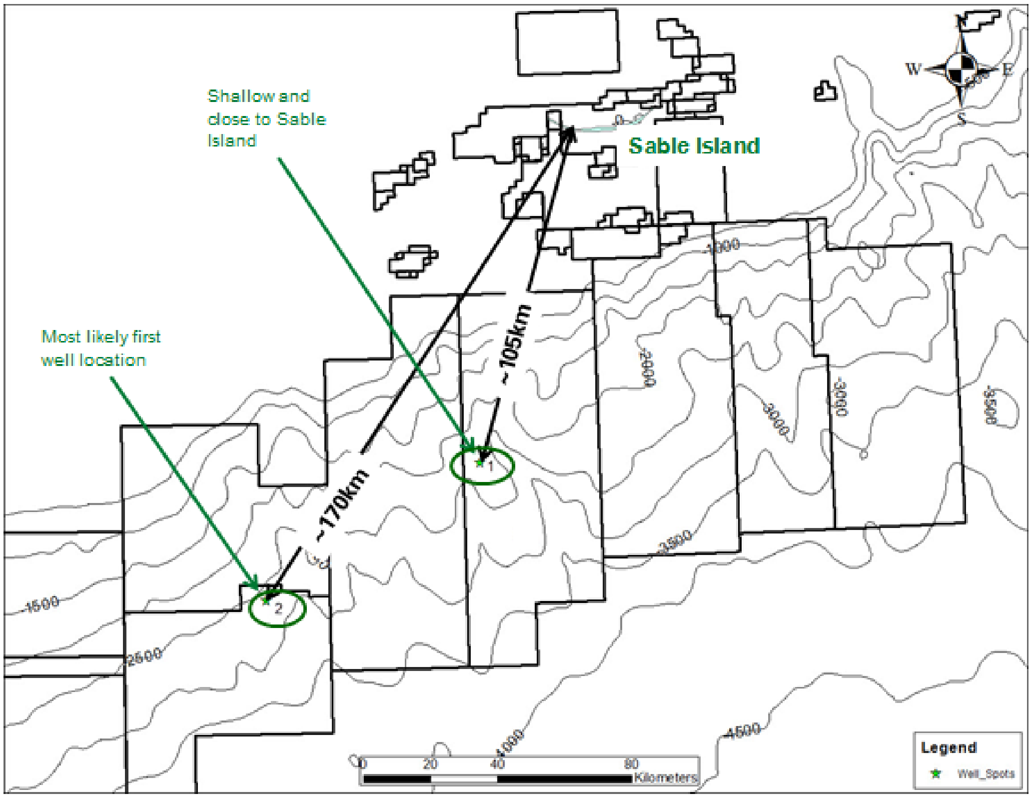


Figure 8.4.1 Release Locations

The scenarios that were modelled were:

1. **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. For a conservative assessment, the location selected for the diesel releases was the wellsite closest to the shoreline of Sable Island.

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

   Two subsea blowout scenarios have been modelled at different locations within the ELs. As a precautionary measure, in both wells, BP assumed 100% oil content in the reservoir sands (*i.e.*, 0% water cut in the formations). Both blowout scenarios assume the presence of two high pressure sands, which are both exposed in a blowout scenario. Release volumes varied between the two locations. The first location (Site 1) at 2,104 m water depth has a total flow rate of 24,890 barrels per day (bpd). The second location (Site 2), at 2,652 m water depth, has a total flow rate of 35,914 bpd.

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. The provisional well design presented in the Project Description (Section 2.4.2) was used as the casing configuration for the well discharge modelling. It has been assumed that if two sands are exposed then the pipe diameter will be 12 ¼ inches.

For modelling purposes, BP has assumed a release duration of 30 days. This duration is slightly more conservative than estimated times for the deployment of a capping stack. BP will mobilize and deploy cap and containment equipment and tools as soon as possible. As described previously, current estimates indicate that the well can be capped between 13 and 25 days after an incident.

In line with the precautionary principle, BP has selected the worst-case credible discharge for each scenario. All modelled scenarios were run unmitigated (*i.e.*, without any oil spill tactical response methods such as those presented in Section 8.3.3.3) with the use of a 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.

Variable environmental conditions for the region, including wind and currents were considered as part of the modelling work. Hindcast metocean data was used as part of the model. The hindcast data incorporates data from January 2006 to December 2010. The impact of large winter storms has therefore been accounted for as these are well-represented in the metocean data. Further information about metocean data used in support of the modelling work is presented in 8.4.5.

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 - April)
- Summer season (May to October)

Forty-five (45) simulations were run per year for each season over the timeframe of the metocean data (*i.e.*, from January 2006 to December 2010) resulting in a total of 210 simulations per season for the blowout scenarios and 225 simulations per season for the surface diesel release scenarios.

The scenarios that have been run as part of the modelling work are summarised in Table 8.4.2.

Table 8.4.2 Modelled Scenarios

Scenario	Location	Water Depth	Modelled Scenario	Released Product	Release Duration	Release Volume	Modelling Type
Scenario 1	Site 1	2,104m	Blowout	Crude Oil (Sture Blend)	30 days	733,000 bbl * (24,890 bpd)	Stochastic & deterministic
Scenario 2	Site 2	2,652m	Blowout	Crude Oil (Sture Blend)	30 days	1,056,000 bbl * (35,914 bpd)	Stochastic & deterministic
Scenario 3	Site 1	2,104m	Batch Spill	Marine Diesel	Instantaneous	10 bbl	Stochastic & deterministic
Scenario 4	Site 1	2,104m	Batch Spill	Marine Diesel	Instantaneous	100 bbl	Stochastic & deterministic
* Note: Flow rate declines over duration of release.							

8.4.4 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 (HPI) database (HPI 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) and 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.

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. Refer to Table 8.4.3 for marine diesel fluid properties.

Table 8.4.3 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

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.

Two potential formations that could be encountered during drilling operations were considered as part of the blowout incident modelling. The estimated properties of the reservoir fluid in the reservoir conditions are presented in Table 8.4.4.

Table 8.4.4 Reservoir Fluid Properties at Reservoir Conditions

Fluid Properties	Lower Sand @ Reservoir Conditions	Upper Sand @ Reservoir Conditions	Units
Reference Pressure	13,000	10,000	psi
Reference Temperature	356 / 180	257 / 125	°F/°C
Boi	1.23	1.24	rvb/stb
Initial Gas Oil Ratio	756	756	scf/stb
Viscosity	0.643	0.738	cp
Compressibility	1.0757	1.0087	10^{-5} psi^{-1}
Density	0.8852	0.8757	g/cc
Psat	2,581	2,077	Psi

Note:
Boi=Oil Formation Volume Factor at Initial Reservoir Pressure; cp=Centipoise; Psat=Saturation Pressure; scf=square cubic feet (surface volume); rvb = reservoir barrel; stb = stock tank barrel

Using the multivariate analysis best fit approach developed by SINTEF described above, Sture Blend oil has been shown to provide the best overall match of oil properties to those predicted for the wells selected for modelling. This is demonstrated in the table below.

Table 8.4.5 Reservoir Fluid Properties

Fluid Properties:	Estimated Fluid Properties	Analogue Sture Blend	Units
API gravity	34.1	35.5	
Specific gravity	0.854	0.847	
Pour point	-5	-3	°C
Wax content	4.1	4	wt%
Asphaltene content	4.6	0.2	wt%
Nickel	5.7	n/a	ppm
Vanadium	4.7	n/a	ppm
Dead oil viscosity at reference (surface) temperature	12.5	10	cP
Reference (surface) temperature	16	13	°C
Live oil viscosity at reservoir temperature	0.7		cP
Reservoir temperature	115		°C

8.4.5 Metocean Model Information

Currents, winds and other metcoean factors are critical parameters which can influence the fate and behaviour of oil following a spill. Metocean data is available from a number of sources and can be formatted to work in the OSCAR model.

BP commissioned an independent, assurance review of potential metocean models to use in modelling work to support the Scotian Basin EIS. The review compared hindcast data of two potential metocean models to published data to identify which is the better representation of the expected conditions in the Scotian Basin.

The assurance work was designed to take account of the following features:

- **Regional:** circulation, sea surface height, sea surface temperature;
- **Sub-regional**: circulation, temperature and salinity transects, tides, drifters; and
- **Scotian Shelf**: hydrography, moorings.

The independent assurance assessment has identified a shortlist of metocean models (identified in Table 8.4.6) that provide the most accurate representation of the anticipated conditions in offshore Nova Scotia. For each physical parameter of interest, hindcast data from between

January 1, 2006 and December 31, 2010 was used to compile a multiyear data set to support the oil spill modelling work.

In the event that spill modelling is required during the drilling campaign to support a response effort, BP will use forecast metocean data. BP has an automated process where forecasts of high quality wind and current data are downloaded on a daily basis to an internal webserver, where they are then automatically reformatted into the correct formats ready for use in OSCAR.

Table 8.4.6 Metocean Data Parameter Inputs

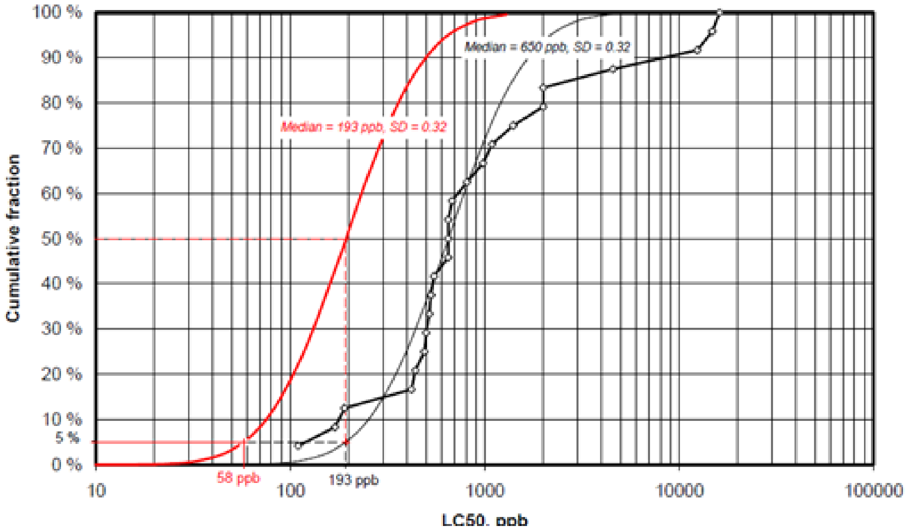
	Input Data	Reference
Bathymetry	GEBCO-1 minute	http://www.gebco.net/
Current velocity components	HYCOM	https://hycom.org/
Sea-surface elevation	HYCOM	https://hycom.org/
Temperature	HYCOM	https://hycom.org/
Salinity	HYCOM	https://hycom.org/
Tides	Oregon TPX07.2	http://volkov.oce.orst.edu/tides/global.html
Wind	NOAA	http://www.noaa.gov/
Atmospheric forcing	CFSR	http://cfs.ncep.noaa.gov/cfsr/
Wave heights	Calculated in OSCAR	n/a
Wind induced current	Calculated in OSCAR	n/a

8.4.6 Modelling Thresholds

Following a spill, it is expected that oil will spread over the water surface and will 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 8.4.7.

Table 8.4.7 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 50µm, 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 µm (10 g/m^2) to 25 µm (25 g/m^2) (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/m^2	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/m^2 (1mm) for vegetation growing along flat shorelines with soft sediments and 100 g/m^2 (0.1 mm) for epifaunal invertebrates (*e.g*., mussels, crabs, starfish). However, a conservative stranded oil threshold of 1.0 g /m^2 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 1" diameter tarballs at 0.12 to 0.14 tarballs per m^2 of shoreline.
In-Water Concentration (dissolved and entrained, top 100m)	
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 - 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 (see Figure 8.4.2).



Source: Neilson *et al.* (2005, as reported in OLF 2008)

Figure 8.4.2 Threshold Concentrations for "No Observed Effect Concentration" (NOEC) for Acute Exposure for Total Hydrocarbons

8.4.7 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.

8.4.7.1 Interpretation of Model Results

Probability of Oiling

The probability of oiling locations was based on a statistical analysis of the resulting accumulation of individual trajectories for each spill scenario (210 individual model runs over 5 years [2006-2010]). The stochastic modelling output figures do not imply that the entire contoured area, or even a large portion of this area, would be covered in oil in the event of an unmitigated spill, but rather the location of possible oil contamination. The figures do not provide information on the quantity of oil in a given area; rather they indicate the probability of oil exceeding the given threshold over the entire accumulation of runs at each point (*i.e.*, location). Figures relevant to water column dispersed and dissolved oil concentration illustrate oiling frequency, but do not specify the given water depth at which oiling will occur. These figures do not imply that the oiling will occur throughout the entire water column (*i.e.*, from the surface to the sea bed).

Minimum Travel Times

The footprint for the "minimum arrival times" figures correspond with the associated probability of oiling figures. Each figure illustrates the shortest time required for oil to exceed the defined thickness or concentration threshold at each point within the footprint of the spill location, based on all individual trajectories run for that scenario.

8.4.7.2 Oil Fate Results

A total of 210 individual releases were modelled for both Sites 1 and 2. Each individual scenario was run for the initial 30 day release period, and an additional 90 days to show the fate and trajectory of oil after the well had been capped (i.e., for 120 days in total). This approach allowed the spill scenarios to be evaluated to the point where either the oil had reached a negligible amount or the shoreline was reached as per the EIS Guidelines.

Each individual run assumed the use of no tactical response methods to contain or control any released hydrocarbons (*i.e.*, the releases were unmitigated). In reality, BP would deploy a suite of spill response methods as explained in Section 8.3.3. This approach of assuming no mitigation measures in the spill fate modelling allows an evaluation of the potential worst case credible effects from a spill and helps to inform the most effective response strategy.

Site 1 is a smaller volume and shallower water release of modelled spilled oil (24,890 bpd at a water depth of 2,104 m), while Site 2 was a larger volume of modelled spilled oil at a greater water depth (35,914 bpd at a depth of 2,652 m). Seasonal summaries of stochastic analyses of potential surface oiling (Figures 8.4.3 to 8.4.6) and water column dispersed and dissolved oil concentrations (Figures 8.4.7 to 8.4.10) illustrate the locations of potential oil contamination in Canadian waters surrounding Nova Scotia and Newfoundland, US waters to the east of New England, and international waters south of Canada for Sites 1 and 2.

As noted above, the oiling footprint locations provided in the stochastic modelling outputs are not the expected extent of oiling from a single release of oil. The locations of the oiling footprints represent the potential areas in which oil could travel following a 30-day unmitigated release. Each scenario was run for the 30 day release period, and an additional 90 days to show the fate of oil after the well was capped. The modelling results predict that the majority of oil will remain in offshore waters with a <20% probability that surface oil exceeding the 0.04 µm (Bonn Agreement Oil Appearance Code (BAOAC) "Sheen") will enter nearshore waters of Nova Scotia for both the summer and winter scenarios. In the event that surface oil was to enter the nearshore area of Nova Scotia, it would take a minimum of between 30 to 50 days to arrive. The in-water dispersed and dissolved oil threshold exceedance of 58 ppb for total hydrocarbons (THC) is also expected to remain in offshore waters; however, the location impacted is predicted to be smaller. The modelling results indicate that the in-water oil exceedance will not reach the nearshore waters of mainland Nova Scotia. Although the winter (November to April) scenario predicts that no in-water oil will reach Sable Island, there is a 5% probability that in-water oil concentrations will exceed the threshold around Sable Island for the summer (May to October) scenario. The minimum arrival times for in-water oil concentrations exceeding the threshold to waters surrounding Sable Island in the summer is predicted to be between 10 and 20 days.

For the two modelled unmitigated blowout scenarios (Sites 1 and 2), the probability of shoreline oiling exceeding the 1 μm threshold (or 0.001 litres/m^2 for "stain/film" oiling) is moderate, ranging up to a maximum of 50 % probability at Sable Island (Site 1 summer season; see Figure 8.4.12). Shoreline oiling is possible for both scenarios (Sites 1 and 2) for both seasons (summer and winter), with the summer season resulting in the most oil stranded onshore. The earliest arrival time for shoreline oil exceeding the threshold for Site 1 occurs during the summer with an arrival time of approximately 3.8 days to the nearest shoreline (Sable Island). In the winter season, the earliest arrival time is approximately 5.8 days to Sable Island. For spill Site 2, the earliest arrival time for shoreline oiling (Sable Island) above the threshold occurs during the summer approximately 6.6 days following the start of the release. During the winter, the earliest arrival time occurs after approximately 10.5 days. Figures 8.4.11 to 8.4.14 depict shoreline oiling probabilities, arrival times, and associated thickness.

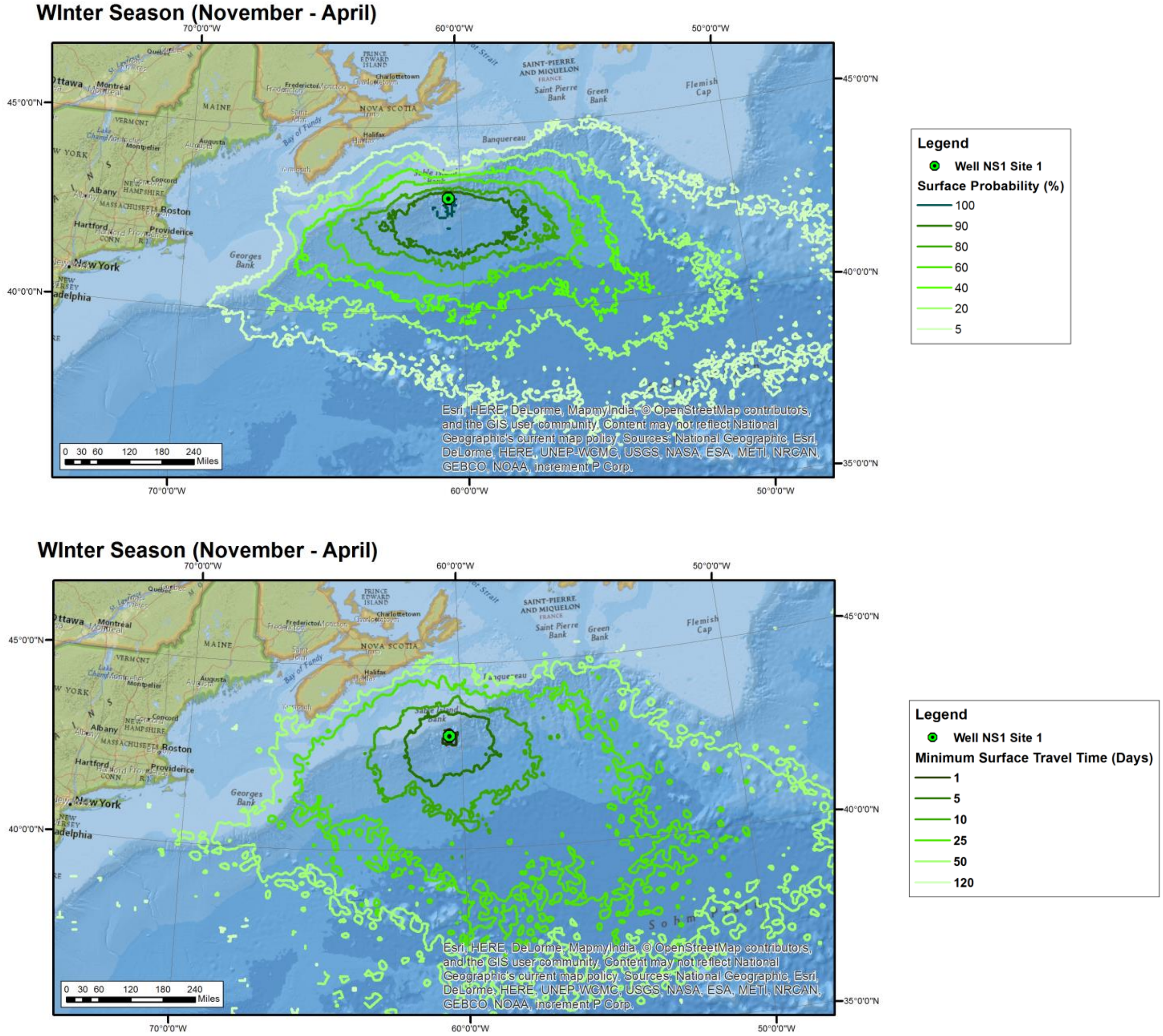


Figure 8.4.3 **Winter (November to April) stochastic model output (210 individual runs) showing maps of the predicted probability of sea surface oiling exceeding the 0.04 µm thickness threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 24,890 bpd blowout incident at Site 1.**

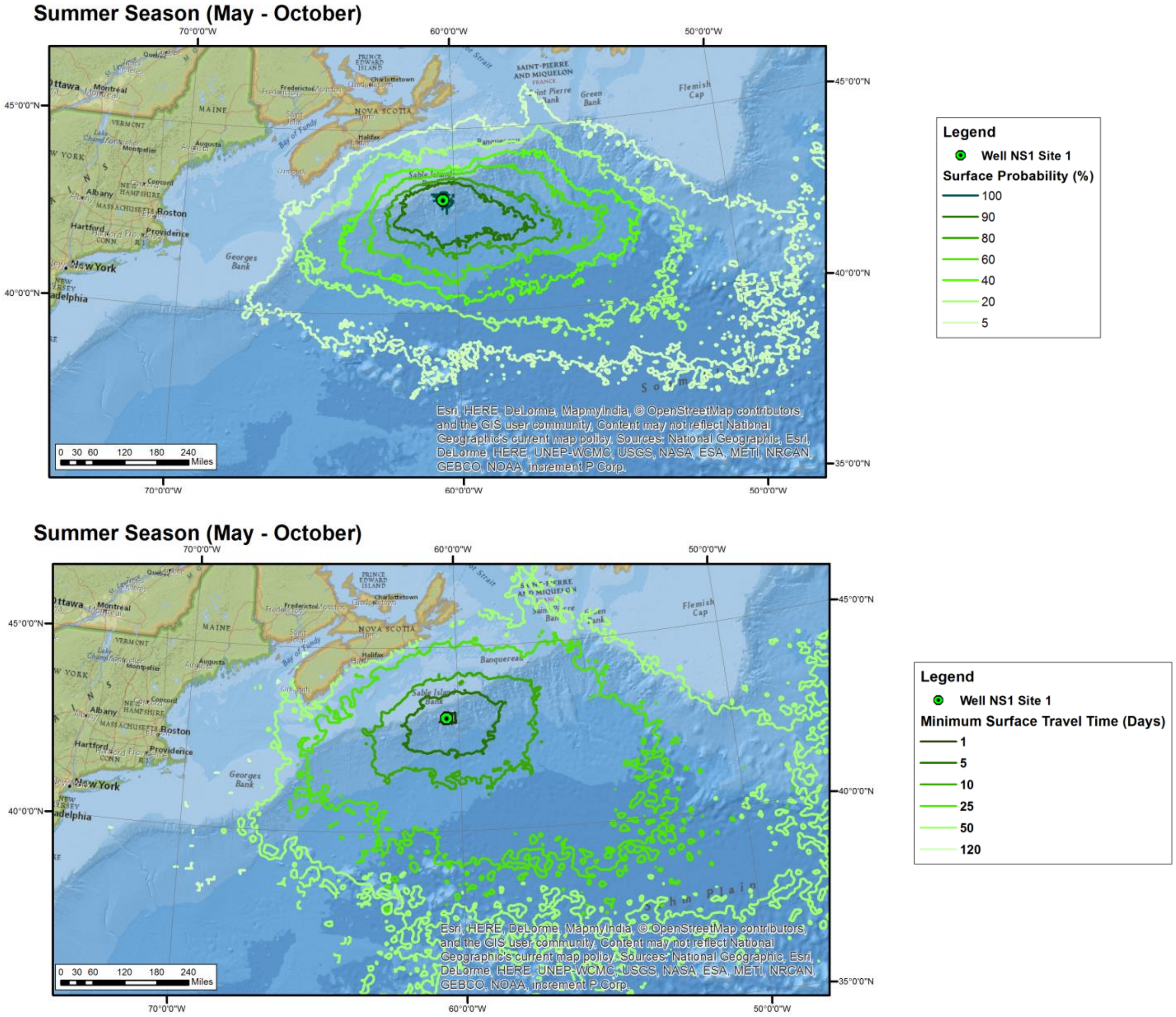
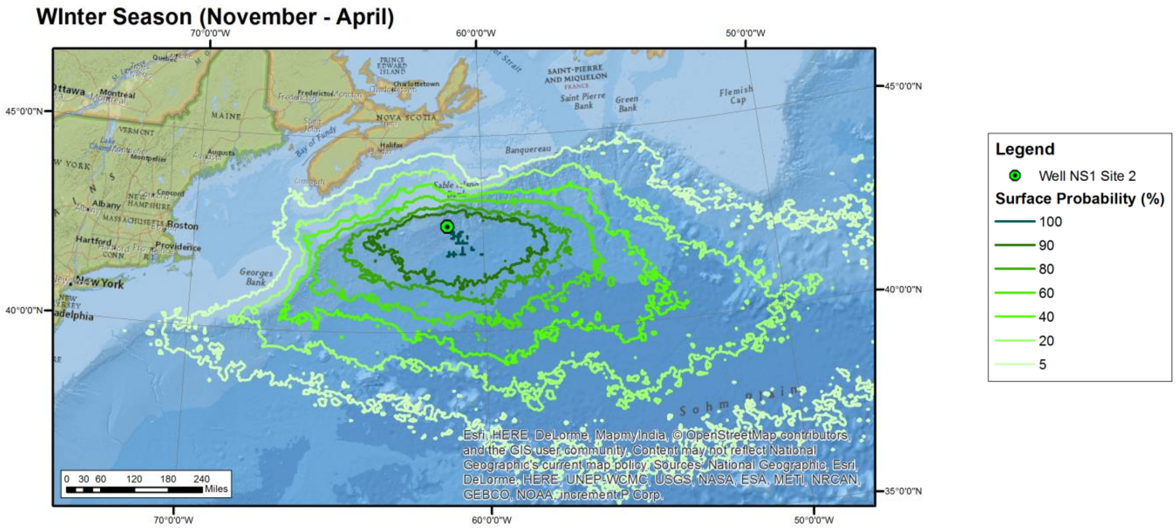


Figure 8.4.4 **Summer (May to October) stochastic model output (210 individual runs) showing maps of the predicted probability of sea surface oiling exceeding the 0.04 µm thickness threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 24,890 bpd blowout incident at Site 1.**



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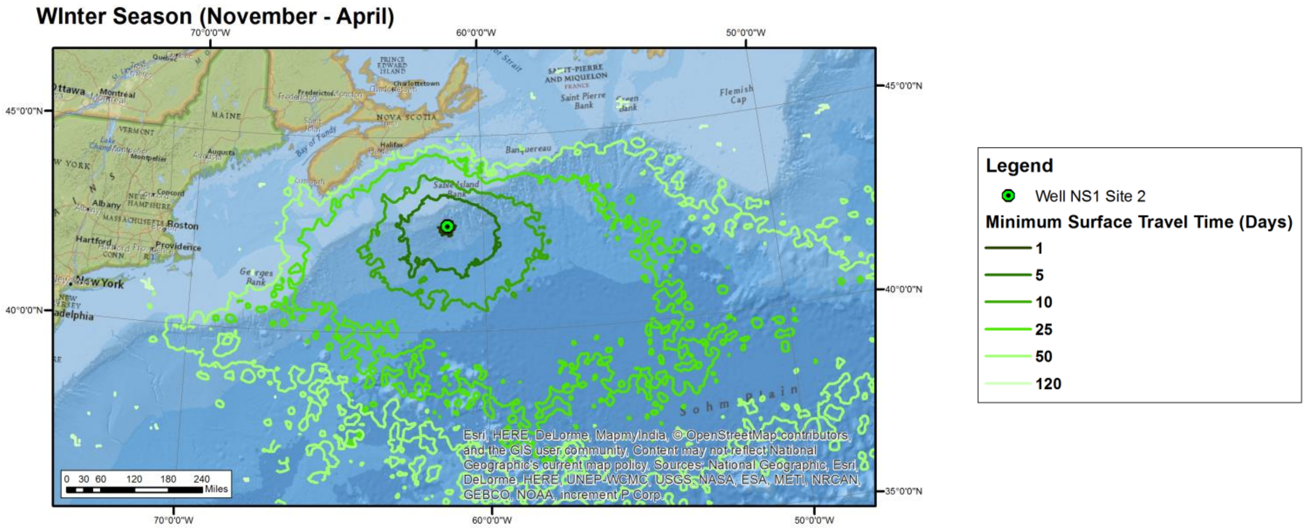

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Figure 8.4.5 Winter (November to April) stochastic model output (210 individual runs) showing maps of the predicted probability of sea surface oiling exceeding the 0.04 µm thickness threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 35,914 bpd blowout incident at Site 2.

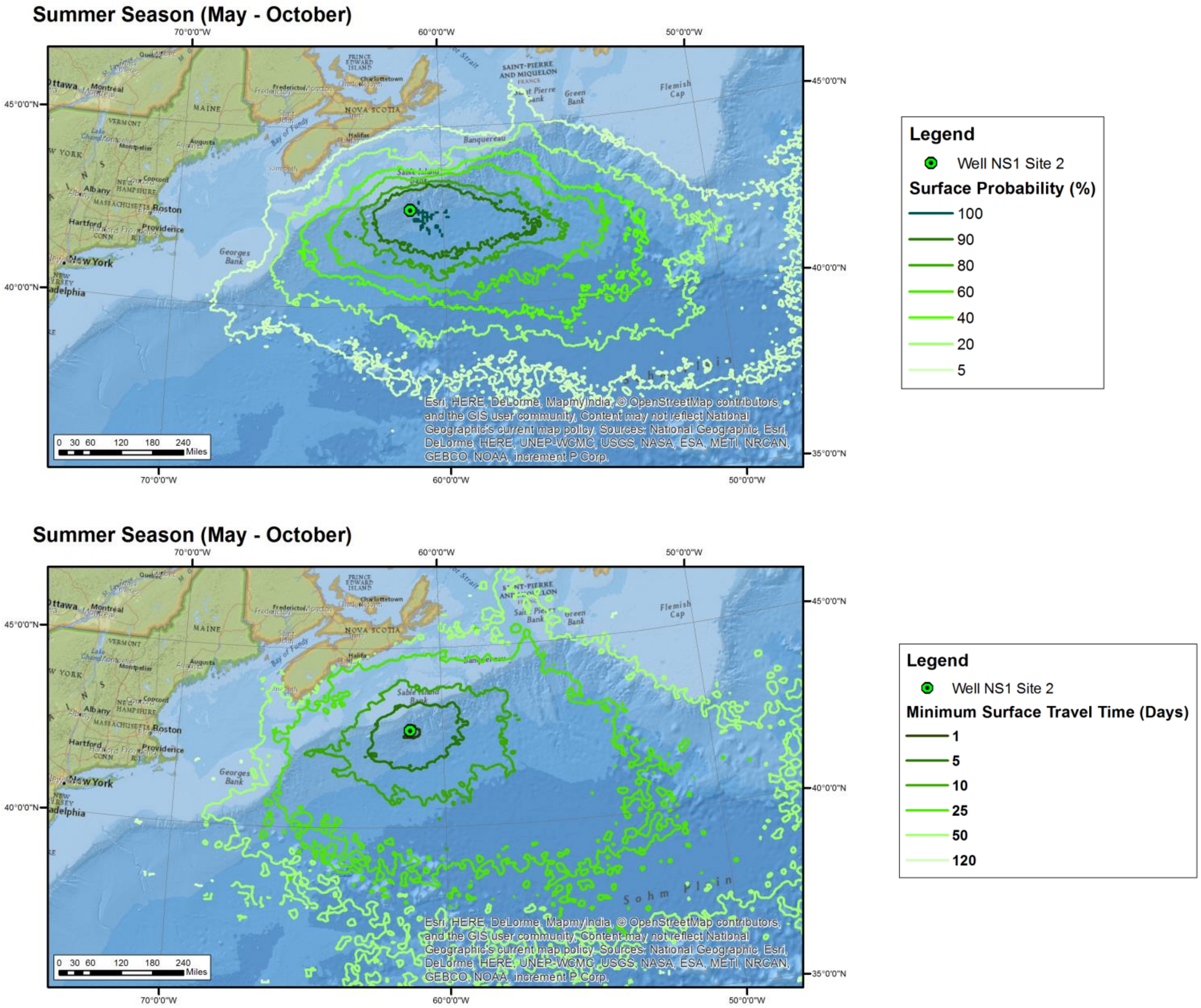

Figure 8.4.6 Summer (May to October) stochastic model output (210 individual runs) showing maps of the predicted probability of sea surface oiling exceeding the 0.04 µm thickness threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 35,914 bpd blowout incident at Site 2.

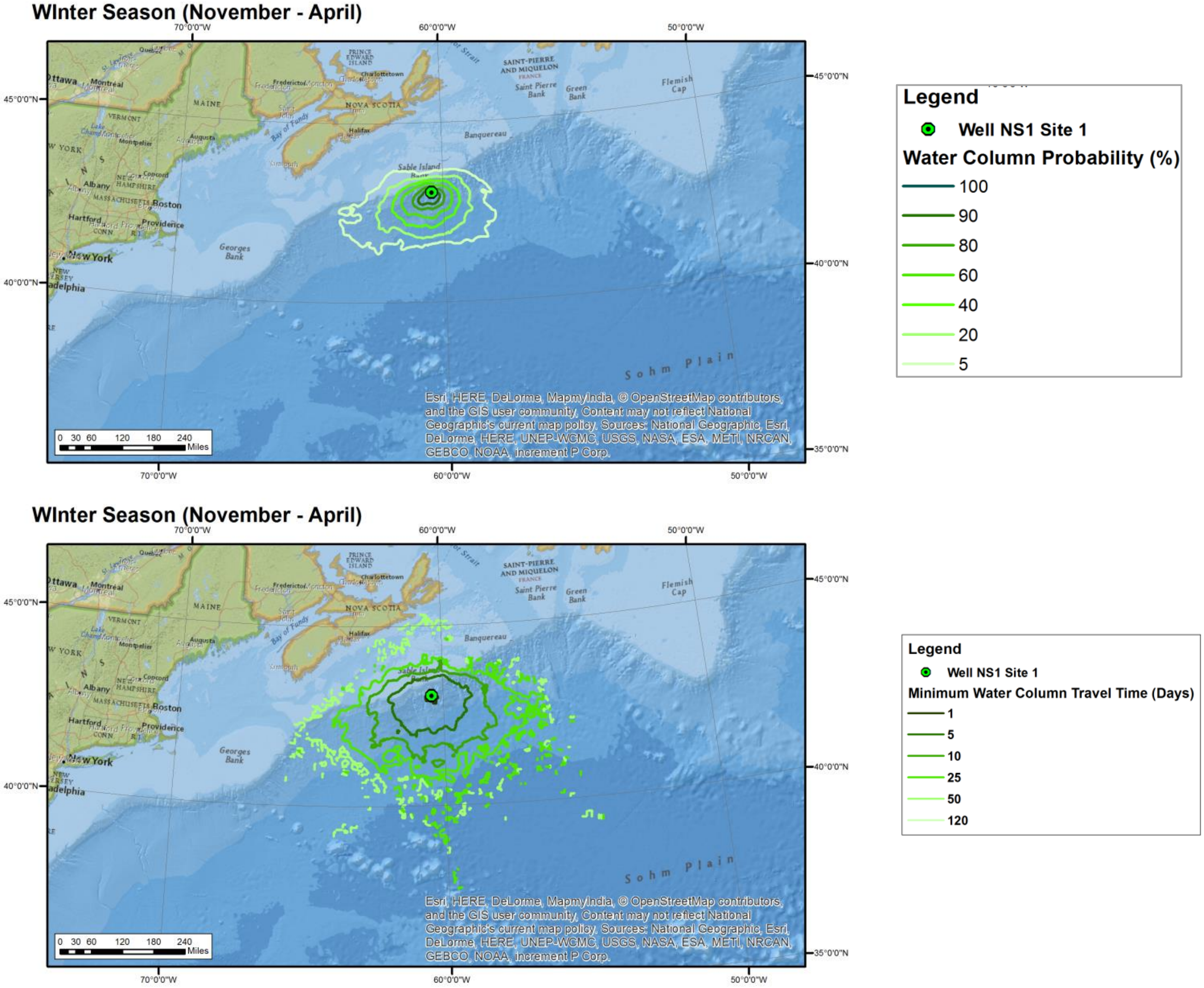

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Figure 8.4.7 Winter (November to April) stochastic model output (210 individual model runs) showing maps of the predicted probability of water column dispersed and dissolved oil concentrations exceeding the 58 ppb total hydrocarbon threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous blowout incident at Site 1.

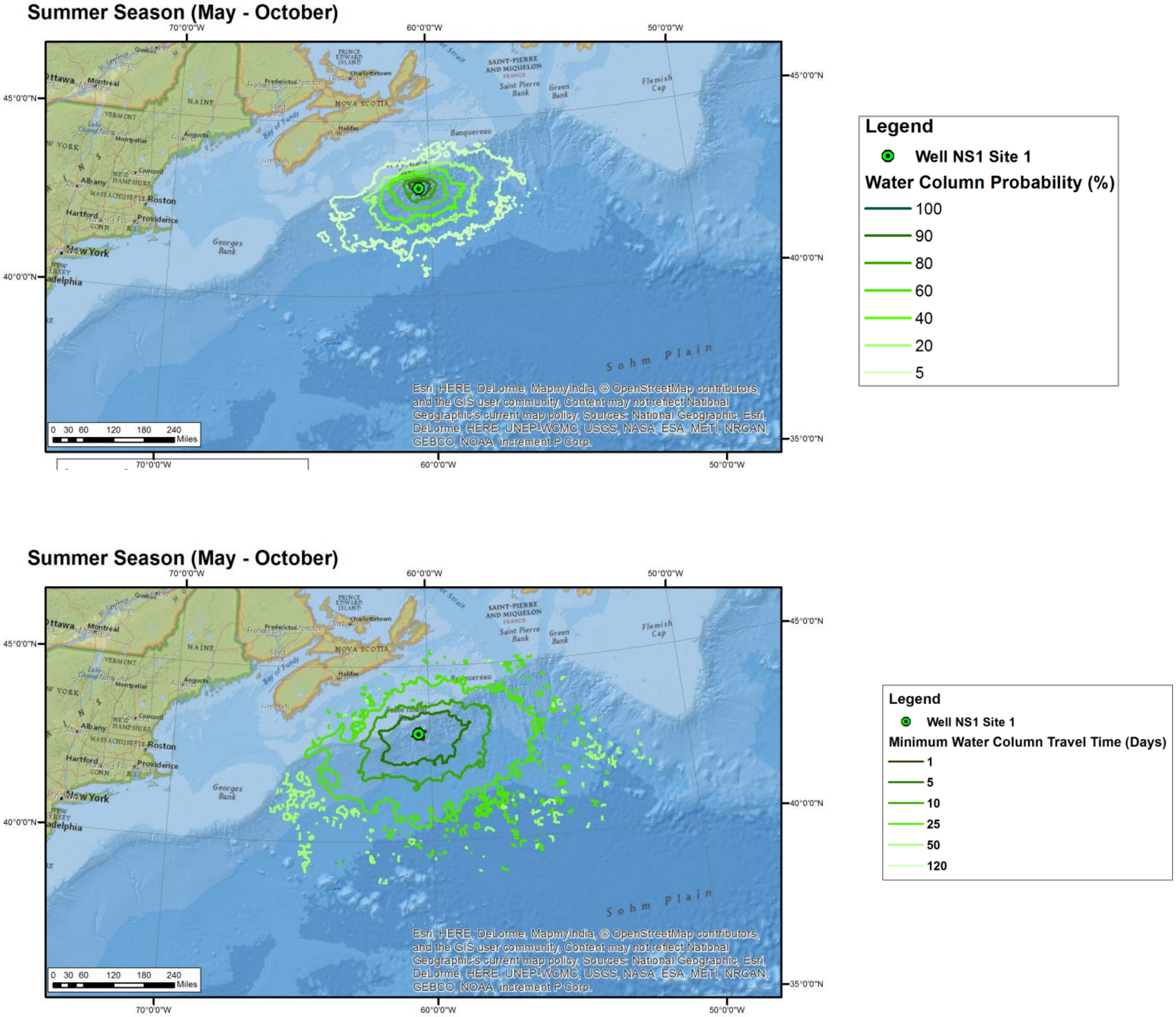


Figure 8.4.8 **Summer (May to October) stochastic model output (210 individual model runs) showing maps of the predicted probability of water column dispersed and dissolved oil concentrations exceeding the 58 ppb total hydrocarbon threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous blowout incident at Site 1.**

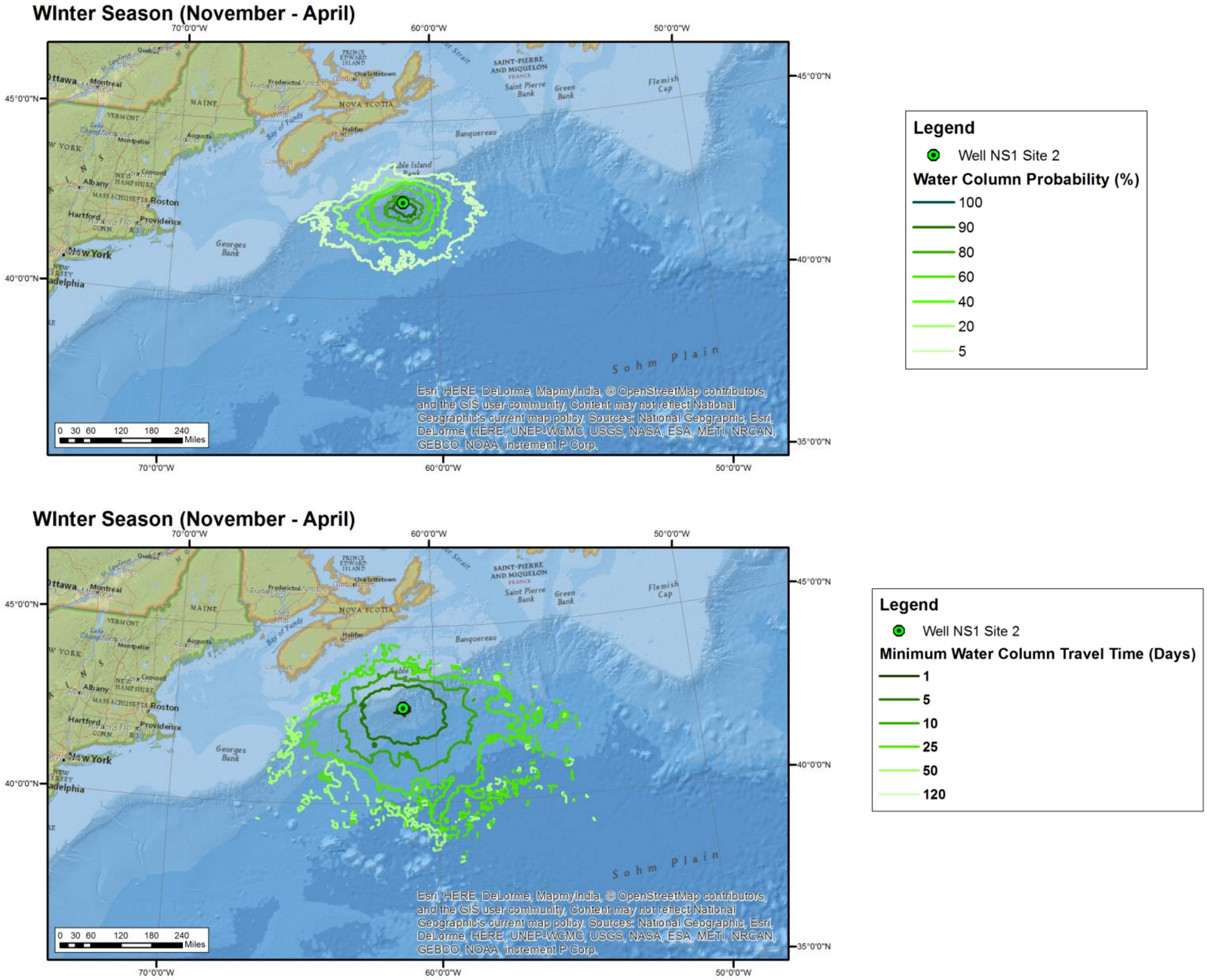


Figure 8.4.9 Winter (November to April) stochastic model output (210 individual model runs) showing maps of the predicted probability of water column dispersed and dissolved oil concentrations exceeding the 58 ppb total hydrocarbon threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous blowout incident at Site 2.

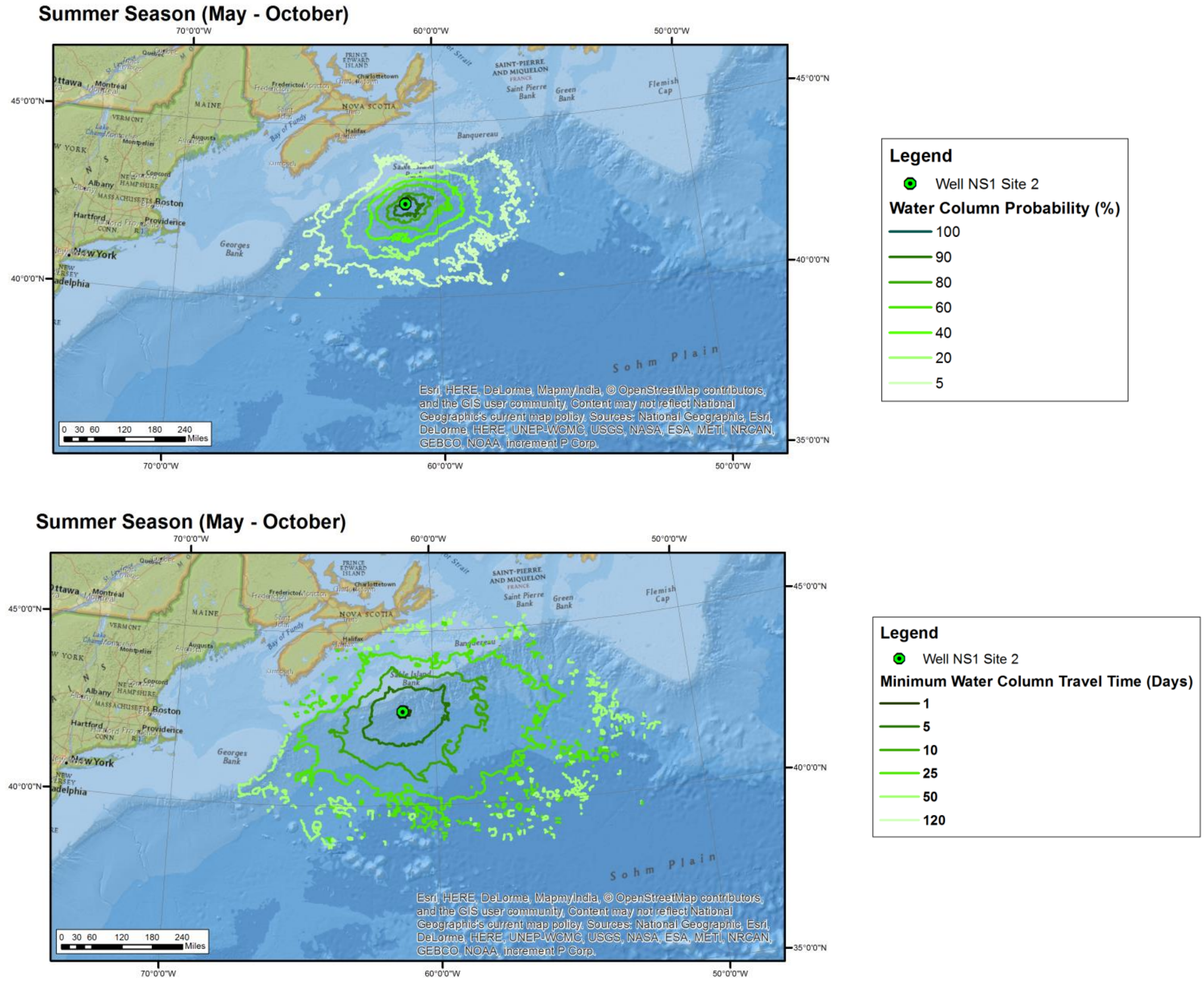
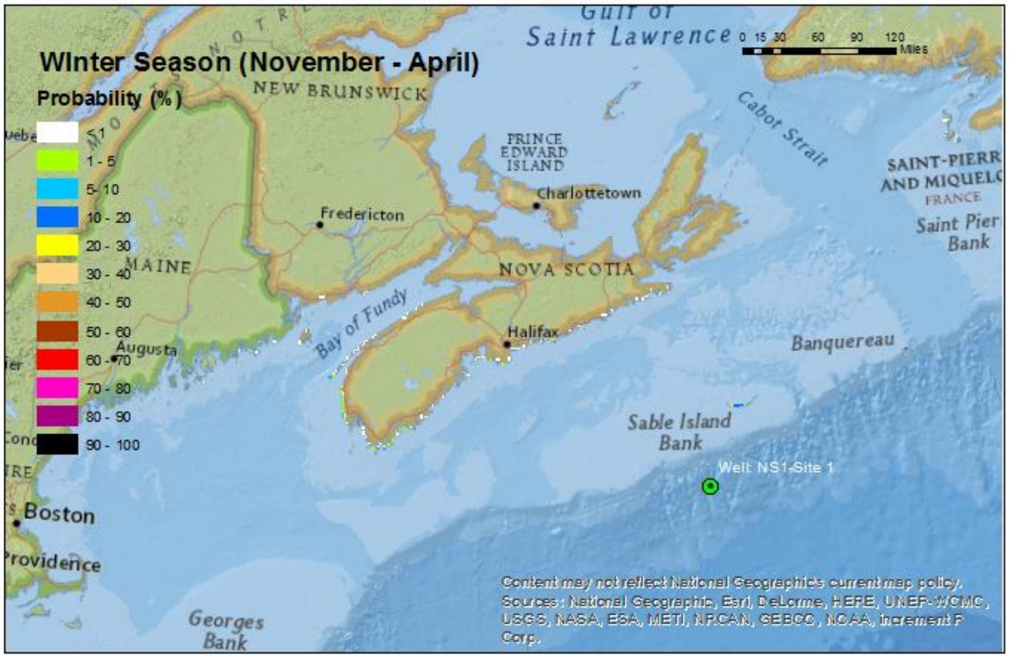


Figure 8.4.10 Summer (May to October) stochastic model output (210 individual model runs) showing maps of the predicted probability of water column dispersed and dissolved oil concentrations exceeding the 58 ppb total hydrocarbon threshold (top panel) and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous blowout incident at Site 2.


Winter Season (November - April)
Probability (%)
< 1
1 - 5
5 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
0 15 30 60 90 120 Miles
Gulf of Saint Lawrence
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
Cabot Strait
SAINT-PIERRE AND MIQUELON
FRANCE
Saint Pierre Bank
NOVA SCOTIA
MAINE
Bay of Fundy
Halifax
Augusta
Banquereau
Sable Island Bank
Well: NS1-Site 1
Boston
Providence
Georges Bank
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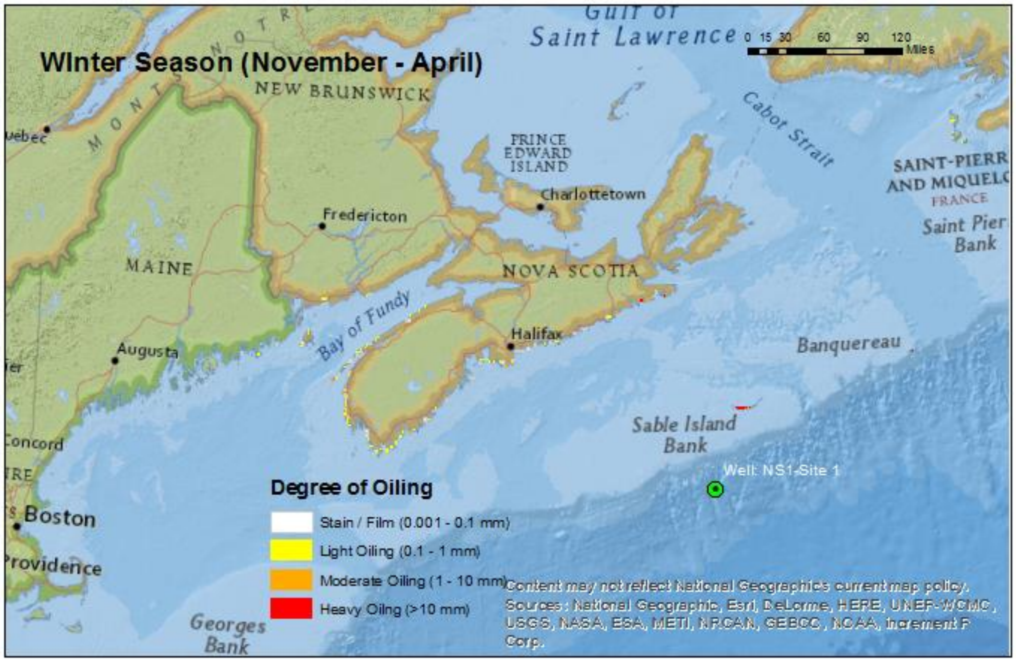
Winter Season (November - April)
0 15 30 60 90 120 Miles
Gulf of Saint Lawrence
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
Cabot Strait
SAINT-PIERRE AND MIQUELON
FRANCE
Saint Pierre Bank
NOVA SCOTIA
MAINE
Bay of Fundy
Halifax
Augusta
Banquereau
Sable Island Bank
Well: NS1-Site 1
Concord
Boston
Providence
Georges Bank
Degree of Oiling
Stain / Film (0.001 - 0.1 mm)
Light Oiling (0.1 - 1 mm)
Moderate Oiling (1 - 10 mm)
Heavy Oilng (>10 mm)
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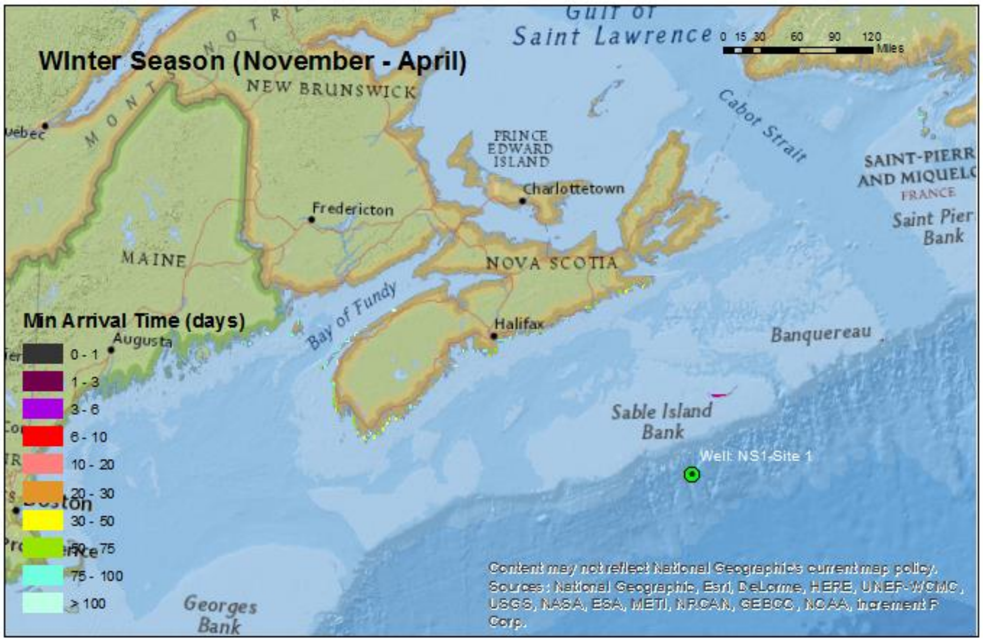
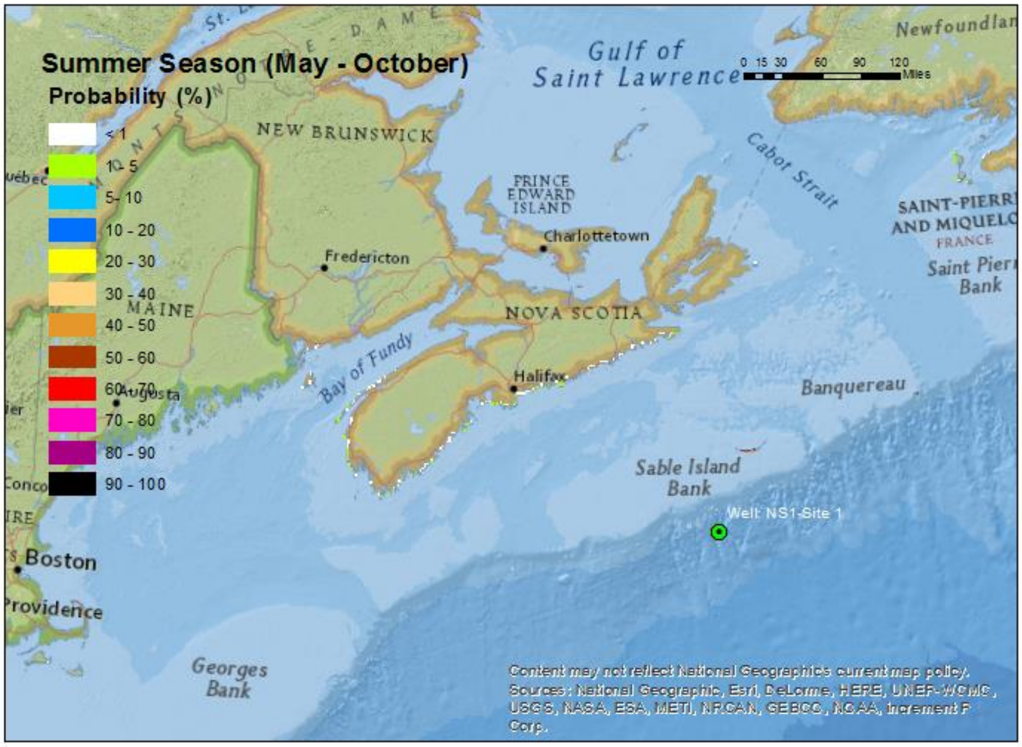


Figure 8.4.11 **Winter (November to April) stochastic model output (210 individual model runs) showing maps of the predicted probability of shoreline oiling exceeding the 1µm threshold (top panel), the maximum accumulated thickness of oil on the shoreline exceeding 1 µm (middle panel), and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 24,890 bpd blowout incident at Site 1.**


Summer Season (May - October)
Probability (%)
< 1
1 - 5
5 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
Gulf of Saint Lawrence
0 15 30 60 90 120 Miles
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
MAINE
Augusta
NOVA SCOTIA
Bay of Fundy
Halifax
Cabot Strait
Newfoundland
SAINT-PIERRE AND MIQUELON FRANCE
Saint Pierre Bank
Banquereau
Sable Island Bank
Well: NS1-Site 1
Boston
Providence
Concord
Georges Bank
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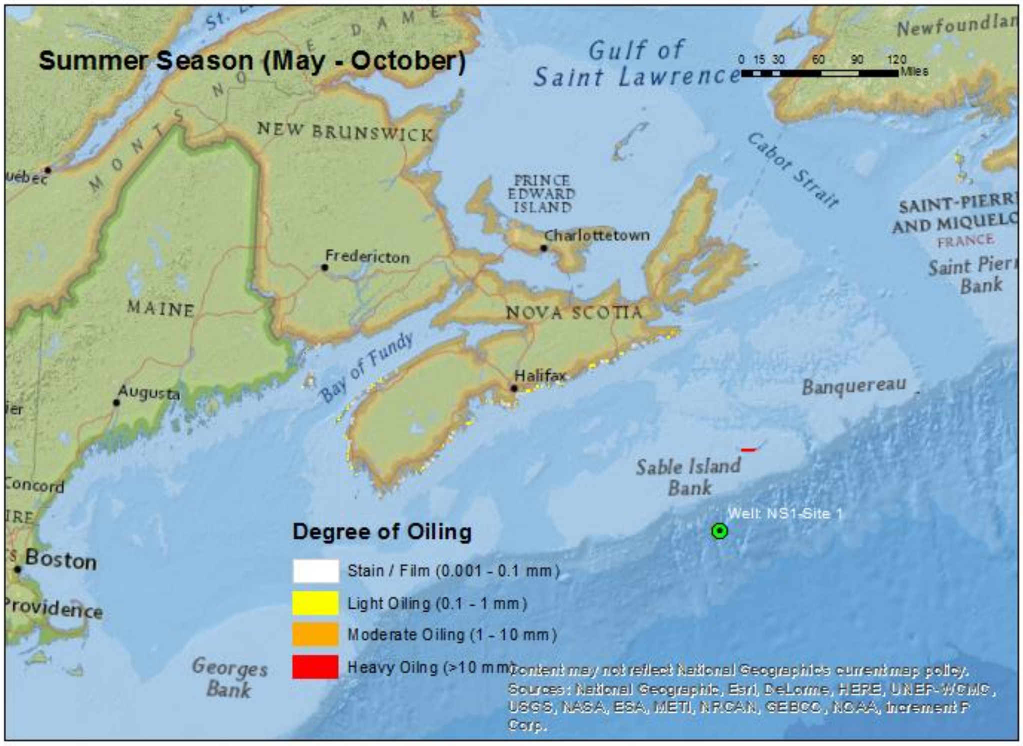

Summer Season (May - October)
Gulf of Saint Lawrence
0 15 30 60 90 120 Miles
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
MAINE
Augusta
NOVA SCOTIA
Bay of Fundy
Halifax
Cabot Strait
Newfoundland
SAINT-PIERRE AND MIQUELON FRANCE
Saint Pierre Bank
Banquereau
Sable Island Bank
Well: NS1-Site 1
Boston
Providence
Concord
Georges Bank
Degree of Oiling
Stain / Film (0.001 - 0.1 mm)
Light Oiling (0.1 - 1 mm)
Moderate Oiling (1 - 10 mm)
Heavy Oilng (>10 mm)
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

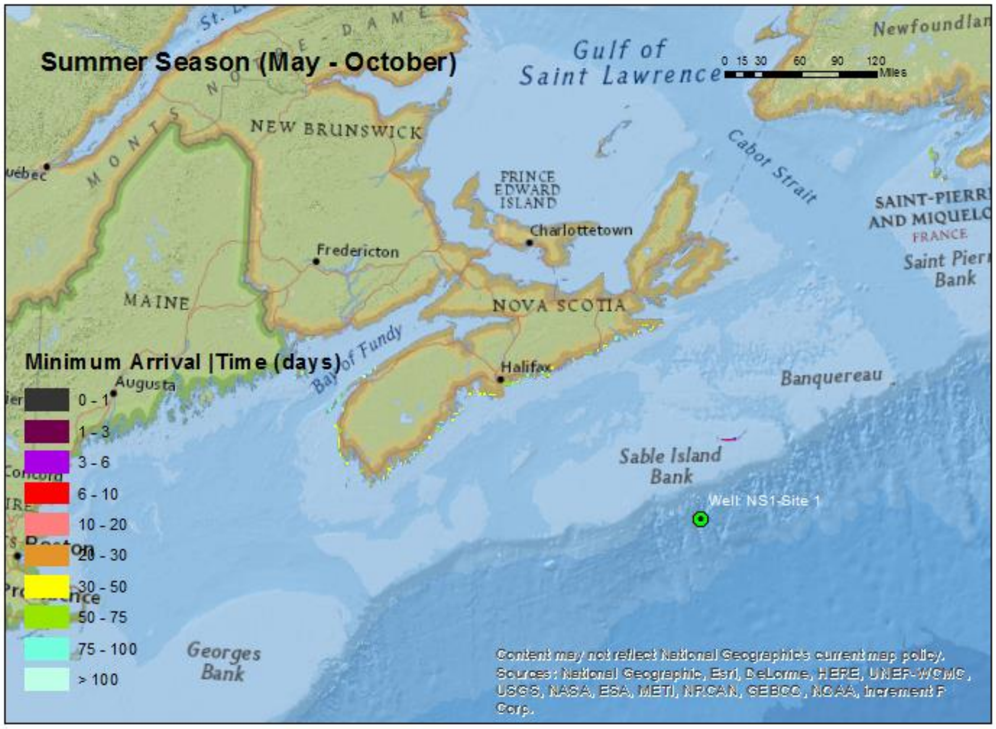
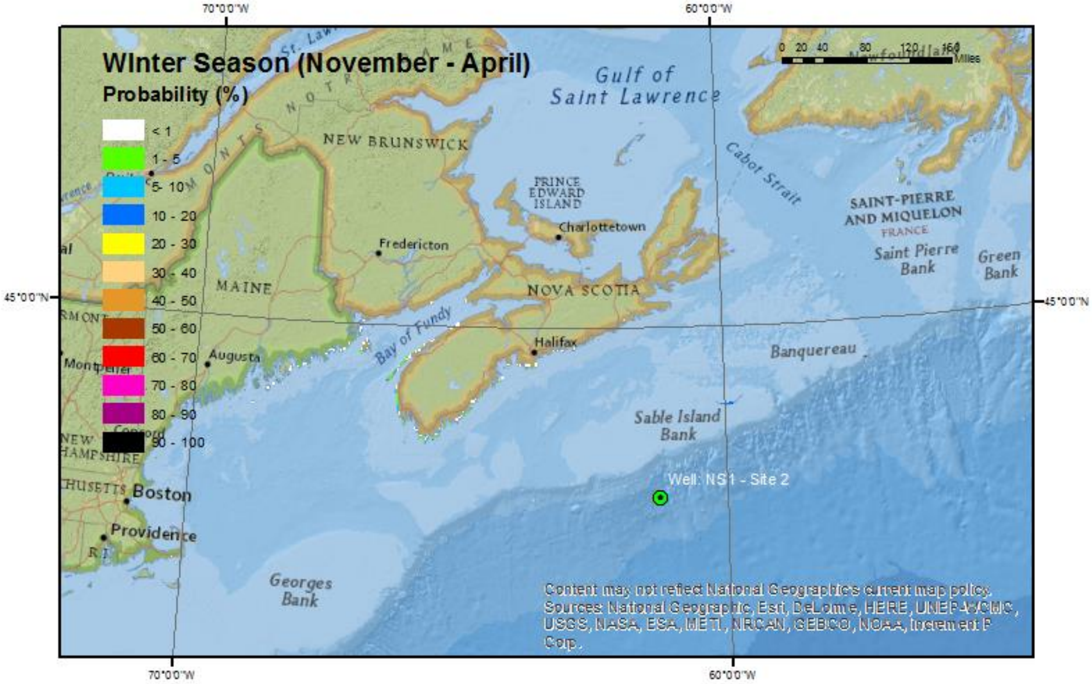


Figure 8.4.12 Summer (May to October) stochastic model output (210 individual model runs) showing maps of the predicted probability of shoreline oiling exceeding the 1µm threshold (top panel), the maximum accumulated thickness of oil on the shoreline exceeding 1 µm (middle panel), and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 24,890 bpd blowout incident at Site 1.


WInter Season (November - April)
Probability (%)
< 1
1 - 5
5- 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
90 - 100
70°0'0"W
60°0'0"W
45°0'0"N
0 20 40 80 120 160 Miles
Gulf of Saint Lawrence
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
Cabot Strait
SAINT-PIERRE AND MIQUELON
FRANCE
Saint Pierre Bank
Green Bank
MAINE
NOVA SCOTIA
Bay of Fundy
Halifax
Augusta
Banquereau
Sable Island Bank
Well: NS1 - Site 2
Boston
Providence
Georges Bank
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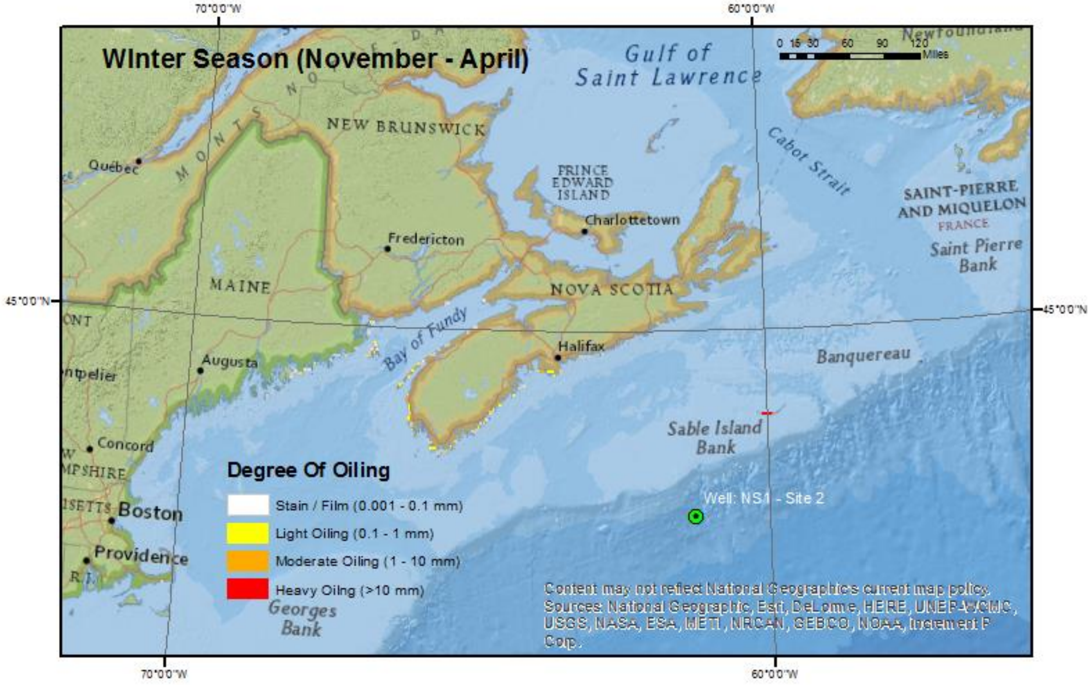
WInter Season (November - April)
Degree Of Oiling
Stain / Film (0.001 - 0.1 mm)
Light Oiling (0.1 - 1 mm)
Moderate Oiling (1 - 10 mm)
Heavy Oilng (>10 mm)
70°0'0"W
60°0'0"W
45°0'0"N
0 15 30 60 90 120 Miles
Gulf of Saint Lawrence
Québec
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
Cabot Strait
SAINT-PIERRE AND MIQUELON
FRANCE
Saint Pierre Bank
MAINE
NOVA SCOTIA
Bay of Fundy
Halifax
Augusta
Concord
Banquereau
Sable Island Bank
Well: NS1 - Site 2
Boston
Providence
Georges Bank
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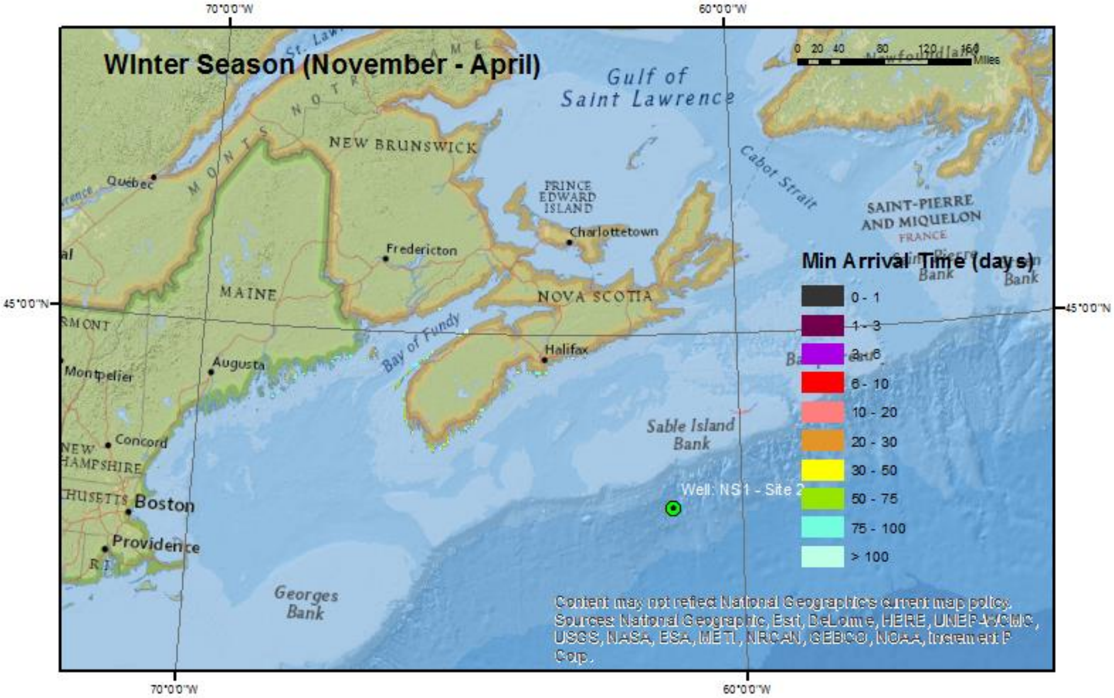
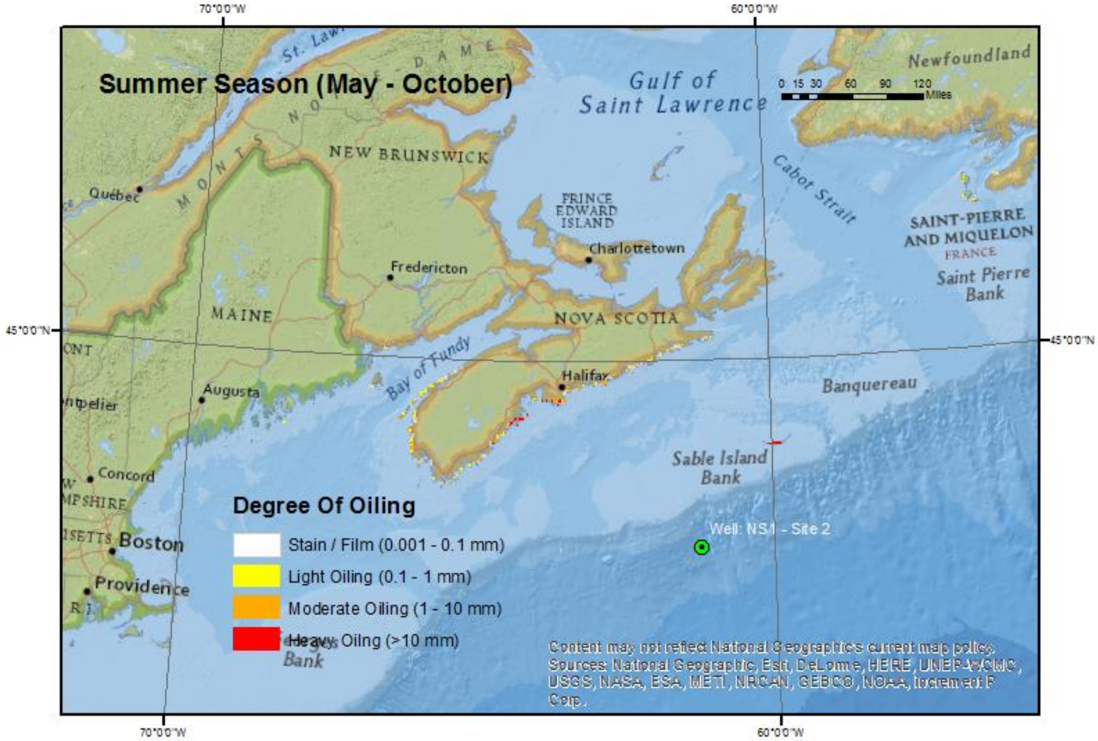


Figure 8.4.13 Winter (November to April) stochastic model output (210 individual model runs) showing maps of the predicted probability of shoreline oiling exceeding the 1µm threshold (top panel), the maximum accumulated thickness of oil on the shoreline exceeding 1 µm (middle panel), and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 35,914 bpd blowout incident at Site 2.


Summer Season (May - October)
Degree Of Oiling
Stain / Film (0.001 - 0.1 mm)
Light Oiling (0.1 - 1 mm)
Moderate Oiling (1 - 10 mm)
Heavy Oilng (>10 mm)
Well: NS1 - Site 2
0 15 30 60 90 120 Miles
70°0'0"W
60°0'0"W
45°0'0"N
Gulf of Saint Lawrence
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
NOVA SCOTIA
Halifax
MAINE
Augusta
Concord
Boston
Providence
Québec
Bay of Fundy
Cabot Strait
Newfoundland
SAINT-PIERRE AND MIQUELON
FRANCE
Saint Pierre Bank
Banquereau
Sable Island Bank
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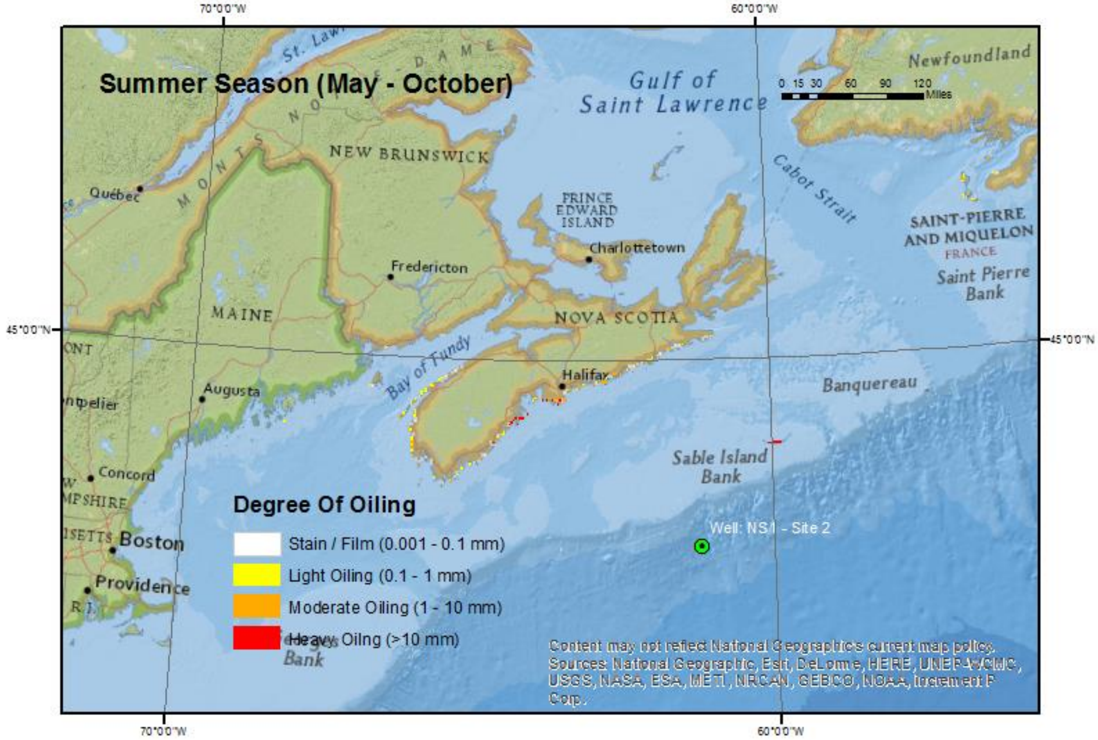
Summer Season (May - October)
Degree Of Oiling
Stain / Film (0.001 - 0.1 mm)
Light Oiling (0.1 - 1 mm)
Moderate Oiling (1 - 10 mm)
Heavy Oilng (>10 mm)
Well: NS1 - Site 2
0 15 30 60 90 120 Miles
70°0'0"W
60°0'0"W
45°0'0"N
Gulf of Saint Lawrence
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Charlottetown
Fredericton
NOVA SCOTIA
Halifax
MAINE
Augusta
Concord
Boston
Providence
Québec
Bay of Fundy
Cabot Strait
Newfoundland
SAINT-PIERRE AND MIQUELON
FRANCE
Saint Pierre Bank
Banquereau
Sable Island Bank
Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

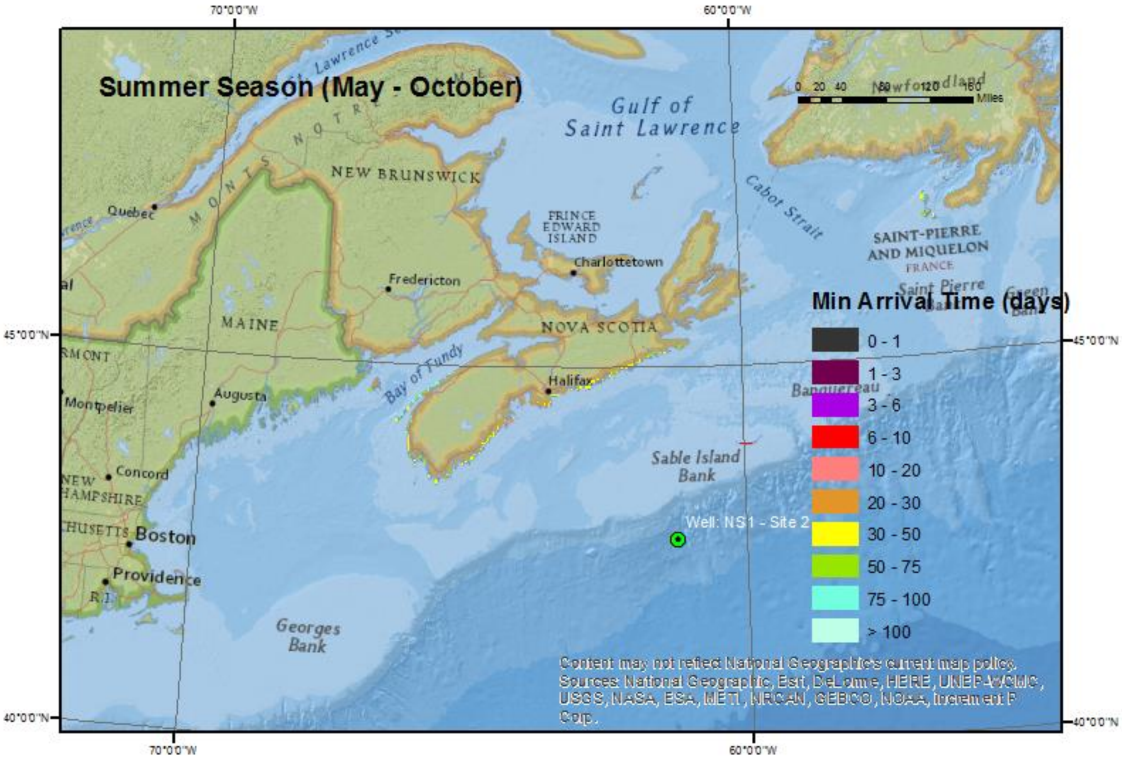

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Figure 8.4.14 Summer (May to October) stochastic model output (210 individual model runs) showing maps of the predicted probability of shoreline oiling exceeding the 1µm threshold (top panel), the maximum accumulated thickness of oil on the shoreline exceeding 1 µm (middle panel), and the associated minimum arrival times (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 35,914 bpd blowout incident at Site 2.

8.4.7.3 Transboundary Effects

A stochastic modelling approach was used to produce statistical outputs that include the probability of where oil might travel and the time taken for the oil to reach a given boundary or shoreline (refer to Section 8.4.2 for a description of the stochastic modelling approach). The stochastic modelling results for this Project demonstrated the potential locations for spill effects exceeding threshold levels beyond the RAA boundary, and in some cases, beyond Canadian jurisdiction. Figure 8.4.15 illustrates the average probability of transboundary effects from an unmitigated spill (Site 1 summer season). Assuming no mitigation, the model estimates a 16 % probability of surface oil resulting as a sheen (0.04 µm surface layer thickness) within the international boundaries of Saint-Pierre et Miquelon (France), which could occur in a minimum of 12 days of a blowout event, but would generally average 34 days for the minimum arrival time. For Site 1 in the summer, the average probability of an unmitigated spill resulting in surface oiling exceeding the threshold level within the US waters is approximately 7% (with a minimal arrival time of approximately 22 days but on average a minimum of 55 days); this average probability increases to 14% for Site 2 in winter with similar minimum arrival times. The average probability of an unmitigated spill resulting in surface oiling exceeding the threshold level within the waters of Bermuda is approximately 2%, with a minimum arrival time of approximately 44 days but on average a minimum of 60 days.

In the unlikely event that a well blowout incident does occur, transboundary effects are unlikely to occur following the implementation of BP’s risk management (refer to Section 8.1) and response management (refer to Section 8.3) measures to control the source of the release, contain, and recover surface oil.

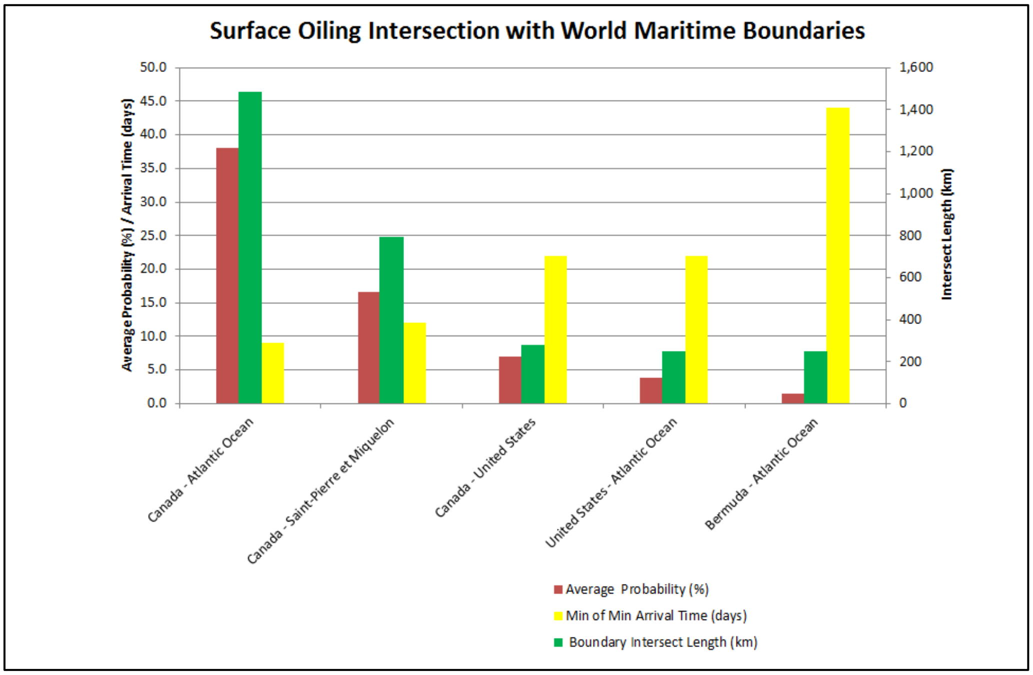


Figure 8.4.15 Site 1 Summer Season Unmitigated Blowout Incident and Sea Surface Oiling Intersection with World Maritime Boundaries (emulsified oil thicknesses exceeding the 0.04 µm (BAOAC "Sheen") thickness threshold)

8.4.8 Deterministic Modelling Results

A single worst-case credible scenario was selected based on the maximum shoreline oiling for both well sites from the stochastic modelling analyses. Deterministic trajectory models were run using these credible worst-case scenarios to illustrate the spatial area and degree of surface, water column, and shoreline oiling that may occur and which cannot be assessed using stochastic models.

The worst-case credible-scenarios for maximum shoreline oiling were identified for each of the 12 monthly stochastic modelling scenarios. These cases were then separated into winter and summer scenarios, and the scenario with the maximum shoreline oiling within each season were identified and run as an individual deterministic trajectory.

The results of representative cases identified for maximum shoreline oiling, from each stochastic analysis, for both well sites and for winter and summer seasons, are provided in Table 8.4.8. Table 8.4.9 also describes the specific details for each scenario including the time for oil to reach the shoreline, maximum mass of oil on the shoreline, length of coastline impacted, and the total amount of oil released.

Figures 8.4.16 to 8.4.19 provide outputs for representative summer, 30-day unmitigated blowout incident scenarios depicting surface oiling, in-water oiling, and shoreline oiling for Sites 1 and 2. Descriptions of these figures are provided below to assist with the interpretation.

1. *Surface Oil Figures:* The surface oil figures show the footprint of maximum floating surface oil and the associated thicknesses (μm) at all-time steps during the individual spill simulation. Surface oil contamination figures show only thicknesses greater than the 0.04 μm threshold.

2. *Water Column Figures:* The water column figures show the footprint of maximum water column concentration of dissolved oil (ppb) at all-time steps during the individual spill simulation. Water column oiling figures show only concentrations ≥58 ppb total hydrocarbon.

3. *Mass Balance Figures:* The mass balance figures provide an estimate of the oil's weathering and fate for a specific run for the entire model duration as a fraction of the oil released up to that point. Components of the oil tracked over time include the proportion of oil on the sea surface, entrained into the water column, stranded on shore, evaporated into the atmosphere, and that which has been degraded through biodegradation.

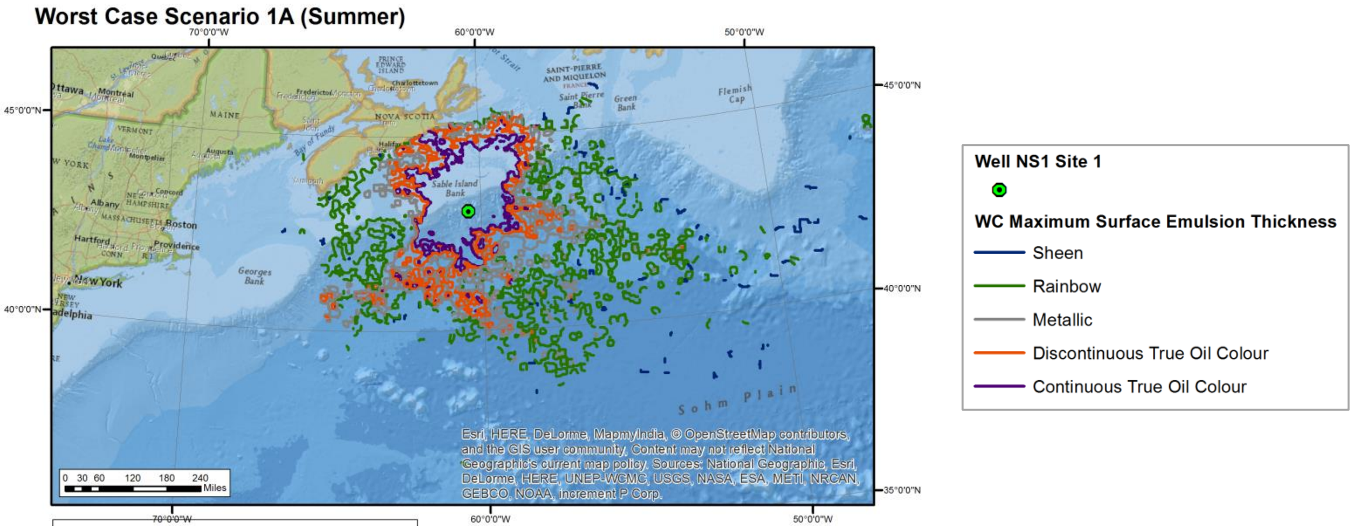
4. *Shoreline Impact Figures:* Figure showing mass of oil deposited onto shoreline. Only shoreline oiling exceeding 1 μm (which is roughly equivalent to 1 g/m^2 [French McCay *et al.* 2004]) is depicted.

The modelling results for Site 1 predict that the majority of oil would remain offshore. In the event that surface oil was to enter the nearshore area of Nova Scotia, it is predicted to have a thickness of between 0.04 and 0.3 μm. Exceedances of the in-water oil threshold are predicted to also be limited to offshore waters; however, the area impacted is smaller than that of surface oiling. Shoreline oiling exceeding the threshold level is expected to be limited to the coastline of Sable Island. Unmitigated oiling on Sable Island is predicted to be heavy with a thickness of > 10 mm. The maximum oil on shoreline scenario predicts that shoreline oiling at Sable Island would occur after 7 days, with a maximum mass of 670 tonnes of oil onshore and 27.8 km of coastline being affected.

The results for Site 2 illustrate that surface oiling exceeding the threshold will occur in the nearshore waters of Nova Scotia, with surface thicknesses ranging from 0.04 μm to 200 μm. The in-water oil threshold follows the same trend with in-water oil concentrations ranging from 58 ppb to 1000 ppb in the nearshore waters around Nova Scotia. A snapshot at day 101 of the deterministic run for Site 2 indicates that there will be shoreline oiling along the coastlines of both Sable Island and mainland Nova Scotia (Figure 8.4.19). The maximum oil on shoreline scenario predicts that shoreline oiling would occur after 12 days, with a maximum mass of 669 tonnes of oil on shore and a maximum length of 79.5 km of coastline being affected.

Table 8.4.8 Summary of Deterministic Modelling Scenarios and Results

Deterministic simulations	**Scenario - Site 1 (Maximum oil on shoreline - Winter Season)**	**Scenario - Site 1 (Maximum oil on shoreline - Summer Season)**	**Scenario - Site 2 (Maximum oil on shoreline - Winter Season)**	**Scenario - Site 2 (Maximum oil on shoreline - Summer Season)**
	24,890 bpd (Initial oil release rate) / 30 days duration (capping stack)	**24,890 bpd (Initial oil release rate) / 30 days duration (capping stack)**	**35,914 bpd (Initial oil release rate) / 30 days duration (capping stack)**	**35,914 bpd (Initial oil release rate) / 30 days duration (capping stack)**
Season	Winter (November - April)	Summer (May - October)	Winter (November - April)	Summer (May - October)
Simulation number	31	13	161	104
Start time	November 4, 2006 21:00	June 19, 2006 23:00	April 18, 2009 3:00	June 24, 2008 3:00
Simulation duration	120 days	120 days	120 days	120 days
Release duration	30 days	30 days	30 days	30 days
Initial Release rate	24,890 bpd	24,890 bpd	35,914 bpd	35,914 bpd
Total oil release	115,377 tonnes	99,190 tonnes	142,902 tonnes	142,903 tonnes
First shore hit	5.0 days	7.0 days	31.0 days	12.0 days
Maximum mass on shoreline	239 tonnes	670 tonnes	224 tonnes	669 tonnes
Ashore time (maximum mass)	18.01 days	42.01 days	37.01 days	32.01 days
Length of coastline impacted (at maximum mass ashore)	27.8 km	27.8 km	23.8 km	27.8 km
Maximum length of coastline impacted	27.8 km	27.8 km	31.8 km	79.5 km
Ashore time (maximum length)	12.0 days	13.0 days	89.0 days	101.0 days
First shore hit (shortest possible)	5.82 days	3.81 days	10.52 days	6.61 days
	140 hours	91 hours	252 hours	159 hours


Worst Case Scenario 1A (Summer)
70°0'0"W
60°0'0"W
50°0'0"W
45°0'0"N
40°0'0"N
35°0'0"N
Sable Island Bank
Georges Bank
Sohm Plain
Flemish Cap
Green Bank
Saint Pierre Bank
NOVA SCOTIA
Halifax
Boston
New York
0 30 60 120 180 240 Miles
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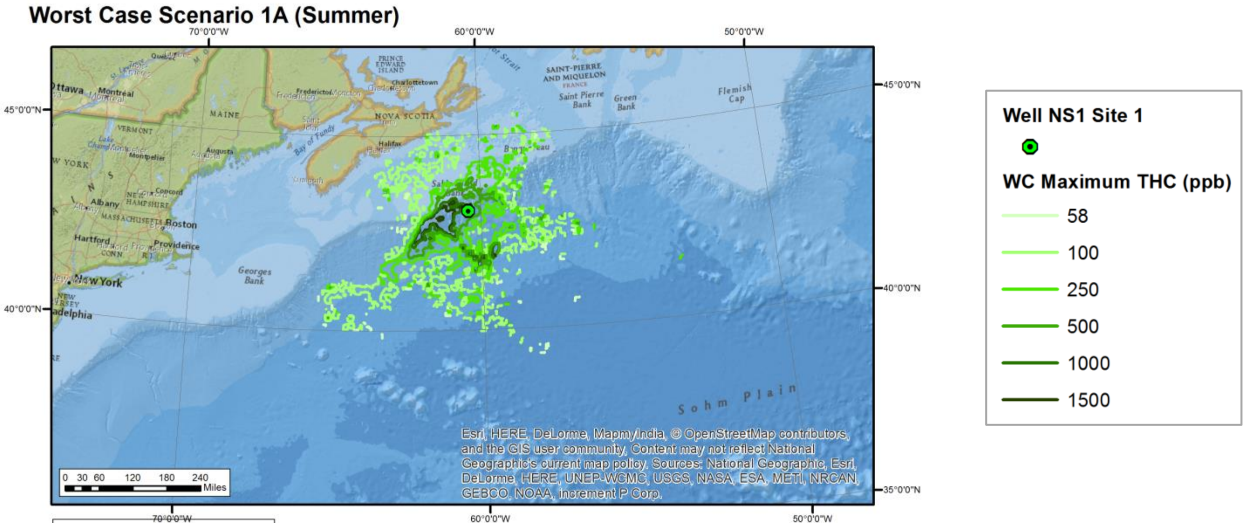
Well NS1 Site 1
WC Maximum Surface Emulsion Thickness
Sheen
Rainbow
Metallic
Discontinuous True Oil Colour
Continuous True Oil Colour


Worst Case Scenario 1A (Summer)
70°0'0"W
60°0'0"W
50°0'0"W
45°0'0"N
40°0'0"N
35°0'0"N
Georges Bank
Sohm Plain
Flemish Cap
Green Bank
Saint Pierre Bank
NOVA SCOTIA
Halifax
Boston
New York
0 30 60 120 180 240 Miles
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Well NS1 Site 1
WC Maximum THC (ppb)
58
100
250
500
1000
1500

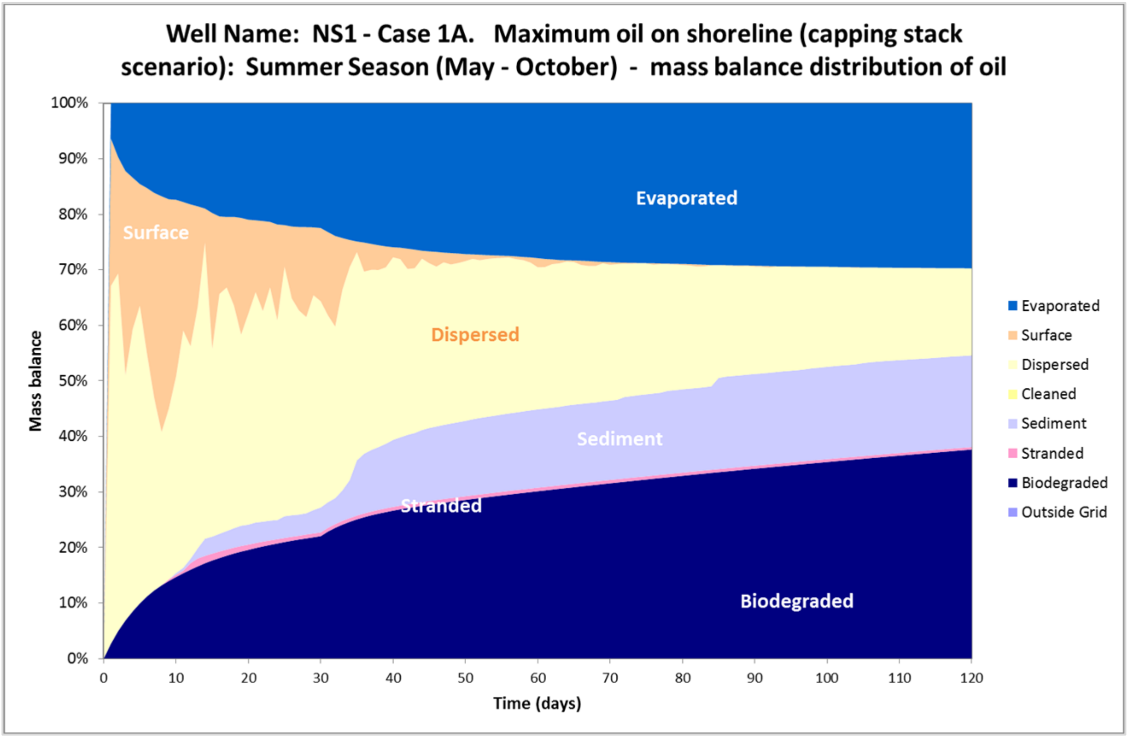


Figure 8.4.16 Site 1 Summer (June 19 2006, 23:00) deterministic model output showing maps of the predicted levels of surface oiling exceeding the 0.04 µm threshold (top panel), the levels of in-water oil concentration exceeding the 58 ppb threshold (middle panel), and the associated mass balance (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 24,890 bpd blowout incident.

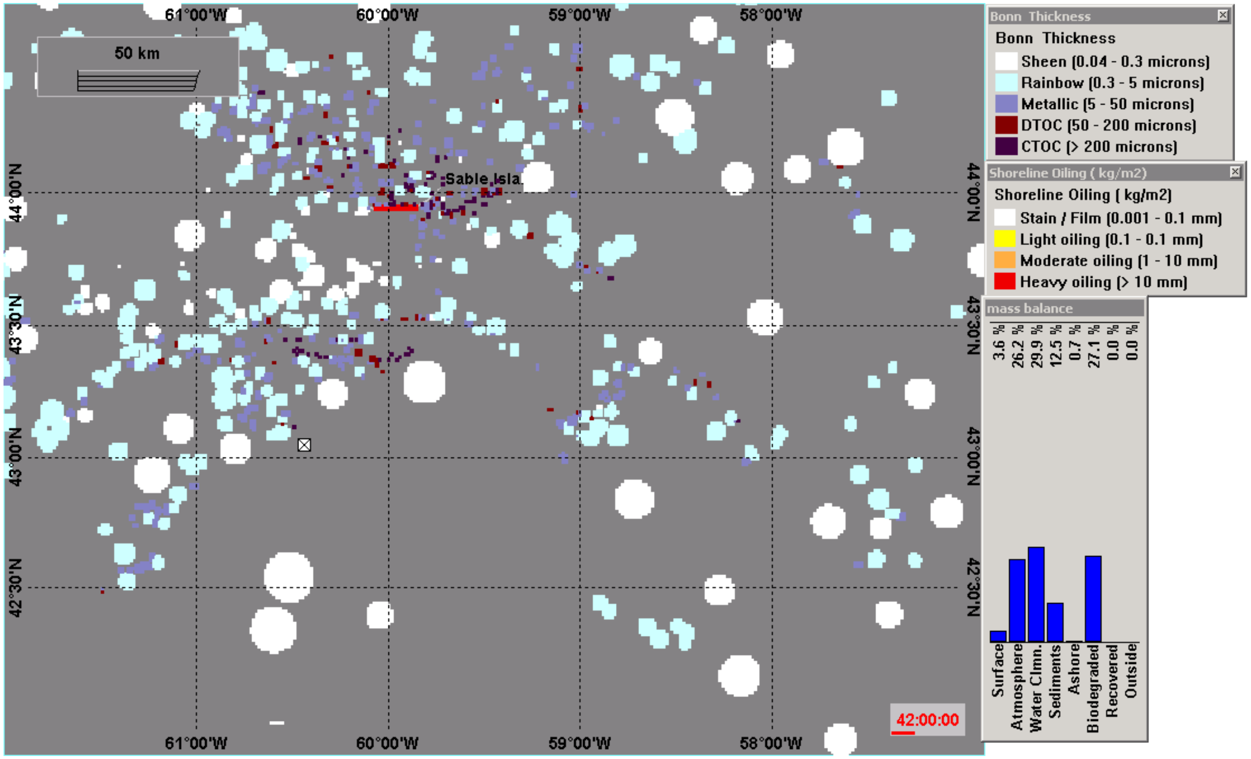
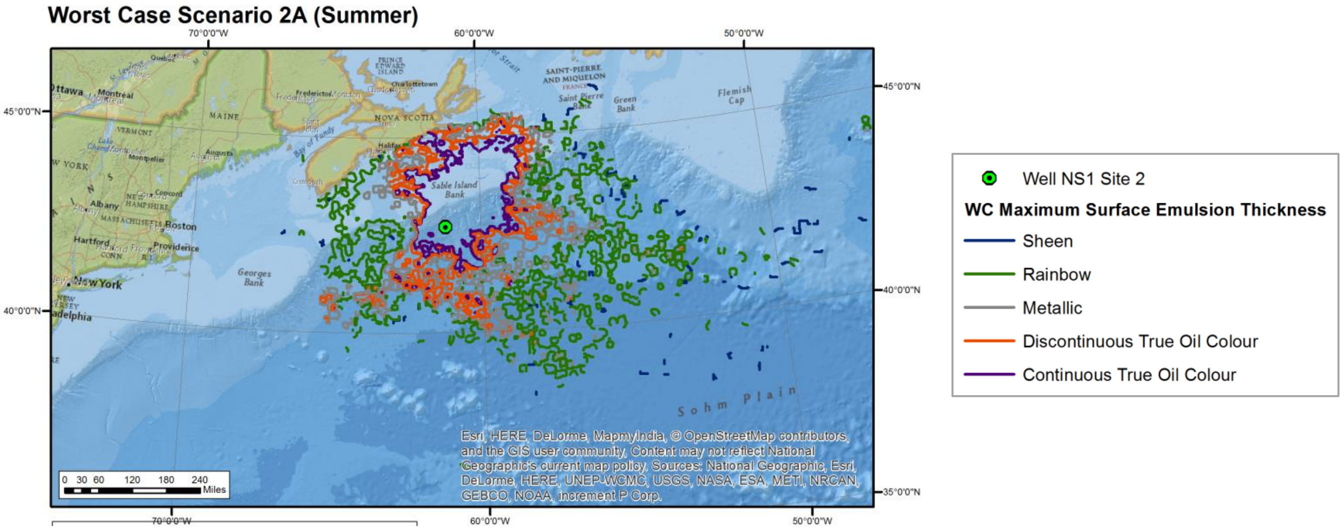


Figure 8.4.17 Site 1 summer (June 19 2006, 23:00) deterministic model output showing a snapshot of shoreline oiling on day 42 after the release for a worst credible case (*i.e.*, unmitigated), 30-day continuous 24,890 bpd blowout incident.


Worst Case Scenario 2A (Summer)
70°0'0"W
60°0'0"W
50°0'0"W
45°0'0"N
40°0'0"N
35°0'0"N
Nova Scotia
Sable Island Bank
Georges Bank
Saint-Pierre and Miquelon
Saint Pierre Bank
Green Bank
Flemish Cap
Sohm Plain
Boston
New York
Halifax
0 30 60 120 180 240 Miles
Well NS1 Site 2
WC Maximum Surface Emulsion Thickness
Sheen
Rainbow
Metallic
Discontinuous True Oil Colour
Continuous True Oil Colour
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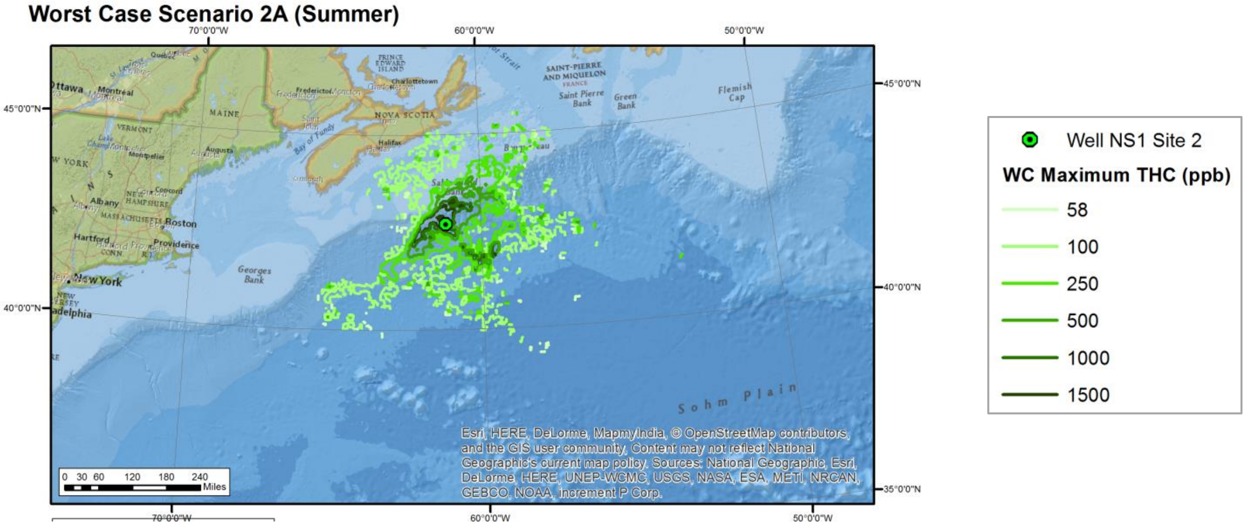
Worst Case Scenario 2A (Summer)
70°0'0"W
60°0'0"W
50°0'0"W
45°0'0"N
40°0'0"N
35°0'0"N
Nova Scotia
Georges Bank
Saint-Pierre and Miquelon
Saint Pierre Bank
Green Bank
Flemish Cap
Sohm Plain
Boston
New York
0 30 60 120 180 240 Miles
Well NS1 Site 2
WC Maximum THC (ppb)
58
100
250
500
1000
1500
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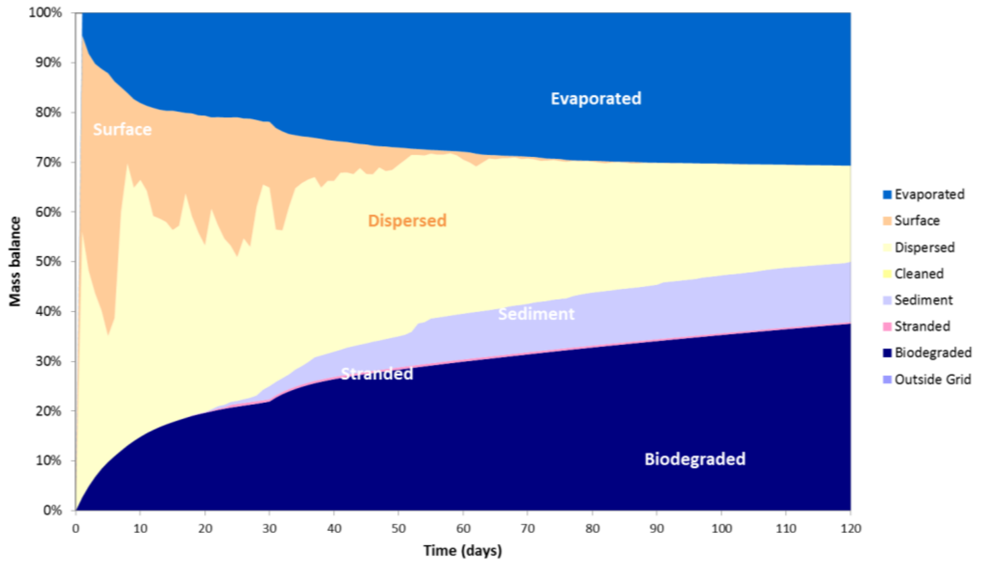

Figure 8.4.18 **Site 2 summer (June 24 2008, 03:00) deterministic model output showing maps of the predicted levels of surface oiling exceeding the 0.04 µm threshold (top panel), the levels of in-water oil concentration exceeding the 58 ppb threshold (middle panel), and the associated mass balance (bottom panel) for a worst credible case (*i.e.*, unmitigated), 30-day continuous 35,914 bpd blowout incident.**

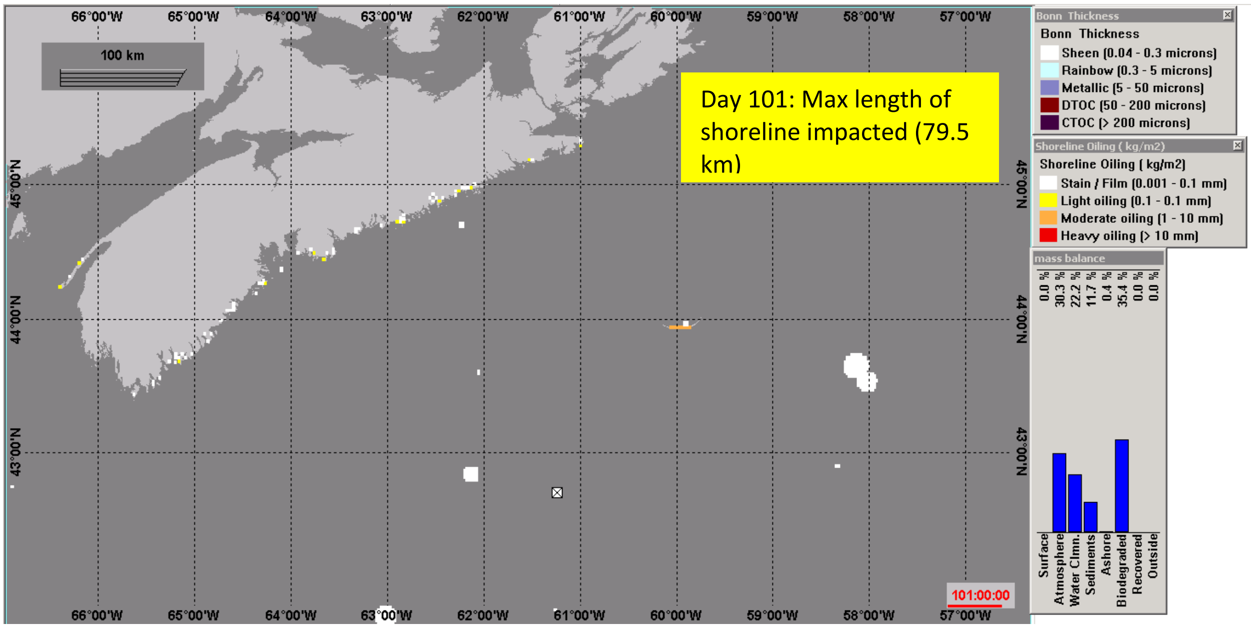

Figure 8.4.19 Site 2 summer (June 24 2008, 03:00) deterministic model output showing a snapshot of shoreline oiling on day 101 after the release for a worst credible case (*i.e.*, unmitigated), 30-day continuous 35,914 bpd blowout incident.

8.4.9 Diesel Batch Spill 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 the course of a 30 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 at Site 1 (Figure 8.4.1). The location of threshold exceedances for effects is expected to occur over a greater area if a spill occurs during the summer than for winter. Stochastic modelling outputs are provided in Figures 8.4.20 and 8.4.21, which depict the probability of sea surface emulsified oil thickness exceeding the 0.04 µm threshold. The models comprise 225 individual modelling runs for the 10 bbl and 100 bbl scenarios. Figures 8.4.22 and 8.4.23 illustrate the stochastic modelling results for the maximum time-averaged emulsified oil thickness on the sea surface exceeding the 0.04 µm threshold for both spill scenarios. Stochastic modelling results indicate that the maximum exposure time for emulsified oil thickness on the sea surface exceeding the 0.04 µm threshold would be less than 1 day.

Deterministic results provided in Figures 8.4.24 and 8.4.25 indicate that, for both scenarios, surface oil would rapidly evaporate and disperse into the water column following release. In the 100 bbl batch spill scenario, approximately 65% of the spill evaporated from the surface within three days following the release, with remaining proportions dispersing or biodegrading within the same period. For the 10 bbl and 100 bbl deterministic scenarios, areas of 23 km^2 and 336 km^2, respectively, experienced maximum total in-water concentrations of dissolved oil in excess of 1 ppb (Figures 8.4.24 and 8.4.25). Results from the 10 bbl and 100 bbl scenario indicate that all of the total in-water dissolved oil falls within the concentration range of 1 to 10 ppb (0.001 to 0.01 ppm). Deterministic runs of the maximum surface emulsified oil thickness indicate that for the 10 bbl batch spill, the maximum area of surface coverage would be approximately 0.82 km^2. The majority of the surface oil thickness is predicted to fall within the range of 0.04 to 5 µm, with a very small area falling within the 5 to 50 µm range. The deterministic run for the 100 bbl batch spill predicts that the oil thickness of the spill would cover a maximum area of approximately 4.4 km^2, with a thickness of 0.04 to 5 µm. The thickness of oiling is predicted to decrease with distance from the release site. Unless the release occurs from a PSV transiting in the nearshore area, it is not expected that a batch spill would reach the coastline of Nova Scotia or Sable Island.

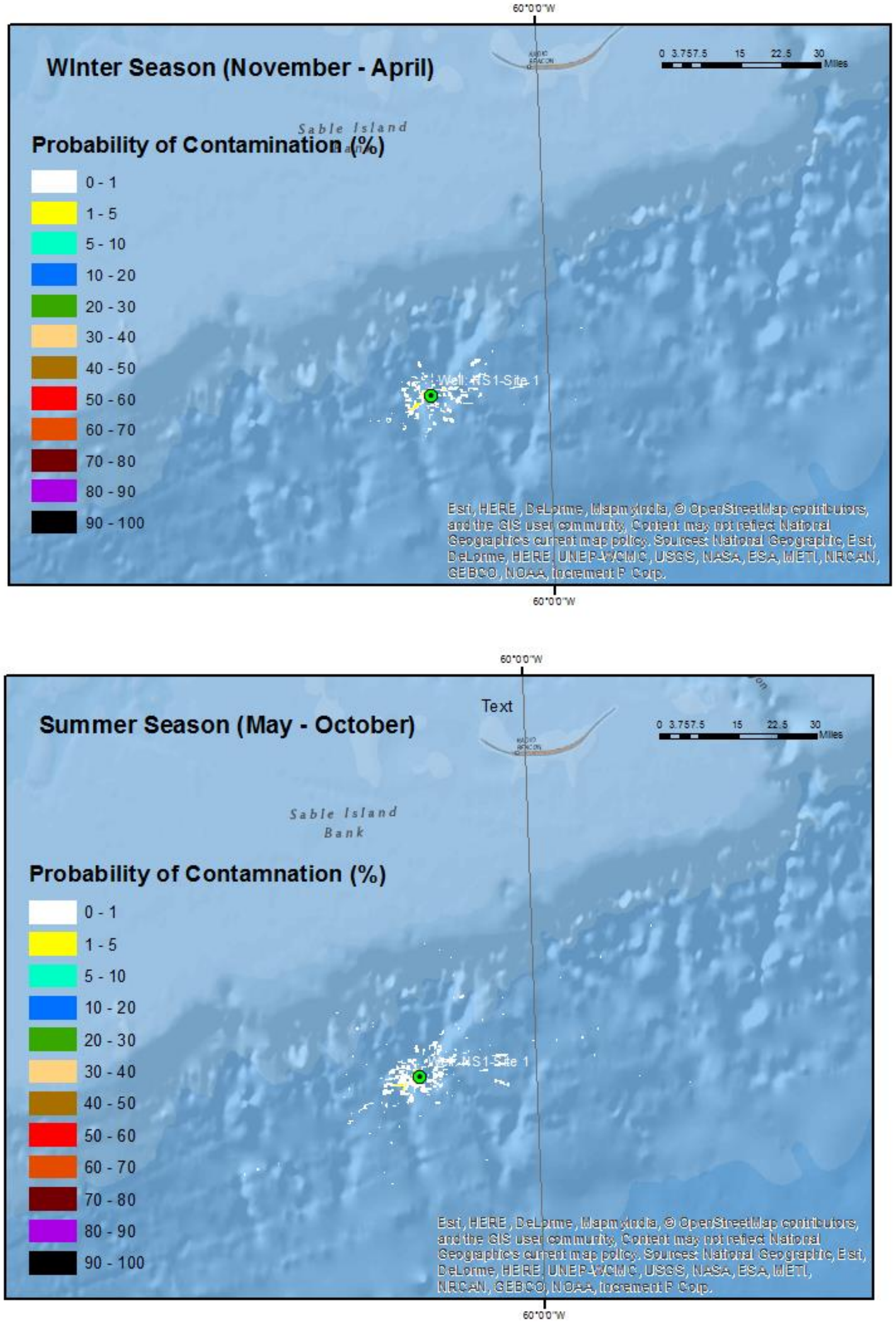

Figure 8.4.20 Stochastic model output (225 individual model runs) showing the probability of sea surface emulsified oil thickness exceeding 0.04 µm for an unmitigated 10 bbl surface batch release of diesel at Site 1.

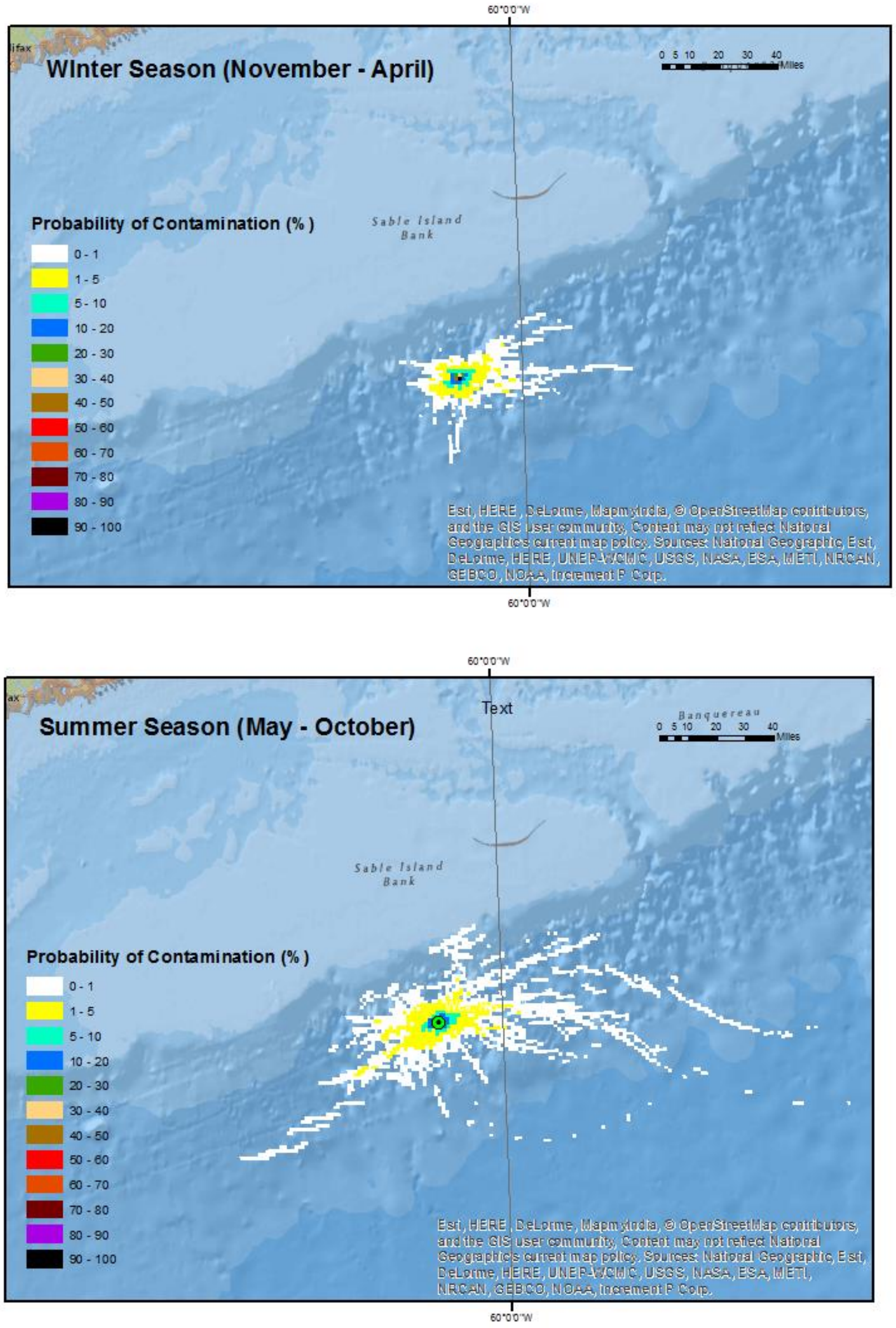

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Figure 8.4.21 Stochastic model output (225 individual model runs) showing the probability of sea surface emulsified oil thickness exceeding 0.04 µm for an unmitigated 100 bbl surface batch release of diesel at Site 1.

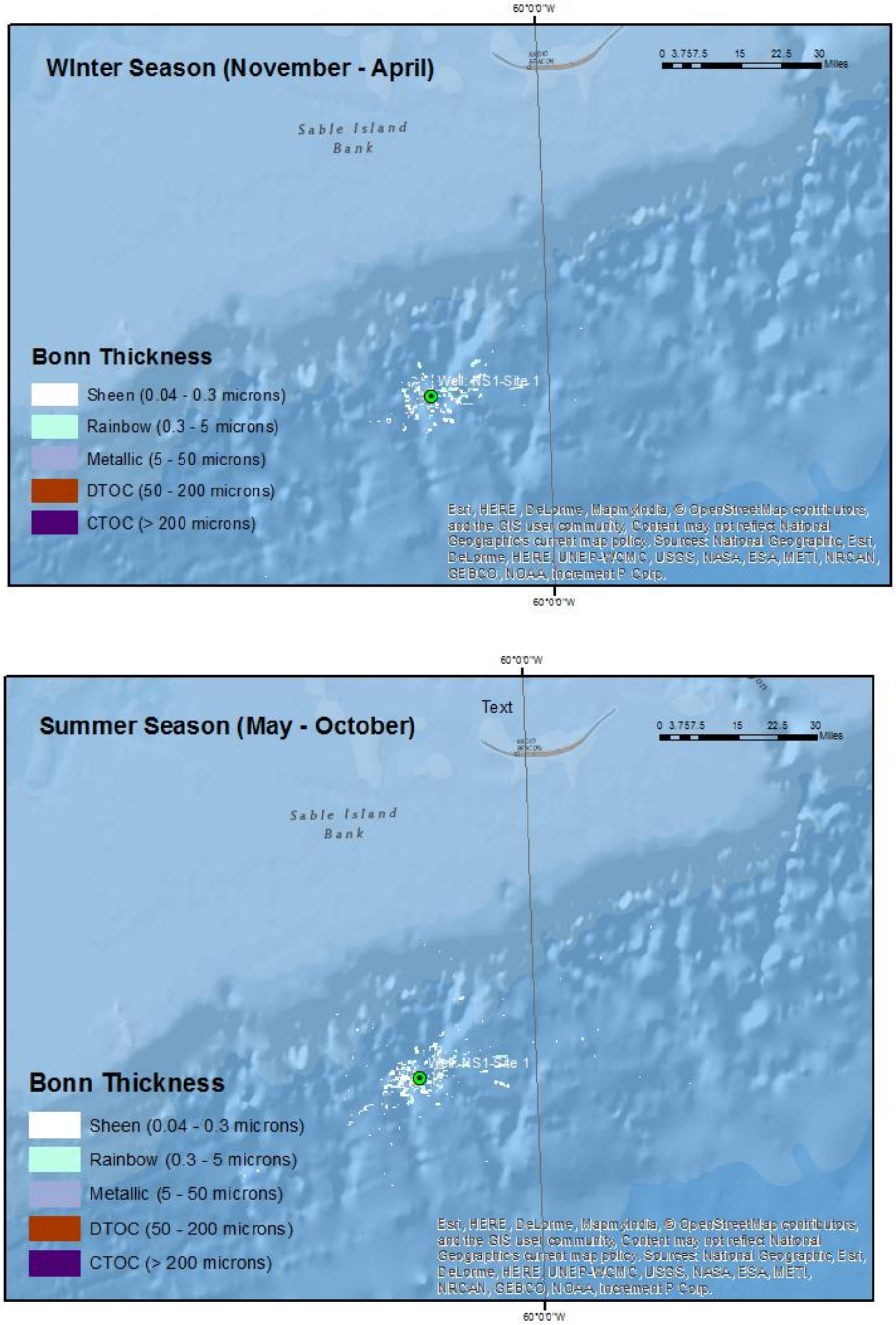

Figure 8.4.22 Stochastic model output (225 individual model runs) showing the maximum time-averaged emulsified oil thickness on the sea surface (exceeding the 0.04 µm threshold) for an unmitigated 10 bbl batch release of diesel at Site 1.

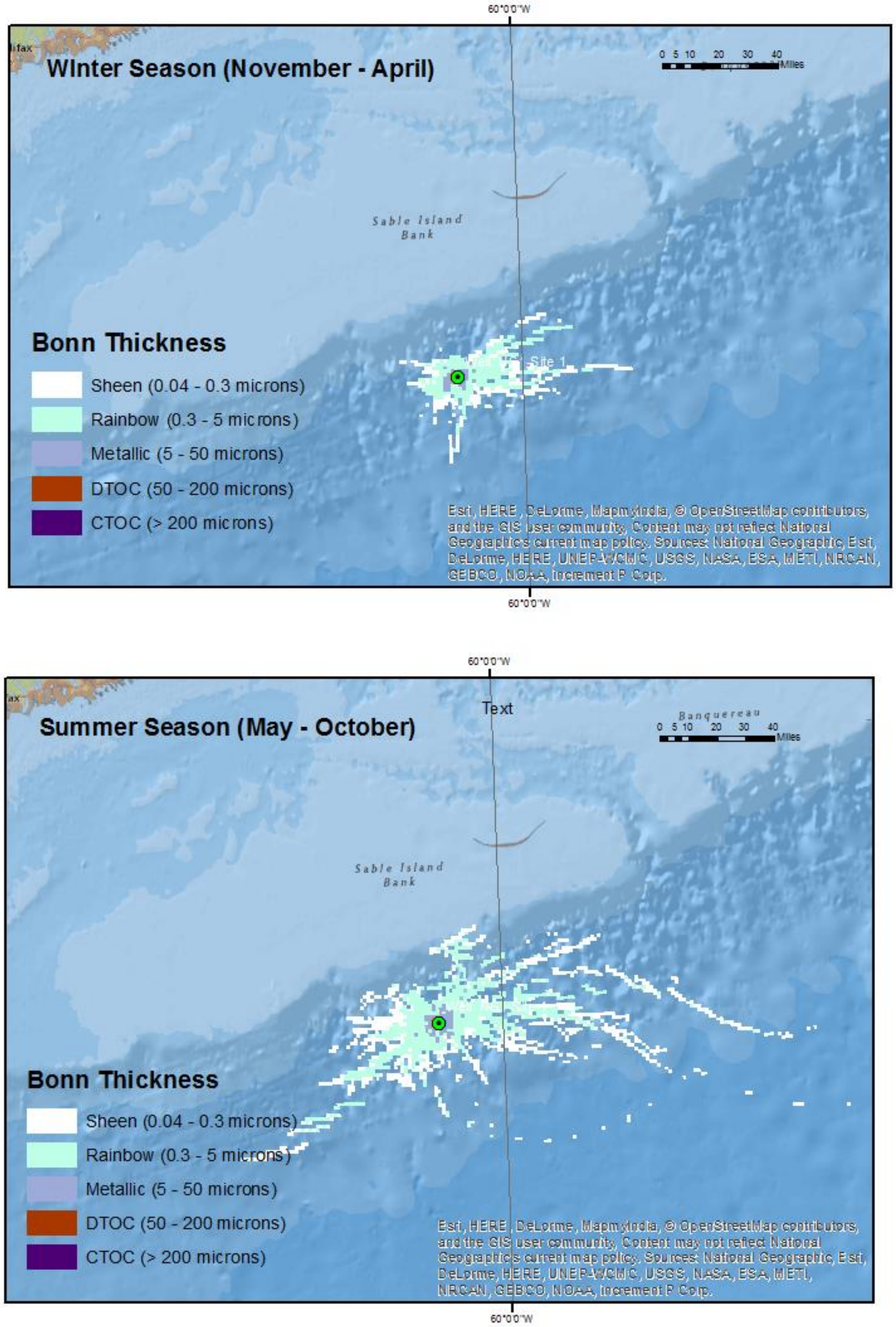

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Figure 8.4.23 Stochastic model output (225 individual model runs) showing the maximum time-averaged emulsified oil thickness on the sea surface (exceeding the 0.04 µm threshold) for an unmitigated 100 bbl batch release of diesel at Site 1.

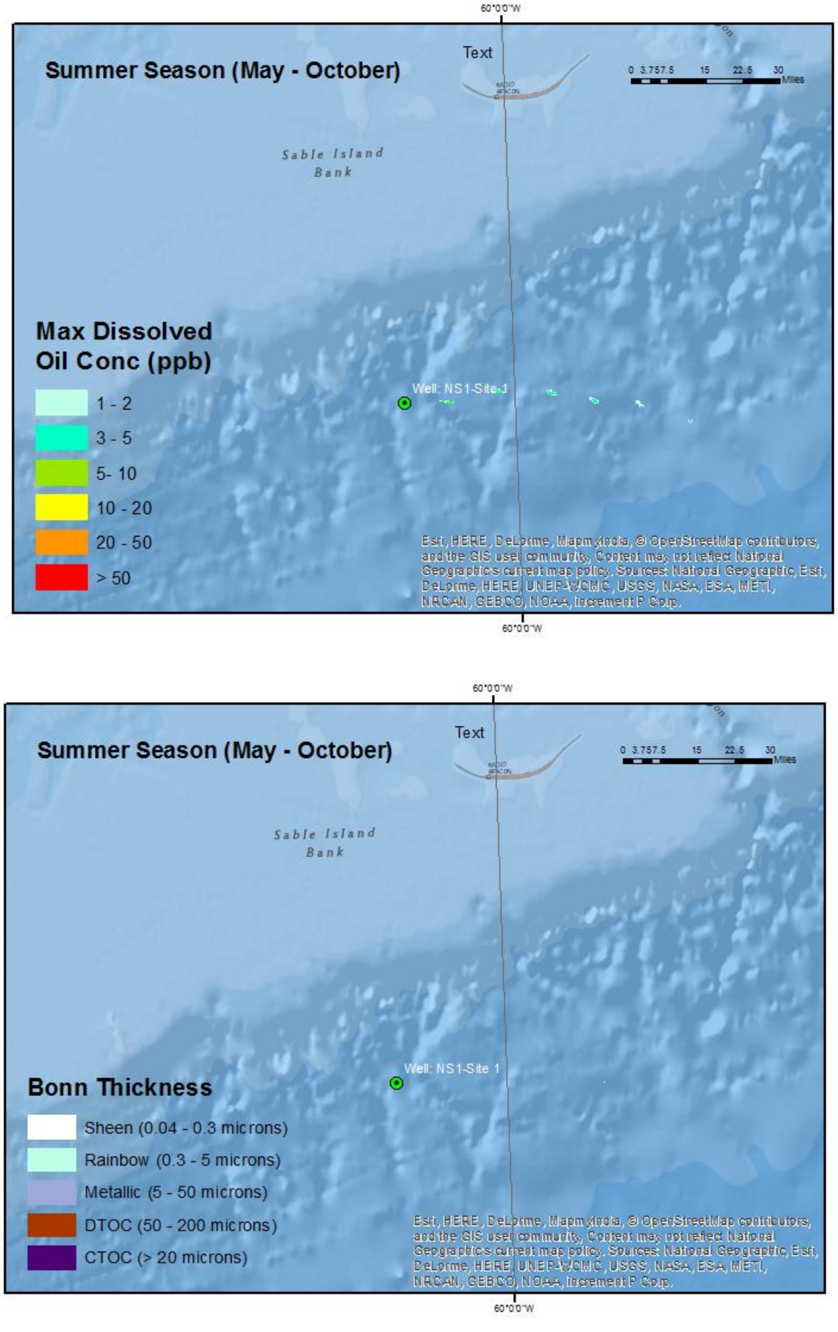
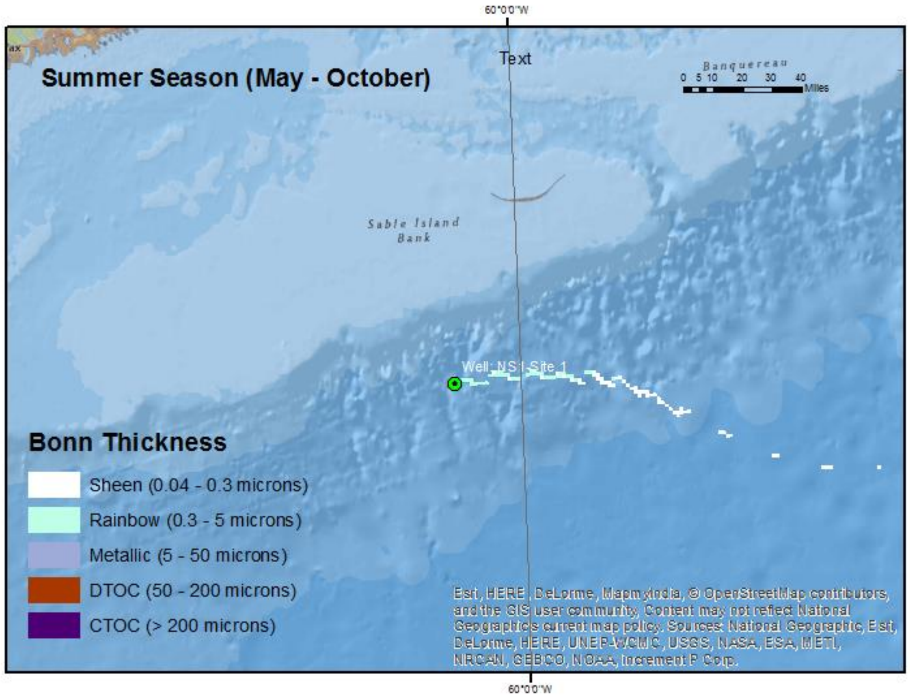


Figure 8.4.24 The total dissolved oil concentration in excess of 1 ppb is depicted for an unmitigated 10 bbl batch diesel spill at Site 1 (top panel) along with the associated surface thickness that is expected over the modelled 30-day period (bottom panel) (deterministic model starting June 3, 2009 at 05:00 GMT).


60°0'0"W
Text
Summer Season (May - October)
Banquereau
0 5 10 20 30 40 Miles
Sable Island Bank
Well: NS-1 Site 1
Bonn Thickness
Sheen (0.04 - 0.3 microns)
Rainbow (0.3 - 5 microns)
Metallic (5 - 50 microns)
DTOC (50 - 200 microns)
CTOC (> 200 microns)
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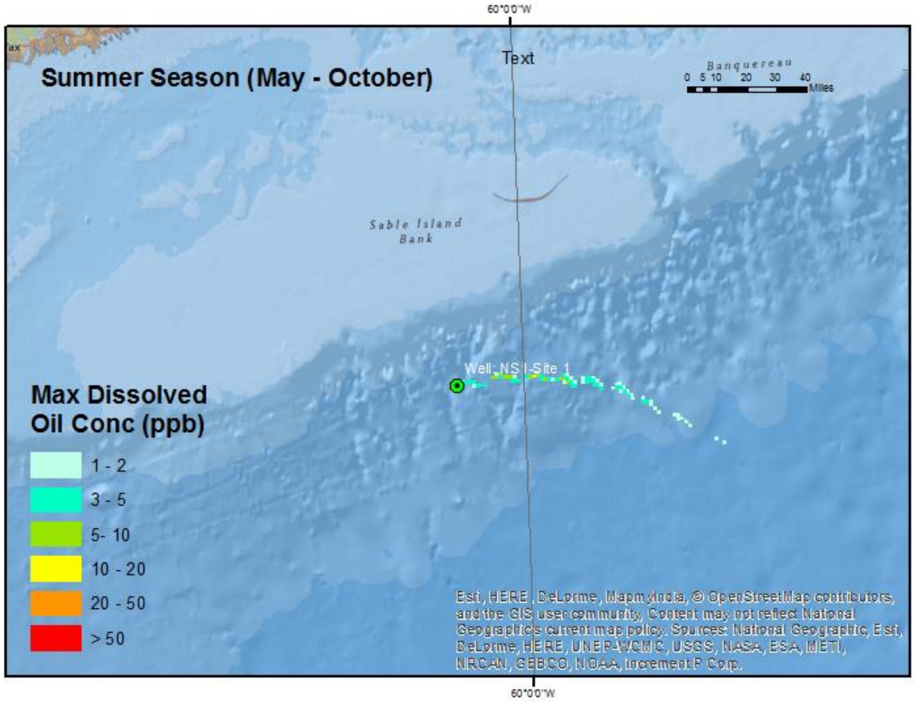
60°0'0"W


60°0'0"W
Text
Summer Season (May - October)
Banquereau
0 5 10 20 30 40 Miles
Sable Island Bank
Well: NS-1 Site 1
Max Dissolved Oil Conc (ppb)
1 - 2
3 - 5
5- 10
10 - 20
20 - 50
> 50
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60°0'0"W

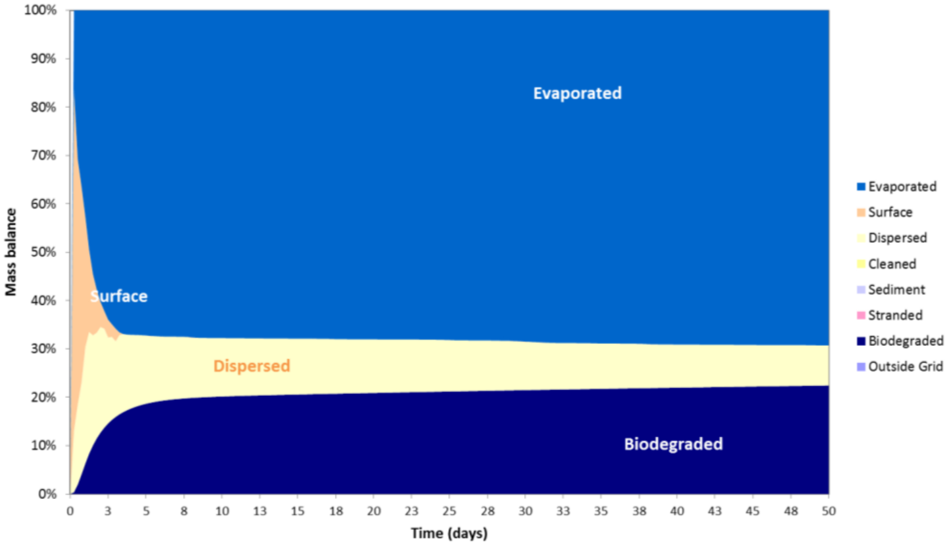

Figure 8.4.25 The total dissolved oil concentration in excess of 1 ppb is depicted for an unmitigated 100 bbl batch diesel spill at Site 1 (top panel) along with the associated surface thickness that is expected over the modelled 30-day period (middle panel). The associated mass balance figure is included (bottom panel) (deterministic model starting June 3, 2009 at 05:00 GMT).

8.4.10 SBM Spill

Given the proximity on the Scotian Slope and similarities in water depth, the modelled predictions for a SBM spill on the Shelburne Basin Venture Exploration Drilling Project are considered valid to inform the assessment for the Project.

For the Shelburne Basin Venture Exploration Drilling Project, a larger volume SBM spill (3,604 bbl; 573 m^3) was modelled to represent a full riser release associated with a disconnection of the riser at the BOP, which is considered the worst-case credible subsea discharge scenario. A smaller volume spill (377 bbl; 60 m^3) was modelled to represent a worst-case credible surface discharge of a full mud tank on the MODU. Both scenarios were modelled at two sites in the Shelburne Basin Venture Exploration Drilling Project Area representing various water depths (1,770 m and 2,550 m).

Modelling conducted by RPS ASA (2014, Appendix C in Stantec 2014a) predicted that due to the relatively small release volumes and fine particle sizes associated with the SBM, the sea surface release (60 m^3) quickly dispersed below levels detectible by the model and did not contribute to mass accumulation on the seabed. Deposition resulting from the 573 m^3 SBM releases on the seabed was limited to thicknesses below 10 mm at both sites. Contours of 1 mm thickness were predicted to extend up to 690 m from the release sites, and cover a maximum area of 0.27 ha of the seabed.

RPS ASA's modelling (2014, Appendix C in Stantec 2014a) also predicted that sediment plumes resulting from the accidental discharges of SBM would extend between 5,080 m and 9,620 m from the release site. As with the patterns of deposition, the extent of the plume and maximum total suspended solids (TSS) concentration were larger for the releases associated with the marine riser as compared to the surface discharges. The maximum predicted concentration of suspended sediments in the water column (corresponding to the weakest current regime) was 29,401 mg/L for the marine riser discharge and 2,424 mg/L for the surface release, with most of the suspended sediment released from the MODU to remain within the uppermost 10 to 20 m of the water column. In all modelled scenarios, the water column was predicted to return to ambient conditions (<1 mg/L) within 30 hours of the release (RPS ASA 2014, Appendix C in Stantec 2014a).

8.5 ENVIRONMENTAL EFFECTS ASSESSMENT

The assessment of accidental events relies extensively on spill modelling conducted for the Project (refer to Section 8.4 for an overview and Appendix H for the modelling report). In line with the precautionary principle, spill modelling work carried out for the Project was based on the worst-case credible for each scenario. No oil spill tactical response methods were applied as mitigation measures and for the blowout incident scenarios, the flow rates used were the worst-case credible discharge at the two potential locations.

Results of spill modelling demonstrate that the geographic extent of an unmitigated spill will most likely be limited within the RAA. It is possible, however, that some blowout spill scenarios could result in some oil extending beyond the boundaries of the RAA. To be conservative, this potential has been considered in the individual VC assessments below, where relevant. The temporal boundaries for the assessment of the Project include the periods of mobilization, operations, and abandonment. Up to seven exploration wells may be drilled sequentially over the term of the ELs, with each well taking up to 120 days to drill.

For each VC, the assessment considers the following accidental spill scenarios:

- instantaneous spill of marine diesel from the MODU including 10 bbl and 100 bbl volume scenarios;
- spill of marine diesel from a PSV;
- continuous 30-day well blowout incident including 733,000 bbl [24,890 bpd] and 1,056,000 bbl [35,914 bpd] scenarios; and
- instantaneous spill of SBM from the MODU (surface release [60 m^3 or 377 bbl] and subsea release [573 m^3 or 3604 bbl]).

These scenarios are consistent with those identified in Section 8.2 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.

Section 8.4.4 describes the characteristics of the marine diesel and crude oil used in the modelling scenarios. The toxicity of oil to marine life varies with exposure, where exposure is a function of oil type, environmental conditions, and the life history and physiology of each species (Lee *et al*. 2015).

Marine diesel spills from a PSV are included as a scenario for assessment in recognition of the potential for a spill to occur as a result of PSV collision during transit to or from the MODU. These spills were not included in the spill modelling study; effects are addressed qualitatively. Diesel spills from a PSV spill are assumed to be in the order of 10 bbls and assumed to interact with marine wildlife similarly to marine diesel spills from the MODU (where 10 bbl spill scenarios were modelled). However, a PSV spill scenario includes a nearshore diesel spill.

As noted in Section 8.4.10, a SBM spill scenario was not specifically modelled for this Project, although recent modelling for the Shelburne Basin Venture Exploration Drilling Project (RPS ASA 2014, included as Appendix C in Stantec 2014a) has been referenced as appropriate to inform the effects assessment.

In identifying interactions between the VC and a potential accident scenario, a credible worst-case event was assumed as described in Section 8.4.3. 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. 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 8.3. Spill modelling results presented in Appendix H are for 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 as used for routine Project activities (refer to Sections 7.2 to 7.7).

8.5.1 Fish and Fish Habitat

As described in Section 5.2.5 and summarized in Section 7.2.6, the Project Area is located to the south of Sable Island and Western Banks on an area of the Scotian Shelf and Slope. The Project Area, LAA and RAA provide habitat for a variety of groundfish, pelagic fish, and invertebrate species. There are 24 fish Species at Risk (SAR) and Species of Conservation Concern (SOCC) that may be present on the Scotian Shelf or Slope at various times of the year. Within the Project Area, LAA and RAA there are five fish species formally protected under the *Species at Risk Act* (SARA): Atlantic salmon (Inner Bay of Fundy population); Atlantic wolffish; Northern wolffish;

spotted wolffish; and white shark. While the potential for occurrence of these SAR in the Project Area is believed to be low based on known habitat preferences, distribution mapping and catch data (where available), in the event of a spill there is potential for interaction with these species in the larger RAA. Section 5.2.5 describes marine fish found in the RAA, with a focus on offshore species most likely to interact with the Project during routine activities.

There is a potential for an interaction between nearshore receptors and oil from a release from a PSV in a nearshore area or well blowout incident. Additional details on inshore fish and fish habitat is provided below. For the purpose of this assessment, offshore is referred to as the zone beyond the nearshore (inshore) 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. Inshore/nearshore is defined as the zone extending from the low tide mark to the offshore, typically reaching water depths of the order of 20-30 m (DFO 1996; Voigt 1998).

A variety of fish species have been recorded in Nova Scotia's nearshore, including groundfish, pelagic species, diadromous species and invertebrates. Some species enter the inshore only to feed and others are seasonal migrants. Some species spend their whole life in inshore areas while others spend only certain life stages of their life in the inshore. Coastal and estuarine areas offer suitable cover for use as spawning and nursery grounds. Species that spawn in inshore areas include Atlantic herring, haddock, pollock, witch flounder and yellowtail flounder (species descriptions for marine fish can be found in Section 5.2.5). Juvenile cod (up to the age of four) prefer habitats that provide protection and cover such as inshore waters with eelgrass or areas with rock and coral (COSEWIC 2010d). Diadromous species, such as alewife and American eel, spend only a portion of their life in the inshore environment.

At least 58 species of groundfish are known to occur in the inshore areas of the Scotian Shelf, although few are restricted to the inshore only (Bundy 2014). Most frequently encountered groundfish are Atlantic cod, skates, winter flounder, pollock, haddock, sea raven (*Hemitripterus americanus*), and yellowtail flounder (Bundy *et al*. 2014). The inshore pelagic habitat extends from surface waters to near bottom (Bundy *et al*. 2014). Large pelagic species observed inshore include bluefin tuna, swordfish, and several shark species (porbeagle shark, spiny dogfish, blue shark and shortfin mako). These species are typical of offshore habitats but enter shallower waters of the Scotian Shelf in the warmer months to feed (Bundy *et al*. 2014). Small pelagics in the inshore include Atlantic herring and Atlantic mackerel.

Diadromous fishes require both salt and freshwater environments to complete their lifecycle. As the interface between salt and freshwater environments, the inshore area is particularly important to diadromous species. Those found in the inshore region of Nova Scotia include: sea lamprey (*Petromyzon marinus*), Atlantic sturgeon, blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudolarengus*), American shad (*Alosa sapidissima*), Atlantic whitefish (*Coregonus huntsmani*), Atlantic salmon, rainbow smelt (*Osmerus mordax*), Atlantic tomcod (*Microgadus tomcod*), striped bass, and American eel.

Many invertebrates spend their entire life in the inshore region (*e.g.*, lobster, green crab (*Carcinus maenas*), rock crab (*Cancer irroratus*), sea urchins, blue mussels (*Mytilus edulis*), and oysters) (Bundy *et al.* 2014). Other invertebrate species that can be found in inshore waters include jellyfish, scallops, shrimp, squid, whelks, numerous crab species, periwinkles, sea cucumbers, sea stars, and sand dollars. The invertebrates found in the inshore region tend to be sessile or have limited mobility and the inshore area provides a variety of food sources to support their life cycle. Many of these species support commercial fisheries (Bundy *et al.* 2014). The highest abundances of American lobster are off southwest Nova Scotia (Hastings *et al*. 2014).

The potential environmental effects, effect pathways, and measureable parameters identified in Table 7.2.1 for Fish and Fish Habitat for routine activities remain valid for the assessment of potential environmental effects as a result of an accidental event. Likewise, the criteria for characterizing residual environmental effects and determining significance (refer to Section 7.2.5) remain valid for the accidental events assessment.

8.5.1.1 Project Pathways for Effects

All of the identified spill scenarios have potential to result in a Change in Risk of Mortality or Physical Injury and/or Change in Habitat Quality and Use for 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. As noted earlier, 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 pathways for a Change in Risk of Mortality or Physical Injury and/or Change in Habitat Quality and Use for 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.

Potential effects pathways for a Change in Risk of Mortality or Physical Injury and/or Change in Habitat Quality and Use for 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. Elevated total suspended solid (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).

Effects of Hydrocarbons on Fish and Fish Habitat

The risk of exposure of fish and invertebrates to an oil spill is dependent on the type of oil and the extent of the spill, 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 mobile 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 mobile 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 mobility and use of contaminated sediments (Yender *et al*. 2002; Lee *et al*. 2015).

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 (Abbriano *et al.* 2011; Seuront 2010). 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 DWH 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 DWH 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 fishes as a result of 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 DWH 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, polycyclic aromatic hydrocarbon (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 from the surface oil slick into the water column. As referenced in Section 8.4.6, 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 and is used to predict environmental effects of hydrocarbon spills (well blowout incident, diesel spills) on marine fish.

Effects of SBM Spill

Synthetic-based mud (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 in line with 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. In the event of an accidental batch spill of SBM, the pathways for effects would be similar to that assessed for routine drilling discharges (refer to Section 7.2). Elevated TSS levels can cause physiological stress, reduce growth and cause adverse effects on survival of fish, although increases in TSS levels would be very temporary as a result of a SBM spill (refer to Section 8.2.2). An accidental spill of SBM would also have the potential to result in a small, thin surface sheen with effects similar to those discussed above for hydrocarbon spills, but more limited in nature.

8.5.1.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. As noted in Section 8.3, the Project will operate under an Incident Management Plan (IMP) which will include a number of specific 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 Spill Response Plan (SRP), will be submitted to the CNSOPB prior to the start of any drilling activity as part of the OA process. The SRP will clarify 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; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response. Refer to Section 8.3 for details on incident management and spill response.

BP will undertake a NEBA as part of the OA process with the CNSOPB to evaluate the risks and benefits of chemically dispersing oil into the water column, including potential effects on fish and fish habitat, and will obtain regulatory approval for any use of dispersants as required.

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.

8.5.1.3 Characterization of Residual Project-Related Environmental Effects

Diesel Spills (PSV and MODU)

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 from one spill site within the EL blocks. Environmental effects are anticipated to occur over the greatest area if a spill was to occur during the summer season. Figures 8.4.24 and 8.4.25 illustrate the cumulative affected area in which dissolved hydrocarbons in the water column over the duration of the simulation exceed 1 ppb during the worst-case credible scenario throughout the stochastic simulations.

Modelling results indicate that diesel spills from the MODU or PSV are not likely to result in biological effects on fish over a large area (refer to Section 8.4.10 or Appendix H). For the 100 bbl spill scenario, approximately 65 % of the spill evaporated within three days. For the 10 bbl and 100 bbl spill scenarios, 23 km^2 and 336 km^2, respectively, experienced maximum total in-water concentrations of dissolved hydrocarbons in excess of 1 ppb. Results from both the 10 bbl and 100 bbl scenario indicate that all of the total in-water dissolved total hydrocarbons fall within the concentration range of 1 to 10 ppb. 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 H). 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) are 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 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.

Well Blowout Incident

A, blowout scenario has the greatest potential for 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.

With respect to Change in Risk of Mortality or Physical Injury to Fish and Fish Habitat in offshore waters, effects on slow moving or sedentary species would be similar to those of diesel on phytoplankton, zooplankton, larval and juvenile fish species, but over a greater area. Greater concentrations of total hydrocarbons in spilled oil and present in the surface mixed layer following an incident during winter conditions, may be expected to result in higher mortalities and sub-lethal effects on fish eggs, larvae and juveniles. In the unlikely event that dissolved hydrocarbons are transported towards inshore waters, residual effects on fish may extend to lethal and sub-lethal effects on the eggs, larvae and juveniles of demersal species and other fish species including those in spawning and nursing areas.

In the event of a blowout scenario, there will be a temporary decline in the abundance of phytoplankton in the immediate area of the spill. Zooplankton communities may be able to avoid exposure. Zooplankton which cannot avoid exposure and experience sub-lethal effects will depurate once the spill has subsided due to mitigation (*e.g.*, containment and/or recovery) and natural weathering processes. The majority of adult finfish will be able to avoid exposure via temporary migration. In the event that the spill encompasses areas where fish eggs or larvae are located, lethal and sub-lethal effects could occur. It should be emphasized that the majority of fish species on the Scotian Shelf and Slope 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.

The majority of spawning areas for fish species in the RAA occur on the Scotian Shelf, with the eggs and larvae of some species being found along the Scotian Slope and shelf break (refer to Section 5.2.1.4). In the event of a large blowout incident, the area affected will not encompass all of the spawning locations for any one species. The majority of fish species on the Scotian Shelf and Slope spawn in multiple locations within the RAA with the exception of a few species. There are a few species which tend to spawn in a limited geographic area. These species include the smooth skate and sand lance. However, these species have the potential to spawn over many months or the entire year and with mitigation (*e.g.*, containment and/or recovery), their spawning window will not be completely affected by a blowout incident. In the event of a major blowout incident, due to the fact that 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 on early life stages of fish species.

Following a continuous, 30-day unmitigated blowout scenario, the geographic extent of residual effects on Change in Habitat Quality and Use (using a 58 ppb total hydrocarbon concentration as an effect threshold) could extend into the RAA with a low probability of extension beyond the RAA. 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. As indicated by the modelling, an unmitigated spill is unlikely to reach the shoreline (except for Sable Island discussed in Section 8.5.4) or nearshore environments and the implementation of mitigation measures would further reduce this likelihood.

The extent of the potential effects will depend on how the spill trajectory and fish and fish habitat overlap in both space and in time. As discussed in Section 8.4 (Table 8.4.7), a 58 ppb concentration of dispersed oil has been identified as a threshold for acute exposure of aquatic species.

Stochastic oil release modelling was undertaken for unmitigated blowout incidents at each of the two well locations based on worst-case credible discharges (WCCD). Modelling was conducted for both summer and winter season spill scenarios. Applying the 58 ppb total hydrocarbon threshold for effects to fish (an in-water concentration of dissolved and entrained oil in the top 100 m), these levels are most likely to be encountered on the Scotian Slope, with 7 to 11% average probability of these levels occurring in the Haddock Box and 9 to 13% average probability of these levels reaching the Emerald, Western, and Sable Banks on the shelf (refer to Figures 8.4.7 to 8.4.10).

The models indicate that the minimum time for in-water oil concentrations >58 ppb to arrive at the maximum distance from the well is between 50 and 75 days (illustrated in Figure 8.4.10, Site 2 summer season). As noted in Section 8.3.3, well intervention response strategies could be implemented within 2 to 5 days for BOP intervention and the well could be capped between 13 and 25 days thereby decreasing the spatial extent of a spill. These activities were not factored into the model in order to demonstrate the worst-case credible scenario of an unmitigated blowout incident. Exposure time to oil concentrations above 58 ppb is also contingent on spill response time. For the unmitigated scenario (Site 2 summer season), the predicted duration of exposure to in-water concentrations of oil >58 ppb around the wellsite is greater than 30 days, while in-water exposure time of one day or less may be expected at the outer extent of the predicted threshold exceedance area (Figure 8.4.10).

SBM Spill

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 highly immobile individuals and benthic prey species within tens of metres from the spill site. Results from the modelling conducted for the Shelburne Basin Venture Exploration Drilling Project (RPS ASA 2014, Appendix C in Stantec 2014a) indicate that effects from both the surface and subsurface SBM spill would likely be temporary, reversible and highly localized around the wellsite. In particular, modelling of accidental SBM spills at the sea floor is limited to thicknesses below 10 mm at both sites. Sediment thickness contours of 1 mm were predicted to extend up to 41 m from the release sites, and cover a maximum area of 0.27 ha of the seabed. This thickness is well below the thickness likely to cause smothering.

With respect to a Change in Habitat Quality and Use following an SBM spill, there would likely be a temporarily and reversible degradation in habitat quality within tens of metres from the spill site. Results from the modelling indicate that effects from an SBM spill would likely be temporary, reversible and highly localized around the wellsite.

Summary

Table 8.5.1 provides a summary of predicted residual environmental effects of accidental events on Fish and Fish Habitat.

Table 8.5.1 Summary of Residual Project-Related Environmental Effects on 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							
10 bbl Diesel Spill	A	L	LAA	ST	S	R	U
100 bbl Diesel Spill	A	M	RAA	ST	S	R	U
PSV Diesel Spill	A	M	RAA	ST-MT	S	R	U
Well Blowout Incident	A	M	RAA*	ST-MT	S	R	U
SBM Spill	A	L	LAA	ST	S	R	U

KEY:
See Table 7.2.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
N: Neutral
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

8.5.1.4 Determination of Significance

Based on information presented above and a consideration of the significance criteria, the predicted residual adverse environmental effects from any of the accidental event scenarios on Fish and Fish Habitat would be not significant. This determination takes into account 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 10 bbl diesel spill and a SBM spill scenarios based on the low magnitude and geographic extent of likely effects. A medium level of confidence is assigned to the 100 bb diesel spill, PSV diesel spill, and well blowout scenarios given the potential for oil to reach spawning areas on the Scotian Shelf and/or nearshore. However, as noted above, the majority of fish species on the Scotian Shelf and Slope 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. Furthermore, 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.

8.5.2 Marine Mammals and Sea Turtles

As described in Section 5.2.6 and 7.3.6 there are six species of mysticetes (baleen whales), eleven species of odontocetes (toothed whales), five species of phocids (seals), and four species of sea turtles (see Tables 5.2.9 and 5.2.12), that could potentially be present in the Project Area and surrounding LAA and RAA. Ten of these species are designated at risk by either SARA or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (three species of mysticetes, four species of odontocetes, and two species of sea turtles; see Table 7.3.3).

The majority of mysticetes are migratory, and are present on the Scotia Shelf and Slope from late spring through fall. The fin whale, however, is present year-round (see Table 5.2.10 for information on presence and timing of marine mammals known to occur near the Project Area). On the Scotian Shelf and Slope there is designated critical habitat under SARA for endangered species including the North Atlantic right whale and the northern bottlenose whale (refer to Figure 5.2.30). Critical habitat for the endangered North Atlantic right whale has been identified in Roseway Basin on the Scotian Shelf within the RAA (Brown *et al*. 2009). Critical habitat for the endangered northern bottlenose whale has been designated in the Gully and in the Shortland and Haldimand Canyons on the east of the Scotian Shelf and Slope (DFO 2010). There have also been sightings of the northern bottlenose whale along the shelf break and within Dawson and Verrill Canyons, within the Project Area.

Seals are most commonly found over the Scotian Shelf, north of the Project Area, in the nearshore waters around Sable Island. They are less common in the open waters over the Scotia Slope, where the Project Area is located. Sable Island hosts the world's largest breeding colony of grey seals (DFO 2011a; Freedman 2014a) (refer to Section 5.2.6). Other species known to breed and forage in the area include harp, hooded, and ringed seals. No seal populations on the Scotian Shelf are designated at risk under SARA or by COSEWIC. Within Halifax Harbour, where PSVs will be transiting to and from the supply base, harbour seals have been observed in large numbers, particularly in the Bedford Basin, during winter; grey seals have also been observed occasionally (Brodie 2000).

Harbour porpoise and Atlantic white-sided dolphins have been sighted at locations in Halifax Harbour, with occasional sightings of larger whales at the approaches to the harbour (Brodie 2000).

Within the Scotian Shelf and Slope waters, four species of sea turtles can be found migrating and foraging. Two sea turtle species, the leatherback sea turtle (listed as endangered on Schedule 1 of SARA) and the loggerhead (assessed as endangered by COSEWIC but not listed under SARA) are most likely to occur. Critical habitat for leatherback turtles in Atlantic Canada has been proposed based on a DFO Science Advisory Process (DFO 2011b) but not yet formally designation under SARA.

The potential environmental effects, effect pathways, and measureable parameters identified in Table 7.3.1 for the assessment of routine Project activities on Marine Mammals and Sea Turtles remain valid for the assessment of potential environmental effects as a result of an accidental event. Likewise, the criteria for characterizing residual environmental effects and determining significance (refer to Section 7.3.5) remain valid for the accidental events assessment.

8.5.2.1 Project Pathways for Effects

All of the identified accidental event scenarios (*i.e.*, batch diesel spill, PSV spill, SBM spill and well blowout incident) have 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 the VC overlap in both space and in time. As noted earlier, the assessment is conservative (*i.e.*, geographic and temporal overlap are assumed to occur and modelling results assume no implementation of mitigation measures).

Effects of Hydrocarbons 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). Aquatic mammals that rely on fur for insulation experience similar effects associated with thermoregulatory failure as is seen in birds (Lee *et al*. 2015) (refer to Section 8.5.3).

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 DWH 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, which is not the type of oil that would result from a spill or blowout incident for this Project. 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). However, hypothermia may be offset somewhat by thick layers of blubber (Lee *et al.* 2015). Following the *Exxon Valdez* spill, harbour seals were observed swimming through and surfacing in floating oil while feeding and moving to and from haulout 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 as they rely primarily on blubber for insulation. 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 (*Enhydra lutris*), harbour seals, Stellar sea lions (*Eumetopias jubatus*), killer whales and humpback whales were most affected by the *Exxon Valdez* oil spill (Lee *et al*. 2015). Continued monitoring over sixteen 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 sixteen 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 significantly 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) which 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 DWH 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 6 individuals were visibly oiled (NOAA 2010). The low estimated carcass recovery rates of cetaceans (as low as 2%) after the DWH 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).

Effects of Hydrocarbons 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) assume 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 DWH 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 2014c). 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). Seventy percent of those captured were Kemp's ridley turtle. 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 2014d). 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 accident 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 as a result of 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.

Effects of SBM Spill

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 considered to be 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.

8.5.2.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. As noted in Section 8.3, the Project will operate under an IMP which will include a number of specific 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 CNSOPB prior to the start of any drilling activity as part of the OA process. The SRP will clarify 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; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response. Refer to Section 8.3 for details on incident management and spill response.

BP will undertake a NEBA as part of the OA process with the CNSOPB to evaluate the risks and benefits of dispersing oil into the water column, including potential effects on marine mammals and sea turtles, and will obtain regulatory approval for any use of dispersants as required.

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.

8.5.2.3 Characterization of Residual Project-Related Environmental Effects

Diesel Spills (PSV and MODU)

Maximum time-averaged emulsified oil thickness on the sea surface (stochastic results) can be seen in Figures 8.4.22 and 8.4.23 in Section 8.4. 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 potential for environmental effects are anticipated to occur over the greatest area if a spill was to occur during the summer months (May to October). In the case of the 10 bbl surface batch spill, the majority of the oil thickness on the surface falls within the 0.04 to 0.3 µm range, with lesser surface area being covered by 0.3 to 5 µm and 5 to 50 µm. The results from the 100 bbl surface batch spill depict higher surface areas covered by thicker oil in a more widespread 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 (refer to Appendix H). 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 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, 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). Except in the case of a vessel spill of diesel during transit to the nearshore, the likelihood of seals coming into contact with oil from a Project-related diesel spill would be very low. 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, due to the fact that 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. In addition, it is expected that most marine mammals would avoid surfacing in areas of harmful hydrocarbon concentrations.

Well Blowout Incident

A well 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 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). This threshold was applied to determine effects to marine mammals and sea turtles from a subsea blowout incident. 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. 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) were to come in contact with surface oil, the risk of mortality is considered low. However, based on an understanding of critical habitat for species at risk and important breeding locations in the RAA for certain marine mammals and predicted well blowout incident modelling results, there is potential for population level effects to occur in the unlikely event of a well blowout incident.

Stochastic modelling predicts the average probability of surface oiling (exceeding a thickness of 0.04 µm) reaching the Gully marine protected area (MPA) (designated critical habitat for the northern bottlenose whale) to be approximately 61% during the summer season (worst-case credible scenario) (May to October). The maximum exposure time for surface oil exceeding the 0.04 µm threshold in the Gully is 4 to 7 days. The maximum time-averaged thickness of surface oil predicted in the Gully MPA may reach more than 200 µm; however, the average time-averaged thickness is predicted to be less than 50 µm. Therefore there is potential for adverse environmental effects on species (including marine mammal species at risk) present in this area in the unlikely event of a well blowout incident. These effects could include physiological effects associated with direct oiling or ingestion of prey as described above in 8.5.2.1 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 predicted to occur as a result of a well blowout scenario.

The likelihood of fur-bearing seals coming into contact with oil from a Project-related spill is low except for seals inhabiting Sable Island where there is a 28% probability of surface oiling (characterized by a 0.04 µm-thick oil layer) and 55% average probability of stranded oil (1 µm) on the coastline, based on stochastic modelling results for a well blowout incident at Site 1 (summer season) (worst-case scenario). The average minimal arrival time for the oil to reach Sable Island using this threshold is predicted to be five days (refer to Figure 8.4.4). French-McCay (2009) proposes a mortality exposure index for wildlife on or along an affected shore to be length of shoreline oiled by 100 µm thick (>100 g/m^2) emulsion. Emulsion thickness of 100 µm thickness would be characterized as "light oiling". Oiling of Sable Island based on modelling of an unmitigated well blowout incident is predicted to be heavy (maximum time-averaged emulsion thickness > 10 mm [10,000 µm]). Increased toxicity associated from the spill as a result of physical contact and from the inhalation of toxic fumes is possible. Given the relatively high potential for shoreline oiling, short minimum arrival time for oil to reach the Sable Island shore, and average degree of oiling, and the known aggregations of breeding seals on Sable Island (including the world's largest breeding colony of grey seals), population level effects could occur in the unlikely event that there is a well blowout incident.

Stochastic modelling of offshore spills indicates a low potential (0 to10%) for shoreline oiling along the Nova Scotia coastline, with most predicted contact locations being less than 1%. A higher probability for shoreline emulsion mass exceeding 1 µm (minimum threshold for "stain/film" oiling) is predicted to occur during the summer season (May to October). The minimal arrival time for this coastline interaction ranges from 20 to 100 days. This timeframe would provide sufficient time to mobilize spill response in these areas. Although physical effects or mortality to seals is possible in the unlikely event that oil reaches the nearshore and shoreline region, population level effects are not anticipated.

SBM Spill

Based on results from the modelling conducted for the Shelburne Basin Venture Exploration Drilling Project (RPS ASA 2014, Appendix C in Stantec 2014a), an accidental release of SBM whole mud would result in elevated levels of TSS in the water column, with modelling of an accidental release of SBM showing that the plume travels with ambient currents until dispersion and turbulence cause the TSS concentrations to fall below the 1 mg/L threshold. These plumes extend from 5 to 10 km from the site with ambient conditions being returned to within 30 hours of the spill. A SBM whole mud spill could 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 8.5.2 provides a summary of predicted residual environmental effects of accidental events on Marine Mammals and Sea Turtles.

Table 8.5.2 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							
10 bbl Diesel Spill	A	L	LAA	ST	S	R	U
100 bbl Diesel Spill	A	M	LAA	ST	S	R	U
PSV Diesel Spill	A	M	LAA	ST-MT	S	R	U
Well Blowout Incident	A	H	RAA*	ST-MT	S	R	U
SBM Spill	A	L	LAA	ST	S	R	U

KEY:
See Table 7.3.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
N: Neutral
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

8.5.2.4 Determination of Significance

Based on the above analysis, it is predicted with high confidence that a diesel or SBM spill scenario associated with the Project will not result in any significant adverse residual environmental effects to Marine Mammals or Sea Turtles. This conclusion is based on 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 potential effects as described in the literature summarized above. A significant adverse residual environmental effect is predicted for Marine Mammals and Sea Turtles in the event of a well blowout incident in recognition of the probability of interaction with breeding seals on Sable Island and marine mammal and sea turtle species at risk inhabiting the affected area. However, this significant effect is not likely to occur given the extremely low probability of a blowout incident occurring. A medium level of confidence is assigned to this significance determination based on the conservatism of the spill modelling and the uncertainty of interaction with breeding seals or species at risk depending on the timing of the spill of this magnitude.

8.5.3 Migratory Birds

As described in Section 5.2.8, an estimated 30 million seabirds use the eastern Canadian waters each year including breeding marine birds and migrating birds from the southern hemisphere and northeastern Atlantic (Fifield *et al*. 2009). The combination of northern hemisphere and southern hemisphere birds results in peak diversity during spring and summer months (Fifield *et al*. 2009). Significant numbers of overwintering birds, including alcids, gulls, and Northern Fulmars can also be found in Atlantic Canadian waters during the fall and winter (Brown 1986), whereas species assemblages are dominated by shearwaters, storm-petrels, Northern Fulmars and gulls in summer (Fifield *et al.* 2009).

The waters of the RAA are known to support approximately 19 species of pelagic seabirds, 14 species of neritic seabirds, 18 species of waterfowl and loons and 22 shorebird species (see Table 7.4.3), with more occurring in the area as rare vagrants or incidentals. It is important to note, however, that many of these species have a coastal affinity and would be unlikely to regularly occur in waters of the Project Area. Seven marine bird species listed as either SAR or SOCC are known to occur in waters of the Scotian Shelf and Slope and could potentially occur within the RAA: Ivory Gull, Piping Plover, Roseate Tern, Red Knot, Harlequin Duck, Red-necked Phalarope and Barrow's Goldeneye. A number of breeding, migrant, and vagrant landbirds also occur within the RAA, including two SAR and SOCC species which have coastal affinities: Peregrine Falcon and Savannah Sparrow.

Throughout the summer months, the coastline of the RAA supports over two hundred colonies of nesting marine birds. These colonies are known to support Atlantic Puffins, Black-legged Kittiwakes, Common Eiders, cormorants, Leach's Storm-petrels, Great Black-backed Gulls, Herring Gulls, Razorbills and terns. Leach's Storm-petrel is the most numerous breeding seabird in the RAA. Sable Island, which is migratory bird sanctuary and contains SARA-designated critical habitat for the Roseate Tern, is also an important breeding area for colonial marine birds, including gulls, terns, cormorants, as well as other migratory birds.

Within the RAA there are 14 coastal Important Bird Areas (IBAs), including Sable Island. These IBAs are scattered throughout the RAA and have been designated as IBAs for a variety of reasons including the presence of breeding habitat for species at risk, important shorebird migration habitat, important coastal waterfowl habitat, and/or the occurrence of regionally significant colonial water bird colonies. Nine of the fourteen IBAs are considered to be globally significant (refer to Section 5.2.8.3). Based on stochastic modelling results for the well blowout scenarios, it is possible that environmental effects could extend beyond the RAA and affect three additional IBAs not previously discussed in Section 5.2.8.3) (see below).

The Brier Island and Offshore Waters IBA (NS021) which is located at the extreme western end of Nova Scotia, 50 km southwest of Digby could potentially experience shoreline oiling. This IBA is recognized as one of the most important bird areas in the Maritimes given the diversity of birds found there. Additionally, it is a great migration trap for landbirds and important year-round feeding area for marine birds. Although no systematic counts have been made, the waters immediately offshore from Brier Island represent one of the most important areas for phalaropes in North America with mixed flocks of Red-necked Phalarope and Red Phalarope regularly numbering in the millions (IBA Canada n.d.[a]). Other marine species seen in large numbers include shearwaters, kittiwakes and alcids. The most common landbird migrants in the fall are Yellow-rumped Warbler (*Setophaga coronate*), Dark-eyed Junco (*Junco hyemalis*), Golden-crowned Kinglet (*Regulus satrapa*), White-throated Sparrow (*Zonotrichia albicollis*), and Magnolia Warbler (*Setophaga magnolia*).

The Scatarie Island IBA (NS052) is located off the northeastern tip of Cape Breton Island and encompasses 6,765 ha (IBA Canada n.d.[b]). It includes Scatarie Island, which is one of Nova Scotia's largest Islands (1500 ha), as well as several other small islands (IBA Canada 2014; NSE 2014). Based on stochastic modelling results for the well blowout scenarios, islands in this IBA could potentially experience shoreline oiling. Scatarie Island is an important breeding area for Bicknell's Thrush (*Catharus bicknelli*), which is listed as Threatened under SARA and COSEWIC and listed as Endangered under the NS *Endangered Species Act*. Although no systematic survey has been completed, the island is believed to support 10 to 25 males of this species (IBA Canada n.d.[b]). In addition, the island serves as a breeding site for Leach's Storm-petrels; it is believed that up to several thousand pairs may breed here in burrows created in rock crevices (IBA Canada n.d.[b]). Migrating Whimbrels (*Numenius phaeopus*) feed on berries found on the island from mid-July to September. Buff-breasted Sandpipers (*Calidris subruficollis*) have also been observed on the island (IBA Canada n.d.[b]).

The Grand Manan Archipelago IBA (NB011) is located on the western side of the mouth of the Bay of Fundy and encompasses 100,076 ha of shoreline, islands, and open ocean (IBA Canada n.d.[c]). The IBA includes a 1-km strip of land along the coast of Grand Manan Island and a 10-km strip of ocean surrounding the large island, which encompasses several smaller islands in the archipelago (including Kent Island) (IBA Canada n.d.[c]). Pelagic birds that feed in this IBA include Red-necked Phalaropes, Greater Shearwaters and Wilson's Storm-petrels (IBA Canada n.d.[c]). Grand Manan is an important IBA for coastal-feeding migrants, including the Semipalmated Plover, Black-bellied Plover, Greater Yellowlegs, and Least Sandpiper. The most notable species of this IBA is the Razorbill, which winters on and around Grand Manan Island. Other species that winter here include Purple Sandpipers, Great Black-backed Gulls, Common Eiders, and the endangered Harlequin Duck. Dovekies, Common Murres and various other species are also known to frequent this IBA (IBA Canada n.d.[c]). This IBA is also an important stopover for landbirds during migration. Around 200 bird species have been recorded on Kent Island, a small island in the archipelago. Kent Island supports a large breeding colony of Herring Gulls and around 1000 pairs of Leach's Storm-petrels (IBA Canada n.d.[c]).

With respect to the nearshore environment near Halifax Harbour, migratory bird habitat in the area has been noted for Great Blue Heron (*Ardea herodias*); Common Eider; Common Tern; Canada Goose; and American Black Duck. Maugher Beach, on the western shore of McNabs Island, provides unclassified tern habitat as well as habitat for Piping Plover. There is also Piping

Plover habitat located on beaches east of the approaches to Halifax Harbour (*e.g.*, Cow Bay Beach and Rainbow Haven Beach).

The potential environmental effects, effect pathways, and measureable parameters identified in Table 7.4.1 for Migratory Birds for routine activities remain valid for the assessment of potential environmental effects as a result of an accidental event. Likewise, the criteria for characterizing residual environmental effects and determining significance (refer to Section 7.4.5) remain valid for the accidental events assessment.

8.5.3.1 Project Pathways for Effects

All of the identified accidental event scenarios (*i.e.*, batch diesel spill, PSV spill, SBM spill and well blowout incident) have the potential to result in a Change in Risk of Mortality or Physical Injury and Change in Habitat Quality and Use for Migratory Birds. The extent of the potential effects will depend on how the spill trajectory and the VC overlap in both space and in time. As noted earlier, the assessment is conservative (*i.e.*, geographic and temporal overlap are assumed to occur and modelling results assume no implementation of mitigation measures).

Effects of Hydrocarbons on Migratory Birds

Aquatic migratory birds are among the most vulnerable and visible species to be affected by oil spills. French-McCay (2009) considered the probability of exposure to oil by grouping seabirds based on their behaviour patterns and developing a combined oil encounter and mortality rate of 99% for surface divers, 35% for nearshore aerial divers, 5% for aerial seabirds and 35% for wetland birds. 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 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 (*Melanitta spp.*), 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 vulnerable to contact with oil because they feed over wide areas and make frequent contact with the water's surface. They are also 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). Determining the numbers of birds potentially affected by a spill can be challenging, particularly since many oiled birds are never recovered, causing mortalities to be under-reported. Mean mortality of over-wintering birds in the Gulf of Mexico following the DWH oil spill was estimated to be between 600,000 and 800,000 birds (Haney *et al.* 2014), although only a fraction of carcasses of oiled birds were recovered, most likely due to inefficient collection methods by limited personnel, lacking in training or experience (Belanger *et al*. 2010). This spill event is believed to have had population level effects on seabird species including Northern Gannet, Brown Pelican (*Pelecanus occidentalis*), Laughing Gull (*Leucophaeus atricilla*), and Royal Tern (*Thalasseus maximus*) (Haney *et al*. 2014).

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 and fulmars (Martec Ltd. 1984, in Hurley and Ellis 2004).

To help provide additional context, it is estimated that approximately 21,000 birds die annually from operational spills on the Atlantic coast of Canada, and 72,000 in all of Canada (Thomson *et al.* 1991). Clark (1984) estimated that 150,000 to 450,000 birds die annually in the North Sea and North Atlantic from oil pollution from all natural and anthropogenic sources.

The scientific literature is divided with respect to long-term population effects on migratory birds as a result of 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, Wiese and Robertson (2004) reported that the chronic oiling due to bilge dumping killed around 300,000 birds annually around southeastern Newfoundland.

Murphy and Mabee (1999) assessed the effects of the *Exxon Valdez* on Black Oystercatchers (*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) looking at recovery of harlequin duck populations in Prince William Sound from 1995 to 1997 concluded that chronic exposure to oil and resulting biochemical and physiological changes in individuals was 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. In particular, 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, they 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 for the purpose of reducing 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 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 the majority of 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).

Effects of SBM Spill

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 significantly 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.

8.5.3.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. As noted in Section 8.3, the Project will operate under an IMP which will include a number of specific 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 CNSOPB prior to the start of any drilling activity as part of the OA process. The SRP will clarify 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; in-situ burning; shoreline protection; shoreline clean up; and oiled wildlife response. Refer to Section 8.3 for details on incident management and spill response.

Of particular relevance to migratory birds are the commitments related to shoreline protection and clean up, and oiled wildlife response (refer to Section 8.3.3). In the event that oil threatens or reaches the shoreline, SCAT teams will be mobilized to the affected areas. SCAT teams will also be used to monitor and evaluate the effectiveness of the clean-up operations. A SCAT survey will be conducted to inform shoreline clean-up and remediation as applicable. BP will also engage specialized expertise to deflect oil from sensitive areas, and recover and rehabilitate wildlife species as needed (refer to Section 8.3.3.3 for BP's oiled wildlife response approach).

BP will undertake a NEBA as part of the OA process with the CNSOPB to evaluate the risks and benefits of chemically dispersing oil into the water column, including potential effects on migratory birds, and will obtain regulatory approval for any use of dispersants as required.

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.

8.5.3.3 Characterization of Residual Project-Related Environmental Effects

Diesel Spills (PSV and MODU)

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 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).

Modelling results indicate that diesel spills from the MODU or PSV are not likely to result in biological effects on migratory birds over a much smaller area relative to a well blowout scenario. Environmental effects are anticipated to occur over the greatest area if a spill was to occur during the summer months (May to October). In the case of the 10 bbl surface batch spill, the majority of the oil thickness on the surface falls within the 0.04 to 0.3 μm range, with lesser surface area being covered by 0.3 to 5 μm and 5 to 50 μm. The stochastic modelling results from the 100 bbl surface batch spill depict locations with a wider area covered by thicker oil. The locations of the 5 to 50 μm thickness in Figures 8.4.22 and 8.4.23 approximates the area in which the 10 μm threshold may be exceeded. For each of the 10 bbl and 100 bbl batch spill scenarios, the majority of the spill locations is below the 10 μm lethal effects threshold. Furthermore, the maximum exposure time for emulsified oil thickness on the sea surface which exceeds 0.04 μm is one day. Deterministic model results indicate that the surface area covered by oil in excess of 0.04 μm will equate to 0.82 km^2 for the 10 bbl spill scenario and 4.4 km^2 for the 100 bbl spill scenario.

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 H). The maximum exposure time for oil on the surface with a thickness greater than 0.04 μm is 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 migrating 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 2016c). 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 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 2016c). 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, causing embryo or nestling mortality.

Well Blowout Incident

A well 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 Migratory Birds. Two thresholds were established to assess the effects to migratory birds. These thresholds were 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”.

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 8.5.3 indicates the combined probabilities of oiling and mortality once oiled for various generic behaviour categories.

Table 8.5.3 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

Table 8.5.3 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]
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.		

Source: Modified from French-McCay 2009

There are six marine bird SOCC that occur within the RAA for the Project: Ivory Gull, Piping Plover, Roseate Tern, Red Knot, Harlequin Duck, and Barrow's Goldeneye, with the Ivory Gull and Roseate Tern being the most likely to occur within the Project Area. Roseate Tern is a diving species known to breed on Sable Island, which based on modelling results, would be susceptible to shoreline and surface oiling as a result of an unmitigated blowout incident. As noted above, deterministic modelling results predicts that surface oiling from an unmitigated blowout could exceed a surface thickness threshold of 10 μm over a total area of 91,778 km^2.

Deterministic models were not run to specifically identify the 10 μm threshold; however, Figures 8.4.16 and 8.4.18 illustrate the maximum time-averaged oil thickness on the sea surface for the two deterministic case models run (refer to Section 8.4.9). The extent of the 5 to 50 μm thickness approximates the area in which the 10 μm threshold coverage may be exceeded.

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 10 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).

Deterministic modelling of a single unmitigated blowout scenario (Site 2 [maximum oil on shoreline – summer season scenario]) predicted a maximum length of affected coastline (oiling above the 1.0 g/m^2 threshold and equivalent to 1 μm oil thickness) to be 79.5 km along Sable Island and mainland Nova Scotia. Stochastic modelling for Site 2 summer season indicated a low probability (1 to 5%) for shoreline oiling to exceed the 1.0 g/m^2 threshold along coasts of the Bay of Fundy, Scatarie Island, Gulf of Maine, and St. Pierre et Miquelon (Figure 8.4.14).

As indicated on Figures 8.4.11 to 8.4.14, there are several coastline areas that could potentially be exposed to shoreline oiling above the 1.0 g/m^2 threshold. For both Site 1 and Site 2 (both winter and summer seasons) Sable Island could be expected to result in heavy oiling (>10 mm thickness of emulsified oil on the shoreline). Stochastic modelling results for Site 2 (summer season) show more extensive shoreline oiling ranging from a stain/film (0.1 to 0.001 mm) to heavy oiling (>10 mm) in some locations along the Nova Scotia mainland coastline. As indicated in Section 5.2.8.3, there are several seabird colonies and IBAs along the coast (including small coastal islands) which potentially could be affected by a well blowout incident. The average minimum timeframe required for oil to potentially reach these areas at a threshold of 1 µm (minimum approximately 30 days for mainland) would allow for response measures and containment equipment to be placed in advance to avoid or mitigate adverse effects. Response measures could result in disruption of nesting birds and reproductive failure. The average minimum arrival time for shoreline emulsion mass exceeding 1 µm at Sable Island would be 5 days (Site 1, summer) which would greatly reduce the opportunity for implementation of response measures to avoid or mitigate adverse effects on birds nesting there.

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.

SBM Spill

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 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. 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 seabird mortality.

Summary

Table 8.5.4 provides a summary of predicted residual environmental effects of accidental events on Migratory Birds.

Table 8.5.4 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							
10 bbl Diesel Spill	A	L	LAA	ST	S	R	U
100 bbl Diesel Spill	A	M	RAA	ST	S	R	U
PSV Diesel Spill	A	M	RAA	ST-MT	S	R	U
Well Blowout Incident	A	H	RAA*	ST-MT	S	R	U
SBM Spill	A	L	LAA	ST	S	R	U

KEY:
See Table 7.4.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
N: Neutral
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

8.5.3.4 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 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.

8.5.4 Special Areas

As discussed in Section 5.2.9, there are two Special Areas partially located within the Project Area: the Scotian Slope EBSA and the Haddock Box. The Scotian Slope EBSA is of importance due to its high productivity; species diversity and richness; unique and sensitive benthic communities; migratory routes; overwintering habitat; foraging area for leatherback sea turtles; and habitat for Greenland sharks (*Somniosus microcephalus*) (Doherty and Horsman 2007; DFO 2014). Approximately 87% of the Project Area falls within the Scotian Slope EBSA. However, the EBSA is roughly 72,568 km^2, and therefore the Project Area constitutes only 17% of the total EBSA area. The Haddock Box represents an important nursery area for the protection of juvenile haddock. This area is closed to the commercial groundfish fishery year-round by DFO. Only 0.01% of the Haddock Box area is within the Project Area, constituting approximately 153 ha.

Beyond the Scotian Slope EBSA and the Haddock Box, there are several Special Areas located within the RAA, most of which could potentially interact with a Project-related accidental spill. Of particular note is the distance of the Project Area in close proximity to Special Areas providing critical habitat for species at risk and/or important habitat for migratory birds including Sable Island National Park Reserve (48 km), the Gully MPA (71 km), Shortland Canyon and Haldimand Canyon (139 km and 171 km, respectively). PSV transit activities could also potentially intersect with the Emerald Basin Sponge Conservation Area, and to a lesser extent, the Sambro Bank Sponge Conservation Area. IBAs are addressed in Section 8.5.3.

Additional designated protected areas (*e.g.*, national park, wilderness areas, nature reserve), along the coast of Nova Scotia could also potentially interact with a Project-related spill. These areas were not previously addressed in Section 5.2.9 since routine Project activities were predicted to not interact with these areas. However, based on stochastic modelling predicting various scenarios where oil from a well blowout incident could potentially reach the Nova Scotia shoreline, these areas have been considered in the context of accidental events. Figure 8.5.1 shows these additional designated protected areas relative to the offshore Special Areas described in Section 5.2.9 assessed in Section 7.5. A brief description is provided in Table 8.5.5. Although the assessment of Special Areas focuses on specific designated protected areas, predicted interactions and effects could be similar for other coastal features (beaches, parks) providing ecological and/or socio-economic (*e.g.*, recreation) value and not specifically identified on Figure 8.5.1 and Table 8.5.5.

The potential environmental effects, effect pathways, and measureable parameters identified in Table 7.5.1 for Special Areas for routine activities remain valid for the assessment of potential environmental effects as a result of an accidental event. Likewise, the criteria for characterizing residual environmental effects and determining significance (refer to Section 7.5.5) remain valid for the accidental events assessment.

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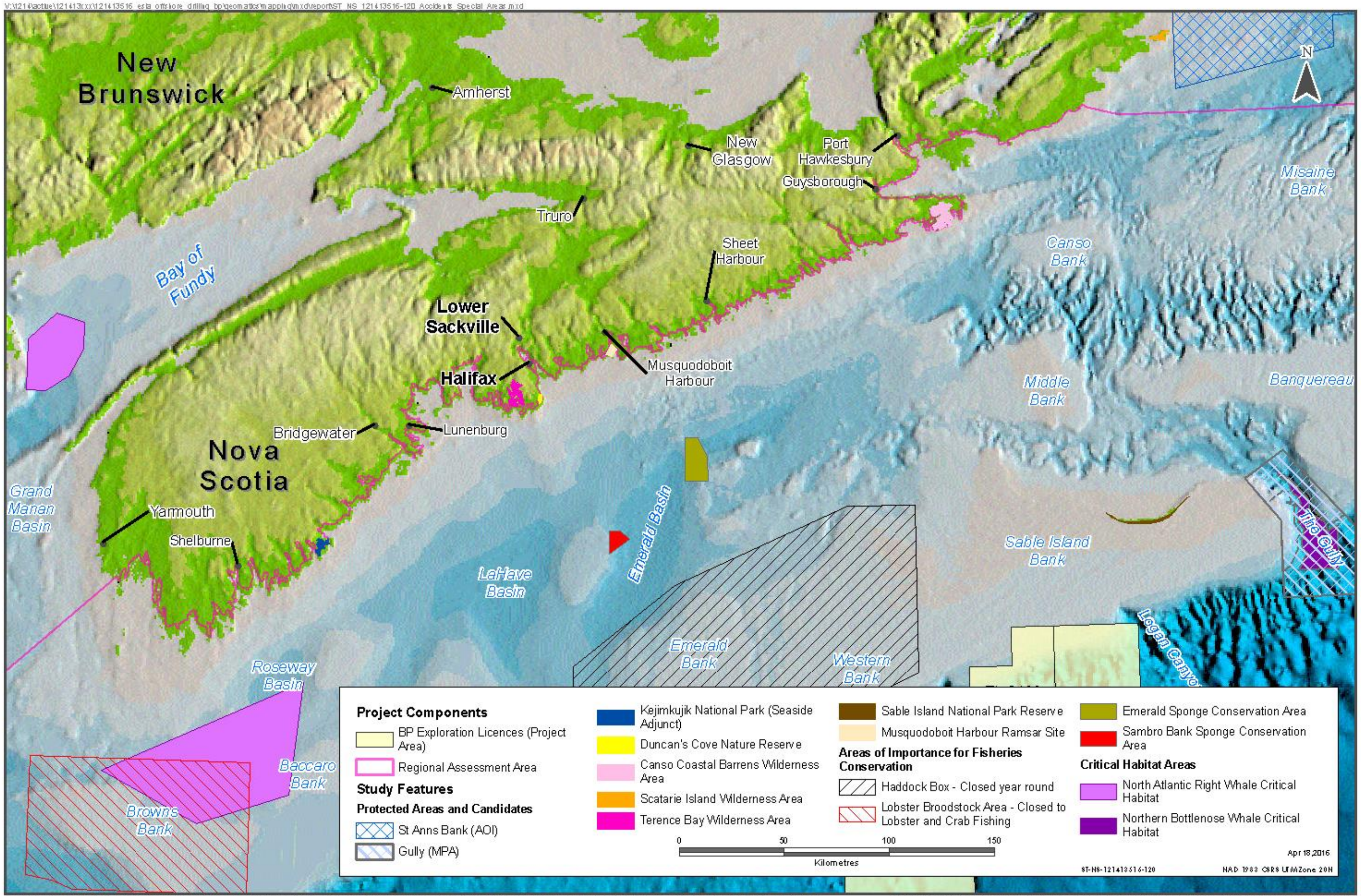

Sources: North Atlantic Fisheries Organization. Canada-Nova Scotia Offshore Petroleum Board. Fisheries and Oceans Canada. Natural Resources Canada. GEBCO global bathymetric grid. Nova Scotia Geomatics Centre

Disclaimer: This map is for illustrative purposes to support this Stantec project; questions can be directed to the issuing agency.

Figure 8.5.1 Special Areas (focusing on Coastal Areas) Considered in Accidental Events Assessment

Table 8.5.5 Coastal Special Areas Potentially Intersected by Stranded Oil and/or Surface Oiling

Description of Special Area	
Kejimkujik National Park - Seaside	
Location and Proximity to Project Area	• The Seaside adjunct to Kejimkujik National Park is located approximately 97 km from the inland portion of the National Park, on the southwest Nova Scotia coastline between Liverpool and Lockeport. The Seaside Adjunct occupies an area of approximately 2,000 ha. • Approximately 260 km from the Project Area.
Designation and Administration	• Kejimkujik was acquired from the province in 1967 and was formally established as a national park in 1974 to protect a representative example of the Atlantic Coastal Uplands Natural Region. Kejimkujik Seaside was acquired from the province in 1985 and was designated as part of Kejimkujik National Park in 1988 to provide protection for the unique coastal attributes of the region (Parks Canada 2010).
Ecological Significance	• Kejimkujik National Park and National Historic Site of Canada (including the Seaside Adjunct) is located within the United Nations Educational, Scientific and Cultural Organization (UNESCO) Southwest Nova Biosphere Reserve, which contains over three-quarters of Nova Scotia's species listed under SARA and/or COSEWIC and the provincial *Endangered Species Act*, including the endangered Piping Plover (Parks Canada 2012).
Bonnet Lake Barrens Wilderness Area	
Location and Proximity to Project Area	• Located on the Canso Peninsula, in Guysborough County, Nova Scotia and approximately 10,380 ha in size. • Approximately 199 km from the Project Area.
Designation and Administration	• Designated in 1999 as a Wilderness Area under the Nova Scotia *Wilderness Protection Act*. Additional lands were designated in 2012 under the Bonnet Lake Barrens Wilderness Area Designation of Additional Lands Regulations pursuant to the Act. • Wilderness Areas protect representative examples of Nova Scotia's natural landscapes, maintain and restore the integrity of natural processes and biodiversity, and protect outstanding, unique, rare and vulnerable natural features. They are used for scientific research, education and a variety of recreation and nature-tourism related activities (NSE 2014).
Ecological Significance	• Includes large, ecologically sensitive raised bogs; rare plants; and an array of water bodies, including Bonnet Lake, which contains unique, crescent shaped beaches originally formed from glacial debris (NSE 2014). • Representative of Canso Coastal Granite Barrens landscape (NSE 2014).

Table 8.5.5 Coastal Special Areas Potentially Intersected by Stranded Oil and/or Surface Oiling

Description of Special Area	
Canso Coastal Barrens Wilderness Area	
Location and Proximity to Project Area	• Located in Guysborough County, Nova Scotia and approximately 8,026 ha in size. • Approximately 197 km from the Project Area.
Designation and Administration	• Designated in 1999 as a Wilderness Area under the Nova Scotia *Wilderness Protection Act*. • Wilderness Areas protect representative examples of Nova Scotia's natural landscapes, maintain and restore the integrity of natural processes and biodiversity, and protect outstanding, unique, rare and vulnerable natural features. They are used for scientific research, education and a variety of recreation and nature-tourism related activities (NSE 2014). • The provincial protected areas program is administered by the Protected Areas Branch of NSE.
Ecological Significance	• Provides habitat for rare, arctic-alpine plants and is frequented by numerous sea and land birds as well as seals. Whales are also present off the coast of the Wilderness Area (NSE 2014). • Representative of Canso Coastal Granite Barrens landscape (NSE 2014).
Duncan's Cove Nature Reserve	
Location and Proximity to Project Area	• Located on the Chebucto Peninsula in the Halifax Regional Municipality (HRM), NS, approximately 17 km south of Halifax in the Pennant Granite Barrens natural landscape (NSE 2014). • Approximately 396 ha in size and approximately 205 km from the Project Area.
Designation and Administration	• Designated in 2004 as a Nature Reserve under the Duncan's Cove Nature Reserve Ecological Site Designation Regulations pursuant to the Nova Scotia *Special Places Protection Act*. • Nature Reserves are areas selected to preserve and protect, in perpetuity, representative (typical) and special natural ecosystems, plant and animal species, features and natural processes. Scientific research and education are the primary uses of nature reserves and recreation is generally restricted (NSE 2014). • The management objectives in the Regulations state that, "[a]s provided for in the *Special Places Protection Act*, Duncan's Cove Nature Reserve is to be managed to a high standard of protection, equivalent to the International Union for Conservation of Nature (IUCN) Class Ia (Strict Nature Reserve), in keeping with the overriding goal of maintenance and restoration of ecological integrity."

Table 8.5.5 Coastal Special Areas Potentially Intersected by Stranded Oil and/or Surface Oiling

Description of Special Area	
Ecological Significance	• Representative coastal headland, barren, and bog complex (NSE 2014). • Particularly valued because of its proximity to the Halifax metropolitan area and its popularity as a natural area (NSE 2014). • It is the only known location in mainland Nova Scotia that supports the provincially rare Arctic blueberry (*Vaccinium uliginosum*) (NSE 2014).
Musquodoboit Harbour	
Location and Proximity to Project Area	• Located on the Eastern Shore of Nova Scotia at the mouth of the Musquodoboit River in HRM. • Musquodoit Harbour Outer Estuary occupies an area of approximately 1,925 ha (NCC 2015). • Approximately 203 km from the Project Area.
Designation and Administration	• Musquodoboit Harbour Outer Estuary was designated as a Ramsar Site in 1987 under the *Convention on Wetlands of International Importance* (Ramsar Convention). It is also recognized as an IBA of international importance (NCC 2015). • The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are 169 Contracting Parties, including Canada (Ramsar 2014). • Martinique (provincial) Game Sanctuary includes most of the aquatic and intertidal areas within the seaward portion of the inlet. Martinique Beach Park (also provincial) encompasses a barrier beach and associated connected islands. Both park and sanctuary were established in the 1970s (IBA Canada n.d.).
Ecological Significance	• Complex system of coastal islands, salt marshes, mudflats, barrier beaches, bogs, barrens and coastal forest (NCC 2015). • IBA NS014 (Musquodoboit) supports huge congregations of Canada geese from the breeding population in Newfoundland and Labrador. During spring migration the site supports approximately 8,000 geese representing 7% of the estimated population; during fall migration it supports approximately 2,000 geese (about 2% of the estimated population); and during the winter it supports approximately 5,000 geese (4% of the population). As more open water has appeared in the mid-1970s, geese have become increasingly more common in winter. Numbers of the Newfoundland/Labrador-breeding geese are now supplemented by local Nova Scotia-breeding birds (IBA Canada n.d.). • American black ducks are also found in Musquodoboit Harbour in winter and can number as high as 2,000 to 3,000 birds (representing 1% of the global population of the species). These numbers are peak numbers, while typical numbers are somewhat lower. Piping Plovers (globally vulnerable, nationally endangered) are also found at this site in breeding season. Other bird species found in the IBA include Savannah Sparrow and Semipalmated Plover (IBA Canada n.d.).

Table 8.5.5 Coastal Special Areas Potentially Intersected by Stranded Oil and/or Surface Oiling

Description of Special Area	
Terence Bay Wilderness Area	
Location and Proximity to Project Area	• Located in Williamswood, HRM, Nova Scotia. • Approximately 4,507 ha in size. • Approximately 213 km from the Project Area.
Designation and Administration	• Designated in 1999 as a Wilderness Area under the Nova Scotia *Wilderness Protection Act*. • Wilderness Areas protect representative examples of Nova Scotia's natural landscapes, maintain and restore the integrity of natural processes and biodiversity, and protect outstanding, unique, rare and vulnerable natural features. They are used for scientific research, education and a variety of recreation and nature-tourism related activities (NSE 2014). • The provincial protected areas program is administered by the Protected Areas Branch of NSE.
Ecological Significance	• The lands of Terence Bay Wilderness Area protect an example of the rugged, granite coastal and near coastal landscape of this part of HRM; provide wildlife habitat and a refuge for vulnerable species, such as rare lichens and the endangered mainland moose; and offer opportunities for recreational activities (*e.g.*, sport fishing, hiking, hunting, canoeing, camping, kayaking, *etc.*) in a wilderness setting (NSE 2010).

8.5.4.1 Project Pathways for Effects

All of the identified accidental event scenarios (*i.e.*, batch diesel spill, PSV spill, SBM spill and well blowout incident) have the 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. As noted earlier, 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 Project-related 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 8.5.1 to 8.5.3 for Fish and Fish Habitat, Marine Mammals and Sea Turtles and Migratory Birds, and are not repeated in this section. The assessment of effects on Special Areas therefore focuses on a Change in Habitat Quality.

In some cases, Special Areas are designated to protect populations that are considered at risk. In these cases, while the effect mechanisms are similar to species not at risk, the significance of the effect can be greater, particularly if the effect involves the loss of a species at risk.

8.5.4.2 Mitigation of Project-Related Environmental Effects

BP will implement multiple preventative and response barriers to manage risk of incidents occurring and mitigate potential consequences. As noted in Section 8.3, the Project will operate under an IMP which will include a number of specific 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 CNSOPB prior to the start of any drilling activity as part of the OA process. The SRP will clarify 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; 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, including, but not limited to, Sable Island National Park Reserve. Refer to Section 8.3 for details on incident management and spill response.

BP will undertake a NEBA as part of the OA process with the CNSOPB to evaluate the risks and benefits of dispersing oil into the water column, including potential effects on Special Areas, and will obtain regulatory approval for any use of dispersants as required.

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.

8.5.4.3 Characterization of Residual Project-Related Environmental Effects

Diesel Spills (PSV and MODU)

A 10 bbl batch spill will be limited in magnitude, geographic extent and duration, and limited to a small portion of the Scotian Slope EBSA. A swath of surface oiling in excess of 0.04 μm from a 100 bbl spill could migrate to the Haddock Box and the Gully MPA. Due to the limited (patchiness) and temporary nature of any surface oiling, it is not expected to result in permanent alteration or destruction of habitat in these Special Areas. A vessel spill could potentially occur anywhere along the transit route between the MODU and the supply base in Halifax Harbour and therefore has the potential to affect the following Special Areas, in addition to the ones discussed above: Sambro Bank Sponge Conservation Area, Emerald Sponge Conservation Area, and shoreline habitat (if a spill should occur close to port). Dissolved hydrocarbons from spilled diesel would be limited to the surface and mixed layer of the water column, therefore the potential for deeper sponges to be exposed is considered low. While haddock is a demersal species, 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.

Well Blowout Incident

A well blowout incident represents the accidental event with the potential for the most widespread effects. Following a blowout incident, for each designated protected area in the RAA, Table 8.5.6 provides the probability from stochastic modelling results of surface oiling exceeding 0.04 μm and the associated exposure time for surface oiling. 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. The probabilities of the areas in Table 8.5.6 being affected are the result of modelling an 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.

The greatest probabilities of surface oiling exceeding 0.04 μm are estimated for offshore protected areas such as the Gully MPA (61.1%) and Sable Island National Park Reserve (28.4%). There are lower probabilities (<2%) for surface oiling exceeding 0.04 μm in coastal protected areas within Nova Scotia. Surface oiling can also be expected to occur within the Haddock Box and sponge/coral conservation areas based on stochastic modelling results. Exposure to oil within these areas would be mostly limited to the surface and mixed layer of the water column;

therefore, the potential for sponges and corals on the seafloor to be exposed to in-water oil is considered low. While haddock is a demersal species, sub-lethal and lethal effects to eggs and larvae that drift in the mixed surface layer of the water column may result following exposure to in-water oil, above the 58 ppb and 200 ppb in-water concentrations, respectively.

Table 8.5.6 Surface Oil Interactions with Designated Protected Areas Resulting from a Well Blowout Incident (Site 1, Summer)

Special Area	Average Probability of Surface Oiling exceeding 0.04 µm in a portion of the Designated Protected Area (%)	Total Intersect Area of Surface Oiling exceeding 0.04 µm (km^2)	Average of Maximum Exposure Time (days)
Coastal Special Areas			
Duncan's Cove Nature Reserve	1.9	0.05	1
Musquodoboit Harbour Ramsar Site	1.0	0.42	1
Terence Bay Wilderness Area	0.7	4.90	1
Canso Coastal Barrens Wilderness Area	0.7	24.25	1
Kejimkujik National Park (Seaside Adjunct)	0.5	0.85	1
Scatarie Island Wilderness Area	0.5	1.60	1
Offshore Special Areas			
Gully MPA	61.1	2,371.28	9
Sable Island National Park Reserve of Canada	28.4	14.45	4
Haddock Box	55.0	12,797	8
Stone Fence coral conservation area (Lophelia Coral Conservation Area)	25.7	15	5
Sambro Bank Sponge Conservation Area	25.0	63	6
Emerald Sponge Conservation Area	22.9	197	4
Northeast Channel Coral Conservation Area	16.8	425	4
Lobster Broodstock Closure Area	7.7	6,561	2
North Atlantic Right Whale - Roseway Basin	6.58	3,319	2
Laurentian Channel Area of Interest	4.6	12,647	2
St Anns Bank Area of Interest	0.9	527	1
North Atlantic Right Whale - Grand Manan Basin	0.48	31	1

Stranded oil is of primary relevance to Special Areas with shorelines. Table 8.5.7 presents probabilities and the average degree of shoreline oiling, above the 1g/m^2 threshold, at designated protected areas with shoreline habitat. Sable Island National Park Reserve has the highest probability of stranded oil exceeding thresholds, with the remaining designated protected areas having a low (<5%) probability of stranded oil interaction. Stochastic modelling for an unmitigated blowout incident at Sites 1 and 2 during winter and summer conditions predict areas of heavy oiling (>10 mm thickness of emulsified oil) for Sable Island, with a minimum arrival time to reach 1 µm thickness threshold of 5 to 10 days.

Environmental effects from stranded oil on Sable Island on migratory birds (including the Roseate Tern) are described in Section 8.3 (Migratory Birds). As noted in Section 5.2.10, Sable Island is also important as it hosts the largest breeding colony of grey seals in the world, a population of wild horses, contains one of the largest dune systems in eastern North America, hosts a number of species at risk and endemic species, and exhibits an extremely dynamic ecology (Freedman 2014). Recovery rate of sand beaches (*e.g.*, recovery of vegetation or structure) following oiling is variable, depending on conditions and initial disturbance during spill response, but is assumed to occur within approximately three years (French-McCay 2009).

Table 8.5.7 Stranded Oil Interactions with Designated Protected Areas Resulting from a Well Blowout Incident (Site 1, Summer)

Special Area	Average Probability of Stranded Oil exceeding 1 g/m^2 in a portion of the Designated Protected Area (%)	Total Intersect Area of Stranded Oil exceeding 1 g/m^2 (km^2)	Average Degree of oiling[1]
Designated Protected Areas			
Sable Island National Park Reserve	55.5	15.41	Heavy
Duncan's Cove	4.0	0.24	Heavy
Canso Coastal Barrens	1.2	17.94	Moderate
Kejimkujik National Park and National Historic site of Canada (Seaside Adjunct)	1.0	5.31	Moderate
Terence Bay	0.7	6.48	Light
Bonnett Lake Barrens	0.6	17.61	Stain/Film
Scatarie Island	0.5	1.49	Moderate

[1]Heavy - >10,000 g/m^2 (> 10 mm thickness)
Moderate – 1,000 – 10,000 g/m^2 (1 -10 mm thickness)
Light - 100 – 1,000 g/m^2 (0.1 – 1.0 mm thickness)
Stain/Film – 1 - 100 g/m^2 (0.001 - 0.1 mm thickness)

As indicated in Section 8.3.3.3, use of chemical dispersants as a spill response method would potentially reduce the likelihood and extent of stranded oil on coastlines, thereby reducing adverse environmental effects on land-based protected areas as listed above.

Summary

The nature and extent of the effects of an accidental event on Change in Habitat Quality for Special Areas vary considerably depending on the type and magnitude of the event, the proximity to the Special Area, and the ecological characteristics of the Special Area. Table 8.5.8 provides a summary of predicted residual environmental effects of accidental events on Special Areas.

Table 8.5.8 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							
10 bbl Diesel Spill	A	L	LAA	ST	S	R	U
100 bbl Diesel Spill	A	M	LAA	ST	S	R	U
PSV Diesel Spill	A	L-M	LAA	ST-MT	S	R	U
Well Blowout Incident	A	H	RAA*	ST-MT	S	R	U
SBM Spill	A	L	LAA	ST	S	R	U

KEY:
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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

8.5.4.4 Determination of Significance

The residual environmental effect of a Change in Habitat Quality for Special Areas for the batch diesel (10 and 100 bbl) and vessel spill scenarios is predicted to be not significant. A medium level of confidence is assigned to the significance determination since the significance would be influenced by a number of factors including volume spilled, duration, location, season, presence of birds, and effectiveness of mitigation.

The residual adverse environmental effect of a Change in Habitat Quality for Special Areas is predicted to be significant for an unmitigated well blowout incident in recognition of potential effects on Sable Island. This significance prediction is made with a high level of confidence given the high probability of heavy oiling and relatively short arrival time of oil to reach the Sable Island shoreline, thereby limiting mitigative response options.

However, the likelihood of a significant adverse effect occurring is considered low given the extremely low probability of a well blowout incident occurring based on historical statistics and the spill prevention and response measures to be implemented by BP on this Project.

The residual environmental effect of an SBM spill on Special Areas is predicted to be not significant with a high level of confidence in recognition of the limited spatial and temporal extent of effects and limited interaction with Special Areas other than the Scotian Slope EBSA.

8.5.5 Commercial Fisheries

The RAA is dominated by commercial fisheries activity with groundfish, pelagic, and invertebrate fisheries occurring on the Scotian Shelf and Slope (see Section 5.3.5). The RAA is located within Commercial Fisheries Management Areas for lobster, shrimp, scallop and crab, and within NAFO Divisions 4VN, 4VS, 4W, 4X, and 5ZE. From 2010 to 2013 in NAFO Divisions within the RAA (Table 5.3.4), invertebrates dominated the commercial landing values with between 71 and 84% of the total catch value in that period. In the Project Area, large pelagics are most commonly harvested (*e.g.,* tuna, swordfish and shark).

Routine Project activities are not predicted to interact with nearshore fisheries, although as shown in stochastic modelling results for an unmitigated well blowout incident, there is potential for oil to reach the nearshore environment. Oil can also interact with nearshore fisheries in the event of a diesel spill from a PSV transiting nearshore waters. Section 5.3.1.2 describes nearshore commercial and recreational fisheries; offshore commercial fisheries are discussed in Section 5.3.5.2. Aboriginal fisheries are discussed in Section 5.3.6 and the Traditional Use Study (Appendix B); effects of accidental events on Aboriginal fisheries are assessed in Section 8.5.6.

Inshore recreational fisheries include American eel, mackerel, herring, and scallop. There are over 250 aquaculture leases in Nova Scotia, including both finfish (*e.g.*, Atlantic salmon, cod, trout) and shellfish (*e.g*., oyster, mussel, scallop, quahaug, clam) operations (NSDFA 2013).

Within Halifax Harbour, where PSVs will be transiting to and from the supply base, nearshore commercial fisheries include a small commercial finish fishery seaward of McNabs Island consisting of groundfish (cod, haddock, pollock and halibut) and pelagic (herring and mackerel) species. The Harbour is located within NAFO Fishery Unit Area 4Wk. Other areas throughout the Harbour support a bait fishery for both commercial and recreational bait (Rozee 2000). Commercial and recreational fisheries for clams and mussels are closed due to fecal coliform levels in the Harbour. Lobster is the primary commercial species harvested within Halifax Harbour with a total of 15 to 20 lobster fishers using the Harbour (Stantec 2014a). The Harbour is included within the boundaries of Lobster Fishing Area (LFA) 33, which extends from Cow Bay, Halifax County to Port La Tour, Shelburne County off southwestern Nova Scotia and into the Bay of Fundy. LFA 33 has the highest landings and most participants of any LFA in Canada (DFO 2013a).

The potential environmental effects, effect pathways, and measureable parameters identified in Table 7.6.1 for Commercial Fisheries for routine activities remain valid for the assessment of potential environmental effects as a result of an accidental event. Likewise, the criteria for characterizing residual environmental effects and determining significance (refer to Section 7.6.5) remain valid for the accidental events assessment.

8.5.5.1 Project Pathways for Effects

Project-related accidental events could potentially affect Commercial Fisheries with respect to a Change in Availability of Fisheries Resources. Section 8.5.1 evaluates effects on Fish and Fish Habitat and concludes that biophysical effects on fish from accidental events will not be significant. However, adverse effects could still be realized by fishers in the event of an offshore or nearshore spill, as a result of reduced access to fishing grounds (*e.g.*, fisheries exclusion), reduced catches, and/or reduced marketability of fish products. In addition, fishing gear or 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.

All of the identified accidental scenarios have the potential to affect Commercial Fisheries, including a batch spill (100 bbl and 10 bbl), PSV spill, SBM spill, and subsea blowout incident.

As noted earlier, the assessment is conservative (*i.e.*, geographic and temporal overlap are assumed to occur and modelling results assume no implementation of mitigation measures).

Effects of Hydrocarbons on Commercial Fisheries

An accidental event could result in effects on availability of fisheries 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 an active fishing area on the Scotian Shelf or shelf break 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 8.5.1, 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).

Effects on fisheries resources can vary depending on the spill location, seasonal timing, and how much oil reaches the fisheries resource. Additionally, changes can 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.

The presence of taint, which is recognized as when a food product has an usual odour or flavor (*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 (ITOPF 2011). 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). 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 DWH 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 produce (ITOPF 2011).

Fishery closures may be imposed after a spill to prevent gear from being contaminated and to protect or reassure seafood consumers. Fishery closures are usually implemented in areas (including a buffer) where: a visible sheen exists on the ocean surface; 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). The threshold of 0.04 µm (visible sheen threshold) was used to present spill trajectory modelling results for surface oiling in recognition of the possibility of a fisheries closure occurring at this threshold (refer to Section 8.4).

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.

Effects of SBM Spill on Commercial Fisheries

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).

8.5.5.2 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 8.3 for details on incident management and spill response plans).

BP will undertake a NEBA as part of the OA process with the CNSOPB to evaluate the risks and benefits of dispersing oil into the water column, including potential effects on fish and fisheries, and will obtain regulatory approval for any use of dispersants as required.

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 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 2002).

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.

8.5.5.3 Characterization of Residual Project-Related Environmental Effects

Diesel Spills (PSV and MODU)

For this Project, modelling results indicate that batch spills from the MODU (10 bbl and 100 bbl) are not likely to result in effects on fish over a large area (Figures 8.4.24 and 8.4.25 in Section 8.4). Accidental discharges of marine diesel resulted in limited modelled effects. Around 65% of the spill evaporated within three days. Further, the maximum exposure time for emulsified oil thickness on the sea surface that exceed 0.04 µm is one day. Deterministic modelling results indicate that the surface area covered by oil in excess of 0.04 µm will equate to 0.82 km^2 and 4.4 km^2 for the 10 bbl and 100 bbl spill scenarios respectively.

Stochastic modelling shows that the locations of surface oiling in excess of 0.04 μm could extend approximately 50 km to the east and 20 km to the north, south, and west for a 10 bbl spill, as a small portion of weathered diesel may continue to be transported at the surface. For a 100 bbl spill, the locations for oiling in excess of 0.04 μm could extend approximately 100 km to the west and southeast and 30 km in all other directions, with a small portion of weathered diesel continuing beyond these distances. However, this swept area would be characterized as a patchy sheen with weathered oil. A nearshore vessel diesel spill would be expected to behave similarly. 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 (Yender *et al.* 2002). However, given the high evaporation rates, exposure of fisheries resources to the diesel would be short-term, thereby reducing risk of contamination of fisheries resources. In the case of a PSV diesel spill, this risk of exposure and subsequent contamination could be greater where there could be a higher density of fisheries resources.

Well Blowout Incident

An unmitigated blowout incident is expected to result in adverse effects to commercial fisheries, with surface and in-water oil expected to predominantly move to the east and southeast of the Project Area as indicated for the deterministic modelling runs (Figures 8.4.24 and 8.4.25). Some seasonal variation in the movement of oil following a release is expected (oil is more likely to be transported to the northeast under summer conditions and move in more uniform, multi-directional transport patterns during winter conditions as indicated for stochastic modelling results). Higher percentages of the released oil were found on the surface in the summer, the result of decreased wind and wave action, which typically disperses and entrain oil into the water column. As indicated by Figures 8.4.3 to 8.4.6, there is a moderate probability of surface oiling (in excess of 0.04 μm) from an unmitigated 35,914 bpd, 30-day continuous blowout reaching the Emerald Basin and Georges Bank. Predictive modelling indicates that the length of time for an unmitigated blowout to reach threshold thickness (0.04 μm for surface oiling) at Emerald Basin or Georges Bank, where fishing effort is considerably more concentrated, would be between approximately 6 to 20 days for Emerald Basin and 30 to 50 days for George's Bank. This would provide an opportunity to notify fishers of the spill and preventing 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. 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. Given the very low probability of a well blowout incident or other release (refer to Section 8.2), and that the predictive modelling referred to above assumes an unmitigated release, the likelihood of effects to these important fisheries areas is considered low.

Modelled blowout scenarios during the summer resulted in the potential for shoreline oiling, including the portions of the Eastern Shore and Southern Nova Scotia, although the likelihood of this occurring was low (less than 5% in most cases; Figures 8.4.12 and 8.4.14). These coastal areas are known to support aquaculture operations that could also be affected by oiling from either an unlikely blowout scenario or a diesel spill from a PSV travelling to Halifax Harbour. 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 NEBA exercise that would be undertaken by BP prior to using dispersants, would consider proximity to aquaculture operations that may be adversely affected by higher in-water oil concentrations.

SBM Spill

Predictive modelling for a spill of SBM completed for the Shelburne Basin Venture Exploration Drilling Project (RPS ASA 2014, Appendix C in Stantec 2014a) predicts that sediment plumes could travel up to 5 to 10 km from the release site to a TSS concentration of 1 mg/L and that TSS concentrations above 1 mg/L could persist up to 30 hours following the spill event in some circumstances.

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 (up to 9.6 km), any measurable effect on water quality would be temporary (up to 30 hours), 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 8.5.10 summarizes predicted residual environmental effects on Commercial Fisheries from various accidental event scenarios.

Table 8.5.9 Summary of Residual Project-Related Environmental Effects on Commercial Fisheries – Accidental Events

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

KEY:
See Table 7.6.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
N: Neutral
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

8.5.5.4 Determination of Significance

The significance of spill-related adverse effects is influenced by 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 Commercial Fisheries. A spill of the same material and volume occurring in the nearshore environment could have potential effects on nearshore fisheries, potentially displacing fishers from traditional fishing grounds for all or most of a fishing season, depending on the volume, location and timing of the spill.

In the event of a 10 bbl diesel spill, adverse environmental effects are predicted to be not significant for commercial fisheries. 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 in the RAA.

In recognition of variances of magnitude depending on the time of year and location of a PSV spill, this spill scenario is also predicted to potentially result in a significant adverse environmental effect on Commercial Fisheries. A significant adverse environmental effect is also predicted to occur in the event of a 100 bbl diesel spill. However, none of these significant effects is considered likely to occur.

Because of the widespread nature of the worst-case, unmitigated blowout incident, a significant effect is conservatively predicted for commercial fisheries for this scenario. The likelihood of this significant effect occurring is considered low, given the potential for a blowout 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 aquaculture operators in Nova Scotia, the likelihood of oil reaching the coast is very low and the time required for oil to reach the shore would give BP and operators time to implement mitigation against oiling of cultivation gear.

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).

Given the predicted affected area (up to 10 km), temporary period of measurable effect on water quality (up to 30 hours), and the low toxicity of the product, effects of a SBM spill are predicted to be not significant for Commercial Fisheries. 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.

8.5.6 Current Aboriginal Use of Lands and Resources for Traditional Purposes

As reported in the Traditional Use Study (TUS) (Appendix B) and discussed in Section 5.3.6, all 13 Mi'kmaq First Nation communities in Nova Scotia currently have communal commercial fishing licences for various species that may be harvested in the RAA. There are 25 species being fished by the Nova Scotia Mi'kmaq First Nation communities under communal commercial licences within the RAA. Fifteen of these species may also be harvested within the LAA and seven within the Project Area: Atlantic cod, bluefin tuna, halibut, mahi-mahi (*Coryphaena hippurus*), silver hake and swordfish. The NCNS fisher 19 species (including by-catch species) within the RAA under communal commercial licences, with 9 of these being fished in the LAA and 7 within the Project Area. Species fished commercially by the NCNS within the Project Area include: albacore tuna, bluefin tuna, bigeye tuna, halibut (by-catch), mahi-mahi (by-catch), swordfish, and yellowfin tuna (MGS and UINR 2016). Additionally, New Brunswick Mi'kmaq and Wolastoqiyik (Maliseet) also hold communal fishing licences for various species that may be harvested from the RAA. Interviews with Fort Folly, Woodstock and St. Mary's First Nation communities revealed that 16 species are fished within the RAA, 10 of which may also be harvested within the LAA. Silver hake and swordfish are the only species that may also be harvested within the Project Area (MGS and UINR 2016).

According to the TUS (Appendix B), no food, social or ceremonial (FSC) fishing was reported to occur in the Project Area, although it is possible FSC fishing could occur presently or in the future. FSC fisheries for Atlantic herring, Atlantic mackerel, Greenland halibut, lobster, redfish, and silver hake are reported by the Nova Scotia Mi'kmaq First Nation communities and/or the NCNS as occurring in the LAA. Additional species are fished for FSC purposes in the larger RAA.

The potential environmental effects, effect pathways, and measureable parameters identified in Table 7.7.1 for Current Aboriginal Use of Lands and Resources for Traditional Purposes for routine activities remain valid for the assessment of potential environmental effects as a result of an accidental event. Likewise, the criteria for characterizing residual environmental effects and determining significance (refer to Section 7.7.5) remain valid for the accidental events assessment.

8.5.6.1 Project Pathways for Effects

All accidental scenarios considered in this assessment could have an adverse environmental effect on Current Aboriginal Use of Lands and Resources for Traditional Purposes. An accidental event could have an effect on the fisheries resource (direct or indirect effects on fished species affecting fisheries success) and/or fishing activity (displacement from fishing areas, gear loss or damage) resulting in a Change in Traditional Use. Although the TUS indicates that 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 offshore FSC activities should they be taking place, nearshore fisheries, and/or 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 Aboriginal peoples, and/or area closures could affect traditional use of marine waters and resources.

In addition to the potential effects on a Change in Traditional Use described above, Section 8.5.5 describes the potential environmental effects of the various spill scenarios on commercial fisheries, Section 8.5.1 describes potential environmental effects on Fish and Fish Habitat, and Section 8.5.4 describes potential effects on Special Areas. These sections also help to inform how the accidental release of hydrocarbons to the marine environment may adversely affect Current Aboriginal Use of Lands and Resources for Traditional Purposes.

As noted earlier, the assessment is conservative (*i.e.*, geographic and temporal overlap are assumed to occur and modelling results assume no implementation of mitigation measures).

8.5.6.2 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 8.3 for details on incident management and spill response plans).

BP will undertake a NEBA as part of the OA process with the CNSOPB to evaluate the risks and benefits of dispersing oil into the water column, including potential effects on fish and fisheries, and will obtain regulatory approval for any use of dispersants as required.

Mitigation to reduce effects from an accidental spill on Current Aboriginal Use of Lands and Resources for Traditional Purposes includes measures which are also intended to mitigate potential effects on Commercial Fisheries including:

- 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 2002)

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.

8.5.6.3 Characterization of Residual Project-Related Environmental Effects

Diesel Spills (PSV and MODU)

For this Project, modelling results indicate that batch spills from the MODU (10 bbl and 100 bbl) are not likely to result in effects on fish over a large area (Figures 8.4.2.4 and 8.4.25 in Section 8.4). Accidental discharges of marine diesel resulted in limited modelled effects. Around 65% 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 0.82 km^2 for the 10 bbl spill scenario and 4.4 km^2 for the 100 bbl spill scenario. The effects from a vessel diesel spill would be expected to be of similar magnitude, although a spill could also affect nearshore commercial and/or FSC fisheries if an incident were to occur while the PSV was approaching or departing the onshore supply base. 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). If a fisheries closure was implemented due to the spill, this could result in a temporary loss of access to Aboriginal fishers for commercial or FSC purposes.

Well Blowout Incident

As discussed in Section 8.5 (Commercial Fisheries), the effects from an unmitigated blowout incident would be more widespread than for the other spill scenarios. The probability of surface oiling (in excess of 0.04 µm) from an unmitigated 35,914 bpd, 30-day continuous blowout incident has moderate potential to reach Emerald Basin and Georges Bank. Predictive modelling indicates that the length of time for oil from an unmitigated blowout incident to reach threshold concentration (0.04 µm for surface oiling) at Emerald Basin or Georges Bank, where fishing effort is considerably more concentrated, would be between approximately 6 to 20 days for Emerald Basin and 30 to 50 days for George's Bank. This would provide an opportunity to notify fishers of the spill and preventing the setting or hauling of gear in the affected area. Fouling of gear and/or catch of contaminated resources would therefore be reduced. As indicated in the mapping included in the TUS (refer to Appendix B), identified fishing areas for demersal and invertebrate fisheries are almost exclusively located on the Scotian Shelf, whereas pelagic fisheries occur throughout the RAA. Given the very low probability of a well blowout incident or other release (refer to Section 8.2), and that the predictive modelling referred to above assumes an unmitigated release, the likelihood of effects to these traditional use areas is considered low.

SBM Spill

Predictive modelling for a spill of SBM conducted for the Shelburne Basin Venture Exploration Drilling Project (RPS ASA 2014, Appendix C in Stantec 2014a) predicts that sediment plumes could travel up to 9.6 km from the release site to a TSS concentration of 1 mg/L and that TSS concentrations above 1 mg/L could persist up to 30 hours following the spill event in some circumstances. 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 (up to 9.6 km), any measurable effect on water quality would be temporary (up to 30 hours), 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 8.5.10 summarizes predicted residual environmental effects on Current Aboriginal Use of Lands and Resources for Traditional Purposes from various accidental event scenarios.

Table 8.5.10 Summary of Residual Project-Related Environmental Effects on Aboriginal Use of Lands and Resources for Traditional Purposes – Accidental Events

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

KEY:
See Table 7.7.2 for detailed definitions

N/A: Not Applicable
Direction:
P: Positive
A: Adverse
N: Neutral
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

8.5.6.4 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 occurring outside the MODU operational safety (exclusion) zone and therefore would not result in a significant adverse environmental effect on Current Aboriginal Use of Lands and Resources for Traditional Purposes. 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.

In the event of a 10 bbl diesel spill, adverse environmental effects are predicted to be not significant for Current Aboriginal Use of Lands and Resources for Traditional Purposes. 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, this spill scenario is also conservatively predicted to potentially result in a significant adverse environmental effect on Current Aboriginal Use of Lands and Resources for Traditional Purposes. A significant adverse environmental effect is also predicted to occur in the event of a 100 bbl diesel spill. However, none of these significant effects is considered likely to occur. 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).

Because of the widespread nature of the worst-case, unmitigated blowout incident, a significant effect is conservatively predicted for Current Aboriginal Use of Lands and Resources for Traditional Purposes 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 operators time to implement mitigation against oiling of cultivation gear.

Given the predicted affected area (up to 10 km), temporary period of measurable effect on water quality (up to 30 hours), and the low toxicity of the product, effects of a SBM spill are predicted to be not significant on Current Aboriginal Use of Lands and Resources for Traditional Purposes. 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.