

## **APPENDIX 29-15. SHIPPING MANAGEMENT PLAN**

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# **AGNICO EAGLE**

**MELIADINE GOLD MINE**

## **Shipping Management Plan**

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**MARCH 2025**

**VERSION 10**

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## DOCUMENT CONTROL

Version	Date	Section	Page	Revision	Author
1	December 2012			First draft of the Shipping Management Plan	John Witteman, Env. Consultant, AEM
2	March 2013			DEIS re-submission; rebranding	
3	April 2014	1.1	1	Anticipated increased shipping traffic	John Witteman, Env. Consultant, AEM
		1.2	4	Updated Figure 1-1	
		3	10-11	Added details on AWPPA and regs. and Shipping Safety Control Zone	
		4	14	Mention of marine birds and ship track data	
		4.2	16	Distance of release from Itivia Harbour Spill vs marine wildlife	
4	January 2016	1.1	1	Decrease in shipping traffic	Phil Rouget, Golder Associates Ltd.
		1.3.3	6	Added details for cyanide	
		2.3	7	Update spill support	
		2.4	8	Added details to SOPEP	
		4.1	13-14	Reference to Spill Risk	
		4.2	14-15	Assessment	
				Updated mitigation and reference to MEMP and MMSO program in accordance with Project Certificate conditions.	
		4.3	15-16	Updated monitoring activities and reference to MEMP and MMSO program.	
		9.2	23	Removed last paragraph	
		10	24	Update to safety	
		A-B		Added Revised Marine Baseline Assessment	
		A-D		Added Marine Environmental Management Plan (MEMP)	
		A-E		Added Revised Spill Risk Assessment	
5	August 2016	1.3.3	6	Up to date Safety Bulletin in relation to vessels	Katelyn Zottenberg, Golder Associates Ltd.
				Added that ammonium nitrate is listed under schedule 1 of the Environmental Emergency Regulations.	
		Table 3-1	12	Update to Navigation Protection Act.	

		4.2	15	<p>Added Section 36(3) of the <i>Fisheries Act</i>.</p> <p>Updated wording “Subject to safe navigation...”</p> <p>Footnote added to include how vessel wake was assessed in the FEIS.</p> <p>Updated to wording around marine mammal mitigation. (changed to 500 m buffer zones).</p>	
		Appendix C	2.2.1.2	<p>Added Government of Nunavut as lead management responsibility for polar bears.</p>	
		Appendix C	Table D-4	<p>Changed wording regarding the handling of birds during a spill.</p>	
		Appendix C Appendix D Figure D3	1.0	<p>Updating wording to state the intent of the MMSO program.</p> <p>Revised</p>	
6	February 2017	Appendix C	2.1.3	<p>Updated to include more detailed protocols for marine mammal and seabird surveys/observations (specifically the ECSAS protocols for seabirds as request by ECCC)</p>	Katelyn Zottenberg, Golder Associates Ltd.
		Figure 1-1 Executive Summary Sections 1.0, 4.0, 11, 12 and 13	4 vi 1, 14, 26, 30, 28	<p>Updated text to reflect comments received from dry cargo shipping contractor (Desgagnes Transarctic). Key edits related to shipping of dry cargo shipping operations included (description of lightering operations, potential anchor location (dry cargo vessels only), number of vessel, and potential nighttime operations).</p>	
7	March 2017	Throughout the Shipping Management Plan		<p>Minor wording updates to the text to reflect comments received from dry cargo shipping contractor (Desgagnes Transarctic).</p>	Katelyn Zottenberg, Golder Associates Ltd.
8	March 2019	Throughout the Shipping Management Plan		<p>Updated wording to reflect current management status.</p>	Dan Gorton
		Section 4.3	17	<p>Updated to address NIRB condition 127.</p>	
9	April 2022	All	All	General Update	Environment Department

				Revised to add references to the <i>Arctic Shipping Safety and Pollution Prevention Regulations (ASSPPR)</i>
				Updated Oil Pollution Emergency Plan (OPEP) for Oil Pollution Emergency and Oil Pollution Prevention Plan (OPEP/OPPP)
10	March 2025	All	All	Updated Ballast Water Management
		All	All	Organized content to provide a more logical and concise presentation of the information.
		All	All	Minor editorial changes.
				Updated figures
		3	Table 3.1	Updated regulations matrix

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## EXECUTIVE SUMMARY

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The Shipping Management Plan was developed in accordance with federal legislation, notably the *Canada Shipping Act (CSA)* and its *Arctic Shipping Safety and Pollution Prevention Regulations (ASSPPR)* and *Ballast Water Regulations*, and the *Arctic Waters Pollution Prevention Act* and associated regulations. It also recognizes the international conventions and protocols signed by Canada. Agnico Eagle provides the necessary human, material, and financial resources to meet or exceed the legal requirements attributable to the company that arise from shipping-related activities. Shipping contractors are encouraged to do the same. Agnico Eagle and its shipping contractors carry third party liability insurance.

All shipping is carried out during the open water season and follows the recommended shipping routes that are presently in use for the annual sea lift to Rankin Inlet and other Kivalliq communities. Ice breaking is not conducted by Agnico Eagle shipping providers to extend the shipping season.

Upon arrival at Rankin Inlet, all vessels anchor either outside or inside Melvin Bay. Dry cargo is lightered onto barges for transport through the access passage using tugs. The barges then transport the dry cargo by barge to the existing offloading area, which is shared with Hamlet of Rankin Inlet during the annual sealift. Large fuel tankers anchor outside of Melvin Bay and ship-to-ship fuel transfer to smaller tankers is the first step in moving the fuel to the Itivia Harbour fuel tank farm. The small tankers navigate the access passage and anchors near the fuel tank farm at Itivia Harbour where ship-to-shore floating hoses transfer the fuel to the tank farm.

It is Agnico Eagle's intent to prioritize the transport of hazardous materials, including explosives and explosive related materials, to the Meliadine site to avoid having such cargo remain in storage at the Itivia Harbour laydown yard.

Several management plans associated with shipping-related activities are in place and include the Spill Contingency Plan, Risk Management and Emergency Response Plan, and the Oil Pollution Emergency Plan and Oil Pollution and Prevention Plan (OPEP/OPPP). Risk and hazard assessments of shore-based marine response activities are undertaken as part of training the Emergency Response Team (ERT).

Agnico Eagle personnel and the Master of the ship are responsible for security matters for shipping-related activities. While it is anticipated that the Royal Canadian Mounted Police (RCMP) will not be involved in security matters, all criminal activities or matters of a grave nature (e.g., smuggling) will be referred to the RCMP in Rankin Inlet. Mitigation measures to prevent smuggling are in place. Mitigation measures are also employed to minimize potential negative socio-economic effects from shipping-related activities; positive socio-economic impacts are anticipated.

Navigation through the Labrador Sea, Hudson Strait, and Hudson Bay is not challenging during the open water season. No major hazards were identified along the shipping and tug-barge routes under

normal conditions. Shipping can be carried out without pilotage as the shipping routes entail minor hazards not significantly reducing ship safety.

All ships, tugs and tankers use electronic charts and other electronic navigational aids to provide safety in transit, reduce the risk of accidents, and remain within the recommended shipping routes. Traffic through the access passage is coordinated to avoid shipping conflicts, and speed is reduced to ensure safety. To maximize the safety of the persons travelling in boats near the Rankin Inlet access passage, Agnico Eagle informs the community of the shipping activities, promotes actions that will allow the ship and the small boats to see one another.

On board waste management (e.g., solid and hazardous wastes, sewage) is the responsibility of shipping contractors. Agnico Eagle requires the shipping contractors to conform to the *Ballast Water Regulations*, which are intended to reduce the risk of invasive and non-indigenous species from being inadvertently introduced in the region as a result of shipping activities. Agnico Eagle requires that shipping contractors and their vessels adhere to applicable environmental regulations and have a superior safety record.

Care is taken to avoid disturbing marine mammals within the shipping routes as much as possible. As part of shipping companies' standard operating procedures, a designated member of the ships crew monitors the shipping routes for marine mammals from the Hudson Strait to Rankin Inlet. Additionally, mitigation measures may comprise, if safe to do so, slowing the ship and stay at distance from marine mammals.

Vessels contracted by Agnico Eagle are required to have an approved Shipboard Oil Pollution Emergency Plan (SOPEP). If an environmental emergency occurs along the shipping routes, the SOPEP is activated. Close coordination is maintained with Agnico Eagle's shore-based supervisors who can activate Agnico Eagle Emergency Response Plan and OPEP/OPPP to provide assistance to a vessel. Accidents or malfunctions during transit will be reported to Transport Canada, in accordance with provisions under the *Canada Shipping Act (CSA 2001)* and subsequent regulations. Spills would also be reported to the Environmental Emergencies 24-Hour Report Line and, if necessary, advice would be requested from the Regional Environmental Emergency Team (REET). Assistance could also be sought from nearby ships and the Canadian Coast Guard (CCG).

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**ACRONYMS**

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Agnico Eagle	Agnico Eagle Mines Limited
BWMP	Ballast Water Management Plan
CCG	Canadian Coast Guard
CSA	Canada Shipping Act
ECCC	Environment and Climate Change Canada
EIA	Environmental Impact Assessment
ERP	Emergency Response Plan
ERT	Emergency Response Team
IMO	International Marine Organization
IMDG	International Maritime Dangerous Goods
MARPOL	International Convention for the Prevention of Pollution from Ships
MEMP	Marine Environmental Management Plan
MMSO	Marine Mammal and Seabird Observer
OHF	Oil Handling Facility
OPEP/OPPP	Oil Pollution Emergency Plan and Oil Pollution Prevention Plan
RCMP	Royal Canadian Mounted Police
REET	Regional Environmental Emergencies Team
SOLAS	International Convention for the Safety of Life at Sea
SOPEP	Shipboard Oil Pollution Emergency Plan
TEU	Twenty-foot Equivalent Unit, a measure used for capacity in container transportation (sea can)
TK	Traditional Knowledge
WSCC	Workers' Safety Compensation Commission

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## SECTION 1 • INTRODUCTION

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Agnico Eagle Mines Limited (Agnico Eagle) gained extensive experience in shipping fuel and dry cargo to the Meadowbank Gold Mine (Meadowbank) since its construction began in 2008. Similar shipping, lightering, and ship-to-shore fuel transfer procedures developed and in use for Meadowbank are employed for the Meliadine Gold Mine.

Dry cargo barges undergo lightering operations at the existing gravel ramp used by the hamlet during the annual sealift in Itivia Harbour<sup>1</sup>. A tank farm, sea can storage, and a laydown yard are located at Itivia Harbour (Figure 1-1).

### 1.1 Shipping Needs

A total of approximately 48,000 metric tonnes of dry cargo (equipment and supplies) and 64 million litres of diesel fuel is required annually for the operations of the Meliadine Mine.<sup>2</sup> To meet these needs, approximately 8 to 12 vessels deliver dry goods and 6 tankers (including mother ships and vessels) deliver diesel fuel annually.

All shipping is carried out during the open water season (typically from early July to late October) and follow the recommended shipping routes presently in use for the annual sea lift to Rankin Inlet and other Kivalliq communities. Ice breaking is not conducted by Agnico Eagle shipping providers to extend the shipping season.

The priorities in shipping dry cargo and fuel are:

- The protection of the crew and others in small boats that the ship may come across;
- The protection of the marine environment; and
- The preservation of the ship and its cargo.

Ships are not serviced in Rankin Inlet and arrive with enough fuel for the return voyage south.

The Meliadine Mine is anticipated to contribute to shipping in Hudson Strait and Hudson Bay by about 8 to 12 ships during operations. This represents an increase in ship traffic in Hudson Strait, Hudson Bay, and to Rankin Inlet, and extra care is required in regards to marine safety. This includes ensuring there is adequate spill response equipment on the ships and at the Itivia Harbour Oil Handling Facility (OHF).

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<sup>1</sup> The current plan is to lighter cargo using the existing gravel ramp in Itivia Harbour. This ramp is also currently used by the Hamlet of Rankin Inlet during the annual sealift. The assessment of potential effects related to the use of this ramp are consistent with those discussed in Section 8.3.4 of the FEIS (e.g., propeller wash from nearshore Mine vessels berthing at the landing ramp may result in adverse effects to marine water quality with associated indirect effects on marine wildlife). The conclusions of the assessment remain the same.

<sup>2</sup> Based on 2024 available numbers

Spill response personnel need to have adequate training and equipment to effectively respond to a spill in the marine environment<sup>3</sup>.

## 1.2 Shipping Routes

The marine transport of dry cargo is comprised of four main segments, all within the recommended shipping routes:

- Bécancour, Québec on the St. Lawrence River, along the coast of Labrador to the Hudson Strait;
- Through Hudson Strait to Hudson Bay (see Appendix A showing the shipping routes);
- Across Hudson Bay to Marble Island, this being approximately 45 km offshore of Rankin Inlet; and
- From Marble Island to the barrier islands, through the islands to an anchoring point either inside or outside of Melvin Bay and Itivia Harbour. Access to anchoring locations inside Melvin Bay occurs through the access passage (Figure 1-1).

Dry cargo and transport barges are loaded onto ocean-going container ships in eastern ports, almost exclusively Bécancour, and delivered directly to Rankin Inlet<sup>4</sup>. The first vessels of the year normally arrive in Rankin Inlet in July. This first container ship includes two (2) transport barges to transport dry cargo to shore, and two (2) tugs.

Up to twelve (12) container ships arrive throughout the open water shipping season delivering dry cargo<sup>5</sup>. All ships, tugs and tankers follow the recommended shipping routes and are equipped with complete electronic navigation aids for navigation in restricted waters.

The port of departure for transporting fuel is different from that for dry cargo. The first leg of the voyage is from an east coast refinery along the coast of Labrador to the Hudson Strait with the remainder of the voyage being the same as for the ships carrying dry goods.

## 1.3 Lightering Procedures

### 1.3.1 Dry Cargo

Sea cans, large equipment, machinery, general cargo, and vehicles are lightered onto the transport barges for transport to shore using tugs and then lightered to shore using the existing gravel ramp at Itivia Harbour. During lightering operations, attention is directed to stabilizing the barges at the gravel ramp, with due consideration being given to the prevailing and expected wind, weather, and tide conditions.

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<sup>3</sup> OPEP/OPPP details spill response at the Itivia Harbour Oil Handling Facility.

<sup>4</sup> Agnico Eagle's shipping routes within Nunavut are non-compulsory pilotage areas during the ice free shipping season.

<sup>5</sup> To this point there are no alternative routes under consideration, however future routing may include Churchill to Rankin Inlet on occasion.

Most dry cargo is transported in Twenty-foot Equivalent Unit marine shipping containers on general cargo vessels fitted with cranes. Most materials arrive in sea cans, which are stacked in the Itivia Harbour laydown yard or moved immediately to site. The use of sea cans provides secondary protection against spills and facilitates efficient transfer from ship to ship and ship to shore.

The tug-barge used to ferry the dry cargo to shore is highly manoeuvrable and capable of transiting the access passage with its changing current patterns. Navigation proceeds at a slow speed in periods of low visibility. Traffic through the access passage is coordinated through communication between the tugs to avoid shipping conflicts and to ensure safety.



**Figure 1 Itivia Harbour and Melvin Bay**

Masters of tugs, large and small tankers, and dry cargo ships are responsible for the safe navigation of their vessels from the port of departure to Rankin Inlet. For tugs this also includes responsibility for the barge they are towing or pushing. When a barge is laid alongside a dry cargo vessel for lightering containers or equipment from the cargo ship to the barge, a loading supervisor on the ship takes charge of the barge. When a cargo barge is stabilized at the gravel ramp for lightering to shore, a shore supervisor takes charge of the cargo barge.

The shore crew then conducts a “roll-on/ roll-off” operation using wheel loaders equipped with forks, trucks, and trailers to unload the cargo from the barges. Cargo is stockpiled on the laydown area before being transported to the Meliadine Mine.

For the majority of the shipping season, outgoing cargo is loaded onto lightering barges and subsequent container ships for the return trip to southern ports. Outgoing cargo could include demobilized construction equipment, hazardous waste being sent to a certified waste management facility for treatment, or other waste / recycling for disposal in another provincial or territorial jurisdiction. No barges, fuel vessels, or tugs remain at Rankin Inlet over the winter; all return to southern ports.

### 1.3.2 Diesel Fuel

Large tankers delivering diesel fuel anchor in the same general location as the dry cargo vessels (Figure 1-1). Ship-to-ship transfer of fuel occurs at this location from the larger tanker to a smaller tanker that can navigate the access passage. The carrying capacity of the small tanker is typically 7,300 m<sup>3</sup> to 10,500 m<sup>3</sup>. The small tankers anchor opposite Itivia Harbour<sup>6</sup> and a floating hose of approximately 300-500 m is connected to a shore-based pipeline for fuel transfer to the tank farm. Contingency measures related to the transfer of fuel are described in the Oil Pollution Emergency Plan and Oil Pollution Prevention Plan (OPEP/OPPP).

### 1.3.3 Explosives and Hazardous Materials

Part of the dry cargo received each year is ammonium nitrate, which is used on site to manufacture explosives. Bulk ammonium nitrate is shipped and stored as prill, which is inert and does not require special handling during transit. The ammonium nitrate and other required raw materials and blasting related products arrive in sea cans and are stored in secure locations at the mine site. Further information related to transport of ammonium nitrate is provided in the Explosives Management Plan.

Agnico Eagle prioritizes the road transport of hazardous materials, including explosive-related materials, to the Meliadine site to avoid having this cargo remain at the Itivia Harbour laydown yard. Sensitive products such as boosters and caps are transported directly to the Meliadine Mine. However, in the event of a delay in their transit to the mine site, these products will be temporarily stored at Itivia Harbour according to applicable regulations which include locked storage and constant surveillance. All handling, transport, storage, manufacture, and use of explosives are subject to federal approval under the *Explosives Act* and the *Nunavut Mine Health and Safety Act*. In addition, the latest Ship Safety Bulletin issued by Transport Canada's Marine Safety Directorate is followed when loading and unloading explosives.

Sodium cyanide is used to optimize gold recovery from the ore at the Meliadine site. The product is transported, stored, handled, transferred and used in compliance with appropriate legislation and applicable Best Management Practices. Agnico Eagle is a signatory to the International Cyanide Management Code.

Hazardous waste is managed on a yearly basis; consequently there will be little to no accumulation of these wastes at the mine site during operations, subject to seasonal shipping considerations. Hazardous

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<sup>6</sup> The anchoring location will vary based on a number of factors such as tide, wind and draught of the small tanker.

waste that cannot be managed on site is appropriately packaged for transport in sea cans and sent via a dry cargo vessel to a certified hazardous waste management facility for treatment, recycling and/or disposal in another provincial or territorial jurisdiction following the Hazardous Materials Management Plan and Spill Contingency Plan. Agnico Eagle contracts shipping companies that are certified under the International Maritime Dangerous Goods code.

Itivia Harbour is presently connected to the hamlet by a municipal road and a private Bypass Road, which is used for the transport of all its dry cargo and fuel around the community. This includes ammonium nitrate, cyanide, and dangerous goods.

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**SECTION 2 • RELATED DOCUMENTS**

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The Shipping Management Plan covers the scope of shipping activities for the Meliadine Mine. It is part of the Environmental Management and Protection Plan.

Management and monitoring plans for the Meliadine Mine that provided input to the Shipping Management Plan include the following:

- Spill Contingency Plan;
- Risk Management and Emergency Response Plan;
- OPEP/OPPP;
- Shipboard Oil Pollution Emergency Plan (SOPEP; shipping companies); and
- Occupational Health and Safety Plan.

**2.1 Spill Contingency Plan**

The cornerstone of spill planning for Agnico Eagle is the Spill Contingency Plan covering spills on land, water and ice. The Spill Contingency Plan, coupled with the Risk Management and Emergency Response Plan, describes the processes to be followed when responding to a spill to the environment.

**2.2 Risk Management and Emergency Response Plan**

The Risk Management and Emergency Response Plan focuses on responding to emergencies in a timely and adequate manner. It commits Agnico Eagle to being prepared for and providing adequate resources - qualified personnel and equipment - to handle a wide variety of emergency situations.

Risk and hazard assessments of shore-based marine response activities are undertaken as part of training for Emergency Response Team (ERT).

**2.3 Oil Pollution Emergency Plan and Oil Pollution and Prevention Plan (OPEP/OPPP)**

The OPEP/OPPP complements the Spill Contingency Plan and provides contingency planning for the Oil Handling Facility (OHF) at Itivia Harbour.

The OPEP complies with the requirements for procedures, equipment, and resources as set out in the *Canada Shipping Act* (s.s. 660.2(4)) specific to the fuel handling facility, the bulk incoming transfer of fuel from ship-to-shore, and spill scenarios directly relating to this operation. Further, the OPEP/OPPP provides direction to Agnico Eagle personnel and/or contractors and to Agnico Eagle's ERT in emergency spill response situations. It also contributes in developing oil pollution scenarios, defining the roles and responsibilities of management and responders, and outlining the measures taken to prevent spills. The OPEP seeks to minimize potential health and safety hazards, environmental damage, and cleanup costs.

Spills resulting from ship-to-ship fuel transfer will be the responsibility of the ships contracted by Agnico Eagle and ship's Master. Agnico Eagle will provide assistance wherever possible in these instances.

## 2.4 Shipboard Oil Pollution Emergency Plan (SOPEP)

SOPEP contains all information and operational instructions as required by the International Marine Organization's (IMO) *"Guidelines for the Development of the Shipboard Marine Pollution Emergency Plan"*. Vessels contracted by Agnico Eagle are required to have an approved SOPEP. The preparation of the SOPEP is the responsibility of the shipping company and is maintained by the vessel's Master. However, close coordination is maintained with Agnico Eagle's shore-based Itivia Harbour supervisors who can activate the Emergency Response Plan (ERP) and OPEP to provide assistance to a vessel in the near-shore area. These two plans have close links to the SOPEP and, as required, include training exercises at regular intervals to ensure ship and shore can cooperate in response to spills of fuel or other hazardous product in the immediate vicinity of Itivia Harbour. SOPEP(s) are required to include how vessel contractor(s) maintain spill equipment and the frequency and framework for training vessel personnel in vessel-based spill response. This includes, but is not limited to:

- Spill equipment audits;
- Maintaining posted list of spill equipment;
- Requirements for spill response drills; and
- On-going training refreshers (e.g. annual renewals).

Accidents or malfunctions during transit will be reported to Transport Canada, in accordance with CSA 2001 and subsequent regulations. If the accident involves the loss of fuel or chemicals, the SOPEP would be activated and on-board spill response materials and equipment put to use. Spills would also be reported to the Government of Nunavut Spill Line and to the Environmental Emergencies 24-Hour Report Line and, if necessary, advice would be requested from the Regional Environmental Emergencies Team. Assistance could be sought from nearby ships and the Canadian Coast Guard (CCG). Spill response resources such as those maintained by the Canadian Coast Guard at select locations along the Kivalliq coast could be dispatched to the spill site. A sea can with spill response materials is maintained by the CCG in Rankin Inlet. Permission to use this material will have to be obtained from CCG before usage.

Outside help could be requested for major accidents such as accidental grounding/stranding of a vessel. The safety of the crew and responders as well as maintaining the integrity of the vessel is the first priority.

## 2.5 Occupational Health and Safety

All activities carried out by Agnico Eagle must consider the attendant risks and be carried out with safety first in mind. Agnico Eagle will conduct all activities in accordance with the Workers' Safety and Compensation Commission (WSCC) Occupational Health and Safety legislation.

### SECTION 3 • APPLICABLE FEDERAL ACTS, REGULATIONS AND GUIDELINES

The Plan was prepared in accordance with federal legislation outlined in Table 3-1. Numerous regulations exist under the *Canada Shipping Act* and these can be found at [www.tc.gc.ca](http://www.tc.gc.ca) and [www.canada.ca](http://www.canada.ca). The regulations included here are most relevant to the environment and the Shipping Management Plan.

**Table 1 Applicable Acts, Regulation and Guidelines**

Acts	Regulations	Guidelines
<b>Federal Legislation</b>		
<i>Canada Shipping Act</i> , 2001 (S.C. 2001, c. 26) [An Oil Pollution Emergency Plan is required under the Act (168(1)d)]	<i>Arctic Shipping Safety and Pollution Prevention Regulations</i> (SOR/2017-286) <i>Response Organizations and Oil Handling Facilities Regulations</i> (SOR/95-405) <i>Environmental Response Regulations</i> (SOR/2019-252) <i>Ballast Water Regulations</i> (SOR/2021-120) <i>Vessel Pollution and Dangerous Chemicals Regulations</i> (SOR/2012-69)	Oil Handling Facilities Standards – TP12402 Environmental Prevention and Response National Preparedness Plan – TP13585 E Guidelines for Reporting Incidents Involving Dangerous Goods, Harmful Substances and/or Marine Pollutants – TP9834E 2009 Arctic Waters Oil Transfer Guidelines, 1997 - TP10783E Response Organizations Standards – TP 12401E 1995 Guide to Canada's Ballast Water Regulations (TP 13617E)
<i>Canadian Transportation Accident Investigation and Safety Board Act</i> (S.C. 1989, c. 3)	<i>Transportation Safety Board Regulations</i> (SOR/2014-37)	
<i>Marine Liability Act</i> (S.C. 2001, c. 6)	<i>Marine Liability and Information Return Regulations</i> (SOR/2016-307)	
<i>Arctic Waters Pollution Prevention Act</i> (R.S.C., 1985, c. A-12)	<i>Arctic Waters Pollution Prevention Regulations</i> (C.R.C., c. 354) <i>Arctic Shipping Safety and Pollution Prevention Regulations</i> (SOR/2017-286))	
<i>Transportation of Dangerous Goods Act</i> (1992, c.34)	<i>Transportation of Dangerous Goods Regulations</i> (SOR/2001-286)	
<i>Marine Transportation Security Act</i> (1994, C.40)	<i>Marine Transportation Security Regulations</i> (SOR/2004-144)	
<i>Safe Containers Convention Act</i> (R.S.C. 1985, c. S-1)		
<i>Oceans Act</i> (S.C. 1996, c. 31)		
<i>Canada Navigable Waters Act</i> (R.S.C. 1985 c. N-22)		
<i>Canada Water Act</i> (R.S.C., 1985 c.11)		

Acts	Regulations	Guidelines
<i>Fisheries Act</i> (R.S.C., 1985, c. F-14)	<i>Marine Mammal Regulations</i> (SOR/93-56) Prohibition of Depositing Deleterious Substances (Section 36[3])	
<i>Species at Risk Act</i> (S.C. 2002 c.29)		Species at Risk Policies
<i>Canadian Environmental Protection Act</i> (S.C., 1999 c.33)	<i>Environmental Emergency Regulations</i> (SOR/2003-307) <i>Cross-Border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations</i> (SOR/2021-25) <i>Release and Environmental Emergency Notification Regulations</i> (SOR/2011-90) <i>Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations</i> (SOR/2008-197)	

Table 3-2 lists international conventions and protocols signed by Canada. Canada is a signatory to IMO International Convention for the Prevention of Pollution from Ships (MARPOL) and International Convention for the Safety of Life at Sea (SOLAS). As such, Canadian maritime laws, regulations, and guidelines are a reflection of these international conventions, protocols, and agreements.

**Table 2 International Conventions and Protocols Signed by Canada**

Conventions	
International Convention for the Prevention of Pollution from Ships MARPOL 73/78 Annexes	
	Objective of Annex is to Prevent Pollution from:
Annex 1	Oil from ships
Annex 2	Noxious liquid substances carried in bulk
Annex 3	Harmful substances carried by ships in packaged form
Annex 4	Sewage treatment and disposal
Annex 5	Garbage handling
Annex 6	Air Pollution from Ships
International Maritime Dangerous Goods Code	
International Convention for the Safety of Life at Sea, 1974, SOLAS 74	

All vessels transiting through and operating in Canadian Arctic waters are required to comply with the Arctic Waters Pollution Prevention Act (AWPPA) including the Arctic Shipping Safety and Pollution

*Prevention Regulations* (ASSPPR), the *Canada Shipping Act 2001* (CSA 2001), the *Marine Transportation Security Act* (MTSA), the *Marine Transportation Security Regulations* (MTSR), the *Marine Liability Act* (MLA), and relevant associated regulations, including requirements for vessel construction and operations. The ASSPPR incorporates the International Code for Ships Operating in Polar Waters (Polar Code). While the provisions of the CSA 2001 apply in all Canadian waters, vessels in Arctic waters north of 60°N and out to the 200 nautical mile limit of Canada's Exclusive Economic Zone are also subject to the provisions of the AWPPA. The AWPPA prohibits discharges of oil, chemicals, garbage and other wastes generated onboard vessels. The *Marine Liability Act* sets out a regime that requires vessels operating in Canadian jurisdiction, including Arctic waters, to carry insurance to pay for damages from oil spills.

Two vessel control systems are established under the *Arctic Shipping Pollution Prevention Regulations* – the Zone/Date System and the Arctic Ice Regime Shipping System, which provide for operational safety by taking into account the vessel's capability to operate safely by virtue of ice strengthening, and the ice conditions it will encounter<sup>7</sup>.

Vessels servicing the Mine will be required to comply with the AWPPA and regulations while in a Shipping Safety Control Zone<sup>8</sup>.

Shipping contractors used by Agnico Eagle will abide by Canadian laws and regulations, applicable MARPOL 73/70 annexes, and international conventions. Inspections carried out by federal inspectors will ensure that all applicable statutes are followed. This could include the review of required plans, an audit of the emergency response equipment carried by the vessel, and the means to prevent the discharge of any oil, contaminated water, or other waste in Arctic waters. Agnico Eagle will notify Transport Canada if contracted shipping companies change.

The certified shipping companies contracted by Agnico Eagle must have an approved SOPEP, and verify that equipment and operating procedures are consistent with Canadian Marine laws, regulations and guidelines, and with IMO agreements to which Canada is a signatory.

Agnico Eagle will provide the necessary human, material, and financial resources to meet the legal requirements attributable to the company that arise from shipping. Shipping contractors will be encouraged to do the same.

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<sup>7</sup> Agnico Eagle will only ship dry goods and fuel during the open water season.

<sup>8</sup> Rankin Inlet is in Zone 16.

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**SECTION 4 • MARINE WILDLIFE**

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Marine mammals have been the basis of the Inuit economy for over 4,000 years. They provide meat, fat, oil, leather, tools and materials for fabrication of arts and crafts. The top layers of the skin yield "muktuk", which is still highly prized as a food rich in vitamin C and high in energy content.

The effects of vessel traffic on marine mammals and birds were assessed in the Final Environmental Impact Statement (FEIS, Golder 2014). This included a Traditional Knowledge (TK) study of the marine environment between Chesterfield Inlet and Whale Cove. Together, scientific and traditional knowledge were used to develop mitigation measures to eliminate potential residual effects. The reaction of marine wildlife to vessel traffic was predicted to not be significant and, providing mitigation measures are employed, should not lead to any residual effects (Golder, 2014). Of greatest interest in the TK study was the distance vessels remained from Marble Island, this being an important area for whales, seals, marine birds, and, on occasion, walruses.

Agnico Eagle requires ships to be mindful of marine areas having a high density of marine mammals and birds and stay within the recommended shipping route, wherever possible<sup>9</sup>. Agnico Eagle monitors ship tracks via tracking data provided by a third-party vendor. Agnico Eagle requests that ships provide their ship track data for inclusion in annual reporting.

Agnico Eagle acquires archived AIS data from a third-party vendor that aggregates AIS data from satellite and shore-based stations. These data vary in frequency based on distance from shore, location of shore-based stations, and position of satellites. In some cases, AIS position data is available on an hourly or sub-hourly basis, but in other cases, position data can be 12 hours or more between fixes, due to the scarcity of satellites over remote areas such as the Arctic. The frequency of fixes is beyond the control of Agnico Eagle, as it is often due to a "gap" in satellite availability over the location of the vessel in the Arctic at the time. Interactions and Potential Effects

Vessel discharges (e.g., bilge water, ballast water), the sight of the vessels and their movement, vessel noise, as well as accidental spills and releases have the potential to interact with and disturb marine wildlife and affect life cycle activities. Possible interactions between shipping and marine wildlife can have the following potential effects:

- Marine mammals may retreat to the water should a vessel pass too close to an island or reef where they have pulled themselves out of the water;
- The foraging of marine birds and mammals may be interrupted when vessels approach and pass them in the shipping route;

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<sup>9</sup> Frobisher Bay and Button Islands key marine habitat sites overlap with the proposed shipping route at their southern and northern boundaries, respectively. This overlap is unavoidable as these two sites almost completely cover the entrance to Hudson Strait from the Atlantic Ocean (see Volume 8 for more details).

- The improper treatment and release of ballast water, grey water, and bilge water could alter the water quality;
- Marine mammal mortalities or injuries may result from collisions with the ship;
- Marine bird mortalities or injuries may result from collisions with the ship; and
- Fuel and/or oil spills could result in mortalities and, for marine birds, could lead to the loss of foraging and brood rearing habitat. A Spill Risk Assessment is provided in Appendix B.

#### 4.1 Mitigation Measures

As part of shipping companies' standard operating procedures, ship crews monitor the shipping route for marine mammals from the Hudson Strait to Rankin Inlet. In addition, a vessel-based Marine Mammal and Seabird Observer (MMSO) program has been implemented during all routine shipping activities in the Regional Study Area (RSA). Protocol for the MMSO program is provided in the Marine Environmental Management Plan (MEMP) in Appendix C. The MEMP is based upon the most current marine mammal and seabird baseline information available for the area impacted by shipping for the Meliadine Mine, as documented in the revised marine baseline report (Appendix D). The ship's Master will be notified if there is a concern of the ship striking a marine mammal. Ship personnel will make a decision if actions are required to avoid a possible collision. This may include, if safe to do so, slowing the ship until the animal has travelled clear of the ship's course. Subject to safe navigation and emergency response, ship personnel shall take every precaution to avoid disturbance, harassment, injury or mortality of marine wildlife by implementation of the following mitigation measures:

- Adherence to monitoring requirements as outlined in the vessel-based MMSO program (Appendix C);
- Ships will, when possible, maintain a straight course and constant speed, and avoid erratic behaviour;
- Use a routing south of Coats Island as the primary shipping route;
- Marine mammals will be given right of way as safe navigation allows. Under no circumstances, other than in the case of an emergency, will ships approach within 300 m of a walrus or polar bear observed on sea ice;
- Ships will remain at least 2 km from Marble Island to avoid disturbing seals, walrus and marine birds that might be in the vicinity. This would significantly reduce interactions between marine wildlife and vessels, and also reduce the noise in near-shore areas;
- Ships will watch for marine mammals and avoid them as possible. If marine mammals are encountered, and remain in the area, effort will be made to avoid them by maintaining a 500 m buffer zone;
- Ships will maintain a minimum distance of 500 m from marine mammals engaged in feeding activities;
- Ships will avoid accelerating within 500 m of a marine mammals;

- If it is not possible for the ship to move away from or detour around a stationary marine mammal or group of marine mammals, the ship will reduce its speed and wait until the animal(s) move to the side and remain at least 500 m from the ship prior to resuming speed;
- When marine mammals appear to be trapped or disturbed by ship movements, the ship will implement appropriate measures to mitigate disturbance, including stoppage of movement until the marine mammal has moved away from the immediate area;
- The ship will not be operated in such a way as to separate an individual member(s) of a group of marine mammals from other members of the group. When weather conditions require, such as when visibility decreases, the ship will adjust its speed accordingly to avoid the likelihood of the ship striking an animal;
- Subject to ship and human safety considerations, the following mitigation techniques will be implemented to avoid impacts to migratory birds nests in low lying shoreline habitats:
  - Tug-barge or shipping vessels will travel at a slow speed (2 knots or less) when transiting through the near shore islands and reefs to reduce wake;
  - Tug-barge or shipping vessels would only travel through the near shore islands and reefs when there is good visibility or adjust their speed according to the conditions;
- Implementation of monitoring and reporting procedures for ship-bird collisions. Any incidents of bird mortalities associated with near-shore lighting and infrastructure, intertidal construction activities, and ship operations are to be recorded and reported to Environment Canada (Canadian Wildlife Services) as outlined in Appendix C;
- Ballast water will only be released as allowed under the relevant regulations and if there is no marine wildlife in the area; and
- Bilge water, grey water and sewage will be released as allowed under the relevant regulations in areas where no marine wildlife is present and at least 50 km from Itivia Harbour.

Spills from ships in transit could affect marine wildlife coming in contact with any petroleum product spilled. In the event of a spill, the ship personnel will discourage marine wildlife from coming in contact with the spilled material. The product most likely to be spilled would be diesel fuel, which floats on the water surface and has a high rate of evaporation. These occurrences are expected to be rare and the activation of the SOPEP in the unlikely event of a spill would significantly reduce their impact. Preventive and contingency measures already in place substantially reduce the risk to marine wildlife from spills.

Adaptive management will allow mitigation measures to be modified in response to new information arising from monitoring carried out by the vessel crews and from traditional knowledge. Appendix C summarizes how and when adaptive management will be implemented during shipping activities for the Meliadine Mine.

#### **4.2 Monitoring and Reporting**

Vessels contracted by Agnico Eagle will be required to collect incidental monitoring data during their voyage and to report it to Agnico Eagle. In addition, a vessel-based MMSO program will be implemented

during routine shipping activities in the RSA. This program will be executed by trained observers stationed on-board vessel(s). A proposed protocol for this program is provided in the MEMP in Appendix C.

The MMSO program includes protocols on data collection and reporting requirements. Agnico Eagle will share the data with Inuit organizations and/or government agencies for their information. If effects monitoring identifies potential for effects on marine mammal populations along the shipping route, Agnico Eagle will provide updates and identify adaptive management measures in consultation with the Kivalliq Inuit Association and the Hunters and Trappers Organizations of the Kivalliq communities. Agnico Eagle will continue to report the observations annually to the Nunavut Impact Review Board (NIRB).

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**SECTION 5 • SAFETY OF PERSONS USING SMALL BOATS IN THE SHIPPING ROUTE**

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The most likely areas where interactions may occur between vessels are:

1. Melvin Bay, particularly in the access passage;
2. Where the ship is transiting through the near shore islands and reefs; and
3. The area between Marble Island and the near shore islands.

Subject to ship and human safety considerations, mitigation measures to safeguard the safety of those in small boats will include the following:

- Agnico Eagle will consult with the community members mooring or beaching their boats in Melvin Bay on the shipping activities that can be expected over the ice free shipping season. Protocols will be developed to minimize the interaction between tug-barge or ship and small boats;
- Tugs-barges and ships will travel at a slow speed (2 knots or less) when transiting through the near shore islands and reefs to reduce the wake and not compromise the safety of people travelling in small boats along the shipping route;
- Tugs-barges or ships would only travel through the near shore islands and reefs when there is good visibility or adjust their speed according to the conditions. This would allow the ship and the small boats to be in visual contact;
- Tugs-barges or ships will restrict themselves to the recommended shipping route thereby not surprising any small boat travelling outside the shipping route;
- The ship will sound its horn if a small boat seems unaware of its presence.

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**SECTION 6 • IDENTIFIABLE THIRD PARTY LIABILITIES**

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Agnico Eagle and its shipping contractors will carry third party liability insurance. Identifiable third party liabilities related to shipping may include (but are not limited to):

- Hamlet of Rankin Inlet, in the event of spill in Melvin Bay that adversely impacts the marine environment;
- Hunters and trappers, should a ship or tanker run aground and adversely impact the marine environment by spilling fuel or other chemicals into the marine environment;
- Hunters and trappers, should a vessel collide with a large marine mammal such as a whale along a shipping route; and,
- Small boat owners, should a ship or tanker collide with a small boat in the shipping route.

Mitigations for possible third party liabilities are identified in Section 11 of this Plan (Hazard Identification Analysis of Marine Routes).

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**SECTION 7 • ON BOARD WASTE MANAGEMENT**

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The six (6) annexes of MARPOL promote the elimination of deliberate, negligent or accidental discharge of ship-source pollutants into the marine environment (see also Transport Canada 2009). The list of harmful ship-source discharges includes: oil, noxious liquid substances and dangerous chemicals, sewage, garbage and air pollution. Canadian laws and regulations mirror the MARPOL annexes and conventions.

Agnico Eagle will contract vessels that meet applicable environmental requirements in addition to being reliable and having a superior safety record.

**7.1 Sewage**

Vessels are to have an approved sewage treatment plant meeting Canadian standards. Holding tanks with the capacity for all grey and treated sewage while in port are expected to be part of the ship's infrastructure. Agnico Eagle will advise ships that disposal of waste water into the environment must follow relevant regulations and is to be avoided within 50 km of Rankin Inlet.

**7.2 Solid Waste**

Solid waste materials are to be incinerated on board. Modern incinerators operating at very high combustion temperatures are expected on all vessels. These will be capable of incinerating food and other domestic waste, residual oil separated from bilge water, waste oil, and sludge. Ash from incineration will be taken for treatment, recycling, and/or disposal in a certified waste management facility.

The design and operation of shipboard incinerators in Canada are specified under the IMO Marine Environmental Pollution Committee 76 (40), Annex V. Standard specifications for shipboard incinerators allow for the incineration of solid wastes approximating in composition to household waste and liquid wastes arising from the operation of the ship, e.g., domestic waste, cargo-associated waste, maintenance waste, operational waste, cargo residues, and fishing gear. Operating temperatures are similar to those for the incinerators at the Meliadine site, and flue gases are cooled rapidly to limit the *in vivo* formation of dioxins.

Tugs will remain on site for the duration of the shipping season. Their waste will be incinerated and the ash will be shipped to a certified waste management facility for treatment, recycling, and/or disposal.

Hazardous waste will be shipped to a certified waste management facility for treatment, recycling, and/or disposal.

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**SECTION 8 • BALLAST WATER MANAGEMENT**

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Ballast water is essential to control trim, list, draught, stability, and/or stresses on a vessel. The *Ballast Water Regulations* came into force on June 3, 2021, and are intended to outline proper management and treatment of ballast water to minimize the probability of introduction of harmful aquatic organisms and pathogens from vessels' ballast water while also protecting the safety of vessels. The Regulations apply to the management of any quantity of ballast water that may be released from a vessel.

The Regulations repeal the *Ballast Water Control and Management Regulations* and:

- (a) Apply to Canadian vessels everywhere and all vessels in waters under Canadian jurisdiction;
- (b) Impose requirements based on the vessel's length, its ballast water capacity, its date of construction, and its area of operation; and
- (c) Maintain foundational requirements from the former regulations that can still be applied to the amended regime, such as reporting requirements.

Vessels to which the Regulations apply are divided into four groups:

1. **International vessels:** Vessels that operate internationally will be required to be in compliance with the International Convention for the Control and Management of Ship's Ballast Water and Sediments (Convention) regime, which requires that vessels:

- Have on board and implement an approved vessel-specific Ballast Water Management Plan (BWMP);
- Be surveyed and carry a Ballast Water Management Certificate;
- Meet a performance standard that limits the number of organisms capable of reproducing in order to reduce the risk of aquatic species invasions (vessels are expected to use a Ballast Water Management System (BWMS) to meet the performance standard);
- Record ballast water operations and maintain a Ballast Water Record Book on board; and
- Be subject to inspections in ports or offshore terminals to ensure compliance.

These vessels will also be subject to some former provisions that remain relevant and are not part of the Convention regime:

- To flush otherwise-empty ballast tanks with open ocean water in order to reduce the risk posed by any residual ballast water and sediments;
- To exchange and flush ballast tanks in addition to meeting the performance standard when traveling to Canadian fresh waters (from outside of waters under Canadian jurisdiction, the Great Lakes and the high seas);
- To conduct any exchange or flushing operation in waters at least 2,000 metres deep, whenever possible; and

- to report on the provenance and management of ballast water released in Canada.
- The Regulations will require all vessels on international voyage to comply with the Convention's requirements. The Convention requires vessels traveling internationally and built on or after September 8, 2017 to meet the performance standard when the vessel is launched. Conversely, as per the Convention, vessels built before September 8, 2017 will be required to meet the performance standard using a phased-in approach from 2019 to 2024.
2. **Domestic and Great Lakes vessels:** These vessels include those that operate exclusively in waters under Canadian jurisdiction, as well as those that operate there and at United States Great Lakes ports and/or on the high seas. To address the spread of species within Canada, domestic and Great Lakes vessels will be required to comply with the same applicable requirements as vessels in Group 1 above. However, those vessels constructed in or after 2009 will have until September 8, 2024 to come into compliance with the performance standard, while those vessels constructed before 2009 will have until September 8, 2030 to come into compliance.
  3. **Non-party vessels (e.g., United States vessels)** that transit through Canadian waters of the Great Lakes Basin without loading or unloading ballast water (other than ballast water necessary for the purpose of ensuring the safety of the vessel on a voyage between non-Canadian ports) will be exempt from the Regulations.

Vessels of Non-parties: The Convention requires Canada to apply the requirements of the Convention to vessels of non-parties to ensure that no favourable treatment is given to such vessels. The Convention's requirements include the development of approved ballast water management plans for meeting the Convention's performance standard wherever ballast water is discharged - even if the ballast is ultimately discharged into waters of non-parties. The Regulations therefore require that vessels that load or discharge ballast water in Canada hold and keep on board a document of compliance issued by, or on behalf of, their flag state that certifies that the vessel meets the requirements of the Convention.

4. **Vessels subject to the equivalent compliance regime:** The Convention allows Canada to establish equivalent compliance requirements for certain international pleasure craft, and search and rescue craft that carry less than eight cubic metres of ballast water and are less than 50 metres in length. The Regulations will do so for these vessels by giving effect to the IMO guidelines for equivalent compliance. For reasons of practicality and feasibility, the Regulations will also allow vessels less than 50 metres in length, as well as non-self-propelled vessels with a gross tonnage of less than 3,000 tons, to follow the equivalent compliance regime if they operate exclusively in waters under Canadian jurisdiction, or in those waters and on the high seas. Equivalent compliance refers to a set of methods and best practices approved by the IMO that allows vessel owners to determine how best to manage ballast water on board their vessel, as installing and operating BWMS and meeting all of the requirements under the Regulations is not always feasible.

Agnico Eagle expects to hire shipping companies that use domestic vessels active in the coastal trade and operate almost exclusively in waters under Canadian jurisdiction. However, it is the shipping company's responsibility to ensure that all relevant requirements within the *Ballast Water Regulations* are adhered to. Agnico Eagle will require contracted vessels to provide an approved copy of their BWMP.

### 8.1 Ballast Water Exchange

The exchange of ballast water in deep ocean areas or open seas offers a means of limiting the probability of harmful aquatic organisms and pathogens being transferred to the marine environment via vessel ballast water. If it is necessary to take on and discharge ballast water in the same port to facilitate safe cargo operations, care will be taken to avoid unnecessary discharge of ballast water that has been taken up in another port as this could introduce harmful aquatic organisms.

The *Ballast Water Regulations* implement the Ballast Water Management Convention (BWMC) in Canada, an international treaty adopted by the IMO, which entered into force on September 8, 2017.

The D-1 and D-2 standards are part of the [https://en.wikipedia.org/wiki/Ballast\\_Water\\_Management\\_Convention](https://en.wikipedia.org/wiki/Ballast_Water_Management_Convention) BWMC and aim to address the control and management of ballast water:

- **D-1 Standard:** The D-1 standard of the BWMC relates to ballast water exchange. It specifies the requirements for conducting ballast water exchange, also known as "open-ocean exchange." Ballast water exchange involves replacing ballast water taken on in one location with water from the open ocean, typically beyond 200 nautical miles from the nearest land and in waters of sufficient depth. The purpose of D-1 is to minimize the number of living organisms carried in ballast water.
- **D-2 Standard:** The D-2 standard of the BWMC sets the requirements for ballast water treatment systems. It specifies the performance criteria for such systems to ensure that they effectively treat ballast water to remove or kill organisms and pathogens. Ballast water treatment systems must meet the criteria outlined in the D-2 standard to be considered compliant with the Convention.

All vessels must conform to at least the D-1 (exchange) standard. The requirements for compliance with the D2 standard of ballast water treatment systems were phased in over a period of time based on the ship's [International Oil Pollution Prevention](#) (IOPP) renewal survey schedule. The specific deadlines for compliance with the D-2 standard depend on the ship's construction date:

- **For new ships:** New ships constructed on or after September 8, 2017, are required to comply with the D-2 standard at the time of delivery.
- **For existing ships:** Existing ships (those constructed before September 8, 2017) are required to comply with the D-2 standard at the time of their first IOPP renewal survey that occurs after

September 8, 2019. This means that existing ships needed to install and operate ballast water treatment systems by the time of their first IOPP renewal survey after the specified date.

The specific compliance deadlines may vary depending on the ship's individual circumstances and survey schedule, but the goal of the BWMC is to ensure that all ships eventually meet the D-2 standard to minimize the environmental impact of ballast water discharge. Shipowners and operators are encouraged to consult with relevant authorities and organizations to understand and meet the compliance requirements of the BWMC.

Vessels take on ballast water in segregated chambers for the main purpose of stabilizing the vessels by adding the weight of the water and maintaining a specified draught. Vessels laden with dry cargo or fuel will take on less ballast water than empty vessels. As all ships on the inward voyage to Chesterfield Inlet will be laden, they will have a minimum of ballast water. However, on the outward journey, these vessels will take on ballast water.

The vessels servicing Agnico Eagle will in all likelihood not voyage more than 200 nautical miles from shore and will not exchange ballast water outside waters of Canadian jurisdiction. It remains the responsibility of the shipping companies to ensure that ballast water exchange standards for all vessels meet the provisions of the Convention standards and the Ballast Water Regulations no later than September 2024 or September 2030, depending on when they were built.

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**SECTION 9 • SAFETY**

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Safety is a top priority for Agnico Eagle. It begins with all personnel (e.g., Agnico Eagle, contract employees, and contractors) wearing the appropriate personal protection equipment suitable for the task at hand and for the weather conditions at the time. Secondly, personnel must understand the hazards associated with the task, the safe procedures in carrying it out, and how not to place oneself in harm's way. Accident prevention will be supported by a proactive program to identify and correct potential hazards before an accident occurs.

Agnico Eagle or contract supervisors will ensure that the interactions between ship and shore are carried out with the safety and the health of the employees first in mind.

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**SECTION 10 • HAZARD IDENTIFICATION ANALYSIS OF MARINE ROUTES**

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Hazard, likelihood, severity and risk are defined as follows:

- **Hazard:** Anything that has the potential to cause harm.
- **Likelihood:** The probability/chance of harm occurring as a result of exposure to a hazard.
- **Severity:** The level of harm that may occur as a result of exposure to or contact with a hazard.
- **Risk:** The likelihood of harm occurring combined with the potential severity to produce a level of risk or risk rating.

No major hazards were identified along the shipping and tug-barge routes under normal conditions. Electronic charts combined with electronic navigation aids for the shipping routes ensure the vessel remains on course where bathymetry and physical hazards are known.

Out of the ordinary events have been identified that could increase the level of hazard and necessitate associated mitigation measures:

- Mechanical failure occurring on the ship or tug thereby placing it or other vessels and infrastructure in jeopardy in the shipping route;
- Tug-barge or ship running aground due to a navigational error or mechanical failure;
- Loss or damage to sea cans in heavy seas;
- Barge tow line breaking in heavy seas;
- Collision of tug-barge or ship carrying dry cargo and fuel to Itivia Harbour through the access passage;
- Tug-barge or ship sinking upon hitting ice; and
- Tug-barge or ship colliding with a small boat.

The access passage deserves special attention as:

- Dry cargo for Agnico Eagle and the hamlet and fuel for Agnico Eagle could be unloaded at the same time; and
- The access passage is 150 m wide at its narrowest point and, although two-way traffic is theoretically possible, it raises the risk of collisions and groundings even in calm conditions. To reduce the risk, it is best that a single tug-barge or ship be in the access passage at any one time.

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**SECTION 11 • RISK ANALYSIS OF MARINE ROUTES**

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All ships, tugs and tankers use electronic charts and other electronic navigational aids to provide safety in transit, reduce the risk of accidents, and remain within the recommended shipping route presently in use for the annual sea lift to Rankin Inlet and other Kivalliq communities. For an extra measure of safety, weather warnings are updated regularly. Also, shipping companies contracted by Agnico Eagle commonly sail in Hudson Bay and to Rankin Inlet and are aware of its marine hazards.

The potential severity of shipping hazards cannot be changed in most circumstances, what can be reduced is their likelihood. This is possible through the application of mitigation measures. And the level of risk can be defined as the likelihood of harm posed by a hazard combined with its potential severity. The objective is to reduce the risk as low as practically possible through the use of mitigation measures. Residual risk is the amount of risk that remains after mitigation measures have been applied. And those having the highest potential residual risk would be aggressively managed.

The following mitigation/safety measures will be implemented subject to ship and human safety considerations:

- Where available, electronic navigation aids be used in all instances;
- Ship speeds in open water remain less than 14 knots in the absence of marine mammals, and once within the barrier islands and reefs near Rankin Inlet, 2 knots or less;
- Shipping is only carried out during the ice free season. Should ice be encountered, the vessel will either sail around it at a reduced speed or proceed slowly through the ice;
- Tug-barge or ship will remain within recommended shipping routes ;
- Fuel tankers and the fuel tanker barges will be double hulled;
- Tug-barge operations will proceed when there is good visibility from the anchor point of the ships to the barge at Itivia Harbour and/or adjust their speed according to the conditions;
- Traffic through the access passage will be coordinated to avoid conflicts and ensure safety. Communication between tugs will coordinate movement through the access passage;
- Agnico Eagle will provide emergency response equipment and materials as outlined in the OPEP if necessary. Tug or ship will also provide their own emergency response equipment.
- Crews will follow standard operating procedures and adherence to these will be monitored; and
- Tug-barge or ship crews are to be trained for responses to hazards that can normally be expected in northern waters.
- In the event of bad weather, communication will be held with the vessel for the decision to proceed with the offloading (of cargo/fuel). The offloading or holding of the materials on the ship is at the discretion of the contracted shipping companies in the event of bad weather.

Appendix D outlines the methodology used in the risk analysis of the transportation routes and how various mitigation measures reduced the risk level.

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**SECTION 12 • SOCIO-ECONOMIC IMPACT OF SHIPPING**

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Shipping may impact socio-economic activities in Rankin Inlet. Itivia Harbour is jointly used by the Hamlet of Rankin Inlet and Agnico Eagle during the ice free shipping season. Mitigation measures will be employed to minimize socio-economic effects:

- Communication between tugs will coordinate movement through the access passage and use of the Designated Hamlet Landing Beach during lightering operations to avoid conflicts and ensure safety;
- Agnico Eagle has a separate cargo storage area from the community.

Positive socio-economic effects will arise from the increased number of dry cargo and fuel tankers coming to the community. The crews of these ships will in all likelihood come ashore when the boat is anchored and contribute to the local economy through the:

- Use of restaurants, hotels and stores in the community;
- Purchase of local Inuit art; and
- Guided tours to the barrens for fishing and wildlife experiences.

Agnico Eagle does not believe that shipping activities related to the Meliadine Mine will result in an increased demand on local public service providers (i.e., fire, police, ambulance, medical, and maintenance) in Rankin Inlet. In most circumstances, emergency response will be undertaken by Agnico Eagle personnel and/or the ship's crew. Agnico Eagle personnel and the Master of the ship will be responsible for security matters related to the shipping-related activities.

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**SECTION 13 • PUBLIC AND MEDIA COMMUNICATIONS**

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When an environmental emergency occurs, the public will be provided with timely and accurate information as to the nature of the incident, the steps being taken to correct the problem, and, if necessary, what citizens should do to protect themselves. This information is intended to protect the overall community well being, to ensure cooperation from interested parties, and to reduce the spread of concern or alarm through the dissemination of inaccurate information.

A coordinated response and media communications is preferred in an emergency situation. However each stakeholder involved in an emergency event may provide its own media communications and designated spokespersons. The lead government Agency is expected to act as the official spokesperson for the response, with support provided by Agnico Eagle and other stakeholders as required.

Transport Canada guidelines will be followed in the event of an emergency situation to ensure proper authorities are informed without delay so that appropriate action may be taken when:

- Any incident occurs involving the loss, or likely loss, of dangerous goods into the marine environment; or
- Any incident occurs giving rise to pollution or threat of pollution to the marine environment; or
- Any oil pollution incident occurs involving the loading or unloading of oil to or from tanker-to-tanker and from tanker to the OHF.

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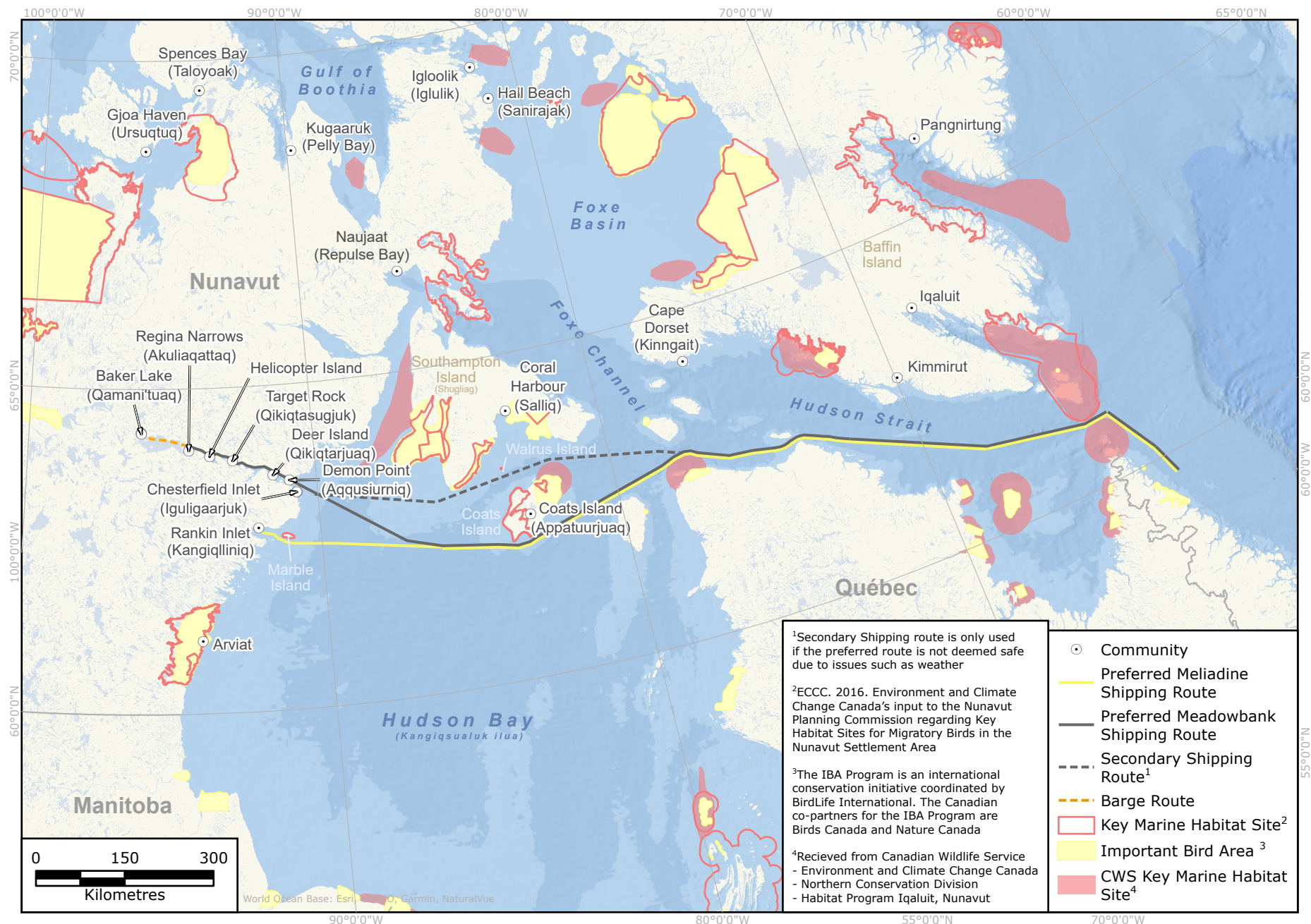
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**APPENDIX A • MARINE SHIPPING ROUTE**

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**FIGURE 1.1-2 MARINE MAMMAL AND SEABIRD OBSERVER PROGRAM STUDY AREA ALONG SHIPPING ROUTE TO MELIADINE MINE AND MEADOWBANK COMPLEX**



**APPENDIX B • SPILL RISK ASSESSMENT**

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**March 10, 2016**

## **SPILL RISK ASSESSMENT**

# **Appendix E**

**Submitted to:**

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**REPORT**



**Report Number: Doc 552-1535029-R-RevA**

**Distribution:**

1 copy - Agnico Eagle Mines Limited  
2 copies - Golder Associates Ltd.





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## SPILL RISK ASSESSMENT

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### ATTACHMENT A

ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

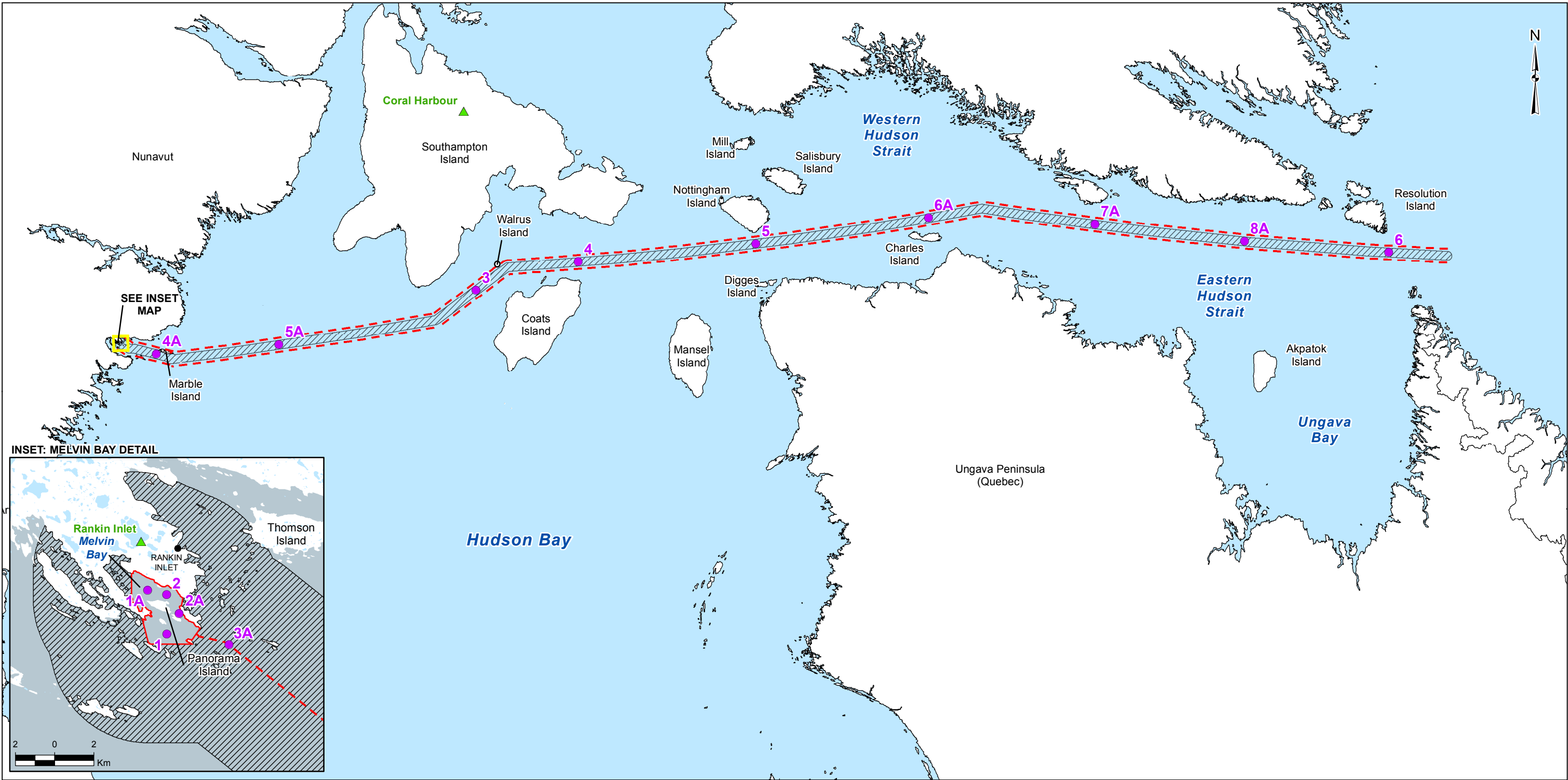


### 1.0 INTRODUCTION

This report presents a desktop level assessment of potential diesel fuel spill risk in the marine environment related to the Meliadine Gold Project (Project). The effects of fuel spills on sensitive biological receptors such as marine mammals and marine birds are discussed in Section 8.3.6.5 of the Final Environmental Impact Statement (FEIS) for the Meliadine Project. Golder Associates Inc. (Golder) has applied a modified version of the risk assessment strategy presented in ITOPF-TIP16 Contingency Planning for Marine Oil Spills (ITOPF 2011) based on existing Project information and available biophysical data in the Project area. This report includes an overview of oil spills in Canadian waters and potential open-water P50 diesel spills near Melvin Bay (ship-to-shore and ship-to-ship fuel transfer areas near Rankin Inlet) and along the primary deep-draught shipping route used by Project vessels during Project construction and operations phases (Figure E-1). The behavior of a diesel fuel spill in the marine environment was assessed at 14 different hypothetical spill locations in the Project area, considering aspects of evaporation, dispersion, spreading and potential distance traveled from the spill location. Five locations near Melvin Bay were considered in the assessment as these corresponded with ship-to-shore and ship-to-ship fuel transfer areas where a higher potential for fuel spills would occur (Figure E-1). Nine locations along the shipping route were also considered in the assessment as these corresponded with navigation zones in close proximity to islands or known sensitive/important coastal areas for marine mammals and/or marine birds; including Walrus Island, Coats Island, Ungava Peninsula, and Eastern Hudson Strait (Figure E-1). This assessment considered a low-probability, large spill scenario of 2 Million Litres (ML) (2,000 cubic metres [ $\text{m}^3$ ]) of P50 diesel and a worst case spill scenario of 20 ML (20,000  $\text{m}^3$ ) of P50 diesel released at sites in Melvin Bay and along the shipping route. An additional spill scenario of a 100,000 litres (L) (100 metres  $\text{m}^3$ ) spill was also considered at the ship-to-ship and ship-to-shore fuel transfer sites near Melvin Bay, representing smaller spills that could occur during fuel transfer activities.

The Project is primarily land-based with operations in the marine environment limited to six fuel tanker transits to Rankin Inlet from eastern North America during the open-water season (approximately August to October), and subsequent transfer of this fuel to shore using established fuel transfer locations near Melvin Bay. There were no Project-specific meteorological or oceanographic data collected as part of the baseline assessment for the Project; therefore, this assessment is based solely on information from existing literature and available third party data. Because of the limited marine operations planned for the Project, resulting in an overall low probability of a spill, this analysis was conducted with a simple fuel weathering model that does not include detailed hydrodynamic modelling.

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECTS\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000MXD\Report\1535029\_Figure\_E-1\_Spill\_Risk\_Assessment.mxd



LEGEND

- MARINE REGIONAL STUDY AREA (MARINE RSA)
- MARINE LOCAL STUDY AREA (MARINE LSA)
- WATERBODY
- SHIPPING ROUTE (APPROXIMATE)
- WIND STATION
- HYPOTHETICAL FUEL SPILL RELEASE LOCATION


REFERENCE

CANVEC DATA OBTAINED FROM © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.  
NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009




PROJECT

AGNICO EAGLE

TITLE

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

SPILL RISK ASSESSMENT  
FOR FOURTEEN LOCATIONS

Golder Associates

PROJECT NO.	1535029	FILE No.	
DESIGN	GC	06 Jan. 2016	SCALE AS SHOWN
GIS	CDB	06 Jan. 2016	REV. A
CHECK			
REVIEW			

FIGURE E-1



### 2.0 OIL SPILLS IN CANADIAN WATERS

No information is available in the public domain/published literature related to existing fuel spill rates (e.g., frequency of spills) in the Hudson Bay region, although broader-scale information is available. The Arctic Monitoring and Assessment Programme (AMAP 2010) conducted an assessment of the effects of oil and gas activities in the Canadian Arctic to quantify the potential impacts from oil spills to the Arctic ecosystem and human health. Spills in the Arctic are considered rare and are typically associated with tanker traffic, with the most common location of spills occurring near ports (ITOPF 2011). From 1972 to 2003, a total of 1,226 oil spills were reported in the Canadian Arctic region; equivalent to a total volume of 3.3 ML (3,300 m<sup>3</sup>) and a spill frequency of 2.5 spills per year. Of this total, 75 spills consisted of diesel fuel, equivalent to 334,000 L (334 m<sup>3</sup>) and a frequency of one spill every 0.4 years (AMAP 2010).

Transport Canada commissioned WSP (formerly GENIVAR) to prepare a risk assessment for marine ship-based spills in Canadian waters north of the 60° North parallel (WSP 2014a). The study found the probability of oil spills in the Canadian Arctic is significantly lower than in the rest of Canada primarily due to the lower vessel traffic and volumes of oil transported. For the years 2002 to 2011, the volume of refined cargo products transported in the Arctic represented 0.18% of total volumes in Canada. The risk assessment found there to be a very low risk across the Canadian Arctic for a ship-source oil spill, however, the risk is slightly higher for the Hudson Strait and the coast of Labrador, mostly due to higher volumes of oil transported and traffic in these areas. Estimates of fuel spill frequency rates in the Arctic ranged from a return period of 285 years (i.e., one spill approximately every 285 years) for small spills (10 to 99.9 m<sup>3</sup>) to 920 years for medium spills (100 to 999.9 m<sup>3</sup>) and 92,000 years for large spills (1,000 to 9999.9 m<sup>3</sup>) (WSP 2014a). According to the study, the frequency estimate for spills larger than 10,000 m<sup>3</sup> (10 ML) is zero for fuel oil and refined cargo products due to the lack of historical spills in this size range.

The trends of spill frequency have decreased over time due to improved technology, navigation, construction of vessels, and more stringent regulations (AMAP 2010; Anderson et al. 2012; WSP 2014b). Marine transportation in the Arctic is limited due to seasonal presence of ice. The lower frequency of ship transits in the Arctic region will downward bias spill rates calculated from Arctic data when compared to global statistics of spill frequency. However, as climate change causes a decrease in ice cover and the potential for transportation and other industrial activities in the Arctic increases, potential for spills may increase as well.

A study titled "Probability of Oil Spills from Tankers in Canadian Waters" by SL Ross Environmental Research Ltd. (SL Ross) predicts the frequency of oil spills from tankers in various areas of Canada (SL Ross 1999). The expected spill rate per year is calculated by multiplying the tonnage of oil loaded and unloaded at Canadian ports by spill frequencies derived from historical statistics. The expected spill rates for large (> 159,000 L) medium (8,000 to 159,000 L), and small (< 8,000 L) spills of product oil is 2.5, 12.3, and 36 spills per 10<sup>8</sup> ML loaded or unloaded per year, respectively.



### 3.0 MARINE TRANSPORT OF DIESEL FUEL FOR THE MELIADINE PROJECT

The FEIS for the Meliadine Project states that approximately 122 ML (122,000 m<sup>3</sup>) of P50 diesel fuel will be delivered annually during operations. P50 is an Arctic diesel fuel with a lower temperature pour point than other diesel fuels. Based on the total volume of diesel fuel that will be transported throughout the life of the Project and spill rates reported by SL Ross (1999), the overall likelihood of a fuel spill for the Project is once every 36 years for small spills and once every 526 years for large spills. The approximate Project life that includes construction, operations, and closure is 18 years.

During construction and operations, approximately six large tankers will arrive to deliver P50 diesel fuel throughout the open-water shipping season. Each vessel trip will deliver approximately 20 ML (20,000 m<sup>3</sup>) of P50 diesel fuel. The large tankers will anchor in deeper waters outside of Melvin Bay upon arrival in Rankin Inlet (Figure E-1). Large tanker to small tanker transfer of diesel fuel will occur at the large freighter anchor location. The carrying capacity of the small tanker will be either 7,300 m<sup>3</sup> or 10,500 m<sup>3</sup>, depending on which vessel is used. Therefore, each of the six large tanker deliveries will take two to three trips to offload all of the fuel. The small tankers will anchor opposite Itivia and a floating pipeline of some 300 to 500 metres (m) will connect to a shore-based pipeline for transfer of fuel to the Project tank farm located near Itivia in Rankin Inlet. Fuel will be transferred through the pipeline at approximately 400 cubic metres per hour (m<sup>3</sup>/h) for about 18 to 26 hours (h), depending on the carrying capacity of the small tanker. Agnico Eagle Mines Limited (AEM) has prepared an Oil Pollution Emergency Plan (SD 8-2) that details necessary actions to be implemented to reduce or minimize the loss of diesel fuel. Communication between the small tanker and the shore will be maintained throughout the transfer to safeguard the transfer of the diesel and to avoid overfilling of the tanks.

### 4.0 WEATHERING PROCESSES OF OIL SPILLS

The fate, toxic effect and weathering of an oil spill depends on the specific gravity, pour point, viscosity, chemical composition of refined and non-refined components, volume released, area of spreading, and the environmental conditions involved (ITOPF 2002). Environmental conditions include wind speed and direction, water depth, wave energy, solar radiation, current speed and direction, water temperature and distance to land. The weathering processes include dispersion, evaporation, spreading, adsorption to sediments, biodegradation, dissolution, emulsification, and photo oxidation (Figure E-2). Dispersion, evaporation, and spreading are the primary processes for determining fate and transport of diesel fuel, which is the primary fuel type being used for the Project. Oil dispersion is largely dependent upon the type of oil and the sea state, dispersing most rapidly with low viscosity oils, in the presence of breaking waves (ITOPF 2002). The rate of evaporation depends on ambient temperatures, wind speeds, and type of fuel. Spreading of the slick depends to a great extent on the viscosity of oil, the volume and the wind stress on the slick and surface water (Lehr et al 2002).

Diesel fuel has a low viscosity and will weather rapidly when spilled into the marine environment (NOAA 2006). With a lower density than water, diesel fuel will tend to stay on the water surface and be readily dispersed by wave action. Over 90% of a small spill of diesel in the marine environment is either evaporated or naturally dispersed over a time scale of several hours to days (NOAA 2006).

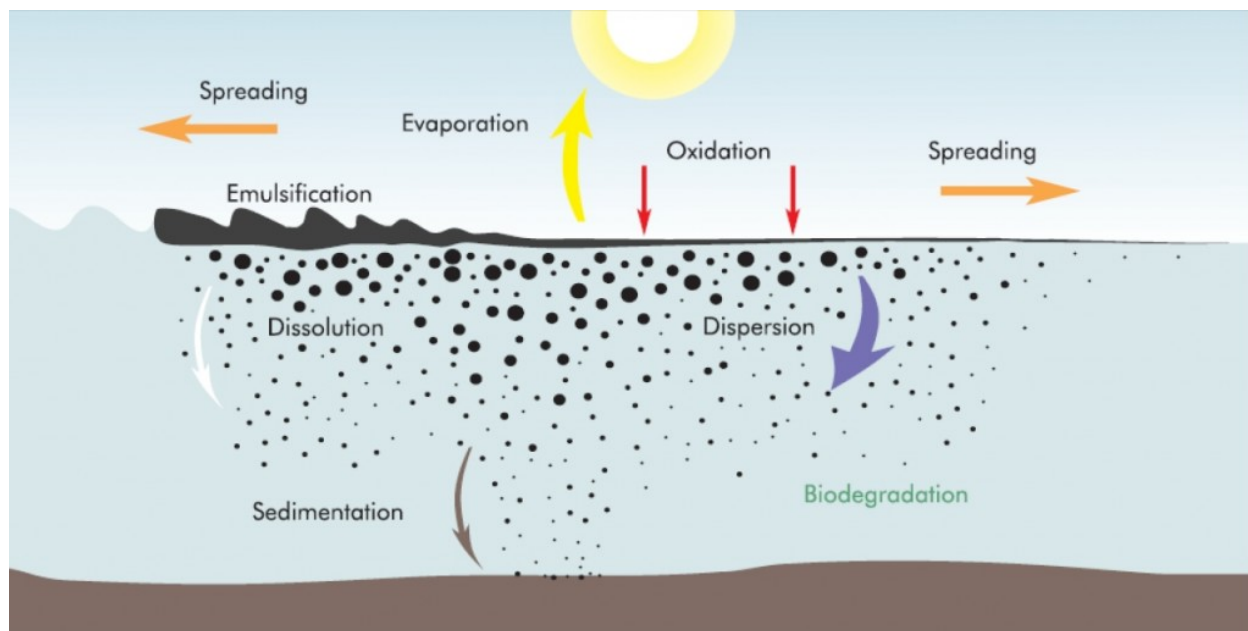


Figure E-2: Weathering Processes Action on Spilled Oil. Source: ITOPF 2002

## 5.0 OIL SPILL INTERACTION WITH SEA ICE

This section provides a summary of the potential ice conditions along the transportation route during the months of August to October and addresses potential effects of oil and fuel interactions and dispersion on ice covered waters in the event of a spill. The ADIOS model does not incorporate oil-ice interaction in its algorithms. Other models like the Oil Weathering Model (OWM) and Sea Ice-Ocean-Oilspill Modelling System (SIOMS) do, but they are still under development. The limited marine operation for the Project and the lack of data along the route limits the necessity and applicability of ice process-based models to this Project.

### 5.1 Sea Ice along the Transit Corridor

Hudson Bay is usually completely covered by ice by December or January and typically free of ice from August to October (Gagnon and Gough 2005). Sea ice in southwestern Hudson Bay typically does not breakup until well into the summer because winds and ocean currents tend to push large accumulations of ice into this region (Etkin 1991). The presence of sea ice into summer keeps waters of Hudson Bay at lower temperatures in comparison with other regions situated at similar latitudes. Hudson Bay is an enclosed bay sheltered by land with limited narrow access channels to larger ocean basins. Therefore, Hudson Bay water temperature, sea ice flows, and circulation are not strongly influenced by ice flows from other ocean basins. Instead, Hudson Bay dynamics are primarily controlled by local meteorological and micro-climate influences such as local wind and air temperature variations (Saucier and Dionne 1998; Gagnon and Gough 2005).

Ice melt starts in May and June, as an open water area develops along the northwestern shore, and a narrow coastal lead (i.e., space between ice floes, refer to Figure E-6) develops around the rest of the Bay. Open water



## SPILL RISK ASSESSMENT

starts to appear and expand around the shorelines in June and July. By the end of July, large patches of ice are limited to only the southern reaches of the Bay (CIS 2011). Figure E-3 shows that along the transportation route, the average ice break-up dates occur on July 2 for most of the route and on June 18 on the west side of Hudson Bay near Rankin Inlet.

Normal clearing of the pack ice progresses southward from the Chesterfield Inlet - Southampton Island area and westward from Eastern Hudson Bay. The melting of sea ice is a slow process which accelerates in July as air and water temperatures begin to warm with increased summer solar radiation. The ice pack in Hudson Bay typically breaks up into several large patches of ice prior to finally clearing in August (CIS 2011).

Sea ice typically begins to form along the northwestern shores of Hudson Bay in late October. Ice flows from Foxe Basin may also start to move into northeastern Hudson Bay in late fall. In November, the sea ice begins to accumulate and thicken as prevailing winds push it east and southeast toward the margins of the Bay. Finally, by December, Hudson Bay becomes covered with first-year ice, which continues to thicken into the winter months (CIS 2011).

In Hudson Strait, freeze-up starts as early as mid-October and as late as the first week of December as shown in Figure E-4, while complete clearing has occurred as early as late as July and as early as September. Sea ice in Hudson Strait and Ungava Bay is mostly formed locally but winds and currents can carry floes from Foxe Basin or Davis Strait into these areas. Freeze-up typically starts in western Hudson Strait and ice formation progresses eastward over the late fall months and cover the entire Hudson Strait by December (CIS 2011).

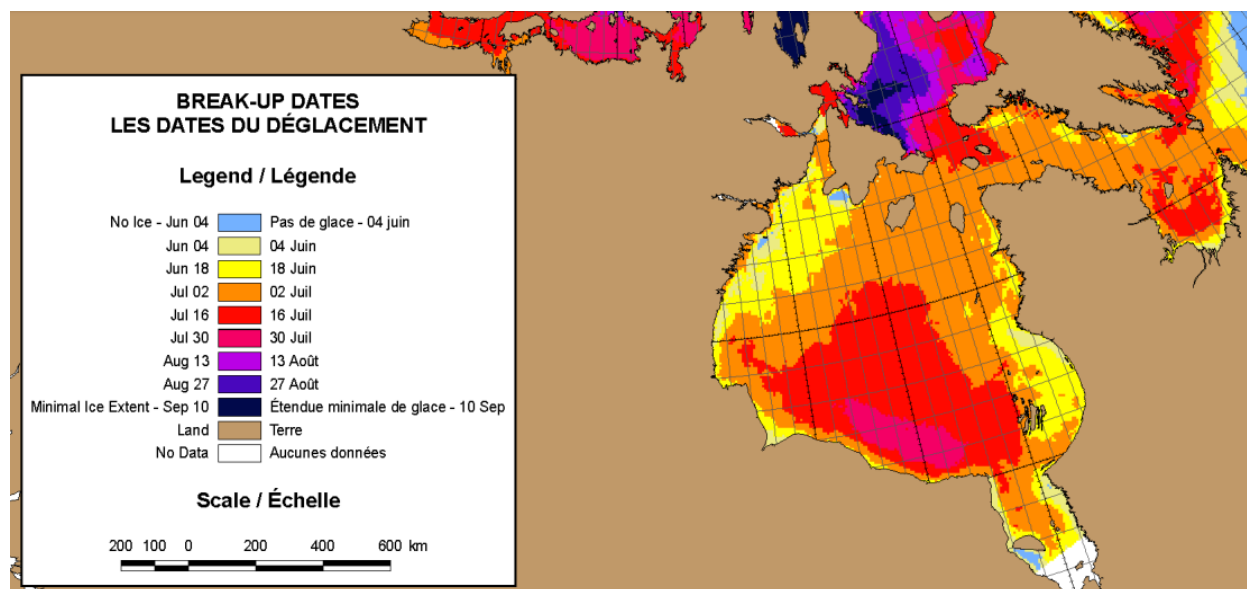


Figure E-3: Ice break-up and dates at Hudson Bay and Hudson Strait, source: CIS (2011)



## SPILL RISK ASSESSMENT

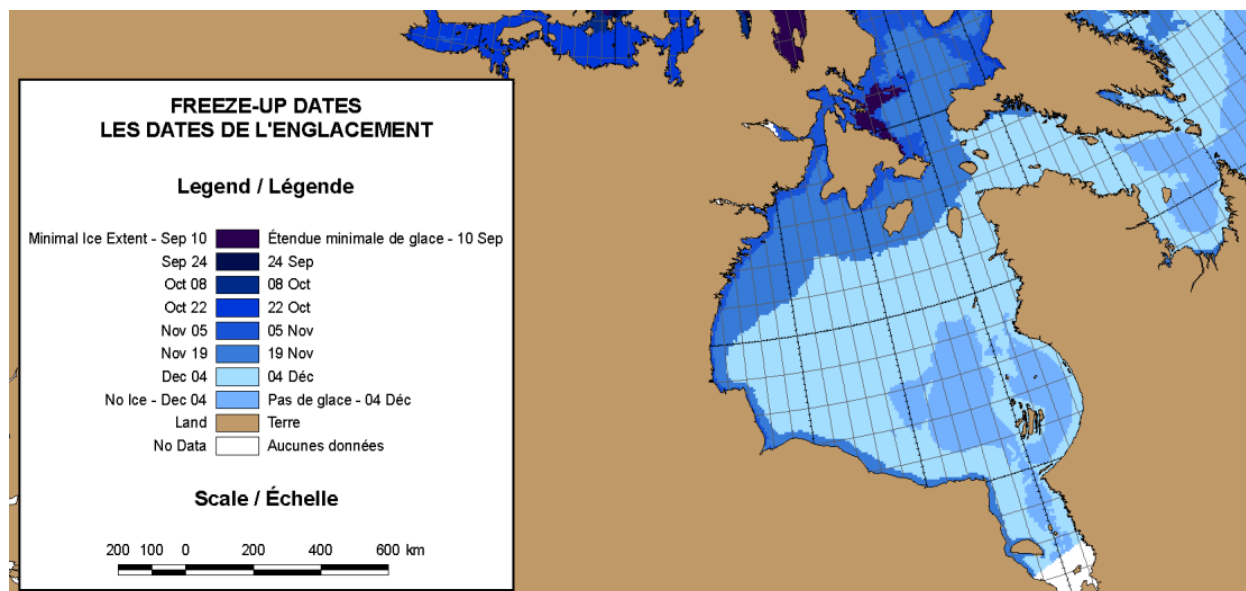


Figure E-4: Ice freeze-up dates at Hudson Bay and Hudson Strait, source: CIS (2011)

Ice-break up along the transportation route break-up occurs on June 18 in northwestern Hudson Bay in northeastern Hudson Bay as shown in Figure E-3. Therefore, early June and July are the months of greatest relevance in terms of potential oil spill interaction with sea ice.

The dates of ice freeze-up and break-up are derived from sea ice concentration data, which refers to the proportional surface area, covered by ice and is categorized over a range presented as fractional tenths (0 to 10/10). The ice break-up date represents the earliest day of the year when ice concentration reaches 5/10 or less. The ice freeze-up date represents the earliest day of the year when ice concentration reaches 5/10 or more (Gagnon and Gough 2005).

Figure E-5 presents ice concentration maps of Hudson Bay from July to November taken from the Sea Ice Climatic Atlas prepared by CIS (2011). The following observations are made from Figure E-5:

- In July (Figure E-5a), the median concentration of ice along the eastern portion of the transportation route is around 3-4/10 (open drift ice) and close pack fast ice (8-9/10) is expected on the northwest shoreline;
- The area within the route is considered ice-free for the months of August (Figure 8.2-B-4a), September (Figure E-5b) and October (Figure E-5c); and
- During November, freeze-up is expected on the northwest shoreline (4-9/10) and south shoreline of Southampton Island.

According to Dickins (2011), 1-5/10 drift ice conditions represent the greatest challenge in terms of spill containment and recovery. For ice concentrations of 6/10 and greater, spilled oil will tend to move at similar drift rates as sea ice. The intrusion of drift ice from Foxe Basin could interfere with Project vessels along the navigation route during the open water season from August to October.



## SPILL RISK ASSESSMENT

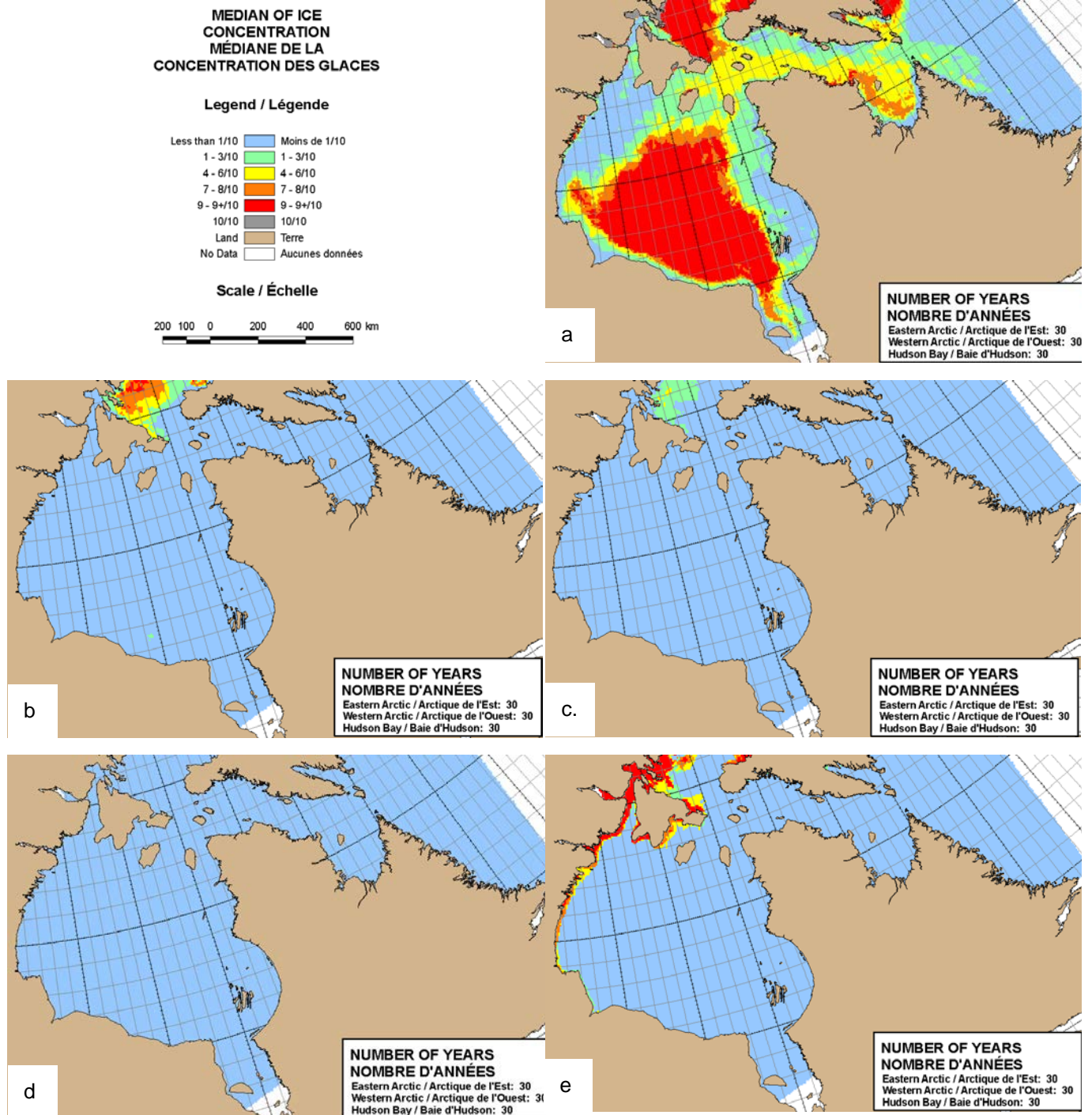


Figure E-5: Median of ice concentration in Hudson Bay and Hudson Strait during a) July, b) August, c) September, d) October and e) November, source: CIS (2011)



### 5.2 Ice Dispersion of a Potential Oil Spill

The behaviour of a spill in ice-covered waters is determined by the sea ice conditions at the time of the spill. Sea ice can be present in the seawater in multiple forms. A thorough understanding of the ice condition, ice coverage, energy conditions and the type of the spill and oil properties may help inform the study to determine the potential spill behaviour and fate and, consequently, improve the effectiveness for human response strategies to different spill events.

Several experiments described in Dickins (2011) have been designed to evaluate the response of the spill in different ice conditions: on and under drift and closed pack and fast ice, on surface melt pools, on snow and ice, in slush between floes, and under ice floes. Figure E-6 presents a schematic showing a range of ice and oil interactions resulting from oil spills in ice-covered waters.

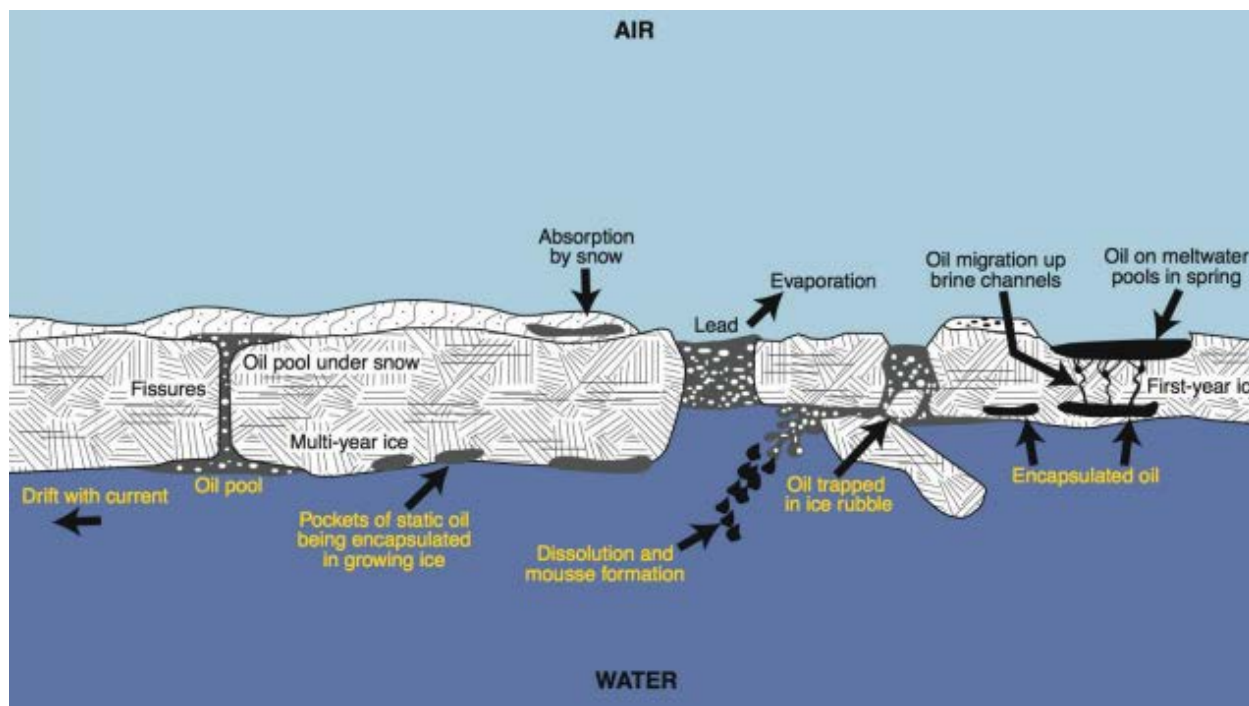


Figure E-6: Schematic showing ice and oil interactions (source: Dickins, 2011; derived from original sketch by A. Allen)

For the purposes of this study, the oil type P50 diesel fuel is examined. Some characteristics of P50 diesel are listed below:

- Most crude oils and light products such as diesel and gasoline experience significant evaporation (Potter et al. 2012);
- Small diesel spills usually evaporate and disperse naturally within a day for spills of 500 to 5,000 gallons, even in cold water (NOAA 2016);
- Diesel oil spreads very quickly to a thin film of rainbow and silver sheens (NOAA 2016);



## SPILL RISK ASSESSMENT

- Diesel has a very low viscosity and is readily dispersed into the water column when winds reach 5-7 knots or with breaking waves (NOAA 2016);
- Since diesel is much lighter than seawater it is not possible to sink and accumulated on the seafloor (NOAA 2016);
- Wave action can disperse diesel to form droplets that are small enough to be kept in suspension and moved by the currents (NOAA 2016);
- Moderately volatile; will leave residue (up to one-third of spill amount) after few days (OSHA 2013);
- Moderate concentrations of toxic (soluble) compounds (OSHA 2013);
- Will “oil” intertidal resources resulting in potential for long-term contamination (OSHA 2013); and
- Cleanup can be very effective (OSHA 2013).

Table E-1 outlines different oil spill response methods for oil releases in cold and icy conditions, including a description of advantages and disadvantages for each method, as described by Lampala (2011).



## SPILL RISK ASSESSMENT

**Table E-1: Response Methods Used on Oil Spill Events**

Method	Description
Mechanical recovery	From the environmental point of view, the mechanical recovery is usually considered as the most favorable oil spill combating method. Several skimmer types and techniques exist, but, because of variations in circumstances and climate conditions, ice coverage varies case-specifically and conditions may change even during response to a single incident, necessitating a toolbox of several response tools.
In-situ burning	<i>In situ</i> burning is particularly suitable for use in icy conditions, sometimes offering the best option for removal of surface oil. <i>In situ</i> burning of thick, fresh oil slicks can often be initiated very quickly through ignition of the oil with simple devices such as an oil-soaked sorbent pad. Oil from the water's surface can be removed efficiently and well via <i>in situ</i> burning: It is reported that the removal efficiency for thick slicks can exceed 90%. Oil removal rates of 2,000 m <sup>3</sup> /hr can be achieved with a fire area of about 10,000 m <sup>2</sup> .
Chemical Recovery	Dispersant chemicals work by enhancing the natural dispersion of the oil into the water column. A dispersant consists of a mixture of surfactants (surface-active agents) in a solvent. When applied to an oil slick, the surfactants will be positioned at the oil–water interface and contribute to formation of small oil droplets that will readily be mixed into the water column and be rapidly diluted and later biodegraded.
Bioremediation	Bioremediation is natural biodegrading of spilled oil, which to a certain extent can be accelerated through the addition of nutrients, oil-degrading bacteria, or both. Nutrient and bacteria addition has been tested, and some positive effects have been observed. It had been assumed that biodegrading does not occur in cold and icy conditions or is at least very slow; however, lab and field tests have shown that a low water temperature and even the presence of ice do not hamper the biodegrading of oil as much as expected. Nonetheless, it should be noted that bioremediation is a slow process that very seldom, if ever, can be considered as the primary countermeasure. The most beneficial use of bioremediation is as a secondary combating method that completes the recovery result after application of some other cleanup method.
Others	<ul style="list-style-type: none"><li>■ Use of vacuum pumps to suck oil between and under ice blocks.</li><li>■ Use of air bubbles to separate the oil and ice, with an air-induced current directing the oil into free water between ice blocks.</li><li>■ Use of propeller flow to direct oil under ice in the desired direction.</li><li>■ Creation of an ice boom to prevent drifting of oil in an undesired direction.</li><li>■ Use of specialized saw to cut slots in ice where oil can be removed.</li></ul>

Note:

The information in this table was derived from Lampala (2011).

In general, interactions between Project vessels and sea ice along the navigation route are predicted to be rare during the open- water season. However, changes in climate and larger scale weather patterns can result in variation to the typical break-up and/or freeze-up dates. Also, occasional incursions of drift ice from Foxe Basin and Davis Strait can be expected along the navigation route, particularly in Hudson Strait and Ungava Bay.



### 6.0 DIESEL FUEL SPILL SCENARIOS

For this analysis, we considered a worst case spill scenario of 20 ML (20,000 m<sup>3</sup>) assuming all (100%) of the P50 diesel fuel carried on the ship was spilled. A second spill scenario was considered for 2 ML (2,000 m<sup>3</sup>) based on the conservative assumption of 10% of the total P50 diesel fuel (20 ML) being carried on a single ship for the Project. Previous research indicates that spill volumes are best expressed as being equivalent to 5% to 10% of the total fuel being transported (McKenna and McClintock 2005; Coastal Ocean Resources 2013). Therefore, the 100% diesel spill assumed in the worst case scenario is extremely conservative and unlikely.

The Automated Data Inquiry for Oil Spills (ADIOS2), an oil weathering model (NOAA 2014), was used to provide estimates of the expected characteristics and behavior of fuel spilled in the marine environment. We analyzed a 20 ML and a 2 ML fuel spill at four locations in Melvin Bay and ten locations along the shipping route (Table E-2). Additional scenarios of 100,000 L (100 m<sup>3</sup>) spills were analyzed at the four fuel transfer locations in Melvin Bay – as these represent smaller-scale spills that could occur during transfer of fuel from ship-to-ship or ship-to-shore. One of the main causes of fuel spills is related to navigational error where a tanker deviates from its planned track along the shipping route. The modelled scenarios assumed that the fuel spill would occur near the center of the main shipping lane and that ships would not deviate from this route (Figure E-1).

**Table E-2: Hypothetical Fuel Spill Locations**

Location Number	Location Name	UTM Zone	Easting (metres)	Northing (metres)
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546,173	6,961,117
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546,143	6,963,142
3	Shipping route south of Walrus Island	16	641,869	6,988,220
4	Shipping route north of Coats Island	17	456,430	7,000,031
5	Shipping route north of Ungava Peninsula	18	351,235	6,986,598
6	Shipping route in Eastern Hudson Strait	20	399,876	6,775,840
1A	West Melvin Bay	15	545,185	6,963,365
2A	East Melvin Bay	15	546,798	6,962,172
3A	Entrance to Melvin Bay	15	549,334	6,960,588
4A	West Hudson Bay	15	585,757	6,949,020
5A	Hudson Bay crossing	16	416,455	6,950,265
6A	Western Hudson Strait	18	546,017	6,967,899
7A	Mid-Hudson Strait	19	415,679	6,911,718
8A	Eastern Hudson Strait	19	570,404	6,842,009



### 6.1 Model Parameters

#### 6.1.1 Extremal Analysis for Rankin Inlet and Coral Harbour Winds

Historical hourly wind records were obtained for Rankin Inlet (station ID: 71083) and Coral Harbour (station ID: 71915). The Rankin Inlet station is located at 62.82° N, 92.12° W at an elevation of 32.3 metres (m) above mean sea level (msl) and the Coral Harbour station is located at 64.78° N, 83.92° W at an elevation of 62.2 m above msl. Figure E-7 shows wind roses for the hourly record at Rankin Inlet from 1981 through 2012 for all wind measurements over the duration of the record (Figure E-7a) and for a filtered subset of only wind measurements made during the open water seasons (August to October) over the duration of the record (Figure E-7b). Figure E-8 shows wind roses for the hourly record at Coral Harbour for the same time period for all wind measurements over the duration of the record (Figure E-8a) and for a filtered subset of only wind measurements made during the open water seasons (August to October) over the duration of the record (Figure E-8b). In general, the prevailing wind direction at both sites is from the north-northwest (prevailing winds from 343° at both stations). The wind distribution observed between the full record and the record limited to open water seasons only are nearly identical at both stations. This indicates that there is no seasonal bias during the open water season that is not observed during the full annual distribution. Wind speed statistics were calculated for both stations and the results are shown in Table E-3 and Table E-4. Data were filtered for “0” values.

Wind speeds recorded at Rankin Inlet and Coral Harbour between 1981 and 2012 were used to determine probability distributions of wind speeds and their associated return periods. A peaks-over-threshold (POT) analysis was used to calculate the peak wind speeds of the largest storms during the 31-year record at each site. Extreme wind speeds were determined by filtering the record for peak wind speeds during storms with speeds greater than the 95 percentile value (Table E-3) sustained for at least 4 hours.

An extremal analysis following Leenknecht et al. (1992) was applied to the station record of extremes in order to determine the 5, 10, 25, 50 and 100-year wind speeds at the site. A time series of 77 maximum wind speeds measured during discrete storms between 1981 and 2012 were input to the extremal analysis. The analysis included the application of Fisher Tippet Type 1 (FT-1) and Weibull distributions to the peak water level time series. Results of the analysis for Rankin Inlet are summarized in Table E-5 and a plot of the Weibull distribution with shape parameter ( $k$ ) = 1.15 is shown in Figure E-9. Results of the analysis for Coral Harbour are summarized in Table E-6 and a plot of the Weibull distribution with  $k$  = 2.00 shown in Figure E-10. The wind analysis indicates that the prevailing winds are from the north-northwest (343°) at both Rankin Inlet and Coral Harbour, while the extreme storm winds are from the north-northwest (343°) at Rankin Inlet and from the northeast (40°) at Coral Harbour. Therefore, wind direction for the 50-year storm should be applied as 343° for oil spill model points near Melvin Bay (represented by Rankin Inlet winds) and as 40° for oil spill model points along Hudson Strait (represented by Coral Harbour winds).



## SPILL RISK ASSESSMENT

**Table E-3: Wind Statistics for Rankin Inlet and Coral Harbour (1981-2012) in Metres/Second**

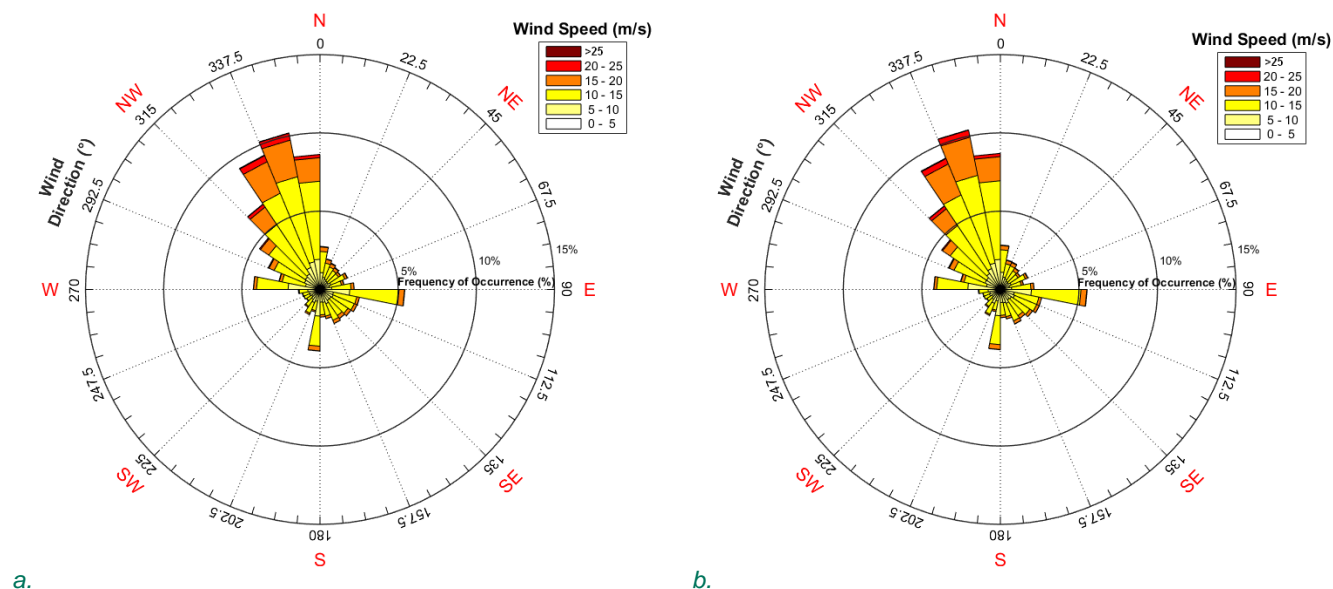
	Min	1%	5%	25%	Median	Mean	75%	95%	99%	Max	Std
Rankin Inlet	0.6	1.1	1.9	4.2	6.1	6.6	8.3	12.8	15.8	28.3	3.3
Coral Harbour	0.6	1.1	1.7	3.1	5.3	5.4	7.2	11.4	15.0	28.3	3.1

Minimum (Min), Maximum (Max), Standard Deviation (Std)

**Table E-4: Wind Statistics for Rankin Inlet and Coral Harbour (1981-2012)**

	Record Length	Missing	Number Invalid	% Invalid
Rankin Inlet	281,088	0	8,474	3%
Coral Harbour	280,608	480	23,285	8%

Invalid = "0" value



*Figure E-7: Wind Roses for Rankin Inlet from 01 October 1981 to 01 October 2012 for (a) all wind measurements and (b) wind measurements during the open water seasons only*



## SPILL RISK ASSESSMENT

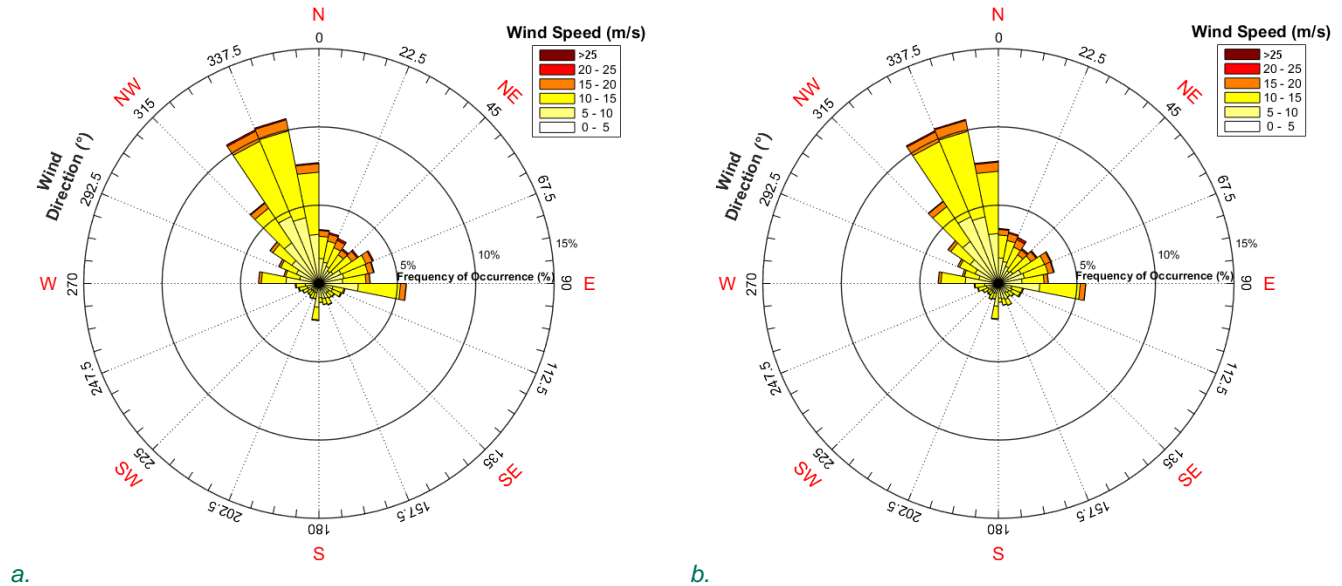


Figure E-8: Wind Roses for Coral Harbour from 01 October 1981 to 01 October 2012 for (a) all wind measurements and (b) wind measurements during the open water seasons only

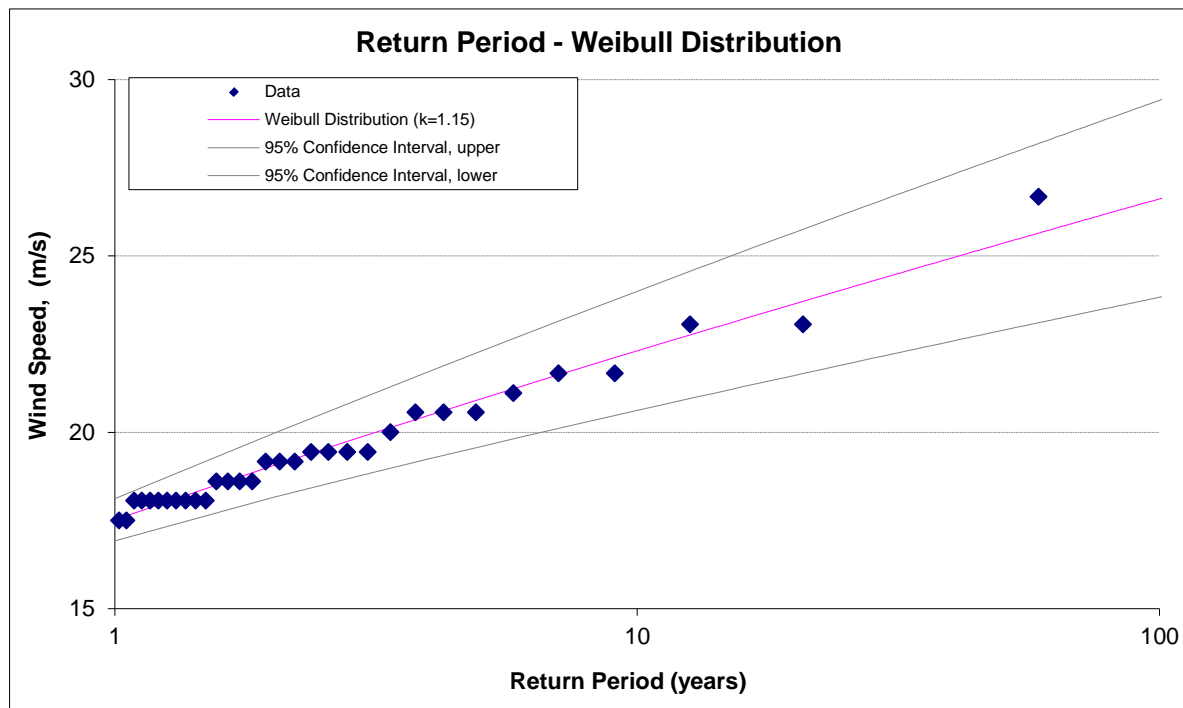


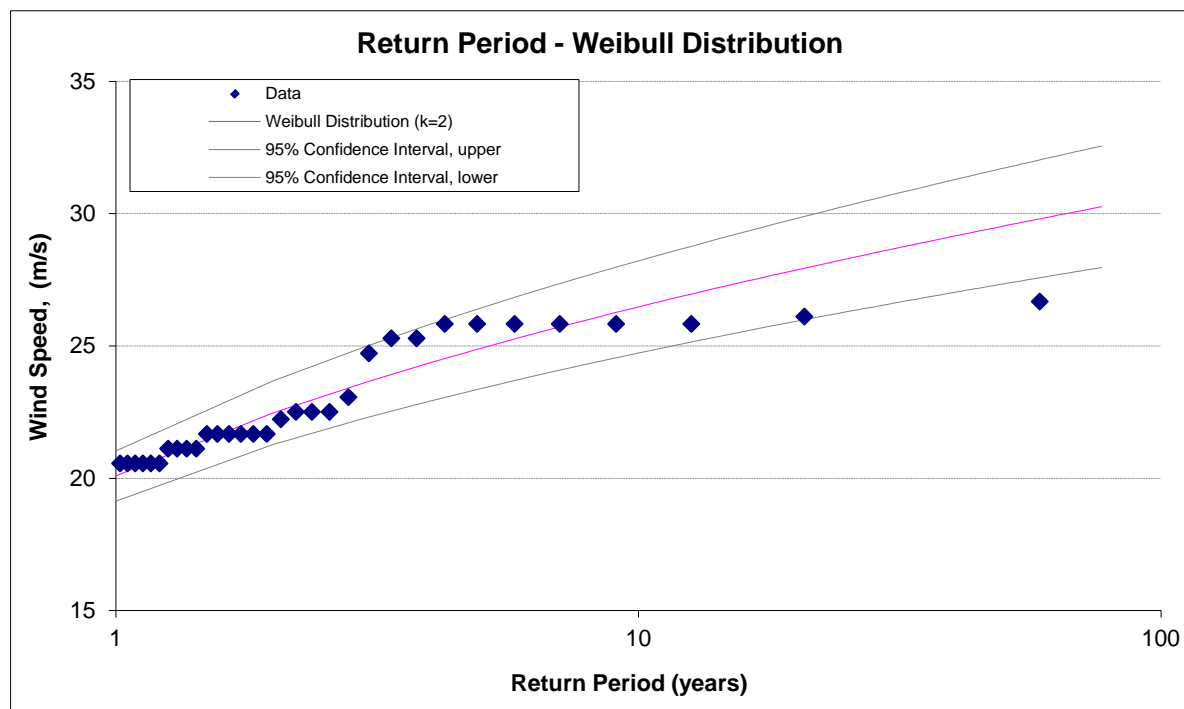
Figure E-9: Wind speed as a function of return period for a Weibull ( $k=1.15$ ) distribution for Rankin Inlet wind record



## SPILL RISK ASSESSMENT

**Table E-5: Extreme Wind Speeds (m/s) and Associated Return Periods for Rankin Inlet**

N= 77	Nu= 1.00	FT-I	Weibull k= 0.75	Weibull k= 1.15	Weibull k= 1.49	Weibull k= 2.00
NT= 77	K= 32					
Lambda=2.41						
Correlation Coefficient	0.9880		0.9711	0.9918	0.9860	0.9708
Sum Square of Residuals	8.23		19.72	5.65	9.64	19.89
Return Period (yr)	m/s	m/s	m/s	m/s	m/s	m/s
2	19.2	18.52	19.05	19.23	19.33	
5	20.8	20.59	20.94	20.92	20.80	
10	22.0	22.34	22.31	22.07	21.73	
25	23.6	24.85	24.06	23.46	22.82	
50	24.7	26.88	25.35	24.44	23.56	
100	25.9	28.20	26.62	25.03	24.00	
Confidence Interval	Return Period (yr)	m/s	m/s	m/s	m/s	m/s
95 % C.I.	5	19.7 - 21.9	18.4 - 22.7	19.6 - 22.3	19.8 - 22.0	19.9 - 21.7
95 % C.I.	10	20.7 - 23.3	19.4 - 25.3	20.6 - 24.0	20.7 - 23.4	20.7 - 22.8
95 % C.I.	25	21.9 - 25.2	20.7 - 29.0	21.9 - 26.2	21.9 - 25.0	21.6 - 24.0
95 % C.I.	50	22.8 - 26.6	21.8 - 31.9	22.9 - 27.8	22.7 - 26.2	22.2 - 24.9
95 % C.I.	100	23.7 - 28.1	22.5 - 33.9	23.8 - 29.4	23.1 - 26.9	22.6 - 25.4



*Figure E-10: Wind speed as a function of return period for a Weibull (k=2.00) distribution for Coral Harbour wind record*



## SPILL RISK ASSESSMENT

**Table E-6: Extreme Wind Speeds (m/s) and Associated Return Periods for Coral Harbour**

N= 77		Nu= 1.00				
NT= 77		K= 32				
Lambda=2.41		FT-I	Weibull	Weibull	Weibull	Weibull
			k= 0.75	k= 1.15	k= 1.49	k= 2.00
Correlation Coefficient		0.9580	0.8222	0.9195	0.9535	0.9757
Sum Square of Residuals		78.25	308.39	147.11	86.46	45.71
Return Period (yr)		m/s	m/s	m/s	m/s	m/s
	2	22.1	20.90	21.83	22.21	22.48
	5	24.8	23.80	24.74	24.92	24.92
	10	26.7	26.26	26.84	26.76	26.48
	25	29.2	29.79	29.54	28.99	28.29
	50	31.1	32.64	31.52	30.57	29.53
	100	32.9	34.49	33.47	31.52	30.26
Confidence Interval	Return Period (yr)	m/s	m/s	m/s	m/s	m/s
95 % C.I.	5	23.0 - 26.5	20.2 - 27.4	22.5 - 27.0	23.1 - 26.8	23.4 - 26.4
95 % C.I.	10	24.5 - 28.9	21.3 - 31.2	24.0 - 29.6	24.6 - 29.0	24.7 - 28.2
95 % C.I.	25	26.4 - 31.9	23.0 - 36.6	26.0 - 33.1	26.4 - 31.6	26.3 - 30.3
95 % C.I.	50	27.9 - 34.2	24.2 - 41.0	27.4 - 35.6	27.6 - 33.5	27.3 - 31.7
95 % C.I.	100	29.3 - 36.5	25.1 - 43.9	28.8 - 38.1	28.4 - 34.7	28.0 - 32.6



### 6.1.2 Spill Scenarios and Input Parameters

ADIOS2 predicts changes over time in the density, viscosity, and water content of diesel fuel, including evaporation and dispersion rates. The following assumptions were made for model set-up:

- ADIOS 2 diesel fuel oil (Canada), equivalent to P50;
- Spill of 100,000 L (100 m<sup>3</sup>) and 2 ML (2,000 m<sup>3</sup>) for near-shore spills;
- Spill of 2 ML (2,000 m<sup>3</sup>) for shipping route spills;
- Spill of 20 ML (20,000 m<sup>3</sup>) for shipping route spills;
- Sea salinity of 32 parts per thousand (ppt);
- Surface water and diesel fuel temperature of 5° Celsius (C);
- Sediment load of 5 milligrams per litre (mg/L);
- Spill occurs near the center of the proposed shipping lane; and
- Spill scenarios assume no mitigation.

Winds and waves are generally the driving physical forces used to determine the oil drift slick speed and distance travelled (DNV 2011). Golder analyzed winds from Rankin Inlet and Coral Harbour and performed an extremal analysis for 31-years of hourly data (Section 6.1.1). For modeling simulations, Golder used mean, 2-year, and 50-year wind conditions. For the 31-year record, the majority of the winds from both stations originated from 343° (North-Northwest). The extreme winds at Rankin Inlet also originate from North-Northwest (typically 343°), but the extreme winds at Coral Harbour originate from the northeast (typically 40°). For all scenarios except the 50-year extreme wind scenario, the fetch was measured along the axis of prevailing wind direction from 343° to 163°. The 50-year extreme wind scenario was measured along the axis of the dominant wind direction. In Rankin Inlet, extreme winds typically blow from 343° to 163° and this wind alignment would be applicable for points in Melvin Bay and Hudson Bay (points 1, 1A, 2, 2A, 3A, 4A, and 5A). At Coral Harbour, extreme winds blow from 40° to 220° and this wind alignment would be applicable for points along Hudson Strait (points 3, 4, 5, 6A, 7A, 8A and 6). Wind-related model parameters (i.e., fetch, distance to shore, and wind speeds) for the hypothetical fuel spill locations are provided in Table E-7. Summary tables and figures from the ADIOS2 model simulations inputs and outputs are provided in Attachment A.

**Table E-7: Wind Related Model Parameters for Spill Scenarios along Shipping Route**

Location (Number)	Fetch (km)			Distance to Shore (km)			Wind Speed (m/s)		
	Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
Ship-to-ship fuel transfer (1)	0.5	Mean <sup>1</sup>	Mean <sup>1</sup>	0.9	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19.0	25.4
Ship-to-shore fuel transfer (2)	0.4	Mean <sup>1</sup>	Mean <sup>1</sup>	0.4	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19.0	25.4
West Melvin Bay (1A)	0.9	Mean <sup>1</sup>	Mean <sup>1</sup>	0.6	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19.0	25.4
East Melvin Bay (2A)	1.3	Mean <sup>1</sup>	Mean <sup>1</sup>	0.3	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19.0	25.4
Walrus Island (3)	43	Mean <sup>1</sup>	134	55	Mean <sup>1</sup>	760	5.4	22.5	29.5
Coats Island (4)	58	Mean <sup>1</sup>	50	23	Mean <sup>1</sup>	22	5.4	22.5	29.5
Ungava Peninsula (5)	16	Mean <sup>1</sup>	24	46	Mean <sup>1</sup>	106	5.4	22.5	29.5
Eastern Hudson Strait (6)	26	Mean <sup>1</sup>	775	46	Mean <sup>1</sup>	325	5.4	22.5	29.5



## SPILL RISK ASSESSMENT

Location (Number)	Fetch (km)			Distance to Shore (km)			Wind Speed (m/s)		
	Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
Entrance to Melvin Bay (3A)	2	Mean <sup>1</sup>	Mean <sup>1</sup>	12	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19	25.4
West Hudson Bay (4A)	14	Mean <sup>1</sup>	Mean <sup>1</sup>	700	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19	25.4
Hudson Bay crossing (5A)	148	Mean <sup>1</sup>	Mean <sup>1</sup>	857	Mean <sup>1</sup>	Mean <sup>1</sup>	6.6	19	25.4
Western Hudson Strait, Charles Island (6A)	183	Mean <sup>1</sup>	115	20	Mean <sup>1</sup>	21	5.4	22.5	29.5
Mid-Hudson Strait (7A)	45	Mean <sup>1</sup>	29	160	Mean <sup>1</sup>	93	5.4	22.5	29.5
Eastern Hudson Strait, north Ungava Bay (8A)	47	Mean <sup>1</sup>	48	305	Mean <sup>1</sup>	164	5.4	22.5	29.5

Notes:

<sup>1</sup> Cells listed as "Mean" indicates that cell values are equivalent to the mean wind case values.

The 2 ML and 20 ML spill scenarios were each modelled with and without the influence of currents on the slick trajectory. A summary of the predominant current velocities at each location is presented in the results table in Section 6.3, Table E-9 through Table E-11. A background literature review was conducted to provide the oceanographic conditions along the shipping route with particular attention to the surface currents along the route. Current velocity along the western portion of the shipping route (Rankin Inlet to Coats Island) is predominantly forced by tides running along the axis of the route, but the eastern portion of the route through Hudson Strait east of Coats Island is dominated by the cyclonic circulation forcing a current to the east-southeast (Drinkwater 1986; Drinkwater 1988; Saucier et al 2004). South of the proposed shipping route in Hudson Bay, currents have been modelled to predict the seasonal cycle of water masses and sea ice by Saucier et al. (2004) and Wang et al. (1994). Currents from the Arctic Ocean flow around both sides of Southampton Island from the north (Ingraham and Prisenburg 1998). Coastal currents flow counter-clockwise along the southwestern portion of Hudson Bay towards James Bay, north along the eastern coast of Hudson Bay and through the southern Hudson Strait into the Labrador Sea. The surface eddy current is strongest during ice-free periods and reaches 15 to 20 centimetres per second (cm/s) (Saucier et al. 2004) in northeastern Hudson Bay. Current enters into Hudson Strait from the Atlantic along the southern shore of Baffin Island and exits along the northern shore of Quebec (Drinkwater 1986; Drinkwater 1988; Ingraham and Prisenburg 1998; Straneo and Saucier 2008). In the center of Hudson Strait there is a cyclonic pattern which brings the current across the channel from the north to south. Figure E-11 provides an overview of circulation patterns for the region, adapted from Straneo and Saucier (2008) and Drinkwater (1986).

Current data are available at several mooring locations in Hudson Strait and west of Southampton Island from the MERICA (*études des MERs Intérieures du Canada*) 2003 to 2007 oceanographic data collection program (DFO 2015). Surface current data from representative sites were used to supplement or verify the literature review.



## SPILL RISK ASSESSMENT

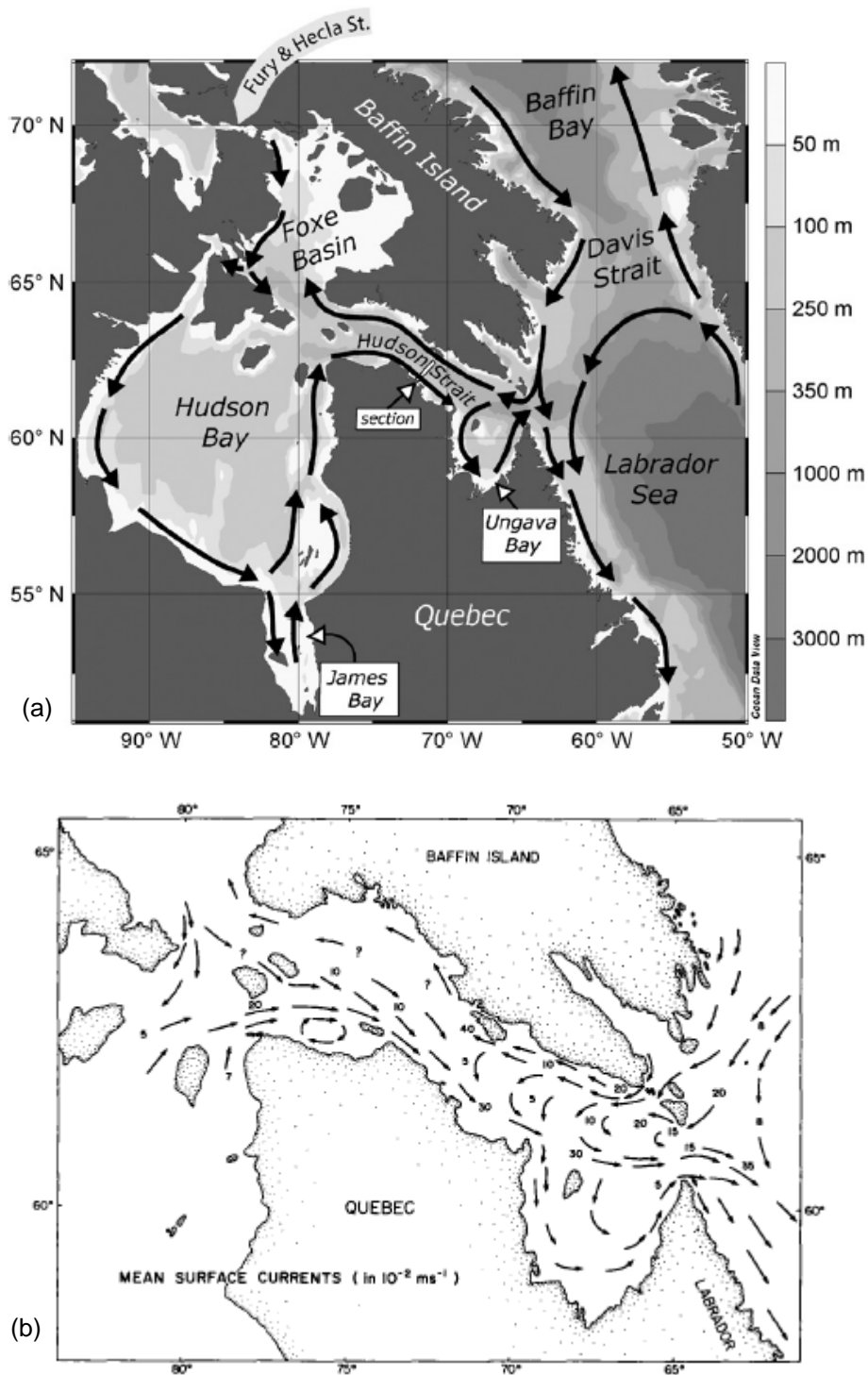


Figure E-11: (a) Hudson Bay system bathymetry and schematic circulation. Source: Straneo and Saucier 2008 and (b) Surface circulation in Hudson Strait and Ungava Bay. Source: Drinkwater 1986



Mean surface currents were considered at the locations along the shipping route when available. No information on currents in Melvin Bay near Rankin Inlet were available, therefore, no currents were applied to locations 1, 2, 1A, 2A, or 3A in the calculations. For the purpose of this analysis, predominant current direction and velocity at each location were used based on the availability of data, influence of currents on dispersion, and periodicity of the tides. Peak tidal currents were not considered because the tides are semi-diurnal and would switch direction multiple times during the course of a potential oil spill which could continue weathering for 12 hours or longer.

Currents were not input into the ADIOS2 model because these scenarios were considered instantaneous releases of fuel and each part of the slick would therefore experience the same net displacement (Lehr et al. 2002). The input of currents into the ADIOS2 model is generally used for modeling a spill from a fixed point such as an offshore platform. Mean surface currents were used for calculation of the slick velocity as a vector sum in combination with drift resulting from wind velocity.

### 6.1.3 Modelling Methodology

The ADIOS2 model output provided weathering half-life, and equations presented by the Australian Maritime Safety Authority were used to calculate the time for a spill to reach shore and the quantity of fuel from a spill that would be deposited on shore (DNV 2011). The quantity and proportion of fuel deposited on shore was determined after calculating the quantity of fuel remaining in the slick at the shore. The time between the occurrence of the spill and the slick initially reaching the shore ( $T_{shore}$ ) depends primarily on the distance to shore ( $D_{zone}$ ), wind velocity in the direction of the shore ( $V_{wind}$ ), and the slick's velocity represented as a fraction (3%) of the wind velocity ( $RV_{drift}$ ) (DNV 2011):

$$T_{shore} = \frac{D_{zone}}{V_{wind}RV_{drift}}$$

The quantity remaining in the slick ( $Q_s$ ) relates to the original spill quantity ( $Q$ ), weathering half-life to the quantity of fuel remaining ( $H$ ), and time to shore ( $T_{shore}$ ) (DNV 2011).

$$Q_s = Q * 2^{-T_{shore}/H}$$

For the scenarios where the mean surface current was considered, the slick velocity was calculated as a vector combination of the wind velocity and the current velocity:

$$V_{slick} = V_{wind}RV_{drift} + V_{current}RV_{drift}$$

Studies have found that slick transport due to surface currents is typically 60% ( $RV_{drift}$ ) of the ambient current speed (Blaikley et al 1977): A new distance to shore was calculated based on the trajectory of the slick ( $V_{slick}$ ) and used to determine the quantity deposited on shore.



## SPILL RISK ASSESSMENT

### 6.2 Spills near Melvin Bay

The spill scenarios in Melvin Bay were completed for three different spill volumes: 100,000 L, 2 ML, and 20 ML, representing an average spill scenario, a large but low-probability spill scenario (10% spilled from a large tanker), and a worst case spill scenario (100% spilled from a large tanker), respectively. The weathering half-life (time required for removal of 50% of the diesel fuel from the sea surface) was determined using the ADIOS2 model. The amount of time it would take for a fuel spill to reach the shoreline given anticipated wind effects was then determined (originating from approximately 343° from the spill location) (Table E-8) along with the proportion of fuel estimated to be deposited on shore under the different spill scenarios.

Weathering characteristics for a 2 ML fuel spill are shown in Figure E-12. This figure illustrates the amount of fuel that would evaporate and disperse over time following the initial spill. For all spill scenarios considered at the fuel transfer locations near Melvin Bay, the weathering half-life was determined to be < 35 h. The time required for the spill to reach shore varied from approximately 6 minutes (min) (0.1 h) to 1 h 20 min. For all sites in Melvin Bay, it was determined that between 89% and 100% of the total volume of spilled diesel fuel would reach shore assuming no responsive mitigation occurred.

**Table E-8: Distance to Shore, Weathering Half-Life, Time to Shore, and Estimated Percent of Spill Deposited on Shore for 100,000 L, 2 ML, and 20 ML Diesel Fuel Spill Scenarios in Melvin Bay**

Location	Spill Amount (L)	Distance to Shore (km)	Weathering Half-Life (h)			Time to Shore (h)			% Deposited on Shore		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
Ship-to-ship fuel transfer (1)	100,000	0.9	7.8	3.4	2.7	1.3	0.4	0.3	89%	91%	92%
Ship-to-ship fuel transfer (1)	2,000,000	0.9	18.5	9.2	6.9	1.3	0.4	0.3	95%	97%	97%
Ship-to-ship fuel transfer (1)	20,000,000	0.9	34.8	16.1	14.8	1.3	0.4	0.3	98%	98%	98%
Ship-to-shore fuel transfer (2)	100,000	0.4	7.8	3.4	2.7	0.6	0.2	0.1	95%	96%	96%
Ship-to-shore fuel transfer (2)	2,000,000	0.4	18.5	9.2	6.9	0.6	0.2	0.1	98%	99%	99%
Ship-to-shore fuel transfer (2)	20,000,000	0.4	34.8	16.1	14.8	0.6	0.2	0.1	99%	99%	99%
West Melvin Bay (1A)	100,000	0.6	8	3.5	2.7	0.8	0.3	0.2	93%	94%	95%
West Melvin Bay (1A)	2,000,000	0.6	18.5	8.7	6.9	0.8	0.3	0.2	97%	98%	98%
West Melvin Bay (1A)	20,000,000	0.6	33.7	16.5	17.4	0.8	0.3	0.2	98%	99%	99%
East Melvin Bay (2A)	100,000	0.3	8	3.5	2.7	0.4	0.1	0.1	97%	97%	97%



## SPILL RISK ASSESSMENT

Location	Spill Amount (L)	Distance to Shore (km)	Weathering Half-Life (h)			Time to Shore (h)			% Deposited on Shore		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
East Melvin Bay (2A)	2,000,000	0.3	18.5	8.7	6.9	0.4	0.1	0.1	99%	99%	99%
East Melvin Bay (2A)	20,000,000	0.3	33.7	16.5	17.4	0.4	0.1	0.1	99%	99%	100%

km (kilometre); yr (year); h(hour); L (liter)

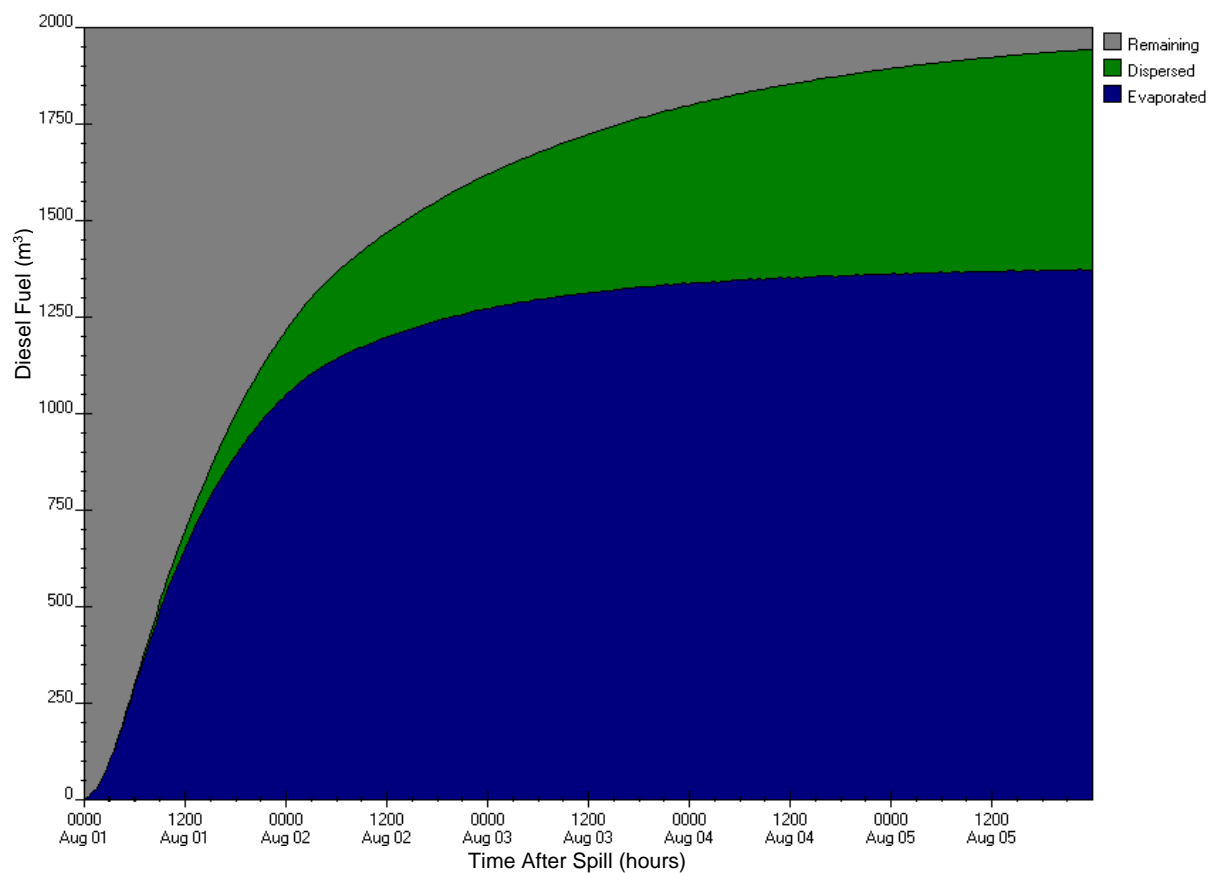
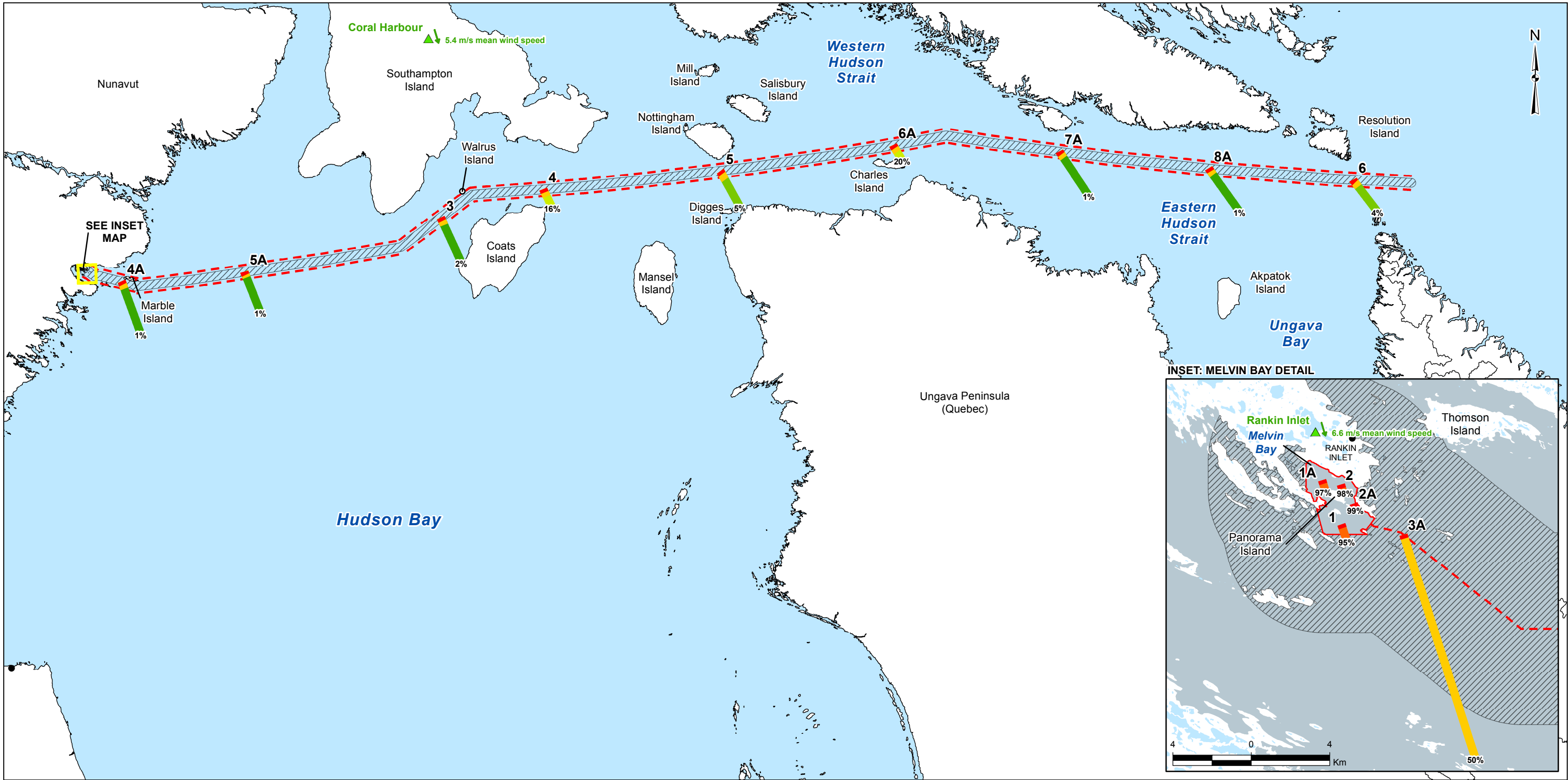


Figure E-12: Weathering Characteristics of a 2 ML Diesel Fuel Spill in Melvin Bay under Mean Wind and Wave Conditions

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LEGEND

	MARINE REGIONAL STUDY AREA (MARINE RSA)	% SPILL VOLUME REMAINING
	MARINE LOCAL STUDY AREA (MARINE LSA)	98.1 - 100.0
	WATERBODY	50.1 - 98.0
	SHIPPING ROUTE (APPROXIMATE)	20.1 - 50.0
	WIND STATION	5.1 - 20.0
	WIND VECTOR (DIRECTION BLOWING TOWARDS)	2.1 - 5.0
		1.0 - 2.0

NOTES

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

REFERENCE

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

**AGNICO EAGLE**

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

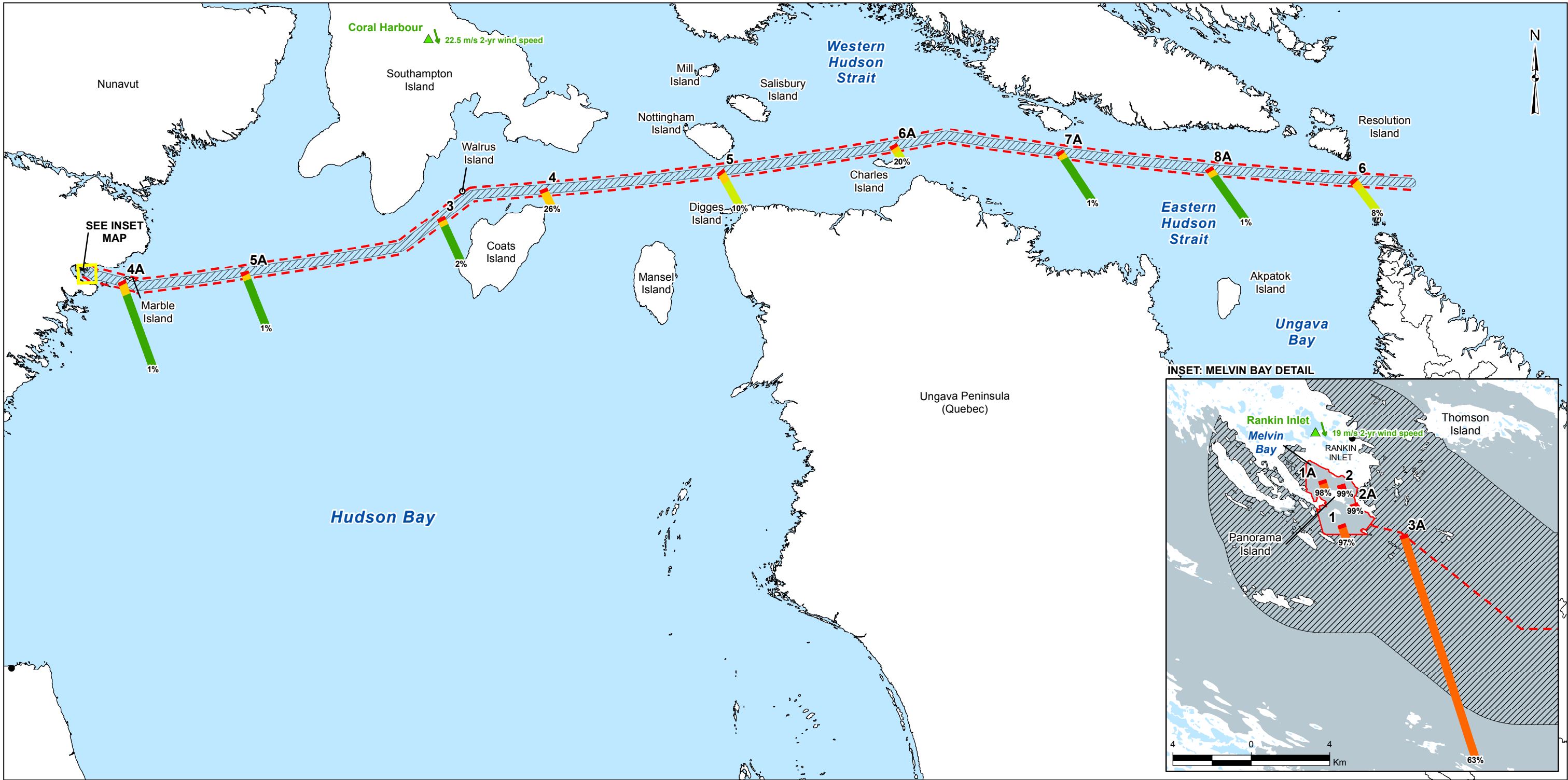
**OIL SPILL SCENARIO:  
2,000,000 L SPILL,  
MEAN WIND, NO SURFACE CURRENT**

**Golder Associates**

DESIGN	GC	06 Jan. 2016	FILE No.	1535029
GIS	CDB	06 Jan. 2016	SCALE AS SHOWN	REV. A
CHECK	JC	06 Jan. 2016		
REVIEW	LY	06 Jan. 2016		

**FIGURE E-13**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-14\_Oil\_Spill\_Scenario\_2ML\_2yr\_wind.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT  
**AGNICO EAGLE**

PROJECT NO. 1535029  
DESIGN GC 06 Jan. 2016  
GIS CDB 06 Jan. 2016  
CHECK JC 06 Jan. 2016  
REVIEW LY 06 Jan. 2016

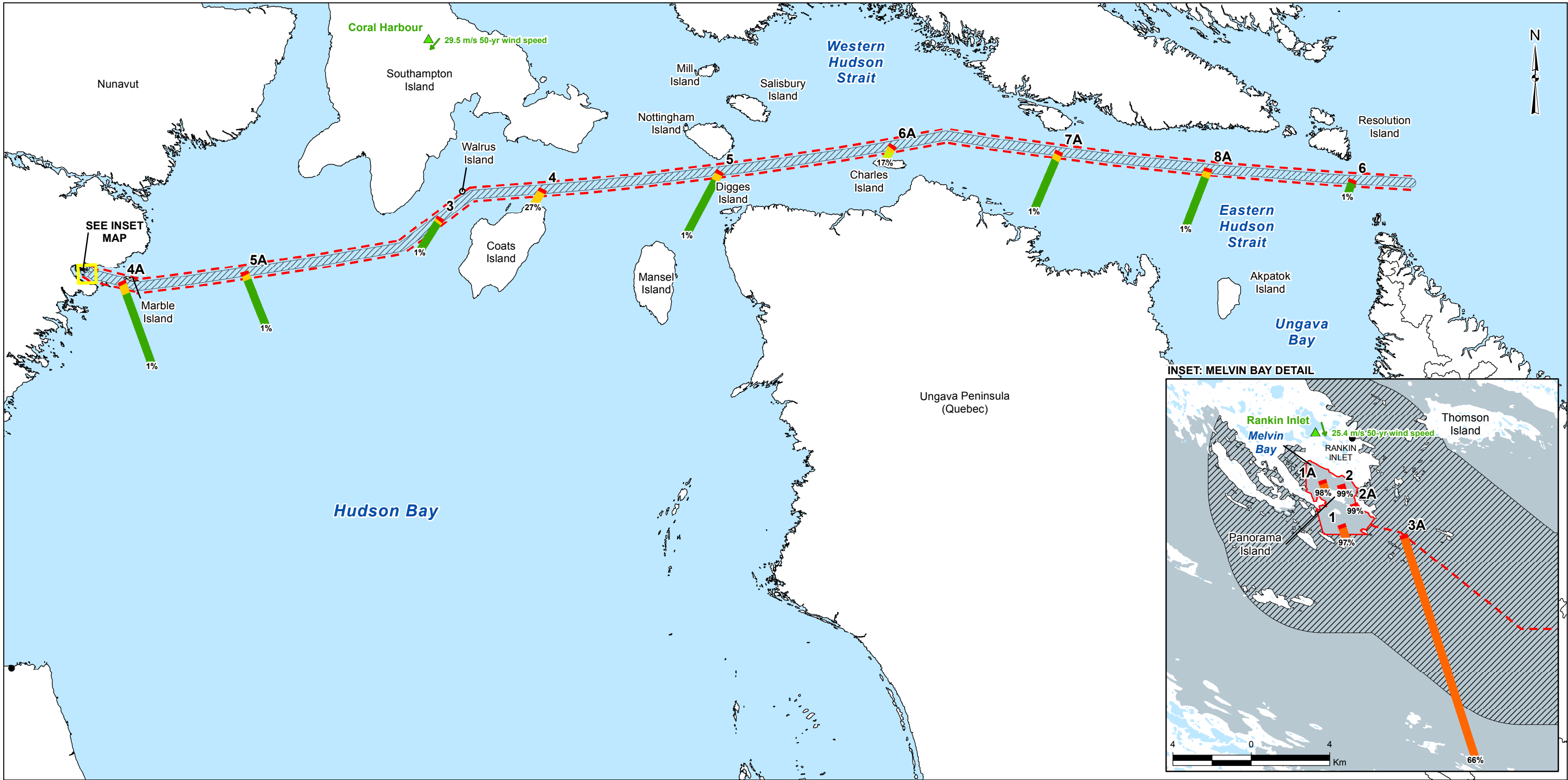
AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE  
**OIL SPILL SCENARIO:  
2,000,000 L SPILL,  
2-YR WIND, NO SURFACE CURRENT**

FILE No.  
SCALE AS SHOWN  
REV. A

**FIGURE E-14**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-15\_Oil\_Spill\_Scenario\_2ML\_50yr\_wind.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE

TITLE

**OIL SPILL SCENARIO:  
2,000,000 L SPILL,  
50-YR WIND, NO SURFACE CURRENT**

PROJECT NO. 1535029

FILE No.

DESIGN GC 06 Jan. 2016

SCALE AS SHOWN

REV. A

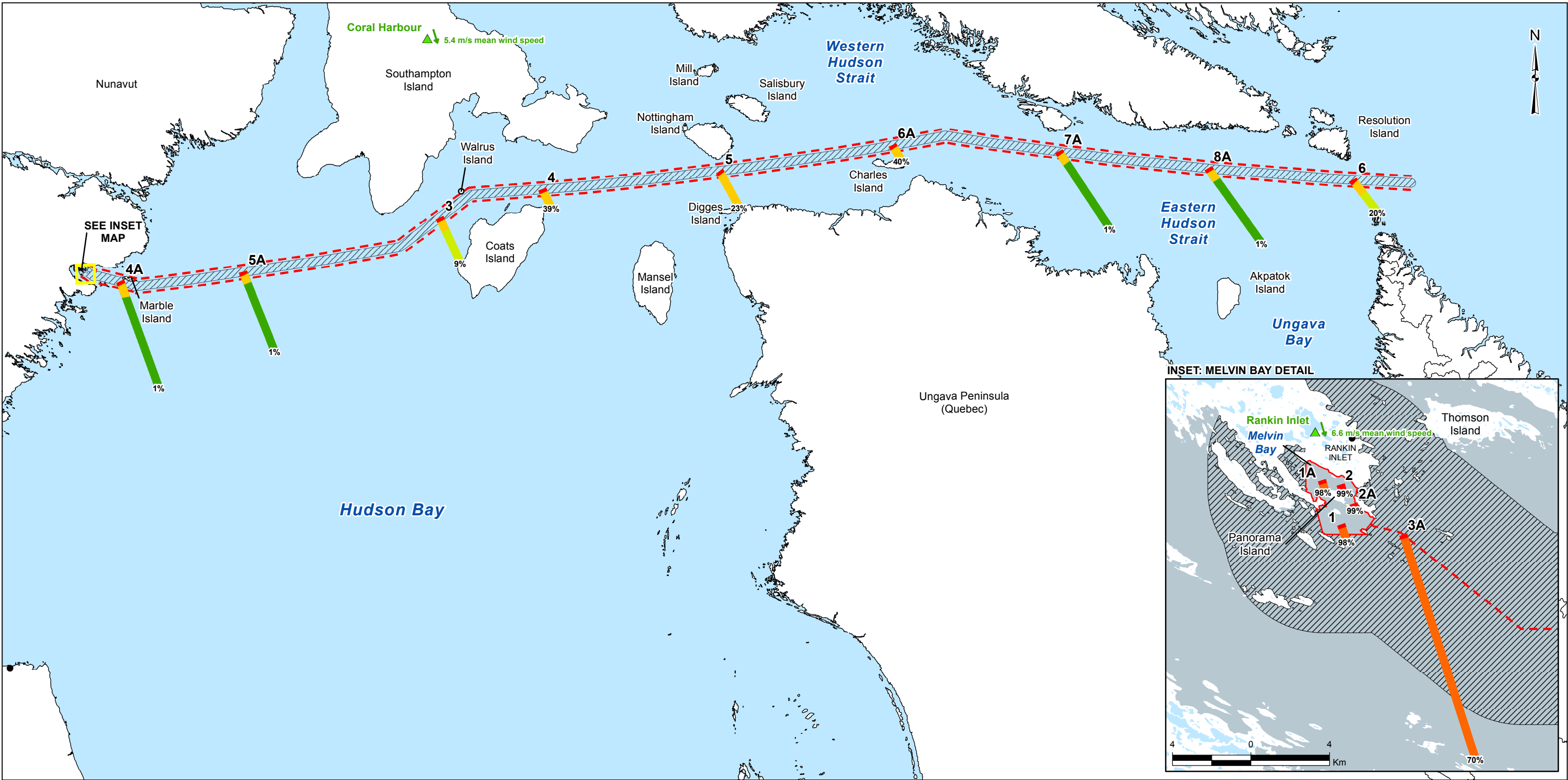
GIS CDB 06 Jan. 2016

CHECK JC 06 Jan. 2016

REVIEW LY 06 Jan. 2016

**FIGURE E-15**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-16\_Oil\_Spill\_Scenario\_20ML\_mn\_wind.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

% SPILL VOLUME REMAINING

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

• LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME

• WIDTH OF LINE IS NOT TO SCALE

• ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**


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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.

DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC


HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE

TITLE

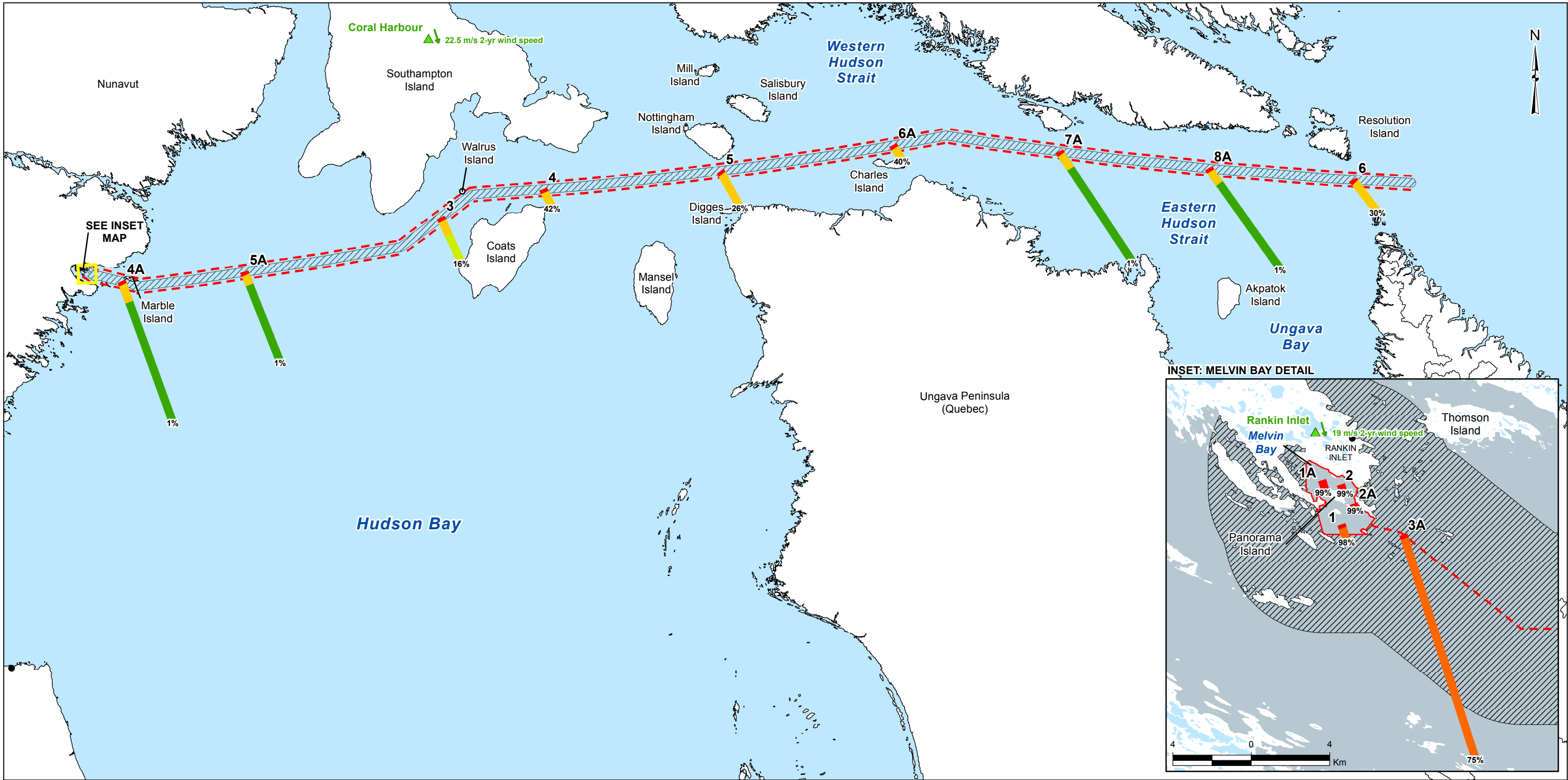
**OIL SPILL SCENARIO:  
20,000,000 L SPILL,  
MEAN WIND, NO SURFACE CURRENT**

Golder Associates

DESIGN	GC	06 Jan. 2016	FILE No.	1535029
GIS	CDB	06 Jan. 2016	SCALE AS SHOWN	REV. A
CHECK	JC	06 Jan. 2016		
REVIEW	LY	06 Jan. 2016		

**FIGURE E-16**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-17\_Oil\_Spill\_Scenario\_20ML\_2yr\_wind.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

% SPILL VOLUME REMAINING

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**


- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009


PROJECT



AGNICO EAGLE

TITLE

OIL SPILL SCENARIO:  
20,000,000 L SPILL,  
2-YR WIND, NO SURFACE CURRENT



Golder Associates

PROJECT NO.

1535029

FILE No.

DESIGN

GC

06 Jan. 2016

SCALE AS SHOWN

REV.

A

CHECK

JC

06 Jan. 2016

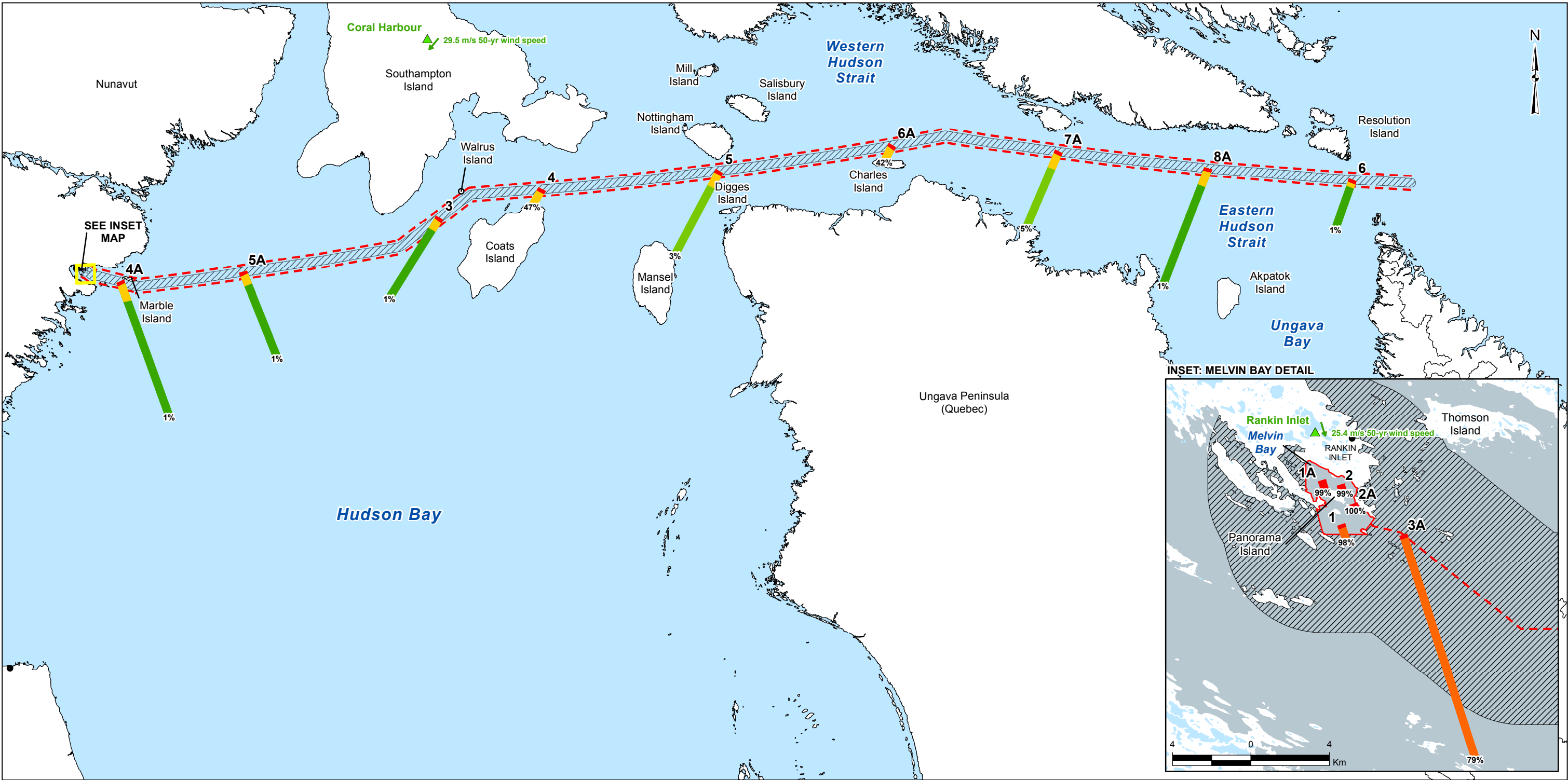
REVIEW

LY

06 Jan. 2016

FIGURE E-17

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-18\_Oil\_Spill\_Scenario\_20ML\_50yr\_wind.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

% SPILL VOLUME REMAINING

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

• LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME

• WIDTH OF LINE IS NOT TO SCALE

• ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.

DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

**OIL SPILL SCENARIO:  
20,000,000 L SPILL,  
50-YR WIND, NO SURFACE CURRENT**

Golder Associates

PROJECT NO. 1535029

FILE No.

DESIGN GC 06 Jan. 2016

SCALE AS SHOWN

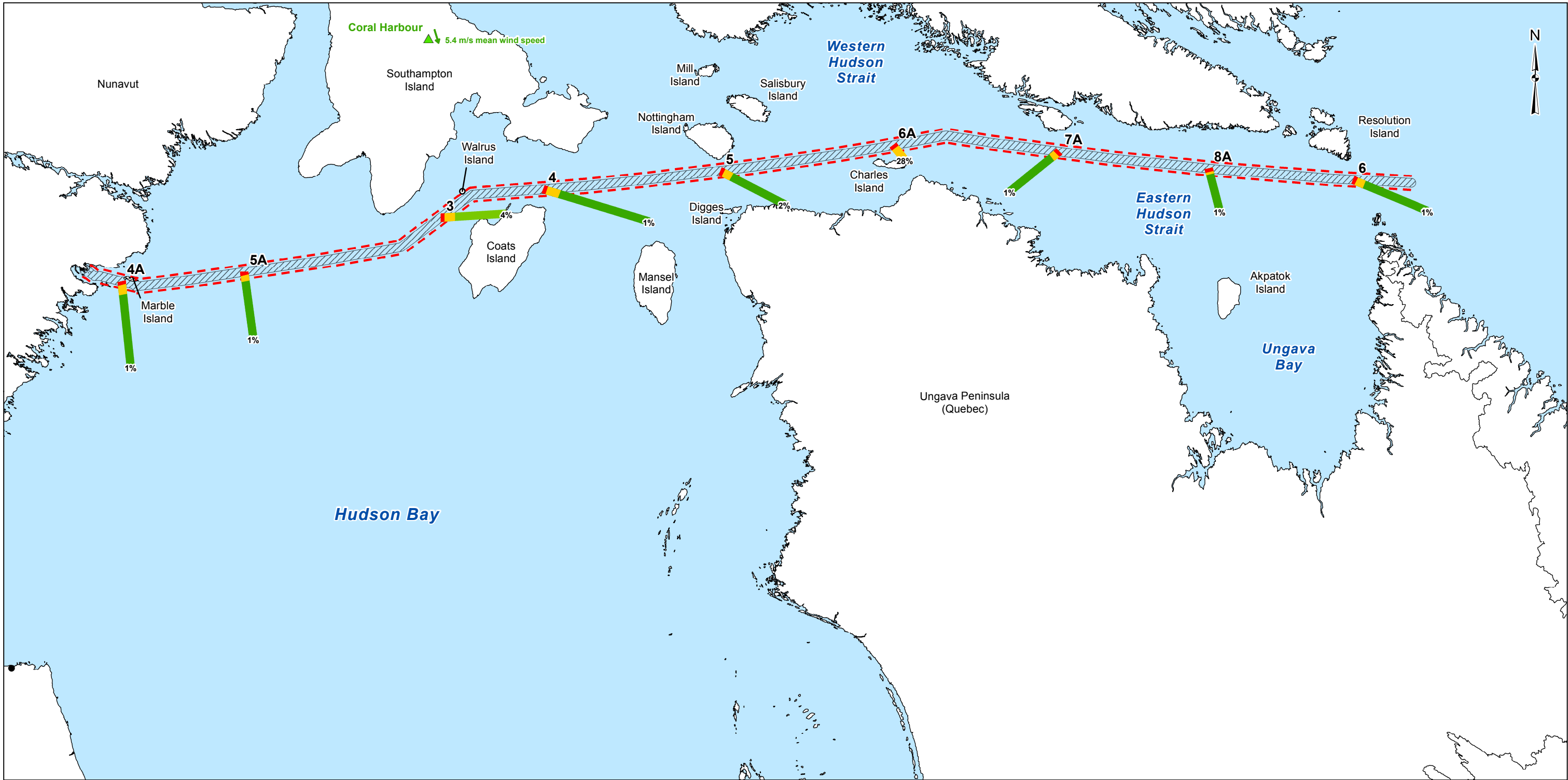
REV. A

CHECK JC 06 Jan. 2016

REVIEW LY 06 Jan. 2016

**FIGURE E-18**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECTS\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-19\_Oil\_Spill\_Scenario\_2\M\_L\_nm\_wind\_curr.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE

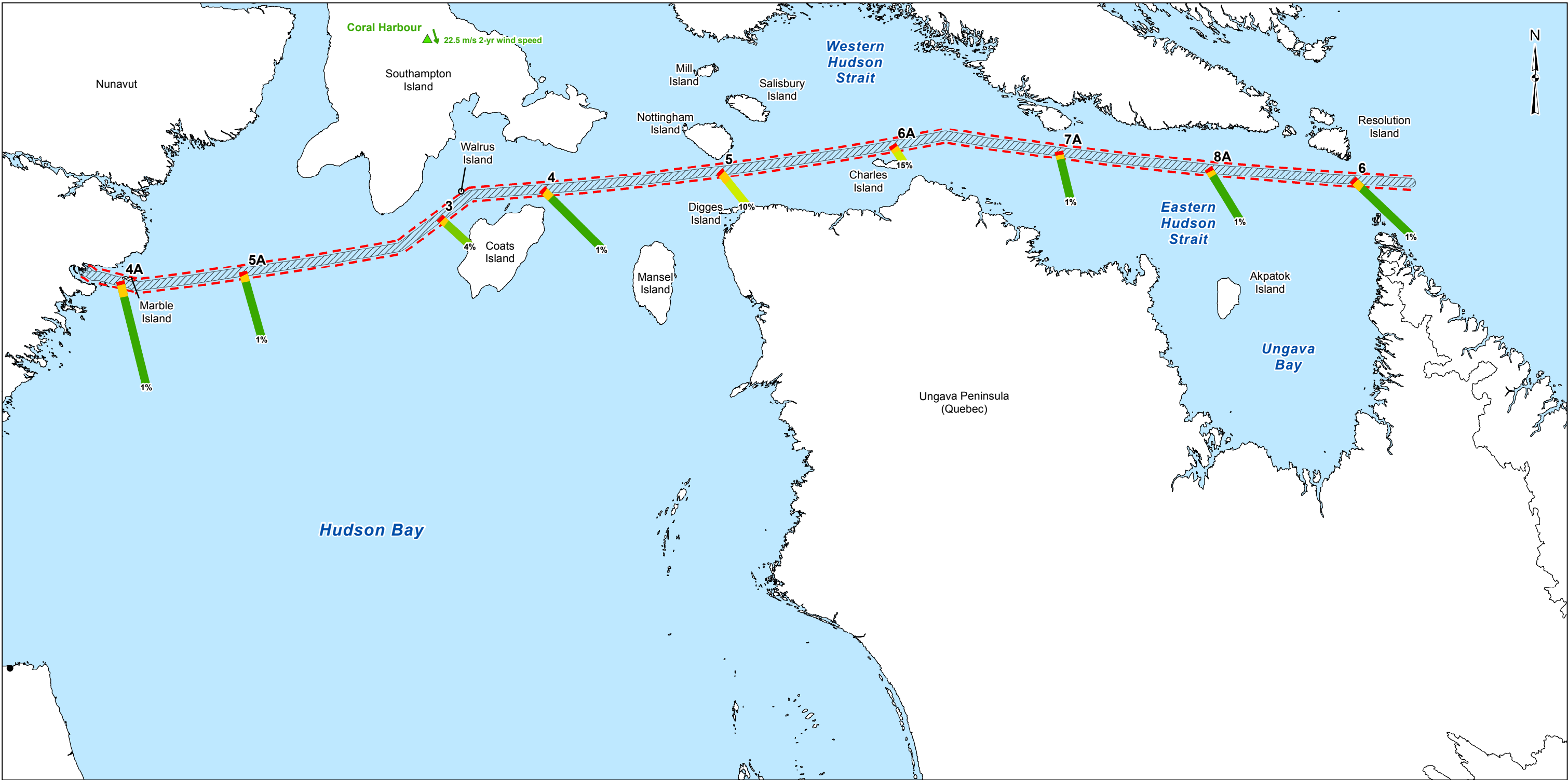
TITLE

**OIL SPILL SCENARIO:  
2,000,000 L SPILL,  
MEAN WIND, SURFACE CURRENT**

PROJECT NO.	1535029	FILE No.	
DESIGN	GC	06 Jan. 2016	SCALE AS SHOWN
GIS	CDB	06 Jan. 2016	REV. A
CHECK	JC	06 Jan. 2016	
REVIEW	LY	06 Jan. 2016	

**FIGURE E-19**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\SV\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-20\_Oil\_Spill\_Scenario\_2ML\_2yr\_wind\_curr.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

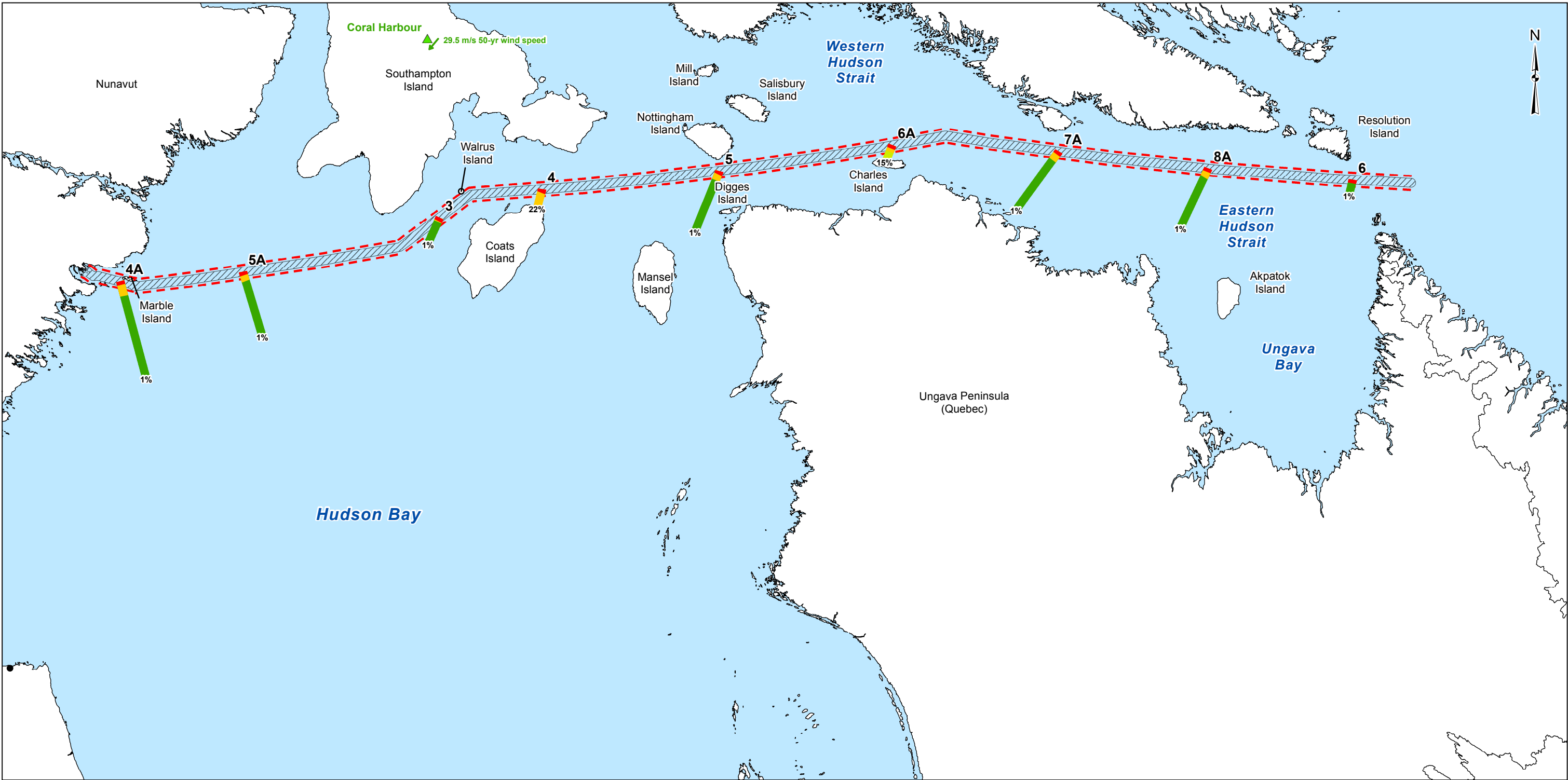
**OIL SPILL SCENARIO:  
2,000,000 L SPILL,  
2-YR WIND, SURFACE CURRENT**

PROJECT NO.	1535029	FILE No.
DESIGN	GC	06 Jan. 2016
GIS	CDB	06 Jan. 2016
CHECK	JC	06 Jan. 2016
REVIEW	LY	06 Jan. 2016

SCALE AS SHOWN  
REV. A

**FIGURE E-20**

Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECT\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000\MXD\Report\1535029\_Figure\_E-21\_Oil\_Spill\_Scenario\_2ML\_50yr\_wind\_curr.mxd



**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

% SPILL VOLUME REMAINING

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

90

0

90

KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

**OIL SPILL SCENARIO:  
2,000,000 L SPILL,  
50-YR WIND, SURFACE CURRENT**

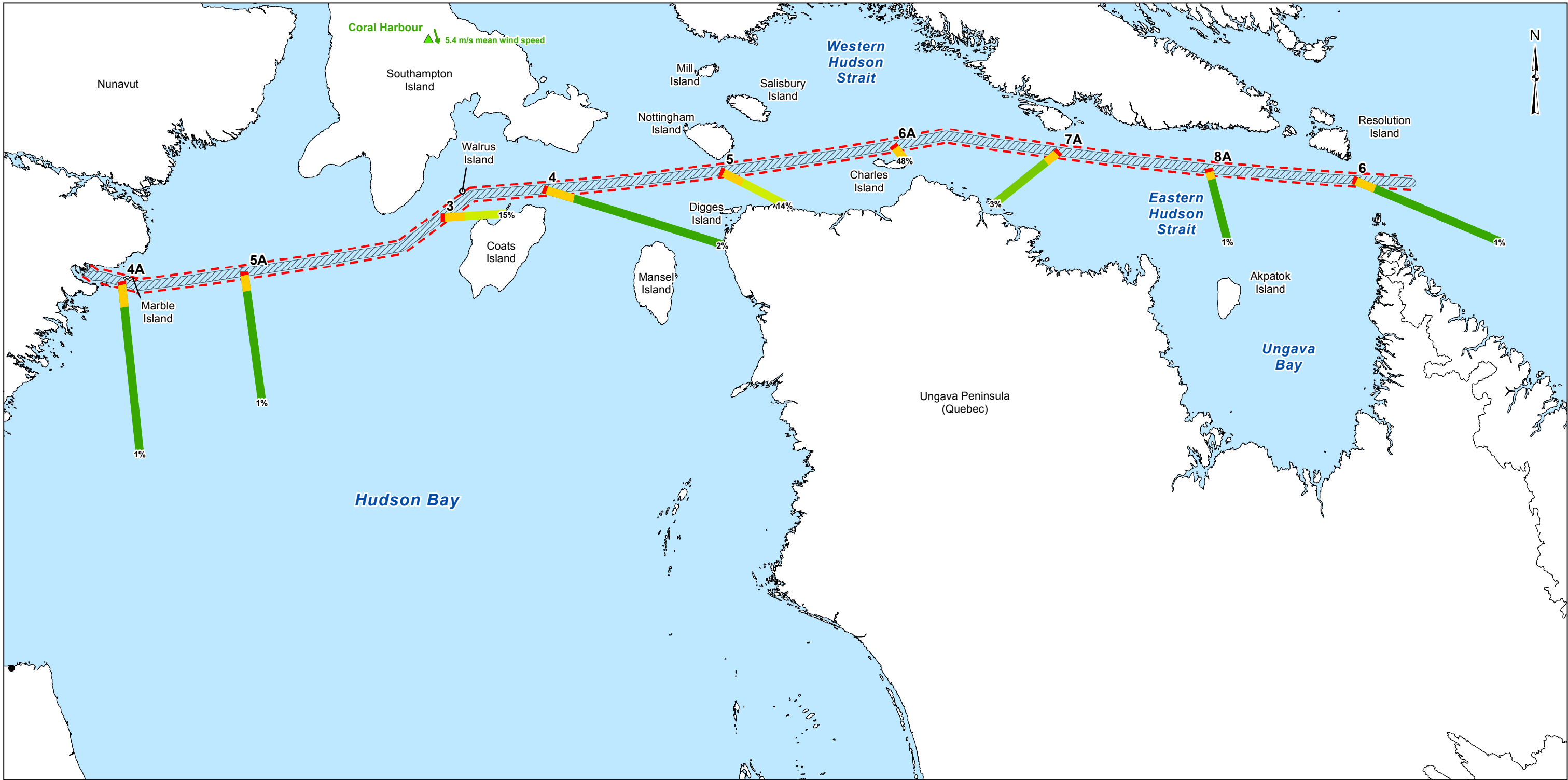
Golder Associates

PROJECT NO.	1535029	FILE No.
DESIGN	GC	06 Jan. 2016
GIS	CDB	06 Jan. 2016
CHECK	JC	06 Jan. 2016
REVIEW	LY	06 Jan. 2016

SCALE AS SHOWN | REV. A

**FIGURE E-21**

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**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

- LENGTH OF LINE REPRESENTS THE ESTIMATED TRAVEL DISTANCE FOR A GIVEN SPILL VOLUME
- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

**REFERENCE**

CANVEC DATA OBTAINED FROM © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.  
NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE

TITLE

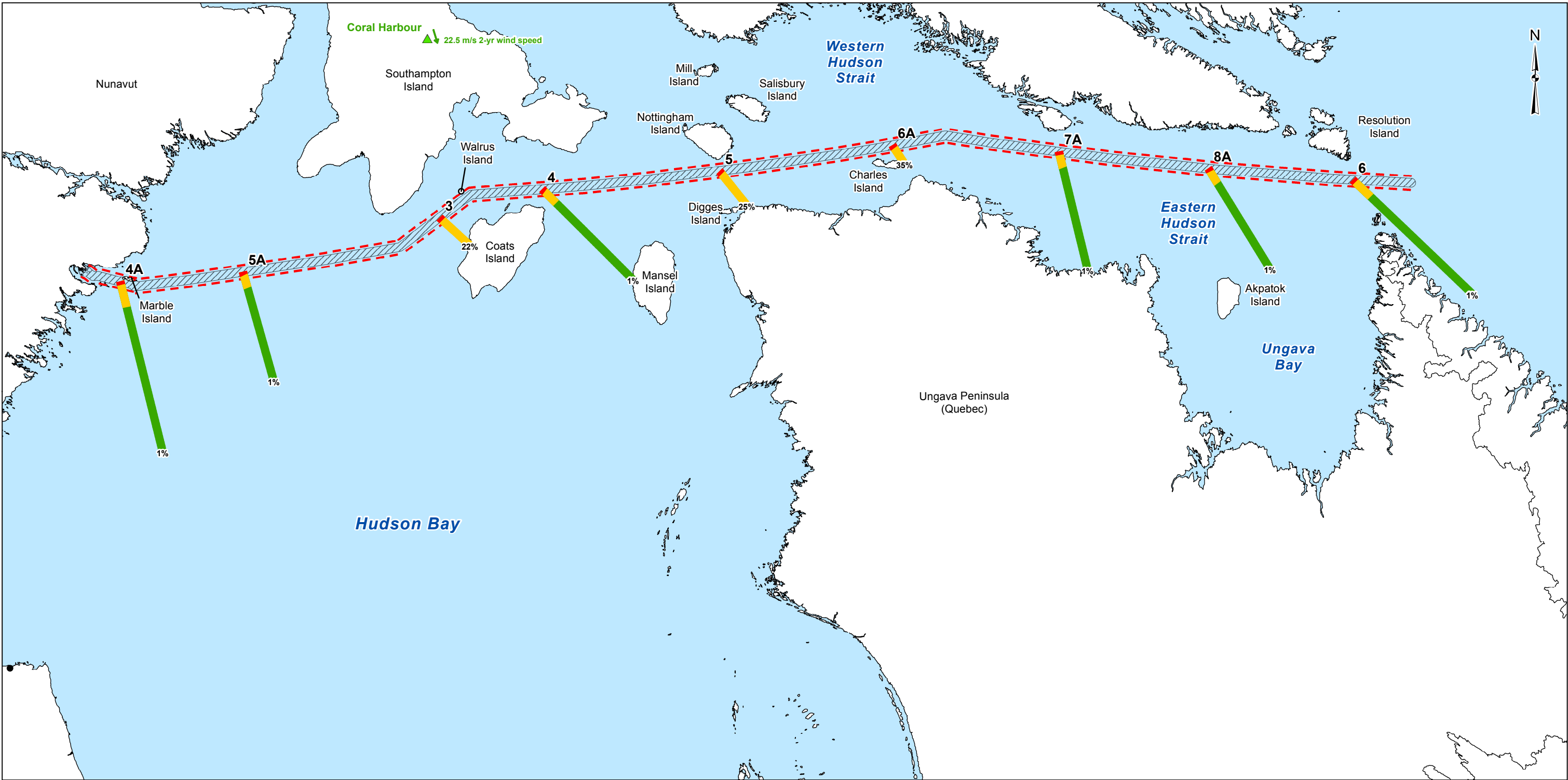
**OIL SPILL SCENARIO:  
20,000,000 L SPILL,  
MEAN WIND, SURFACE CURRENT**

PROJECT NO.	1535029	FILE No.
DESIGN	GC	06 Jan. 2016
GIS	CDB	06 Jan. 2016
CHECK	JC	06 Jan. 2016
REVIEW	LY	06 Jan. 2016

SCALE AS SHOWN	REV.	A
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**FIGURE E-22**

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**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

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- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

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DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
4	Shipping route north of Coats Island	17	456430	7000031
4A	West Hudson Bay	15	585757	6949020
5	Shipping route north of Ungava Peninsula	18	351235	6986598
5A	Hudson Bay crossing	16	416455	6950265
6	Shipping route in Eastern Hudson Strait	20	399876	6775840
6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

90

0

90

KILOMETRES

PROJECT

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

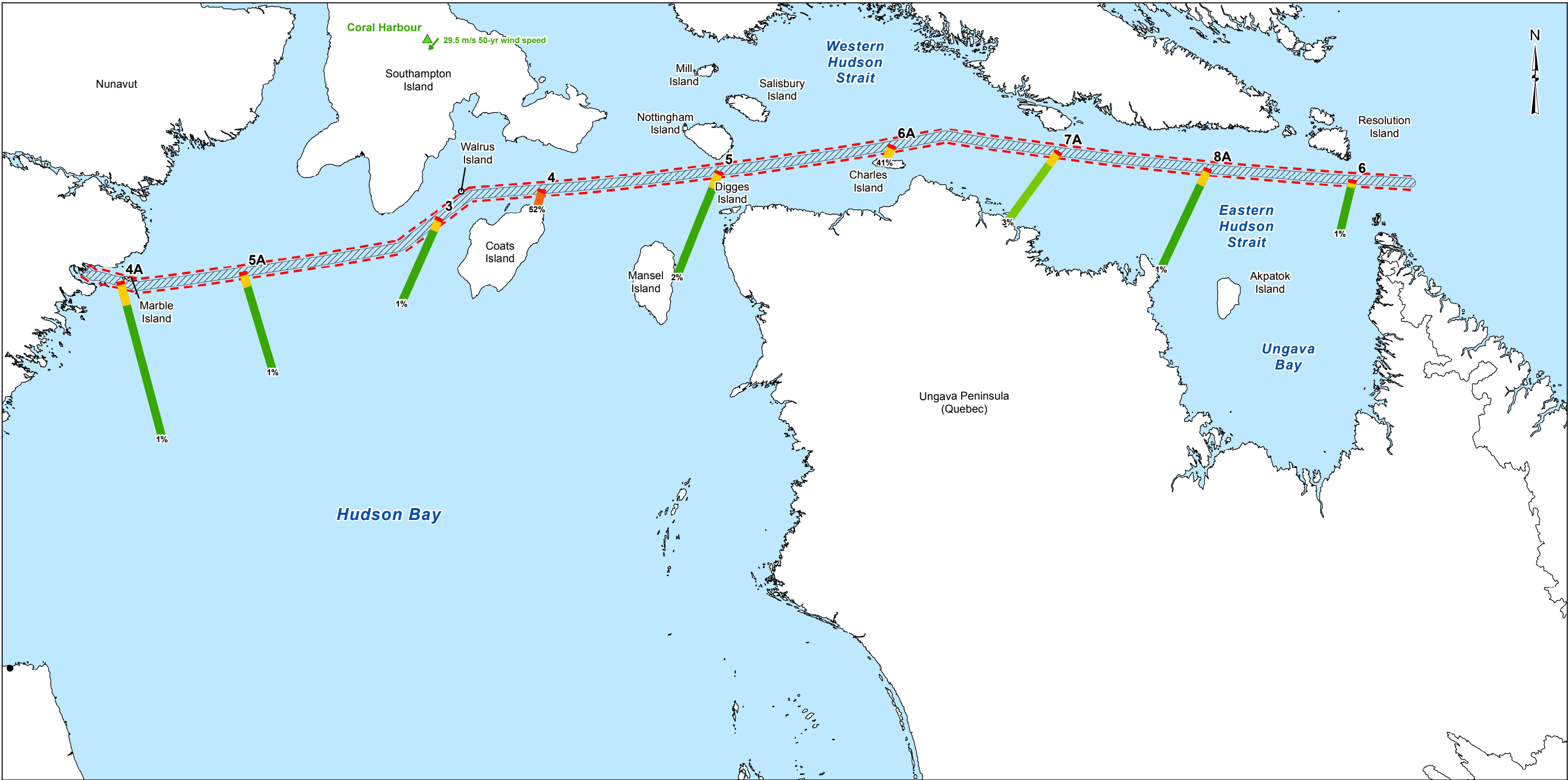
**OIL SPILL SCENARIO:  
20,000,000 L SPILL,  
2-YR WIND, SURFACE CURRENT**

PROJECT NO.	1535029	FILE No.
DESIGN	GC	06 Jan. 2016
GIS	CDB	06 Jan. 2016
CHECK	JC	06 Jan. 2016
REVIEW	LY	06 Jan. 2016

SCALE AS SHOWN  
REV. A

**FIGURE E-23**

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**LEGEND**

MARINE REGIONAL STUDY AREA (MARINE RSA)

MARINE LOCAL STUDY AREA (MARINE LSA)

WATERBODY

SHIPPING ROUTE (APPROXIMATE)

WIND STATION

WIND VECTOR (DIRECTION BLOWING TOWARDS)

98.1 - 100.0

50.1 - 98.0

20.1 - 50.0

5.1 - 20.0

2.1 - 5.0

1.0 - 2.0

**NOTES**

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- WIDTH OF LINE IS NOT TO SCALE
- ANGLE OF LINE REPRESENTS THE CALCULATED SPILL TRAJECTORY

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NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: NAD 83 PROJECTION: LAMBERT CONFORMAL CONIC

HYPOTHETICAL FUEL SPILL RELEASE LOCATION	LOCATION NAME	UTM ZONE	EASTING	NORTHING
1	Ship-to-ship fuel transfer site outside Melvin Bay	15	546173	6961117
1A	West Melvin Bay	15	545185	6963365
2	Ship-to-shore fuel transfer site in Melvin Bay	15	546143	6963142
2A	East Melvin Bay	15	546798	6962172
3	Shipping route south of Walrus Island	16	641869	6988220
3A	Entrance to Melvin Bay	15	549334	6960588
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4A	West Hudson Bay	15	585757	6949020
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5A	Hudson Bay crossing	16	416455	6950265
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6A	Western Hudson Strait, Charles Island	18	546017	6967899
7A	Mid Hudson Strait	19	415679	6911718
8A	Eastern Hudson Strait, north Ungava Bay	19	570404	6842009

PROJECT

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

**OIL SPILL SCENARIO:  
20,000,000 L SPILL,  
50-YR WIND, SURFACE CURRENT**

PROJECT NO.	1535029	FILE No.
DESIGN	GC	06 Jan. 2016
GIS	CDB	06 Jan. 2016
CHECK	JC	06 Jan. 2016
REVIEW	LY	06 Jan. 2016

SCALE AS SHOWN  
**FIGURE E-24**



### 6.3 Spills along Shipping Route

Diesel fuel spills have the potential to occur anywhere along the shipping route. For the purpose of the ADIOS2 analysis, ten (10) sites were chosen along the shipping route that correspond with either areas of the route that are in close proximity to land (e.g., pinch points) or established sensitive habitat areas for marine mammals and/or marine birds. These sites include Walrus Island, Coats Island, Ungava Peninsula and Eastern Hudson Strait (sites numbered 3 to 6); and entrance to Melvin Bay, western Hudson Bay, Hudson Bay crossing, western Hudson Strait near Charles Island, mid-point Hudson Strait, and eastern Hudson Strait north of Ungava Bay (sites numbered 3A to 8A). Tables E-4 and E-5 include the weathering half-life, time to shore, and proportion of spill deposited on shore for the 2 ML and 20 ML spill scenarios, respectively, (for mean, 2-yr, and 50-yr wind speeds). The weathering half-life was predicted to be less than 19 h for all the 2 ML scenarios and less than 34 h for all the 20 ML scenarios. Depending on the distance to shore and wind scenario, the time to shore would vary from about 4 h to 50 days for the 2 ML scenario and the amount of fuel predicted to be deposited on shore would vary from 0% to 66%. For the 20 ML scenario, the amount of fuel predicted to be deposited on shore would vary from 0% to 79%. The trajectory of the slick drift is a primary factor in the amount, if any, of fuel deposited on shore. For example, at site 3 (Walrus Island), 16% of the spill is deposited on shore for the 20 ML, 2-yr wind spill scenario because the direction of the slick drift is 163°, directly towards Coats Island. For the 50-yr wind scenario, the direction of the slick drift is 220°, towards the open water of Hudson Bay.

The influence of currents on the trajectory of the slick drift was considered using the mean currents at each site when data was available. Table E-9 provides the mean current velocity at each site, resultant wind and current vector speed and direction, distance to shore in the direction of the resultant vector, time to shore, and proportion of spill deposited on shore for the different 2 ML and 20 ML spill scenarios.

The predominant current patterns enhance the rate at which the fuel would spread across the water surface, particularly along narrower portions of the route where current speeds can be enhanced and slicks spread in the direction of the current. This typically results in the slick trajectory being altered to more parallel to the shipping route and in most cases less fuel deposited on the shore. However, in some cases, the change in trajectory results in a shorter distance to shore and a higher proportion of fuel deposited onshore.



## SPILL RISK ASSESSMENT

**Table E-9: Distance to Shore, Weathering Half-Life, Time to Shore, and Estimated Percent of Spill Deposited on Shore for 2 ML Diesel Fuel Spill Scenarios along Shipping Route**

Location (Number)	Distance to Shore (km)	Distance to Shore (km); 50-yr wind	Weathering Half-Life (h)			Time to Shore (h)			% Deposited on Shore		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
Walrus Island (3)	55	760	15.6	4.1	2.1	94.3	22.6	239	2%	2%	0%
Coats Island (4)	23	22	14.7	4.9	3.7	39.4	9.5	6.9	16%	26%	27%
Ungava Peninsula (5)	46	106	18.5	5.8	3.8	78.9	18.9	33.3	5%	10%	0%
Eastern Hudson Strait (6)	46	325	17.0	5.3	0.9	78.9	18.9	102	4%	8%	0%
Entrance to Melvin Bay (3A)	12	N/A	17.5	8.7	7.4	16.8	5.8	4.4	51%	63%	66%
West Hudson Bay (4A)	700	N/A	13.3	7.6	5.5	982	341	255	0%	0%	0%
Hudson Bay crossing (5A)	857	N/A	10.4	4.9	3.7	1202	417	312	0%	0%	0%
Western Hudson Strait, Charles Island (6A)	20	21	14.8	3.5	2.6	34.3	8.2	6.6	20%	20%	17%
Mid-Hudson Strait (7A)	160	93	15.6	4.2	3.4	274	65.8	29.2	0%	0%	0%
Eastern Hudson Strait, north Ungava Bay (8A)	305	164	15.6	4.5	3.4	523	126	51.5	0%	0%	0%

Notes:  
km (kilometre); yr (year); h(hour); L (liter)



## SPILL RISK ASSESSMENT

**Table E-10: Distance to Shore, Weathering Half-Life, Time to Shore, and Estimated Percent of Spill Deposited on Shore for 20 ML Diesel Fuel Spill Scenarios along Shipping Route**

Location (Number)	Distance to Shore (km)	Distance to Shore (km); 50-yr wind	Weathering Half-Life (h)			Time to Shore (h)			% Deposited on Shore		
			Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
Walrus Island (3)	55	760	26.8	8.7	5	94.3	22.6	239	9%	16%	0%
Coats Island (4)	23	22	28.7	7.6	6.4	39.4	9.5	6.9	39%	42%	47%
Ungava Peninsula (5)	46	106	37	9.7	6.4	78.9	18.9	33.3	23%	26%	3%
Eastern Hudson Strait (6)	46	325	33.7	10.9	2.8	78.9	18.9	102	20%	30%	0%
Entrance to Melvin Bay (3A)	12	N/A	32.8	14.4	12.7	16.8	5.8	4.4	70%	75%	79%
West Hudson Bay (4A)	700	N/A	26.8	12.4	8.9	982	341	255	0%	0%	0%
Hudson Bay crossing (5A)	857	N/A	20.3	8	5.7	1202	417	312	0%	0%	0%
Western Hudson Strait, Charles Island (6A)	20	21	26	6.2	5.3	34.3	8.2	6.6	40%	40%	42%
Mid-Hudson Strait (7A)	160	93	26.8	9.3	6.7	274	65.8	29.2	0%	1%	5%
Eastern Hudson Strait, north Ungava Bay (8A)	305	164	26.8	8.7	6.7	523	126	51.5	0%	0%	0%

Notes:  
km (kilometre); yr (year); h(hour); L (liter)



## SPILL RISK ASSESSMENT

**Table E-11: Weathering Half Life and Time to Shore for 2 ML and 20 ML Diesel Fuel Spill Scenarios along Shipping Route with Currents**

Location (Number)	Mean Current		Vector Sum Speed (Direction), m/s and deg			Distance to Shore (km)			Time to Shore (h)			% Deposited on Shore 2 ML			% Deposited on Shore 20 ML		
	Speed (m/s)	Dir (deg)	Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr	Mean	2-yr	50-yr
Walrus Island (3)	0.45 <sup>(a)</sup>	60	0.3(94)	0.7 (140)	0.6 (212)	74	46	732	73.1	19.0	316	4%	4%	0%	15%	22%	0%
Coats Island (4)	0.45 <sup>(a)</sup>	90	0.4 (116)	0.8(144)	0.7 (204)	211	144	22	167	49.9	8.2	0%	0%	22%	2%	1%	52%
Ungava Peninsula (5)	0.2 <sup>(b)</sup>	80	0.2 (129)	0.7 (153)	0.8 (214)	81	49	127	106	19.3	44.0	2%	10%	0%	14%	25%	2%
Eastern Hudson Strait (6)	0.2 <sup>(b)</sup>	90	0.2 (133)	0.7 (154)	0.8 (214)	1000	354	33	1227	136	113	0%	0%	0%	0%	0%	0%
West Hudson Bay (4A)	0.2 <sup>(c)</sup>	200	0.3 (177)	0.7 (169)	0.9 (168)	600	650	652	547	270	210	0%	0%	0%	0%	0%	0%
Hudson Bay crossing (5A)	0.2 <sup>(c)</sup>	200	0.3 (177)	0.7 (169)	0.9 (168)	684	784	789	623	325	255	0%	0%	0%	0%	0%	0%
Western Hudson Strait, Charles Island (6A)	0.2 <sup>(b)</sup>	135	0.2 (155)	0.7 (161)	0.9 (216)	21	25	23	27.2	9.5	6.8	28%	15%	15%	48%	35%	41%
Mid-Hudson Strait (7A)	0.4 <sup>(b)</sup>	290	0.2 (248)	0.6 (183)	1.0 (233)	92	138	97	133	67.4	27.0	0%	0%	0%	3%	1%	3%
Eastern Hudson Strait, north Ungava Bay (8A)	0.1 <sup>(b)</sup>	290	0.1 (184)	0.6 (167)	0.9 (224)	134	319	125	280	137	38.1	0%	0%	0%	0%	0%	1%

Notes:

km (kilometre); yr (year); dir (direction); ML(million litres); m/s (metres per second); N/A (not available)

<sup>a</sup> DFO (2015); mooring H9

<sup>b</sup> Drinkwater (1986)

<sup>c</sup> DFO (2015); mooring H7



### 6.4 Discussion of Mapped Results

Maps representing the results of the hypothetical spill scenarios are presented in Figure E-13 through Figure E-24. The maps are provided for the 2 ML and 20 ML spill scenarios, three (mean, 2-yr, and 50-yr) wind scenarios, and with and without currents. Each map shows the estimated trajectory of the spill at the fourteen locations based on the wind and current for the given scenario and the spill volume remaining (percentage) at a given distance based on the weathering results from the ADIOS2 model. The percentage of the spill volume remaining is shown by the color ramp gradation from red (more remaining) to green (less remaining). The extent of the slick drift is shown at the start of the spill (100% volume), at one half-life (50% spill volume remaining), and when the slick reaches shore or is weathered to 1% of the spill volume remaining (whichever occurs first). If the slick is estimated to reach shore, the percentage of the spill volume remaining is labeled at this location. In some cases, particularly in Melvin Bay, the spill reaches shore quickly and only two colored lines are shown on the map. Wind vectors are also provided for each scenario to illustrate the wind direction and speed used for a given map scenario.

There is a slight apparent difference in spill trajectory angles between the westernmost points when compared to the easternmost points despite scenarios that use the same wind direction. This slight apparent difference in spill trajectory angles is a function of the map projection extending over a large area and over multiple UTM zones and is therefore a projection distortion rather than a measureable difference in trajectory.

It is important to consider these maps as a depiction of the potential fuel spill trajectory and percent remaining at a coarse scale under a very specific set of climate conditions. As noted on the maps, the length of the fuel spill path represents the estimated travel distance and the angle represents the calculated spill trajectory given the specific wind, current, and spill volume conditions bracketed by each spill scenario. The actual distance travelled and the angle of the spill trajectory will be highly dependent on the site-specific ambient conditions and the nature and location of the spill at the time of a potential spill. In general, the width of a fuel spill at land fall and the length of shoreline that could potentially be affected by a given fuel spill is difficult to estimate due to the high degree of uncertainty related to the spreading of a slick (DNV 2011).

A summary of the mapped scenarios follows:

- The dominant slick drift trajectory for the modelled scenarios is towards the south-southeast (163°) for all scenarios without currents except for the 50-yr wind scenario at sites east of site 5A, where it is towards the southwest (220°). The south-southeast trajectory results in a slick trajectory headed towards open water at sites 4A, 5A, 7A, and 8A. At sites in Melvin Bay (1, 2, 1A, and 2A) the fuel slick reach shore within a few hours. Trajectory at these sites is less important as they are almost entirely bounded by land, resulting in a majority of the spill reaching land in any direction. At sites 3A, 3, 4, 5, 6A, and 6, the slick is estimated to reach shore with 50% or less of the spill volume remaining.
- The 50-yr wind scenario at sites 3 and sites further east results in a slick trajectory to the southwest (220°). Under this scenario a slick at site 3 would head towards open water and sites 5 and 6 would have a longer distance to travel to shore than for the other wind scenarios. Differences in the direction to shore for slicks originating at sites 4, 6A, 7A, and 8A are minimal between wind scenarios.
- The percentage of the fuel deposited on shore increases for the 20 ML spill scenario versus the 2 ML spill scenario because of the increase in the weathering half-life.



- The addition of mean currents in the modelling typically results in altering the slick trajectory to a more parallel orientation to the shipping route and in most cases less fuel deposited on the shore. However in some cases the trajectory results in a shorter distance to shore and more fuel deposited on the shore. For example, at site 6 the trajectory of the spill drift is altered when an eastward current is considered such that the slick heads towards open water rather than south-southeast towards land in close proximity. Conversely, for site 3, 9% of a 20 ML spill volume is estimated to reach shore for the mean wind and no surface current scenario, but due to the orientation of the shipping route with respect to Coats Island, 15% of the spill volume is estimated to reach shore when the surface current is considered. Similarly, site 6A increases from 20% to 28%, and site 7A increases from 1% to 3% with the addition of the current forcing.

## 7.0 CONCLUSIONS

Although diesel spills have a low likelihood of occurrence, it is important to understand where the spill will travel and the best way to mitigate impacts. Based on the total amount of diesel fuel transported and predicted spill rates reported by SL Ross (1999), the overall likelihood of a fuel spill ranges from a return period of 285 years (i.e., one spill approximately every 285 years) for small spills (10 to 99.9 m<sup>3</sup>) to 920 years for medium spills (100 to 999.9 m<sup>3</sup>) and 92,000 years for large spills (1,000 to 9999.9 m<sup>3</sup>) (WSP 2014a). If a spill was to occur near Melvin Bay, it is predicted that for all spills, a majority of the fuel would reach the nearby shoreline within several hours without mitigation efforts. If a spill was to occur along the shipping route, the amount of weathered fuel, the trajectory of the slick, and amount deposited on shore varies by site and wind and current scenario. The different spill scenarios are provided in summary tables in Sections 6.2 and 6.3 and presented in oil spill projection maps in Appendix C. Proximity of land in the direction of the slick drift is a primary consideration for the potential for fuel to be deposited on shore. The inclusion of mean currents in the modelling typically results in reorienting the slick trajectory along an alignment that is more parallel to the shipping route and in most cases this results in less fuel deposited on the shore, with the exception of sites 3, 6A, and 7 where there is an increase in percentage (of about 2% to 8%) of remaining fuel that reaches the shore.

An important consideration when interpreting the hypothetical fuel spill scenarios is the relative response times. Without mitigation, a spill in Melvin Bay is estimated to reach shore relatively quickly and with a higher proportion of the spill reaching shore before being naturally dispersed, however, there is potential for a more rapid spill response in this area. Open water spills along the shipping route are predicted to be less severe in most cases, but the potential response time is slower due to the distance offshore. As part of the Oil Pollution Emergency Plan (SD 8-2), AEM has committed to pre-emptive and responsive mitigation actions to reduce or minimize the loss of diesel fuel during ship-to-ship and ship-to-shore transfers near Melvin Bay.

This analysis has been conducted to assess the potential for impacts associated with a diesel fuel spill in the marine environment. The ADIOS2 model was used with the input of local wind speed to approximate wave conditions and then predict the weathering half-life of the fuel. This is a one-dimensional analysis and does not account for other site-specific effects such as modifications to the wave height, period and direction due to local bathymetry. Therefore it is an approximation of the travel time and percent diesel fuel remaining to be used for planning and decision making purposes.



### 8.0 CLOSURE

We trust that this report meets your immediate requirements. If you have any questions regarding the content of this report, please do not hesitate to contact this office.

#### GOLDER ASSOCIATES LTD.

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Senior Coastal Oceanographer

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Associate, Senior Coastal and Ocean Engineer

KC/GC.JC/asd

[https://capws.golder.com/sites/capws2/1114280011meliadine/type a water license/5\\_post-submission/project certificate conditions/shipping management plan/appendix e - spill risk assessment/552-1535029-r-reva-sd8-1-appespill risk assmt.docx](https://capws.golder.com/sites/capws2/1114280011meliadine/type%20a%20water%20license/5_post-submission/project%20certificate%20conditions/shipping%20management%20plan/appendix%20e%20-%20spill%20risk%20assessment/552-1535029-r-reva-sd8-1-appespill%20risk%20assmt.docx)



### 9.0 REFERENCES

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# **ATTACHMENT A**

## **ADIOS2 Hypothetical Spill Modelling Inputs and Outputs**



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

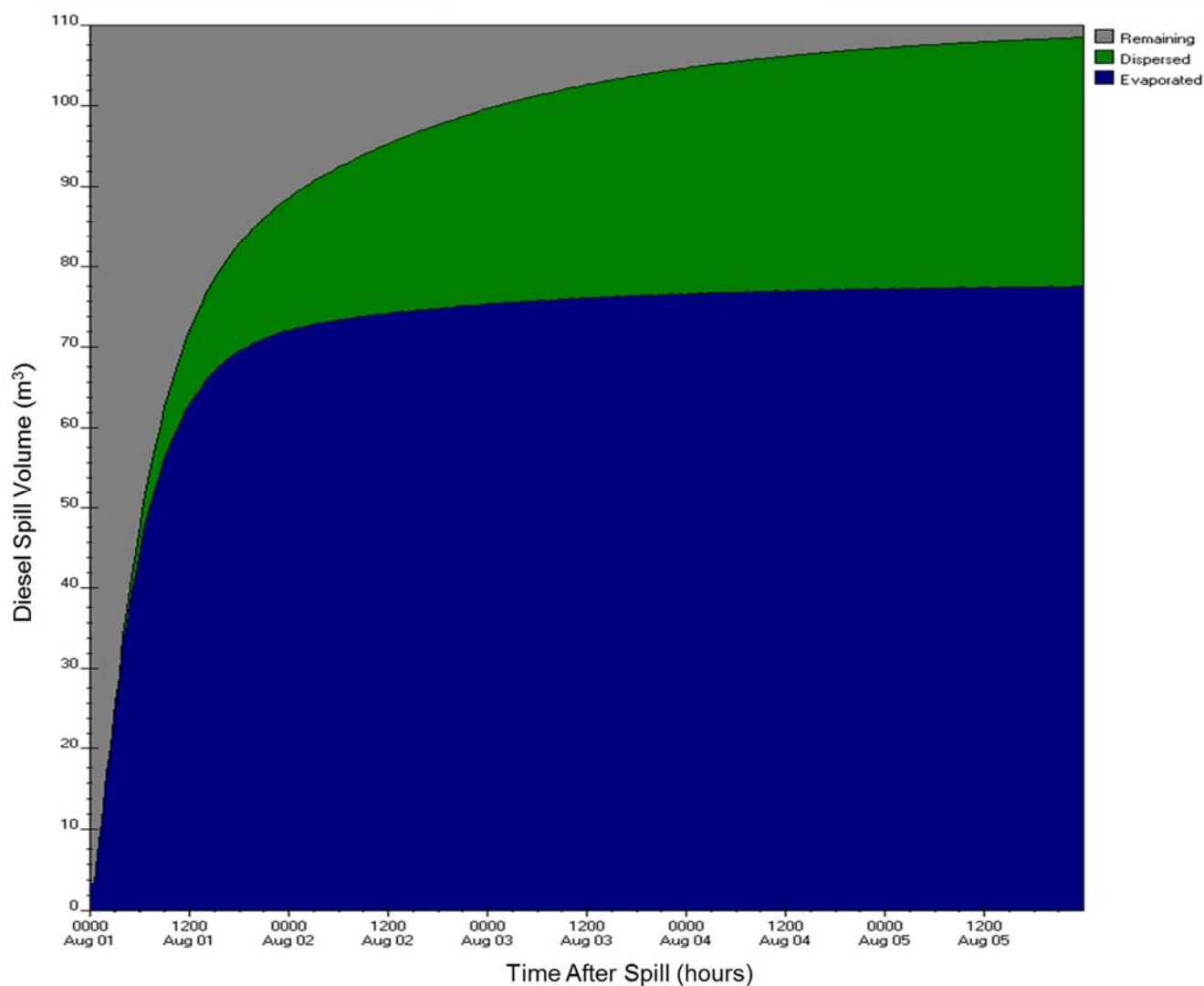


Figure E-A1: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 100 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

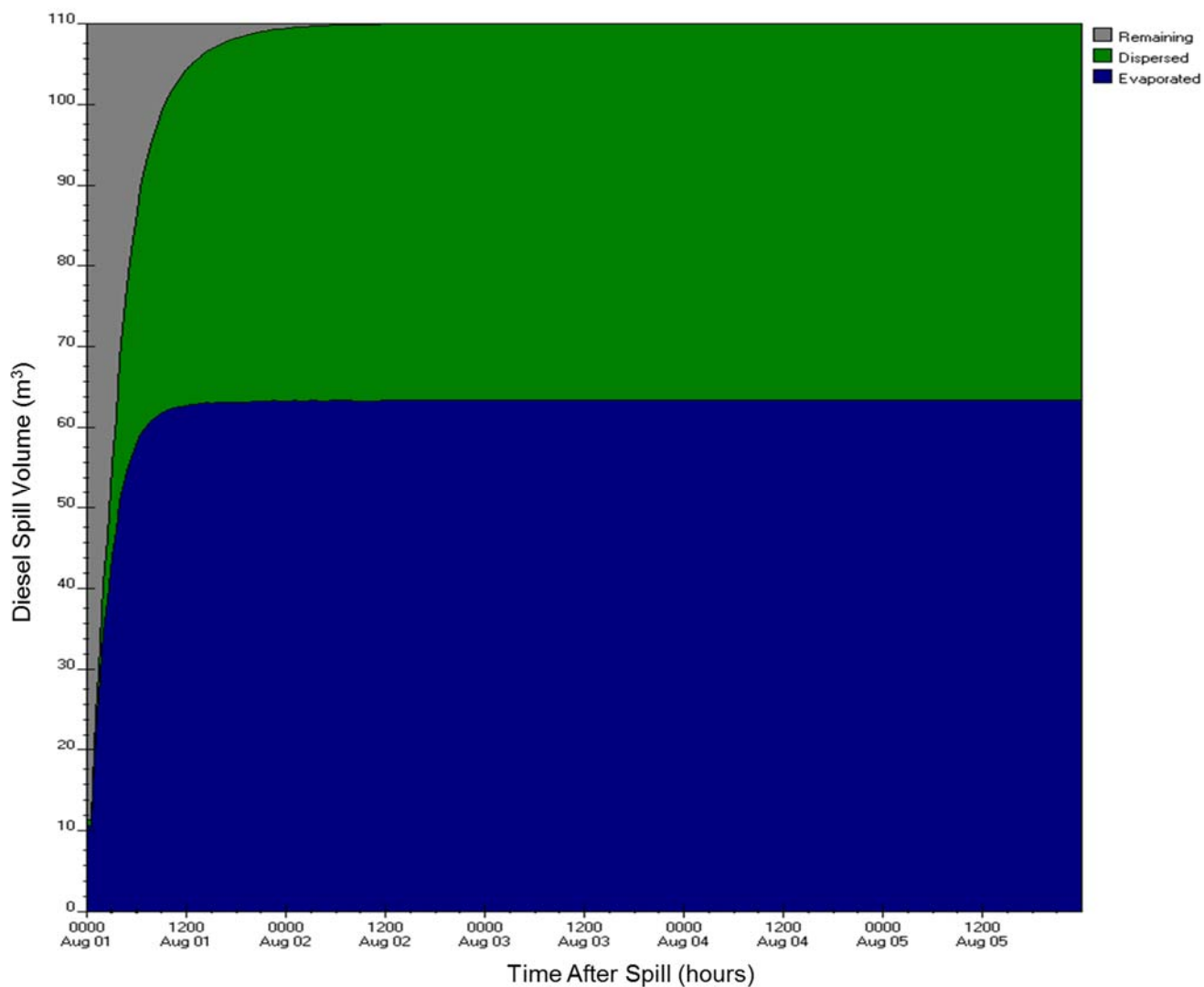


Figure E-A2: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 100 m<sup>3</sup>, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

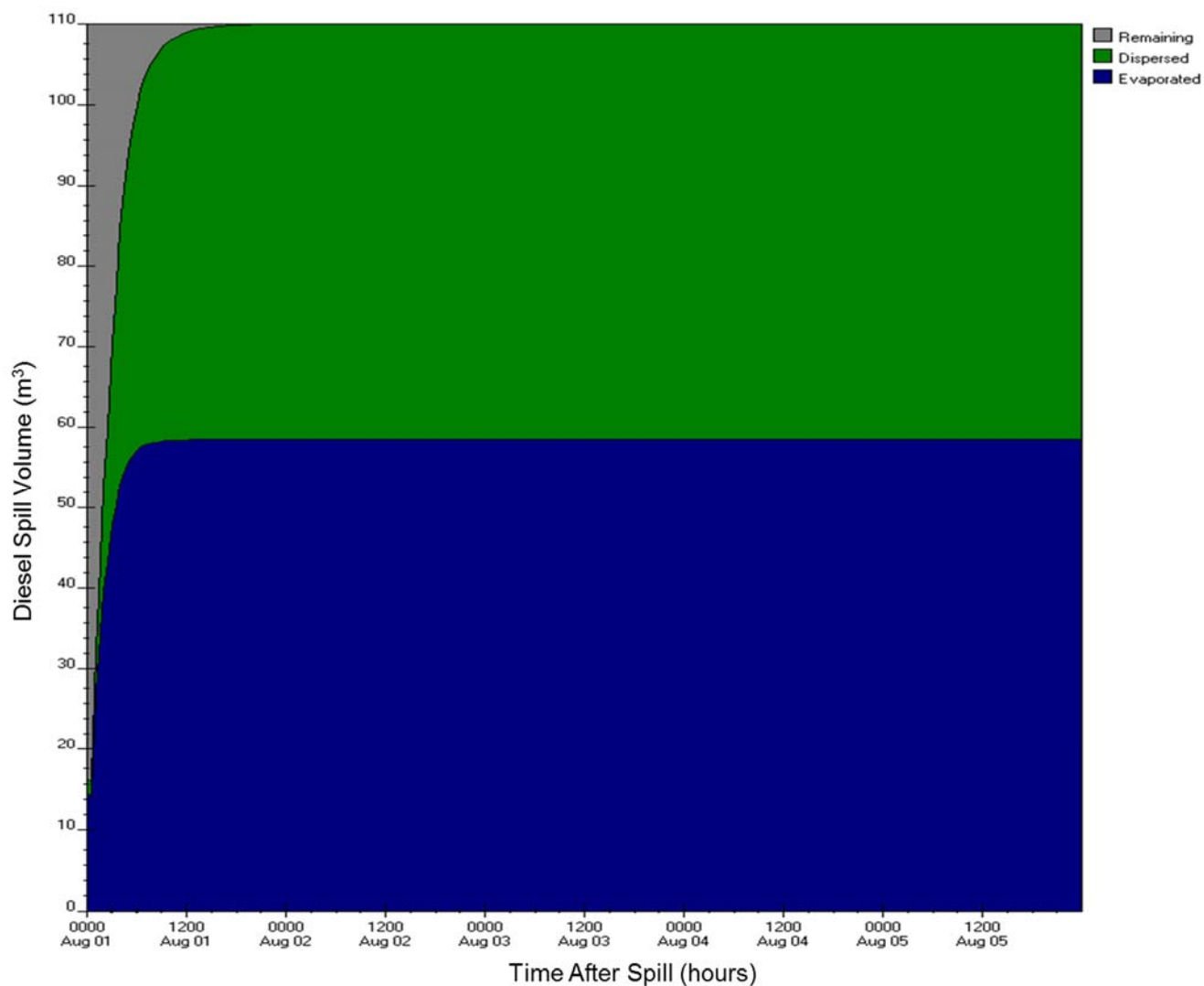


Figure E-A3: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 100 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

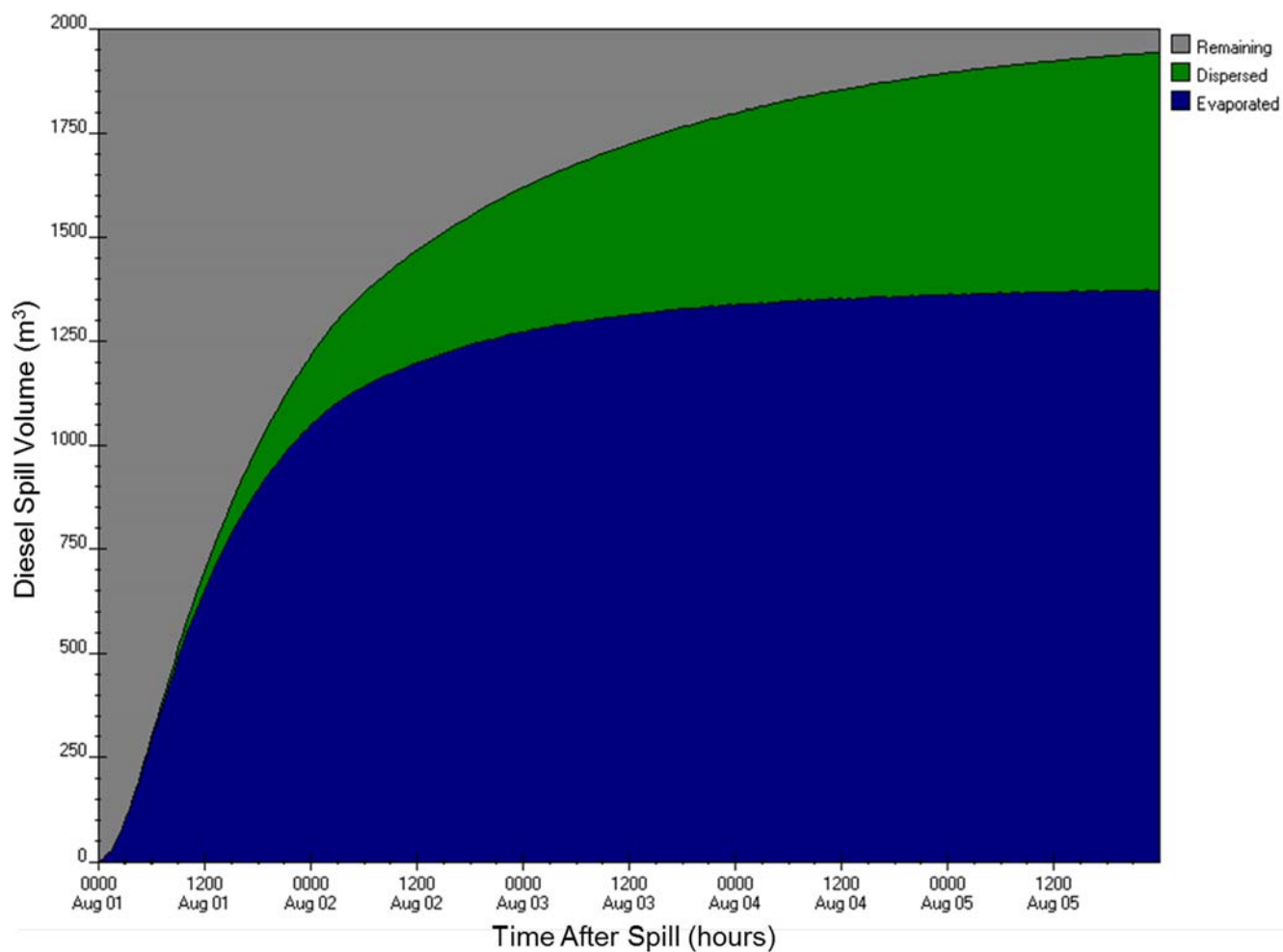


Figure E-A4: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 2,000 m³ spill, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

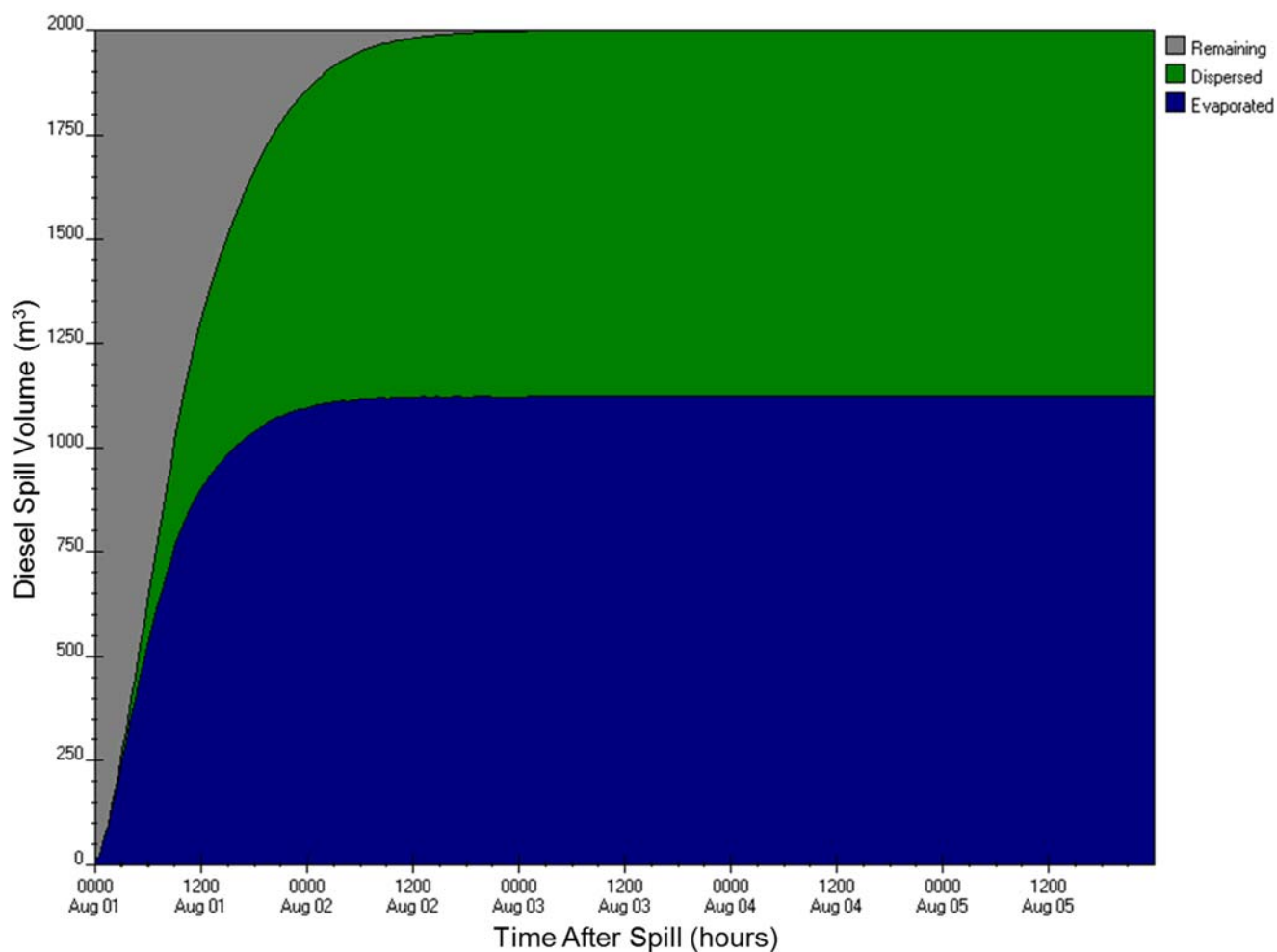


Figure E-A5: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

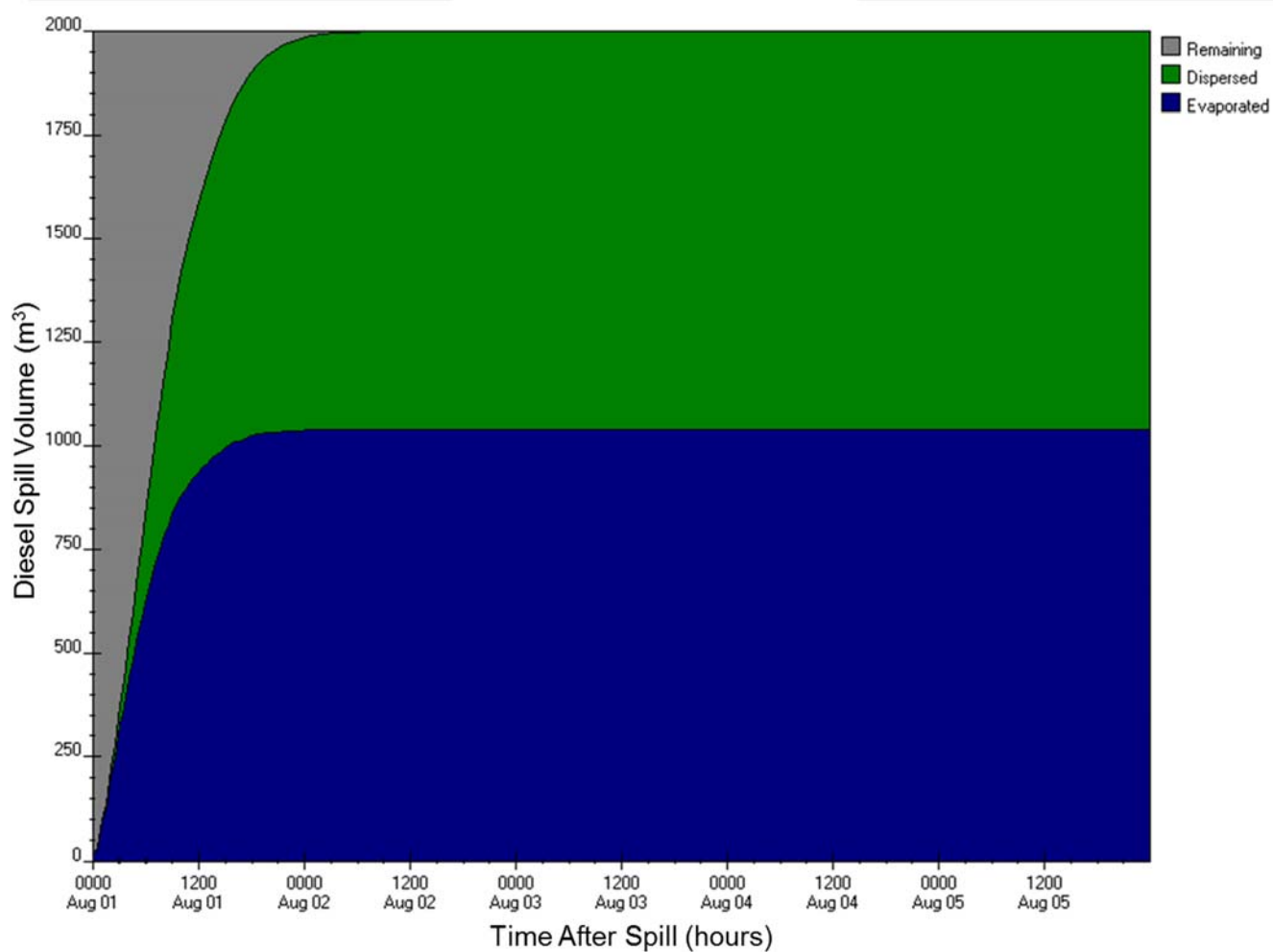


Figure E-A6: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

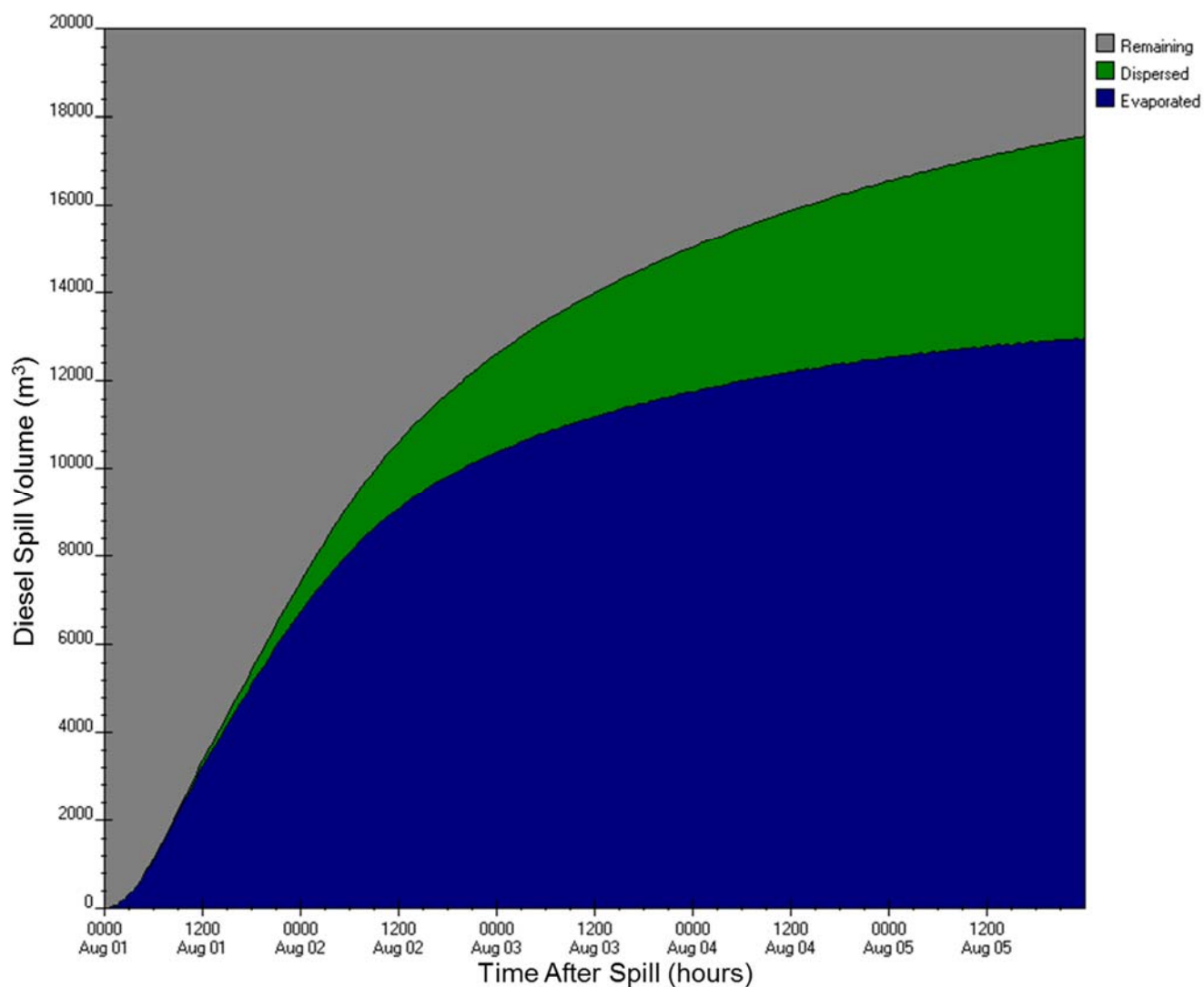


Figure E-A7: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 20,000 m³ spill, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

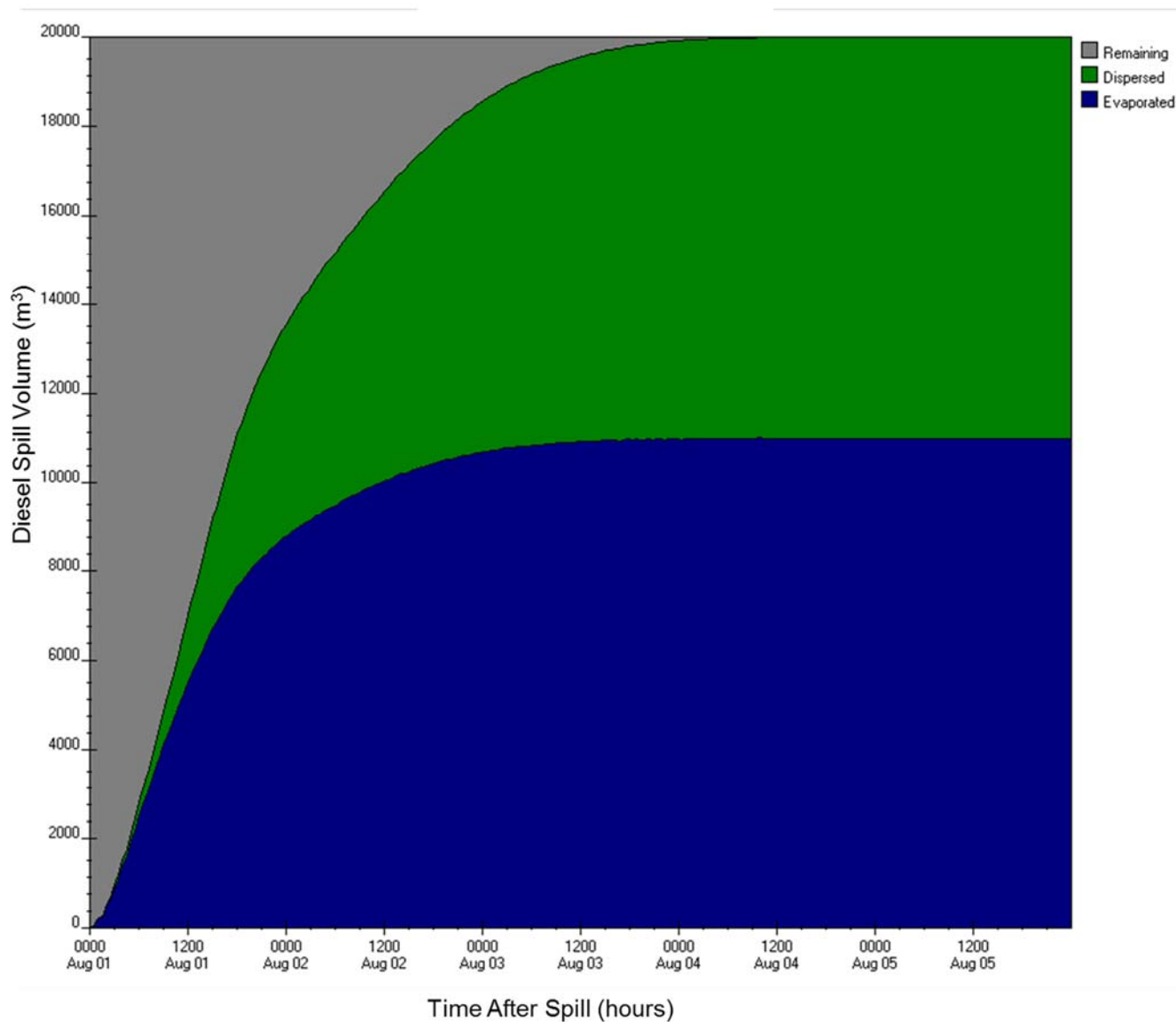


Figure E-A8: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 20,000 m<sup>3</sup>, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

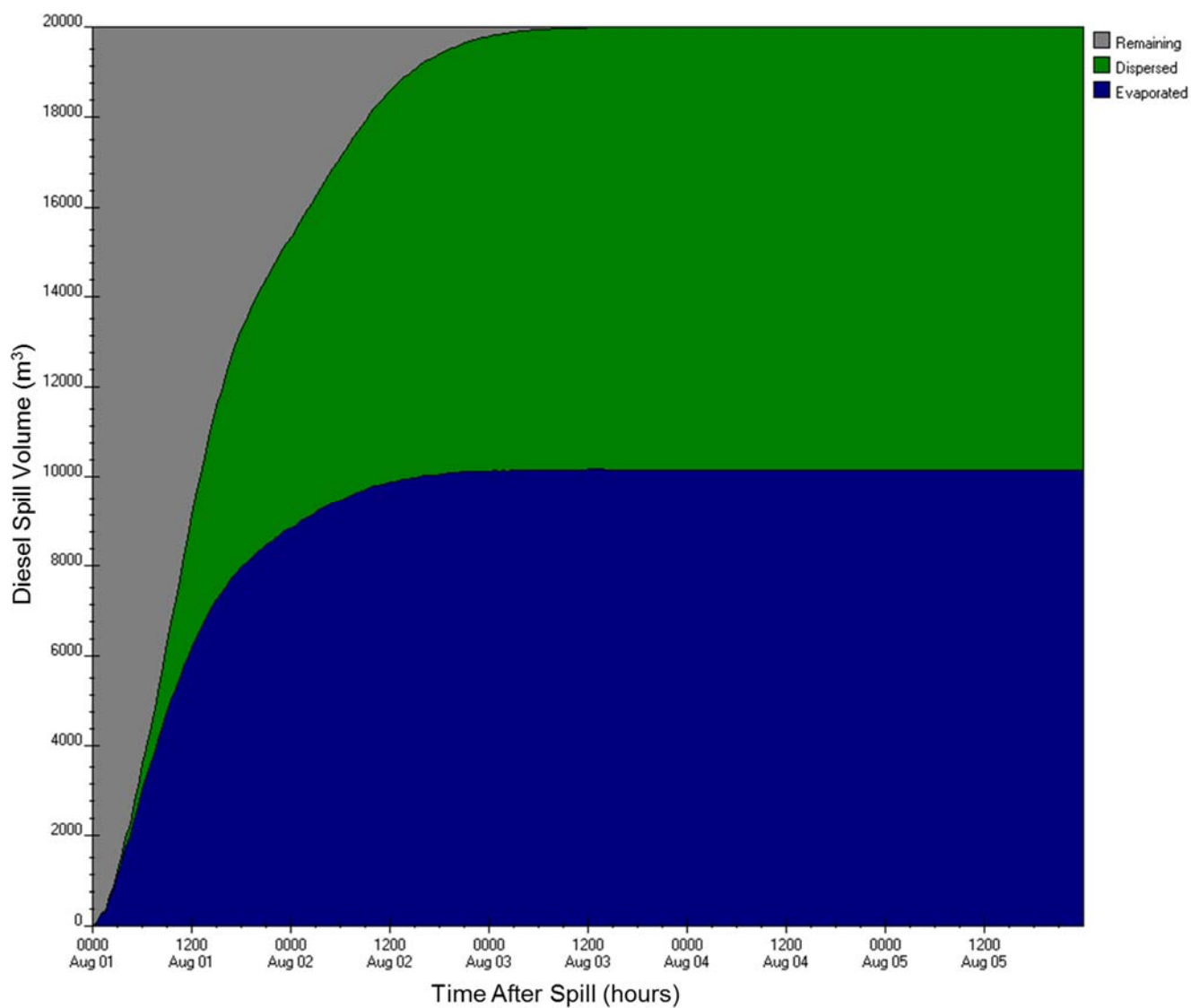


Figure E-A9: ADIOS2 diesel fuel budget output for two fuel transfer stations (1 and 2) near Melvin Bay for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

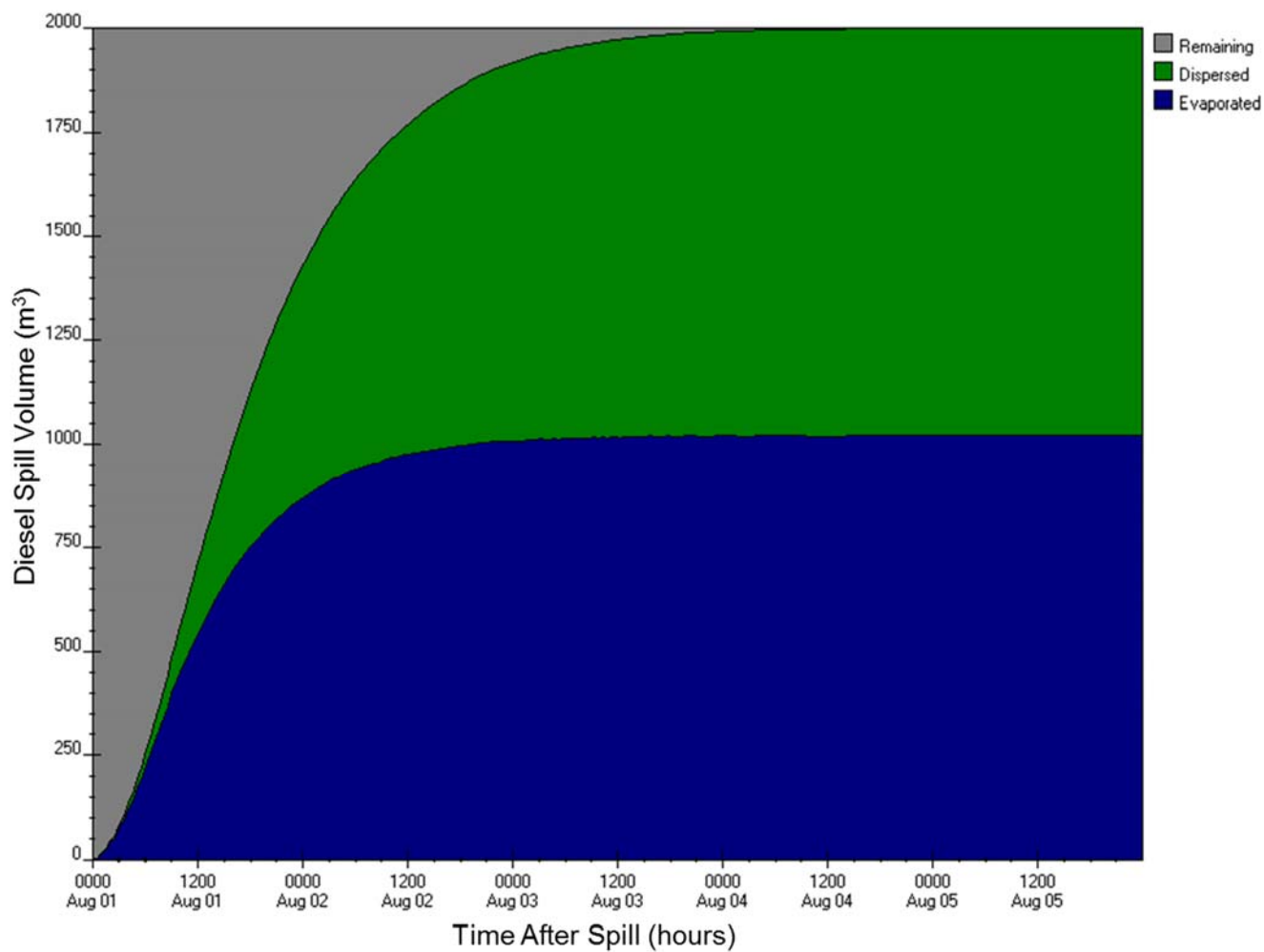


Figure 8E-A10: ADIOS2 diesel fuel budget output for Walrus Island station (3) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

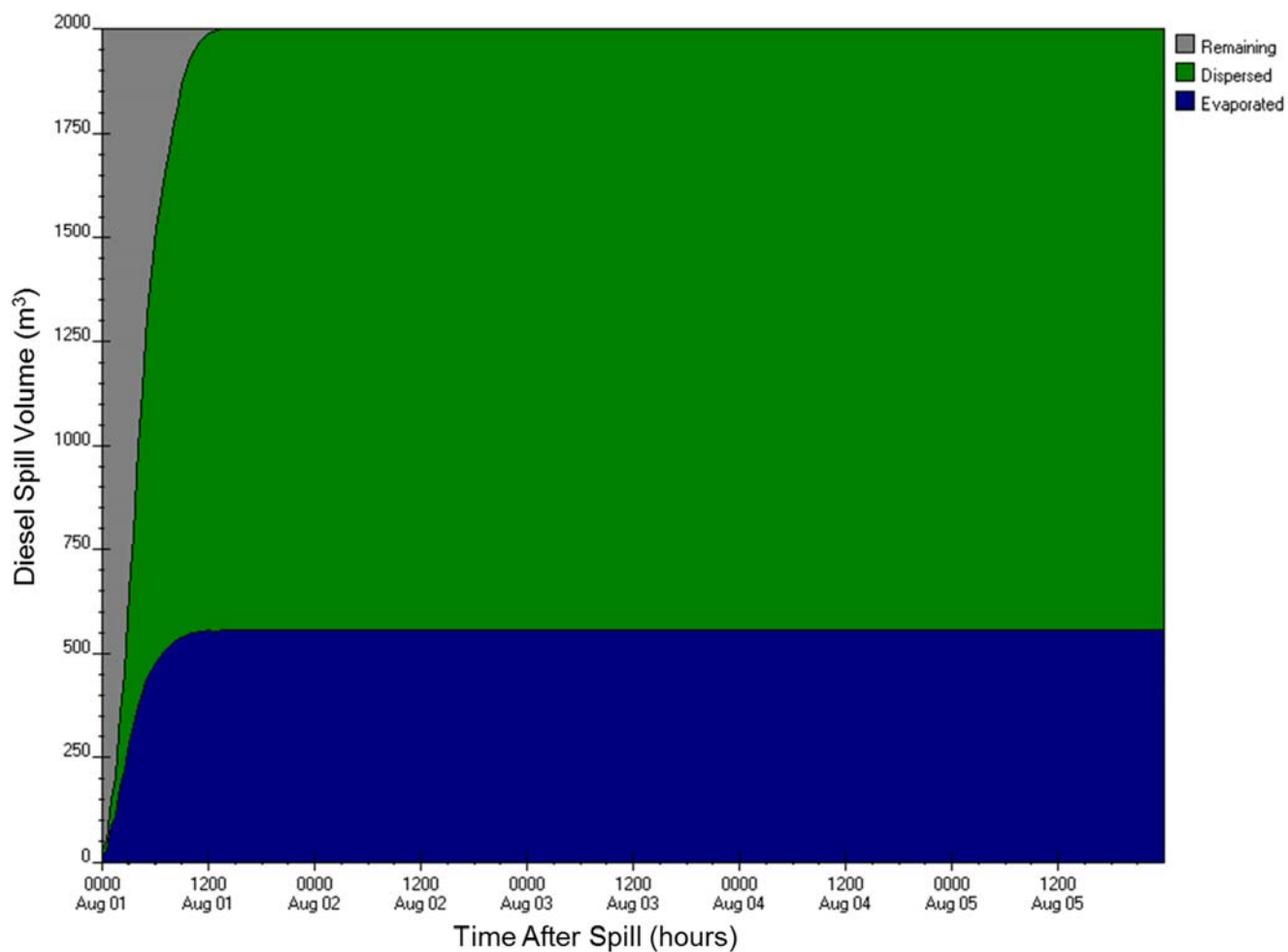


Figure E-A11: ADIOS2 diesel fuel budget output for Walrus Island station (3) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

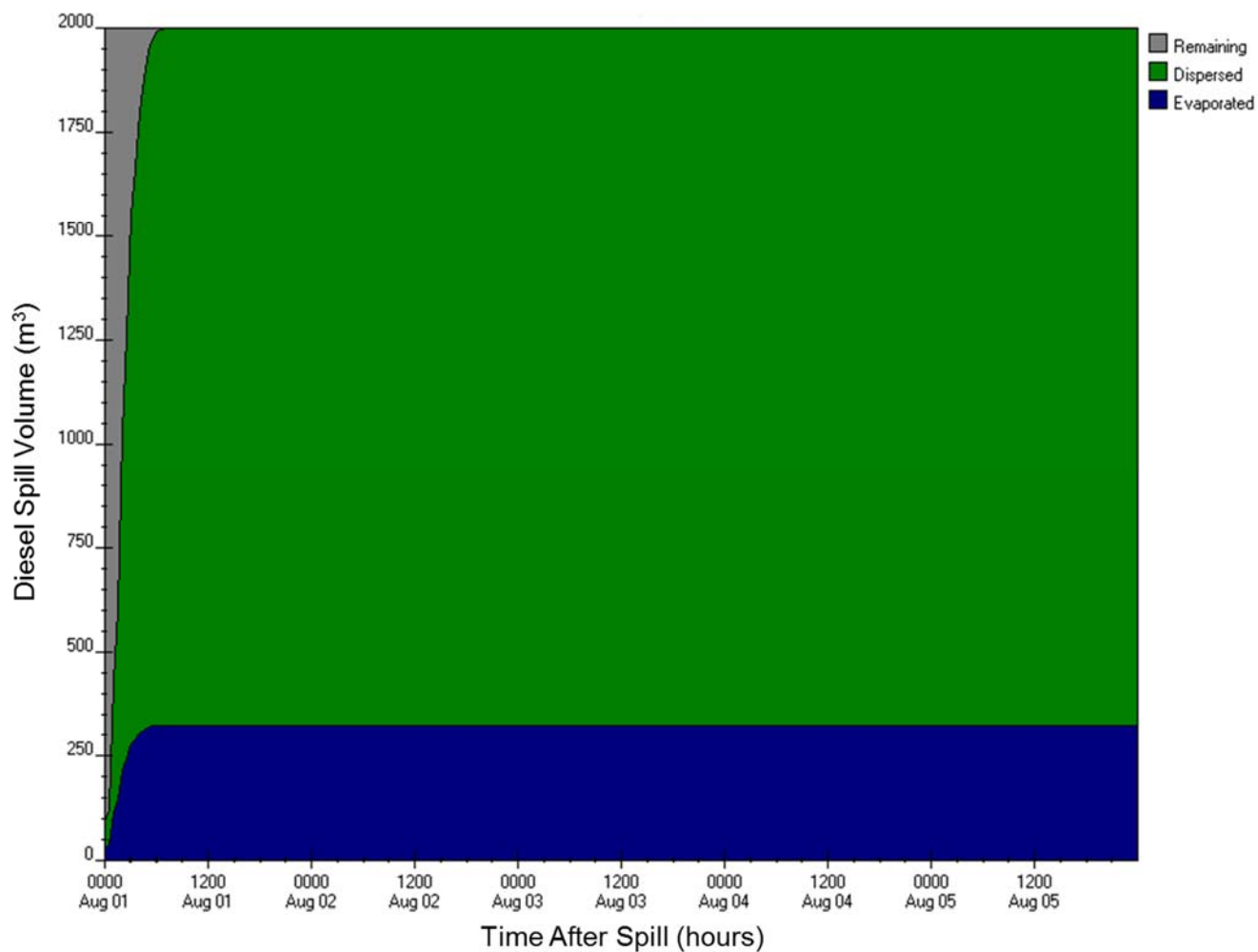


Figure E-A12: ADIOS2 diesel fuel budget output for Walrus Island station (3) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

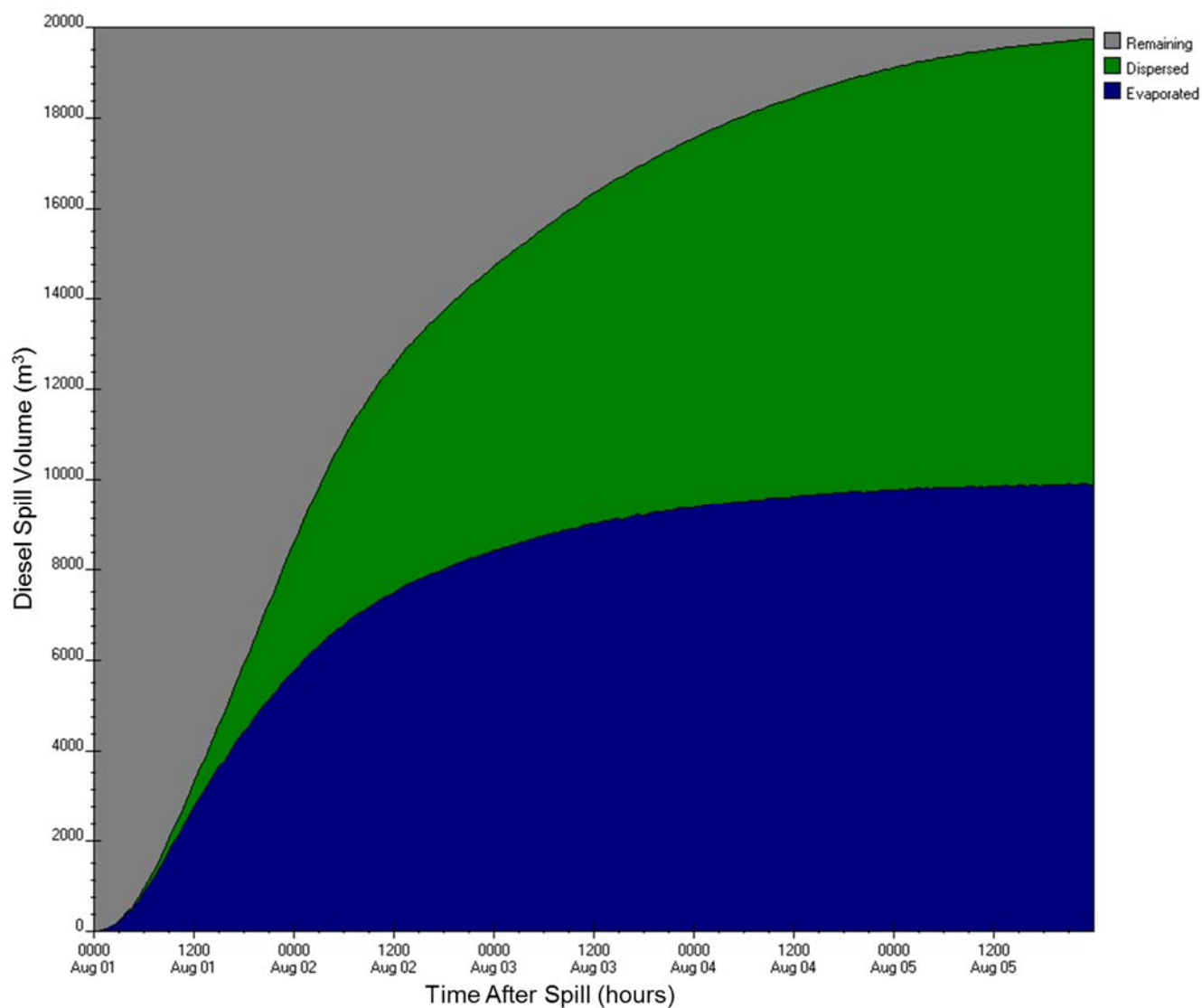


Figure E-A13: ADIOS2 diesel fuel budget output for Walrus Island station (3) for 20,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

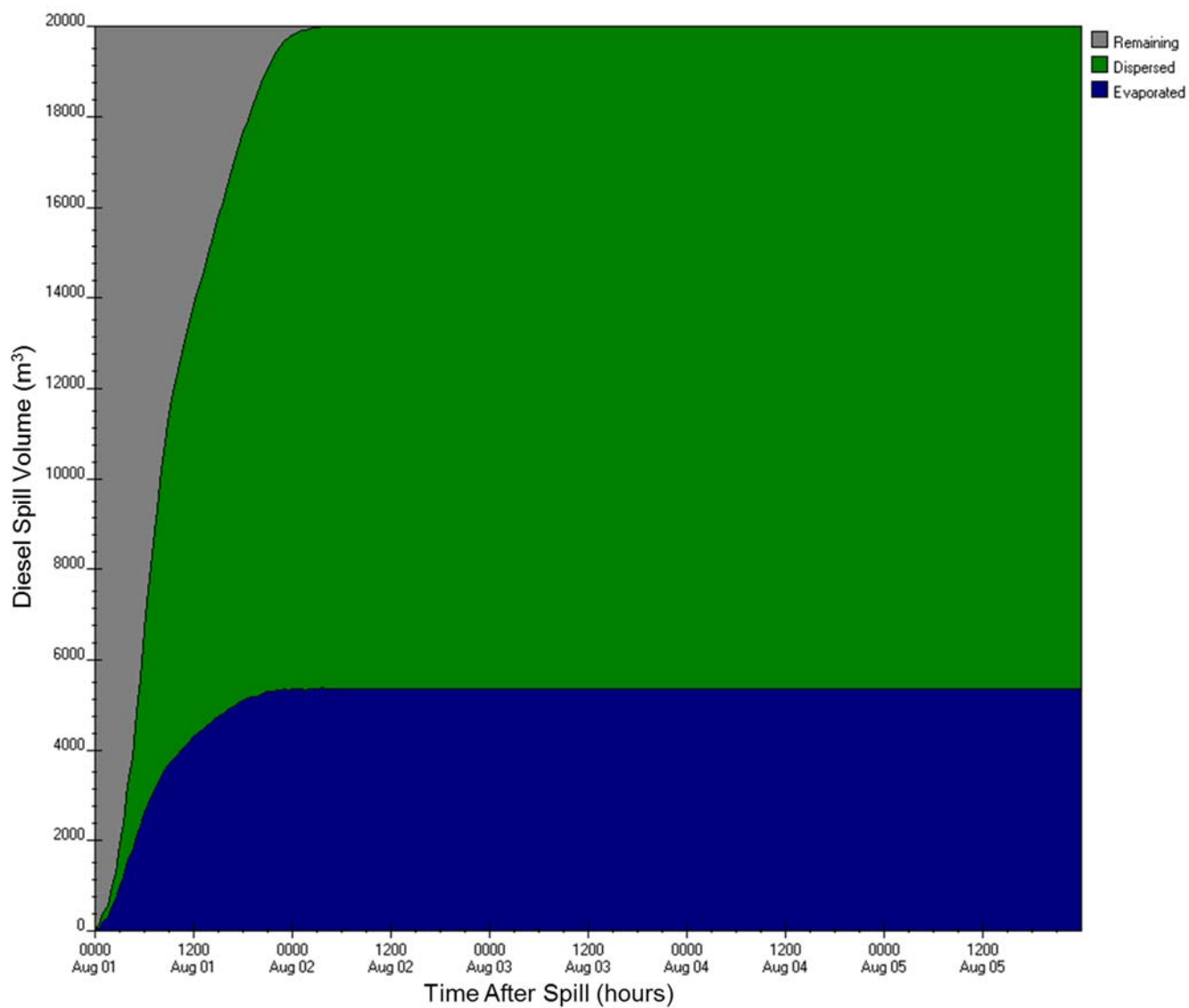


Figure E-A14: ADIOS2 diesel fuel budget output for Walrus Island station (3) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

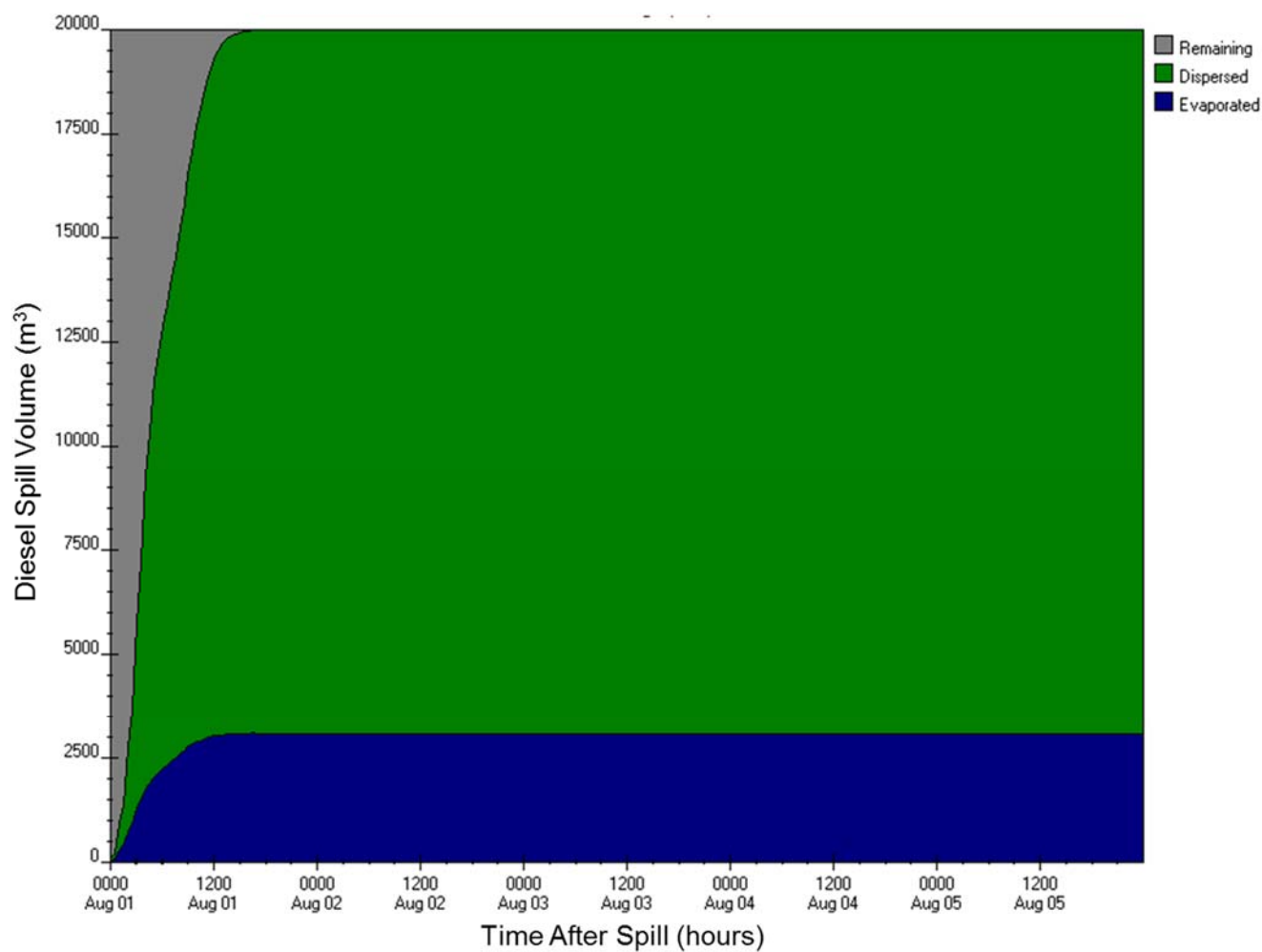


Figure E-A-15: ADIOS2 diesel fuel budget output for Walrus Island station (3) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

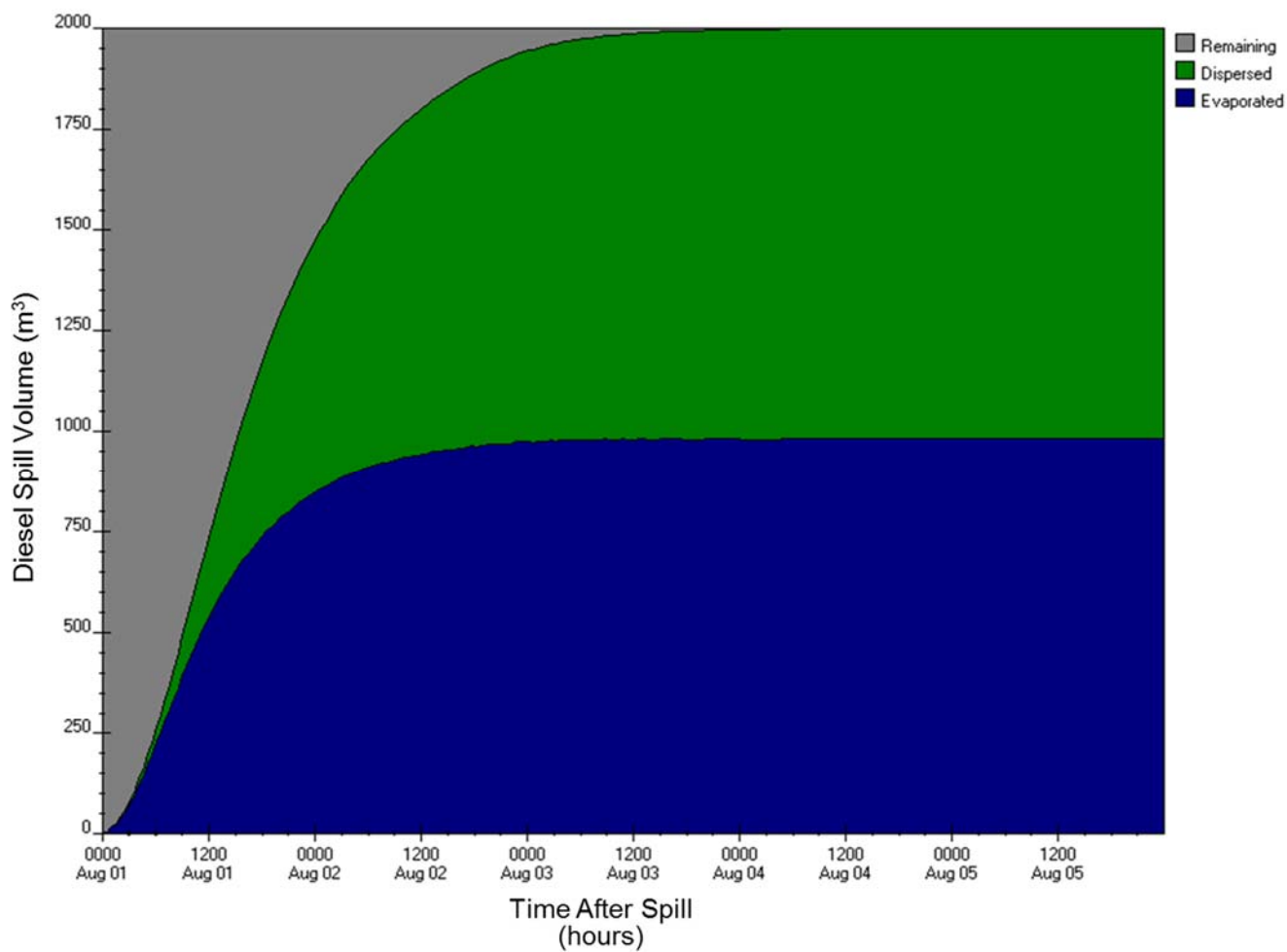


Figure E-A16: ADIOS2 diesel fuel budget output for Coats Island station (4) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

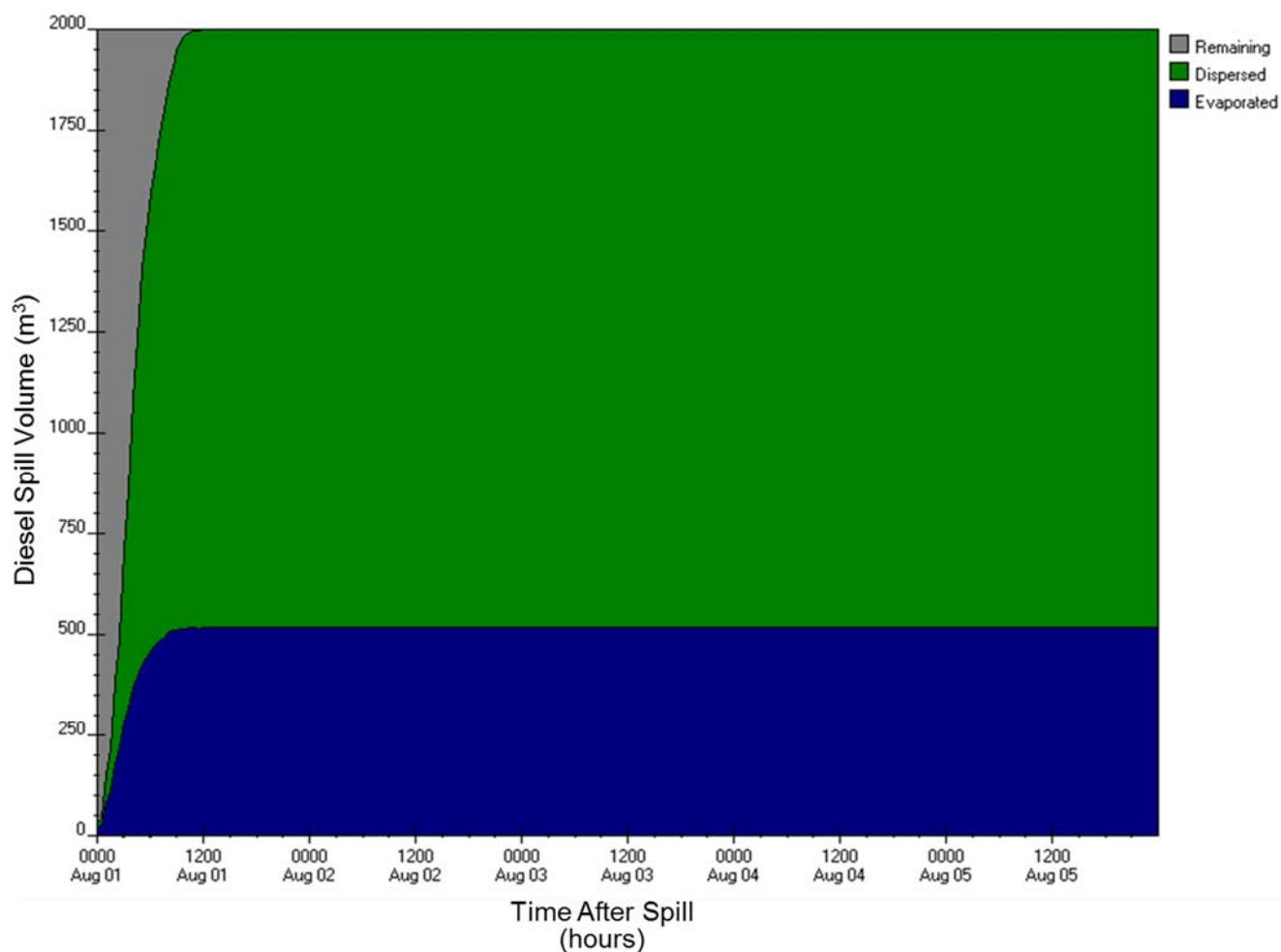


Figure E-A17: ADIOS2 diesel fuel budget output for Coats Island station (4) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

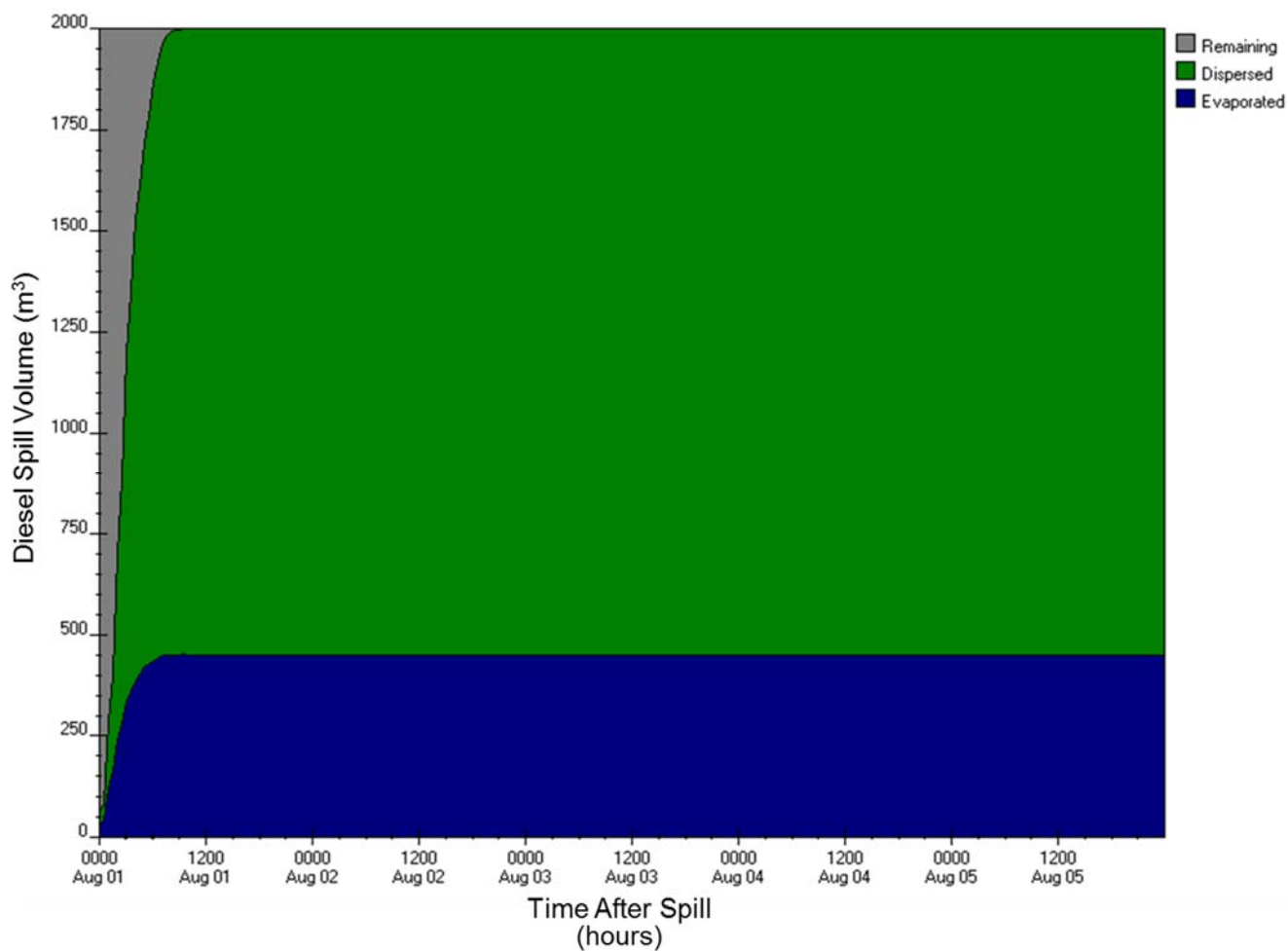


Figure E-A18: ADIOS2 diesel fuel budget output for Coats Island station (4) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

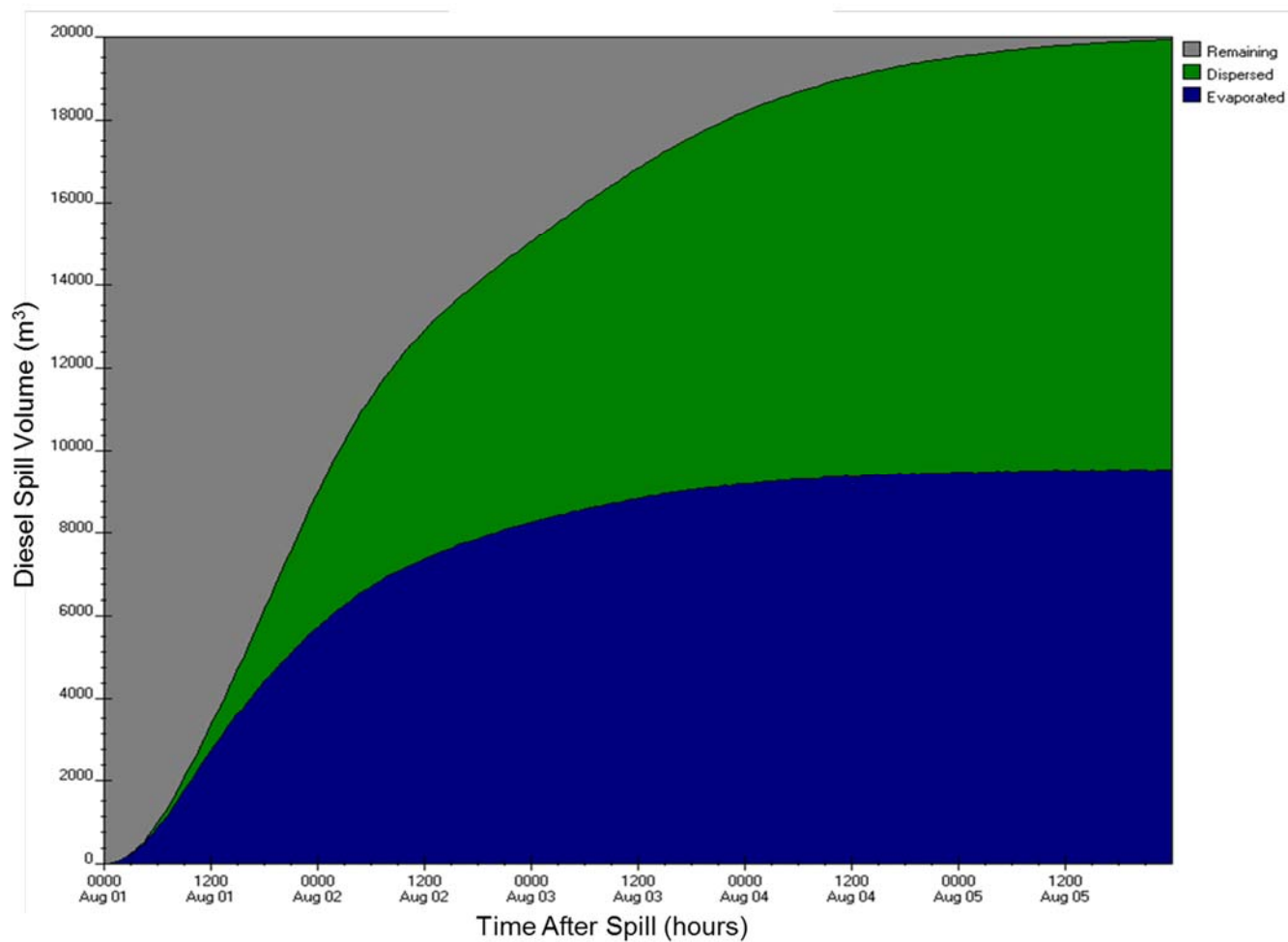


Figure E-A19: ADIOS2 diesel fuel budget output for Coats Island station (4) for 20,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

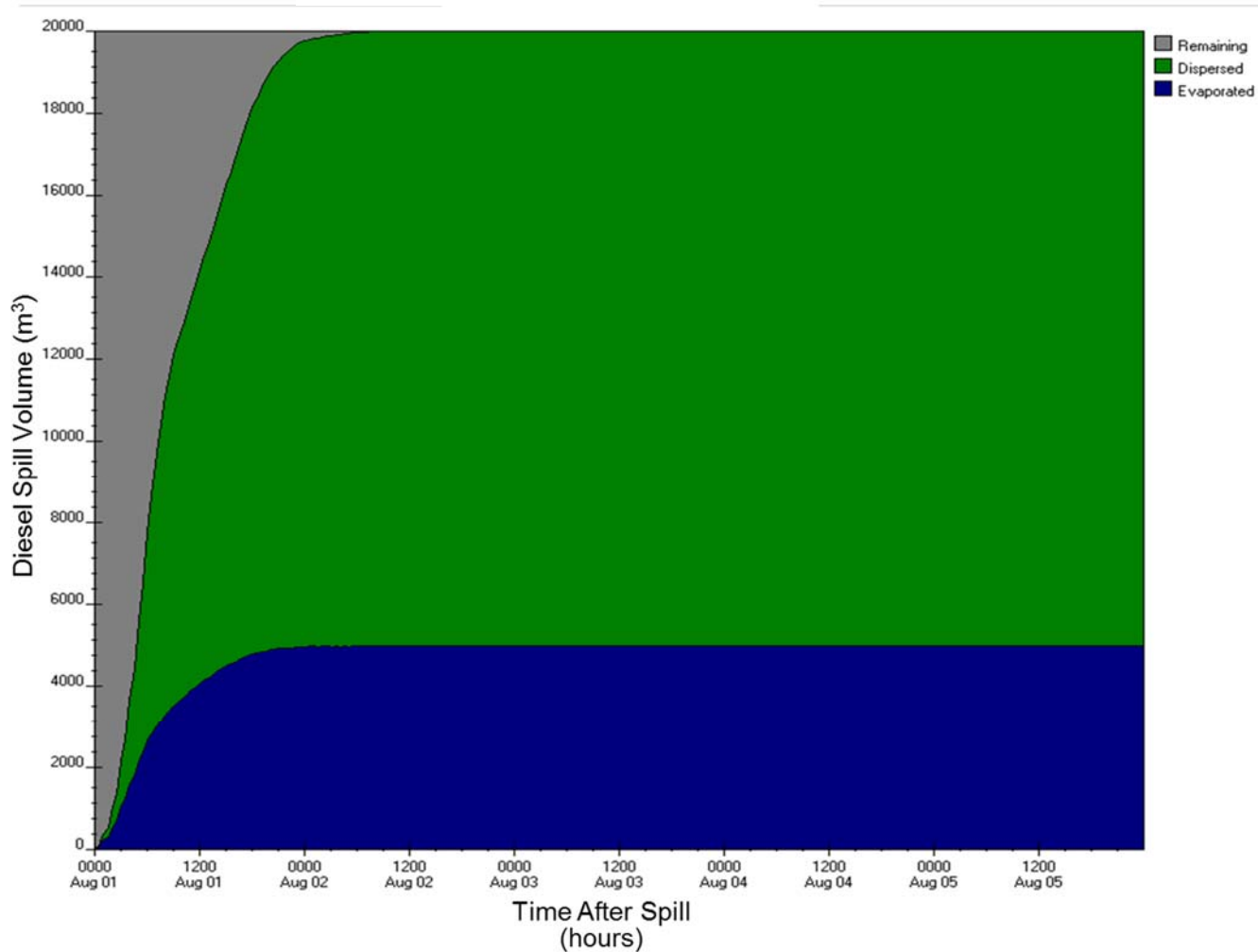


Figure E-A20: ADIOS2 diesel fuel budget output for Coats Island station (4) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

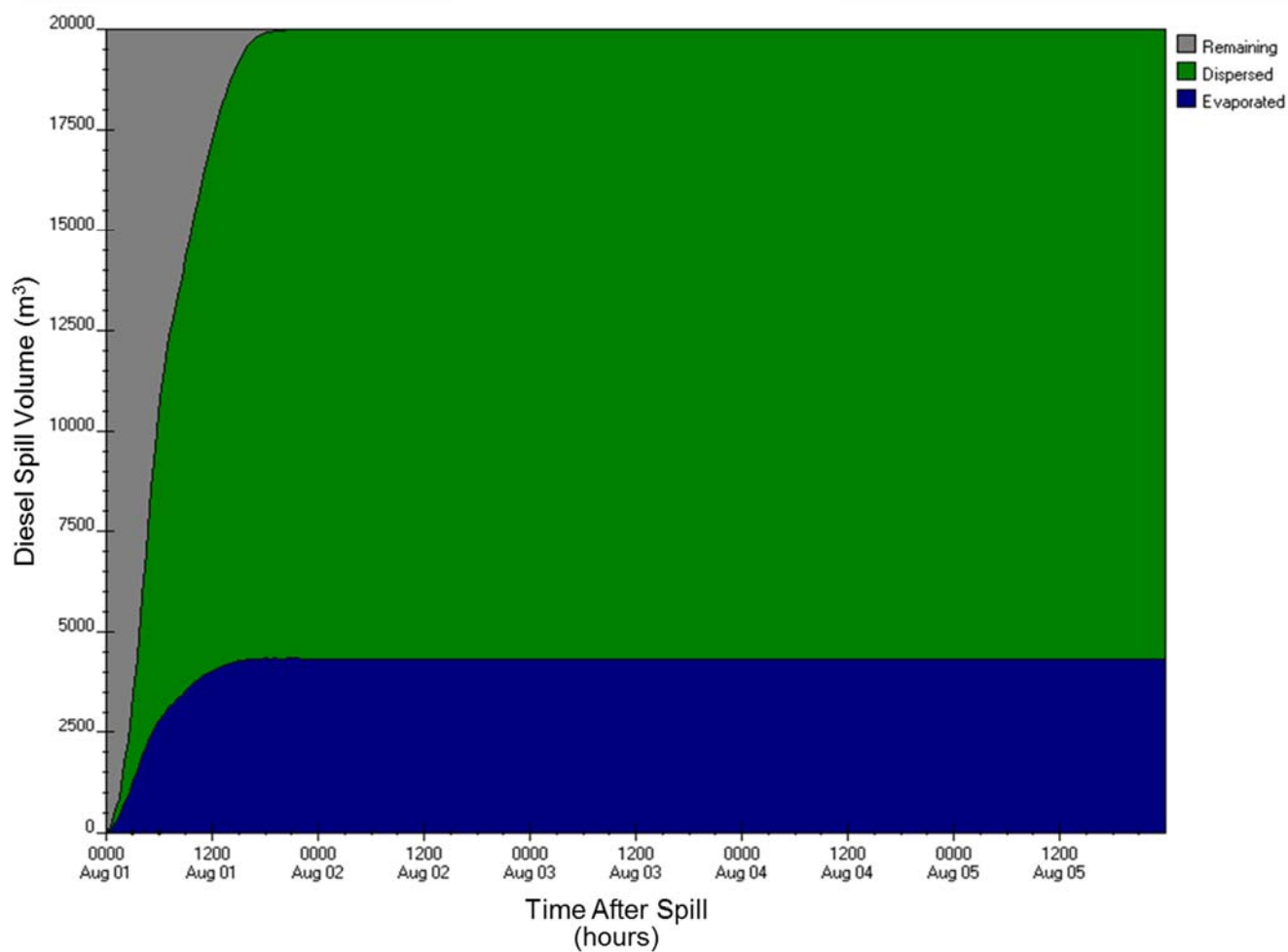


Figure E-A21:ADIOS2 diesel fuel budget output for Coats Island station (4) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

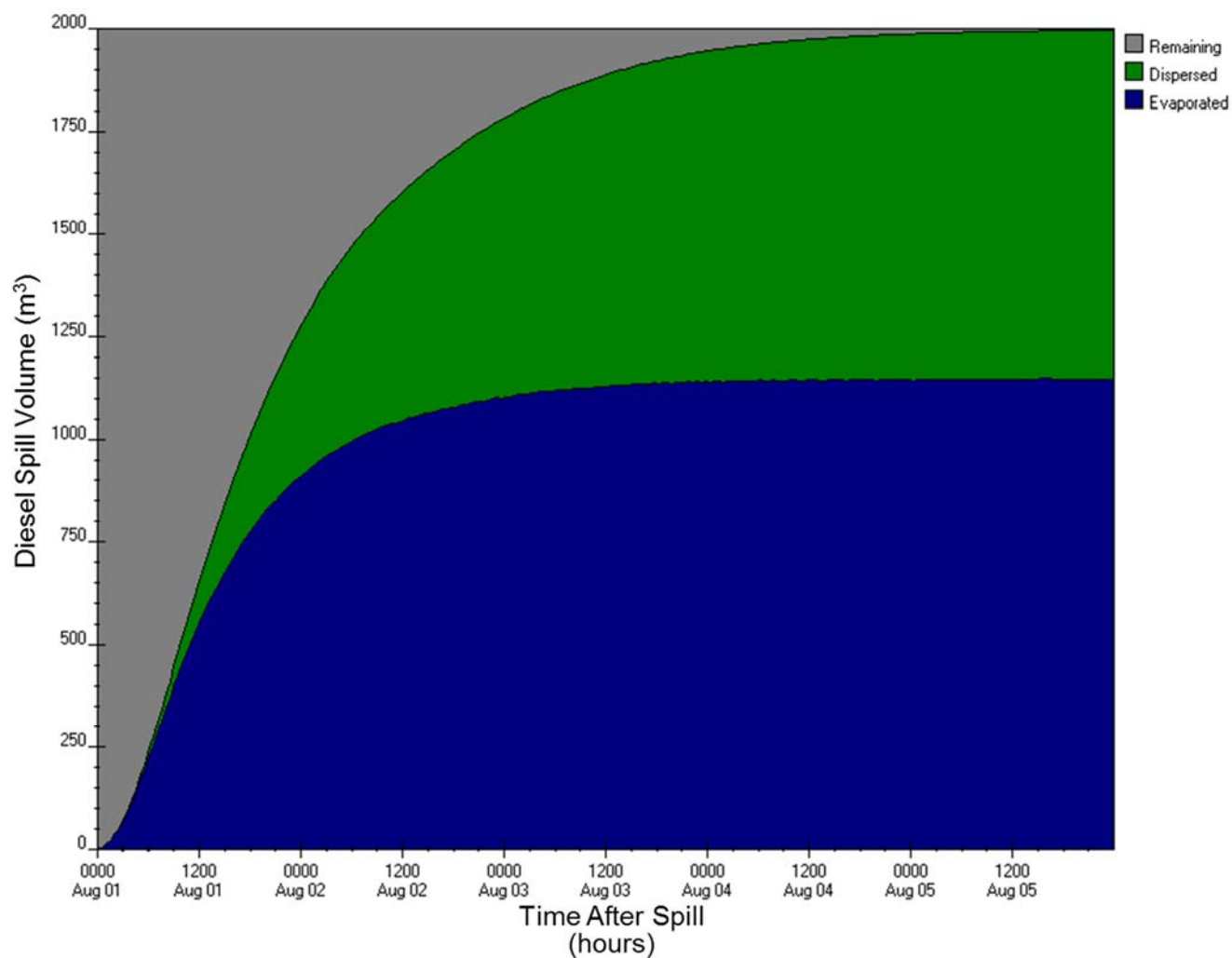


Figure E-A22:ADIOS2 diesel fuel budget output for Ungava Peninsula station (5) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

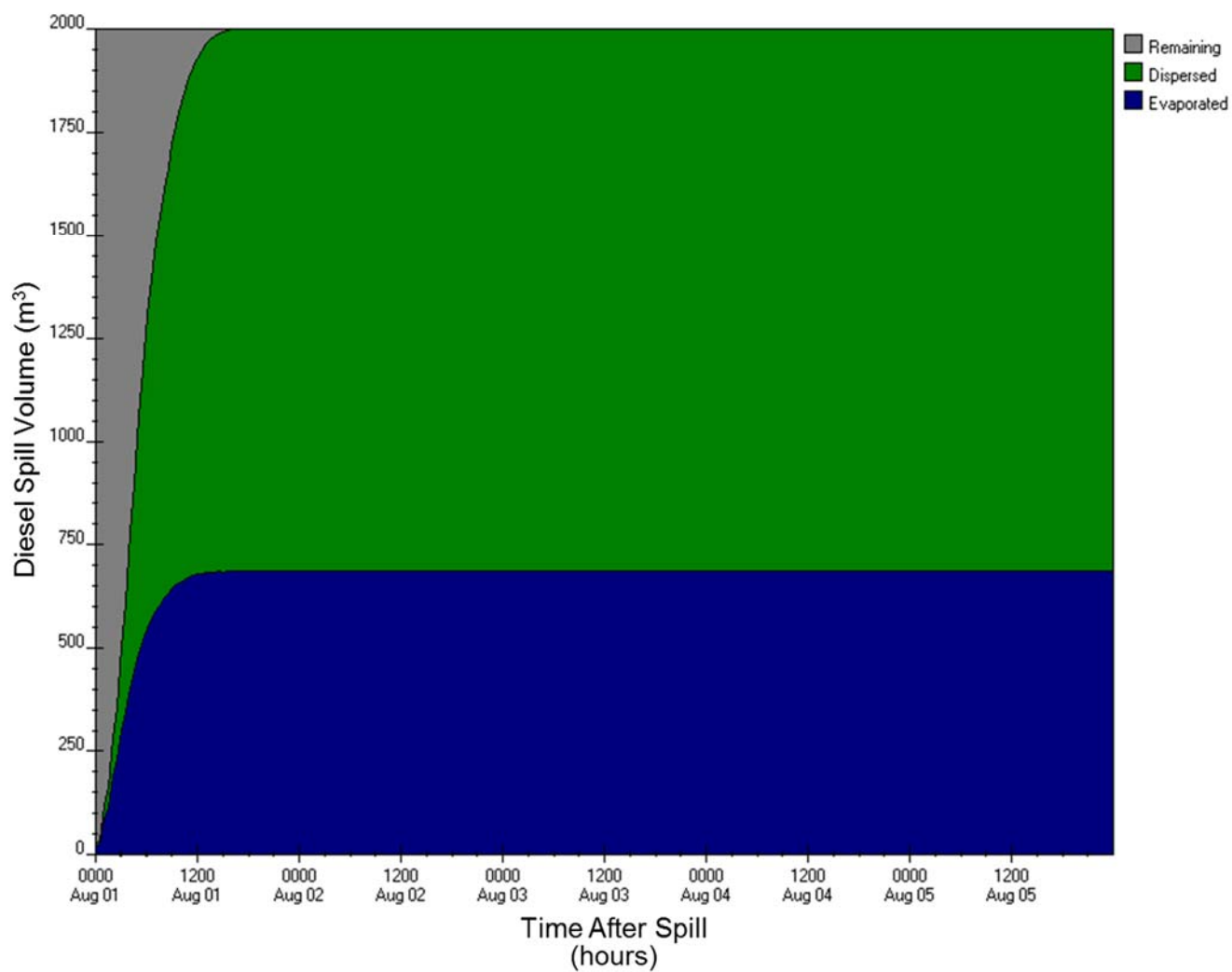


Figure E-A23: ADIOS2 diesel fuel budget output for Ungava Peninsula station (5) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

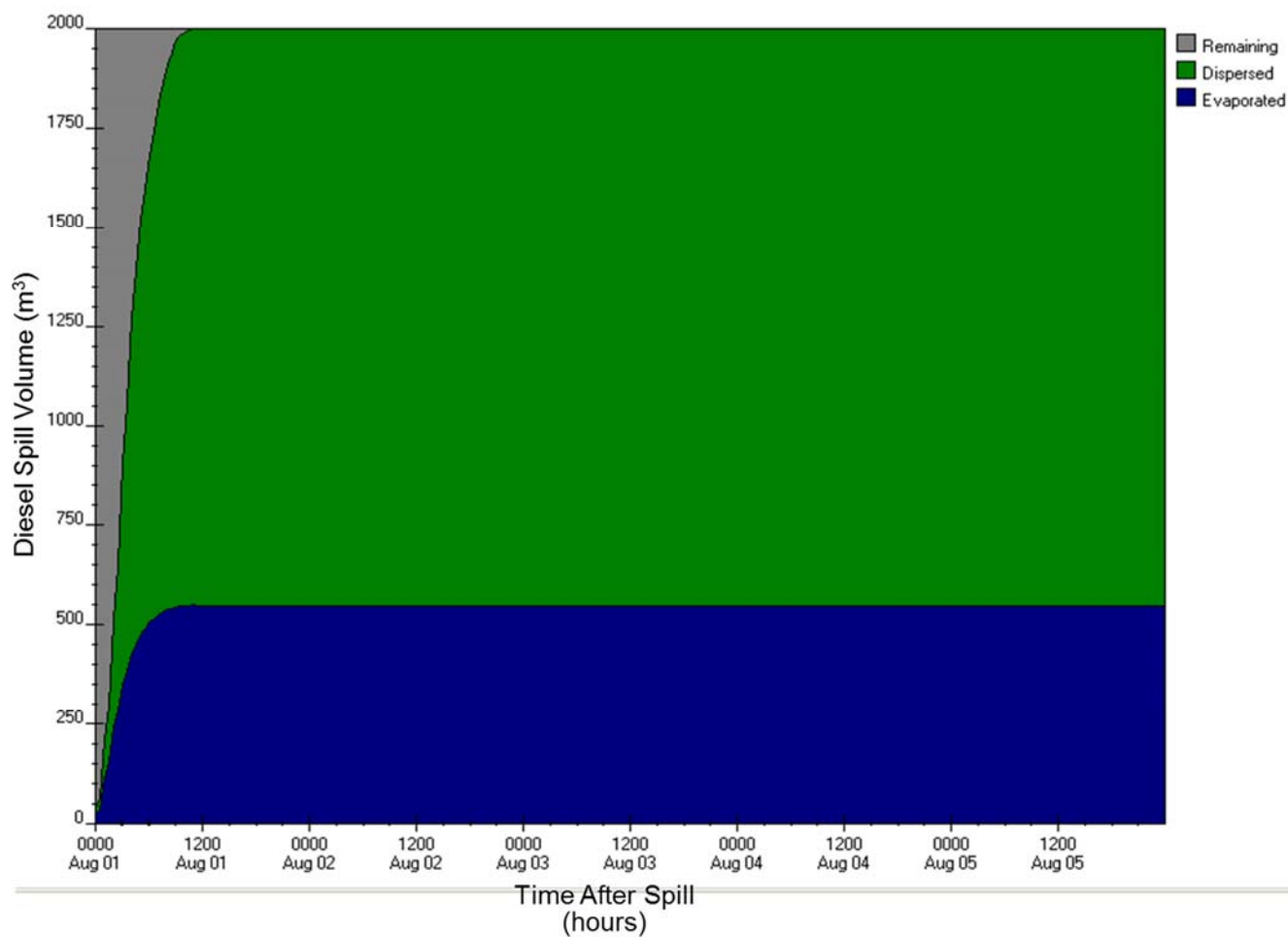


Figure E-A24: ADIOS2 diesel fuel budget output for Ungava Peninsula station (5) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

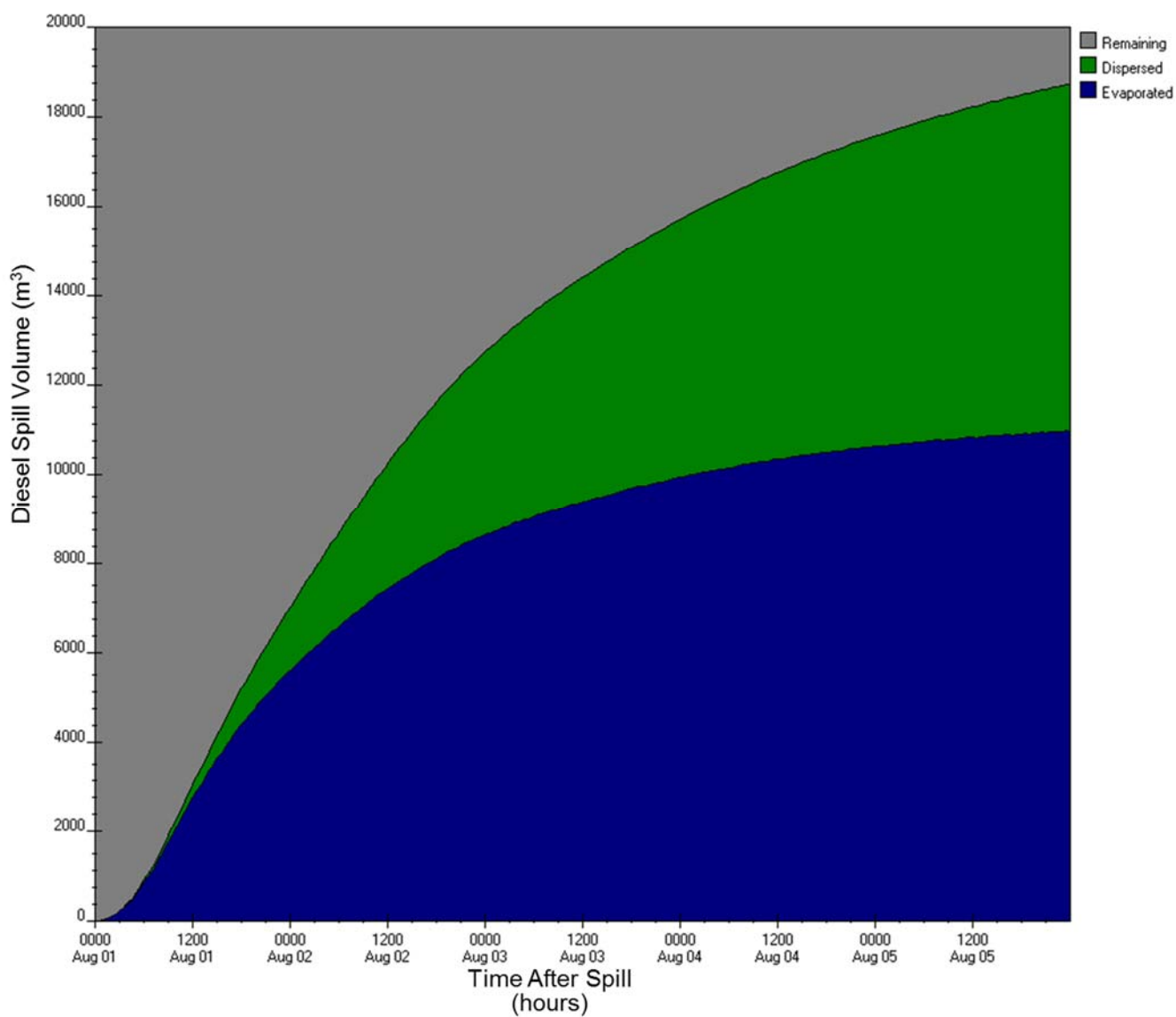


Figure E-A25: ADIOS2 diesel fuel budget output for Ungava Peninsula station (5) for 20,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

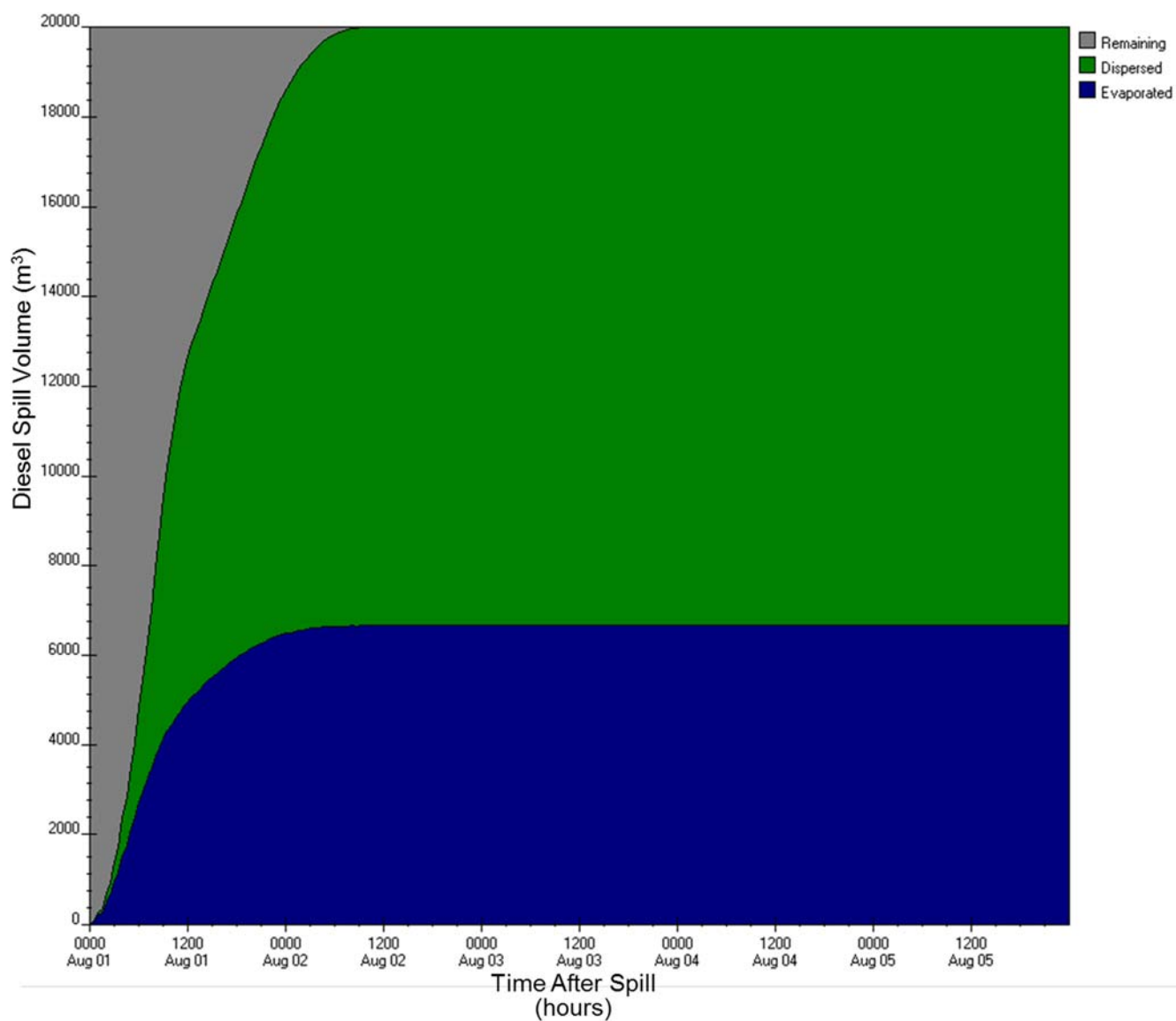


Figure E-A26: ADIOS2 diesel fuel budget output for Ungava Peninsula station (5) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

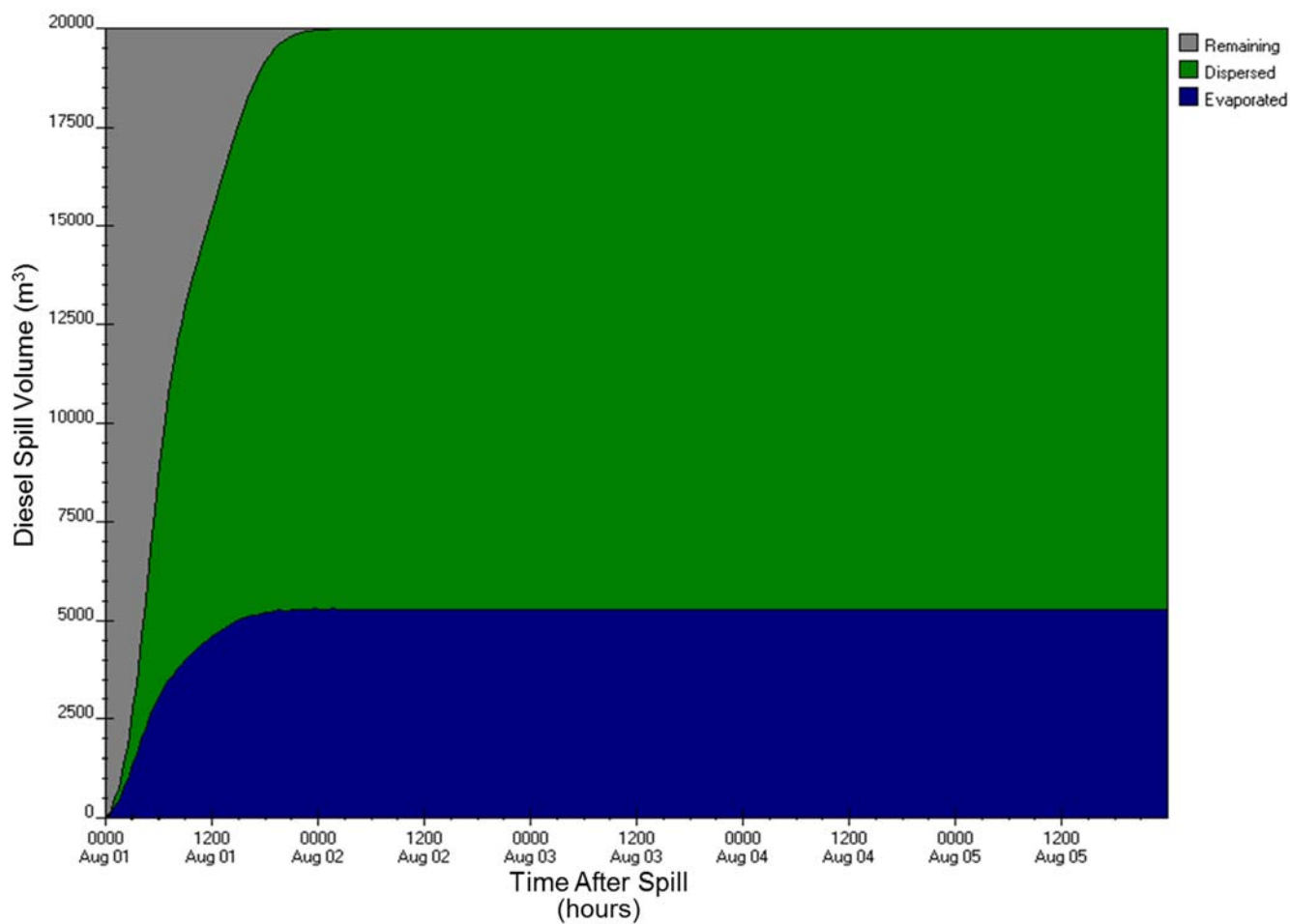


Figure E-A27: ADIOS2 diesel fuel budget output for Ungava Peninsula station (5) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

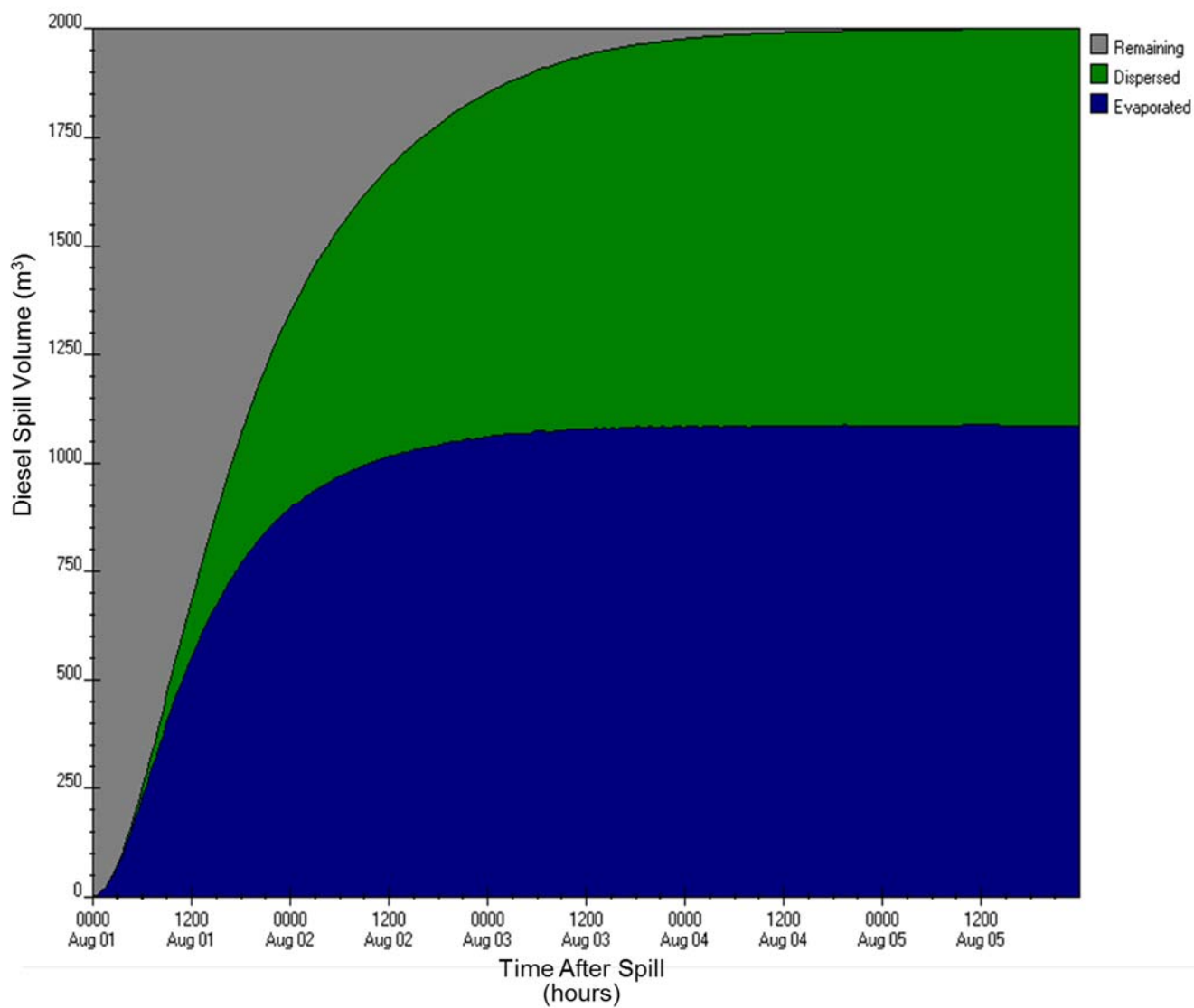


Figure E-A28: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (6) for 2,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

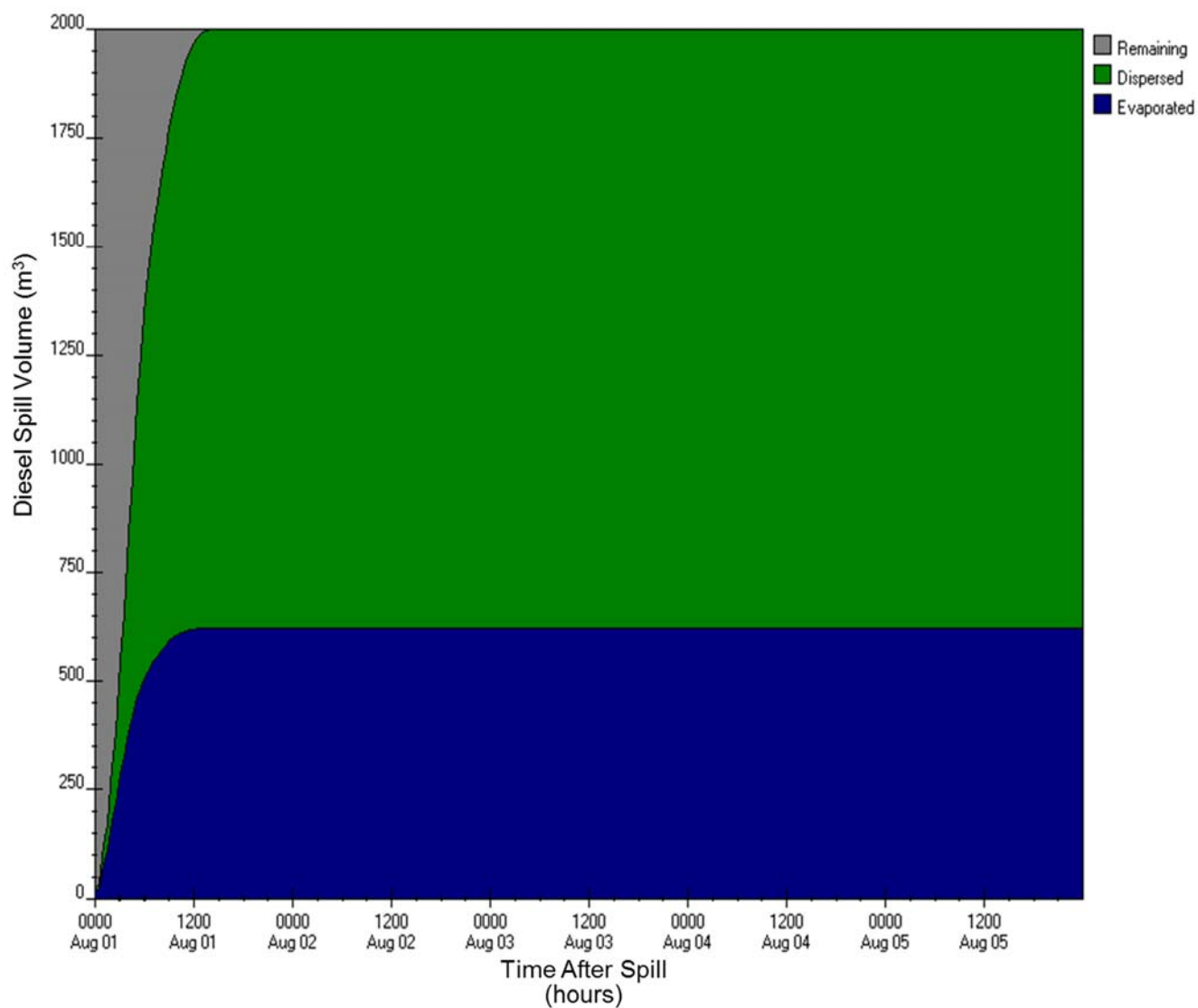


Figure E-A29: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (6) for 2,000 m<sup>3</sup>, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

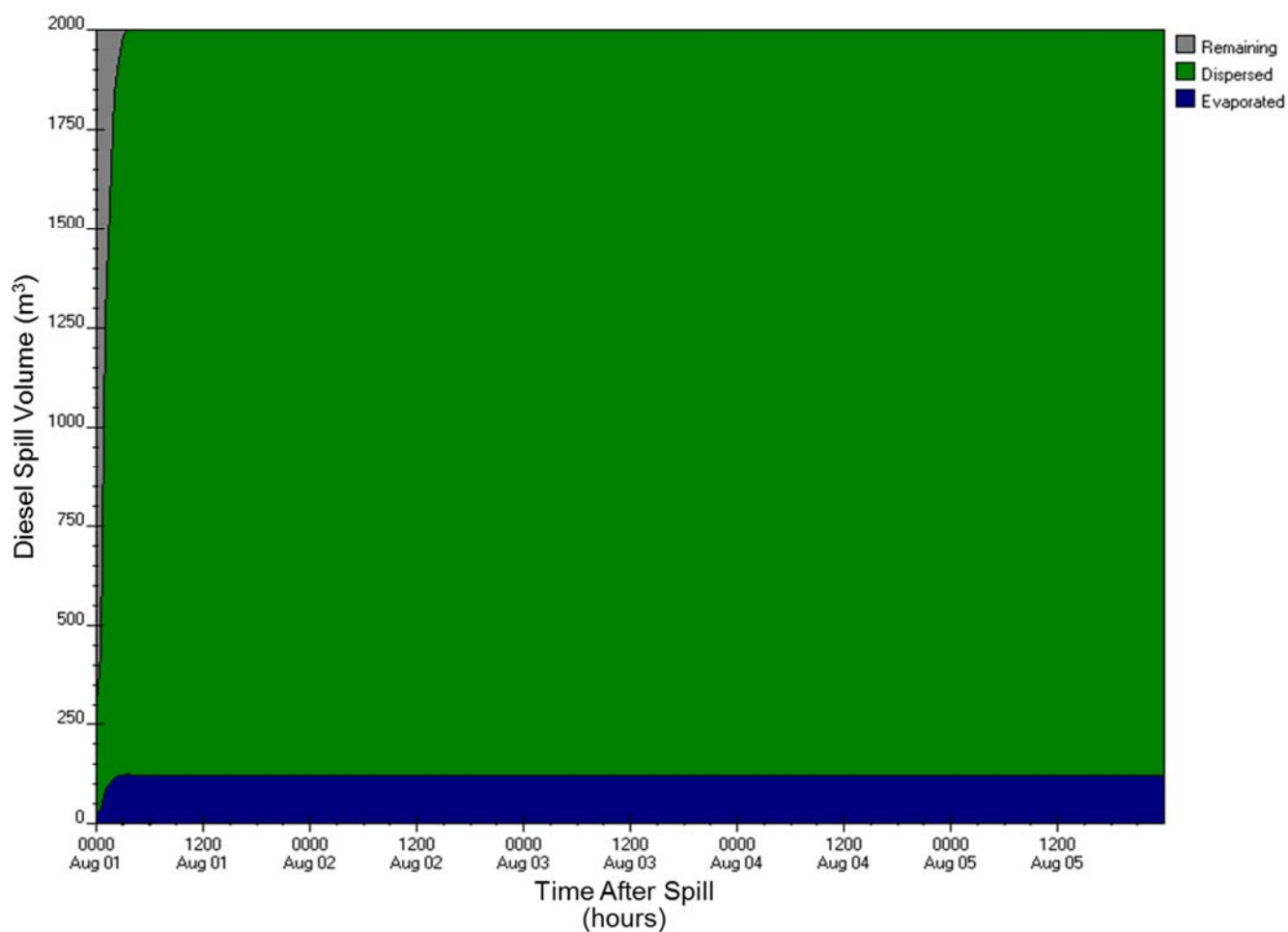


Figure E-A30: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (6) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

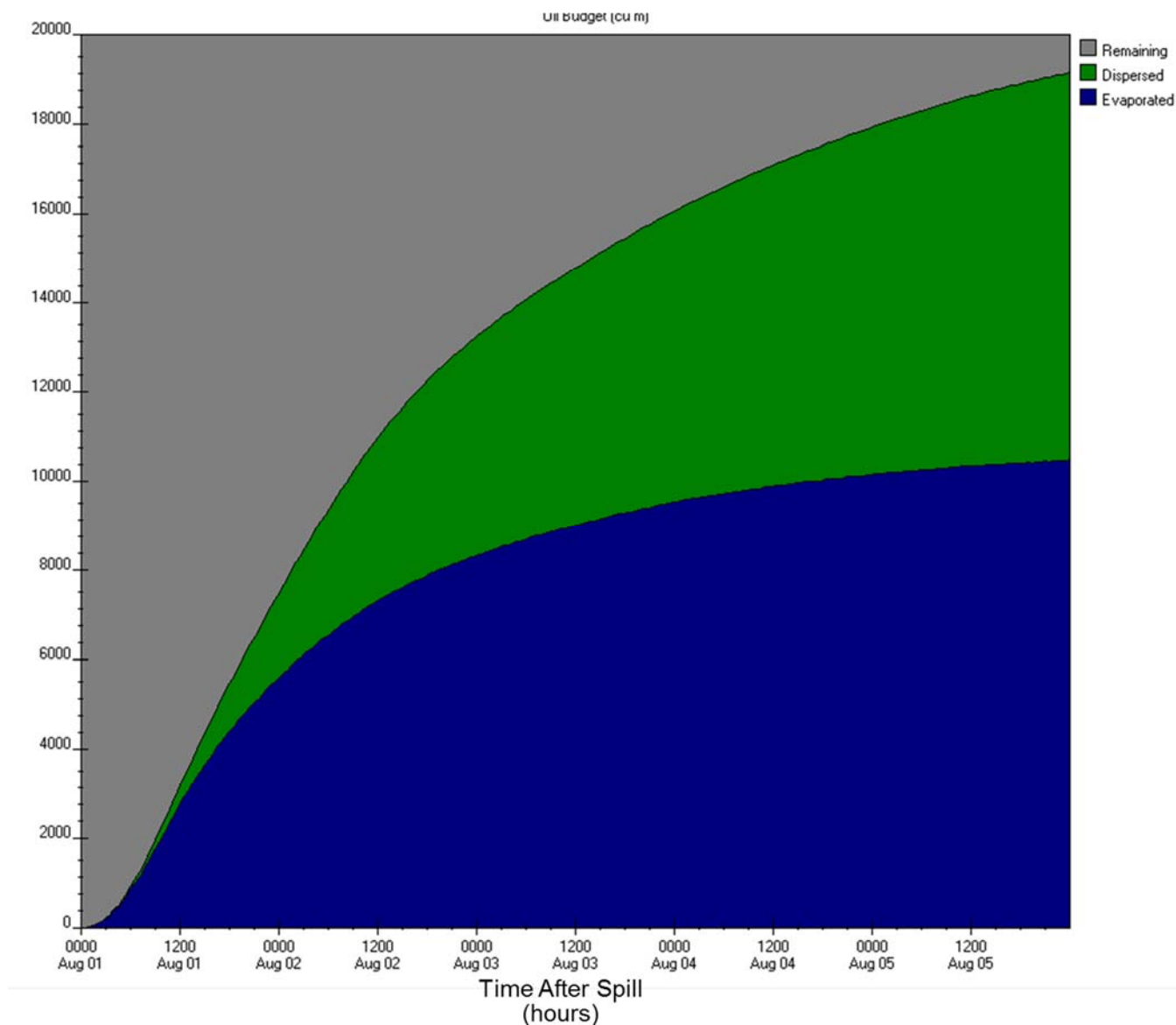


Figure E-A31: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (6) for 20,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

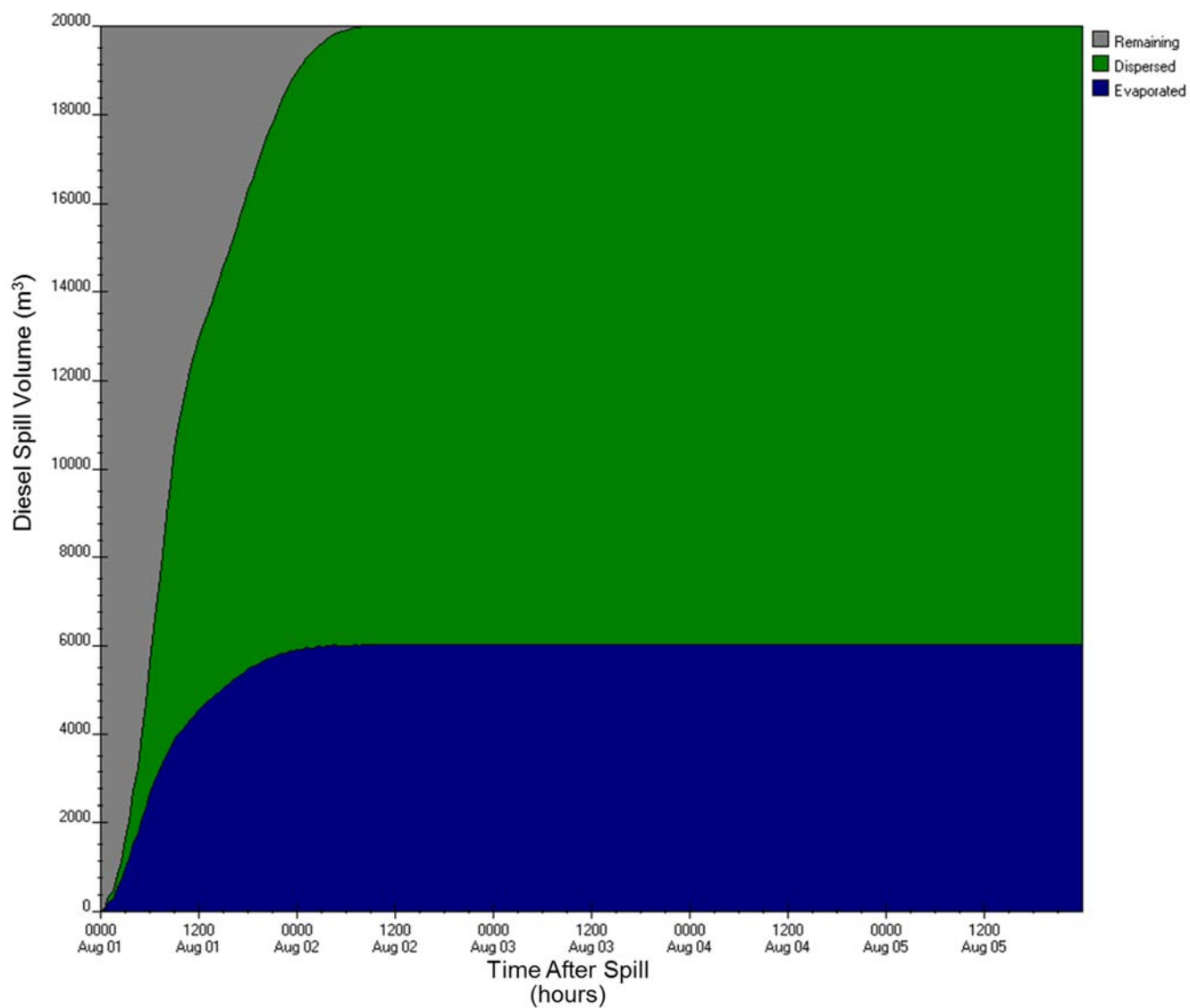


Figure E-A32: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (6) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

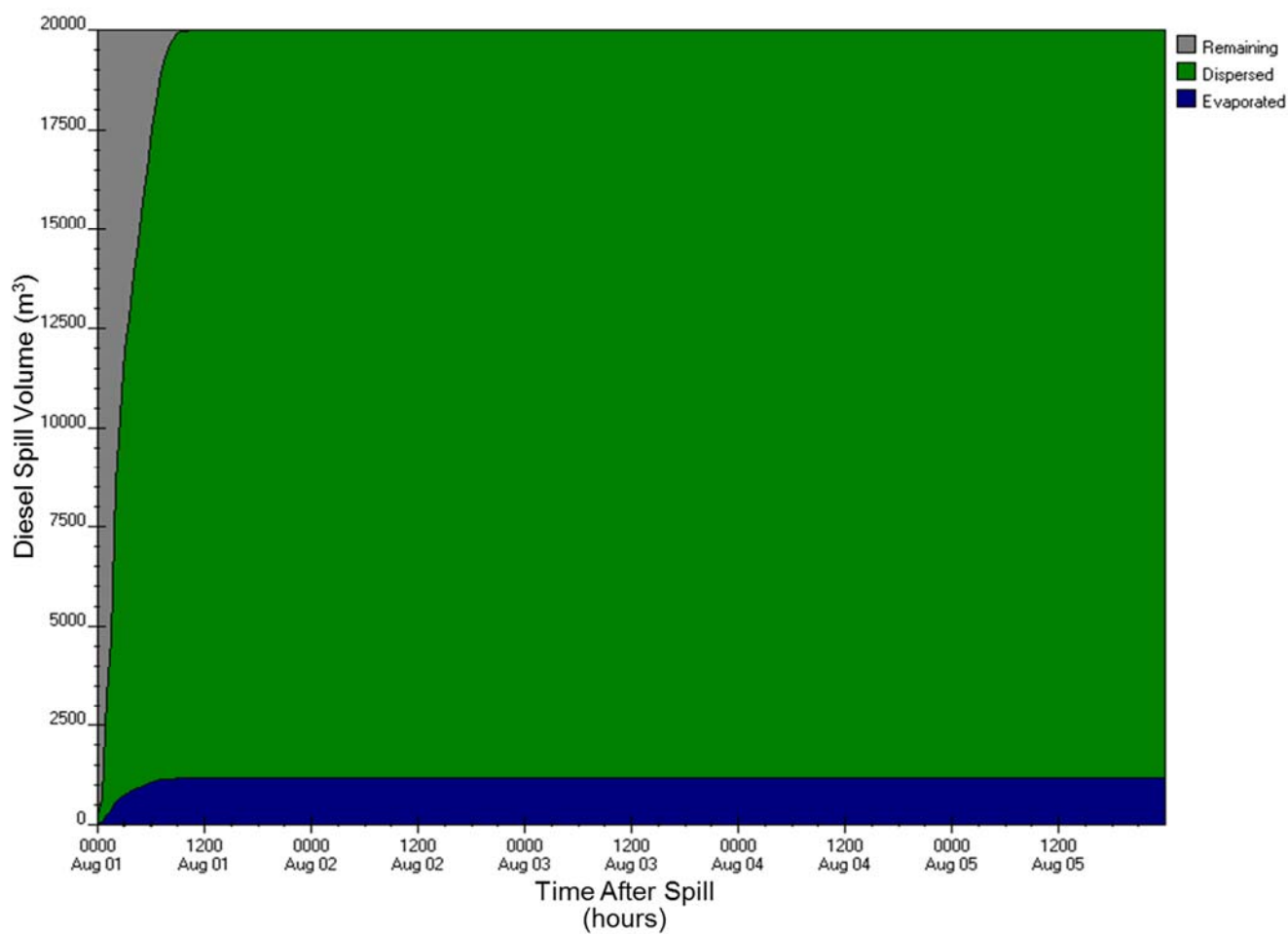


Figure E-A33: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (6) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

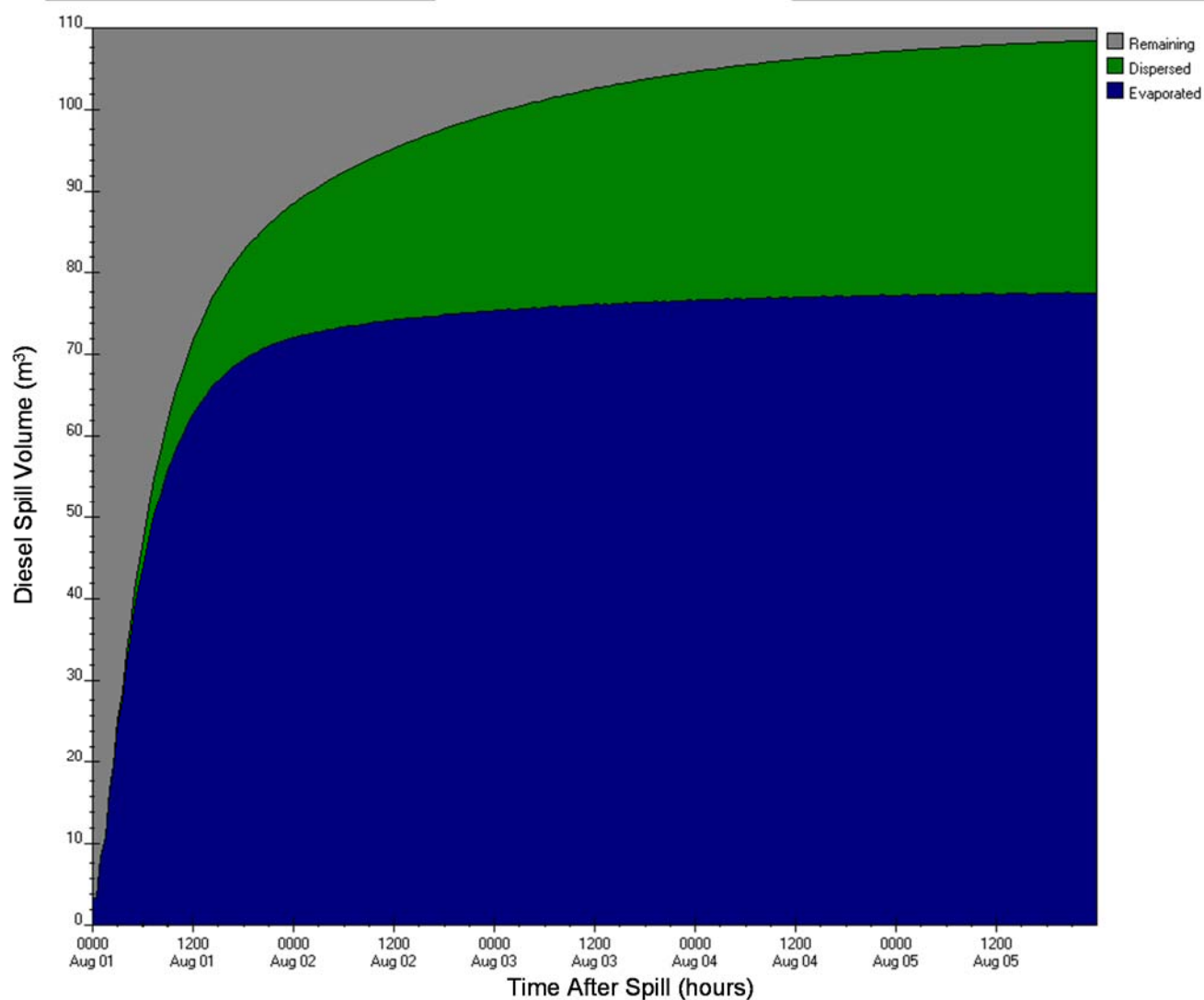


Figure E-A34: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 100 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

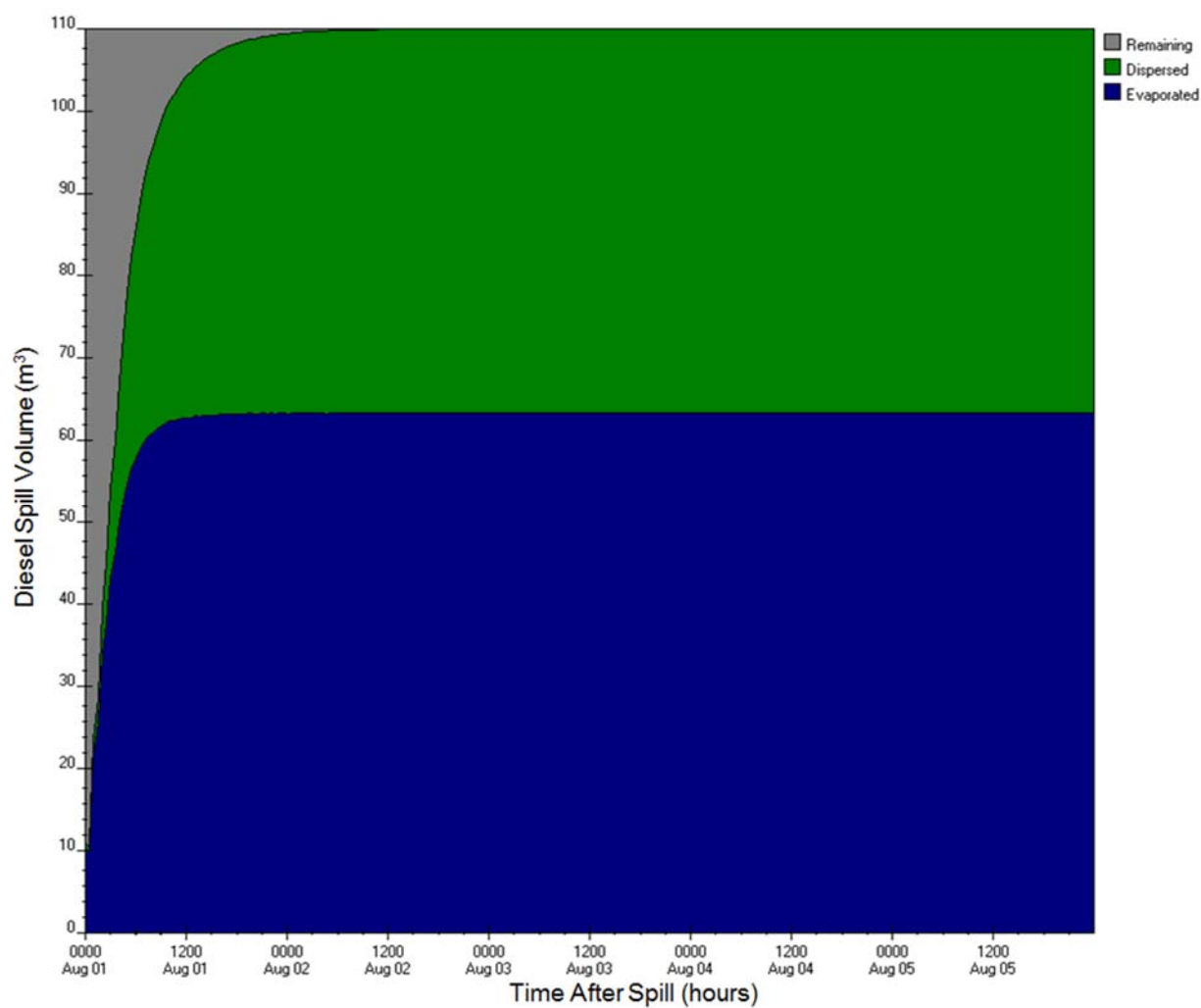


Figure E-A35: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 100 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

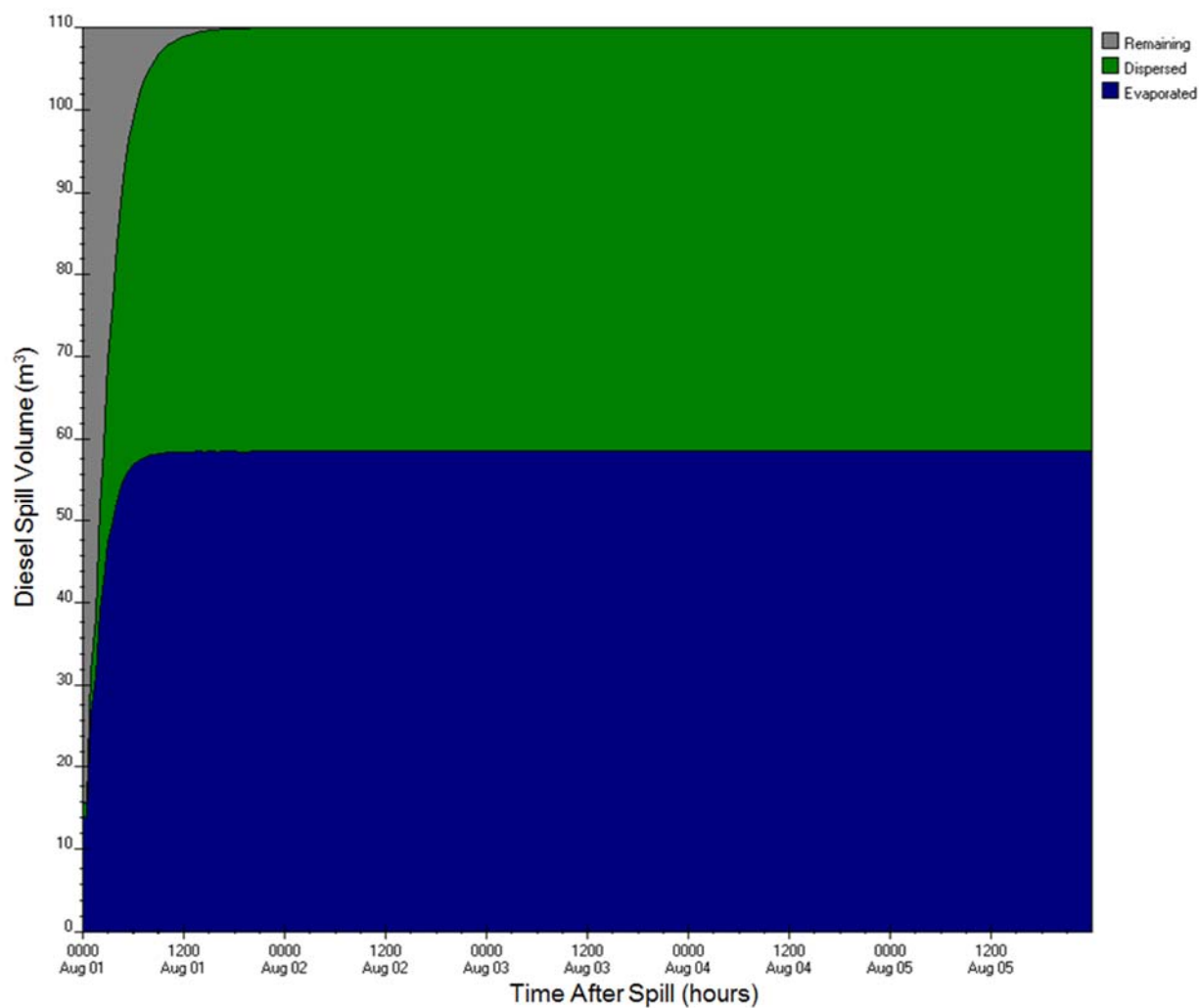


Figure E-A36: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 100 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

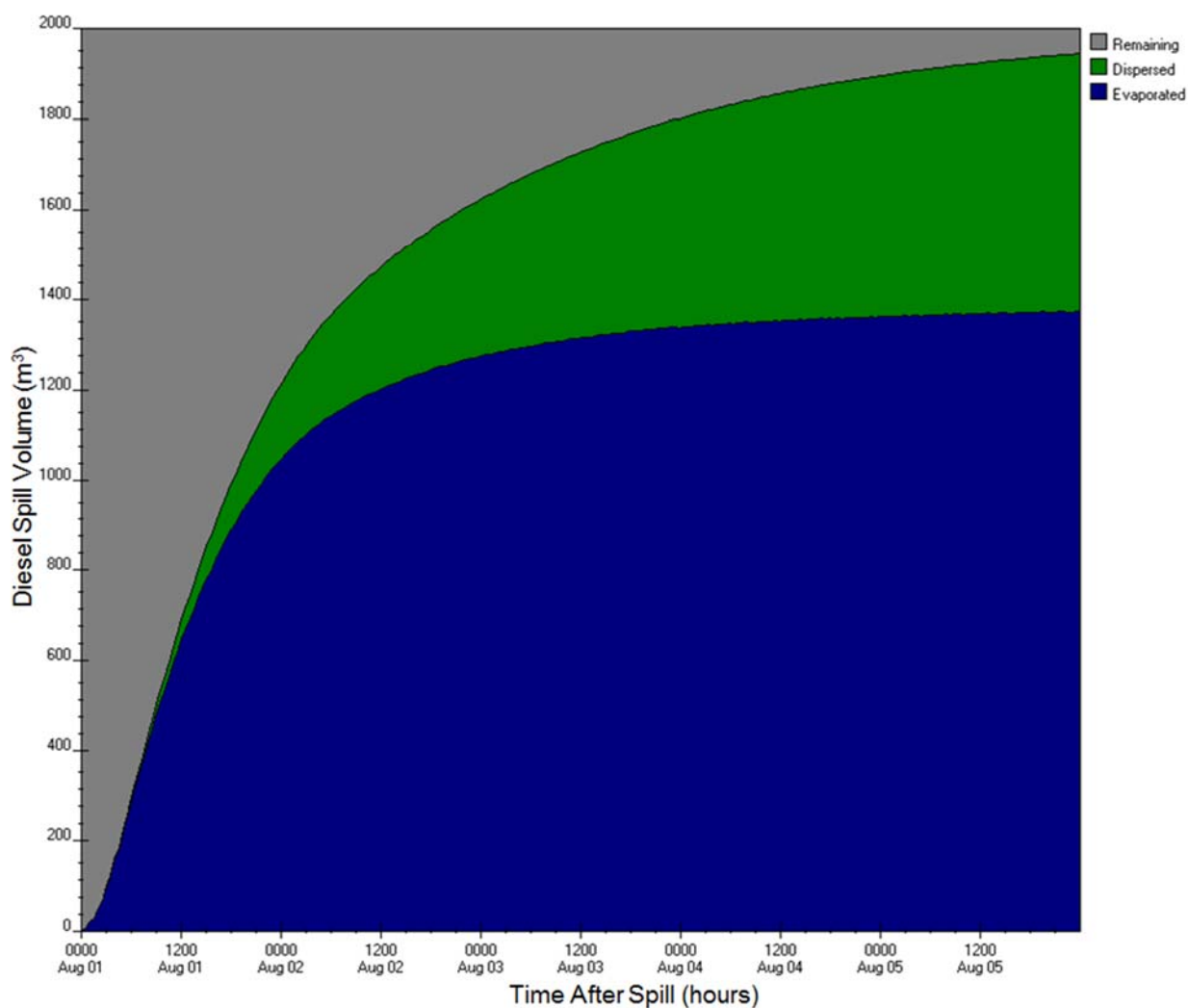


Figure E-A37: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

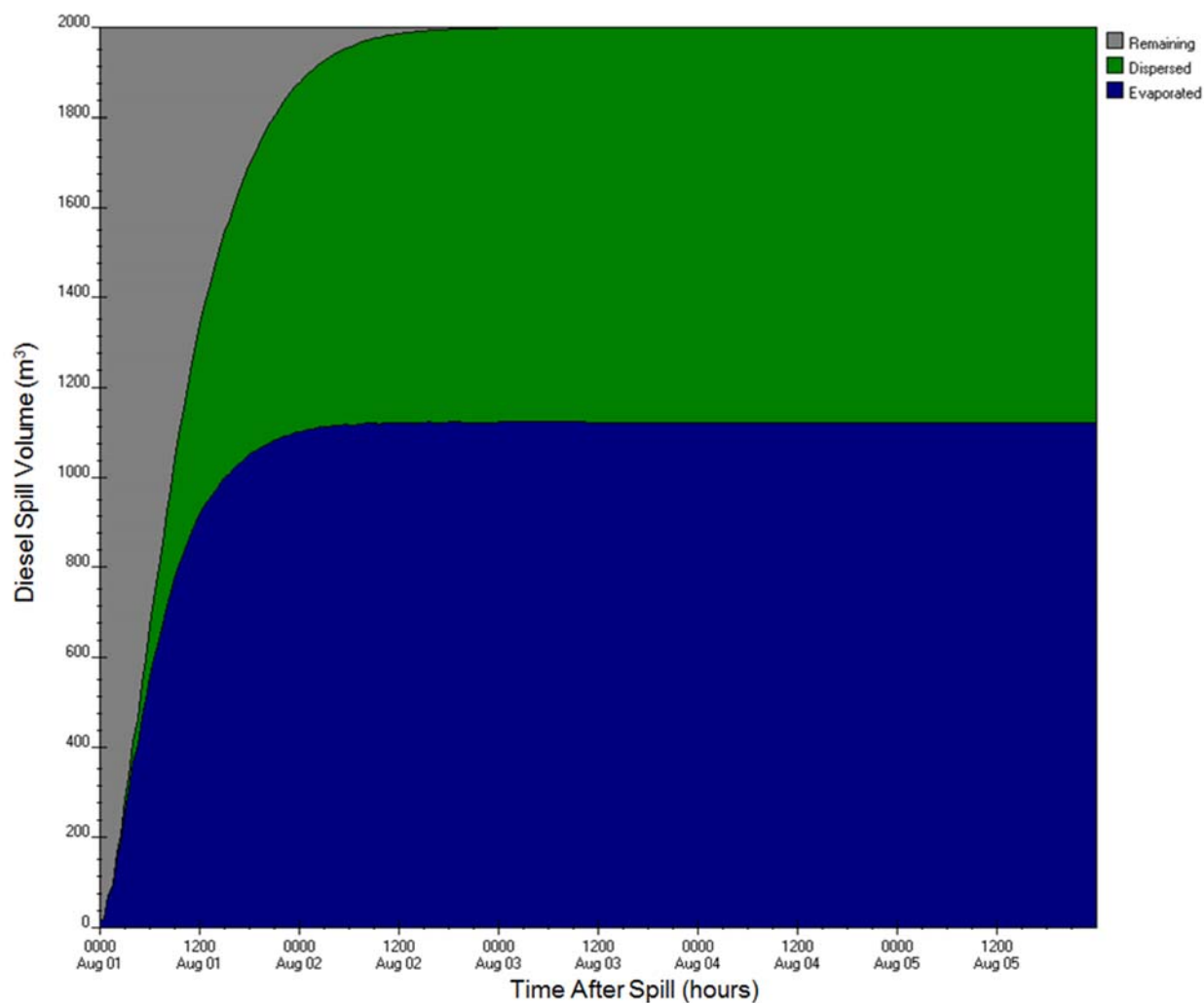


Figure E-A38: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

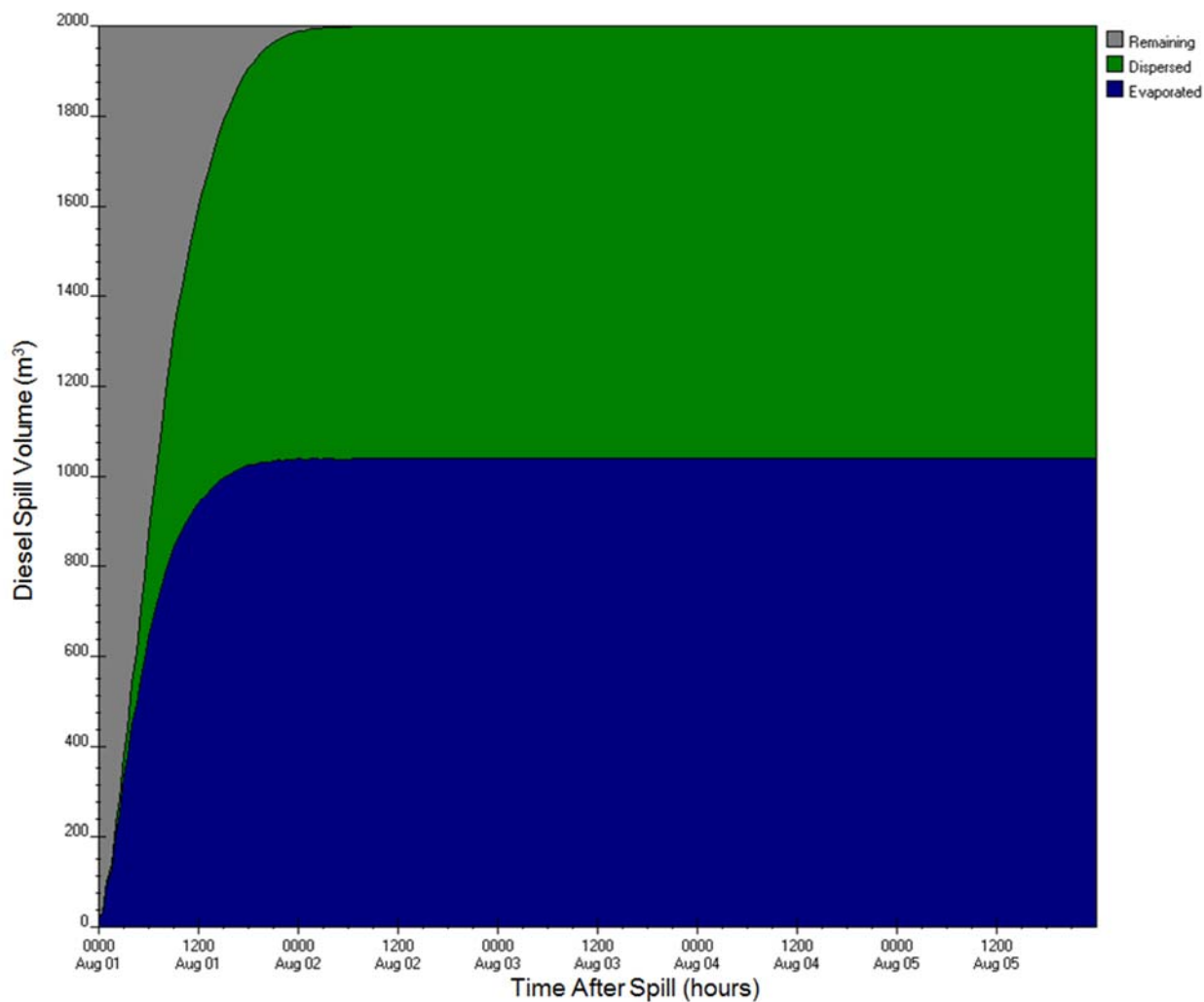


Figure E-A39: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

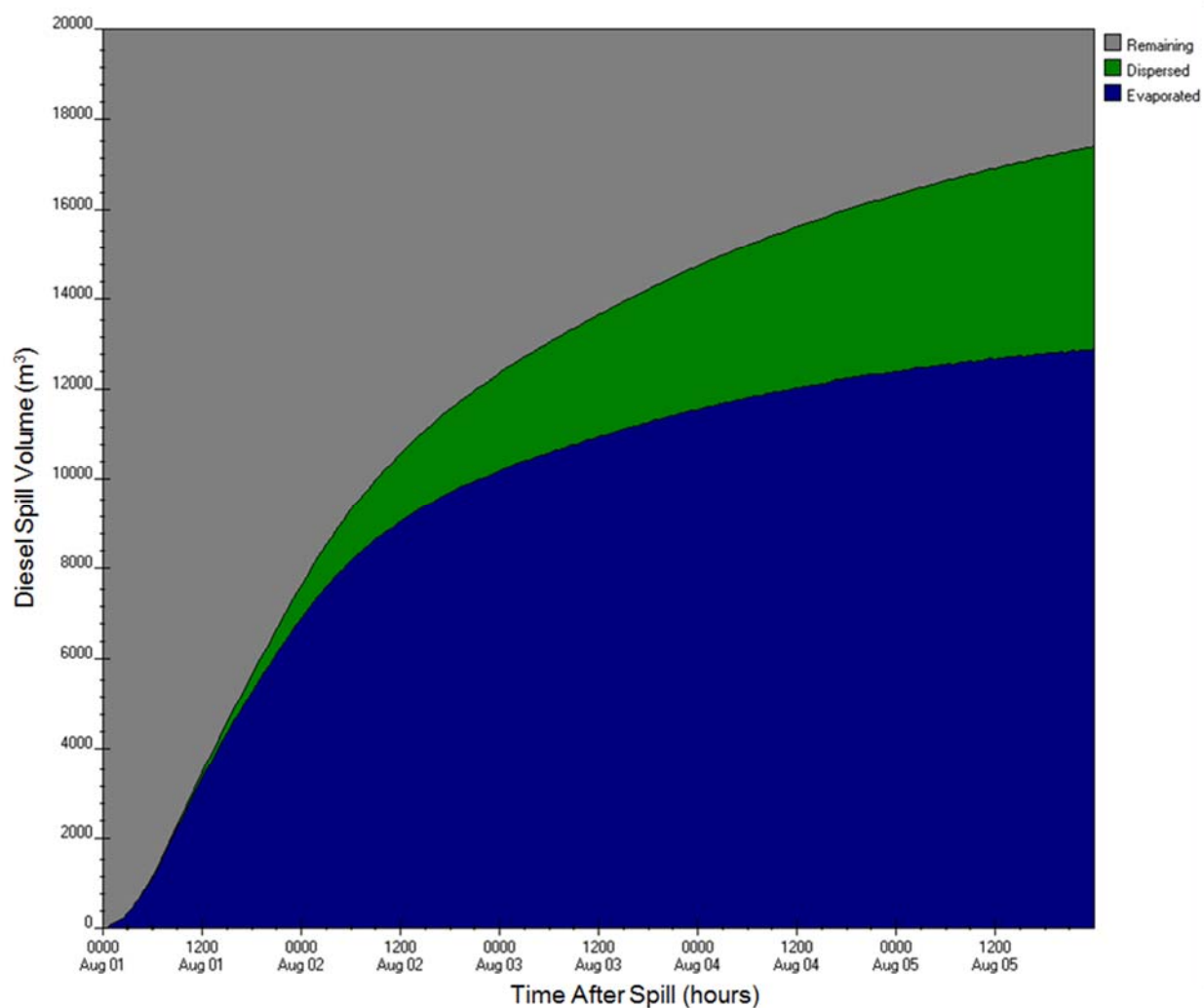


Figure E-A40: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 20,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

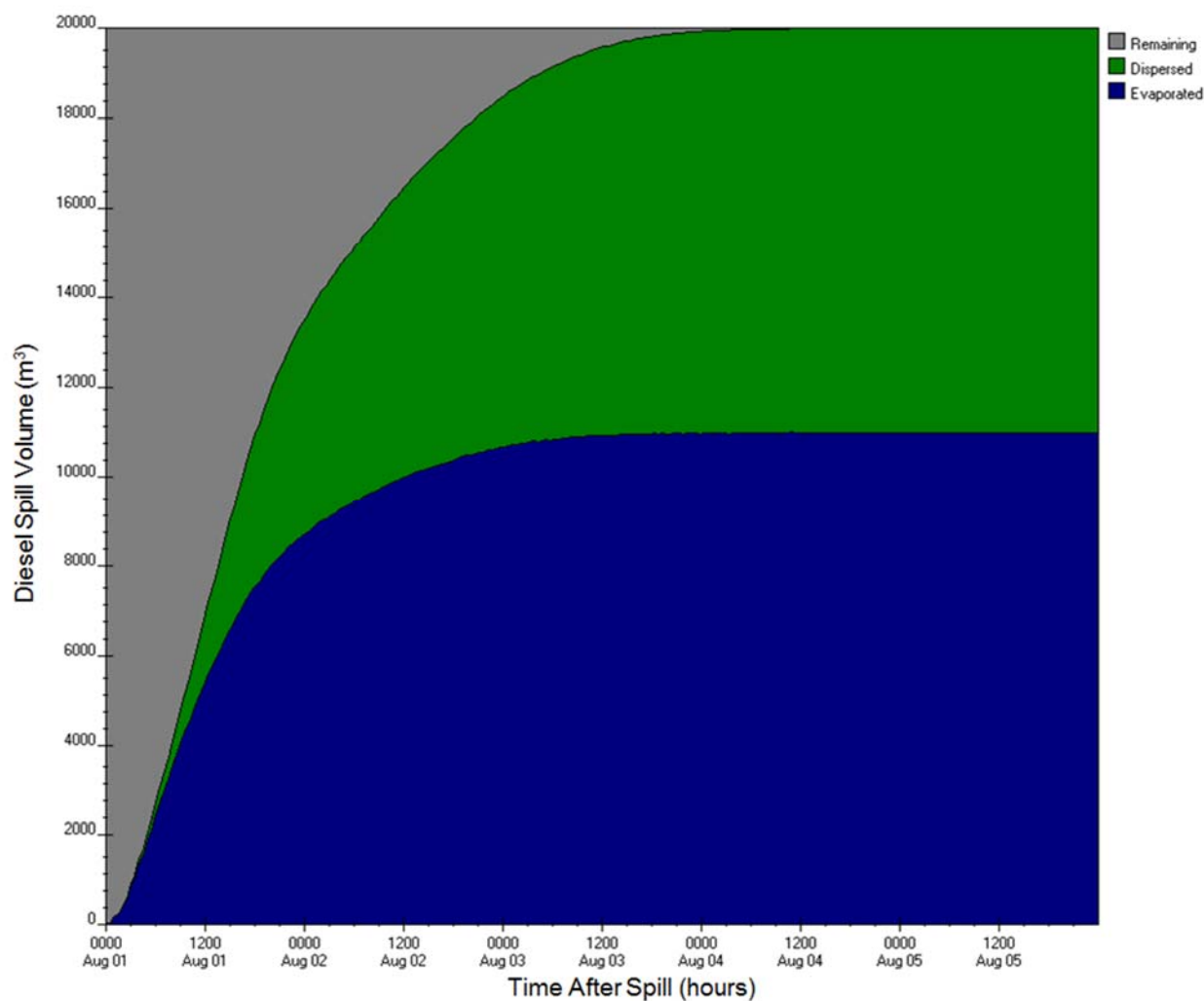


Figure E-A41: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

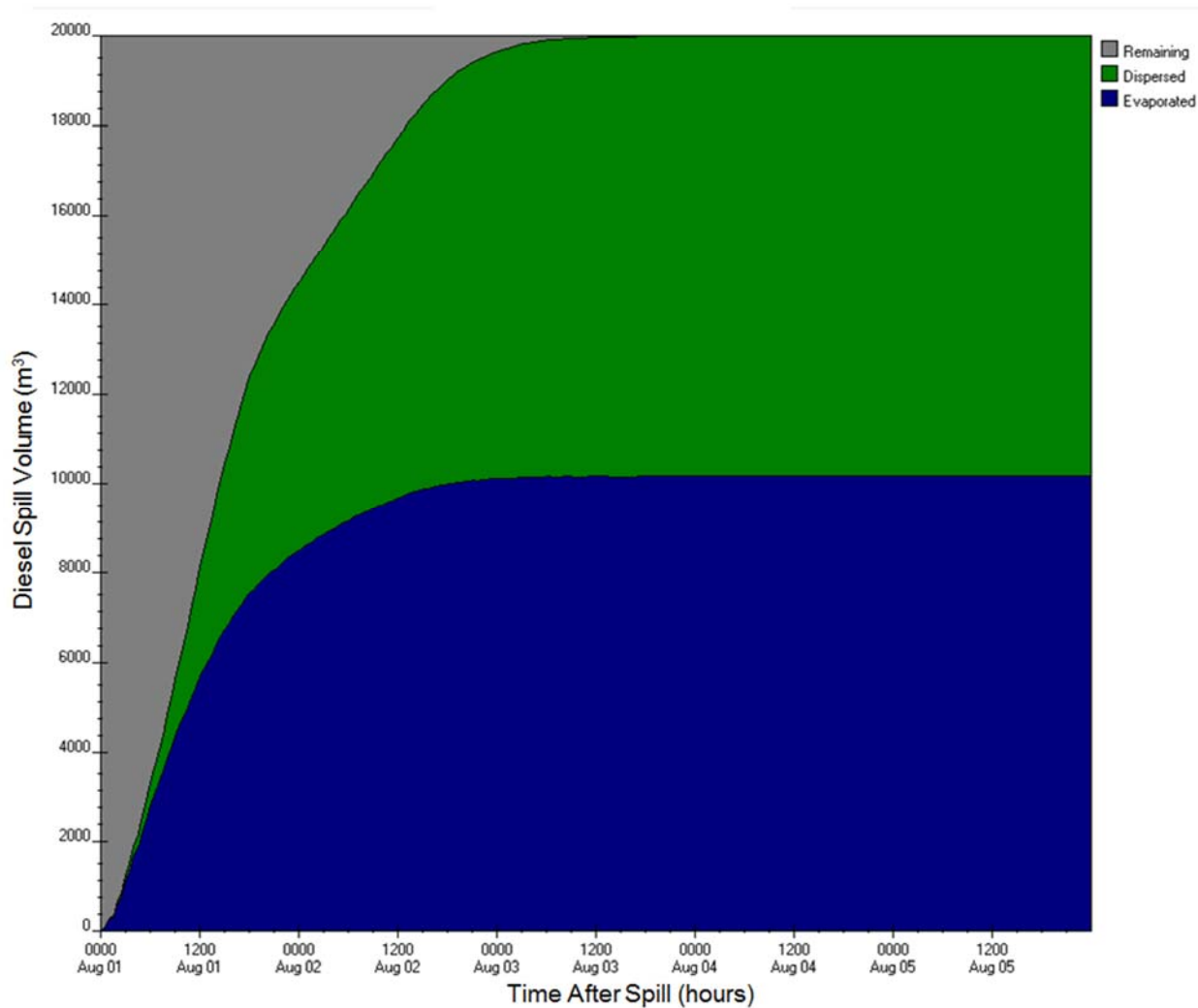


Figure E-A42: ADIOS2 diesel fuel budget output for West and East Melvin Bay stations (1A and 2A) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

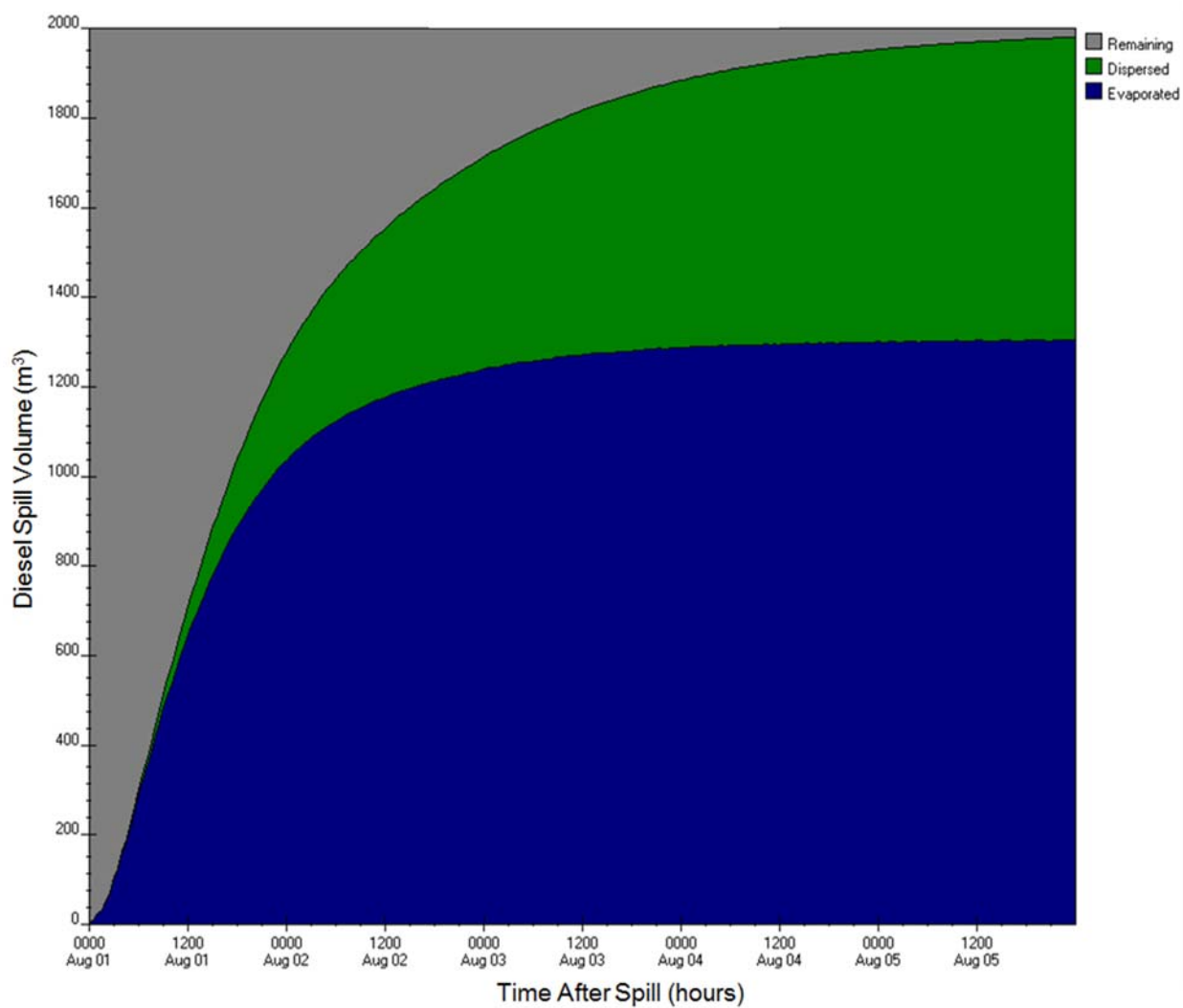


Figure E-A43: ADIOS2 diesel fuel budget output for Entrance to Melvin Bay station (3A) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

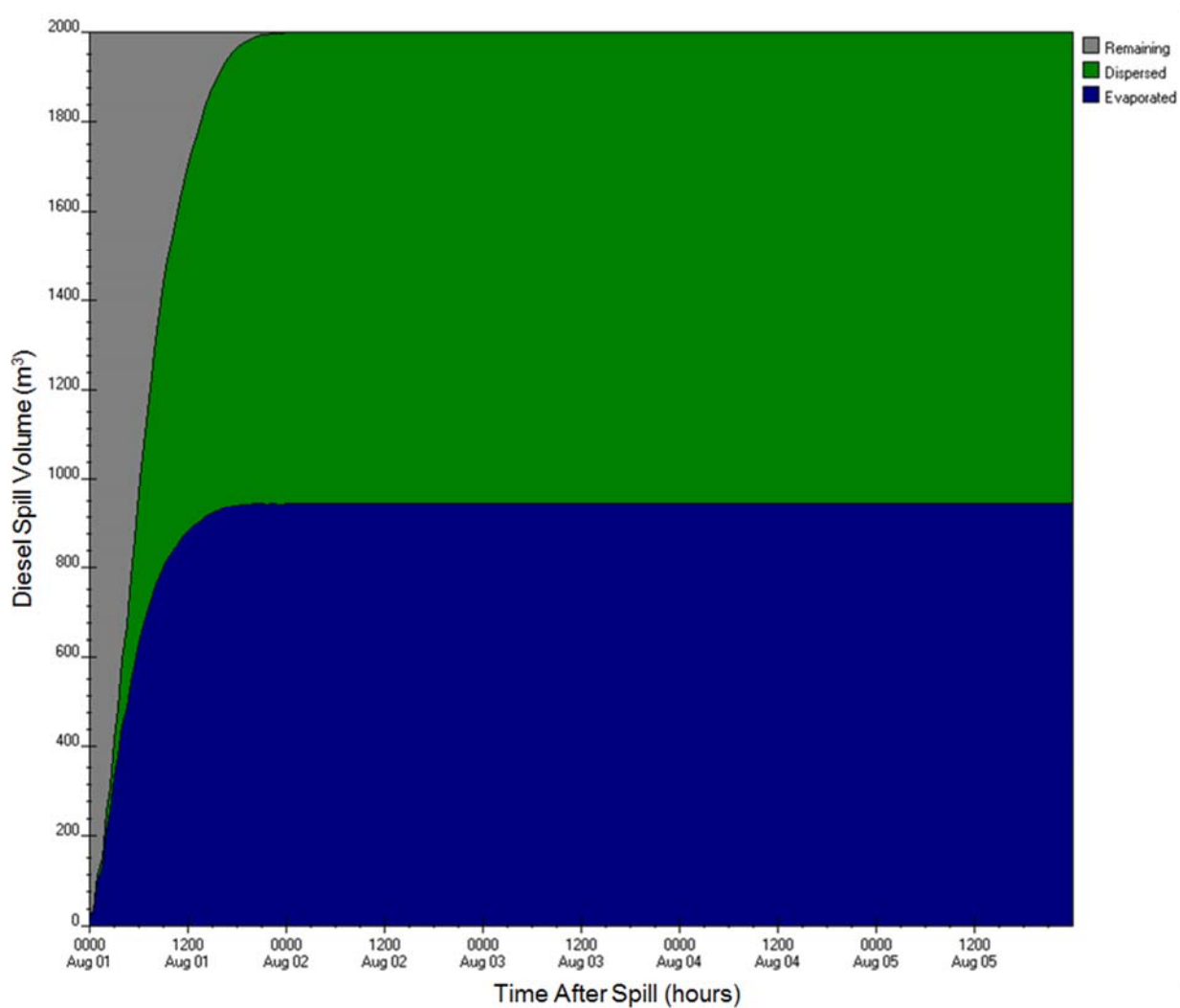


Figure E-A44: ADIOS2 diesel fuel budget output for Entrance to Melvin Bay station (3A) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

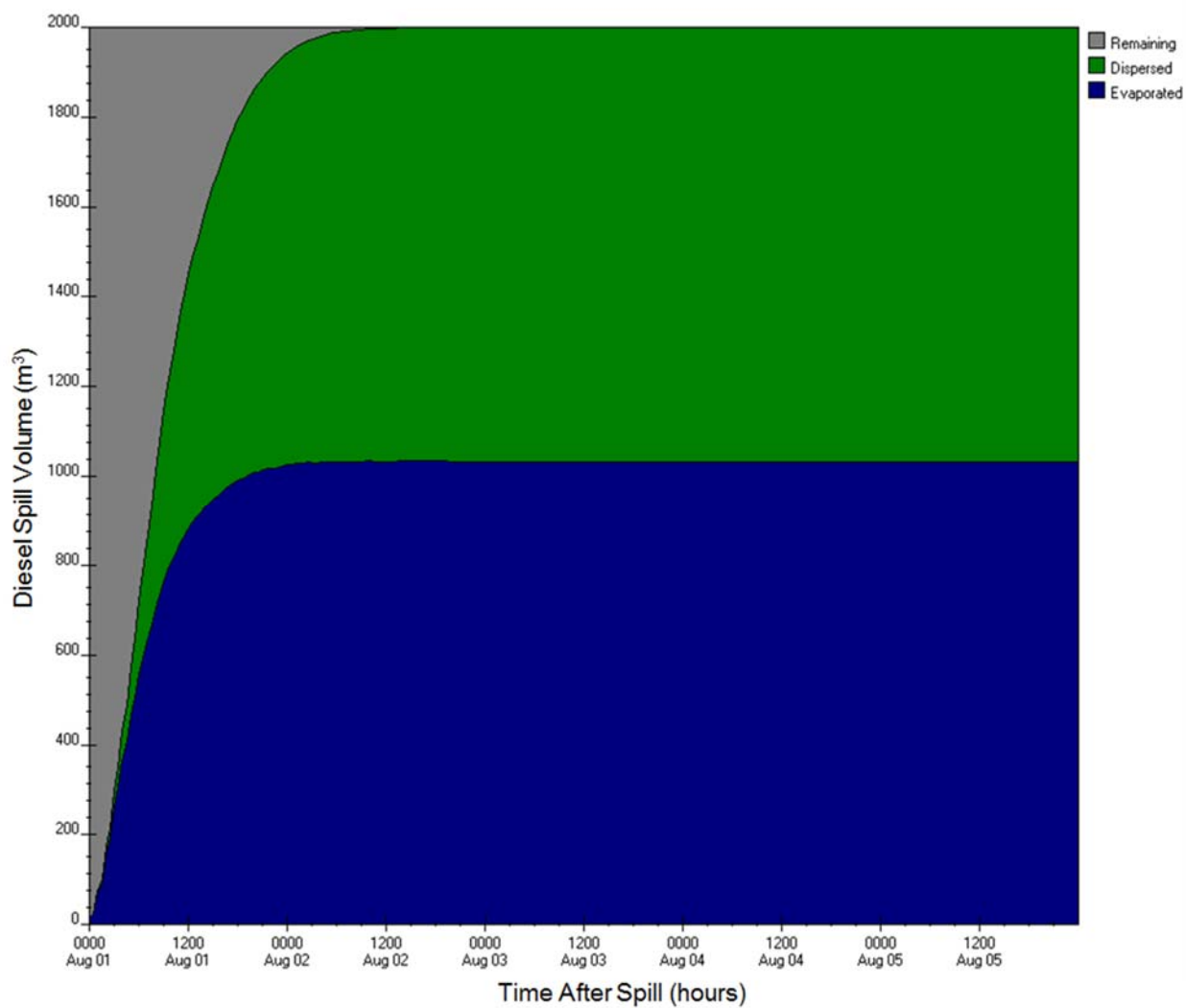


Figure E-A45: ADIOS2 diesel fuel budget output for Entrance to Melvin Bay station (3A) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

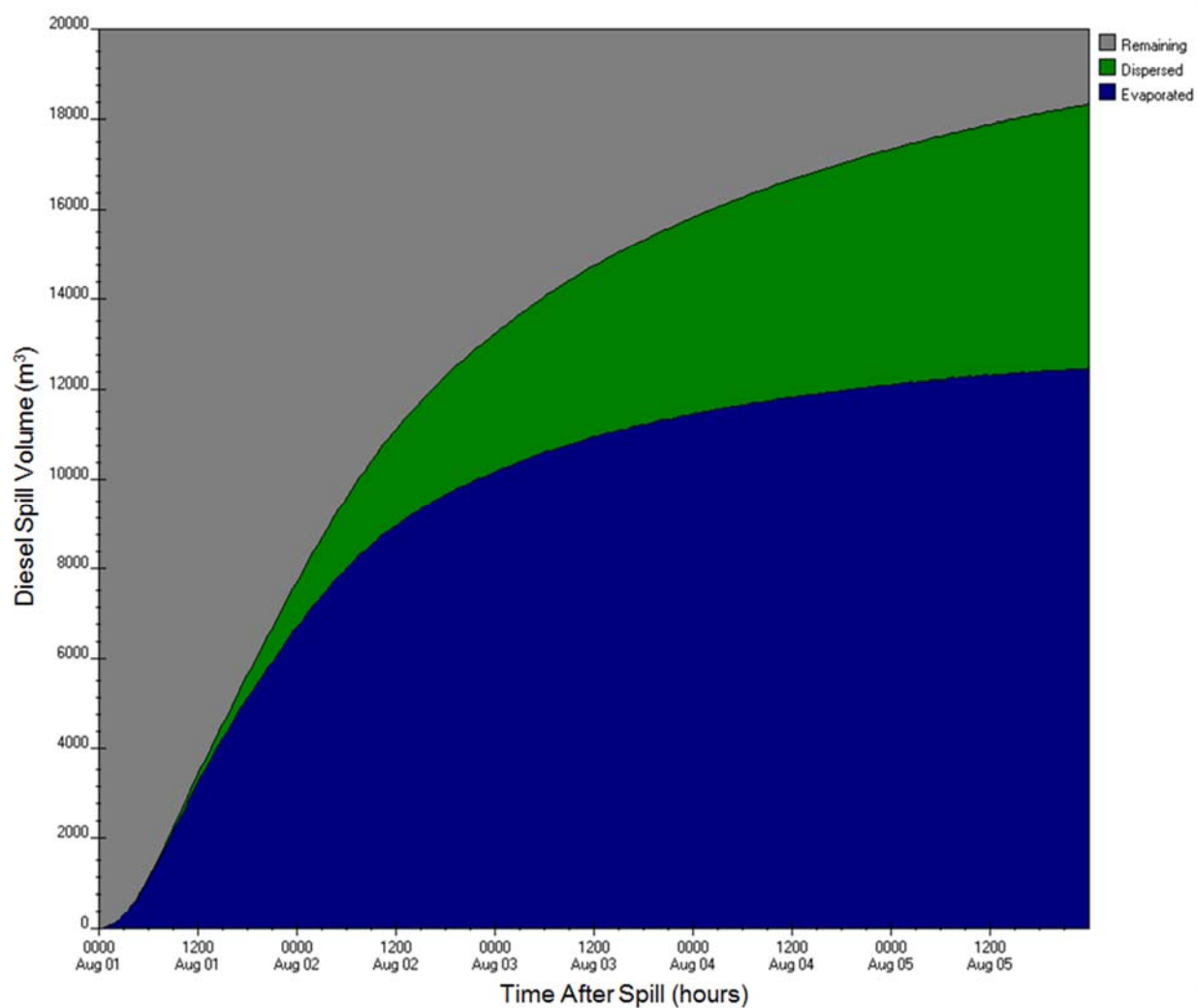


Figure E-A46: ADIOS2 diesel fuel budget output for Entrance to Melvin Bay station (3A) for 20,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

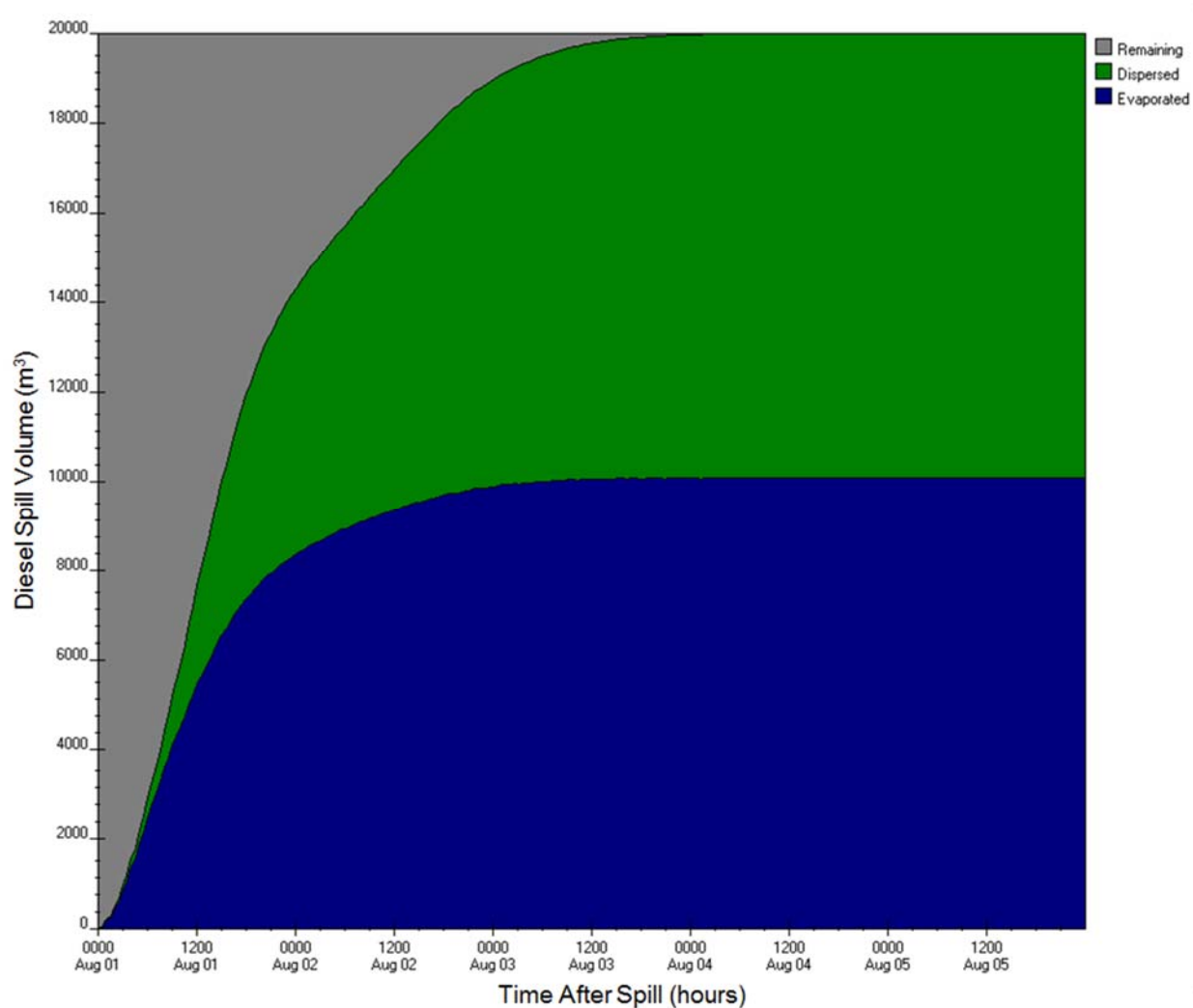


Figure E-A47: ADIOS2 diesel fuel budget output for Entrance to Melvin Bay station (3A) for 20,000 m<sup>3</sup>, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

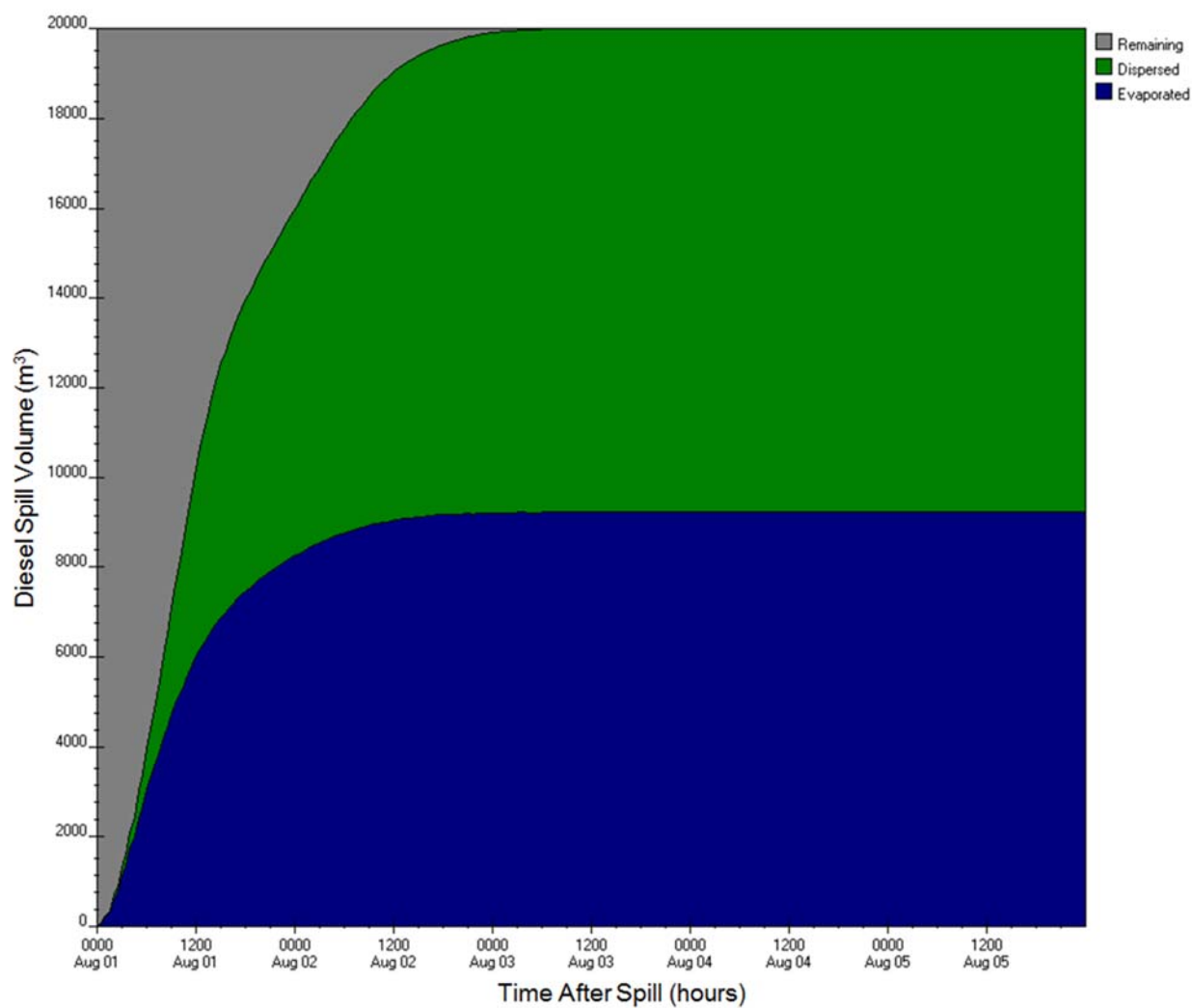


Figure E-A48: ADIOS2 diesel fuel budget output for Entrance to Melvin Bay station (3A) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

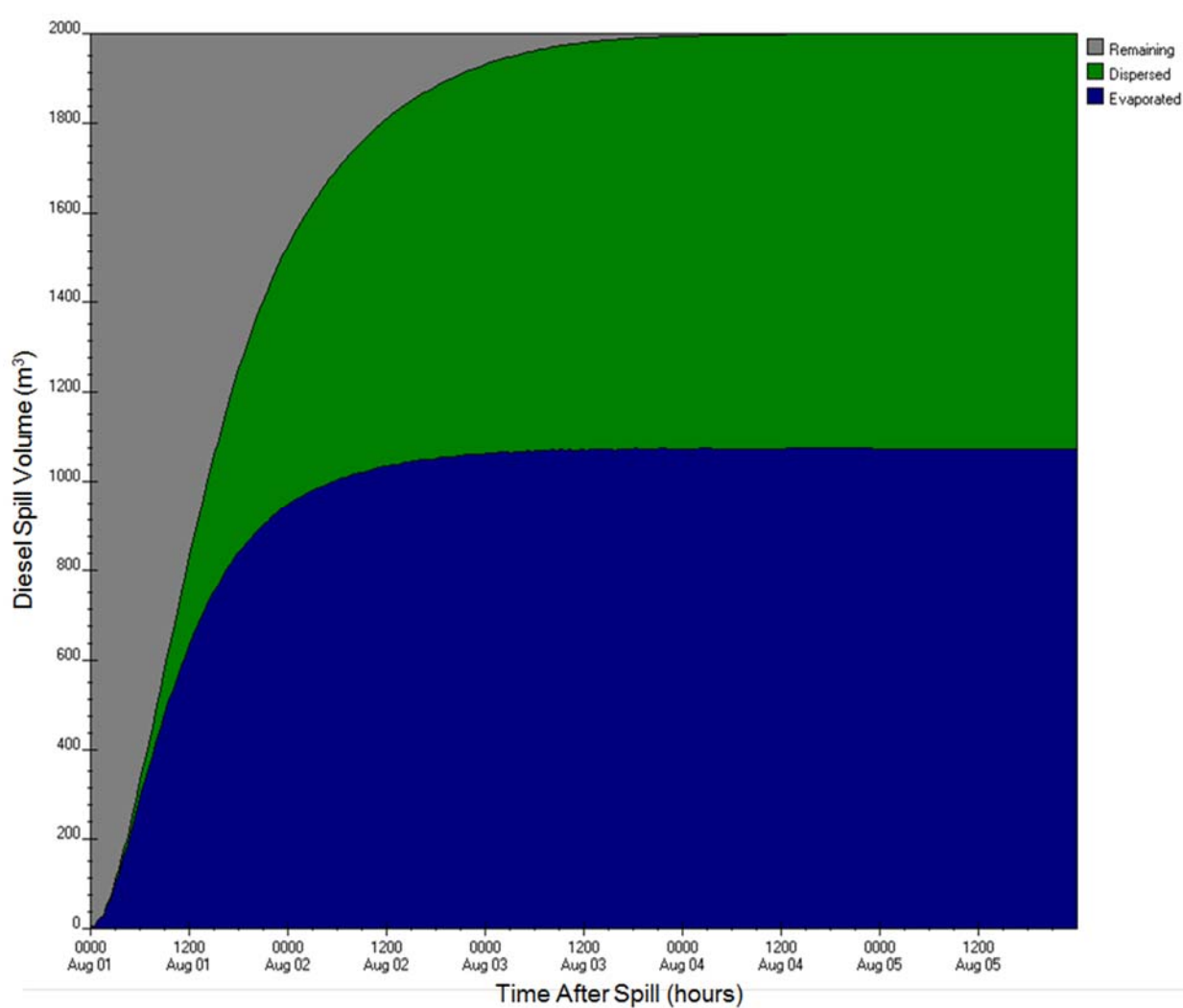


Figure E-A49: ADIOS2 diesel fuel budget output for West Hudson Bay station (4A) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

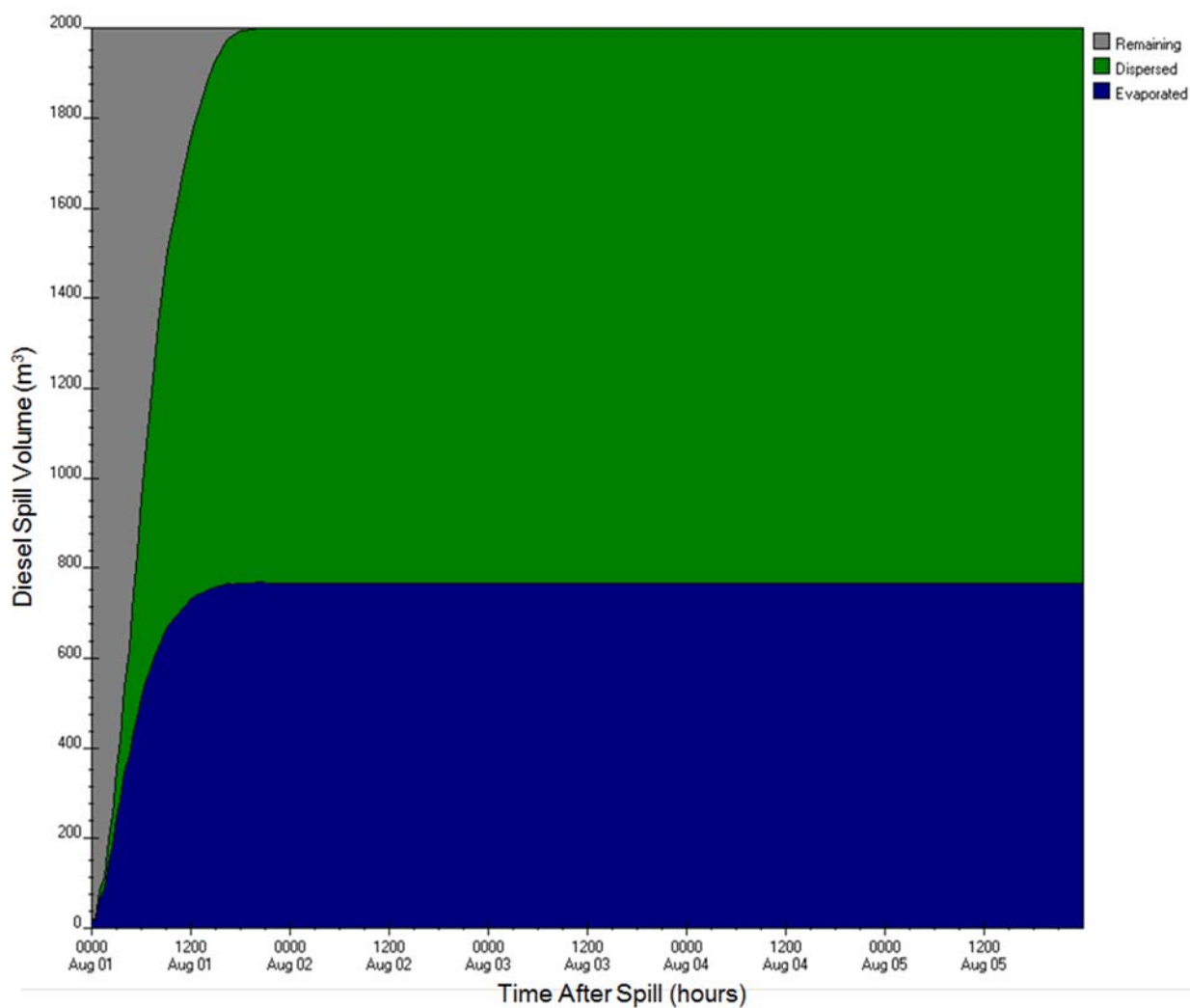


Figure E-A50: ADIOS2 diesel fuel budget output for West Hudson Bay station (4A) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

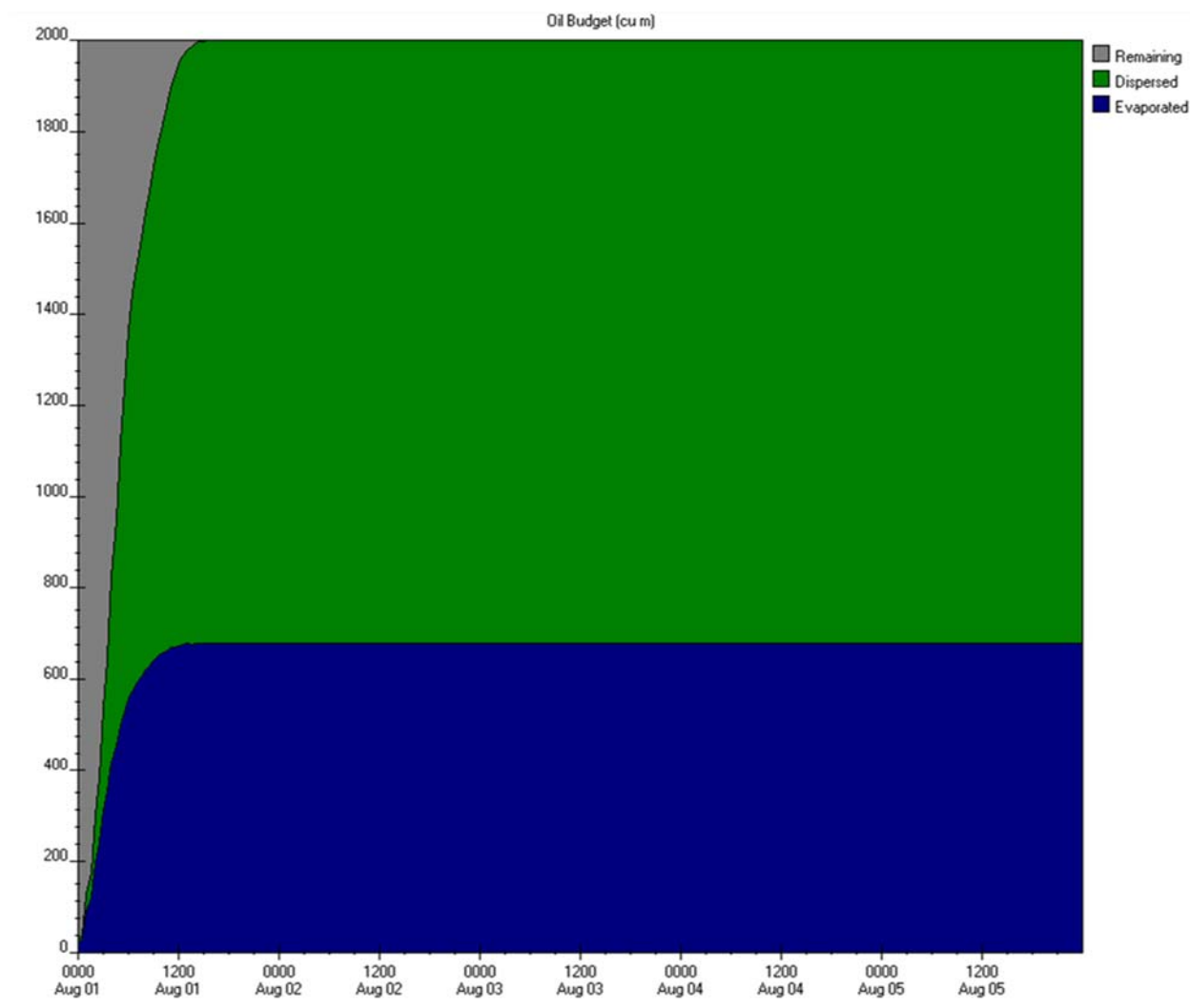


Figure E-A51: ADIOS2 diesel fuel budget output for West Hudson Bay station (4A) for 2,000 m<sup>3</sup>, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

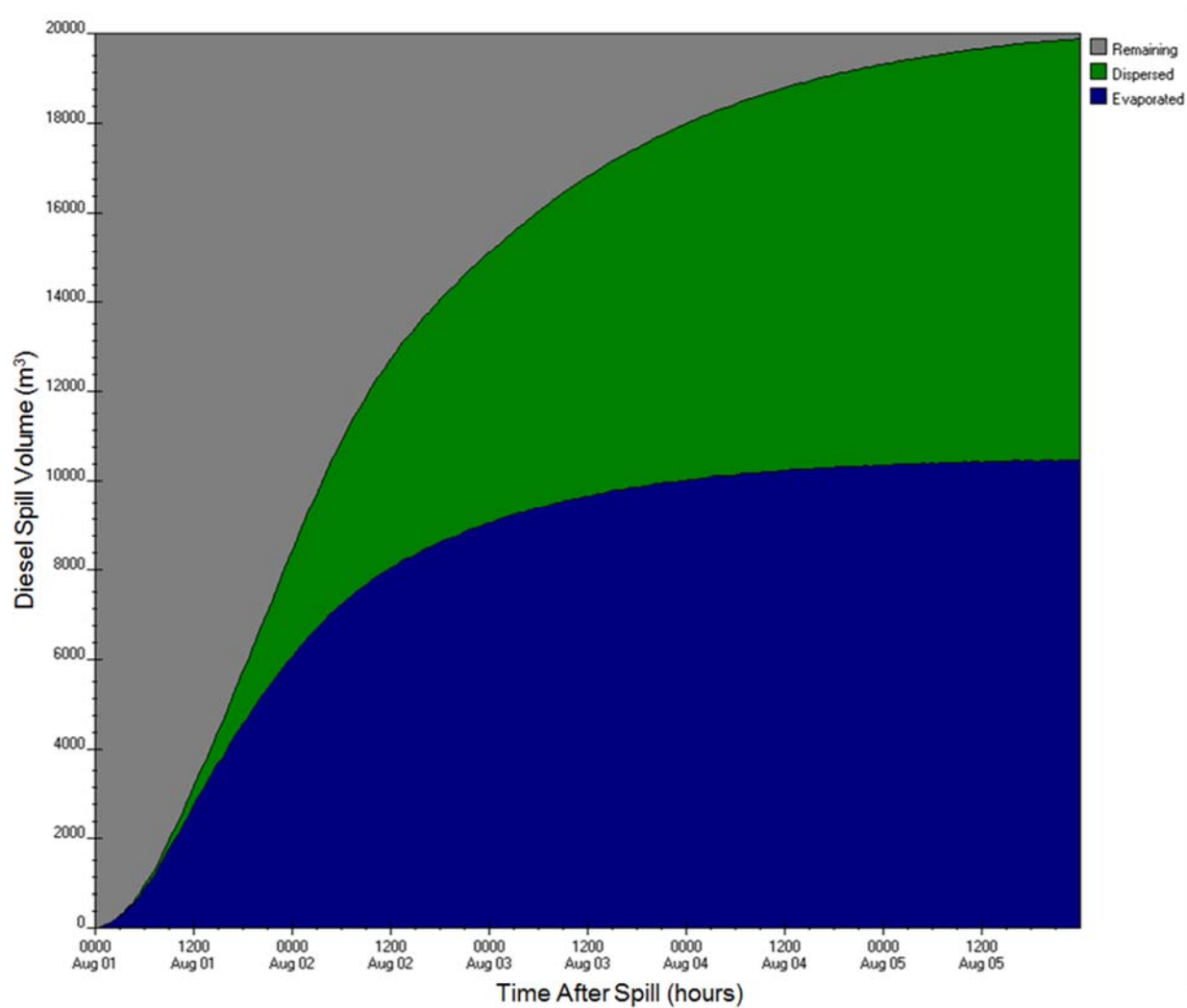


Figure E-A52: ADIOS2 diesel fuel budget output for West Hudson Bay station (4A) for 20,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

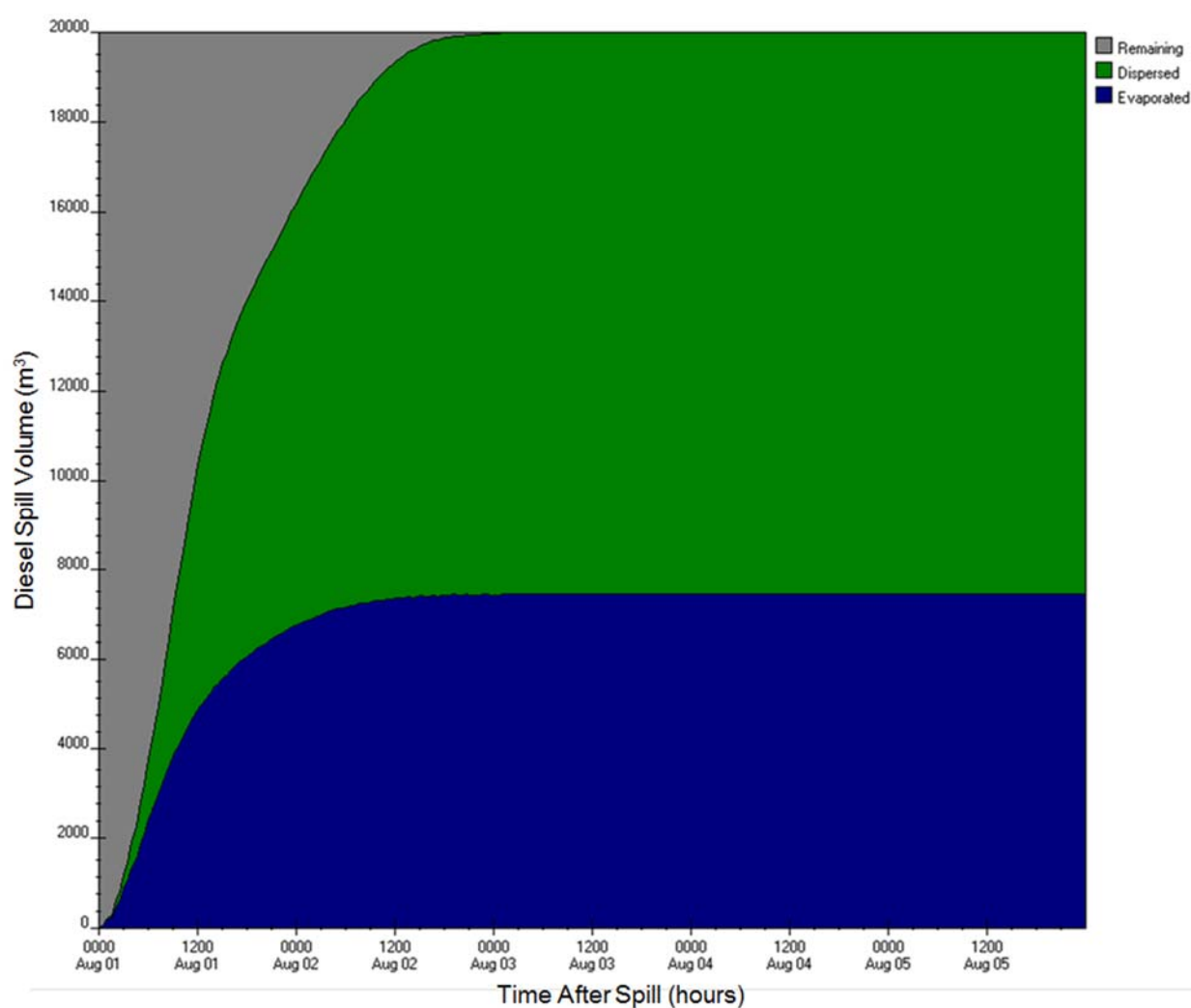


Figure E-A53: ADIOS2 diesel fuel budget output for West Hudson Bay station (4A) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

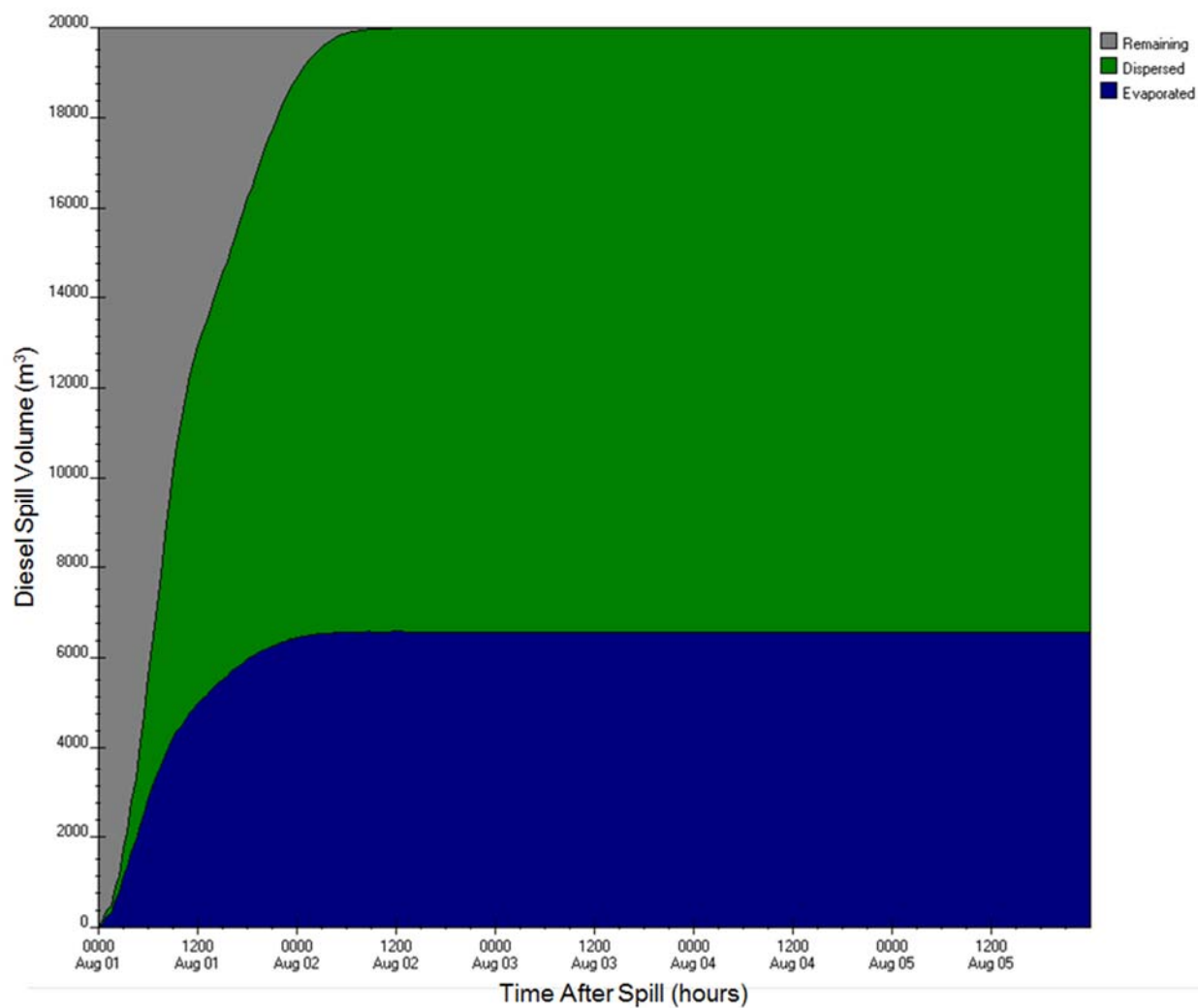


Figure E-A54: ADIOS2 diesel fuel budget output for West Hudson Bay station (4A) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

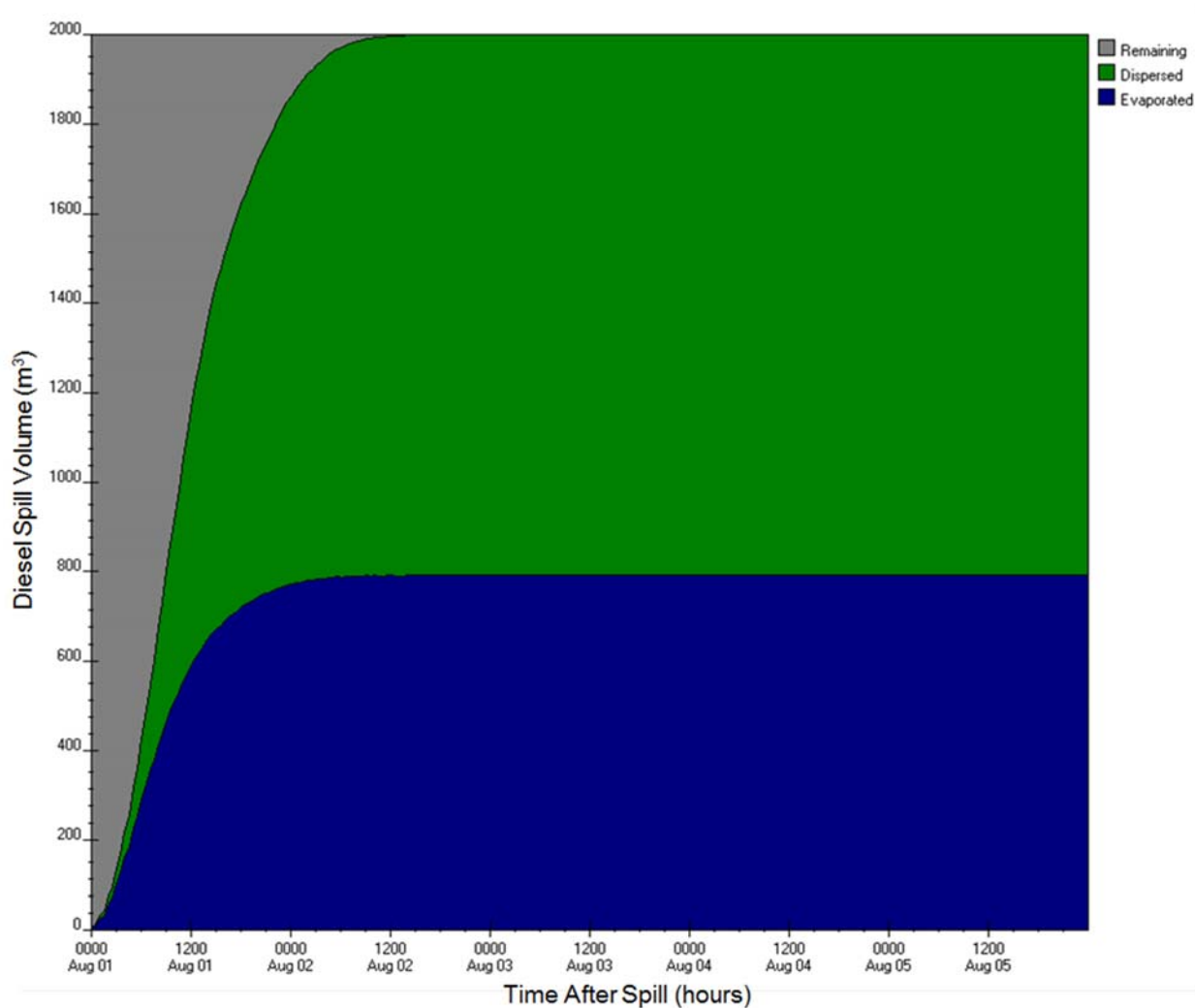


Figure E-A55: ADIOS2 diesel fuel budget output for Hudson Bay crossing station (5A) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

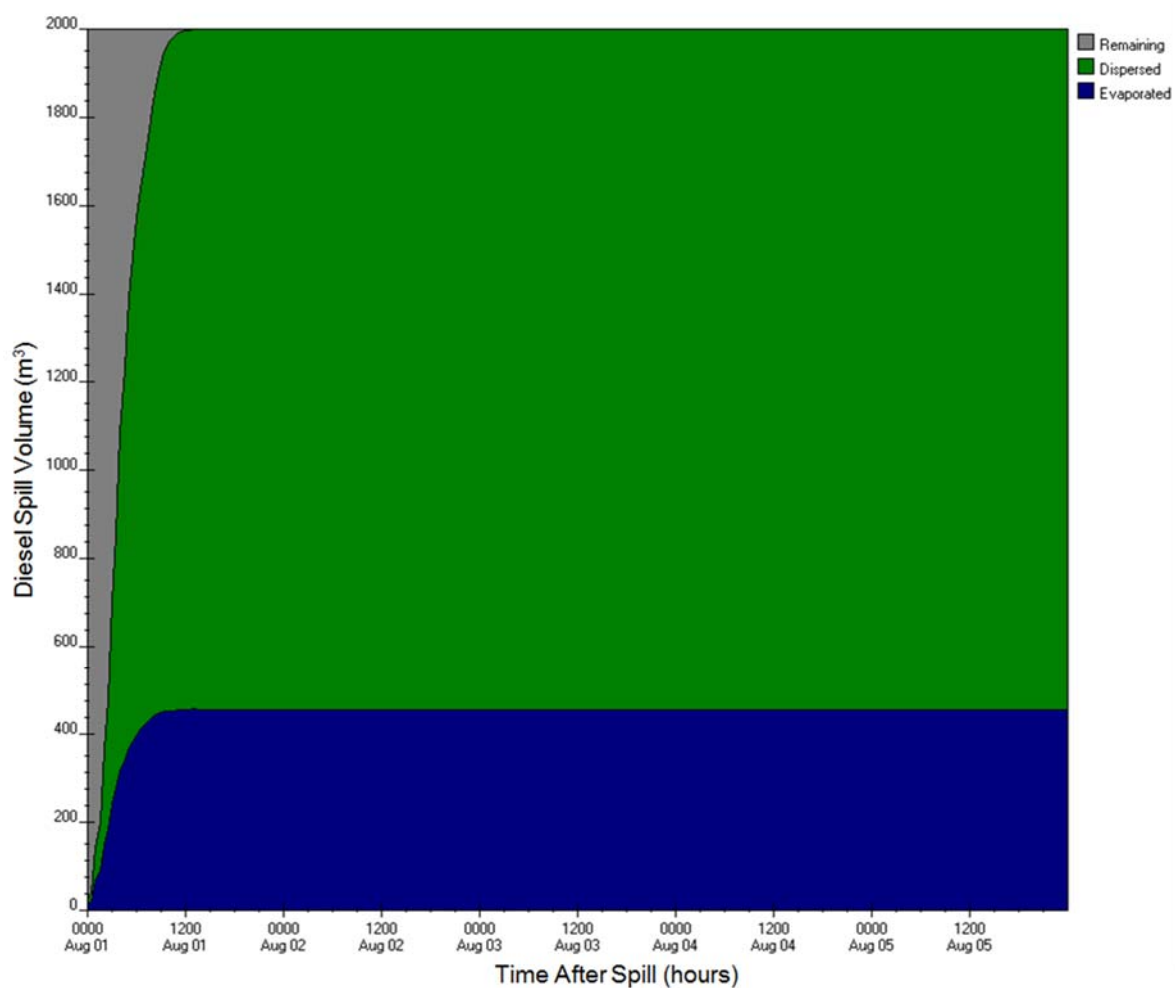


Figure E-A56: ADIOS2 diesel fuel budget output for Hudson Bay crossing station (5A) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

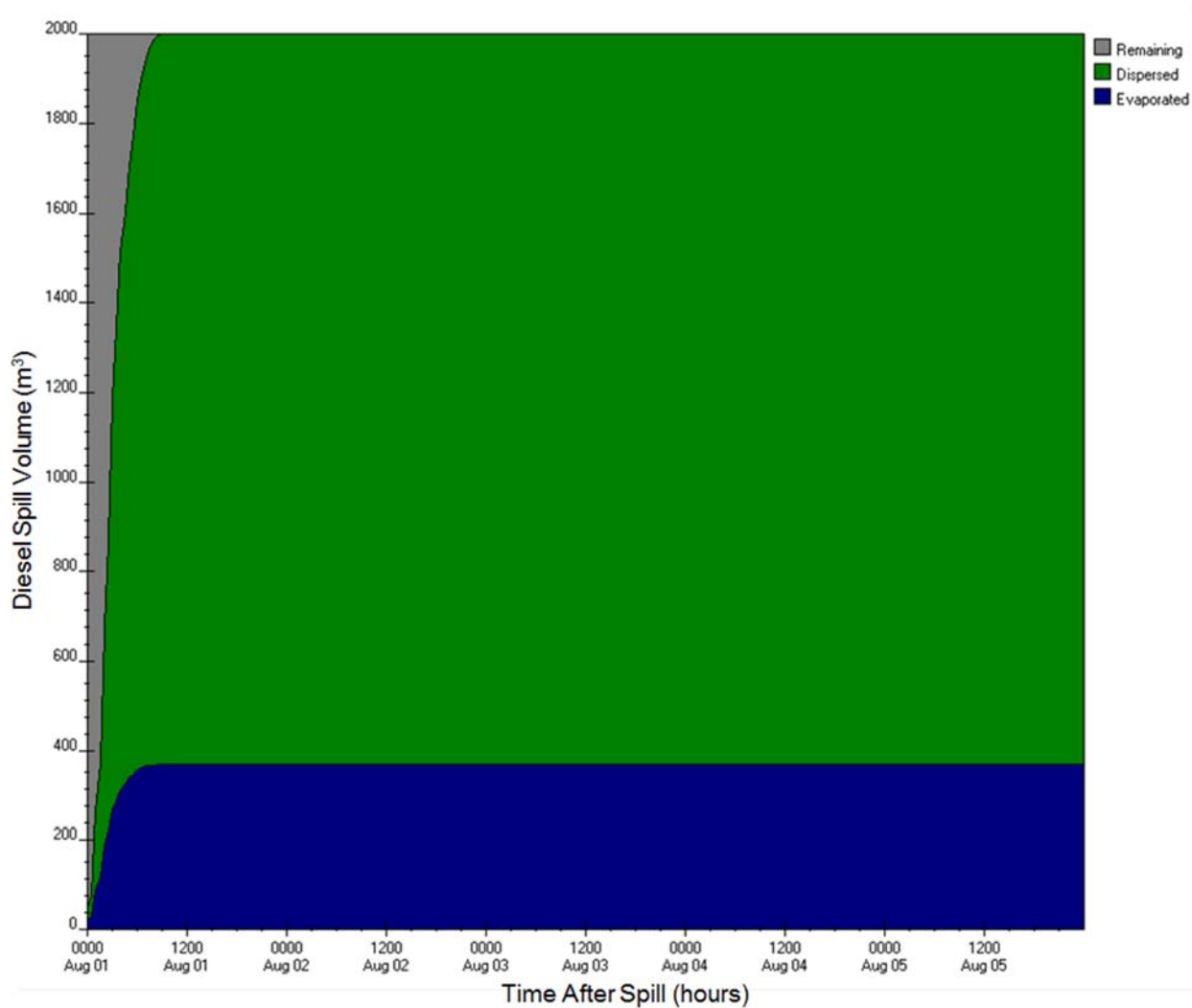


Figure E-A57: ADIOS2 diesel fuel budget output for Hudson Bay crossing station (5A) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

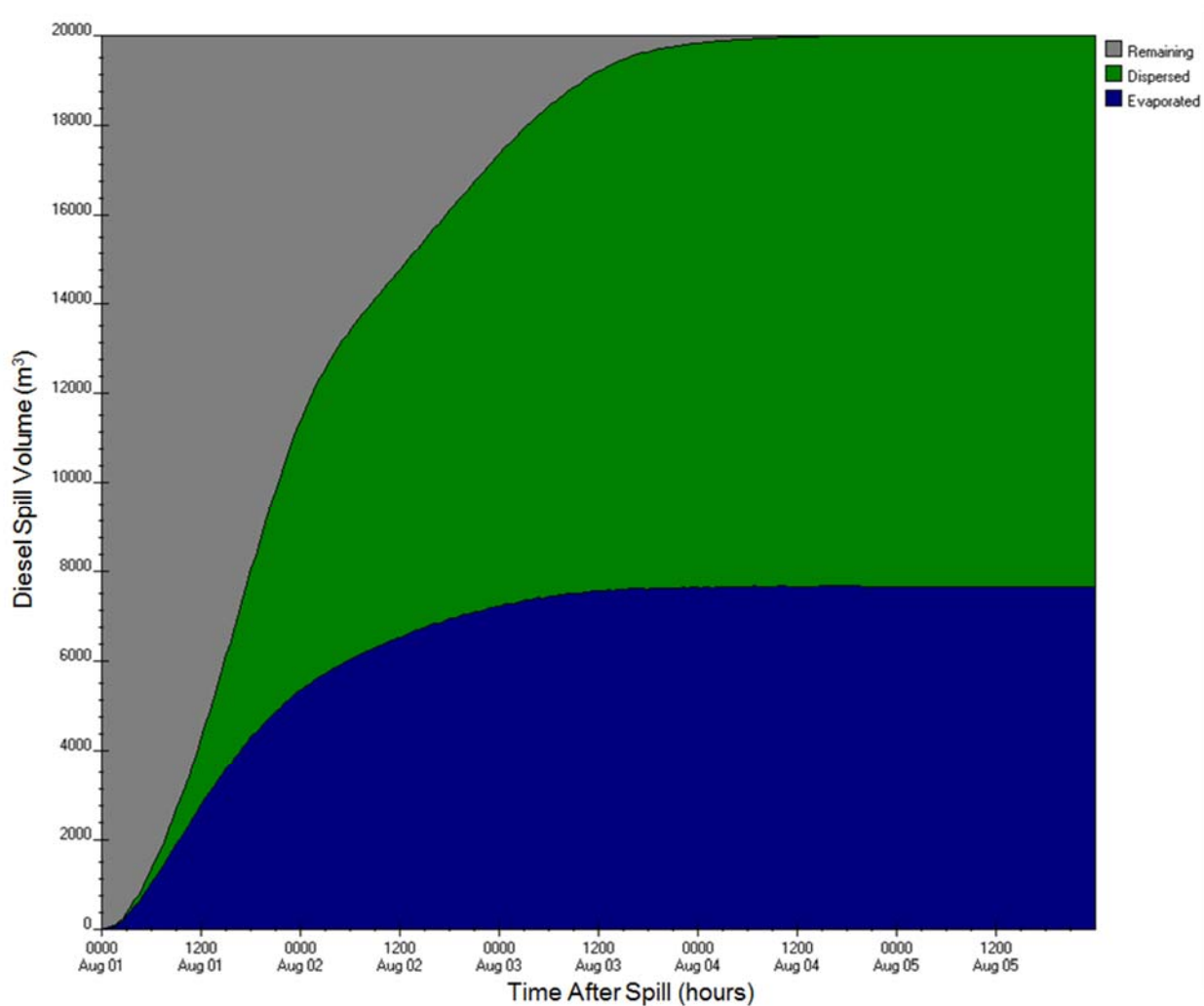


Figure E-A58: ADIOS2 diesel fuel budget output for Hudson Bay crossing station (5A) for 20,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

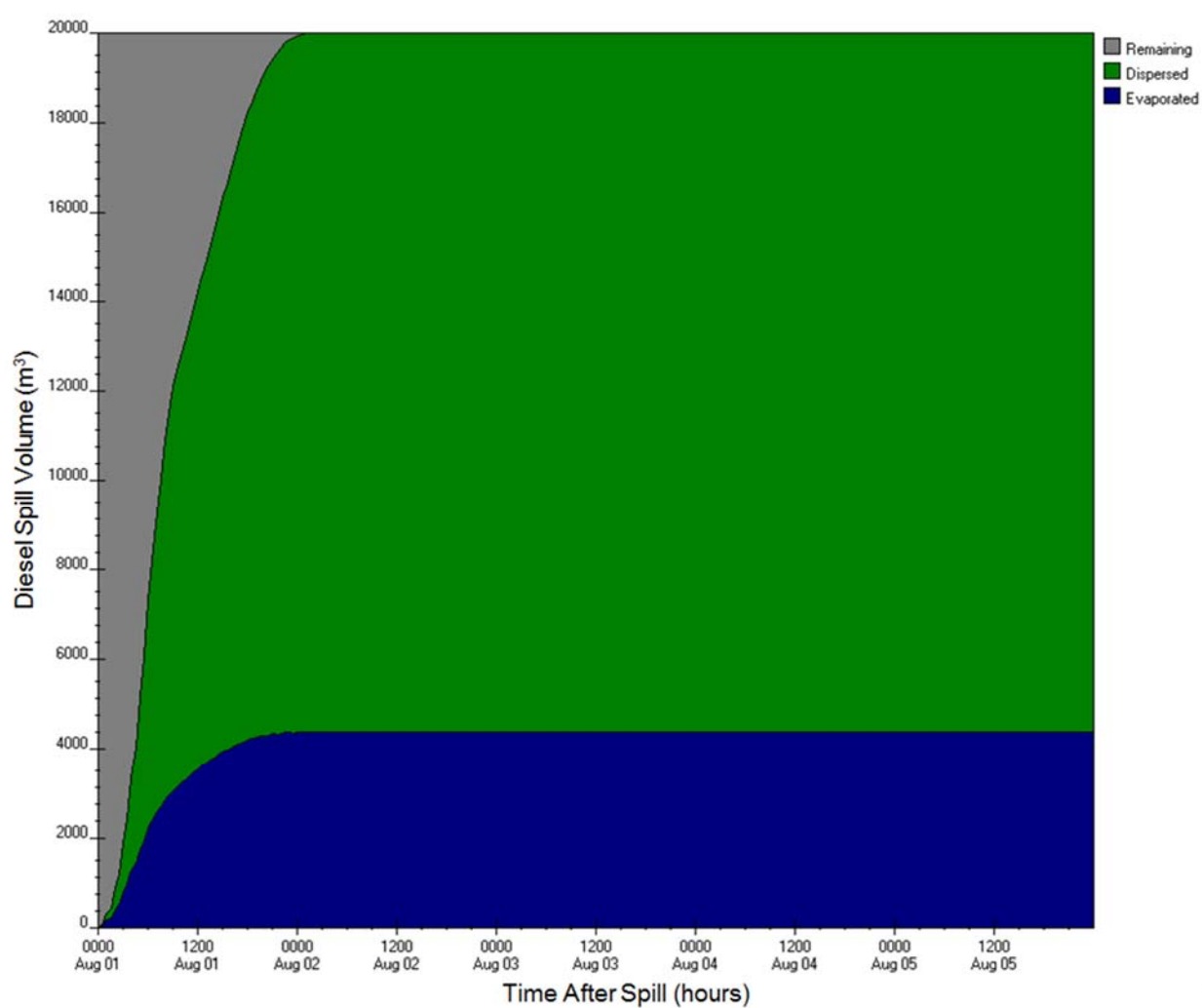


Figure E-A59: ADIOS2 diesel fuel budget output for Hudson Bay crossing station (5A) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

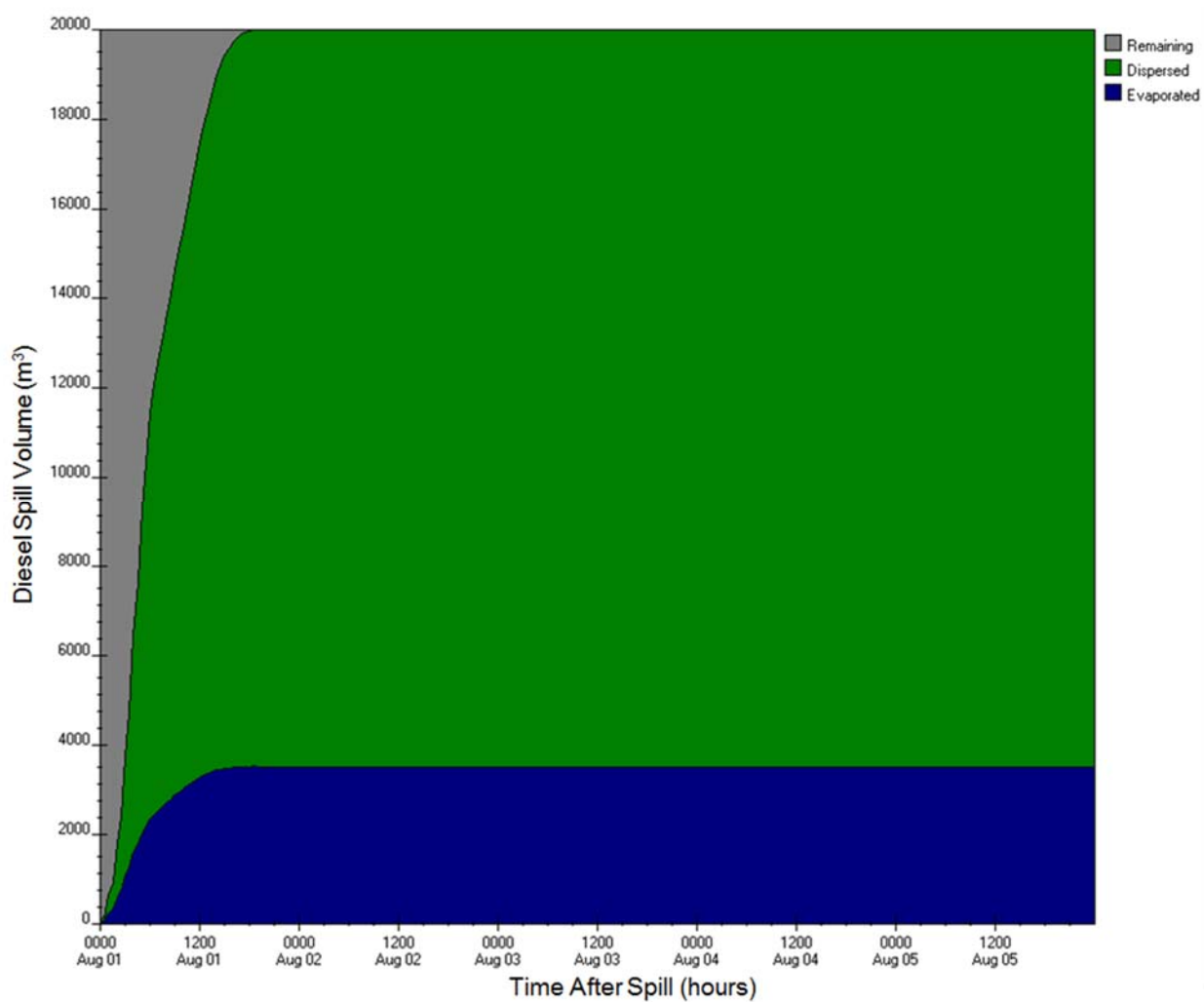


Figure E-A60: ADIOS2 diesel fuel budget output for Hudson Bay crossing station (5A) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

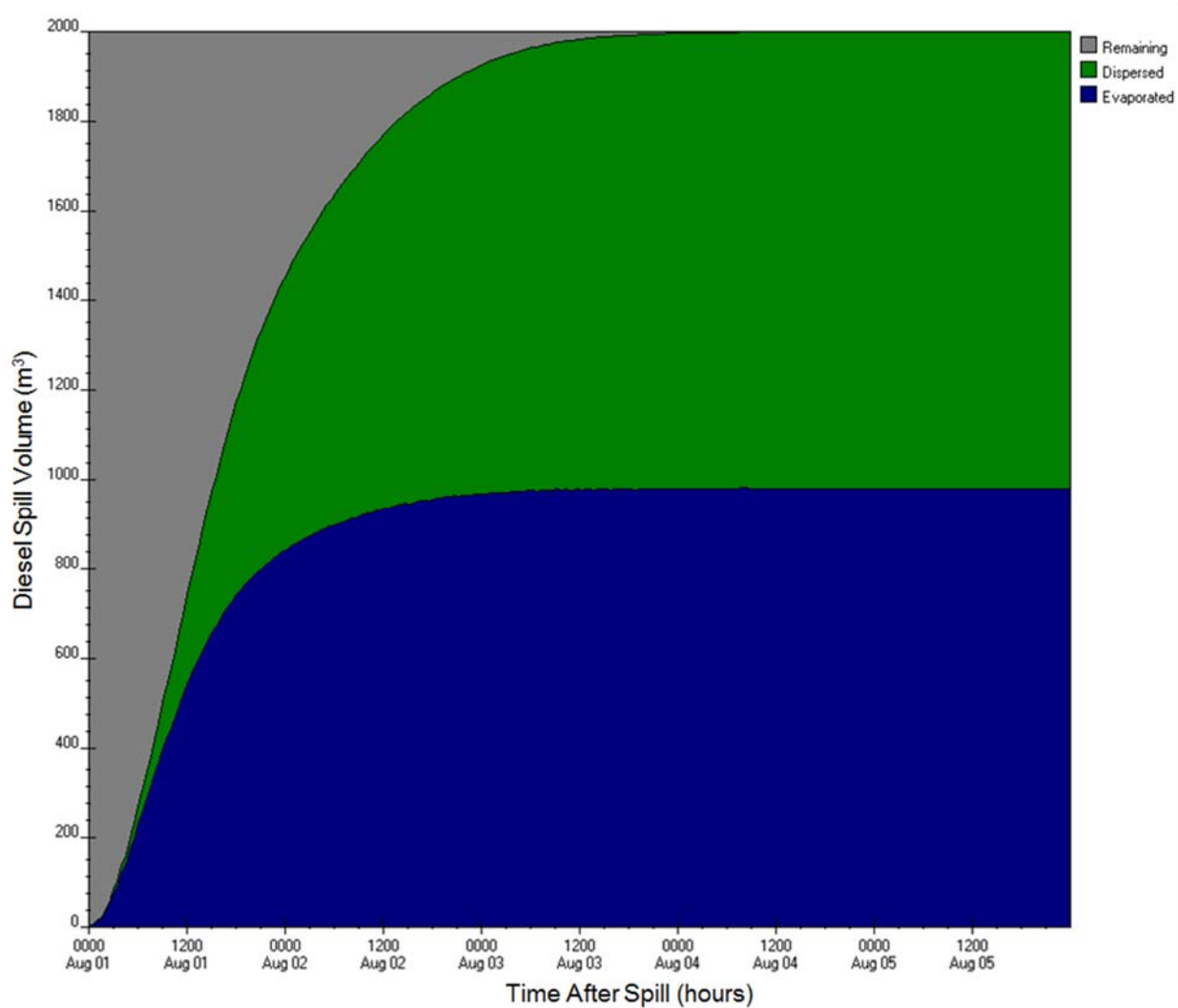


Figure E-A61: ADIOS2 diesel fuel budget output for Western Hudson Strait, Charles Island station (6A) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

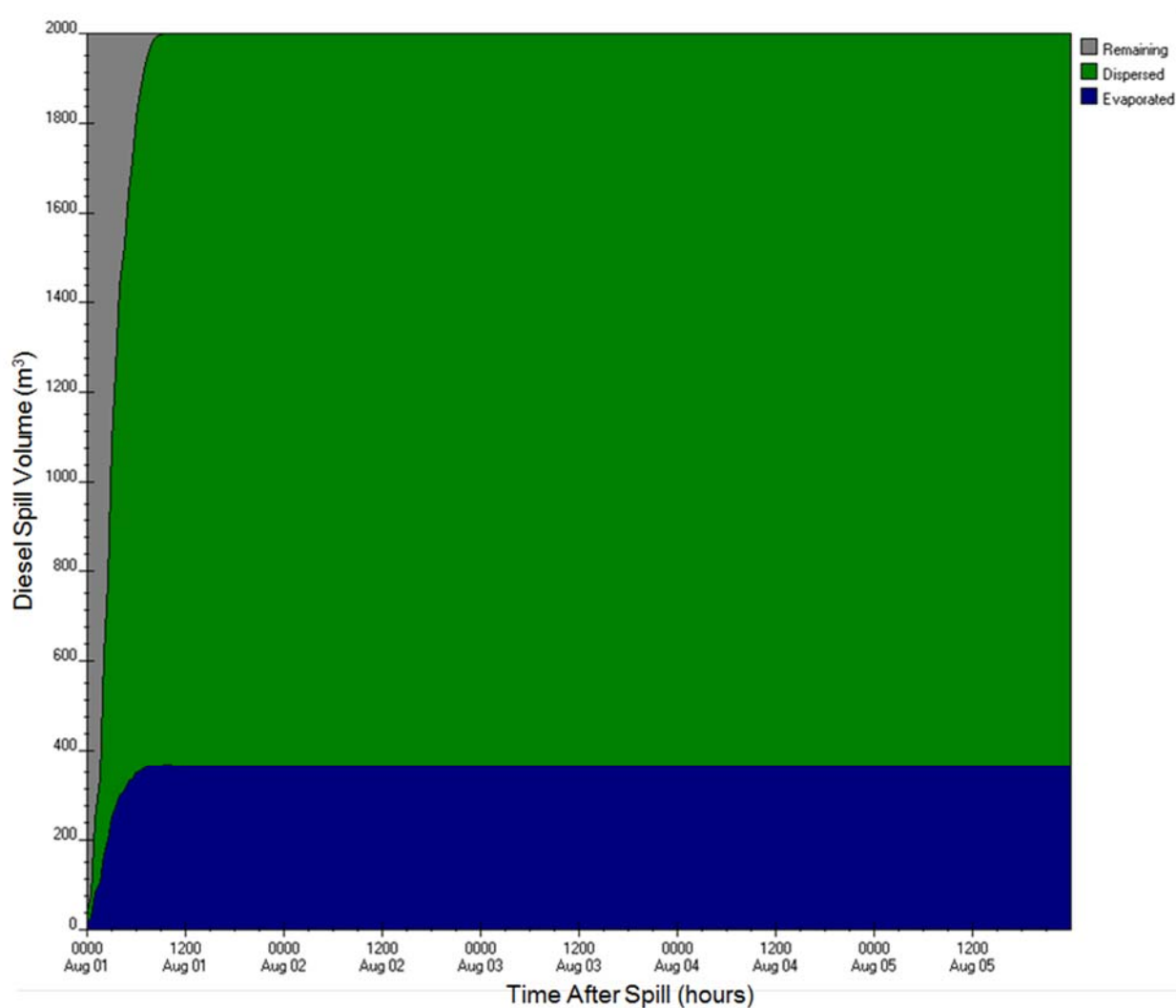


Figure E-A62: ADIOS2 diesel fuel budget output for Western Hudson Strait, Charles Island station (6A) for 2,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

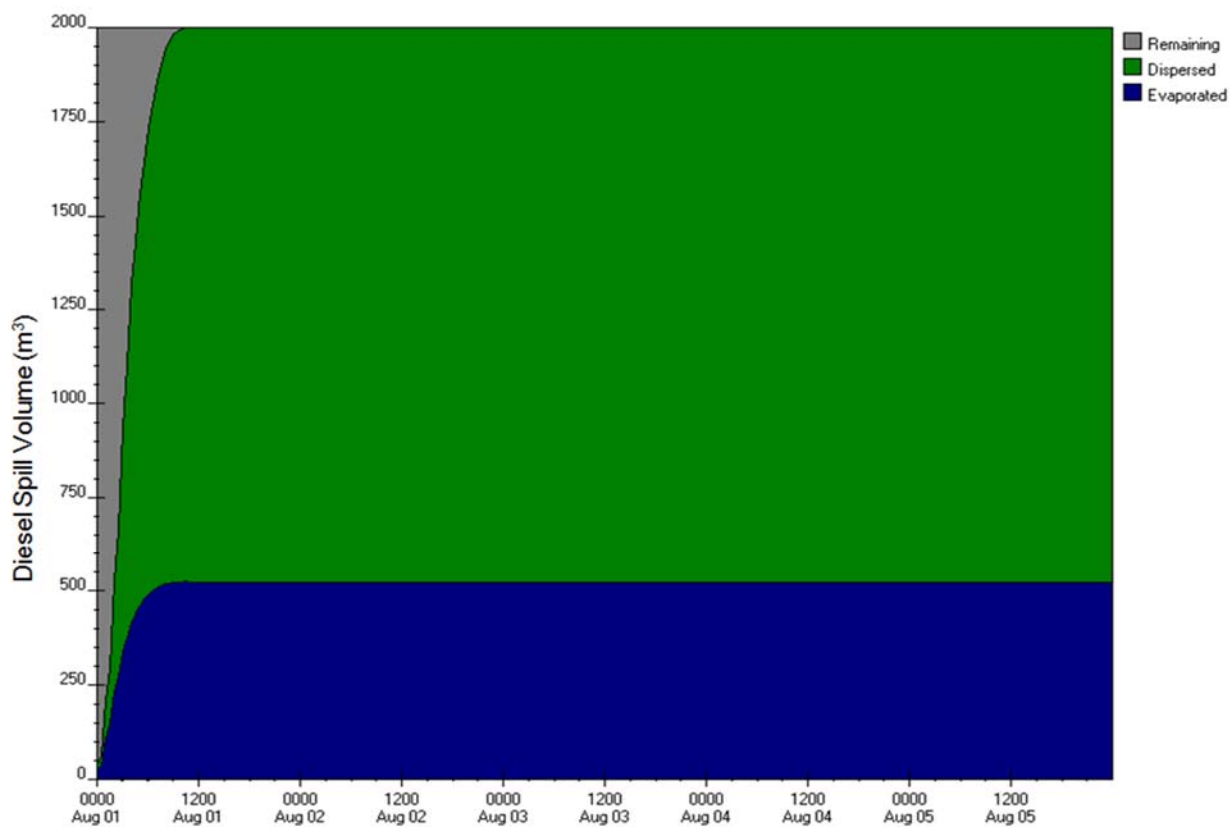


Figure E-A63: ADIOS2 diesel fuel budget output for Western Hudson Strait, Charles Island station (6A) for 2,000 m<sup>3</sup>, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

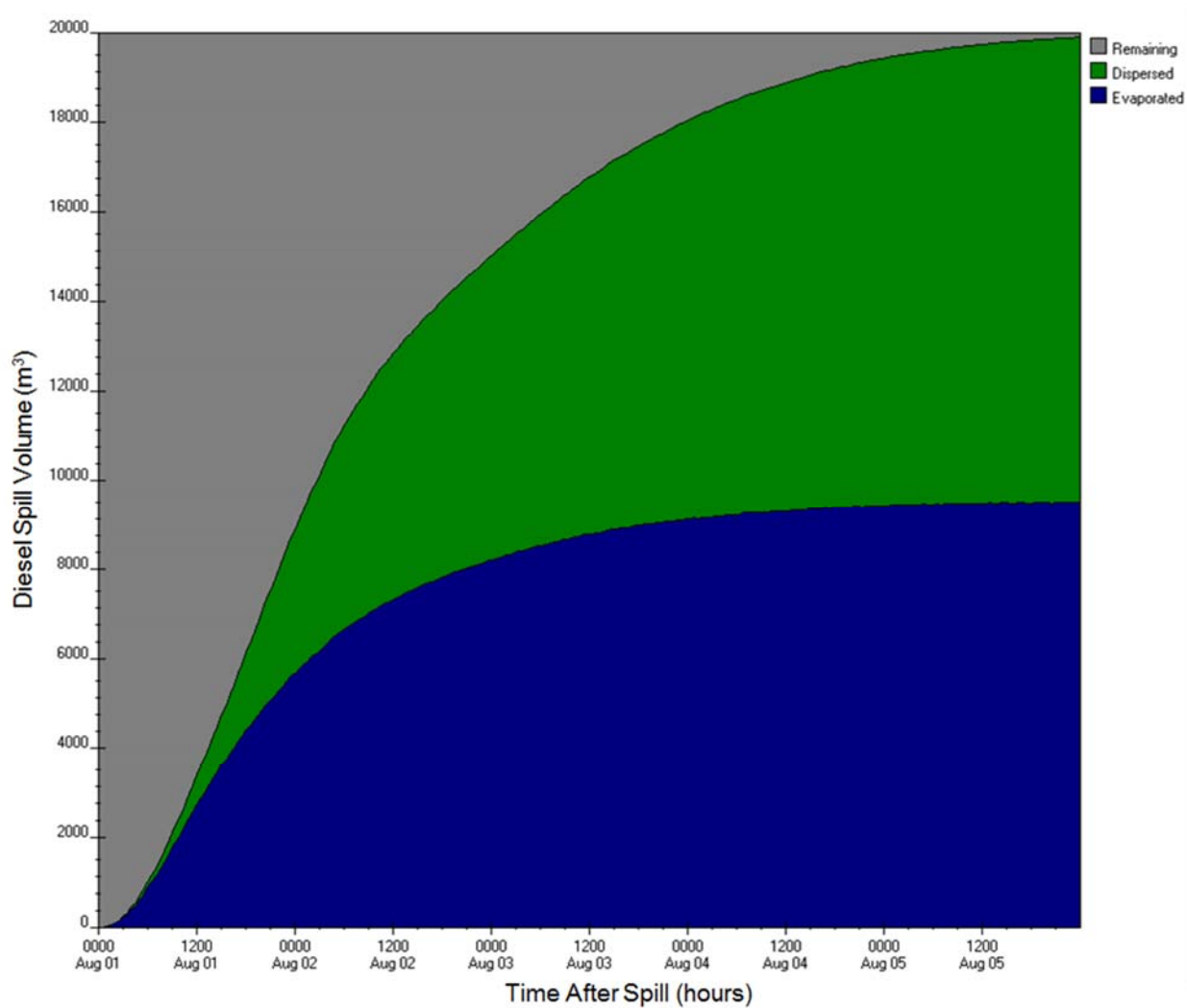


Figure E-A64: ADIOS2 diesel fuel budget output for Western Hudson Strait, Charles Island station (6A) for 20,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

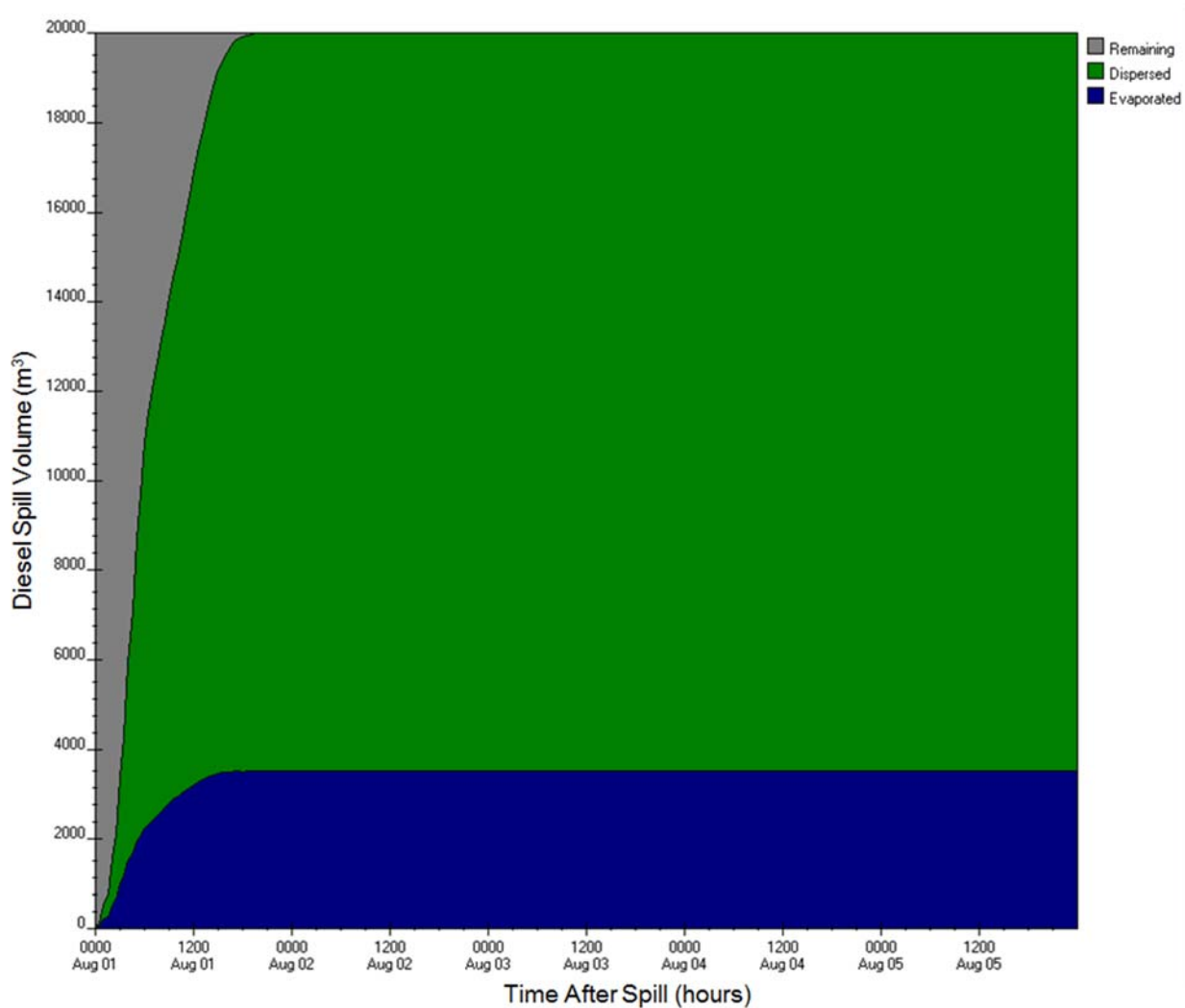


Figure E-A65: ADIOS2 diesel fuel budget output for Western Hudson Strait, Charles Island station (6A) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

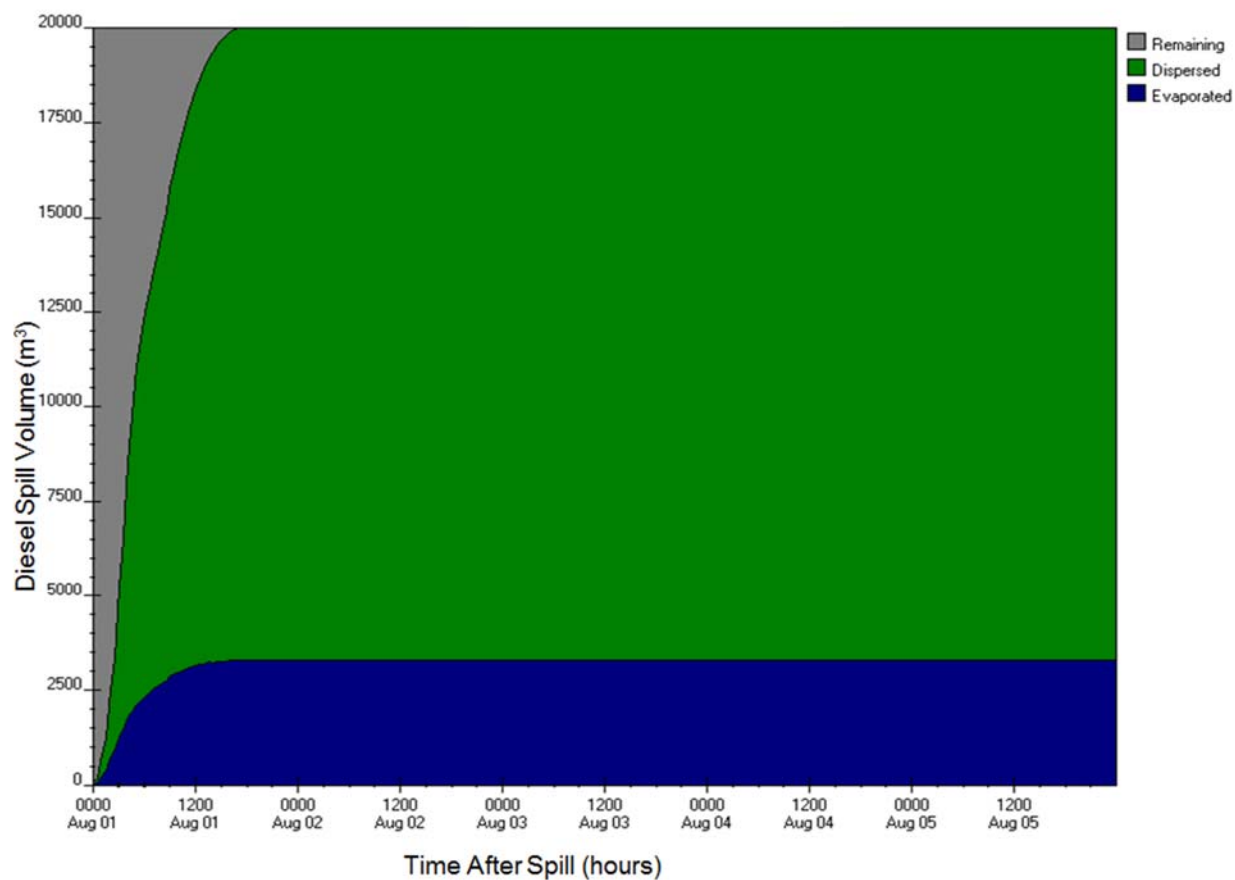


Figure E-A66: ADIOS2 diesel fuel budget output for Western Hudson Strait, Charles Island station (6A) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

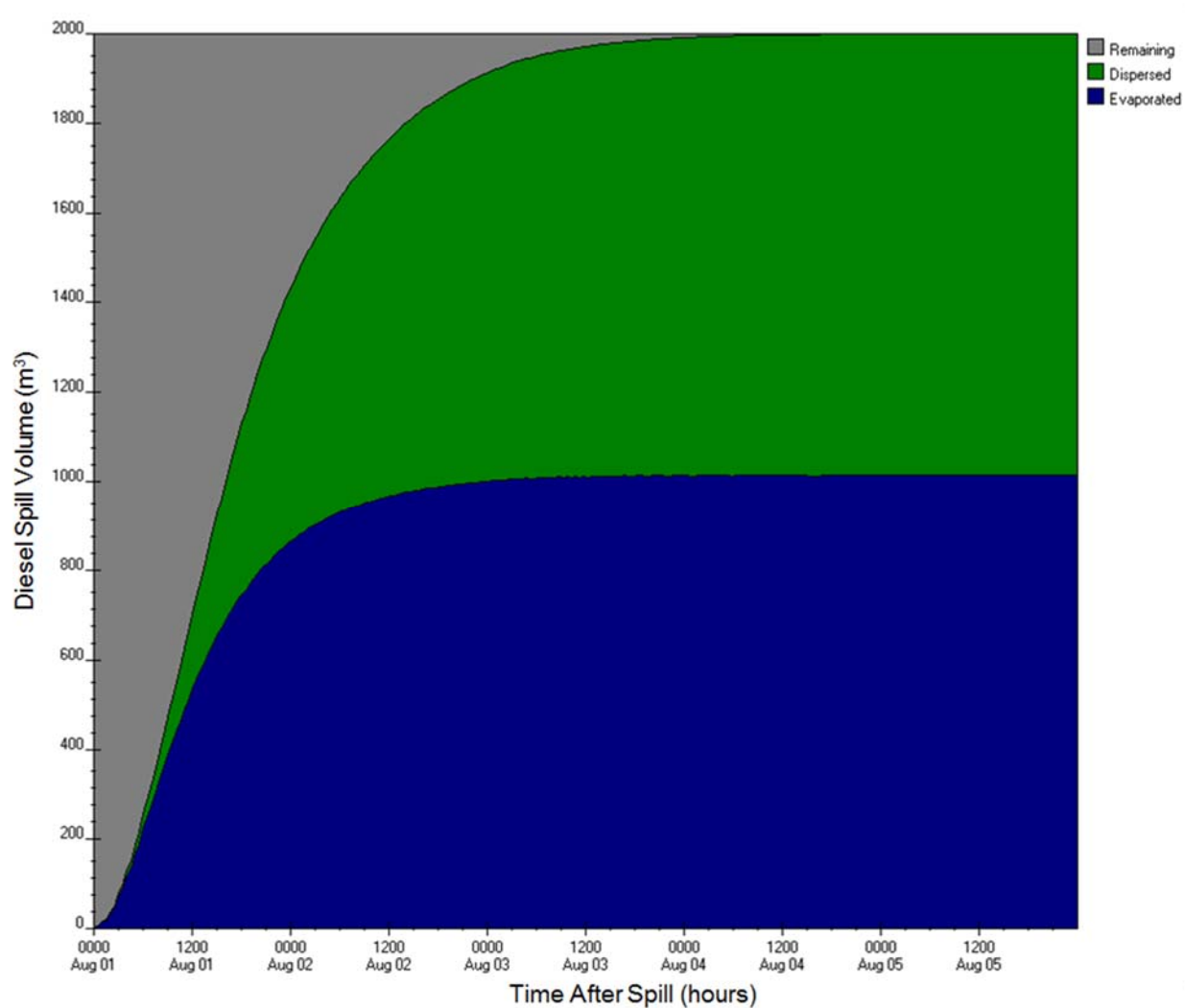


Figure E-A67: ADIOS2 diesel fuel budget output for Mid Hudson Strait station (7A) for 2,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

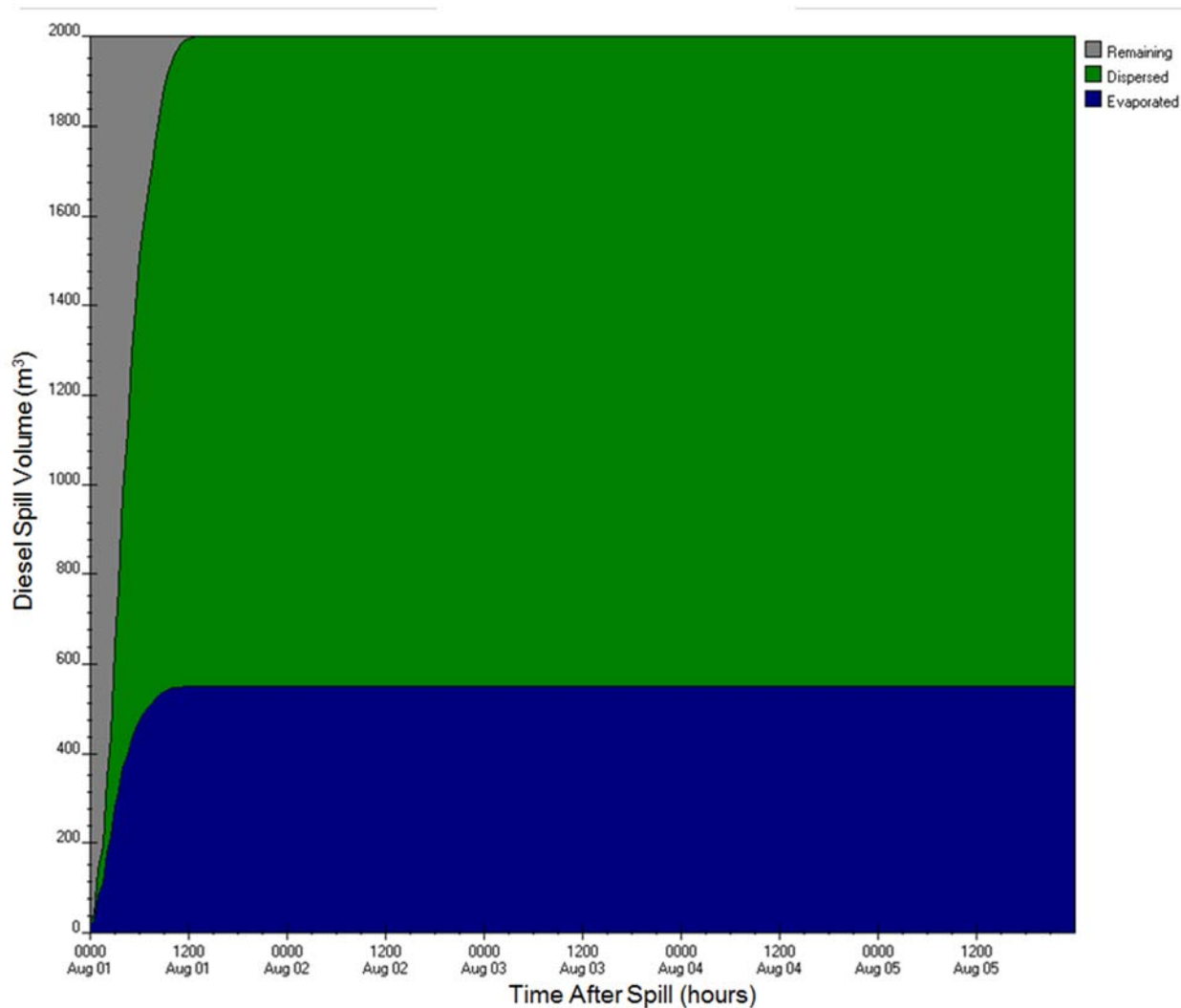


Figure E-A68: ADIOS2 diesel fuel budget output for Mid Hudson Strait station (7A) for 2,000 m<sup>3</sup>, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

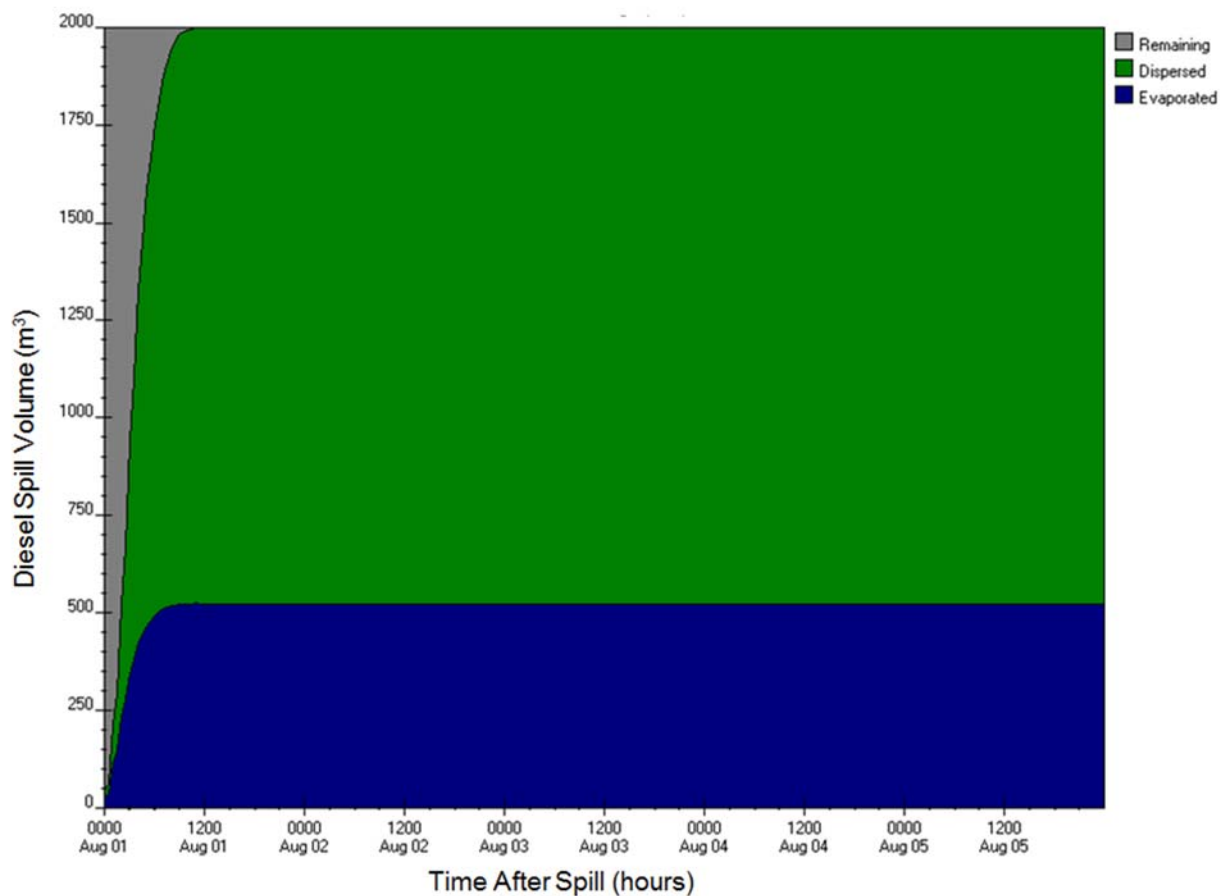


Figure E-A68: ADIOS2 diesel fuel budget output for Mid Hudson Strait station (7A) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

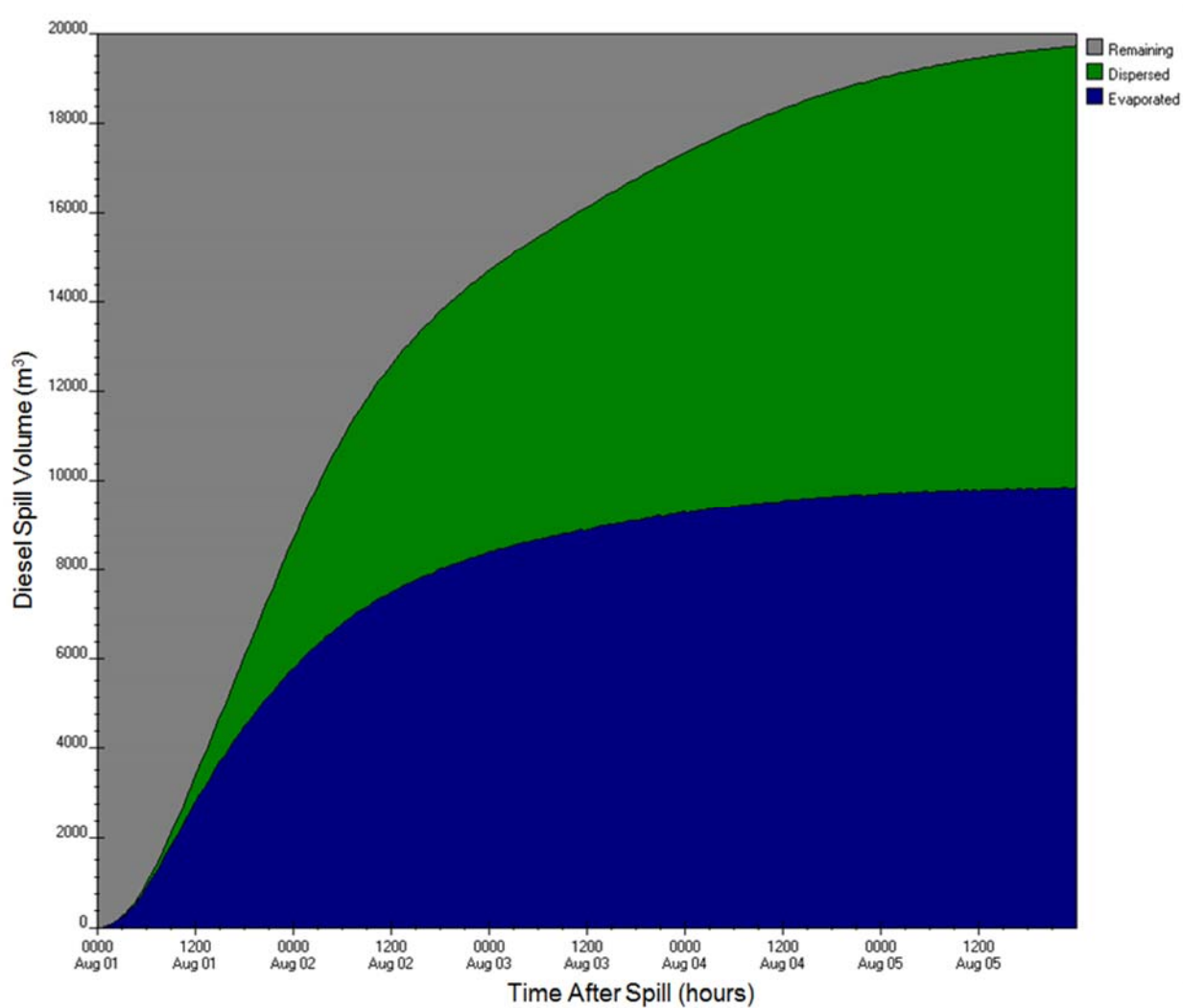


Figure E-A69: ADIOS2 diesel fuel budget output for Mid Hudson Strait station (7A) for 20,000 m³, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

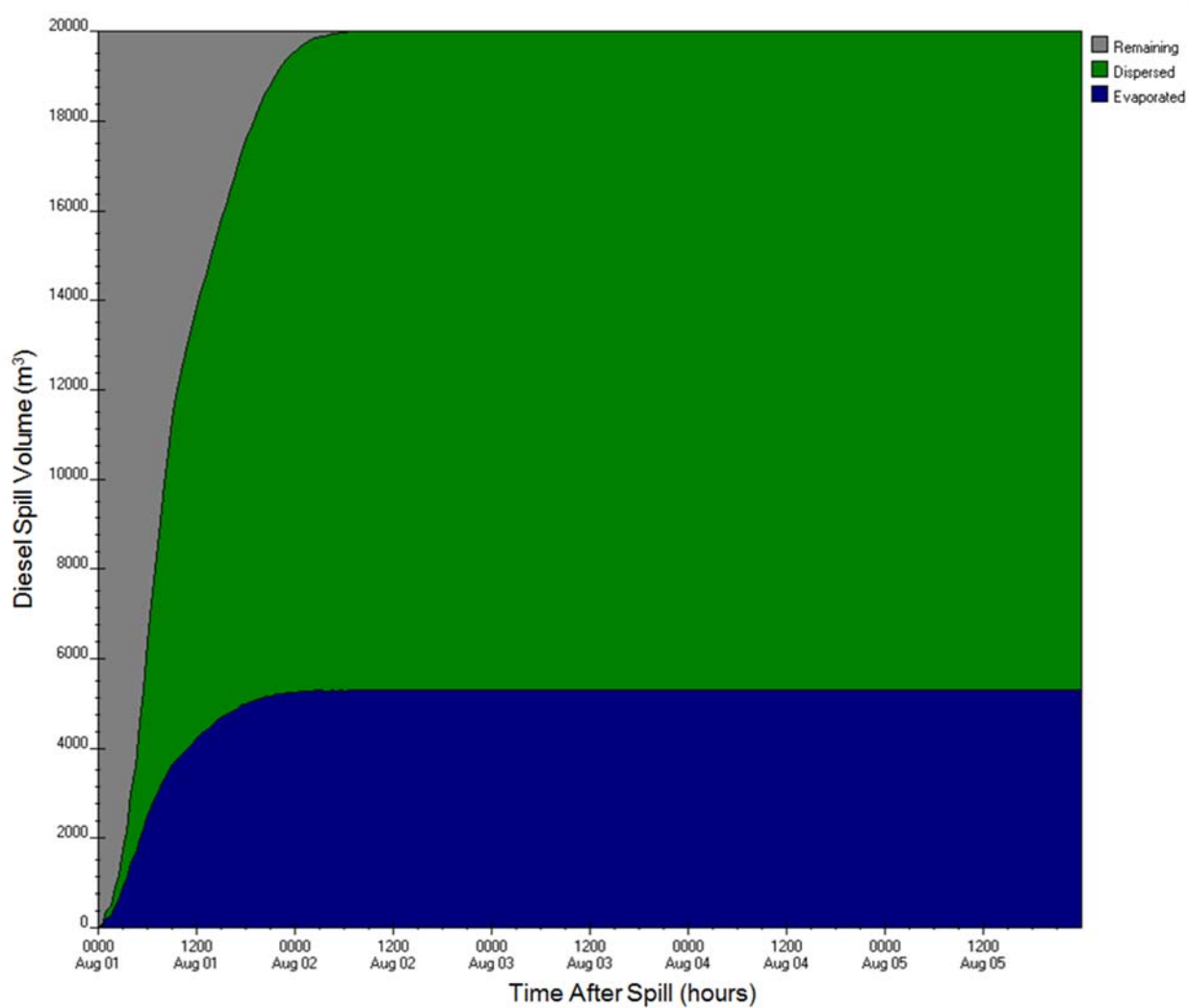


Figure E-A70: ADIOS2 diesel fuel budget output for Mid Hudson Strait station (7A) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

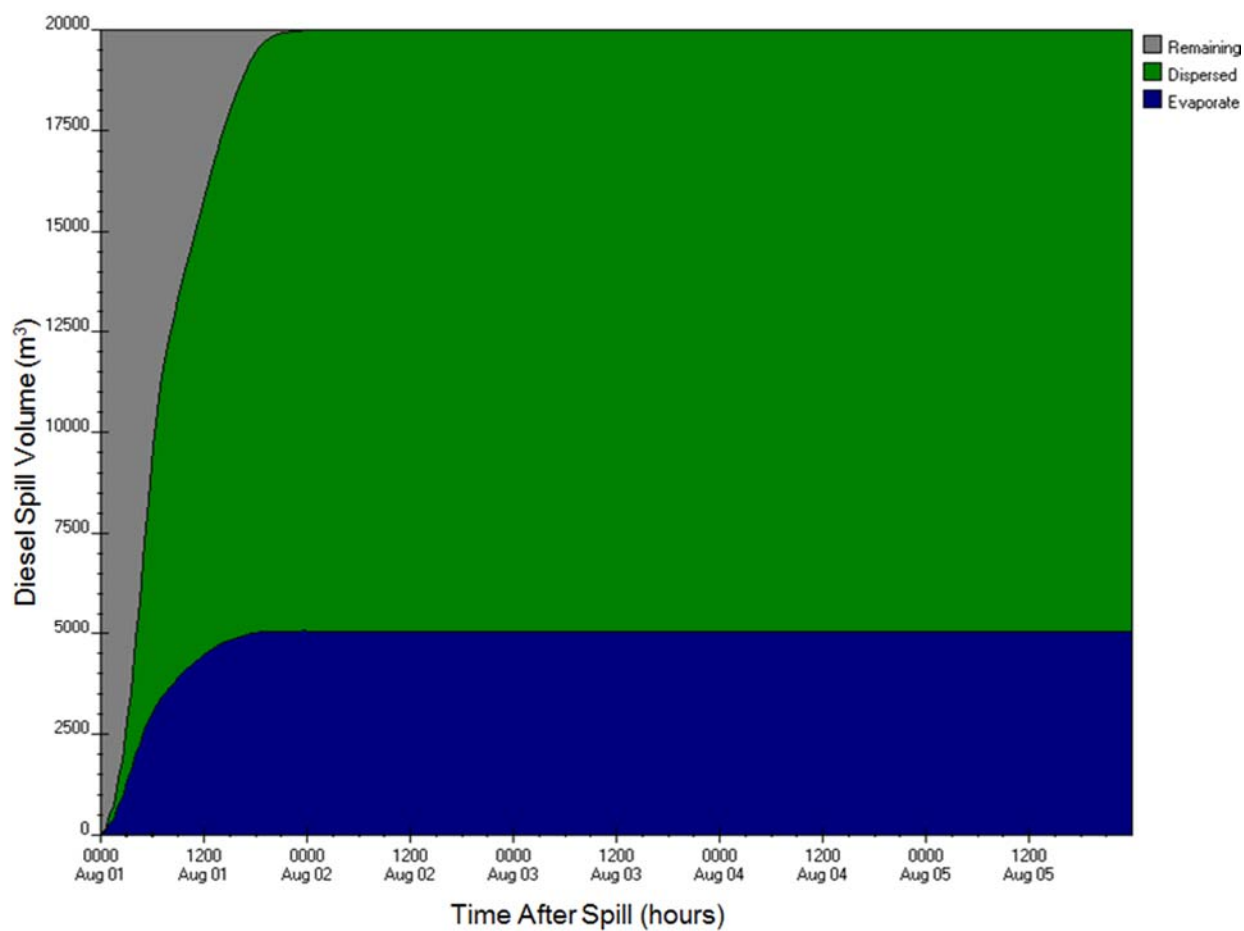


Figure E-A71: ADIOS2 diesel fuel budget output for Mid Hudson Strait station (7A) for 20,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

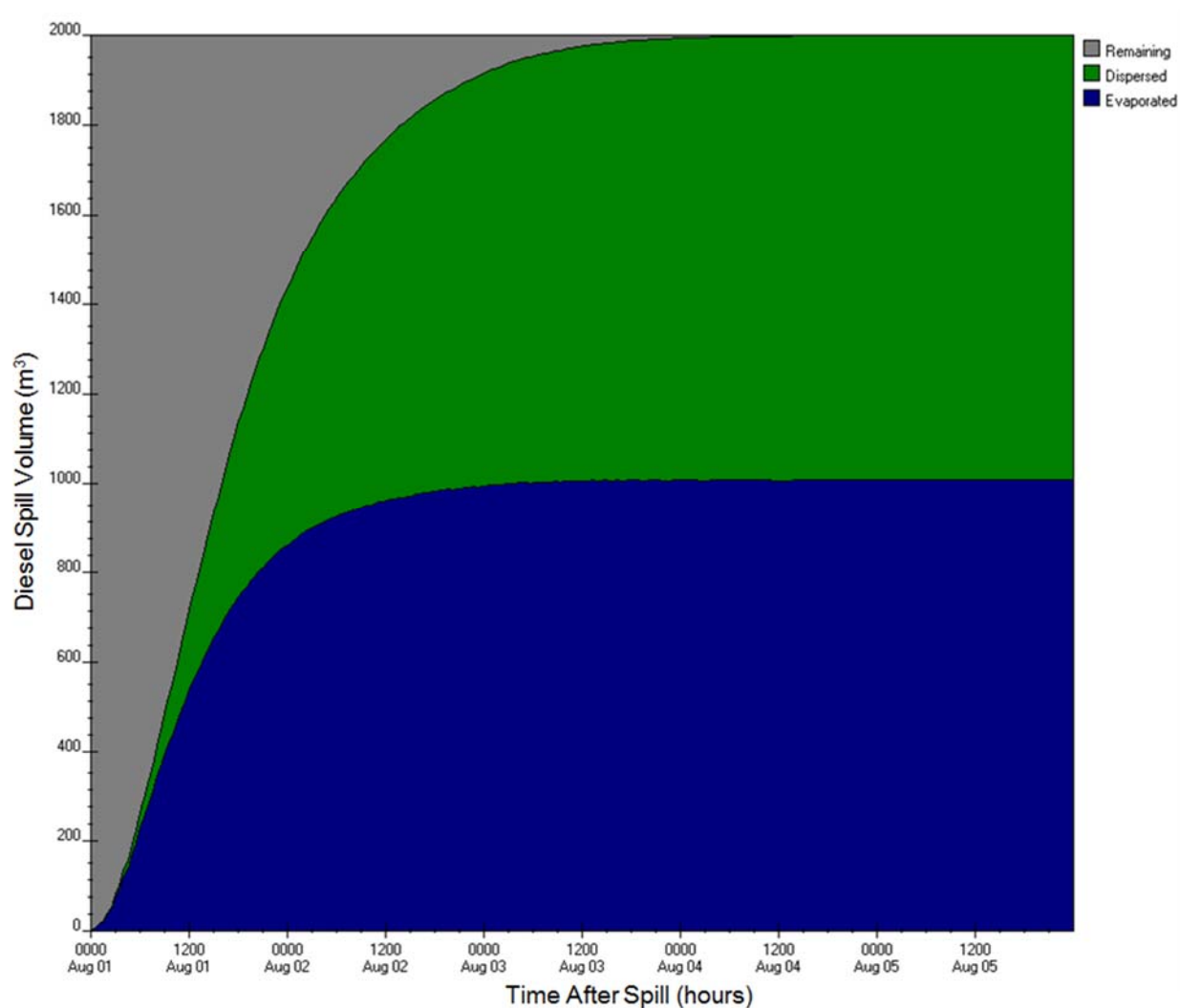


Figure E-A72: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (8A) for 2,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

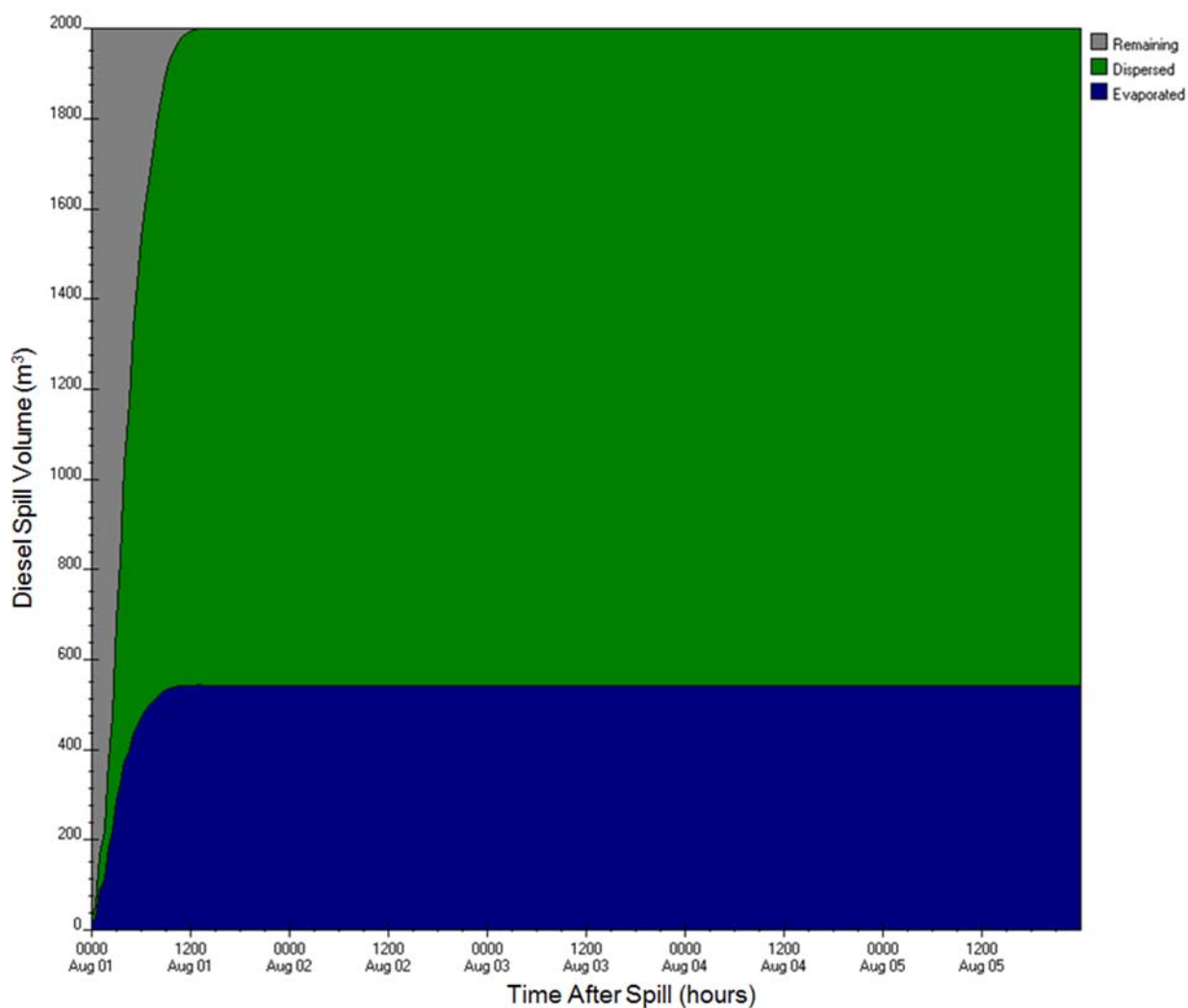


Figure E-A73: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (8A) for 2,000 m<sup>3</sup>, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

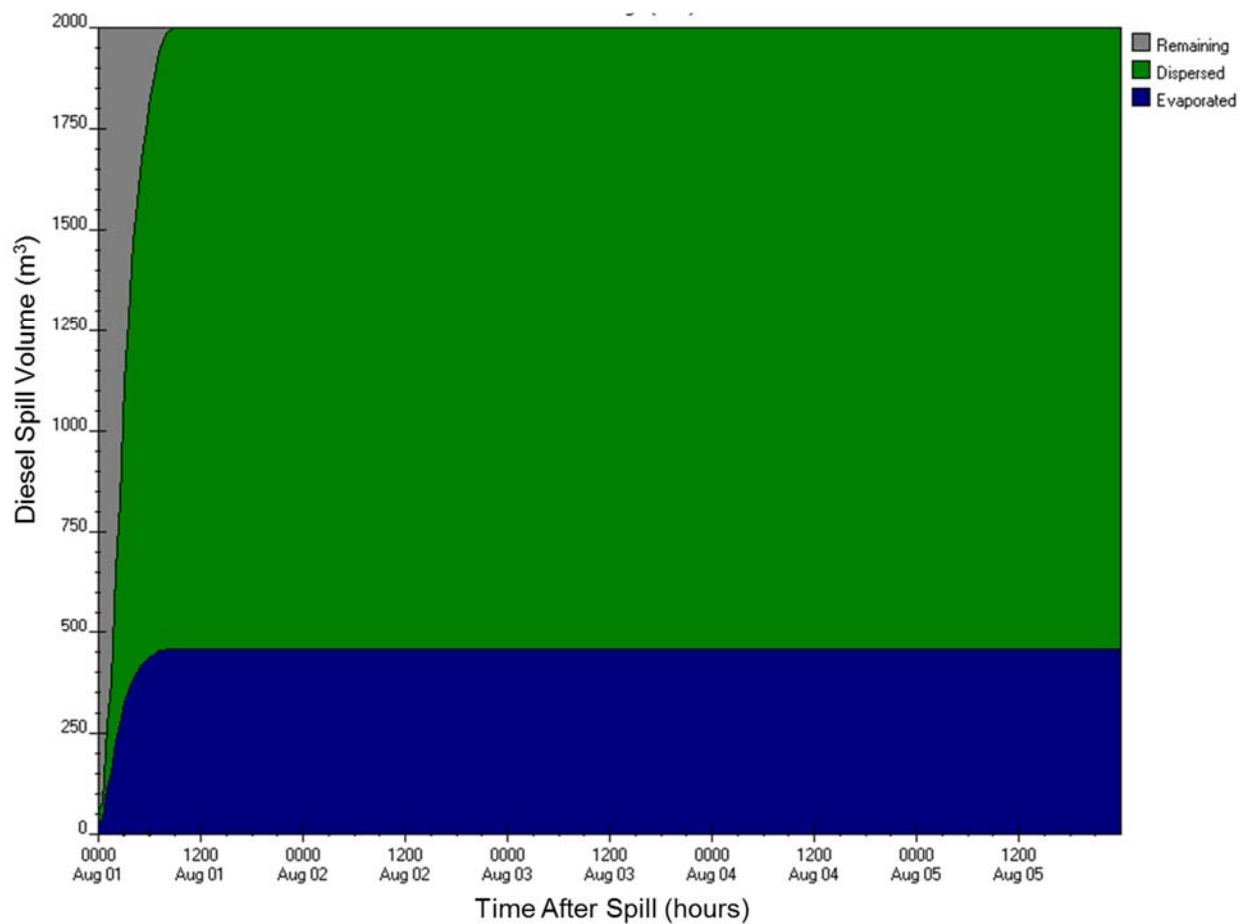


Figure E-A74: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (8A) for 2,000 m³, 50-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

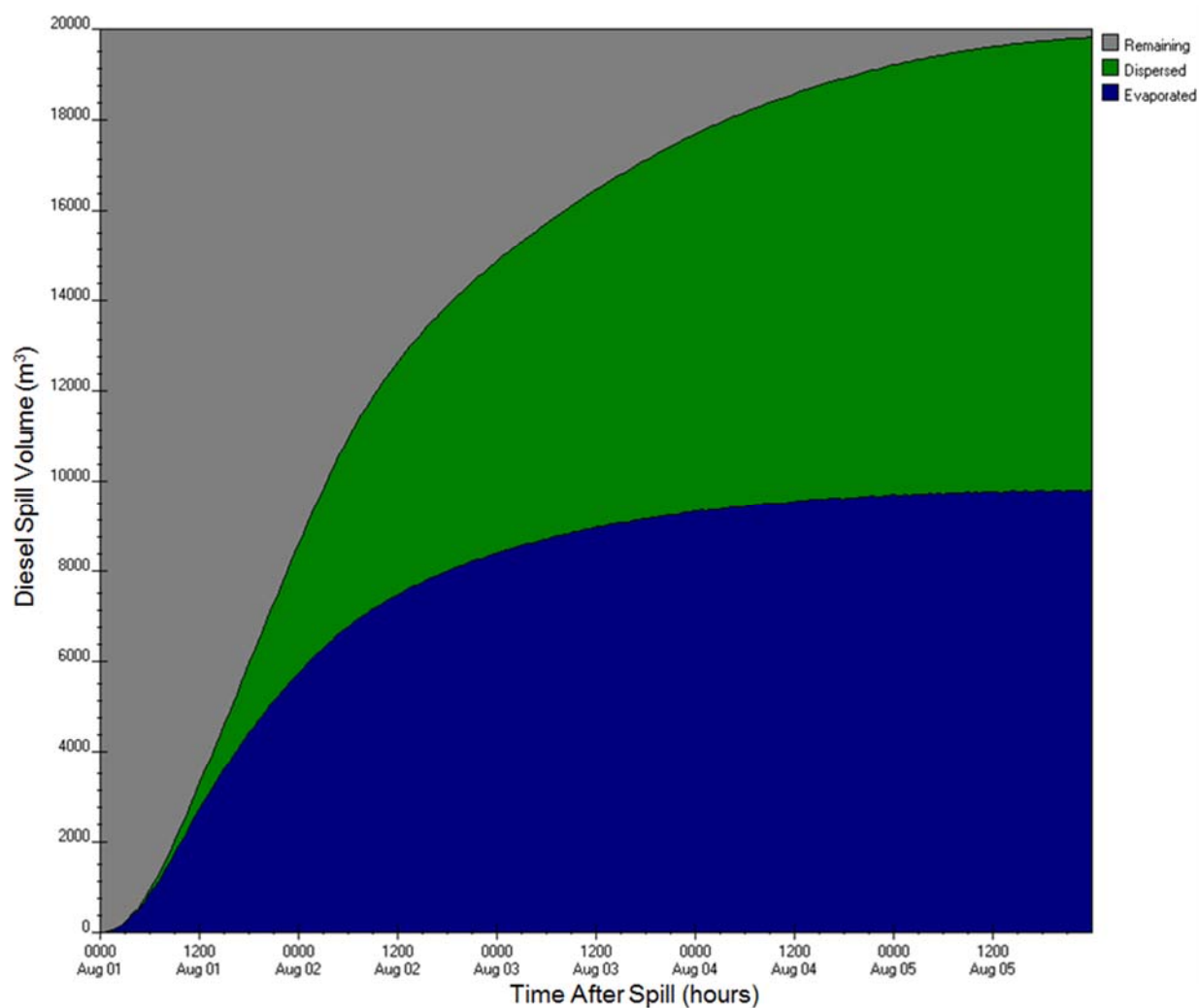


Figure E-A75: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (8A) for 20,000 m<sup>3</sup>, mean wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

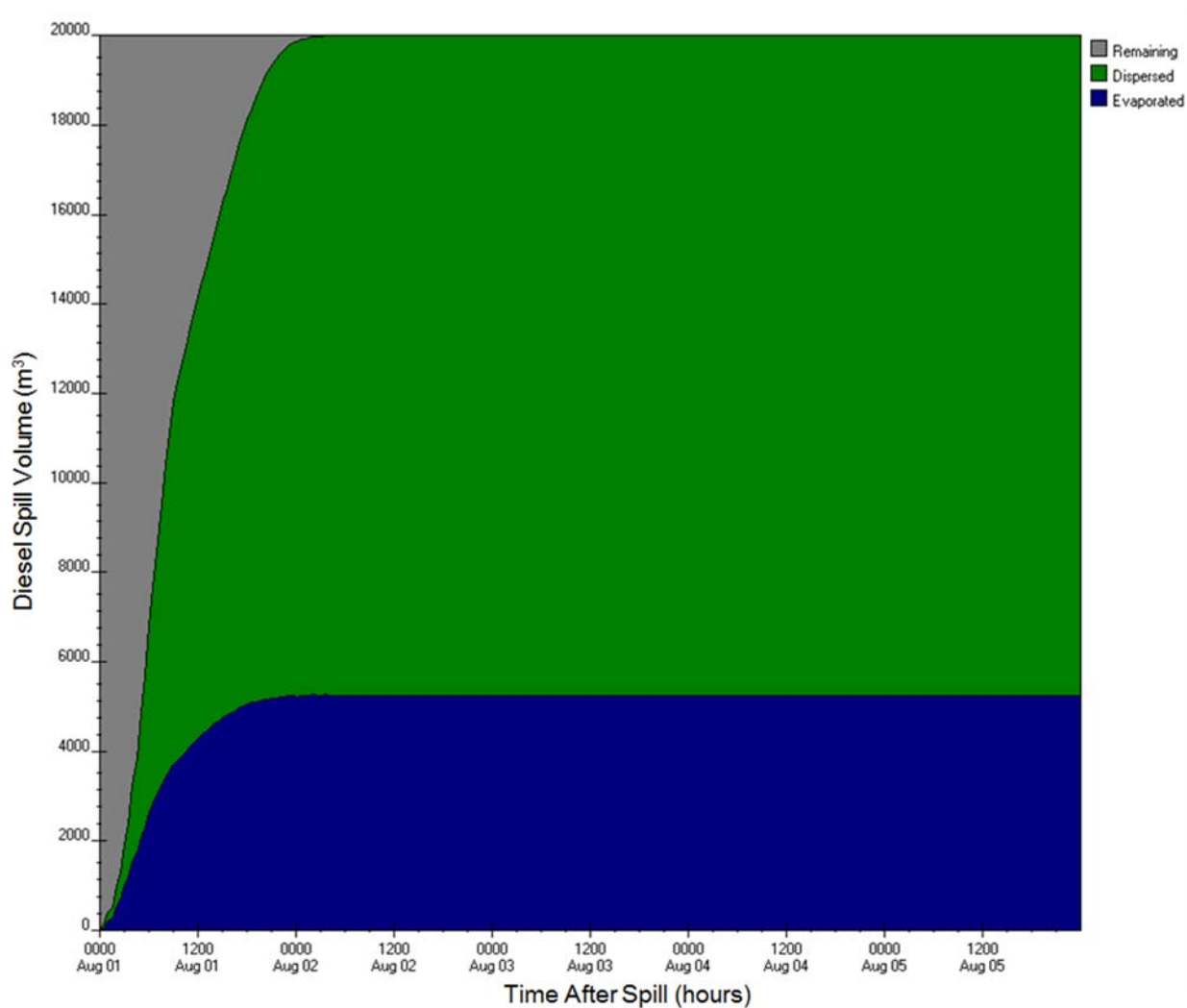


Figure 8.2-B-B-76: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (8A) for 20,000 m³, 2-yr wind speed scenario



## ATTACHMENT A

### ADIOS2 Hypothetical Spill Modelling Inputs and Outputs

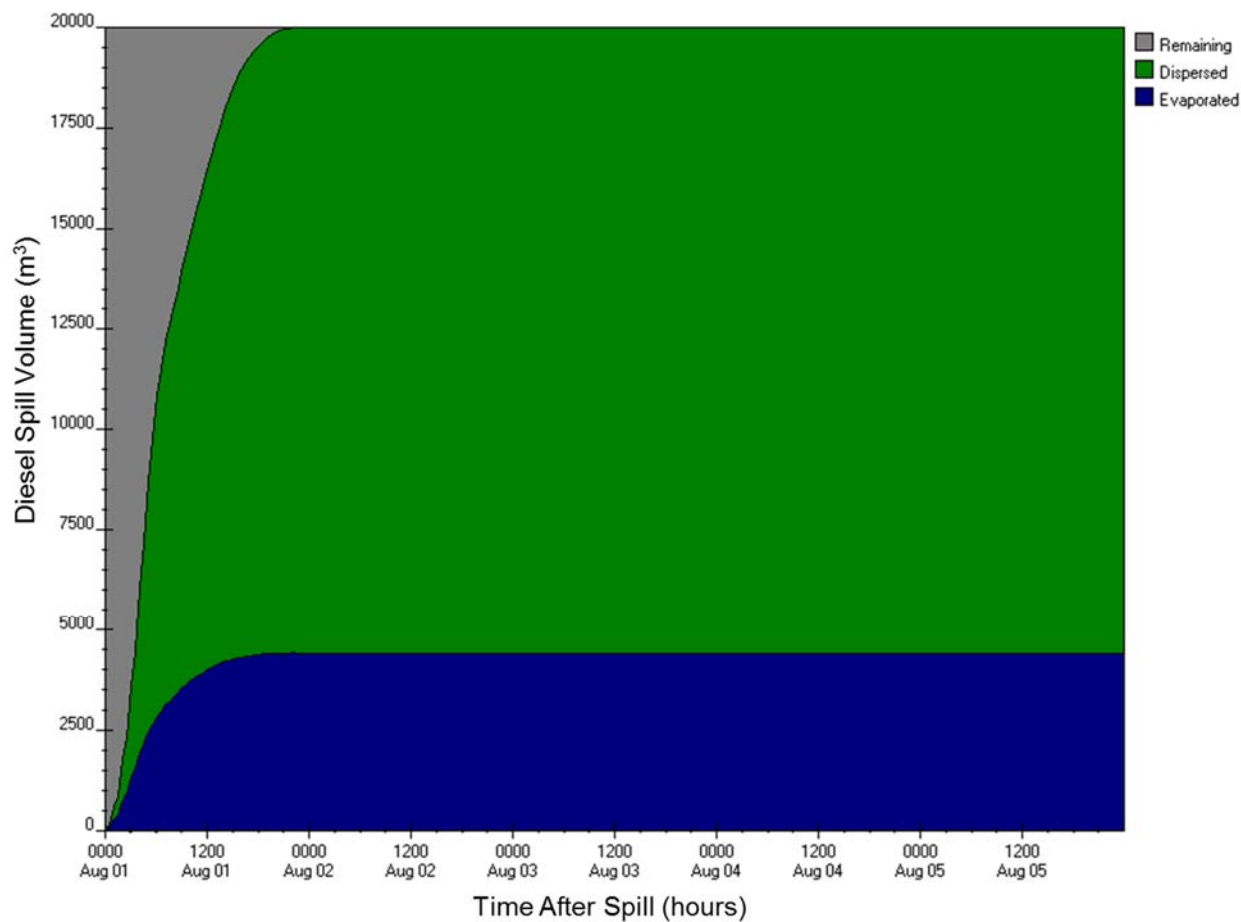


Figure E-A77: ADIOS2 diesel fuel budget output for Eastern Hudson Strait station (8A) for 20,000 m<sup>3</sup>, 50-yr wind speed scenario

[https://capws.golder.com/sites/capws2/1114280011meliadine/type a water license/5\\_post-submission/project certificate conditions/shipping management plan/appendix e - spill risk assessment/att a.docx](https://capws.golder.com/sites/capws2/1114280011meliadine/type%20a%20water%20license/5_post-submission/project%20certificate%20conditions/shipping%20management%20plan/appendix%20e%20-%20spill%20risk%20assessment/att%20a.docx)

**APPENDIX C • MARINE ENVIRONMENTAL MANAGEMENT PLAN (MEMP)**

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March 29, 2017

## MARINE ENVIRONMENTAL MANAGEMENT PLAN (MEMP)

### Appendix D

**Submitted to:**

Agnico Eagle Mines Limited  
10200, Route de Preissac  
Rouyn-Noranda QC  
Stephane Robert, Manager Regulatory Affairs

REPORT



**Report Number: Doc 613-1671431**

**Distribution:**

1 copy - Agnico Eagle Mines Limited  
2 copies - Golder Associates Ltd.





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## MARINE ENVIRONMENTAL MANAGEMENT PLAN (MEMP)

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### ATTACHMENTS

#### **Attachment A**

Marine Mammal Sightings Record

#### **Attachment B**

Record Sheet for a Moving Platform Survey<sup>3</sup>

Record Sheet for a Stationary Platform Survey<sup>3</sup>

Appendix I - Estimating Distance Categories Using Ruler Gauge<sup>3</sup>

Appendix II Through VI - Codes for General Weather Conditions and Glare, Sea State and Beaufort Wind Force, Ice Conditions, Species Codes for Eastern Seabirds, and Codes for Associations and Behaviours<sup>3</sup>

#### **Attachment C**

MMSO Daily Reporting Template

#### **Attachment D**

Birds and Oil - CWS Response Plan Guidance

#### **Attachment E**

DFO's Marine Foreshore Environmental Assessment Procedure



### Acronyms

Agnico Eagle	Agnico Eagle Mines Limited
BTEX/VPH	benzene, toluene, ethylbenzene, o-xylene, m-xylene, p-xylene/Volatile Petroleum Hydrocarbons
CCG	Canadian Coast Guard
CWS	Canadian Wildlife Service
DFO	Fisheries and Oceans Canada
ECSAS	Eastern Canada Seabirds at Sea
ECCC	Environment and Climate Change Canada
ERT	Emergency Response Team
EPH	Extractable Petroleum Hydrocarbon
IQ	Inuit Qaujimajatuqangit
JNCC	Joint Nature Conservation Committee
MEMP	Marine Environmental Management Plan
MMSO	Marine Mammal and Seabird Observer
PAHs (parent)	Polyaromatic Hydrocarbons
QEP	Qualified Environmental Professional
RSA	Regional Study Area
SOPEP	Shipboard Oil Pollution Emergency Plan
TOC	Total Organic Carbon
TK	Traditional Knowledge
UTM	Universal Transverse Mercator
VOCs	Volatile Organic Compounds



### 1.0 INTRODUCTION

Agnico Eagle Mines Limited (Agnico Eagle) plans to ship approximately 40,000 tonnes of dry cargo (equipment and supplies) and 122 million litres of diesel fuel annually for the operations of the Meliadine Gold Mine in Rankin Inlet, Nunavut (the Mine). To meet these needs, approximately 8 ships per year will be needed to deliver dry cargo and up to 4 additional ships per year to deliver fuel. All shipping will be carried out during the open water season (typically from early July to late October) and will follow recommended shipping routes that are presently in use for the annual sea lift to Rankin Inlet and other communities (Figure D-1 and Figure D-2). The Mine will not involve any ice breaking to extend the shipping season. This Marine Environmental Management Plan (MEMP) has been developed for the Mine to meet the Terms and Conditions of the Project Certificate related to shipping activities and potential marine spills. It should be considered a living document that can be updated throughout the Mine lifecycle in order to implement adaptive management techniques. Updates shall be made in consultation with the relevant regulatory agencies (e.g., DFO, CWS, and the Government of Nunavut) as appropriate.

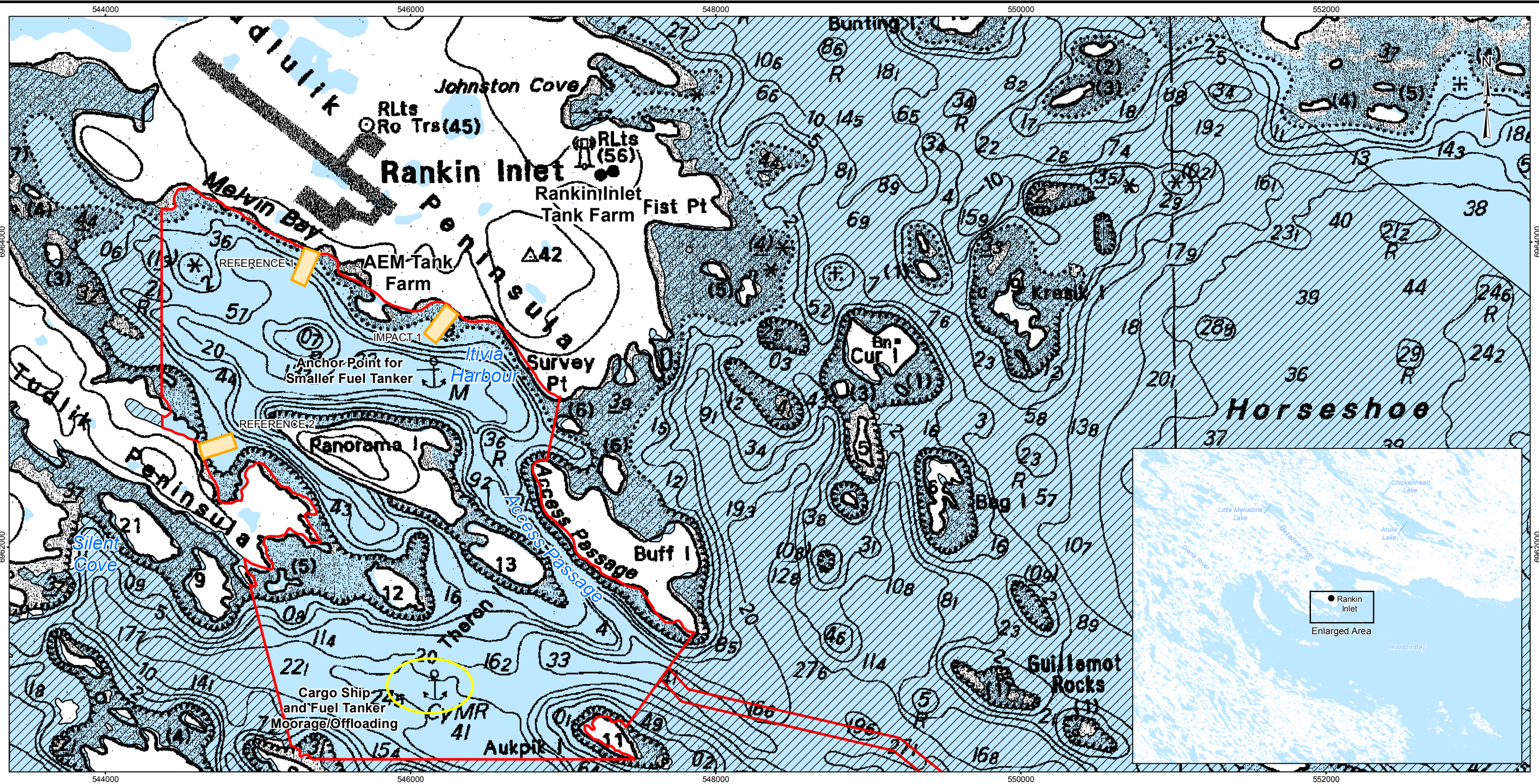
The MEMP has been designed to provide protocols for conducting a vessel-based Marine Mammal and Seabird Observer (MMSO) program during all routine shipping activities in the Local and Regional Study Area (LSA and RSA) and for conducting monitoring of marine wildlife and their habitats (wildlife defined as mammals, fish, and birds - including upland birds, migratory birds, waterbirds, raptors, and seabirds) in the event of any Mine-related fuel spill in the RSA.

During routine shipping operations, Mine-specific mitigation measures designed to minimize Mine impacts on marine mammals and seabirds will be initiated by vessel-based MMSOs and implemented by the ship's crew. In the event of a spill, the shipping contractor will be responsible for retaining a qualified environmental professional (QEP)<sup>1</sup> to implement the wildlife monitoring framework described below. The MMSO will work with the QEP to provide on-site information as required.

Data collected by the MMSOs will provide information to the Government of Nunavut and other applicable regulators (e.g., Canadian Wildlife Service) regarding the location, behaviour, abundance, and species observed as well as any interactions with Mine vessels during shipping activities in the RSA.

---

<sup>1</sup> An applied scientist or technologist who is registered and in good standing with an appropriate professional organization constituted under an Act. The QEP must be acting under that association's code of ethics, and subject to the organization's disciplinary action. The QEP should have experience in the area of interest. In this case the area of interest includes marine spill response monitoring for marine mammals, birds fish and their habitats.

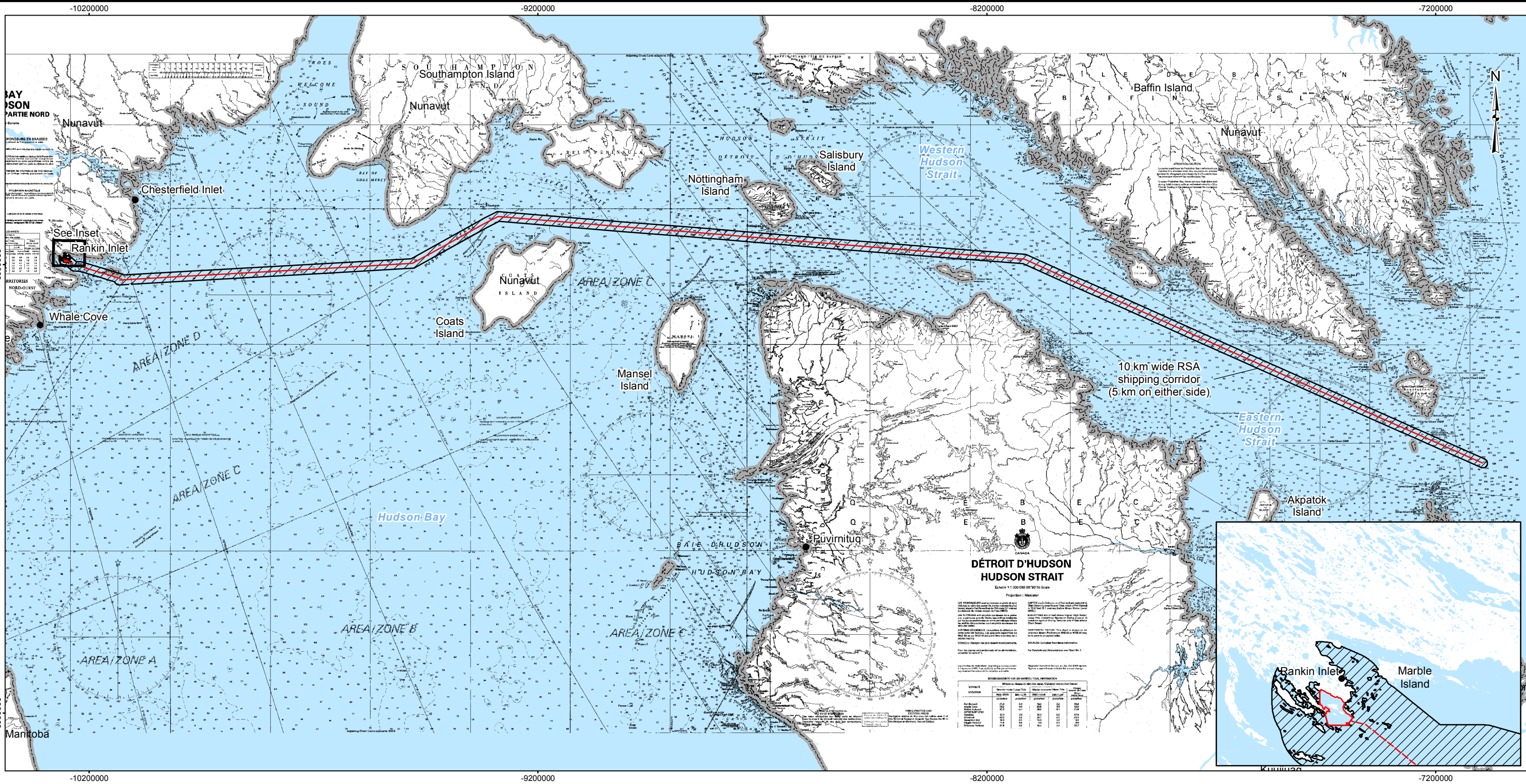


### LEGEND

## REFERENCE



Y:\burnaby\CAD-GIS\Client\Agnico\_Eagle\_Mines\_Ltd\Meliadine\_Gold\_Project\09\_PROJECTS\1535029\_WL\_Tech\_Sup\02\_PRODUCTION\5000MXD\Report\1535029\_Figure\_D-2\_Marine\_RSA\_Nautical\_Charts.mxd



**LEGEND**

- MARINE REGIONAL STUDY AREA (MARINE RSA) (SEE INSET)
- MARINE LOCAL STUDY AREA (MARINE LSA)
- COMMUNITY
- WATERBODY

**REFERENCE**

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED (AEM).  
CANVEC DATA OBTAINED FROM © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.  
NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: WGS 84 PROJECTION: WORLD MERCATOR

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

MARINE REGIONAL STUDY AREA

Golder Associates

PROJECT NO.	1535029	FILE No.
DESIGN	AK 16 Jul. 2012	SCALE AS SHOWN
GIS	DSC 18 Jul. 2012	REV. 0
CHECK	PR 18 Jan. 2013	FIGURE D-2
REVIEW	DW 18 Jan. 2013	



## 2.0 MARINE MAMMAL AND SEABIRD OBSERVER PROGRAM

### 2.1 Routine Shipping Operations

This section outlines the protocol for undertaking a vessel-based Marine Mammal and Seabird Observer (MMSO) program involving full-time marine wildlife monitoring during all routine shipping activities in the LSA and RSA (Figure D-1 and Figure D-2) in accordance with Project Certificate Condition 82, which states the following:

*"The Proponent shall require all contracted shipping companies to provide full-time marine wildlife monitoring using trained observers and established data collection and recording protocols. Monitoring plans should include provisions for all Species at Risk Act (SARA) and for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed species (birds and mammals)."*

The seabird survey protocols were revised in February 2017 to include specific survey protocols for seabirds as laid out in Section 4.0 of the Eastern Canada Seabirds at Sea (ECSAS) standardized protocol for pelagic seabird surveys from moving and stationary platforms.

A review of relevant marine mammal survey protocols was also undertaken and the marine mammal survey protocols were revised based on the following guidance documents:

- Guidelines for Minimising the Risk of Disturbance and Injury to Marine Mammals from Seismic Surveys (JNCC 2010).
- Recommended seabird and marine mammal observational protocols for Atlantic Canada (Moulton and Mactavish 2004)

The MMSOs will record marine mammal and seabird observations based on the protocols presented below through the LSA and RSA (Figure D-1 and Figure D-2). Datasheets outlined in Attachment A and Attachment B and daily reports outlined in Attachment C will be completed throughout the transit, copied for backup purposes and provided to Agnico Eagle upon arrival in Rankin Inlet or, when transiting from Rankin Inlet, will be provided as online communications allows, once the vessel has exited the RSA. Additional reporting requirements in the event of a spill are outlined in Section 2.2.1.5.

#### 2.1.1 Observer Qualifications and Training

Appropriately qualified MMSOs should be selected based on their knowledge and experience with the MMSO protocols laid out below. Previous wildlife observation field experience will be considered an asset during the MMSO selection process. Depending on the level of experience of the selected MMSO, a MMSO training session(s) will be considered and will be completed by qualified/certified marine wildlife observers with previous arctic wildlife monitoring experience. The training, if required, will review the monitoring protocols outlined below and provide instruction on how to spot and identify marine mammal and seabird species.

Primary objectives of the training will could include the following, dependent on the expertise of the MMSOs:

- Role and responsibilities of MMSOs;
- Review of the MEMP including mitigation measures;
- Health, Safety, and Environment;



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- Review of marine mammal and seabird species identification (including upland birds (including migratory birds), waterbirds, raptors, as well as seabirds) observation, identification, and distance estimation methods;
- Review of operation of MMSO equipment (reticle binoculars, GPS system);
- Distances estimation techniques for various scenarios (reticle binoculars, no horizon);
- Review of, and classroom practice with, data recording and data entry; and
- Reporting templates and requirements.

### 2.1.2 Program Protocol

Mitigation measures outlined in Section 4.2 of the Shipping Management Plan will be implemented during all Mine shipping activities by the shipping contractor(s). MMSOs will not be directly responsible for implementing mitigation measures. The role of the MMSO is to record and report on marine mammals and seabird sightings during shipping activities, and to advise the contractor (i.e., captain and ship crew) on the location of observed marine mammals and if any action is recommended based on mitigation measures outlined in the Shipping Management Plan.

The following protocol will be implemented during the MMSO program:

- A minimum of one trained MMSO will be present on-board the Mine shipping vessels during all transits within the RSA;
- The MMSO will conduct marine mammal and seabirds observations in the RSA from the bridge during daylight hours as described in Section 2.1;
- The MMSO will observe and record sightings of marine mammals and birds during vessel movements in the RSA (including upland birds, migratory birds, waterbirds, raptors, and seabirds) as well as environmental conditions as described in Section 2.1;
- A communication plan will be established between the MMSO(s) and the ship's crew in order to provide information regarding marine mammal and seabird sightings;
- The shipping contractor will initiate mitigation measures designed to minimize Mine impacts on marine mammals and seabirds, as identified in the Shipping Management Plan; and
- MMSOs will assist in observing for marine mammals and seabirds in the event of a spill (see Section 2.2).

The MMSO program will allow for the opportunity of adaptive management techniques to be implemented if monitoring identifies potential for adverse effects on marine wildlife along the shipping route. This may include modification of mitigation measures in response to new information arising from the monitoring carried out by the MMSO and vessel crew. Adaptive management will be conducted in consultation with the Kivalliq Inuit Association, the Hunters and Trappers Organizations of the Kivalliq communities, and the relevant regulators.



### 2.1.3 Marine Mammal Observing Protocols

Dedicated marine mammal observations will be conducted in the RSA. The protocol outlined in this section are best conducted along a transect line, therefore, it is best to start a marine mammal observation period when the vessel is and will be moving in a straight line for an extended period of time. Note the time and location (GPS) of the start and end of each observation period as well as the vessel speed (in knots). If vessel speed or direction changes significantly during the observation period, record the time and location and the change.

#### Observer Position

Observations will be done from a high location on the vessel and ideally outdoors if possible and will be conducted at the same location each time. For marine mammal observations with a single observer, the MMSO will position themselves in the middle of the ship at the front (bow) to observe marine mammal on both the starboard and the port side (Figure D-3).

#### Observation Period

MMSO observation periods (marine mammal and seabird observations) should not last longer than 2 hours to mitigate observer fatigue and eye strain, and a MMSO observation day should not exceed 12 hours. Based on these requirements, dedicated marine mammal observations will be conducted over a 1.5 hours period following a seabird survey (approximately 30 minutes). A suggested MMSO schedule for moving and stationary ships is provided below in Table D-1 and Table D-2.

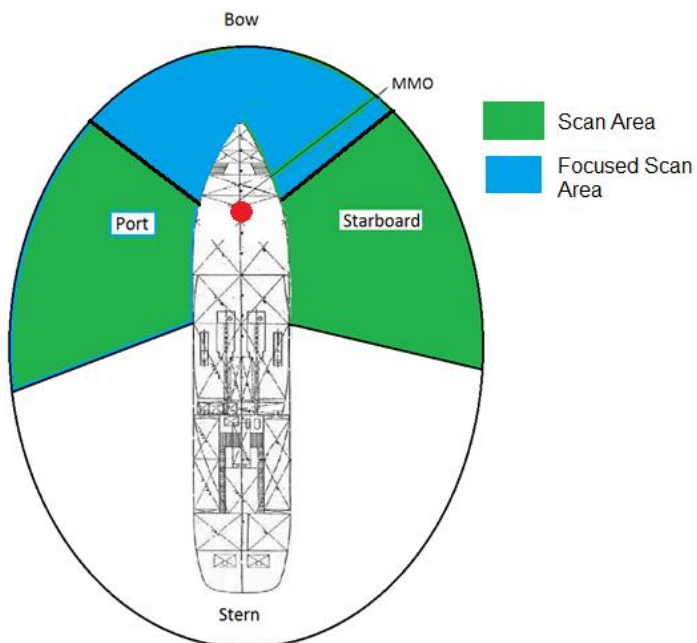


Figure D-3: MMSO position and respective observation field on a hypothetical ship



### 2.1.3.1 Scan Routine

The following scan routine should be conducted throughout the marine mammal observation period. Scan the water with the naked eye and use binoculars only to focus on possible sightings. Perform S and U scans of the observation field about every 20 seconds (Figure D-4). The most important aspect of marine mammal observing is to constantly scanning the observation field to capture animals that could be located in the peripheral view for brief moments (e.g., surfacing). Scans should be made from the middle of the vessel (for one MMSO) and cover the scan area shown in Figure D-3 with a focus on the water ahead and to the side to the moving vessel (e.g., focused scan area in Figure D-3). If the vessel is stationary (e.g., anchored) scans should be conducted over the entire scan area (e.g., blue and green in Figure D-3) in a uniform fashion. When the vessel is stationary, less priority can be attributed to marine mammal observations and the MMSO can switch to an observation schedule similar to that shown in Table D-2.



Figure D-4: S and U scanning techniques

All marine mammals observed during the dedicated marine mammal observational periods as well as incidental sightings will be recorded including GPS location, distance to animal, angle to animal, number of individuals, species, behaviour etc. (see Section 2.1.5.2 below). If a species is unknown or if a blow is the only detection of the animal observed, then mark the sighting as unknown. Marine mammals in large groups that are close together should be marked as a single sighting. When possible, photographs of marine mammal sightings will be taken and recorded alongside sightings records.

Angle to a marine mammal or group of marine mammal can be calculated using a Pelorus or by estimating the angle with an angle board. Figure D-5 shows how an angle to a marine mammal from the vessel should be estimated.

On-effort sightings should be recorded by the MMSO only, with no assistance permitted by other crew members. If additional sightings are made by other crew members or if sightings are made outside the designated marine mammal observation period (see Table D-1) then these sightings should be marked as incidental sightings on the marine mammal sighting record (Attachment A). Sightings of pinnipeds hauled-out on land will be recorded as off-effort sightings. Bow-riding dolphins or porpoises are also not recorded as on-effort sightings unless they are observed prior to their initial approach to the vessel (as it was assumed that the sighting of a bow-riding cetacean was not random but rather influenced by the presence of the vessel). Bow-riding dolphins or porpoises are recorded as incidental (off-effort) sightings.



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All efforts will be made to avoid double counting individuals or groups of individuals. If a marine mammal is counted twice in the sightings record, then a note of a re-sighting should be marked. Additional information to be collected for marine mammals is outlined in Section 2.1.5.2 below.

**Table D-1: Example of Daily MMSO Schedule – Moving Ship**

Time of Day (24 hour Clock, UTM)	Shift Type
7:00	Seabird
7:30	Marine Mammal
8:00	Marine Mammal
8:30	Marine Mammal
9:00	Break
9:30	Break
10:00	Seabird
10:30	Marine Mammal
11:00	Marine Mammal
11:30	Marine Mammal
12:00	Break
12:30	Break
13:00	Seabird
13:30	Marine Mammal
14:00	Marine Mammal
14:30	Marine Mammal
15:00	Break
15:30	Seabird
16:00	Marine Mammal
16:30	Marine Mammal
17:00	Marine Mammal
17:30	Break
18:00	Daily Reporting
18:30	Daily Reporting

**Table D-2: Example of Daily MMSO Schedule – Stationary Ship**

Time of Day (24 hour Clock, UTM)	Shift Type
7:00	Seabird
7:30	Marine Mammal
8:00	Seabird
8:30	Marine Mammal
9:00	Break
9:30	Break
10:00	Seabird
10:30	Marine Mammal
11:00	Seabird
11:30	Marine Mammal
12:00	Break
12:30	Break
13:00	Seabird
13:30	Marine Mammal
14:00	Seabird
14:30	Marine Mammal
15:00	Break
15:30	Seabird
16:00	Marine Mammal
16:30	Seabird
17:00	Marine Mammal
17:30	Break
18:00	Daily Reporting
18:30	Daily Reporting

Notes: The full 30 minutes may or may not be used for seabird surveys depending on the survey method implemented. Further details are described in Section 2.1.4 below.

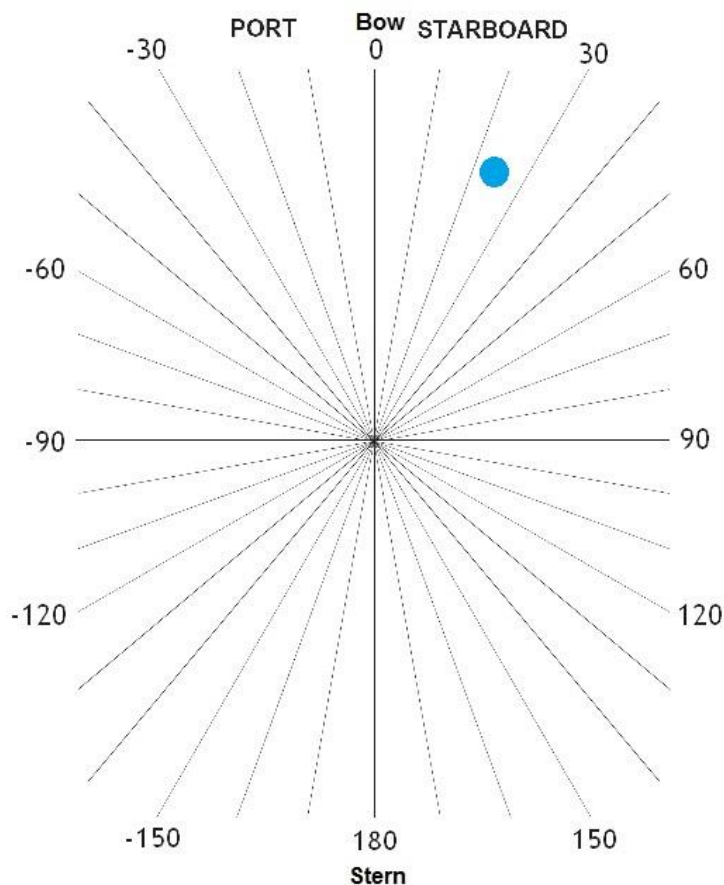


Figure D-5: Angle to Marine Mammal (blue dot) is approximately 22°

### 2.1.3.2 Estimating Distance

Observers should practice estimating the distance bands prior to beginning surveys. This can be accomplished by using reticle binoculars as described below or with a distance gauge made from a transparent plastic ruler (see Attachment B).

Record the distance to each marine mammal or group of marine mammal (to the centre of the group). For all marine mammals, estimate the angular distance between the marine mammal(s) and the observer.

#### Using Reticle binoculars

Reticle binoculars have a built in scale called a reticle (Attachment B). Estimating distances to marine mammals using reticles is based upon the distance to the horizon which is dependent on:

- the height of the observer eye above sea level in meters; and
- radians per reticle mark for the type of binoculars.



The height of the eye includes the height of the platform above the surface of the water. The number of radians (usually milliradians<sup>2</sup>) will depend on the type of reticles binoculars that are used. The number of radians per reticle mark can be used to produce a distance table based on an equation provided by the binocular manufacture. An example of an equation provided by Fujinon 2006 is:

$$\text{Distance} = (\text{eye height} + \text{height above sea level in meters}) \times 1000 / \# \text{ of milliradians}$$

Reticle binoculars cannot be used to estimate distance if the horizon is obscured (by fog or land), or if they are used from a different height above sea level. Their use becomes minimal in nearshore waters.

### 2.1.4 Seabird Survey Protocols

Seabird survey will be conducted in the RSA. The protocols laid out below were extracted and adapted from the Canadian Wildlife Service (CWS) standardized protocol for pelagic seabird surveys from moving and stationary platforms (Gjerdrum et al. 2012).

#### Observer Position

Observations should be done from a high location on the vessel, when possible, at a location as close to the edge of the platform as possible to increase the detection of seabirds, especially for individuals that use the waters at the base of the vessel. All surveys should be conducted at the same location each time.

#### 2.1.4.1 Survey Protocol – Moving Vessel

##### Transect Methods

Moving vessel seabird surveys should be conducted along a transect line when the vessel is and will be moving along a straight line for an extended period of time. Note the time and location (GPS) of the start and end of each survey period (described below) as well as the vessel speed (in knots) as laid out in the seabird survey sighting form (Attachment B).

During transect surveys, the observer is to look forward from the vessel, scanning at a 90° angle from either the port (left) or starboard (right) side depending where he or she is located. The transect width within seabirds are recorded is 300 m from the side of the vessel (see Figure D-6). Scan ahead regularly (e.g., every minute) to spot birds that may dive as the vessel approaches.

All birds observed within this 300 m transect, whether flying or on the water, are recorded and are considered in-transect sightings. The methods for recording birds on the water versus birds in flight are outlined below. All five minute surveys should begin with a snapshot survey to capture flying birds. The perpendicular distance from the line to the seabirds detected on the water or in flight is estimated for each sighting. Birds observed outside the 300 m transect are also recorded if this does not affect observations within the 300 m transect. Distance categories “E” and “T” in Figure D-6 are both considered not in transect. Binoculars and spotting scopes can be used to confirm species identification and other details as necessary. Information that will be collected during each sighting is outlined in Section 2.1.5.4.

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<sup>2</sup> unit of angular measurement



Moving platform transect survey are best conducted when travelling at a minimum of 4 knots (7.4 km/h) and a maximum of 19 knots (35.2 km/h). These surveys can be done when the ship is travelling less than 4 knots, but birds are often attracted to slow moving or stationary ship. If birds are clearly gathering around the ship and settling on the water when the ship is moving at decreased speeds cease the surveys until the ship resumes a higher speed. If the ship is no longer moving (e.g., anchored or on standby) switch to the stationary platform survey methods described below.

### Observation Period

Each seabird survey period will be conducted during six consecutive five-minute periods which is repeated three times a day to capture morning, afternoon and evening periods (see Table D-1). These five minute surveys should be dedicated to surveying for seabirds only. These surveys should be completed regardless if birds are present or not. If the vessel is not moving (stationary), use the method for stationary vessel described in Section 2.1.4.2 below.

Short breaks should be taken at the end of each five minute period to record the vessel's position and any conditions that may have changed since the last five minute survey period. If ship speed or direction changes significantly the survey period, record the time and location (GPS), cease the current survey and begin a new five minute survey period.

The frequency of the seabird surveys outlined in Table D-1 has been selected to provide time for the MMSO to:

- have dedicated seabird and marine mammal observation periods (as described above);
- take necessary breaks to avoid observer fatigue; and
- conduct daily reporting.

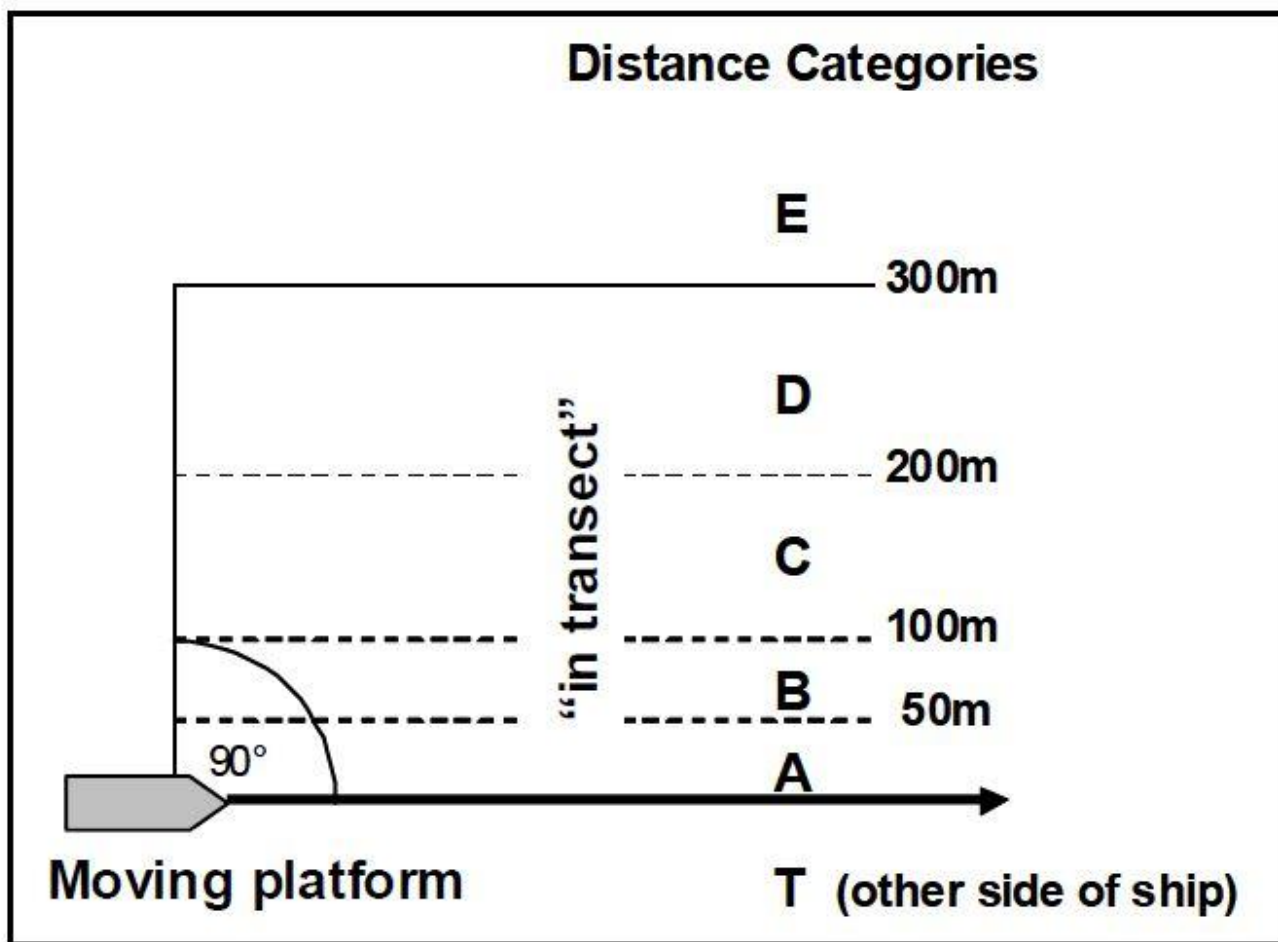


Figure D-6: Illustration of a survey using a 90° scan, covering a 300 m transect from a moving platform (extracted from Gjerdrum et al. 2012)

### Birds on the Water

All birds observed on the water are continuously recorded throughout the five minute survey period. If birds in the transect fly off the surface of the water as the vessel approaches, use binoculars to help count them, and record these birds as being on the water as outlined in the seabird survey sighting form (Attachment B). These birds are not subsequently counted as a flying bird during a snapshot survey (described below for flying bird).

Birds on the water may be observed up ahead of the platform, perhaps as far as 400 m or 500 m, but still within the 300 m transect (Figure D-6). Because these individuals may dive or fly away as a result of the approaching ship, they should be counted as in transect and their perpendicular distance recorded when they are first observed. If the five minute survey will end before the ship reaches them they should be recorded in the next five minute survey period.



### Birds in Flight – Snapshot method

All five min surveys should begin with a snapshot of flying birds. Flying birds are not recorded continuously throughout the five minute survey period as with birds on the water, as this would overestimate bird density. Create a routine of snapshot counts to record flying birds during the survey period. Only use the snapshot method when there are many birds observed flying in the area. The number of snapshots done will depend on the speed of the vessel (Table D-3).

During each snapshot, record flying birds as in transect if they are flying above the 300 m transect. Record all other flying birds that are seen outside of the 300 m transect or between snapshot intervals as not in transect.

Some species may fly in long lines across the 300 m survey transect. At the time of the snapshot, the number of birds in the flock is recorded and the distance class is assigned according to the location of the centre of the flock. All the birds in the flock are recorded as in transect if the centre is within the 300 m transect. If the centre of the flock is outside the 300 m transect, all birds are recorded as not in transect.

### Large Groups of Birds

When very large numbers of birds are encountered that overwhelm the observer's ability to count the number of birds and measure the distance to flocks the snapshot method can be used to count all birds in flight and on the water. If this protocol is used, note the change in protocol on the seabird survey sighting form (Attachment B). If it is not practical to estimate distance to each bird or flock of birds, the observer should at least indicate whether the birds were observed in or out of transect. If it is not practical to note which birds are on the water and which are in flight use the following guidelines:

- If the majority of the birds are in the air, they can be recorded as flying.
- If birds appear first on the water and then fly away as the vessel approached, or they continuously move between the water and air, recorded them being as on the water.

### Birds that follow the Vessel

To avoid double counting birds, once a bird is recorded in-flight it is not subsequently recorded again if it follows the ship and it is not recorded on subsequent snapshots. If many birds are following the vessel and it becomes difficult to determine which individuals have already been recorded, the number of birds following the ship can be estimated and recorded at regular intervals (i.e., in between each five minute survey or as possible).

**Table D-3: Intervals at Which Instantaneous or “Snapshot” Counts of Flying Birds Should be conducted during a Moving Vessel Survey**

Platform Speed (knots)	Interval Between Counts (minutes)
<4.5	2.5
4.5 – 5.5	2.0
5.5 – 8.5	1.5
8.5 – 12.5	1.0
12.5 - 19	0.5



### Poor Visibility

When a survey period cannot be done because of poor visibility (i.e., when the entire width of the 300 m transect is not visible), the extent of visibility should be noted on the seabird survey information form.

### Observation Periods with no birds

If no birds are observed during a five minute survey period, “no seabirds observed” must be noted on the seabird survey information form.

#### 2.1.4.2 Survey Protocol – Stationary Vessel

##### Scan Method

Surveys while the vessel is stationary (e.g., on standby or anchored) are done using instantaneous counts, or “snapshots” of birds within a 300 m “semi-circle” area from the vessel. These surveys are conducted by scanning through a 180° arc, limiting observations to a semi-circle around the observer (Figure D- 7)

The area should be scanned from one side to the other, and all seabirds on water and in flight that are observed within 300 m are systematically recorded. Birds visible beyond 300 m are also, if possible. The distance to seabirds (inside and outside the 300 m area) from the observer is estimated and recorded for all birds. Birds observed outside the 300 m semi-circle are recorded as not in semi-circle on the seabird survey information form. Binoculars and spotting scopes can be used to confirm species identification and other details as necessary.

##### Observation Period

When the vessel is stationary, less priority can be attributed to marine mammal observations. Therefore, scans should be completed once every hour when the vessel is stationary (Table D-2). The length of each scan will depend on the number of birds present at the time of the scan (e.g., it may only last a few seconds if there are no birds present).

### Poor Visibility

When an observation period cannot be done because of poor visibility (i.e., when the entire width of the 300 m transect is not visible), the extent of visibility should be noted on the seabird survey information form.

### Observation Periods with no birds

If no birds are observed during a five minute survey period, “no seabirds observed” must be noted on the seabird survey information form.

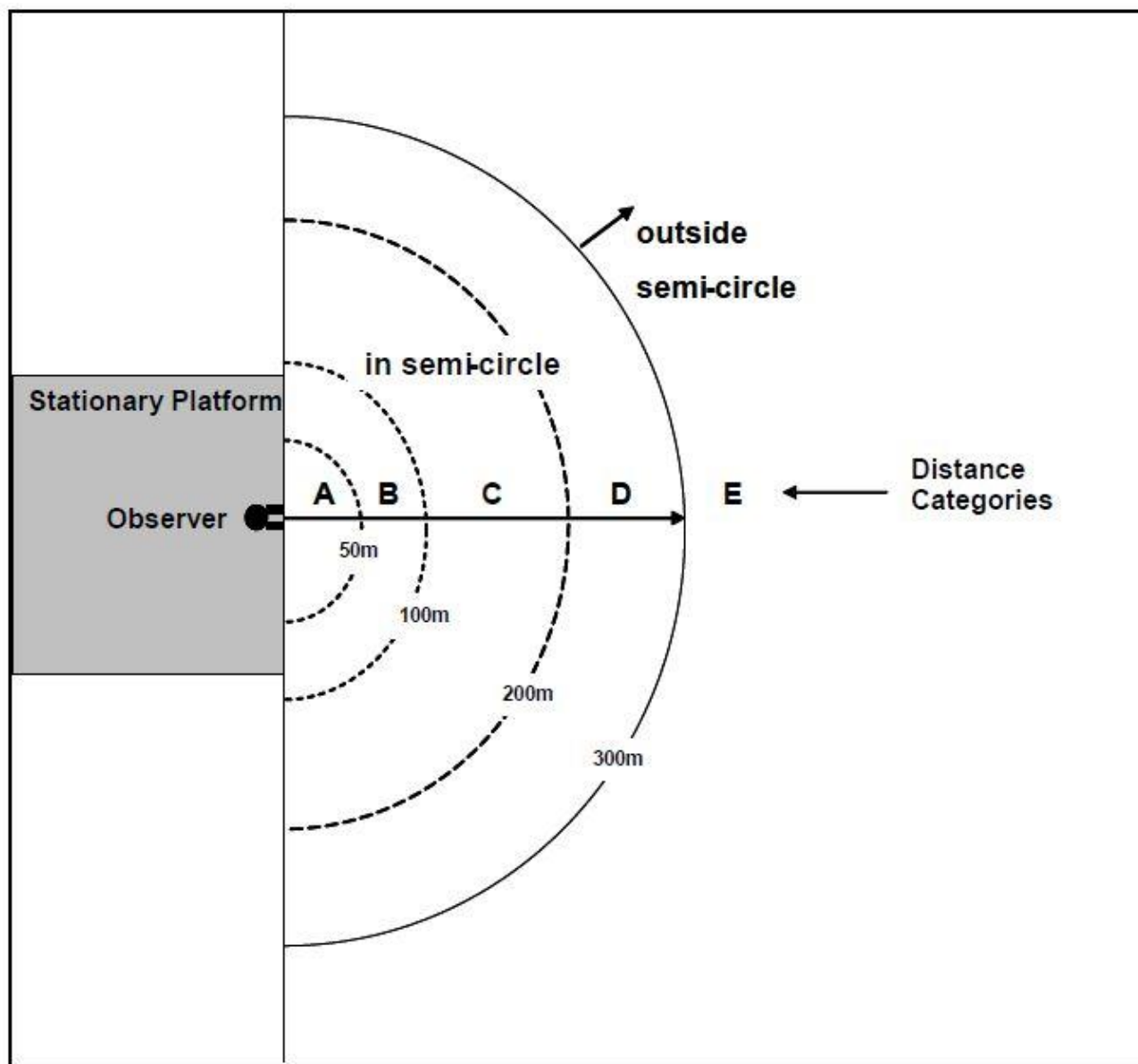


Figure D- 7: Survey using an 180° scan, surveying an area 300 m from a stationary observer (Extracted from Gjerdrum et al. 2012)

### 2.1.4.3 Estimating Distance

Observers should practice estimating the various distance bands prior to beginning surveys. This can be accomplished by using reticle binoculars as described above in Section 2.1.3.2 or with a distance gauge made from a transparent plastic ruler (see Attachment B).



Record the distance to each bird or flock of birds (to the centre of the flock). For all birds, estimate the perpendicular distance between the bird(s) and the observer (Figure D-6). If a group of birds is straddling the 300 m boundary with the flock centre located in D (some individuals inside and some individuals outside the transect) record the entire flock as being in D. If the flock centre is outside the transect, record the entire flock as distance class E. It is very important to record distance to birds within the 300 m strip, but if this is not possible (i.e., too busy), you may use the code 3 = within 300 m but no distance recorded. Distance T is used to indicate that the bird or flock was observed on the opposite side of the vessel.

### 2.1.5 Recording Observations

#### 2.1.5.1 General Environmental Information

This information should be collected for both marine mammal and seabird observations as shown on the marine mammal and seabird sightings forms in Attachment A and Attachment B.

**Ship name, agency and type:** Agency is the company that has requested the survey (e.g., Agnico Eagle Mines Limited, Meliadine Division). Type may include container vessel, barge, tug, or fuel supply vessel.

**Observer(s):** Indicate the first and last name of the observer. Also record the name of any additional observers assisting with the survey.

**Date:** Date that the observation period occurred. Use format DD-MMM-YYYY (e.g. 12-Apr-2008)

**Time start/Time end:** Time (using 24-hour notation) at the start and end of each seabird survey or marine mammal observation. Use Universal Time (UTC) to standardize across regions.

**Coordinates at start and end of observation period of track of observation period:** GPS coordinates of the vessel.

**Platform activity:** Platform activity may influence observations and should therefore be noted. Activities could include traveling, off-loading, anchored etc.

**Visibility:** Estimate visibility in km from 0.3 (which is 300 m) to 20 km; estimates should also be made on foggy days.

**Sea state code:** Select Sea state code according to codes in Appendix II.

**Swell height:** Estimate the height of the swell.

**Weather conditions:** Record the general weather conditions at the time of the survey according to codes in Appendix II. Record the most prominent conditions within the survey area. For example, if there are distant fog patches that do not directly affect the survey conditions, the weather code will be 0 or 1. Alternatively, if there is <50% cloud cover but you are travelling through fog patches, the weather code will be 2.

**Glare conditions:** Light reflecting off the surface of the water can often influence detection. Record the glare conditions at the time of the survey according to codes in Appendix II.

**Wind speed or force:** Enter the speed of the wind in knots if instrument to measure wind is available on the bridge or use Beaufort code from Appendix III. When taking measurements from a moving platform, be sure to record the TRUE wind speed/direction.



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**Wind direction:** Enter compass direction (**N, NE, E, SE, S, SW, W, or NW**) of the wind. See note above regarding true wind speed/direct.

**Ice Type and Concentration:** If ice is present during the survey, indicate the type and concentration using codes from Appendix IV. Indicate in the notes if the ice is present only beyond the transect limits.

**Platform speed (knots):** If speed changes during observation period, enter new speed and time that the change happened.

**Platform direction:** Enter compass direction (**N, NE, E, SE, S, SW, W, or NW**); if direction changes during the observation period enter new direction and time at which change happened.

**Observation side:** Starboard (right) or Port (left).

**Height (metres):** Enter height of observers' eye above water from observation point in metres.

**Outdoors or Indoors:** Circle **Out** when doing observations from a position outdoors and **In** for indoor observations. Remember survey should be conducted from the same location on the vessel each time.

**Other Notes:** Make note of disturbances or relevant activities in the area, especially if there are large vessels or fishing activities nearby, or if your vessel is sounding the fog horn.

### 2.1.5.2 Marine Mammal Sightings Record

**Species:** choose the species observed. Record all unknowns, even if they are identified only as "baleen whale" or "toothed whale".

**Number of individuals:** Record the number of marine mammals in each sighting. Record groups as one sighting (e.g., one line item), if they behave as a group and have the same morphological and behavioural characteristics (e.g., all adults of the same species). Record other individuals from the group that have different characteristics (e.g., different species or juveniles of the same species) in the next line but link all the sighting together to indicate they were a single sighting.

**Distance:** Record the distance to the marine mammal when first observed

**Angle:** Sighting angle to the marine mammal can be calculated using a Pelorus or an angle board

**Behaviour:** Chose a behaviour based on the list below

- **Surfacing:** Marine mammals will surface in order to breathe, often exposing their backs.
- **Breaching:** full or partial jump out of the water
- **Fluking:** Some whales bring their tail flukes high up into the air on a deeper dive.
- **Flipper-slapping:** Marine mammals may use their flippers to slap the surface of the water.
- **Lob-tailing:** Whales raise their fluke high into the air in order to slap the surface of the water.
- **Spyhopping:** Head of the marine mammal will surface out of the water as a means to get an in-air look.



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- **Porpoising:** high speed swimming is more efficiently accomplished if an animal jumps out of the water, usually observed in dolphins, porpoises, and pinnipeds.
- **Bow- or Wake-riding:** Some species of dolphins and porpoises are attracted to ride the bow or the wake of a passing vessel.
- **Logging:** Marine mammals resting at the surface.
- **Feeding:** Marine mammals observed feeding on fish, krill or other marine mammals
- **Hauled-out:** For pinnipeds only. When they haul themselves onto land. Remember these individuals should be recorded as off-effort sightings.

**Age:** If possible, select whether the marine mammal is a:

- **Adult**
- **Juvenile**
- **Immature**

**Sex:** If possible, Male or Female

**Direction of travel (N, NE, E, SE, S, SW, W, or NW):** which direction the marine mammals are traveling. Not if they change the direction of travel in response to the vessel.

**Note:** Space is provided to record other important information, such as the presence of fishing vessels in the survey area, if the marine mammal suddenly changes behaviour etc.

### 2.1.5.3 Seabird Sightings Record

**Observation period information:** Fill in all the fields within the seabird survey form at the beginning of every five minute transect survey period (moving survey) or every scan (stationary survey).

**Scan type (for stationary platforms only):** Conduct a 180° scan for all stationary surveys. If part of the survey area is obstructed, indicate the scan angle used.

**Scan direction (for stationary platforms only):** Indicate the true (not magnetic) bearing when looking straight ahead, at centre of semi-circle.

**With snapshot?** Enter whether the snapshot method for birds in flight is being used by checking **Y** or **N**.

**Species:** choose the species observed. Record all unknowns, even if they are identified only as “gull” or “bird”.

**Number of individuals:** Record the number of birds in each sighting in the count field. Record groups of birds as one sighting, if they behave as a group and have the same morphological and behavioural characteristics (e.g., all adults of the same species in breeding plumage flying in the same direction). Record other individuals from the group that have different characteristics (e.g., different species or juveniles of the same species) in the next row but link all the sighting together to indicate they were a single sighting.



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**In transect or semi-circle? Y or N:** Enter whether a bird observed is in (Y) or out (N) of the transect. Give priority to birds that are in transect; record birds seen outside of the observation area if this does not affect “in-transect” observations.

**Behaviour (flying, on sea, and/or feeding):** Record which activity a bird or group of birds is doing by selecting the activity from the drop-down menu.

**Associated with platform? Y or N:** Enter whether birds are following/associated with the moving platform with either a **Y** (Yes) or **N** (No).

**Distance:** Record the distance to each bird or flock of birds (to the centre of the flock). For all birds, estimate the perpendicular distance between the bird(s) and the observer (Figure D-6). Distance categories are as follows: A = 0 to 50 m, B = 51 to 100 m, C = 101 to 200 m, D = 201 to 300 m, and E = >300 m.

**Age:** If possible, select whether the bird is a:

- **A** (adult plumage)
- **J** (juvenile, first coat of true feathers acquired before leaving nest)
- **I** (immature, first fall or winter plumage that replaces juvenile plumage and may continue in a series that includes first-spring plumage, but is not the complete adult plumage).

**Plumage of adults:** If possible, choose whether the bird has:

- **B** (breeding plumage usually in spring and summer – will apply to most birds seen during the survey)
- **NB** (non-breeding plumage, fall and winter plumage)
- **M** (moult, transitional phase between these two plumages, often with some flight feathers missing; generally not flying when molting)

**Sex:** (Male or Female)

**Flight direction (N, NE, E, SE, S, SW, W, or NW):** which direction birds in flight are heading, if not associated with platform (this info can be obtained from instruments on the bridge). If birds are flying erratically such that no one direction is appropriate, record them as ND (no direction).

**Note:** Space is provided to record other important information, such as the presence of fishing vessels in the survey area, if a particular bird was carrying fish, etc.

### 2.1.5.4 Additional Information

MMSOs will record any responsive actions undertaken by the vessel crew in response to sightings (e.g., reducing vessel speeds). This will be recorded on a daily basis as outlined in the MMSO daily reporting template provided in Attachment C and will include:

- Description of any vessel mitigation implemented (e.g., reduction in speeds, evasive maneuvers etc.); and
- Record of any vessel-animal collision (marine mammal or seabird) including the following information:
  - date, time, spatial coordinates;



- wind speed and direction, visibility, precipitation, sea state;
- number of animals found dead or injured on the deck (seabirds) and on the water (seabirds or marine mammals); and
- if search lights or vessel lighting sources were active at the time of collision.

This information will be summarized in a daily report by the MMSO. All records of vessel strikes on marine mammals and bird collisions will be provided to Fisheries and Oceans Canada (DFO) and the Canadian Wildlife Service (CWS) on a weekly basis, as vessel communications allow (i.e., as internet connections allow). Immediate reporting will be required in the event that a ship strike occurs on a marine mammal, or multiple bird collisions occur (involving more than five individuals) and the incidents appear related (i.e., similar time period, location, and weather conditions). In this instance, the regional Environment Canada (EC) Wildlife Enforcement Officer (contact information provided below) will be contacted to provide advice on the implementation of adaptive management techniques (see Merkel and Johansen 2011) to attempt to reduce the likelihood of collisions occurring in the future.

## 2.2 Spill Scenario

This section outlines the protocol for undertaking wildlife monitoring in the event of a major fuel spill in the LSA and RSA in accordance with Project Certificate Condition 64, which states the following:

*“The Proponent shall develop a framework for monitoring of marine bird species and their habitat in the event of a major marine fuel spill. Specific details regarding the scope of follow-up monitoring may be further refined if and when such an event were to occur.”*

There are three potential scenarios during Mine shipping operations when a fuel spill could occur:

- 1) During shipping activities;
- 2) During ship-to-ship fuel transfer; or
- 3) During ship-to-shore transfer of fuel.

A spill risk assessment (SD8-1: Appendix E) was conducted at 14 sites along the shipping route to better understand how a potential fuel spill would behave over time within the RSA.

In the event of a fuel spill, the following wildlife monitoring framework will be implemented. It will be the responsibility of the shipping contractor(s) to employ a qualified environmental professional (QEP) to implement this framework in the event of an incident and will be a requirement of the shipping contract. It is recommended that a QEP be retained under contract on a stand-by basis during the shipping season to be able to respond to a spill in a timely fashion.

Not all spill scenarios will require the implementation of all aspects of this framework (i.e., a small spill contained close to the vessel will not require the same level of monitoring as a larger spill). It is the responsibility of the QEP, in consultation with the relevant regulators, to determine what aspects of the framework should be implemented.

The monitoring framework outlined below is intended to be a ‘living document’ which provides an opportunity for adaptive management techniques to be implemented throughout an event. The objective of the framework is to provide a strategy for the coordination of marine wildlife monitoring in order to minimize potential effects as a result of an incident. The framework should be amended as new information becomes available (e.g., changes to the extent of a spill) and should ultimately address both potential acute effects to wildlife and their habitats as well as potential long term chronic effects.



There is an opportunity to involve local communities and hunters, other organizations, institutions, government departments and/or individual researchers during the initial response phase and the follow-up phase during an incident. These opportunities include, but are not limited to:

- Providing information regarding sensitive resources in the area;
- Assisting in collecting baseline sediment and water quality samples;
- Assisting with wildlife surveys;
- Collecting wildlife who have come into contact with the spill;
- Providing information regarding the extent and direction of a spill; and
- Assisting with on-going wildlife monitoring.

The involvement of these organizations in the wildlife monitoring framework should be coordinated by the QEP as well as the vessel response team (to be identified in Shipboard Oil Pollution Emergency Plan (SOPEP) or Agnico Eagle's Emergency Response Team (ERT) depending on who is taking on coordination of the clean-up efforts (See section 2.0 of the Shipping Management Plan).

Monitoring during a spill event is divided into two phases, an 'Initial Response Phase' and a 'Follow-up Phase'.

### 2.2.1 Initial Response Phase

The initial response phase addresses the management of anticipated acute effects of the spill on marine wildlife and their habitats. The framework for the initial response phase should be managed and updated to incorporate new information as it becomes available.

Within 24 hours of an incident, the following marine wildlife monitoring objectives should be achieved:

- Identify a QEP to coordinate the wildlife monitoring framework; and
- Set-up of a 24 hour communication line and provide contact information to the community where local community members and other interested parties can call-in to report fouled or at-risk wildlife sightings.

#### 2.2.1.1 Surveys and Sampling

##### 2.2.1.1.1 Marine Wildlife

During the initial phases of a spill, all wildlife observed in direct contact with the fuel spill or present in the vicinity of the spill will be recorded in a wildlife sightings record (see example in Table D-4). Encounters may be called in by local community members, other vessels, MMSO(s) onboard Mine vessel(s), or by the spill response teams themselves. If possible, the QEP or suitable designate will conduct an initial survey of the affected area to record all species occurrences as soon as possible following a spill. This may be via ground, small support vessel or by aircraft and if possible, should be continued on a daily basis until the spill is contained. Aerial surveys can assist the focus of ground surveys, depending on the extent of a spill. The purpose of these surveys is to identify wildlife resources at risk within the vicinity of the spill and develop appropriate management strategies for minimizing risk and/or impacts to these resources. Resources to be identified during the surveys include presence of pelagic birds, waterfowl, marine mammals, and sensitive fish and wildlife habitat.



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In the event that a spill reaches landfall, an intertidal community structure survey should be completed in affected areas and at suitable reference locations in the region. The intertidal surveys should involve intertidal quadrat-based transect sampling and should be conducted in accordance with DFO's marine habitat assessment guidelines as outlined in Attachment E.

**Table D-4: Example of a Wildlife Sightings Record in the Event of a Spill**

Common Name	Number of Individuals	Date/Time	Location (GPS location if possible in UTM)	Behaviour	Condition of Animal*	Photos**
<b>MAMMALS</b>						
<b>BIRDS</b>						
<b>FISH</b>						

Notes: \* - note if the animal has been in contact with the spill or not, if individuals have been observed moving towards the spill, or if the animal is dead.

\*\* Photos should be attached when possible

### 2.2.1.1.2 Marine Habitats and Benthic Communities

Marine water, surficial sediment, and benthic invertebrate tissue samples should be collected in the affected area(s) as soon as practical to establish baseline and initial spill conditions for water, sediment and tissue quality at the time of the spill. Samples should be collected from a near field to far field direction and should start as close to the spill as possible. The sampling plan should be evaluated on an on-going basis during the initial response phase to determine if the sampling intensity is appropriate relative to the nature of the spill (e.g., additional sampling sites may be required if the trajectory of the fuel spill changes).

Standard sample collection and environmental effects monitoring methods and analytical requirements implemented during fuel spills are provided in Table D-5. Ultimately, monitoring requirements will be at the discretion of the applicable regulators (e.g., EC-CWS and DFO).



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**Table D-5: Example of Sampling Methods and Analytical Requirements**

Parameter	Location	Collection Methods	Laboratory Analyses
Water	Sites should be distributed from a near field to far field direction. Locations as close as possible to the perimeter of the spill should be collected first.	<p><i>In situ</i> measurement of pH, conductivity, salinity, temperature and turbidity throughout the water column.</p> <p>One sample should be collected at each site with a grab sampler (e.g., a Niskin bottle or Kemmerer).</p> <p><i>In situ</i> and water samples should be collected at the surface, mid-water and deep water.</p>	<ul style="list-style-type: none"> <li>• BTEX/VPH</li> <li>• EPH</li> <li>• VOCs</li> <li>• PAHs (parent)</li> <li>• Total and Dissolved Metals (including mercury)</li> <li>• TOC</li> <li>• Major ions</li> <li>• General parameters</li> </ul>
Sediment	Sites should be distributed from a near field to far field direction. Locations as close as possible to the perimeter of the spill should be collected first.	<p>Five replicates collected at each shore site where sediments are sand-sized (e.g., less than approximately 2.0 mm) or finer.</p> <p>For shoreline areas, samples collected with a grab sampler (e.g., Ponar) at high tide, or a stainless steel spoon and bowl at low tide, with replicates randomly distributed within the sample area. For each station, samples should be collected at high and mid to low intertidal zone. For deepwater stations, one surface sediment sample should be collected.</p>	<ul style="list-style-type: none"> <li>• BTEX/VPH</li> <li>• EPH</li> <li>• VOCs</li> <li>• PAHs (parent)</li> <li>• Metals (including mercury)</li> <li>• TOC</li> <li>• Grain size distribution</li> </ul>
Tissue – Requires a DFO scientific fish collection permit	Sites should be distributed from a near field to far field direction. Locations as close as possible to the perimeter of the spill should be collected first.	Five replicates consisting of a composite of 20 individual bivalves collected randomly at each station where bivalves are present. Bivalves should be shucked and the soft tissues rinsed in with deionized water to remove shell pieces and other debris. Tissue samples will be handled with clean stainless steel instruments (i.e., scalpels), weighed and divided between two certified-clean, laboratory-supplied glass containers with Teflon®-lined lids, which will be then stored in a freezer. The samples will be transported on ice (frozen) to an accredited lab for analysis of parent and alkylated PAHs (following silica-gel cleanup to remove natural polar organic compounds that can cause false positives), metals, lipids and moisture content.	<ul style="list-style-type: none"> <li>• PAH (parent) after silica-gel clean-up.</li> <li>• Metals</li> <li>• Moisture</li> <li>• Lipids</li> </ul>



### 2.2.1.2 Species and Habitats of Immediate Risk

Marine species and habitats of immediate risk from the spill should be identified in order of priority (see Table D-6). This will depend on a variety of factors including the location of the spill, timing, and prevalent weather conditions. Examples of sensitive habitats of potential immediate risk include fish bearing streams, narwhal congregation areas, walrus haul-outs, coastal nesting bird sites etc. Specific locations of habitats are important to note. A revised marine baseline report (SD8-1: Appendix B of the Shipping Management Plan) provides the most current information on known sensitive marine resources in the RSA. Figure B-3 of SD8-1: Appendix B – Revised Baseline – Marine Environment outlines the various coastal habitat types in Melvin Bay in the event of a spill within the limits of the harbour.

The above information should be provided by the QEP to the spill response team and others involved in the spill clean-up (e.g., the Canadian Coast Guard) along with recommendations on what environmental resources are of greatest concern to protect. The QEP should also be involved in discussions relating to the implement of mitigation measures to avoid impacts to sensitive resources. Recommendations regarding mitigation from the QEP should be made in consultation with the relevant regulatory agencies (DFO for marine mammals and fish, CWS for marine birds and the Government of Nunavut for polar bears). The CWS provides spill response guidance on what techniques are available to be used during a spill in relation to marine birds (provided in Attachment D), this includes:

- Hazing;
- Dispersing Oil;
- Bird Collection;
- Wildlife Monitoring (as covered by this framework);
- Beached Bird Surveys (as covered by Section 3.2.1.1);
- Drift Blocks; and
- Live Oiled Bird Response (CWS 2012).

Several of these techniques require specific training and permit authorization before implementation. Therefore, prior to initiation of any of these techniques, the CWS should be contacted for input and guidance.

No similar guidance is provided by DFO for dealing with marine mammals in the event of a spill. DFOs Marine Mammal Response Program is responsible for tracking and responding to contaminated animals (DFO 2015). In the event of a major fuel spill in the RSA, DFO should be contacted immediately by the QEP to determine appropriate mitigation techniques to be utilized to limit potential adverse impacts on marine mammals.

**Table D-6: Species and Habitats of Immediate Management Concern**

Species and/or Habitat	Location*	Comments

Notes: \* A general description of the location of the species (e.g., haul-out areas, congregating areas, fish bearing streams etc.) or specific GPS locations (in UTM) if available



### 2.2.1.3 Fish and Marine Wildlife Permitting

Table D-7 provides an overview of permitting requirements that may be required to implement the wildlife monitoring framework in the event of a major fuel spill. The CWS and DFO should be contacted to determine the course of action in relation to the collection of live or dead wildlife during the initial response phase.

**Table D-7: Potential Permitting Requirements**

Agency	Permit	Required for
CWS	Variance Order to the Migratory Bird Regulations	Required for collection, transportation, holding, treating and hazing of migratory birds (live and dead).
DFO	Fish Collection Permit	Required for the collection of marine species (live or dead).
Government of Nunavut	Scientific Research Permit	May be required for the collection of wildlife in Nunavut (live or dead).

### 2.2.1.4 Daily Assessment Objectives in Order of Priority

Daily assessment objectives should be reviewed each morning and updated as necessary by the QEP. An example of daily assessment objective list is provided below. These objectives will change over the course of an event as the spill is contained and cleaned up.

- 1) Determine maximum extent of spill area to define hazard zones to marine wildlife and their habitats. The extent of the spill will be in-flux, therefore, seek an update each morning from the spill response team.
- 2) From the spill origin, travel by boat along the shoreline to search for wildlife or evidence of wildlife.
- 3) Survey pelagic areas for birds and marine mammals.
- 4) Document species observations and important habitat areas that may potentially be at risk from spilled product. Bird species observations should detail species, number, behaviour, condition (oiled, not oiled), and location (UTMs). Visual and auditory indications should be used.
- 5) Conduct marine mammal monitoring; use binoculars to scan for the presence of marine mammals within spill area from on-shore vantage points located at a high location that have good vantage areas. The MMSO(s) can assist with this duty.
- 6) Update the spill response team and relevant regulators (CWS and DFO) regarding the observations of wildlife.
- 7) Maintain and monitor the 24 hour wildlife hotline and respond to information gathered.
- 8) Document impacts to wildlife and habitat, severity of impact, and potential biological implications on a daily and cumulative basis.
- 9) Implement and maintain wildlife deterrence strategies from oil impacted areas in consultation with the relevant regulatory agency.



### 2.2.1.5 Reporting

Updates to CWS and DFO regarding observations of wildlife should be a daily objective during a major fuel spill event. In addition, all wildlife sightings records (Table D-4) should be provided on a weekly basis to DFO and the CWS by the QEP.

### 2.2.2 Follow-up Phase

During the initial phase, all resources should be focused on limiting the effects of the spill. The follow-up phase consists of follow-up monitoring that should be executed through a long-term monitoring framework. The objective of this framework is to assess impacts to wildlife resources and their habitats as a result of the spill and any cleanup measures implemented (e.g., dispersants), as well as to measure the success of applied mitigation techniques.

The follow-up monitoring framework should be developed after the completion of the initial phase monitoring. This allows the follow-up monitoring to focus on species and habitats that have been most impacted by the spill. The framework may contain, but will not be limited to:

- Marine bird surveys;
- Coastal nest surveys;
- Marine mammal surveys;
- Fish surveys;
- Sediment quality monitoring; and
- Water quality monitoring.

The follow-up phase framework should be completed in consultation with the relevant regulatory agencies. It should also provide a mechanism to allow for local community members to be involved in monitoring, remediation and reporting efforts.

## 3.0 SUMMARY

This MEMP outlines the protocol for monitoring of marine mammals and seabirds during routine shipping operations of the Meliadine Gold Mine. Mine-specific mitigation measures designed to minimize Mine impacts on marine mammals and seabirds will be initiated by vessel-based MMSOs and implemented by the ship's crew. The MEMP also provides a framework to monitor for marine wildlife and their habitats in the event of a Mine-related spill. An opportunity for inclusion of local community members exists and should be considered an asset when implementing this plan. Communication and consultation with relevant regulatory agencies is essential when attempting to implement adaptive management strategies during routine operations as well as during a spill event.

This plan should be considered a living document that can be updated throughout the Mine in order to implement adaptive management techniques.



### Report Signature Page

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# **ATTACHMENT A**

## **Marine Mammal Sightings Record**

Observation Period Information:				
Company/agency			Sea state code	
Platform name and type			Wave height (m)	
Observer (s)			True wind speed (knots) <b>OR</b> Beaufort code	
Date (DD/MMM/YYYY)			True wind direction	
Time at start ( UTC )			Ice type code	
Time at end (UTC )			Ice concentration code	
Latitude at start / end			True platform speed (knots)	
Longitude at start / end			True platform direction	
Visibility (km)			Observation side	Starboard      Port      Middle
Weather code			Height of eye (m)	
Glare conditions code			Outdoors or Indoors	Out              or              In
Platform Activity			Notes	

Date and Time of Sighting	Vessel Travel Direction and Speed	Weather / Sea State	Re-Sighting? (Y or N)	Sighting Waypoint or Lat/Long(Garmin GPS)	Species, Number of Individuals	Distance to Animal (m or km)	Angle to Sighting	Behaviour/Travel Direction	Age/Sex	Mitigation Required?	Photo Number (if any)
Notes:											

Species	How Animal Was Spotted	Certainty of ID	Animal Activity
Narwhal Whale	By Eye	Definite	Slow Swimming
Beluga Whale	Reticle Binoculars	Probable	Medium Swimming
Bowhead Whale	Big-eye Binoculars	Possible	Fast Swimming
Atlantic Walrus			Looking – Seals
Bearded Seal			Feeding
Ringed Seal			Flipper Slapping
Harbour Seal			Surfacing
Hooded Seal			Resting
Harp Seal			Diving
Polar Bear			Diving (Fluke Visible)
Killer Whale			Splashing
			Surfacing
			Fluking
			Lobtailing
			Bow Riding
			Wake Riding
			Porpoising
			Spyhopping
			Breaching
			Acrobatic
			Startle Response
			Milling
			Unknown





# ATTACHMENT B

Record Sheet for a Moving Platform Survey<sup>3</sup>

Record Sheet for a Stationary Platform Survey<sup>3</sup>

Appendix I - Estimating Distance Categories Using Ruler Gauge<sup>3</sup>

Appendix II Through VI - Codes for General Weather Conditions and Glare, Sea State and Beaufort Wind Force, Ice Conditions, Species Codes for Eastern Seabirds, and Codes for <sup>3</sup>Associations and Behaviours<sup>3</sup>

---

<sup>3</sup> Eastern Canada Seabirds at Sea (ECSAS) Seabird Sightings Records and Background Material (Extracted from Gjerdrum et al. 2012)

## Record sheet for a moving platform survey

### Observation Period Information:

Company/agency		Sea state code	
Platform name and type		Wave height (m)	
Observer (s)		True wind speed (knots) <b>OR</b> Beaufort code	
Date (DD/MMM/YYYY)		True wind direction (deg)	
Time at start ( UTC )		Ice type code	
Time at end (UTC )		Ice concentration code	
Latitude at start / end		True platform speed (knots)	
Longitude at start / end		True platform direction (deg)	
Platform activity		Observation side	Starboard    Port
Visibility (km)		Height of eye (m)	
Weather code		Outdoors or Indoors	Out    or    In
Glare conditions code		Snapshot used?	Yes    or    No

**Notes:**

### Bird Information: \*this field must be completed for each record

* Species	* Count	* Fly or Water?	* In transect?	* Distance <sup>1</sup>	Assoc.	Behav.	Flight Direc. <sup>2</sup>	Age <sup>3</sup>	Plum. <sup>4</sup>	Sex	Comments

<sup>1</sup> **A** = 0-50m, **B** = 51-100m, **C** = 101-200m, **D** = 201-300m, **E** = > 300m, **3** = within 300m but no distance recorded.

<sup>2</sup> Indicate flight direction (**N**, **NE**, **E**, **SE**, **S**, **SW**, **W**, or **NW**); **ND** = no apparent direction

<sup>3</sup> **J**(juvenile), **I**(mmature), or **A**(dult); <sup>4</sup> **B**(reeding), **NB**(non-breeding), **M**(oult)

## Record sheet for a stationary platform survey

### Scan Information:

Company/agency		Weather code	
Platform name and type		Glare conditions code	
Observer (s)		Sea state code	
Date (DD/MMM/YYYY)		Wave height (m)	
Time at start (UTC)		True wind speed (knots) <b>OR</b> Beaufort code	
Latitude		True wind direction (deg)	
Longitude		Ice type code	
Platform activity		Ice concentration code	
Scan type	180° or other (specify: )	Height of eye (m)	
Scan direction		Outdoors or Indoors	Out or In
Visibility (km)			

**Notes:**

### Bird Information: \*this field must be completed for each record

* Species	* Count	* Fly or Water?	* In semi- circle?	* Distance <sup>1</sup>	Assoc.	Behav.	Flight Direc. <sup>2</sup>	Age <sup>3</sup>	Plum. <sup>4</sup>	Sex	Comments

<sup>1</sup> **A** = 0-50m, **B** = 51-100m, **C** = 101-200m, **D** = 201-300m, **E** = > 300m, **3** = within 300m but no distance recorded.

<sup>2</sup> Indicate flight direction (**N**, **NE**, **E**, **SE**, **S**, **SW**, **W**, or **NW**); **ND** = no apparent direction

<sup>3</sup> **J**(juvenile), **I**(mmature), or **A**(dult); <sup>4</sup> **B**(reeding), **NB**(non-breeding), **M**(oult)

## APPENDIX I. Estimating distance categories

The various distance categories can be estimated using the following equation<sup>1</sup>:

$$d_h = 1000 \frac{(ah3838\sqrt{h}) - ahd}{h^2 + 3838d\sqrt{h}} \quad \text{e.g. if } a = 0.730 \text{ m, } h = 12.5 \text{ m, and } d = 300 \text{ m}$$

then  $d_h = 30.0 \text{ mm}$

where:

$d_h$  = distance below horizon (mm)

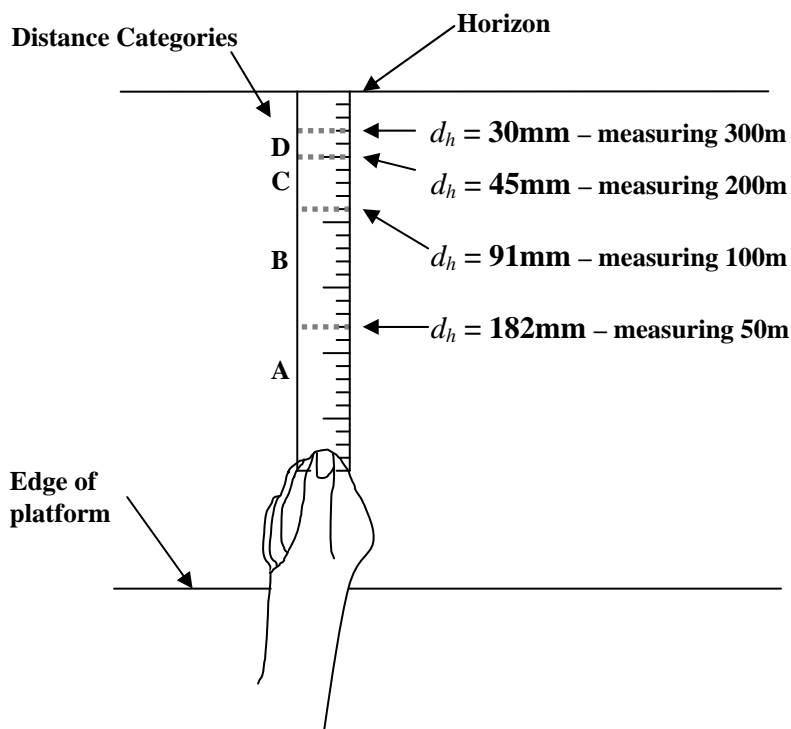
$a$  = distance between the observer's eye and the ruler when observer's arm is fully out-stretched (m)

$h$  = height of the observer's eye above the water at the observation point (m)

$d$  = distance to be estimated (m; a separate calculation is required for each of 50, 100, 200, 300)

Distances are easily estimated using a gauge made from a transparent plastic ruler. A different ruler will be required for each combination of observer arm length ( $a$ ) and platform height ( $h$ ). Calculate  $d_h$  for the boundary of each distance class (A, B, C, D) and mark them on the ruler (dashed lines in figure). To use the gauge, extend the arm fully and keep the top end of the ruler aligned with the horizon. The dashed lines now demark the distance class boundaries on the ocean surface. Keep the gauge nearby during surveys to quickly verify bird distances.

Measurements for an observer with  $a = 73 \text{ cm}$  and  $h = 12.5 \text{ m}$ :



<sup>1</sup> Formula derived by J. Chardine, based on Heinemann 1981. A spreadsheet is available from the corresponding author to perform this calculation.

## APPENDIX II. Codes for general weather conditions and glare

Code	Description	Explanation
<i>Weather conditions</i>		
0		< 50% cloud cover (with no fog, rain, or snow)
1		> 50% cloud cover (with no fog, rain, or snow)
2		patchy fog
3		solid fog
4		mist/light rain
5		medium to heavy rain
6		fog and rain
7		snow
<i>Glare conditions</i>		
0		none
1		slight/grey
2		bright on the observer's side of vessel
3		bright and forward of vessel

### APPENDIX III. Codes for sea state and Beaufort wind force

Wind Speed (knots)	Sea state code and description	Beaufort wind force and description
<b>0</b>	<b>0</b> Calm, mirror-like	<b>0</b> calm
<b>01 – 03</b>	<b>0</b> Ripples with appearance of scales but crests do not foam	<b>1</b> light air
<b>04 – 06</b>	<b>1</b> Small wavelets, short but pronounced; crests do not break	<b>2</b> light breeze
<b>07 – 10</b>	<b>2</b> Large wavelets, crests begin to break; foam of glassy appearance; perhaps scattered white caps	<b>3</b> gentle breeze
<b>11 – 16</b>	<b>3</b> Small waves, becoming longer; fairly frequent white caps	<b>4</b> moderate breeze
<b>17 – 21</b>	<b>4</b> Moderate waves with more pronounced form; many white caps; chance of some spray	<b>5</b> fresh breeze
<b>22 – 27</b>	<b>5</b> Large waves formed; white foam crests more extensive; probably some spray	<b>6</b> strong breeze
<b>28 – 33</b>	<b>6</b> Sea heaps up; white foam from breaking waves blows in streaks in direction of wind	<b>7</b> near gale
<b>34 – 40</b>	<b>6</b> Moderately high long waves; edge crests break into spindrift; foam blown in well-marked streaks in direction of wind	<b>8</b> gale
<b>41 – 47</b>	<b>6</b> High waves; dense streaks of foam in direction of wind; crests of waves topple and roll over; spray may affect visibility	<b>9</b> strong gale
<b>48 – 55</b>	<b>7</b> Very high waves with long overhanging crests; dense foam streaks blown in direction of wind; surface of sea has a white appearance; tumbling of sea is heavy; visibility affected	<b>10</b> storm
<b>56 - 63</b>	<b>8</b> Exceptionally high waves; sea is completely covered with white patches of foam blown in direction of wind; edges blown into froth; visibility affected	<b>11</b> violent storm
<b>64 +</b>	<b>9</b> Air filled with foam and spray; sea completely white with driving spray; visibility seriously affected	<b>12</b> hurricane

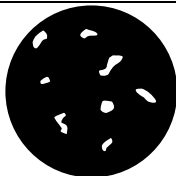
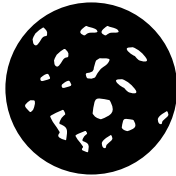

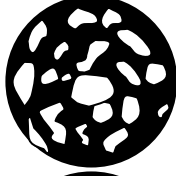

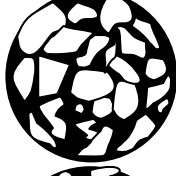
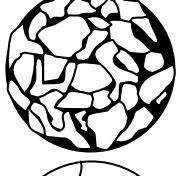
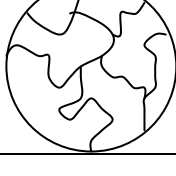
## APPENDIX IV. Codes for ice conditions

Adapted from NOAA: Observers Guide to Sea Ice

### *Sea Ice Forms*

Code	Name	Description
0	New	small, thin, newly formed, dinner plate-sized pieces
1	Pancake	rounded floes 30 cm - 3 m across with ridged rims
2	Brash	broken pieces < 2 m across
3	Ice Cake	level piece 2 - 20 m across
4	Small Floe	level piece 20 - 100 m across
5	Medium Floe	level piece 100 - 500 m across
6	Big Floe	level, continuous piece 500 m - 2 km across
7	Vast Floe	level, continuous piece 2 - 10 km across
8	Giant Floe	level, continuous piece > 10 km across
9	Strip	a linear accumulation of sea ice < 1 km wide
10	Belt	a linear accumulation of sea ice from 1 km to over 100 km wide
11	Beach Ice or Stamakhas	irregular, sediment-laden blocks that are grounded on tidelands, repeatedly submerged, and floated free by spring tides
12	Fast Ice	ice formed and remaining attached to shore

### *Sea Ice Concentration*

Code	Concentration	Description	
0	< one tenth	"open water"	
1	two-three tenths	"very open drift"	
2	four tenths	"open drift"	
3	five tenths	"open drift"	
4	six tenths	"open drift"	
5	seven to eight tenths	"close pack"	
6	nine tenths	"very close pack"	
7	ten tenths	"compact"	

## APPENDIX V. Species codes for birds seen in Eastern Canada

Common name	Species code	Latin name
<b>COMMON, REGULAR OR FREQUENTLY SEEN SPECIES</b>		
Northern Fulmar	NOFU	<i>Fulmarus glacialis</i>
Great Shearwater	GRSH	<i>Puffinus gravis</i>
Manx Shearwater	MASH	<i>Puffinus puffinus</i>
Sooty Shearwater	SOSH	<i>Puffinus griseus</i>
Wilson's Storm-Petrel	WISP	<i>Oceanites oceanicus</i>
Leach's Storm-Petrel	LESP	<i>Oceanodroma leucorhoa</i>
Northern Gannet	NOGA	<i>Morus bassanus</i>
Red Phalarope	REPH	<i>Phalaropus fulicaria</i>
Red-necked Phalarope	RNPH	<i>Phalaropus lobatus</i>
Long-tailed Jaeger	LTJA	<i>Stercorarius longicaudus</i>
Parasitic Jaeger	PAJA	<i>Stercorarius parasiticus</i>
Pomarine Jaeger	POJA	<i>Stercorarius pomarinus</i>
Great Skua	GRSK	<i>Stercorarius skua</i>
Herring Gull	HERG	<i>Larus argentatus</i>
Iceland Gull	ICGU	<i>Larus glaucoides</i>
Glaucous Gull	GLGU	<i>Larus hyperboreus</i>
Great Black-backed Gull	GBBG	<i>Larus marinus</i>
Black-legged Kittiwake	BLKI	<i>Rissa tridactyla</i>
Common Murre	COMU	<i>Uria aalge</i>
Thick-billed Murre	TBMU	<i>Uria lomvia</i>
Razorbill	RAZO	<i>Alca torda</i>
Dovekie	DOVE	<i>Alle alle</i>
Atlantic Puffin	ATPU	<i>Fratercula arctica</i>
<b>SPECIES MORE COMMONLY SEEN INSHORE</b>		
Common Loon	COLO	<i>Gavia immer</i>
Red-throated Loon	RTLO	<i>Gavia stellata</i>
Red-necked Grebe	RNGR	<i>Podiceps grisegena</i>
Horned Grebe	HOGR	<i>Podiceps auritus</i>
Great Cormorant	GRCO	<i>Phalacrocorax carbo</i>
Double-crested Cormorant	DCCO	<i>Phalacrocorax auritus</i>
Greater Scaup	GRSC	<i>Aythya marila</i>
Common Eider	COEI	<i>Somateria mollissima</i>
Harlequin Duck	HARD	<i>Histrionicus histrionicus</i>
Long-tailed Duck	LTDU	<i>Clangula hyemalis</i>
Surf Scoter	SUSC	<i>Melanitta perspicillata</i>
Black Scoter	BLSC	<i>Melanitta nigra</i>
White-winged Scoter	WWSC	<i>Melanitta fusca</i>
Red-breasted Merganser	RBME	<i>Mergus serrator</i>
Black Guillemot	BLGU	<i>Cephus grylle</i>

Common name	Species code	Latin name
<b>INFREQUENTLY OR RARELY SEEN SPECIES</b>		
Cory's Shearwater	COSH	<i>Calonectris diomedea</i>
Audubon's Shearwater	AUSH	<i>Puffinus lherminieri</i>
Lesser Scaup	LESC	<i>Aythya affinis</i>
King Eider	KIEI	<i>Somateria spectabilis</i>
South Polar Skua	SPSK	<i>Stercorarius maccormicki</i>
Bonaparte's Gull	BOGU	<i>Larus philadelphia</i>
Ivory Gull	IVGU	<i>Pagophila eburnea</i>
Black-headed Gull	BHGU	<i>Larus ridibundus</i>
Laughing Gull	LAGU	<i>Larus articilla</i>
Ring-billed Gull	RBGU	<i>Larus delawarensis</i>
Lesser Black-backed Gull	LBBG	<i>Larus fuscus</i>
Sabine's Gull	SAGU	<i>Xema sabini</i>
Common Tern	COTE	<i>Sterna hirundo</i>
Arctic Tern	ARTE	<i>Sterna paradisaea</i>
Roseate Tern	ROTE	<i>Sterna dougallii</i>
<b>CODES FOR BIRDS IDENTIFIED TO FAMILY OR GENUS</b>		
Unknown Bird	UNKN	
Unknown Shearwater	UNSH	<i>Puffinus</i> or <i>Calonectris</i>
Unknown Storm-Petrel	UNSP	Hydrobatidae
Unknown Duck	UNDU	Anatidae
Unknown Eider	UNEI	<i>Somateria</i>
Unknown Phalarope	UNPH	<i>Phalaropus</i>
Unknown Jaeger	UNJA	<i>Stercorarius</i>
Unknown Skua	UNSK	<i>Stercorarius</i>
Unknown Gull	UNGU	Laridae
Unknown Tern	UNTE	<i>Sternidae</i>
Unknown Alcid	ALCI	Alcidae
Unknown Murre or Razorbill	MURA	<i>Uria</i> or <i>Alca</i>
Unknown Murre	UNMU	<i>Uria</i>

## APPENDIX VI. Codes for associations and behaviours

From Camphuysen and Garthe (2004). Choose one or more as applicable.

Code	Description
<i>Association</i>	
10	Associated with fish shoal
11	Associated with cetaceans
13	Associated with front (often indicated by distinct lines separating two water masses or concentrations of flotsam)
14	Sitting on or near floating wood
15	Associated with floating litter (includes plastic bags, balloons, or any garbage from human source)
16	Associated with oil slick
17	Associated with sea weed
18	Associated with observation platform
19	Sitting on observation platform
20	Approaching observation platform
21	Associated with other vessel (excluding fishing vessel; see code 26)
22	Associated with or on a buoy
23	Associated with offshore platform
24	Sitting on offshore platform
26	Associated with fishing vessel
27	Associated with or on sea ice
28	Associated with land (e.g., colony)
50	Associated with other species feeding in same location

Code	Description	Explanation
<i>Foraging behaviour</i>		
30	Holding or carrying fish	carrying fish towards colony
32	Feeding young at sea	adult presenting prey to attended chicks (e.g., auks) or juveniles (e.g., terns)
33	Feeding	method unspecified (see behaviour codes 39,40,41,45)
36	Aerial pursuit	kleptoparasitizing in the air
39	Pattering	low flight over the water, tapping the surface with feet while still airborne (e.g., storm-petrels)
40	Scavenging	swimming at the surface, handling carrion
41	Scavenging at fishing vessel	foraging at fishing vessel, deploying any method to obtain discarded fish and offal; storm-petrels in the wake of trawlers picking up small morsels should be excluded
44	Surface pecking	swimming birds pecking at small prey (e.g., fulmar, phalaropes, skuas, gulls)
45	Deep plunging	aerial seabirds diving under water (e.g., gannets, terns, shearwaters)
49	Actively searching	persistently circling aerial seabirds (usually peering down), or swimming birds frequently peering (and undisturbed by observation platform) underwater for prey
<i>General behaviour</i>		
60	Resting or apparently sleeping	reserved for sleeping seabirds at sea
64	Carrying nest material	flying with seaweed or other material; not to be confused with entangled birds
65	Guarding chick	reserved for auks attending recently fledged chicks at sea
66	Preening or bathing	birds actively preening feathers or bathing
<i>Distress or mortality</i>		
71	Escape from ship (by flying)	escaping from approaching observation platform
90	Under attack by kleptoparasite	bird under attack by kleptoparasite in an aerial pursuit, or when handling prey at the surface
93	Escape from ship (by diving)	escaping from approaching observation platform
95	Injured	birds with clear injuries such as broken wings or bleeding wounds
96	Entangled in fishing gear or rope	birds entangled with rope, line, netting or other material (even if still able to fly or swim)
97	Oiled	birds contaminated with oil
98	Sick/unwell	weakened individuals not behaving as normal, healthy birds, but without obvious injuries
99	Dead	bird is dead



# **ATTACHMENT C**

## **MMSO Daily Reporting Template**

## 1.0 MARINE MAMMALS AND SEABIRD OBSERVING (MMSO) DAILY REPORT

### Project Information

Client:

Date:

Project Name:

Location:

### Ship Contractor Information

Ship Contractor Name:

Site Supervisor or Captain:

Ship Name/Type:

MMSO name:

General weather conditions (throughout the day)

Cloud cover:

Precipitation:

Wind (knots):

Sea state:

Swell height:

Air temperature:

Ice presence:

Notes:

Time start/Time end MMSO duties (UTC):

## 2.0 MITIGATION LOG

Mitigation Implemented	Time (UTC)	GPS Location	Rational for Implementation

Under Activity note the following: Description of any vessel mitigation implemented (e.g., reduction in speeds, evasive maneuvers etc.)

## 3.0 RECORD OF VESSEL-ANIMAL COLLISIONS/INTERACTIONS

Species	Number of Individuals	Time (UTC)	GPS Coordinates	Visibility/Sea State	Comments



## 4.0 MMSO CHECKLIST

## 5.0 SUMMARY OF ISSUES AND RECOMMENDATIONS / ACTIONS

Date Noted	Issue	Recommendation/Action	Completed (Date Resolved)	Comments



# **ATTACHMENT D**

## **Birds and Oil - CWS Response Plan Guidance**

## Birds and Oil - CWS Response Plan Guidance

In all circumstances where a polluter is identified the burden of cleanup and response lies with the polluter. However, responsibility for government overview of a response to an oil spill depends on the source of the spill. The identified **lead agency** has responsibility to monitor an oil spill response and to take control if an appropriate response is not undertaken by a polluter or their agent.

Lead agency responsibilities lie with:

- **Environment Canada**
  - For spills and incidents on federal lands and from federal vessels
  - Potentially for land-based incidents in waters frequented by fish
  - May take lead if environment is not being protected by other leads, Cabinet Directive 1973
- **Canadian Coast Guard**
  - For spills from ships
  - All spills of unknown sources in marine environment
- **Provincial Department of Environment**
  - For spills from land-based sources
- **Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB) and Canada-Nova Scotia Offshore Petroleum Board (C-NSOPB)**
  - For spills related to offshore oil and gas exploration and production
- **Transport Canada**
  - To investigate ship source and mystery spills in the marine environment

The Canadian Wildlife Service has the responsibility for licensing activities which involve the handling or disturbance of birds, and of providing advice and often direction to other agencies, responders and the polluter during oil spill incidents.

### 1. Hazing<sup>1</sup>

*Purpose:* Prevent birds from coming in contact with oil

*Options:*

- Hazing by helicopter
- Hazing by FRC or other watercraft
- Release of scare devices (e.g. Breco Buoys, Phoenix Wailer)
- Use of hazing sound makers: propane cannons, whizzers, bangers, pyrotechnic devices etc.

Scare devices have a limited range of influence and likely are not a viable option with a large slick. Use of Breco Buoys and Phoenix Wailers can be used but we consider them to be largely ineffective in the situation of a large slick. Logistically, helicopter hazing would be difficult unless it was possible for a helicopter to remain on a platform offshore overnight. Hazing by FRC or other vessels would be ideal.

---

<sup>1</sup> There are several scare techniques which may be effective and do not require a permit, however a permit under the Migratory Bird Regulations **is required** for the use of aircraft or firearms (defined as capable of emitting at projectile at more than 495 feet per second). Propane cannons, blank pistols or pyrotechnical pistols firing crackers shells with **less than 495fps are legal without a permit**. Most scare tactics are relatively short lived in terms of effectiveness as birds acclimatize to the disturbance so scare techniques should be alternated to be effective.

Short-term focused hazing by the most expedient means should be attempted to move the birds away from the slick, if logistical conditions permit. Vessels at the site should have the ability to use sound makers (propane canons, pyrotechnic devices) to disperse birds in local areas. Such equipment should be deployed immediately to these ships with trained personnel to operate them. The vessels on site should be tasked to actively search and monitor for congregations of birds which could be vulnerable to oiling. If such groups are found then attempts should be made to disperse the birds away from the oil.

## **2. Disperse oil**

*Purpose:* Prevent birds from contacting oil by getting oil off the surface of the water as soon as possible.

*Options:*

- Dispersants
- Mechanical dispersal with FRCs or other vessels
- Natural dispersal by environmental conditions

For small spills, mechanical dispersal would be the preferred method.

## **3. Bird Collection<sup>2</sup>**

*Purpose:* Implement a humane response to oiled birds as required by Environment Canada's National Policy on Oiled Birds and Oiled Species At Risk (<http://www.ec.gc.ca/ee-ue/default.asp?lang=En&n=A4DD63E4-1>)

*Options:*

- The only option would be a ship-based effort to detect and collect dead and live oiled birds, both within the slick and adjacent to it.

All vessels in or near the slick should understand the need to collect birds. All vessels should have dip-nets, large plastic collecting bags to hold dead birds, and cloth bags or cardboard boxes in which to hold live oiled birds. Efforts should be made to retrieve live oiled birds to ensure they are dealt with humanely.

## **4. Wildlife monitoring**

*Purpose:* Determine potential impact of spill

*Options:*

- Ship-based surveys for oiled and unoled wildlife
- Aerial surveys for oiled and unoled wildlife. Will require structured surveys (e.g. strip or transect surveys of spill area)
- Placement of CWS staff on vessels and aircraft

---

<sup>2</sup> Only those individuals authorized to do so (nominee on an existing federal salvage permit) can be involved with the collection of migratory birds.

Dedicated ship-based bird surveys should be initiated immediately. Ideally arrangements should be made to have a CWS observer on vessels or flights. In addition trained seabird observers need to be placed on all vessels monitoring a slick. This should continue until the slick is dispersed.

## **5. Beached Bird Surveys**

*Purpose:* Determine impact of spill on wildlife and retrieve any live oiled wildlife on beaches.

*Options:*

- Conduct daily beached bird surveys during the incident and until one week after slick has been removed or dissipated.

CWS or other government officials (CCG, Enforcement Officers) will oversee the collection of dead and live oiled birds<sup>3</sup> as instructed in CWS' protocol for collecting birds during an oil spill response. This would only be required in circumstances where a large number of birds are potentially oiled or if the spill occurs in a sensitive area.

## **6. Drift Blocks**

*Purpose:* Drift blocks may be deployed in slick to provide an estimate of bird mortality.

*Options:*

- Release from vessel
- Release from aircraft

The deployment of drift blocks would only be expected if there was a large spill and blocks should be released as soon as possible after a spill (CWS should be consulted to determine protocol for drift block deployment and tracking). The polluter or their agent would be expected to ensure drift blocks are tracked and collected as appropriate.

## **7. Live oiled bird response**

*Purpose:* Implement a humane response to oiled birds as required by Environment Canada's National Policy On Oiled Birds And Oiled Species At Risk

*Options:*

- Rehabilitation
- Euthanization

CWS will be consulted to determine the appropriate response and treatment strategies which may include cleaning and rehabilitation or euthanization. CWS policy specifically requires that species at risk or other species of concern be rehabilitated.

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<sup>3</sup> Only those individuals authorized to do so (nominee on an existing federal salvage permit) can be involved with the collection of migratory birds.



# **ATTACHMENT E**

## **DFO's Marine Foreshore Environmental Assessment Procedure**

## MARINE FORESHORE ENVIRONMENTAL ASSESSMENT PROCEDURE

Marine development projects have the potential to effect fish<sup>1</sup> and fish habitat<sup>2</sup>. Fisheries and Oceans Canada (DFO) is responsible for the protection and management of fish habitats under the authority of the *Fisheries Act* and may request plans, specifications and environmental assessments specific to marine projects where more detailed information is required. Assessments may be necessary for all types of projects, including, but not limited to aquaculture, log handling, industrial port development, marinas, private moorage facilities, marine repair facilities, pipeline or outfall installations, vessel launches or barge ramps, dredging projects and shoreline protection projects (breakwaters and seawalls). Presented below are standardized, transect-based assessment procedures intended to provide DFO with the basic information required to determine the potential effects of a development project on fish habitat.

### Assessment Area

For comparative purposes, the assessment area should include both the foreshore site proposed for development as well as the adjacent foreshore. This will provide a context for the project and may provide data about cumulative effects if similar developments already occur on-site. A large scale site plan, preferably an enlargement of the hydrographic chart, with a small scale insert of the general geographic location will serve as a base map of the study area.

### Tidal Height and Water Depth Measurements

The lowest normal tide (0.0 m), or chart datum, will be used as the reference point for the measurement of tidal height and water depth. Tidal height is recorded as positive relative to chart datum, while water depth below chart datum will be recorded as a negative value. For example, if the assessment is made when the tide is at 2 m, and observations are taken at a water depth of 6 m, then the depth will be recorded as -4 m. Tidal height will be corrected using the closest secondary port to the reference port found in the Canadian Tide and Current Tables, with further correction made for daylight savings time as required.

### Transect Layout

Transects should be established perpendicular to the shoreline at regular intervals both within and adjacent to the proposed or active development area so as to sample representative fish habitat conditions. A preliminary low water reconnaissance or dive survey may be advisable to establish

---

<sup>1</sup> shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals;

<sup>2</sup> shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals;

appropriate boundaries for the assessment. Transects should begin at the highest high water mark (HHWM: distance referenced as Station 0.0 m) and, at a minimum, extend to a depth of -20 m (-30 m if the development has the potential to effect deeper benthic habitats). Though small-scale intertidal projects may only require intertidal transects, care must be taken to ensure that a representative sample is collected across the proposed development area. Procedural manuals are available from DFO if sampling of intertidal clam or benthic invertebrates is required. To ensure complete assessment of marine plants and animals in the photic zone, deeper transects may be necessary, especially to determine the effects of sunken debris or woodwaste accumulations resulting from existing developments. Transects should be spaced approximately 25 m apart, although this interval may vary depending on the width of the site. The number of transects required will depend on the nature of the foreshore development proposed, anticipated effects of the development, and local site conditions (tides and currents, geography, fetch, geology, etc.). Transects should be individually numbered and indicated on the site plan, and their commencement point referenced to benchmarks, where possible.

### **Recording Observations**

Habitat inventories should be conducted during the more productive spring and summer months. At that time, algae and saltmarsh species are more readily identifiable, enabling a better assessment of the productive capacity of the site.

Observations should be recorded every 5 m along the transect or at significant changes in habitat type. Observations should include substrate type and composition, presence and relative abundance of marine animals and plants, and any other notable features (e.g., debris accumulations) using the following format:

#### **Substrate**

Substrate types are to be subdivided into the following size class categories:

- Bedrock
- Boulder (>256 mm diameter)
- Cobble (64-256 mm diameter)
- Gravel (2-64 mm diameter)
- Sand (0.0625-2 mm diameter)
- Silt/Mud/Clay (<0.0625 mm diameter)

Substrate types are recorded cumulatively as percentages out of a total of 100% (e.g., Boulder 5%; Cobble 15%; Gravel 60%, Sand 20%)

### **Marine Plants**

Marine plants include rooted vascular vegetation (e.g., eelgrass, saltmarsh vegetation, etc.) and marine algae (e.g., rockweed, kelp, etc.). Marine plant observations are recorded as percent areal coverage estimated per 5 m × 1 m transect segment. Observations can be recorded as percentages (5%, 10%, 15%, etc.) or by utilizing the following areal coverage classes:

+	<5%
1	5-25%
2	>25-50%
3	>50-75%
4	>75-100%

### **Sessile Animals**

Many marine animals permanently attached to substrates function as important fish habitat (e.g., barnacles, bay mussels, etc.). Sessile animals are recorded as percent areal coverage along the transect line using either estimated percentages or by areal coverage classes, as presented above.

### **Motile Animals**

Motile animals include fish and marine invertebrates such as crabs and snails. These can be individually counted along the transect or, where too numerous, their estimated numbers can be recorded. Population estimates will most likely be applied to species such as herring or mysid shrimp that naturally occur in large numbers.

### **Other Features**

Accumulations of wood bark and debris, sunken logs or other waste materials arising from onsite or nearby development activities should also be recorded. For wood bark and related small size debris, observations are recorded as percent areal coverage estimates per 5 m × 1 m transect segment and estimated deposition depth (e.g., 15% / 10 cm). For larger materials (sunken logs, wood chunks, etc.), observations can be recorded by individual piece count or by estimate of percent areal coverage.

Observations should be correlated to the transect distance from the HHWM and (corrected) tidal height or water depth (e.g., Sta. 0+80 m / +4.5 m), with information compiled in tabular form, by transect. Common names of observed animals and plants are acceptable for the data table; a species list with scientific names should, however, be appended to the report.

General marine plant categories (e.g., rockweed, eelgrass, bull kelp, saltmarsh, etc.) and any other notable features should be sketched to scale directly on a copy of the site plan, drawings or photographs of the site. A site profile should be prepared for each transect showing the slope of the foreshore and the location of indicator marine plants or invertebrates. A sketch of the proposed marine development should be superimposed over the site plan so that any potential effect of the project on fish habitat is clear. Compensatory habitat proposed for offsetting altered habitat should also be sketched on site maps and profiles to enable review of the positioning of replacement habitat relative to the project.

### **Photographic Documentation**

It is essential to produce a photographic record along the intertidal and subtidal transects. A videographic record of subtidal transects is also recommended. Photos and videos provide a real-time record of characteristic fish habitat at the proposed site and can be invaluable to future post-development site monitoring. Photographic records also facilitate comparison of the productivity of natural habitats with any compensatory habitat constructed to offset habitat losses. As visibility may be a problem, careful attention should be given to appropriate tidal levels, and midday lighting conditions are recommended. Aerial photos, taken at low tide, are often useful to put the site into context with the surrounding area and to verify information provided from other sources.

Assessment reports should include photographs of representative fish habitat types. Depending upon the scope of the proposed foreshore development, an unedited, labelled copy of the assessment video may also be required for the report submission. The video footage should be referenced with pertinent information (e.g., time, date, depth, heading, etc.), and a written or recorded interpretation should accompany the video.

### **Summary of information to be submitted**

1. Basemap showing tenure area boundaries, surrounding area, transect locations and sampling stations
2. Shoreline video/photographs of intertidal zone
3. Underwater video/photographs of transects
4. Tabular data for each transect describing substrate type and composition, marine plants, sessile and motile marine animals, and other notable features
5. Habitat map showing location of different substrate types, plants, animals and operational infrastructure
6. Profile diagrams of each transect showing slope, sediment types and the major marine plants or animals observed
7. Photographs of site and aerial photographs if available.

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**APPENDIX D • REVISED MARINE ENVIRONMENTAL BASELINE**

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**August 10, 2016**

## **REVISED MARINE ENVIRONMENTAL BASELINE REPORT**

### **Appendix B**

**Submitted to:**

Agnico Eagle Mines Limited  
10200, Route de Preissac  
Rouyn-Noranda QC  
Stephane Robert, Manager Regulatory Affairs

**REPORT**



**Report Number:**

**Distribution:**

1 copy - Agnico Eagle Mines Limited  
2 copies - Golder Associates Ltd.





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## 1.0 MARINE ENVIRONMENT REVISED BASELINE

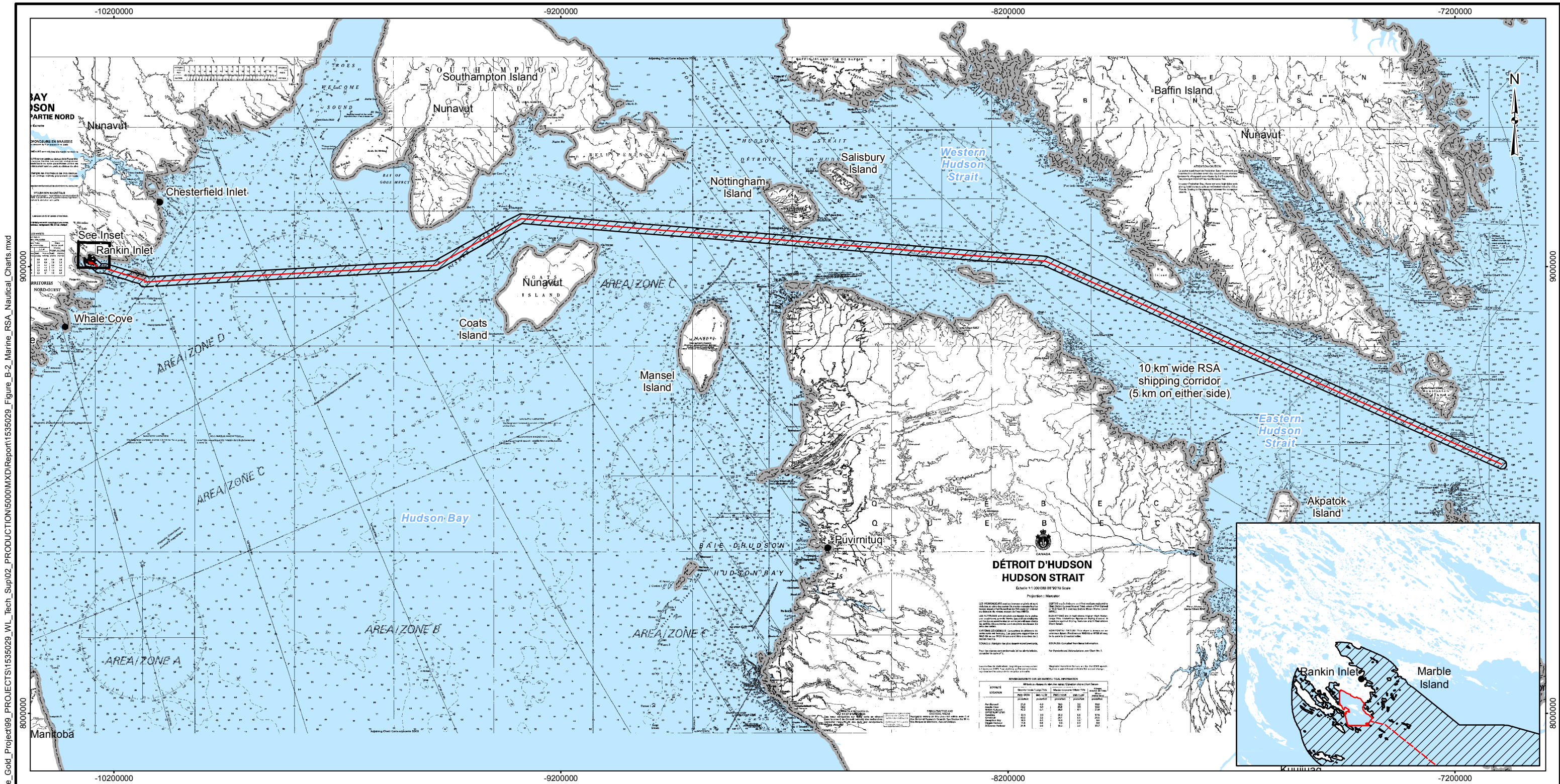
### 1.1 Purpose and Scope

This report represents an update to the marine baseline information originally presented in Agnico Eagle's Final Environmental Impact Statement (FEIS). These revisions have been undertaken in accordance with Meliadine Gold Project (Project) Certificate Condition 79, which states the following:

*"Prior to any Project-related shipping, the Proponent will update its marine baseline information to ensure that it includes the most recent information on marine wildlife abundance and distribution, carefully considers seasonal distribution patterns of marine wildlife, and incorporates western scientific and Inuit Qaujimajatuqangit knowledge sources. The updated marine baseline should be made available to appropriate authorities for feedback, then incorporated into the Proponent's Shipping Management Plan (SMP), with continued updates on a regular basis as new information becomes available."*

This report was updated with new environmental information now available in the public domain (as of January 2016), as well as information provided through consultation with regulators and as a result of technical responses prepared by the proponent in response to information requirements (IRs) submitted as part of the FEIS review process. The majority of the new information provided relates specifically to the abundance and distribution of marine wildlife species in the Local Study Area (LSA) and Regional Study Area (RSA) (Figure B-1 and Figure B-2) and incorporates best available science with Inuit Qaujimajatuqangit. Information presented in this report should be reviewed in conjunction with the Marine Environmental Management Plan (MEMP) (Appendix D) and the Spill Risk Assessment (Appendix E), to inform monitoring, mitigation and adaptive management strategies for the Project.





- LEGEND**
- MARINE REGIONAL STUDY AREA (MARINE RSA) (SEE INSET)
  - MARINE LOCAL STUDY AREA (MARINE LSA)
  - COMMUNITY
  - WATERBODY

**REFERENCE**

BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED (AEM).  
CANVEC DATA OBTAINED FROM © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.  
NAUTICAL CHART DATA OBTAINED FROM THE CANADIAN HYDROGRAPHIC SERVICE. PROVINCIAL DATA OBTAINED FROM ESRI.  
DATUM: WGS 84 PROJECTION: WORLD MERCATOR

PROJECT

**AGNICO EAGLE**

AGNICO EAGLE MINES LIMITED  
MELIADINE GOLD PROJECT  
NUNAVUT

TITLE

**MARINE REGIONAL STUDY AREA**

**Golder Associates**

PROJECT NO.	1535029	FILE No.
DESIGN	AK 16 Jul. 2012	SCALE AS SHOWN
GIS	DSC 18 Jul. 2012	REV. 0
CHECK	PR 18 Jan. 2013	<b>FIGURE B-2</b>
REVIEW	DW 18 Jan. 2013	

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### 1.2 Existing Environment in Melvin Bay / Itivia Harbour

In August 2011, a field program was conducted by Nunami Stantec at Itivia and at two nearby reference sites in Melvin Bay (Figure B-1). The objective of the field program was to collect physical and biological baseline information in the marine LSA (Figure B-1), with a focus on the Project footprint corresponding with the proposed floating dock facility (landing barge). The field program investigated bathymetry, water and sediment chemistry, aquatic lower-trophic organisms (phytoplankton, zooplankton, and benthic invertebrates) and fish and fish habitat. Results from Nunami Stantec's field program are provided in detail in Appendix 8.2-A of the FEIS, with a general summary provided below for bathymetry, water, and sediment chemistry (Agnico Eagle 2014).

#### 1.2.1 Physical Environment

Depth soundings were collected along shore-perpendicular transects in the LSA. Water depths at Itivia and in Melvin Bay were determined to be shallow, with maximum depths in the Project footprint reaching 6.6 metres (m). A large rocky reef is present approximately 125 m offshore of the high water mark near the proposed landing barge facility. Cobble and gravel were the dominant substrates in the nearshore environment of the Project footprint ( Figure B-3).



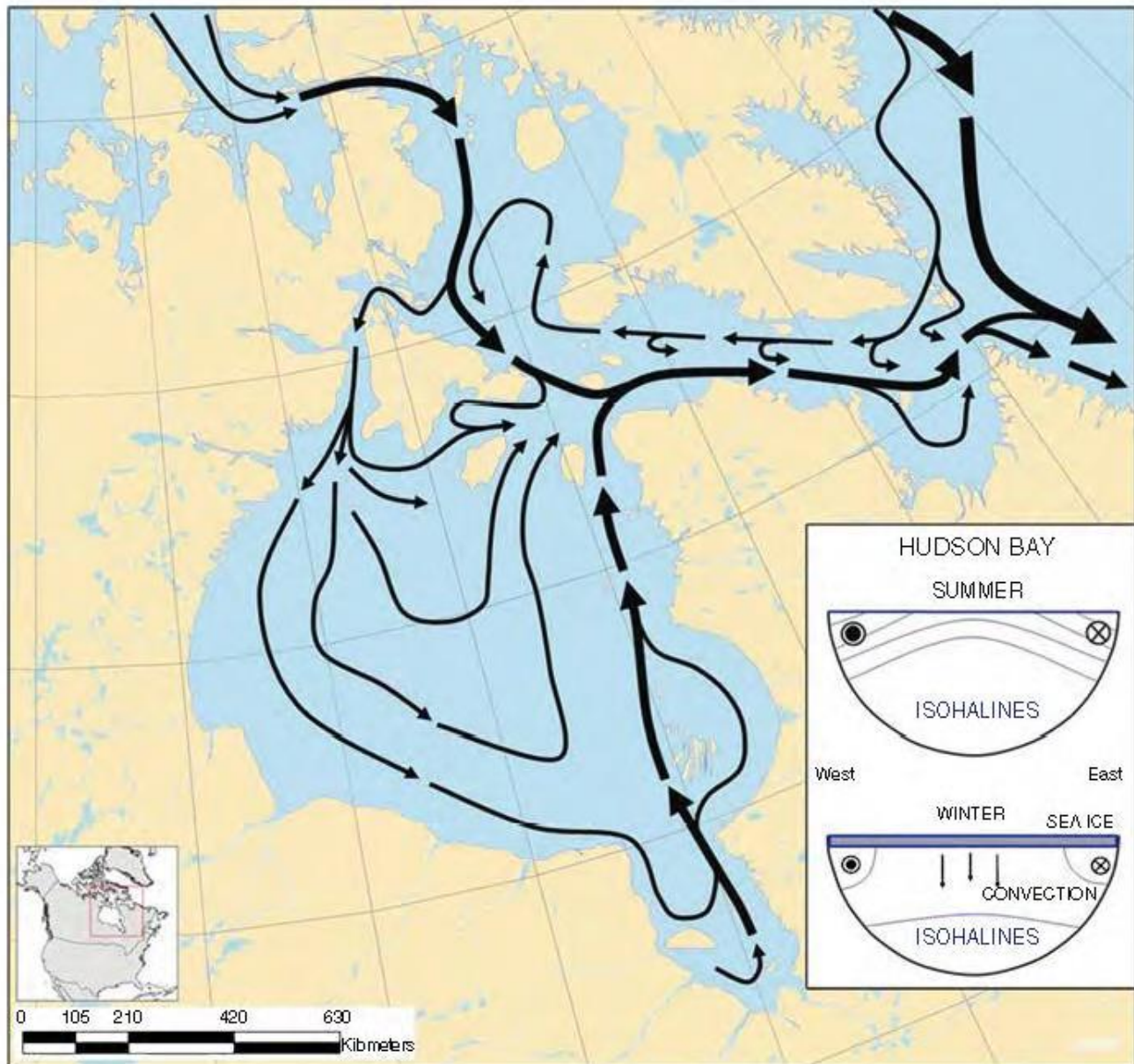


Figure B-4: Summer circulation of water in the Hudson Bay Complex (extracted from Stewart and Barber 2010; inset after Ingram and Prinsenberg 1998)

Water quality profiles were collected at one location in the LSA with an YSI 600QS multi-meter. Parameters measured included temperature, conductivity, pH, dissolved oxygen, salinity, and oxidation-reduction potential. Mean surface water temperature (at 1 m depth) in the harbour was  $8.86 \pm 0.52$  degrees Celsius ( $^{\circ}\text{C}$ ), with a salinity of  $29.32 \pm 0.03$  ppt, and a pH of  $8.08 \pm 0.03$ . Bottom water was slightly colder than surface water at  $8.49 \pm 0.57^{\circ}\text{C}$ ; with similar salinity and pH values. No thermal stratification was observed. The pH was near constant across the LSA (range from 8.05 to 8.10) and throughout the water column (range from 8.05 to 8.10).



Mean conductivity ranged from  $45.6 \pm 0.1$  mS/cm at the surface to  $45.7 \pm 0.1$  mS/cm at the bottom. Dissolved oxygen ranged from  $114.5 \pm 1.0\%$  at the surface to  $114.1 \pm 1.2\%$  at the bottom.

Water samples were collected for chemistry analysis at one location in the LSA using a Van Dorn sampler deployed at mid-depth. Parameters analyzed included major anions, alkalinity, total suspended solids, total dissolved solids, pH, conductivity, total metals, total Kjeldahl nitrogen, ammonia, nitrate and nitrite, total phosphate, and total organic carbon. Results were compared to Canadian Council of Ministers of the Environment (CCME) guidelines (maximum levels) for Protection of Marine Aquatic Life (PMAL). Total alkalinity in the marine LSA ranged from 142 to 144 milligrams per litre (mg/L), with bicarbonate ( $\text{HCO}_3^-$ ) as the major representative ion. Nitrate, nitrite, total Kjeldahl nitrogen, dissolved orthophosphate, and total phosphorus were below detection limits (typically  $<0.050$  mg/L). Total organic carbon values were low (ranging from 2.8 to 3.6 mg/L). Approximately 78% of all analyzed metals (33 of 42) were below detection limits. All sample parameters for which CCME PMAL guidelines exist were within acceptable limits.

Sediment samples were collected for chemistry analysis at 3 locations in the marine LSA footprint using a petite ponar grab. Metal concentrations were compared to CCME Interim Sediment Quality Guidelines (ISQG). Sediment chemistry was near constant across the LSA. Metal concentrations were variable and ranged from below analytical detection limits to exceeding CCME ISQCs. Chromium slightly exceeded the CCME ISQG of 52.3 milligrams per kilogram (mg/kg) at all sample stations, with average ( $\pm$ SD) concentrations in the marine LSA footprint measured at  $55.8 \pm 5.89$  mg/kg. The precision analyses (CV) indicate some heterogeneity of marine sediments in the study area.

### 1.2.2 Biological Environment

#### Plankton

Phytoplankton abundance, richness, and diversity were similar across all sites within the marine LSA, and a total of 33 taxa were recorded. Dinoflagellates were the dominant taxa at all sites and included *Peridinium*/*Gonyaulax* spp. and *Dinophysis* spp. The ciliate *Tintinnida* was present at low percentages at 2 of the sites.

Zooplankton abundance, richness, and diversity differed between sites, and a total of 44 taxa were recorded. An unidentified rotifer species, possibly Notommatidae, was identified as the dominant taxa at all sites. Calanoid copepods were also present at all 3 sites.

#### Benthic Invertebrates

Benthic invertebrate abundance, richness, and diversity differed amongst sites. Polychaetes were the dominant taxa at all sites and included Polychaeta: Sedentaria (burrowing or tube-dwelling), Capitellidae, and Cirratulidae and/or Paraonidae. Polychaeta: Errantia (free-swimming) were the next dominant taxa and included Nephtyidae, Syllidae, and Pholoidae. Also present was nematode subclass Hoplonemertea, the Myidae and Tellinidae clams, the amphipod families of Ischyroceridae, Oedicerotidae, and Zopfiaceae, as well as 11 additional polychaete families. At 1 site, a single sponge (*Porifera*), 2 hydrozoan taxa, 1 flatworm (*Platyhelminthes*), Terebellidae and Opheliidae polychaetes, 3 gastropod, and 3 bivalve taxa, several crustaceans (copepod, amphipod, decapods), and one sea squirt (*Urochordata*) were also identified.



Benthic species are not thought to occupy the intertidal zone in Hudson Bay on a permanent basis; rather, they occur seasonally when the habitat is not influenced by ice (Stewart and Lockhart 2005). Baseline studies completed in the LSA support this assumption (Nunami Stantec Ltd. 2012). Few invertebrate species were observed in the nearshore habitat, and abundance was low. Most of the individuals observed were less than 1 cm, suggesting a low biomass. Nearshore macrophyte coverage was found to be equally sparse (ranging from 2 to 5% coverage).

### Fishes

Six species of marine fish (n=156) were identified during gill net and beach seine sampling in the marine LSA, including Greenland cod (*Gadus ogac*) (52%), slender eelblenny (*Lumpenus fabricii*) (27%), fourhorn sculpin (kanayok in Inuktitut) (*Myoxocephalus quadricornis*<sup>1</sup>) (15%), unidentified sculpin (possibly juvenile; 3%), Arctic staghorn sculpin (*Gymnocanthus tricuspis*) (2%), and Arctic sculpin (*Myoxocephalus scorpioides*) (1%). The range of total lengths of the dominant fish taxa were 118 to 520 mm for Greenland cod, 180 to 210 mm for slender eelblenny, and 205 to 315 mm for fourhorn sculpin species. Arctic char were not observed during the baseline field study but were reported to be in the area at the time of the field study (west of Melvin Bay near the Barrier Islands).

### Marine Birds

A black guillemot (*Cephus grylle*) and a pair of sandhill cranes (*Grus canadensis*) were identified in the LSA during the baseline field program.

### Marine Mammals

No marine mammals were observed in the LSA during the baseline field program.

## 1.3 Existing Environment within Hudson Bay / Hudson Strait Shipping Corridor

Golder conducted a comprehensive literature review to characterize the physical and biological environment in the proposed shipping corridor in Hudson Bay and Hudson Strait (Figure B-2). The following information sources were reviewed:

- available records of consultation with regulatory agencies, public stakeholders, and Inuit communities;
- available scientific literature / data reports;
- DFO Integrated Fisheries Management Plans;
- DFO Stock Status Reports;
- DFO's Mapster database;
- DFO's Ocean Data Inventory;

<sup>1</sup> Referenced by it's European (*Trigloporus quadricornis*) name in Appendix 8.2-A of the FEIS - Nunami Stantec Marine Baseline Report for Itivia Harbour, Rankin Inlet, NU



- Environment Canada's Key Marine Habitat for Migratory Birds;
- Fisheries and Oceans Canada's (DFO) Mapster database;
- governmental and non-governmental environmental resources including:
- Important Bird Areas (IBAs) spatial database;
- Marine Baseline Report - Itivia and Melvin Bay, Rankin Inlet, NU produced by Nunami Stantec Ltd. (2012);
- NIRB Guidelines for the Preparation of an Environmental Impact Statement for the Agnico Eagle Mines Ltd. Meliadine Project (NIRB File No. 11MN034) (NIRB 2012);
- Nunavut Planning Commission web resources including the Nunavut Wildlife Resource and Habitat Values final report (2008);
- Nunavut Wildlife Management Board Reports / Guidance Documents;
- OBIS-Seamap database (Duke University);
- previous marine-based environmental impact statements completed in the Project area (e.g., AREVA and others as available);
- regional fisheries catch statistics (e.g., DFO annual catch data);
- federal Species at Risk Act (SARA) database;
- The Canadian Circumpolar Institute and the Tungavik Federation of Nunavut, Nunavut Atlas (1992); and
- Inuit Qaujimajatuqangit (IQ) collected for local coastal areas.

### 1.3.1 Physical Environment

Hudson Bay is one of the world's largest inland seas, with a total surface area of approximately 830,000 square kilometres (km<sup>2</sup>) (Prinsenber 1984). It is connected to the Atlantic Ocean by Hudson Strait and the Labrador Sea; and to the Arctic Ocean by the Foxe Basin, Fury and Hecla Strait. Hudson Bay is a relatively shallow waterbody, with an average depth of approximately 100 m. The oceanographic regime in Hudson Bay is complex and manifests all the features of an Arctic system (Macdonald and Kuzyk 2011). It is highly influenced by the influx of cold saline waters (between approximately 32.5 and 33.5 ppt) from the Arctic Ocean and Baffin Bay, through Foxe Basin and Hudson Strait, by wind-stress during both the open-water and ice-cover season, by powerful tides (Stewart and Barber 2010), and by a large freshwater input from both runoff and ice melt (Stewart and Lockhart 2005; Ingram and Prinsenber 1998). Less saline surface outflows occur along the eastern shores of James Bay and Hudson Bay north to Hudson Strait. In Hudson Bay, estimates of average residence time of water range from 1.0 to 6.6 years (Ingram and Prinsenber 1998).

Water in the region freezes over each winter and becomes ice-free each summer, with sea-ice first forming in late October and continuing to expand until a maximum ice cover is reached by the end of April. In winter and early spring, the ice floes that cover most of Hudson Bay are kept in constant motion by wind forces. A shore lead system develops along the land-fast ice that forms from the coast of Hudson Bay as a result of wind blowing



seaward (Barber and Massom 2007). Major polynyas (stretches of open-water surrounded by sea ice) are found in the northwest sector (including Foxe Basin) and in the vicinity of the Belcher Islands in Eastern Hudson Bay. The northwestern region of Hudson Bay, encompassing part of the Project LSA and RSA, is an area where there is a large and persistent reoccurring polynya (Saucier et al. 2004).

Waters in the Hudson Bay region are characterized by moderate to strong semidiurnal tides of Atlantic origin, a marked summer pycnocline, and greater mixing inshore than offshore (Stewart and Lockhart 2005; Ingram and Prinsenberg 1998). Although marine productivity in Hudson Bay proper is low in comparison with other oceans of similar latitudes, productivity in Hudson Strait is typically twice higher than in other oceans of similar latitudes because of the sustained nutrient availability supplied by tidal mixing throughout an extended ice-free season (Ferland et al. 2011; Sibert et al. 2011).

The southern James Bay region is shallower and influenced to a much greater extent by freshwater runoff, thus supporting a wider variety of temperate-water species that are rare or absent elsewhere in Canada's Eastern Arctic waters (Stewart and Lockhart 2004). Seasonal ice cover also occurs in James Bay, with ice beginning to recede in late May, and the area becoming ice-free by the end of July. Polynyas are found predominantly along both coasts of James Bay during winter.

The Hudson Bay marine ecosystem is abnormally cold relative to other regions of the same latitude, and its climate is characterized by long and cold winters and cool summers (Stewart and Lockhart 2004). The entire area exhibits extreme temporal (seasonal and annual) and spatial variations in the range of average temperatures and average precipitation. Northwestern Hudson Bay experiences the greatest influence of cold Arctic air masses and has the harshest climate, with typical strong winds and persistent low temperatures. Other areas of the bay have less extreme conditions affected by moderate southern or marine influences. There is also a strong average precipitation gradient across the region, from less than 200 millimetres (mm) per year in the northwest to over 800 mm per year in the southeast (Stewart and Lockhart 2004). The upper air circulation of weather systems over Hudson Bay water is mainly related to the persistent, counter-clockwise air flow around a low pressure vortex that is situated over Baffin Island in winter, but weakens and retreats northward in summer (Stewart and Barber 2010).

There is considerable seasonal variation in Hudson Bay with respect to water circulation. In summer, surface water in Hudson Bay moves cyclonically (counter clockwise), influenced by cold saline Arctic water from Foxe Basin that enters in the northwest via Roes Welcome Sound (Prinsenberg 1986a; Tan and Strain 1996). During the transit, surface water is diluted by meltwater and runoff from the land, warmed by the sun, and mixed by the wind as it circulates, thus generating strong vertical stratification of the water column. Most of the river runoff water remains in the nearshore coastal regime in summer, with limited exchange into the interior of the Bay (Granskog et al. 2011). These water masses move eastward along the southern coast and are subsequently deflected northward and exit to the northeast into Hudson Strait (Figure B-2). About half of the freshwater transport from Hudson Bay to Labrador Sea is the result of water pulses associated with anticyclonic, surface-trapped eddies that propagate through Hudson Strait as a result of storms and/or local instability processes (Sutherland et al. 2011). Deep water in Hudson Bay moves in the same general direction as surface water, although it is influenced by bottom topography (Ingram and Prinsenberg 1998; Wang et al. 1994). Intermittent flow of this dense water (approximately 34.1 ppt) over the sill that separates Foxe Channel from Hudson Bay likely maintains the homogeneous bottom layer in Hudson Bay (Stewart and Barber 2010). The incursion of



Arctic waters creates Arctic oceanographic conditions in Hudson Bay, which extend farther south than elsewhere in North America and serve as the main driver of the Hudson Bay ecosystem (Stewart and Lockhart 2004).

The residual currents in Hudson Bay that are independent of tides are wind-driven and density-driven. Monthly mean current velocities are in the range of 4 to 6 centimetres per second, with stronger currents occurring in summer than in winter and more variability occurring at the surface than at depth (Prinsenber 1986b). Winds are generally weaker and more variable in summer than in fall when strong northwesterly winds occur. The density-driven component is stronger in early summer when surface freshwater input from runoff and ice melt is highest (Prinsenber 1982), and weakest in late winter/early spring when surface runoff input is lowest, local salinity is offset by salt excreted by the growing sea-ice, and wind-driven mixing of surface waters is not possible due to ice cover.

The tidal regime in Hudson Bay is influenced by powerful tides from the Atlantic Ocean that surge twice a day via Hudson Strait (Stewart and Barber 2010). These tides move as a Kelvin wave and propagate counter clockwise around Hudson and James Bay following the shoreline contour and overshadowing local tides and the Arctic tidal influence (Freeman and Murty 1976). In general, both tidal amplitude and range decreases as one moves counter-clockwise along the coast. The semidiurnal tidal amplitude ranges from 1.50 m along the western shore at Churchill to 0.10 m along the eastern shore near Inukjuak (Prinsenber and Freeman 1986; Prinsenber 1988a). The range in height between high and low water also varies, ranging from 0.5 m at Inukjuak (Inoucdjouac) and 2 m along the east side of James Bay to as high as 4.6 m along the west coast of Hudson Bay (Dohler 1968).

Hudson Bay is nearly entirely covered by ice in winter and is free of ice in summer. Depending on the weather, timing of sea ice formation or breakup may occur earlier or later by up to a month, but the general patterns remain similar. The ice formation in Hudson Bay usually begins in the north-western part (Repulse Bay) in October and spreads rapidly southward along the western coast during November (Cohen et al. 1994). By mid-December, from 90 to 100% of Hudson and James bays are covered with ice. Maximum ice cover usually occurs in April and May, and maximum ice thickness can occur between late February and early June and can reach 285 centimetres (cm) (Loucks and Smith 1989). The ice breakup begins in June in southern James Bay and Chesterfield Inlet and the region is usually entirely ice free in the first week of August (Stewart and Lockhart 2004; Cohen et al. 1994). Ice cover is an important feature of the Hudson Bay marine ecosystem. Ice distribution determines the distribution of marine biota and affects marine ecological processes in the water column and near the ice edge (Melnikov 1980). During ice formation, most of the seawater salt is expelled from the ice. This increases the salinity of the surface water, thereby increasing its density and deepening its layer (up to 100 m) and enhancing mixing of the water column (Prinsenber 1988b). Formation of dense deep water is facilitated in the shore lead polynya system within which increased brine rejection is able to overcome buoyancy in the surface layer. This provides a mechanism to shunt approximately 6 to 16% of river runoff inputs into deeper waters that have an apparent residence time of about 4 to 14 years (Granskog et al. 2011).

As the pack-ice forms in northwestern Hudson Bay, predominant northwest winds continuously push it to southeastern Hudson Bay. The pack-ice forms rafts and ridges and increases in overall ice thickness, which increases freshwater input in this area in the spring (Prinsenber 1988b). In northwest Hudson Bay, in contrast, the ice is constantly formed and removed continuing the salt input into the water column. This constant removal of the ice by northwest winds and tidal mixing develops leads and recurring polynyas. There are several polynyas that form close to shore, such as in Roes Welcome Sound, at the northern tip of Coats Island, and at



Akimiski Island, which is one of the most southerly polynyas in Canadian waters. These polynyas provide important habitat for various species of marine birds, such as the Hudson Bay eider, which overwinters in this region (Martini and Protz 1981; Nakashima 1988).

The Hudson Bay marine ecosystem is characterized by strong vertical stratification of the water column in spring and summer, particularly offshore (Roff and Legendre 1986; Anderson and Roff 1980; Prinsenberg 1986a). The vertical stratification is caused by a dilution of cold Arctic saline surface water by freshwater runoff and sea-ice melt, which is subsequently warmed by the sun, and mixed by the wind. The stratification results in a strong vertical density gradient between fresh, warm water at the surface and cold, saline deeper water. The vertical density gradient impedes vertical mixing, thereby limiting nutrient input to surface waters and lowering biological productivity. A strong summer pycnocline can be observed at depths between 15 and 25 m (Anderson and Roff 1980; Prinsenberg 1986a; Ferland et al. 2011). Heating of the surface layer and freshwater input decrease as summer progresses. This increases the depth of the pycnocline. In winter, the vertical stratification is the weakest due to the increase in density of surface water and, therefore, there is an increase in vertical mixing.

Physical conditions that promote large-scale mixing or upwelling in the region during spring and summer remain limited, but ice edges along the well-developed shore lead system (where the coastal fast ice and mobile pack ice meet) correspond with areas of upwelling and associated stimulation of nutrient fluxes and primary production (Stewart and Barber 2010). In the area where the shore lead prevails (nearshore), the isotopic composition of phytoplankton during summer suggests the presence of an open system influenced by the upwelling of deep waters and related nutrient replenishment (Kuzyk et al. 2010). Another key process that supports the re-injection of nutrients in surface waters in Hudson Bay is the vertical mixing driven by tidal currents (Sibert et al. 2011). Tides in the region are known to enhance marine productivity (Stewart and Barber 2010) and to contribute to the development of local biological hotspots that are used by marine mammals as summer habitats, such as in the northwest region of the Bay (Higdon and Ferguson 2010).

At a deep-water station in southeastern Hudson Bay, surface salinity ranged from 24 ppt in August to 28 ppt in April, and surface temperature ranged from -1.5°C in April to 8°C in August (Figure B-5). At depths below 50 m, water temperature and salinity were relatively stable throughout the year. As water depth increased, water temperature progressively decreased as salinity increased, with mean water temperature below -1.4°C and salinity greater than 33 ppt at approximately 100 m water depth (Ingram and Prinsenberg 1998).

Freshwater runoff, wind-driven mixing, and tidal influence have great effects on water column characteristics in the Hudson Bay ecosystem. Vertical stratification near large river plumes varies seasonally and spatially. It is usually directly related to the runoff volume and inversely related to the tidal kinetic energy (Freeman et al. 1982). The water column stratification is stronger during freshet and weaker with distance from the river mouth. The salinity and temperature gradients are usually weaker when wind-driven mixing and tidal energy are strongest. The volume of the freshwater runoff in the region is high, with a mean discharge rate of 30 900 cubic metres per second for all rivers combined (The Canadian Encyclopaedia). These high runoff volumes determine oceanographic conditions in the area by creating very low surface salinities and strong vertical density gradients.



## REVISED MARINE ENVIRONMENTAL BASELINE REPORT

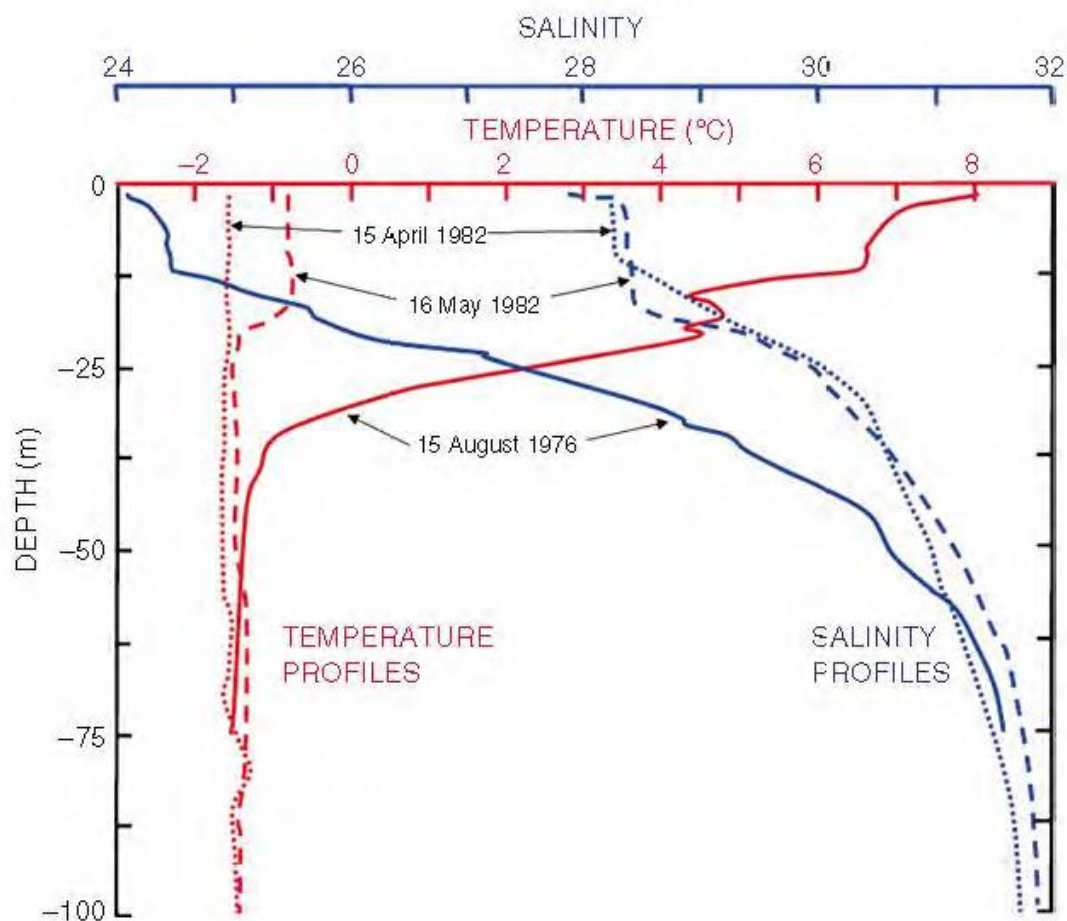


Figure B-5: Representative Vertical Profiles of Temperature and Salinity in Southeastern Hudson Bay in April (dashed line), May (dashed-dotted line), and August (solid line) (extracted from Stewart and Barber 2010; Redrawn from Ingram and Prinsenberg 1998)

High freshwater runoff volumes are also partly responsible for the difference between inshore and offshore oceanographic conditions in Hudson Bay during summer. In general, salinity and temperature in Hudson Bay increases with distance from shore (during summer). For example, surface salinity in Hudson Bay ranged from 10 ppt near major rivers to 30 ppt in offshore locations of the bay, and surface temperature ranged from 4°C in nearshore areas to 11°C in offshore locations (Anderson and Roff 1980; Prinsenberg 1986a). Lower salinities in the inshore region are due to dilution effects, whereas lower nearshore temperatures in western Hudson Bay are due to strong northwesterly wind effects causing upwelling of colder deep water to the surface (Figure B-6). In southern Hudson Bay, lower temperatures are a result of pack-ice, which lingers along the shore well into summer. Higher temperatures offshore cause stronger vertical stratification. During periods with low water temperatures (−1.75°C to 1.25°C), considerably higher rates in both bedload and suspended sediment transport are observed along the shore in comparison with a summer situation (9°C to 17°C), with similar wave heights and current velocities (Héquette and Tremblay 2009). The winter increase in suspended sediment transport is likely due to lower sediment settling velocities resulting from significant increases in fluid kinematic viscosity at low temperature. Hudson Strait is a wide, deep-water channel (on average 150 km wide, 750 km long, and



400 m deep) that connects Hudson Bay and Foxe Basin with the Labrador Sea and Davis Strait (Harvey et al. 2001). It acts as a transition zone between brackish waters in Hudson Bay and more oceanic waters of the Labrador Sea. Hudson Strait is covered with ice from mid-December to July (Hudon et al. 1993). The oceanographic regime in Hudson Strait is affected by strong tidal currents (up to 2 to 3 m/s) and high tidal elevations (tidal amplitudes are 6 to 9.5 m). These tides cause intensive vertical mixing in the water column, disrupting vertical density stratification and, therefore, enhancing biological productivity by increasing nutrient availability in the surface layer (Drinkwater and Jones 1987; Drinkwater 1986, 1990; Harvey et al. 2001).

The physical processes in Hudson Bay and Hudson Strait have a strong influence on the oceanographic and biological processes over the Labrador Shelf, affecting the water temperature and salinity characteristics in the area (Drinkwater and Harding 2001). At the eastern entrance of Hudson Strait, low salinity waters from Hudson Bay and Foxe Basin flowing eastward converge with cold Baffin Land Current waters from the north and warmer deep West Greenland Current waters. The Hudson Strait strong tidal currents result in intensive vertical mixing of these waters and the residual current carries the resulting mixture eastward onto the Labrador Shelf (Drinkwater and Jones 1987). This results in increased mixing over the Labrador Shelf, with reduced vertical density stratification relative to the Baffin Island Shelf to the north (Lazier 1982). Primary productivity is subsequently enhanced by elevated surface nutrient concentrations in eastern Hudson Strait (Drinkwater and Jones 1987) and on the northern Labrador Shelf (Kollmeyer et al. 1967).

Since 2005, recurrent expeditions of the CCGS Amundsen in Hudson Bay (Arcticnet 2014) have supported the collection of ambient noise and acoustic backscattering data. The primary dataset is composed of records obtained with a SIMRAD EK60 3-frequency split-beam echosounder that was operated continuously during the field campaigns (Polar Data Catalogue 2014). In parallel, AURAL-M2 (Autonomous Underwater Recorder for Acoustic Listening-Model 2) passive hydrophones were attached on mooring arrays deployed nearby Churchill and Great Whale River to document the seasonality of underwater sound, including marine mammal vocalizations and ambient noise (Polar Data Catalogue 2014).