PORT RISK MANAGEMENT STRATEGY

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Introduction

As part of the process of developing a Canadian policy on places of refuge for ships in need of assistance, the authors designed and tested a unique risk assessment procedure for port risk management, using a standard risk screening matrix.

A survey of port and ship management personnel in eastern Canada in 2009 identified the critical activities and hazards related to bringing a stricken ship into a Canadian place of refuge. The risk assessment procedure was developed to address these critical activities and hazards, assign risk categories and propose mitigating measures to reduce their risks. The application of this procedure led to the classification of Canadian ports into four risk categories. Finally, the risk assessment procedure was applied to a realistic commercial scenario to determine the comparative suitability of two potential places of refuge - Bayside, New Brunswick and Eastport, Maine – in the Head Harbour Passage between Canada and the United States.

This risk assessment methodology is suitable for all Canadian ports and can be used as a port risk assessment tool worldwide. It is flexible and has applicability in any maritime region. It can be adapted for computer modeling to provide port risk classification, risk mitigation measures and estimates of the resources needed to upgrade the refuge suitability of ports.

Time Element of Successful Response

The most important consideration in the decision to grant or refuse refuge to a ship in need of assistance is the issue of risk. The assessment of risk is not limited merely to the success or failure of measures implemented to support the ship, her crew or cargo. When there is a request for refuge, the consideration receiving the highest priority should be what happens if the endangered ship is beyond assistance and develops into a total loss while at the place of refuge

and in the vicinity of the coastline. Should this situation occur, the local community and the environment around the site of the stricken vessel would be severely affected with adverse consequences – economic, social, environmental and political. A risk assessment procedure is a tool to determine the potential impact caused to the area around the proposed refuge site by the presence of the damaged ship and the mitigating measures needed to reduce risks to an acceptable level.

Granting refuge in cases of potential distress or serious danger was customary law over centuries of maritime trade. Providing refuge to a ship in distress or danger is not merely a humanitarian gesture to save the lives of the crewmembers. It also mitigates developing accidents. The European examples of the sinking of the *Erika* (off the French coast in 1999) and the *Prestige* (off the Spanish coast in 2002) vividly demonstrate the consequences to the environment and coastal communities when refuge is not granted.

The issue of prime concern in the assessment of risk is balancing the perceived and objective risks to the environment and community in the refuge decision-making process. For an acceptable solution in a democratic society, it is vital to involve all relevant parties and stakeholders in the process, in a meaningful and effective manner.

To fulfill these crucial objectives, the best solution is obviously to agree on a transparent, thorough and structured risk assessment before accidents occur. If such a methodology can be designed and applied in particular cases, the risks are generally accepted in an objective and dispassionate manner. Such acceptance is imperative due to the timing of successful refuge responses. The quicker the response, the higher the chance of success and the less expenditure of effort and resources.

Port Risk Management

Risk Management is based on the formula: Risk = Likelihood x Consequence. This means risk can be managed by reducing the likelihood or the consequences of harmful events occurring. Risk Management requires an assessment of:

- the risks
- who or what is at risk
- what safeguards are already in place to mitigate the risks and
- what else needs to be done to reduce or mitigate the risks to acceptable levels,

followed by monitoring and evaluating.

The purpose of a risk assessment is to ensure that every effort is made to protect people, resources, the environment, commercial and private interests and all assets from harm or damage by preventing accidents or unforeseen occurrences or reducing the risk of them happening and establishing management systems to control risks or to manage the consequences, with the least possible detrimental effects. To be useful and easy to implement, risk assessments should be simple and straightforward and should cover the breadth of the activity. The risk assessment should be prepared and made available to all participants involved in the decision-making and management process of a place of refuge scenario.

It is universally agreed that decisions generally involve an uncertain degree of risk. Risk can be expressed as the likelihood of an adverse consequence occurring. Minimizing the likelihood of the occurrence of the loss, injury or adverse consequence by mitigating measures is the objective of risk management. As the nature of the decisions made in a request for refuge is usually spontaneous, a qualitative risk assessment procedure is the most appropriate tool for evaluating a request. Under conditions of uncertainty, expert judgment is a key-reasoning source. Having a qualitative risk assessment procedure removes the inherent subjectivity of arbitrary judgment by having a readily accessible database of ‘Critical Activities’ and ‘Hazards’, against which the ‘Consequence of Hazard Occurrence’ and ‘Likelihood of Occurrence’ can be estimated, based on the characteristics of the place of refuge under consideration and its facilities and resources. Such an analysis leads one to deduce an ‘Initial Risk Factor’. The application of ‘Risk Mitigation Measures’ in the risk assessment procedure provides a ‘Residual Risk Factor’, which the decision-maker can use as a yardstick to gauge the suitability of a proposed place of refuge.

This risk assessment procedure assumes that potential risks can be identified for any possible problem or operation. Then identified risks are evaluated against risk acceptance criteria. If the risk acceptance criteria do not permit the assessed risk, risk control measures are applied so that the risk can be limited to an acceptable level. This acceptable level of risk is generally referred to as the 'As Low As Reasonably Practicable' (ALARP) principle. This principle recognizes that risk cannot be completely eliminated, as this is often not feasible or financially viable. Neither is it necessary to completely eliminate risk as people generally accept risk as an inherent part of their daily existence. However, it is also important to note that risks should be kept to the lowest achievable level.

There are significant variations among the Canadian coasts with respect to the type of marine traffic that would precipitate the need for places of refuge. The prevailing volumes and types of traffic and future trends indicate that the East Coast of Canada is most at risk. Despite the east coast being most at risk, every port on the East Coast of Canada should not be a designated place of refuge. The resources available at a port, its physical features and its environs as well as the distance from the ship in need of assistance would determine the suitability of a port as a place of refuge. Risk analysis takes into consideration such factors as:

- Proximity to major shipping lanes
- Spill response equipment available
- Ship repair facilities available
- Tug assistance available
- Fire-fighting services and equipment available
- Cargo unloading equipment available
- Depth of water in the harbour and its physical characteristics
- Proximity to major population centres
- Ecological sensitivity of the coastal environment
- Economic activity along the coast
- Compensation for damage caused
- Safety and security considerations
- Agreements with neighbouring states
- Marine Protected Areas (MPAs)
- Socio-economic impact

When performing a risk assessment each risk factor need not be considered. The critical ones are based on the type of marine casualty and features of the place of refuge. The analysis of critical risk factors would then be carried out and mitigating measures implemented to reduce the risks to an ALARP level. If the final residual risks are too high for acceptance, the vessel must be refused refuge at that site and must proceed to another refuge site where the residual risks can be reduced by implementing risk-mitigating measures.

Risk Screening Matrix

The 'Risk Screening Matrix' shown in table 1 is an operational tool that standardizes the qualitative risk assessment process and facilitates the categorization of risks from threats to health, safety, the environment and reputation. The objective of using the risk screening matrix is to apply an accepted standard of risk classification to determine the level of risk and to use mitigating measures to lower the risk to an acceptable level wherever possible.

Table 1: The Risk Screening Matrix

		Frequency/Probability/Likelihood of Occurrence			
	Likelihood / Consequence	***A*** ***Frequent***	***B*** ***Probable***	***C*** ***Possible***	***D*** ***Unlikely***
Consequence/Impact of Hazard	***1) Severe***	**Very High Risk**	**Very High Risk**	**High Risk**	**Medium Risk**
	2) Serious	**Very High Risk**	**High Risk**	**Medium Risk**	**Medium Risk**
	3) Moderate	**High Risk**	**Medium Risk**	**Medium Risk**	**Low Risk**
	4) Low	**Medium Risk**	**Medium Risk**	**Low Risk**	**Low Risk**

Source: Adapted from: G. Jeffrey Robinette and Janet S. Marshall, "An Integrated Approach To Risk Management and Risk Assessment" *Integrated Risk Assessment – Probability/Consequence Screening Tool*, Dayton, Ohio, October 1999, 116

The result of a port risk assessment is the establishment of an inventory of controls and defenses to reduce the risk of a given operation to acceptable limits. Appropriate controls on places of refuge for ships in need of assistance can be identified in accordance with the following guidelines:

1) If possible, eliminate the hazard altogether by engineering it out. For example, use a safe and environmentally friendly chemical for oil dispersion and absorption, instead of a toxic one.
2) If elimination is not possible, endeavour to reduce the risk. For example, use a high powered tug for towing or assisting the damaged ship, instead of a low powered tug.
3) Assign operations and tasks in connection with the entry of the ship into the place of refuge to designated individuals, officials, companies and groups with the necessary capabilities, expertise, facilities and equipment.
4) Keep abreast of technical improvements and take advantage of technical progress, to improve controls.
5) Give precedence to controls that protect all the stakeholders.
6) If necessary, use a combination of technical and procedural controls.
7) Ensure emergency arrangements are in place for unexpected eventualities.
8) Ensure personal protective equipment is available for and used by those performing dangerous or risky operations, thus mitigating risks.

Port Risk Assessment Procedure

The port risk assessment procedure designed in this research consists of identifying the hazards present, assessing the consequences and likelihood of occurrence, applying risk mitigating measures where necessary and reducing the potential risks to a residual ALARP risk level.

The risk analysis is conducted using the following process.

1) Identify the ‘Critical Activities’ and the associated ‘Hazards’ pertaining to bringing the ship into the potential place of refuge.
2) For each hazard, assess the potential ‘Consequence’ of the hazard in terms of it being: Severe, Serious, Moderate or Low.

3) Then assess the 'Likelihood' of the occurrence of the hazard in terms of it being: Frequent, Probable, Possible or Unlikely, using the most applicable historical information associated with each hazard.
4) The 'Initial Risk Factor' is then determined by cross-referencing under 'Likelihood' and 'Consequence' on the Risk Screening Matrix.
5) Then identify all the 'Risk Mitigating Measures' that can reasonably be employed to offset the threat posed by each hazard.
6) With defenses in place, determine the 'Residual Risk Factor' taking into consideration the features, infrastructure and resources at the port being evaluated.
7) Explore other possible 'Risk Mitigating Measures' that can be applied to further reduce the 'Residual Risk Factor'.
8) The final 'Residual Risk Factor' is the level of risk that is 'As Low As Reasonably Practicable' (ALARP).
9) Classify the risk category of the port based on the highest 'Residual Risk Factor'.

Application of this risk assessment procedure reveals the risk mitigation measures required for a port being considered as a place of refuge. Ports can be classified into four risk categories, on the basis of which their refuge suitability can be ascertained and resources needed to upgrade their refuge capability estimated. The four risk classes are displayed in table 2.

The conclusions of the survey of port and ship management personnel identified an oil tanker as the benchmark vessel to be used in the designing of a Canadian port risk assessment procedure, among the various types of vessels visiting their ports. The survey also highlighted the 'Critical Activities' and associated 'Hazards' pertaining to bringing a stricken oil tanker into a place of refuge in a port. These 'Critical Activities' and associated 'Hazards' are tabulated in table 3.

Table 2: Risk Classification of Ports

Serial No.	Risk Category	Description of Risk
1	**Very High Risk Port**	Trained personnel and adequate equipment are not available at these ports and would have to be obtained from distant ports in the geographic region, to deal with assisting a ship seeking refuge. These ports are unsuitable as places of refuge.
2	**High Risk Port**	Trained personnel and adequate equipment are not available in sufficient quantities and types at these ports and would have to be obtained from nearby ports or from several nearby ports, to deal with assisting a ship seeking refuge. These ports are unsuitable as places of refuge.
3	**Medium Risk Port**	Trained personnel and response equipment are available in these ports but in moderate quantities and types. Additional support and resources would have to be summoned from a nearby port, to deal with assisting a ship seeking refuge. These ports are unsuitable as places of refuge but can be considered if the situation warrants access into these ports. In other words, these ports are suitable as places of refuge only if the risk mitigation measures of the known risks are understood and addressed.
4	**Low Risk Port**	Trained personnel and adequate equipment of all types are easily available and accessible at the port, to deal with assisting a ship seeking refuge. These ports are suitable as places of refuge. These ports are usually the large city ports with high traffic volumes and extensive infrastructure.

Table 3: Critical Activities and Associated Hazards of Bringing a Stricken Oil Tanker into a Place of Refuge in a Port

Serial No.	Critical Activity	Hazard
1	Towing Vessel to Port	a) Tugs not available for towing b) Inadequate depth of water in port
2	Berthing Vessel in Port	Inadequate depth of water at the Berth
3	Cargo Unloading	Pumping Equipment Not Available
4	Damage Repair	No Repair Facilities in the Local Area
5	Fire-Fighting	Inadequate Fire-Fighting Equipment in Port
6	Oil Spill Response	Inadequate Response Equipment and Facilities

Testing of the Port Risk Assessment Procedure

The risk assessment procedure developed in this study was initially tested on two ports – Bayside, New Brunswick and Eastport, Maine. The scenario was developed on the basis of current commercial projects for transporting Liquefied Natural Gas (LNG) on tankers to

marine terminals in Maine. Relevant information on both ports was obtained from port visits and discussions with port managers.

Canada's Head Harbour Passage is between the northern tip of Campobello Island and Deer Island, in southern New Brunswick, as seen in figure 1. The only maritime route to three proposed LNG Terminals in Washington County, Maine, is through Canadian internal waters via Head Harbour Passage and Western Passage.

Quoddy Bay LLC in partnership with the Sipayik Tribal Government in Pleasant Point has proposed a 45 acre LNG Import and Regassification Terminal at Split Rock, near Eastport, Maine. The terminal is to include a pier, two vessel berths and a regassification process platform. It will transport up to 14 million cubic metres of LNG per day into the Maritimes and Northeast Pipeline.

Downeast LNG has proposed a similar sized LNG terminal and storage facility on 80 acres at Mill Cove. It will include a pier, two LNG storage tanks, regassification equipment and a pipeline to transport the gas to the Maritimes and Northeast Pipeline.

Calais LNG has proposed a 300 acre terminal and storage facility south of Calais, Maine, between Red Beach and Devil's Head, and across the St. Croix River from New Brunswick's port of Bayside. The gas will be piped along the pier to two storage tanks and then to consumers in Maine and New England states.

The political and public debate on permitting large foreign ships (LNG tankers) into these waters has been fraught with vested interests and concerns – some justified, others not. The rational determination of a place of refuge for an LNG tanker in need of assistance in Head Harbour Passage, would go a long way to appease public concerns and demonstrate that emergency measures have been established. As seen in the map in figure 1, if an LNG tanker approaching one of these terminals would be in need of assistance, the possible places of refuge in the Passamaquoddy Bay region are:

1) Port of Eastport, Maine, and
2) Port of Bayside, New Brunswick

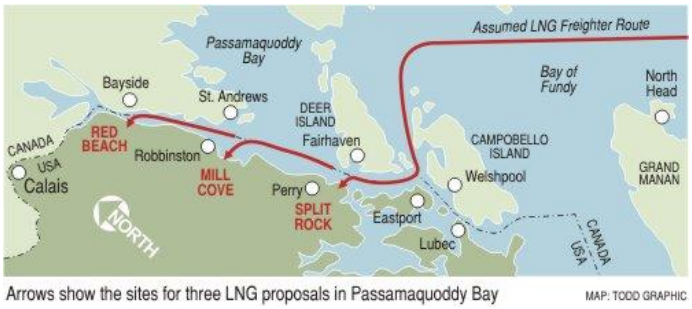

Figure 1: Proposed Nautical Route of the LNG tankers bringing Natural Gas to three Terminals in Passamaquoddy Bay.

Port of Eastport, Maine

The Port of Eastport, Maine is the easternmost port facility in the United Sates. It is a natural port located at the mouth of the Bay of Fundy on the American-Canadian border. It has the deepest water of any port in the contiguous United States and no dredging is necessary. It is one of the fastest growing cargo ports in New England. The anchorage area outside the port has 13 metres of water depth.

At the 275 metre long Estes Head Cargo Terminal pier on the west side of Eastport, there is 19.5 metres of water depth at low tide and adequate space to turn large ships around. There is a second 167 metre long berth on the shore side of the Estes Head Cargo Terminal pier. Approach water depths to this pier are in excess of 30 metres and the mean low water depth is 19.5 metres.

The Eastport Breakwater Terminal can berth vessels up to 213 metres in length. Approach water depths to the Breakwater Terminal are over 30 metres and the mean low water depth is 12.8 metres. An equipment maintenance shop, the Eastport Port Authority office, U.S. Customs and Coast Station Eastport are located just off this pier. The terminal is also used by the aquaculture industry, commercial fishermen, and recreational boaters and fishermen. Petroleum cargoes account for less than 10 percent of port tonnage.

The port has three tugs of 2,400 horsepower, 1,200 horsepower and 260 horsepower respectively. The port's primary commodity handled is the export of northern bleached hardwood kraft pulp (over 320,000 tonnes per annum in recent times). The value of the exports through the port in 2008 was $US 202 million.

The town of Eastport has a population of about 2,000 and its biggest industries are fishing and tourism. Eastport is also the home of the United States Coast Guard's most easterly Division and Border Patrol.

Port of Bayside, New Brunswick

The Port of Bayside, New Brunswick is located on the border between Canada and the United States, on the St. Croix River.

The port has three berths with lengths of 100, 80 and 140 metres respectively and corresponding water depths of 8.1, 6.5 and 9.75 metres. The approach channel has a water depth of 21.3 metres. The anchorage area outside the harbour has a water depth of 9.1 metres. The port has a ship loader for quarried material. The Marine Terminal at Bayside has a two berth facility. It is experiencing a period of growth with the main source of maritime traffic being gypsum and potatoes. Pilotage into the port of Bayside is available but there are no tugs for assisting ships into and out of the port. The port has a fixed crane with a 100 tonne lifting capacity. Petroleum cargoes account for less than 10 percent of the tonnage of the maritime traffic in Bayside. The total tonnage handled by Bayside in 2006/2007 was approximately 1.2 million tonnes.

The village of Bayside is predominantly rural with a population of a little over 500 people. There are about one hundred and sixty-five dwellings of which about eighteen per cent are mobile homes. Residential development is strung out along Route 127 with no identifiable community node.

Risk Assessments for Eastport and Bayside

From the survey conclusions and application of the risk assessment methodology designed in this study, a risk assessment table can be

developed to determine the risk category of the two ports. The risk assessment tables for the two ports are shown in tables 4 and 5.

The 'Residual Risk' of one of the major 'Hazards' of the port of Eastport is: 'iii) Medium', making Eastport a 'Medium Risk Port' as a place of refuge. The 'Residual Risk' of four of the major 'Hazards' of the port of Bayside is: 'iii) Medium', making Bayside also a 'Medium Risk Port' as a place of refuge. On a comparative basis however, Eastport is more suitable as a place of refuge for ships in need of assistance because of its 'Residual Risk Factors' being:
'iv) Low', for all but one major 'Hazard'.

The 'Hazard' of the tugs being of insufficient power to tow a stricken vessel into the port has a final 'Residual Risk' of: 'iii) Medium', as there are no tugs at Bayside. Tugs would have to be brought-in from Saint John, which would mean the loss of valuable time at a critical stage. The 'Hazard' of inadequate water depth at berth shows the 'Residual Risk' as: 'iii) Medium', despite the 'Risk Mitigation Measure' of unloading some of the cargo at an anchorage outside the port, because of the restricted depth of water at the berths in the port, with the deepest berth having a water depth of only 9.75 metres. The 'Hazard' of pumping equipment not being available shows the 'Residual Risk' as: 'iii) Medium', despite the 'Risk Mitigation Measure' of the terminal bringing-in pumps from Saint John, because of the time that would be lost in getting these pumps to Bayside and the consequent possibility of exacerbation of the environmental damage from an accident. It is not possible to reduce any of these: 'iii) Medium' 'Residual Risks' further.

The risk analyses presented in tables 4 and 5 reveal that Eastport is the more suitable place of refuge as the 'Residual Risk Factor' is:
'iv) Low' for 5 of the 6 'Hazards', as shown in table 4, whereas in the case of Bayside the 'Residual Risk Factor' is: 'iv) Low' for only 2 of the 6 'Hazards'.

The Decision Tree Analysis for place of refuge decision-making, between the ports of Eastport, Maine and Bayside, New Brunswick, is shown in figure 2.

Table 4: Risk Assessment for bringing a Striken LNG Tanker with hull damage into the Port of Eastport

CONSEQUENCE: 1) SEVERE, 2) SERIOUS, 3) MODERATE, 4) LOW
LIKELIHOOD: A) FREQUENT, B) PROBABLE, C) POSSIBLE, D) UNLIKELY
RISK FACTOR: i) Very High ii) High iii) Medium iv) Low

Critical Activity	Hazards	Conse-quence	Likeli-hood	Initial Risk Factor	Risk Mitigation Measures	Residual Risk Factor
Towing Vessel to Port	a) Tugs of insufficient power	Serious	Possible	Medium	Charter another tug from Portland.	**Low**
	b) Inadequate Depth of Water en route to Port	Severe	Unlikely	Medium	Use of a Harbour Pilot	**Low**
Berthing Vessel at the Terminal	a) Inadequate Depth of Water at Berth	Severe	Unlikely	Medium	Unload some of the Cargo at Anchorage outside port.	**Low**
	b) Insufficient Berth Mooring Arrangements	Serious	Possible	Medium	Double-Up the Mooring Lines	**Low**
Cargo Unload-ing	Pumping Equipment Not Available	Serious	Possible	Medium	Terminal to use Stand-By Pumps	**Low**
Damage Repair	No Repair Facilities in the Local Area	Severe	Probable	Very High	Arrange for contracting-in from Bangor or Portland	**Medium**

Table 5: Risk Assessment for bringing a Striken LNG Tanker with hull damage into the Port of Bayside

CONSEQUENCE: 1) SEVERE, 2) SERIOUS, 3) MODERATE, 4) LOW
LIKELIHOOD: A) FREQUENT, B) PROBABLE, C) POSSIBLE, D) UNLIKELY
RISK FACTOR: i) Very High ii) High iii) Medium iv) Low

Critical Activity	Hazards	Conse-quence	Likeli-hood	Initial Risk Factor	Risk Mitigation Measures	Residual Risk Factor
Towing Vessel to Port	a) Tugs of insufficient power	Serious	Probable	High	Charter two tugs from Saint John.	**Medium**
	b) Inadequate Depth of Water en route to Port	Severe	Unlikely	Medium	Use of a Harbour Pilot	**Low**
Berthing Vessel at the Terminal	a) Inadequate Depth of Water at Berth	Severe	Probable	Very High	Unload some of the Cargo at Anchorage outside port.	**Medium**
	b) Insufficient Berth Mooring Arrangements	Serious	Possible	Medium	Double-Up the Mooring Lines	**Low**
Cargo Unload-ing	Pumping Equipment Not Available	Serious	Probable	High	Terminal to bring- in pumps from Saint John	**Medium**
Damage Repair	No Repair Facilities in the Local Area	Severe	Probable	Very High	Arrange for contracting-in from Saint John	**Medium**

This test case shows that the risk assessment procedure developed in this study can be applied to other ports for demonstrating the different risk categories existing among Canadian ports and the risk mitigation measures needed.

Conclusions

A survey of port and ship management personnel provided a realistic framework for the designing of a risk assessment methodology to classify ports based on their degree of exposure to risk. This risk assessment procedure extracts the greatest benefit from the existing infrastructure and resources of Canadian ports by classifying them based on their risk categories and by identifying the resources needed for upgrading the refuge suitability of ports. Determining the risk

category of Canadian ports is essential for responding rapidly and effectively to a request for refuge, especially in view of the rising tanker traffic on the east coast.

The ports with the lowest risk (low risk port) would be best suited as places of refuge while ports with the highest risk (very high risk port) would be least suited. The intermediate risk categories (medium risk port and high risk port) would have varying levels of suitability as places of refuge for ships in need of assistance. The testing of the risk assessment procedure developed in this research on the ports of Bayside and Eastport proved its usefulness in systematically identifying a suitable place of refuge for an LNG tanker in the Head Harbour Passage.

This risk assessment procedure can be used in computer models to quickly and accurately deduce the risk category of ports and the risk mitigation measures necessary. Appropriate inputs are: the port's characteristics, infrastructure, resources and equipment. Thus, this unique and flexible risk management methodology provides a pragmatic maritime safety and environmental conservation tool with worldwide applicability.

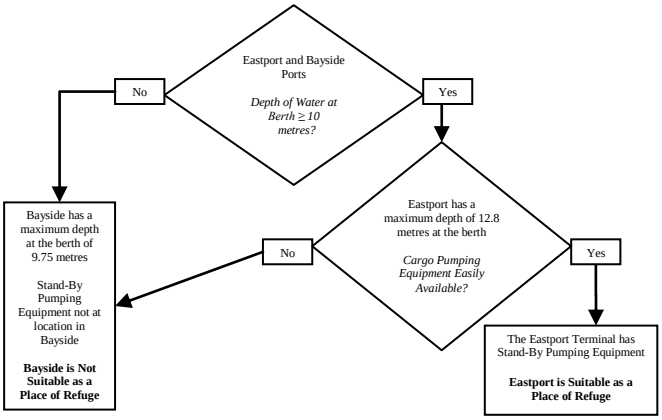

Figure 2: **Decision Tree Analysis for place of refuge decision-making, between the ports of Eastport, Maine and Bayside, New Brunswick.**