Submission to Nunavut Impact Review Board

Mary River Project – Early Revenue Phase

Response to Technical Meetings (November 26-28 2013)

Commitment # 21

December 20, 2013

Risk Assessment for the Introduction of Aquatic Nonindigenous Species through Ballast Water Discharge at Milne Inlet

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Revised November 22, 2013

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1.0 INTRODUCTION

Baffinland Iron Mines Corporation ("Baffinland" or "the Company") proposes to develop an open-pit iron ore mine in northern Baffin Island, Nunavut Territory. The Mary River Project (the Project) will extract iron ore from Deposit No. 1, located in the Qikiqtaaluk Region of Nunavut. Reserves consist of approximately 365 million tonnes (Mt) of direct shipping iron ore at an average grade of 64 % (Mary River Project 2012). In addition to this, Baffinland has proposed an Early Revenue Phase (ERP) whereby 3.5 Mt per annum will be shipped through Milne Inlet during the open water season via an upgraded tote road. It is anticipated that, during ERP operations, shipping will occur annually through Milne Inlet over a period of 90 days between July 15 and October 15. Chartered Supramax (Ice class 1C), Panamax and Post Panamax vessels (55,000, 70,000 and 90,000 DWT respectively) will be retained by Baffinland depending on availability. With a fleet of approximately 18 chartered vessels (estimated to be six (6) Supramax; ten (10) Panamax, two (2) Post Panamax), approximately 53 total trips will occur at a voyage time of 26 days. Over the 90 day shipping period, each chartered vessel will make one to three round trips. All vessels are anticipated to ship the iron ore to a European port such as Rotterdam.

During the review of the Draft Mary River Project Environmental Impact Statement, Fisheries and Oceans Canada (DFO) requested that Baffinland "provide a risk assessment to assess whether accumulating ballast water discharges would significantly increase the potential for species introduction" (DFO 2012a). This report was produced as part of the Mary River Project Addendum to the Final Environmental Impact Statement. The Mary River Project Addendum submission, including this ballast water risk assessment report, went through technical review by agencies, including DFO. This revised document is intended to address these review comments.

The purpose of this document is to present the results of the requested risk assessment of the potential for ballast water discharge in Milne Inlet to result in the unintended introduction of aquatic nonindigenous species to the marine environment. Factors such as the affect of climate change were not considered and are outside the scope of this risk assessment.

A fully quantitative risk assessment is not possible at this stage of design for the Early Revenue Project, nor is it a requirement of the regulatory process (Ballast Water Control and

Management Regulations). It has, however, proven possible to complete a semi-quantitative risk assessment consistent with the methodology employed by DFO (Chan *et al*., 2012) in which the authors considered the potential for introduction of aquatic nonindigenous species to ports in the Canadian Arctic, including Milne Inlet. This exercise was carried out by DFO in their role as expert advisor to Transport Canada with regards to ballast water issues.

The study by Chan *et al*. (2012) covered Canadian waters north of 60° as well as other Northern locations - Ungava Bay, Hudson Bay, and James Bay. All harbour zones and wharfs that received vessel traffic between 2005 and 2008 in the Northern Canada Vessel Traffic Services (NORDREG) Zone were included in the analysis. The top ten ports in terms of international merchant vessel traffic and ballast water discharge were determined to be Churchill MB, Milne Inlet NU, Deception Bay QC, Iqaluit NU, Aupaluk QC, Kangiqsujuaq (George River) QC, Quaqtaq (Koartak) QC, Tasiujaq QC, Wakeham Bay/Kangiqsualujjuaq/Maricourt QC, and Arviat/Eskimo Point NU.

The Mary River Project Early Revenue Phase (ERP) will be subject to Section 6(1) of the Canadian Ballast Water Control and Management Regulations and as per the International Maritime Organization (IMO) Ballast Water Convention Regulation D-1. These regulations require that transoceanic vessels travelling to Canadian ports carry out a mid-ocean exchange of ballast water. Such an exchange must occur 200 nautical miles from shore where water depth is at least 2,000 m. The theory behind mid-ocean exchanges is that open-ocean organisms would have a more difficult time surviving in freshwater and coastal environments (Chan *et al*., 2012). As per DFO Science (2012b), studies have shown that mid-ocean ballast water exchange can physically remove 80-100 % of the organisms present in the ballast water. As well Baffinland is committed to using ballast water treatment systems once the International Convention for the Control and Management of Ships' Ballast Water and Sediment comes into force.

Vessels in transit to Milne Inlet will discharge approximately 20 % of their ballast water prior to docking. This discharge will begin when safe conditions are encountered upon entering Eclipse Sound. It will be evenly distributed over approximately 200 km prior to entering Milne Inlet. Upon arrival at Milne Port, the charter ships will discharge the exchanged ballast water and load ore. As no icebreaking activities will be required, only a partial load of ballast water will be required. Vessels will carry approximately 25 to 30 % ballast water on board. This amounts to

12,000 to 14,000 tonnes for 55,000 DWT vessels, 15,000 to 17,000 tonnes for the 70,000 DWT vessels and 22,000 to 27,000 tonnes for the 90,000 DWT vessels. At the dock vessels will discharge approximately 9,600 to 21,600 tonnes of ballast water.

The discharge rate of vessels is estimated to be 1,000 tonnes per hour at an average discharge volume of 12,500 tonnes. Discharge will occur over a 12 hour period and occur 53 times at Milne Port. This equates to an approximate average total discharge of 662,000 tonnes of ballast water each shipping season.

2.0 METHODS

This document has applied the methods described by Chan *et al*. (2012) in a manner which allows for comparison of the risks to Milne Port in relation to the risk at the three Canadian Arctic ports assessed by these authors with regards to international merchant vessels.

The risk of an invasion from an aquatic nonindigenous species was estimated using a three-step process (Figure 1).

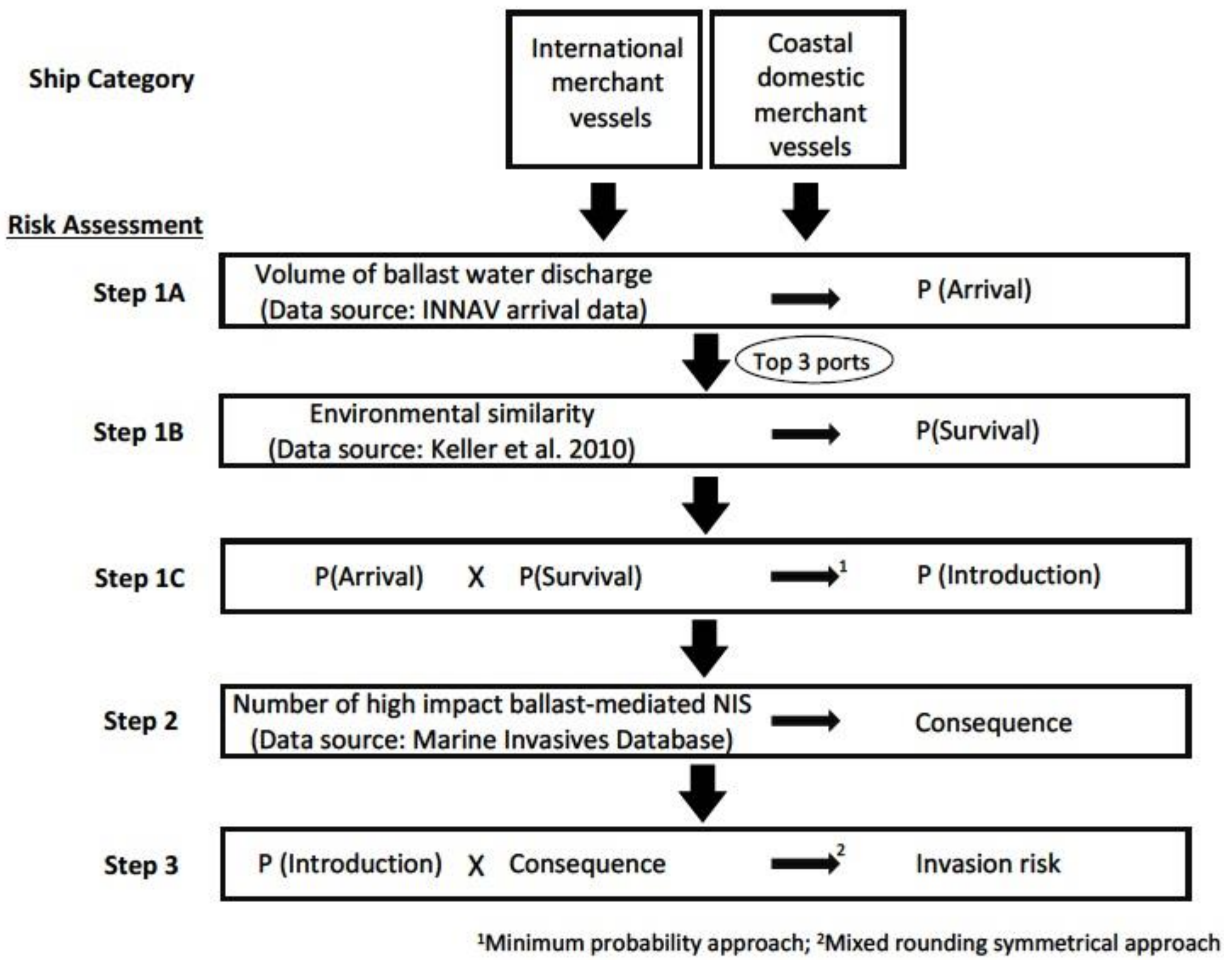

Figure 1 Flow Chart Illustrating Steps for Risk Assessment (taken from Chan *et al*., 2012)

Step 1 - Probability

Two aspects related to probability were examined – Probability of Arrival and Probability of Survival. In total, these two factors combine to create a Probability of Introduction.

The Probability of Arrival is based on the corrected ballast water volume that will be discharged. A correction factor was applied to the total annual volume of ballast water to be discharged due to the fact that the ERP will apply mandatory management activities (mid-ocean exchange). This correction factor is employed in order to determine the discharged volume of water that may contain founding individuals of aquatic nonindigenous species, also known as propagules, after a mid-ocean exchange. This correction factor is based on exchange efficiency rates as determined by total zooplankton abundance which was determined to be 90 % for saline water (Ruiz and Smith, 2005). Based on this efficiency rate, a correction factor of 0.1 was applied by Chan *et al*. where mid-ocean exchange could be assumed.

The Probability of Survival is based on the concept of "environmental distance", a calculation developed from four parameters:

1. Average Annual Salinity
2. Average Annual Water Temperature
3. Average Water Temperature of Warmest Month
4. Average Water Temperature of Coldest Month

These parameters were standardized using a z-transformation (standard score formula) in order to ensure that each parameter had equal weight. The formula for the environmental distance calculation is based on Euclidean distance in four dimensional space. The formula is as follows:

$$\sqrt{((1_{\text{European Port}} - 1_{\text{Milne}})^2 + (2_{\text{European Port}} - 2_{\text{Milne}})^2 + (3_{\text{European Port}} - 3_{\text{Milne}})^2 + (4_{\text{European Port}} - 4_{\text{Milne}})^2)}$$

The greater the environmental similarity between the two locations, the smaller the environmental distance that exists, and hence the greater the probability of propagule survival. The combination of the Probability of Arrival and the Probability of Survival yields the overall Probability of Introduction. This value was estimated based on the minimum probability method, i.e., retain the value with the lower rating. This method has been employed in various other risk assessments (e.g., Canadian Food Inspection Agency Weed Risk Assessment Guidelines, Aquatic Nuisance Species Task Force and Commission for Environmental Cooperation Risk Assessment Guidelines).

Step 2 - Consequences

The severity of consequences was established by considering the number of high impact aquatic nonindigenous species that may be introduced into the receiving port through connected source ports. A cumulative method for calculating the number if NIS from the ecoregion of each source port is used. The methodology in Chan *et al.* (2012) for estimating the magnitude of consequences is cumulative due to the fact that each connected port has the potential to be a donor of all nonindigenous species currently existing within that ecoregion, which, can therefore result in a cumulative tally of a single NIS species if it found over various connected ports. It does not state that that multiple transits from a single source port results in a cumulative effect.

The number of harmful nonindigenous species that could potentially be introduced from connected ecoregions is available from two sources - the Marine Invasive Database of the Nature Conservancy (Molnar *et al.*, 2008) and a database available online at www.conserveonline.org/workspaces/global.invasive.assessment. Given the destination of ERP ore carriers the listings for the North Sea ecoregion were used in the calculation.

Step 3 - Risk

The Risk associated with the subject port was determined by combining Probability and Consequences. Probability of Introduction and Consequences as determined by the approach described above, were combined in a symmetrical mixed-rounding matrix as shown in Table 1 (from Chan *et al*., 2012). Three levels (lower, intermediate and higher) of risk ranking are assigned as a conclusion to the assessment.

Table 1 **Matrix used to combine Probability of Introduction and Magnitude of Consequences into Final Risk Rankings[1] (taken from Chan *et al*., 2012)**

		P (Introduction)				
		Lowest	Lower	Intermediate	Higher	Highest
Consequence	Highest	Yellow	Yellow	Red	Red	Red
	Higher	Yellow	Yellow	Yellow	Red	Red
	Intermediate	Green	Yellow	Yellow	Yellow	Red
	Lower	Green	Green	Yellow	Yellow	Yellow
	Lowest	Green	Green	Green	Yellow	Yellow

1 Green = lower risk, Yellow = intermediate risk and Red = higher risk

As this study is semi-quantitative, there exists a certain level of uncertainty to this study. While the uncertainty does not directly apply to the methods, it is important to ensure that uncertainty is characterized in a standardized way, and as such, levels of uncertainty were assigned based on the quality of data available for analysis. These levels range from very high to very low. Table 2 below provides a description of the levels of uncertainty.

Table 2 **Description of Uncertainty Levels (taken from Chan *et al*., 2012)**

Levels of Uncertainty	Description
Very High	Little or scientific information; no supporting data
High	Limited scientific information; circumstantial evidence
Moderate	Moderate levels of scientific information; first hand, unsystematic observations
Low	Substantial scientific information; expert opinion
Very Low	Extensive scientific/systematic information; peer-reviewed data sources/information

3.0 RESULTS

3.1 Probability

As noted, the estimation of probability combines two considerations – Probability of Arrival and Probability of Survival. The indicator of Probability of Arrival is the total volume of ballast water. The Probability of Survival is based on an indicator that reflects the environmental similarity of the “donor” and “recipient” environments.

3.1.1 Arrival Probability

Upon arrival at Milne Port, the charter ships will discharge the exchanged ballast water to allow for the loading of ore and this will occur approximately 53 times per year. At the dock vessels will discharge approximately 9,600 to 21,600 tonnes of ballast water, with the average ballast water load for the chartered vessels being approximately 12,500 tonnes. An average volume quantity was selected for this report based on an estimated fleet and estimated number of voyages during the shipping season. Due to these parameters not being finalized the average volume was selected as a conservative value for ballast water discharge at the port site during the shipping season. Other vessels such as tugs, fuel tankers, and cargo vessels are not anticipated to discharge ballast water in Milne Inlet and as such are not included in this analysis. An average of approximately 662,000 tonnes of ballast water is anticipated to be discharged into Milne Port during the shipping season each year (Table 3). The ballast water discharged prior to arriving at the port site that may enter Milne Inlet was not included in these calculations as that amount is minimal compared to the estimate volume to be discharged at the site and would not alter the ranking for the probability of arrival.

Chan *et al.* (2012) use a correction factor of 0.1 for marine ballast water in order to estimate the propagule supply. Bailey *et al*. (2011, as cited in Chan *et al*., 2012) noted that mid-ocean exchange of ballast water drastically reduces the potential propagule supply to Canadian ports. As well Chan *et al*. discuss that with mid-ocean exchange occurring in international merchant vessels, these vessels may no longer play a prominent role in the introduction of aquatic nonindigenous species.

Table 3 Annual Ballast Water Discharge at Milne Port

Port	Number of Discharges (per year)	Average Total Ballast Water Discharged per year (m^3)	Corrected Foreign Exchange (X0.1) (m^3)	P(Arrival)
Milne	53	662,000	66,200	Highest

The value calculated for Milne Port lies outside the range of values calculated for the ports considered by Chan *et al*. (2012). Thus, for the purposes of this evaluation, the scale of rankings was modified.

The modified range was applied to top three ports for international merchant vessels - Churchill, Deception Bay and Milne Port. Table 4 shows the results of the revised range, with Milne Port ranked highest.

Table 4 Ranking for Probability of Arrival (modified from Chan *et al.*, 2012)

Mean annual corrected volume of ballast water discharged (m^3)	P(Arrival)	Ranking
0 – 13,240	Lowest	Deception Bay
13,241 – 26,480	Lower	
26,481 – 39,720	Intermediate	Churchill
39,721 – 52,960	Higher	
52,961 – 66,200	Highest	Milne Inlet

Due to the unconfirmed number of vessel that will be deployed for the shipping of ore, the level of uncertainty is ranked high.

3.1.2 Survival Probability

The environmental distance for Milne Port to Rotterdam was supplied by DFO (Sarah Bailey, pers. comm.). The environmental distance value between these two ports is 3.87.

The value calculated for Milne Port occurs within the ranges calculated in Chan *et al*. (2012). Comparing the environmental distance of Milne to Rotterdam to the environmental distance of Churchill to Rotterdam (2.70, from Chan *et al*., 2012) and Deception Bay to Aarhus (2.81, from Chan *et al*., 2012), the Milne to Rotterdam shipping route has a larger environmental distance than both. Within the ranking system the Milne to Rotterdam distance results in an intermediate ranking (see Table 5). While Chan *et al*. did not compare the route of Deception Bay to

Rotterdam, Aarhus (located in Denmark) is a port located within the North Sea and as such is considered to be a viable comparison for the purpose of this study.

Table 5 Ranking System for Probability of Survival

Environmental Distance	P(Survival)	Ranking
0.00 – 1.40	Highest	
1.41 – 2.80	Higher	Churchill
2.81 – 4.20	Intermediate	Deception Bay, Milne Inlet
4.21 – 5.60	Lower	
5.61 – 7.00	Lowest	

In comparison with the other top ranked locations, the probability of survival is ranked Intermediate for Milne Port.

The uncertainty of this determination has been ranked high based on the limited studies have been conducted on nonindigenous species in Arctic ports.

3.1.3 Introduction Probability

While there is a very high probability of nonindigenous species arriving at Milne Inlet, there is low probability of their survival. The drastic differences in the two ports (Port of Rotterdam vs. Milne Port) equates to a potentially lethal environment for nonindigenous species coming from the North Sea ecoregion. While nonindigenous species may arrive at Milne Port, they are unlikely to survive and as such the Probability of Introduction is ranked as Intermediate. Consequently, as shown in Table 6, the Milne Port ranking tied with that of Churchill and above Deception Bay.

Table 6 Ranking System for Probability of Introduction

Port	Probability of Arrival	Probability of Survival	Probability of Introduction
Milne	Highest	Intermediate	Intermediate
Churchill	Intermediate	Higher	Intermediate
Deception Bay	Lowest	Intermediate	Lowest

The level of uncertainty is rated high due to the limited studies have been conducted on nonindigenous species in Arctic ports.

3.2 Consequences

With respect to Milne Port, only a single source port is connected throughout the life of the ERP. This source port is located within the North Sea ecoregion and contains a total of 51 harmful nonindigenous species. It is assumed that all 51 species could potentially be introduced. In comparison with the other ports considered by Chan *et al.* (2012), this value achieves a rank of Lowest (Table 7). This does not take into account high impact species that are native to the North Sea ecoregion, or species that may cause high impacts in Milne Inlet despite having a low or negligible impact on the North Sea ecoregion.

Table 7 Ranking System for Magnitude of Consequence (taken from Chan *et al*., 2012)

Cumulative number of high impact ballast-mediated nonindigenous species	Magnitude of consequence	Ranking
701 - 875	Highest	Churchill
526 - 700	Higher	
351 - 525	Intermediate	
176 - 350	Lower	
0 - 175	Lowest	Milne Inlet, Deception Bay

3.3 Invasion Risk (Combining Probability and Consequences)

For Milne Port the Probability of Introduction was estimated to be intermediate, and the magnitude of Consequences was estimated to be lowest. Consequently, the Invasion Risk for a nonindigenous species to invade Milne Port is rated as "Lower" (Table 8). It is notable that the level of uncertainty of this ranking is high, in large measure because of the limited experience with shipping from Milne Port. Nevertheless, a "Lower Risk" conclusion has been reached by employing accepted risk assessment methods.

Table 8 **Relative Invasion Risk of Top Artic Ports (as determined in Chan *et al*., 2012) and Milne Inlet by Ballast-mediated Nonindigenous Species for International Merchant Vessels Ballast Water Discharges**

Port	P(Arrival)		P(Survival)		P(Introduction)		Magnitude of Consequences		Invasion Risk	
	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty	Ranking	Level of Uncertainty
Milne Inlet, NU	Highest	Moderate	Intermediate	High	Intermediate	High	Lowest	High	Lower	High
Churchill, MB	Intermediate	Moderate	Higher	Moderate	Intermediate	Moderate	Highest	Moderate	Higher	Moderate
Deception Bay, QC	Lowest	Low	Intermediate	Moderate	Lowest	Moderate	Lowest	Moderate	Lower	Moderate

4.0 CONCLUSION

This revised semi-quantitative risk assessment of ballast water concludes that ore shipping operations at Milne Port (as per the Early Revenue Phase proposal) is ranked "Lower" with regards to the potential for an aquatic nonindigenous species invasion. This outcome confirms that the Early Revenue Phase of the Mary River Project is unlikely to significantly increase the potential for species introduction as a consequence of ballast water discharges to Milne Inlet.

5.0 REFERENCES

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