Remedial Option Decision Document

Boat Harbour Remediation Planning and Design

Nova Scotia Lands Inc.

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Executive Summary

Boat Harbour was originally a tidal estuary connected to the Northumberland Strait in Pictou County Nova Scotia. The Province constructed the Boat Harbour Effluent Treatment Facility (BHETF) in 1967 to treat effluent from industrial sources; this reconstruction converted the natural tidal estuary into a closed effluent stabilization lagoon. The Province has committed to ceasing the reception and treatment of new effluent to the BHETF by January 31, 2020, and the subsequent remediation of Boat Harbour (and lands associated with the BHETF) to restore the tidal estuary.

Remediation of the BHETF involves: infrastructure decommissioning, including the pipeline, treatment buildings, causeway and dam; remediation of sediment, surface water, and soil in a fresh water environment; remediation of sediment in a marine environment; closure of the existing on-site disposal cell; management of all wastes generated during remediation; and construction of a bridge in the location of the decommissioned causeway. The purpose of this Remedial Options Decision Document (RODD) is to present the approach and methodology used for the development and evaluation of the remedial options, present the detailed concept descriptions for the options considered, and document the evaluation results and recommended remedial option(s).

The overall goal of the Boat Harbour Remedial Design (BHRD or Project) is to develop a remedial solution that is:

- Founded on proven technologies
- Identified and assessed using a collaborative approach
- Evaluated in an open, transparent, and traceable manner
- Protective of human health and the environment
- Constructible and includes mechanisms to manage Project risks
- Meets established timelines and milestones
- Provides the best value to the Province

The ultimate goal of the RODD process is to facilitate determination of the Qualified Remedial Options and identify assumptions that need to be validated through Pilot Scale Testing in a collaborative approach.

The RODD addressed all major design components required for the Project, including water, sediment, soil, infrastructure decommissioning, new infrastructure requirements, and temporary requirements as an integrated process, categorized as follows:

- Bridge at Highway 348
- Waste Management
- Wetland Management
- Infrastructure Decommissioning
- Remediation Methodology and Approach

Evaluation criteria were initially developed by GHD with input and agreement from NS Lands and technical advisors. The evaluation criteria included both qualitative and quantitative components for the various design requirements identified in Design Requirements Document (DR Document) (GHD September 2017). Establishment of the evaluation and weighting matrix was completed prior to identification of the Feasible Concepts to ensure that the recommended solution was unbiased, traceable, and best aligned with the Project goals. The scoring matrix included five indicator categories (i.e., Regulatory, Technical, Environmental, Social, and Economic) and weighting distributions which were determined collaboratively with NS Lands during the Evaluation Criteria and Weighting Matrix workshop.

Through development of the RODD, GHD has implemented a logical and stepped approach for the identification and assessment of remedial components; the methodology began with the identification of Approaches for each remedial component, which were then broken down to Alternative Means. The identification of Alternative Means for each remedial component was largely based on technical expertise of the team, collaboration with subject matter experts, and research. As necessary, the assessment process was supported by communication with vendors to obtain proof of performance and/or to better understand limitations and challenges associated with specific approaches. Through the application of (binary and comparative) filters, Alternative Means that were not feasible were eliminated. The remaining feasible Alternative Means which were likely to be most suitable for application on the Project were then assembled into Feasible Concepts. The Feasible Concepts were further developed to provide more detailed information (in the form of a detailed concept descriptions), and evaluated using comparative Evaluation Criteria and Weighting Matrix.

A Remedial Options Decision Workshop was held with NS Lands and technical advisors to review and discuss the evaluation of each Feasible Concept. Subsequent to this workshop, formal consultation with Nova Scotia First Nations' Leadership was initiated in April 2018 and Pictou Landing First Nation was consulted on the general status of remediation plans and timeline and, specifically, on this RODD.

The results of the comparative evaluation process yielded the selected Qualified Remedial Options to be put forward as recommended components for the BHRD upon which the BHETF Remediation will be based.

A summary of the qualified remedial options selected for each major design component is presented in the following paragraphs:

Bridge at Highway 348: Feasible Concept 1 – Concrete Girder Bridge | The new bridge structure will be an approximately 34 m long, single-span structure, maximizing the flow beneath the span through elimination of a center pier. A concrete superstructure was selected due to its durability, longevity, and low long-term maintenance costs. The bridge design will incorporate a new support system for the water main, including galvanized steel brackets equally spaced at approximately 1.8 to 2.4 m across the bridge.

Waste Management: Feasible Concept 1 – Use Existing Disposal Cell | Solid waste generated during remediation will be disposed of in the existing 6.7 hectare disposal cell. Vertical expansion of the disposal cell will be required to accommodate the waste. The disposal cell will be further modified to enhance the leachate collection layer and facilitate placement and dewatering of the sludge/sediment in a one step operation. Final landfill cover contours will be designed to accommodate the anticipated range of final waste volumes, minimize precipitation infiltration through the cap, control the release of landfill gas, and accommodate end use.

Wetland Management: Feasible Concept 2 – Ex Situ Remediation | Wetlands will be dewatered through a continuous pumping system. Approximately 260,000 cubic metres (m^3) of impacted sediments and root mass present in Former Settling Ponds 1, 2 and 3 will be removed by excavation using land based earthmoving equipment, and subsequently managed in the same manner as all other sludge/sediment removed from the rest of the Site (see Remediation below). Organic material matching the former hydraulic regime will be brought on Site as part of wetland restoration activities. The restoration phase will include, in addition to the infilling and regrading of wetlands, planting or seeding of native aquatic and terrestrial vegetation in the construction areas.

Infrastructure Decommissioning | Key infrastructure components to be decommissioned as part of BHETF remediation include: a 2,305 m section of 0.915 m diameter fiberglass reinforced plastic pipe (RPP) buried on land; a 1,220 m section of 1.1 m diameter high density polyethylene (HDPE) pipe buried at the bottom of the East River; Treatment Buildings and several small structures that form part of the BHETF; and the dam located north of the Highway 348 causeway.

- **Pipeline on Land and Pipeline Under Water: Feasible Concept 1 - Clean, Inspect, and Abandon |** Cleaning the pipeline to remove any accumulated solid residue and other liquids that otherwise could pose an environmental risk/liability, and render the pipeline free of gross process residues. Abandonment will consist of leaving the cleaned and inspected pipeline in place. The ends of the pipeline will be plugged with an appropriate cap (e.g., concrete plug).
- **Treatment Buildings: Feasible Concept 1 – Decommission and Demolish |** Treatment Building and smaller infrastructure will under go chemical sweep, cleaning, designated substance removal, if any followed by demolition using mechanical means. Footing and foundations will be cut and buried. Only above-grade structures will be removed.
- **Dam: Feasible Concept 1 – Decommissioning and Demolition |** The dam will be demolished using mechanical equipment. The earthen berm connecting the dam to the banks will also be removed.

Remediation Methodology and Approach | Remediation includes addressing Site areas that have been impacted from the operation of the BHETF. At the core of remediation will be dredging impacted sediments/sludge and management and treatment of all associated effluents including Bulk Water (surface water from the active and historical BHETF components), Dewatering Effluent (effluent generated from dewatering sludge/sediment), and Leachate (from on Site sludge disposal cell).

- **Sediment Management: Feasible Concept 1A - Removal in the Wet with Geotube Dewatering |** Removal in the wet will involve dredging sludge under wet conditions, and will be predominantly completed through hydraulic dredging at a rate of 2,000 m^3 of in place sludge per day. Hydraulically dredged sludge slurry will be pumped through discharge lines to geotubes located in the disposal cell and dewatered. It is estimated that between 50 and 130 geotubes will be required to manage sludge from the effluent ditching, twin settling basins, ASB, Boat

Harbour stabilization lagoon, and estuary, however, will vary based on the size of geotube used.

- **Bulk Water Management** and **Dewatering Effluent Management: Feasible Concept 1 – On Site Management Using Low Technology Treatment System |** Bulk water and dewatering effluent will be treated using a precipitation, coagulation, and adsorption based process.
- **Leachate Management - Feasible Concept 2 -Off-Site Disposal |** Leachate will be collected in a storage tank connected to a truck loading station. Leachate will then be transferred to haul trucks for off-site disposal at a municipal wastewater treatment plant or an industrial water treatment facility.

Assumptions carried through the RODD process were developed based on best practices and expertise, as well as laboratory treatability testing and discussion with specific vendors. To reduce Project risk, verification of assumptions with the greatest potential to impact Project success with be verified through pilot scale testing.

Detailed costing for the Qualified Remedial Options along with costing assumptions are provided in the RODD. The Class D cost estimate for Remediation of the BHETF [GHD Memo-020 dated March 28, 208] includes the following Project components:

- Pilot scale testing including comprehensive environmental monitoring and quality assurance as outlined in GHD Memo-017 dated February 23, 2018
- Construction of remedial works including bridge, environmental monitoring, quality assurance, and construction contract administration based on Qualified Remedial Options identified in the RODD
- Engineer of record including site professional and technical assistance

The total Class D cost estimate for pilot scale testing, construction of remedial works, and engineer of record is $270,900,000. Based on the accuracy of this estimate (-30 to + 50%), the actual cost is expected to be between $189,630,000 and $406,350,000. A breakdown of the cost is provided on in Table 1 of GHD Memo-020. All costs are in 2018 Dollars without the consideration of the time value of money. Following discussion with NS Lands, alternative costing was provided for Wetlands component, updated pilot scale testing based on advancement of Pilot Scale Testing design, and eliminated the select vendor technology under Pilot Scale Testing and Full Scale remediation. The revised cost range is $139,440,000 to 298,800,000.

NS Lands has indicated to GHD that this RODD is qualified as follows:

- The RODD provides qualified remedial options based upon a comparative evaluation process which may not be the final decision on a particular remedial option
- The final decision may be taken as a result of direction from executive branch, direction from a condition or approval from regulators, disclosure of new information arising as a result of assessments to come including pilot scale work, any current unknowns or unforeseens which may arise in the future, and outcomes of the environmental assessment process.
- NS Lands has provided direction to GHD that material effort on detailed design of remedial options for Infrastructure Decommissioning - Treatment Building, Wetland Management, and

Waste Management be deferred until such time as specific direction on the remedial option is confirmed.

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1. Introduction

1.1 Purpose

Remediation of the Boat Harbour Effluent Treatment Facility (BHETF) involves: infrastructure decommissioning including the pipeline, buildings, causeway and dam; remediation of a sediment, surface water, and soil in a fresh water environment; remediation of sediment in a marine environment; closure of the existing on-site disposal cell; management of all wastes generated during remediation; and construction of a bridge in the location of the decommissioned causeway. The purpose of this Remedial Options Decision Document (RODD) is to present the approach and methodology used for the development and evaluation of the remedial options, present the detailed concept descriptions for the options considered, and document the evaluation results and recommended remedial option(s).

The overall goal of the Boat Harbour Remedial Design (BHRD or Project) is to develop a remedial solution that is:

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- Identified and assessed using a collaborative approach
- Evaluated in an open, transparent, and traceable manner
- Protective of human health and the environment
- Constructible and includes mechanisms to manage Project risks
- Meets established timelines and milestones
- Provides the best value to the Province

The ultimate goal of the RODD process is to facilitate determination of the Qualified Remedial Options and identify assumptions that need to be validated through Pilot Scale Testing in a collaborative approach.

GHD developed a logical and stepped approach for the identification and assessment of remedial components, which is described further in Section 2.0. The methodology begins with the identification of Approaches for each remedial component, which are then broken down to Alternative Means. The identification of Alternative Means for each remedial component was largely based on technical expertise of the team, collaboration with subject matter experts, and research. As necessary, the assessment process was supported by communication with vendors to obtain proof of performance and/or to better understand limitations and challenges associated with specific approaches. Through the application of (binary and comparative) filters, Alternative Means that are not feasible were eliminated. The remaining feasible Alternative Means which are likely to be most suitable for application on the Project, were assembled into Feasible Concepts. The Feasible Concepts were further developed to provide more detailed information (in the form of detailed concept descriptions), and evaluated using comparative Evaluation Criteria and Weighting Matrix. The results of the evaluation of Feasible Concepts identify the Qualified Remedial Option upon which the BHETF Remediation will be based.

The RODD addresses all major design components required for the Project, including water, sediment, soil, infrastructure decommissioning, new infrastructure requirements, and temporary requirements as an integrated process, categorized as follows:

- Bridge at Highway 348
- Waste Management
- Wetland Management
- Infrastructure Decommissioning
- Remediation Methodology and Approach

It is noted that three additional components were identified in the Design Requirements Document (GHD, September 2017) including: Return to Tidal Conditions, End Use, and Provision of Benefits; however these components do not require a remedial design process, and have therefore been captured in the evaluation of other components.

1.2 Background

Boat Harbour, formerly known as A'se'k in Mi'kmaq, was originally a tidal estuary[1] connected to the Northumberland Strait in Nova Scotia. The Province constructed the Boat Harbour Effluent Treatment Facility (BHETF) in 1967 to treat effluent from industrial sources including a chlor-alkali plant and a bleached pulp Kraft Mill. Its construction included reconstructing the natural tidal estuary into a closed effluent stabilization lagoon. The Kraft Mill owner is currently responsible for operating the facility under a lease agreement with the Province. The Province has committed to ceasing the reception and treatment of new effluent to the BHETF by January 31, 2020 in accordance with the Boat Harbour Act. Once operations have ceased, the Province will remediate Boat Harbour and lands associated with the BHETF and restore Boat Harbour to a tidal estuary. As part of the restoration work, the existing causeway along Highway 348 and the dam will be removed and replaced with a bridge that will permit boat access to Boat Harbour.

The main components of the BHETF include: the wastewater effluent pipeline (over 3 km in length) that runs from the Kraft Mill and extends eastward, below the East River of Pictou (East River), to the BHETF property; twin settling basins and an Aeration Stabilization Basin (ASB) west-southwest of Boat Harbour; and the Boat Harbour stabilization lagoon (BH or Boat Harbour). Effluent from Boat Harbour discharges through a dam (northeast of Boat Harbour) into an estuary before being released to the Northumberland Strait. Prior to the construction of the twin settling basins and ASB, effluent was routed by open ditch from the pipeline on the east side of Highway 348 to a natural wetland area (Former Ponds 1, 2, and 3) before being discharged into the stabilization lagoon.

The Study Area (or Site) for this Project spans from the effluent pipeline, described above, from the first standpipe on the Kraft Mill property, existing and historic BHETF lands, and Boat Harbour and its banks to the dam. The Study area also extends beyond the BHETF to Northumberland Strait and on to adjacent lands including a portion of Pictou Landing First Nation (PLFN) IR 24, 24G and

[1] Partially enclosed coastal body of water, having an open connection with the ocean, where freshwater from inland is mixed with saltwater from the sea

37 Lands. The total Site area is approximately 546 hectares (ha) of which 141 ha is Boat Harbour. A plan showing the Study Area is provided on Figure 1.

1.3 Nature and Extent of Contamination

A Phase 1 Environmental Site Assessment (ESA) (GHD, October 2017) was complete to identify, through non-intrusive investigation, the existence of any significant, actual or potential areas of environmental concern (APEC) for the Site. The Phase 1 ESA was completed in accordance with the Nova Scotia Contaminated Sites Regulations (July 2013) Phase 1 Environmental Site Assessment Protocol and Canadian Standards Association (CSA) Standard Z768-01 – Phase 1 Environmental Site Assessment.

Following completion of the Phase 1 ESA, a Phase 2 ESA[2] was completed to determine the nature and extent of contamination in all media at all APEC identified from the Phase 1 ESA. Analytical results were compared to applicable Federal and Provincial criteria to identify the areas requiring remediation; and to develop a conceptual site model (CSM) for the site. Based on early findings of the Phase 2 ESA, supplemental Phase II ESA activities are required to further delineate impacts; and field investigations are required to verify connectivity between the surface water and overburden and bedrock groundwater aquifers in the vicinity of PLFN well field. The Phased ESA and other field investigations will be used in preparation of the Remedial Action Plan, following completion of this RODD, and will be used to inform the detailed remedial design.

Based on the findings from the Phase 1 and 2 ESAs including historical document review, and discussions with the various regulatory agencies, the remedial solution for BHETF requires the following:

- Management of residual mill effluent within the BHETF
- Risk management and/or removal, treatment, and disposal of impacted sediments/sludge and dewatering effluent from former effluent ditch and natural wetlands, twin settling basins, ASB, Boat Harbour, and the estuary
- Remediation of impacted surface water and potentially groundwater and soil[3]
- Use and closure of the existing sludge disposal cell, or transportation and disposal at an approved off-Site facility
- Decommissioning of BHETF infrastructure including the pipeline, causeway, dam, and support facilities
- Restoration of Highway 348 including construction of a bridge in the location of the existing causeway

1.4 Assumptions

Assumptions carried through the RODD process have been developed based on best practices and expertise, as well as laboratory treatability testing and discussion with specific vendors. To reduce

2 The Phase 2 ESA is planned to be finalized in June 2018

3 To be determined through Supplemental Phase 2 ESA

Project risk, verification of assumptions with the greatest potential to impact Project success will be verified through pilot scale testing.

1.4.1 Laboratory Treatability Study

Laboratory Treatability Testing (i.e., bench scale testing) was completed by GHD and specific vendors in parallel with the RODD development.

The primary objectives of the bench scale testing were to:

- Determine the optimum treatments for removal of sediments in the wet including dewatering and required treatment of dewatering effluent and dewatered sediment
- Determine the optimum treatments for excavation in the dry including treatment of surface water and treatment of excavated sediment
- Determine whether untreated sediment can be can be sent directly to an off-Site disposal facility without treatment

Laboratory Treatability Study results are provided in Appendix A. The results were used to inform the selection of the recommended Qualified Remedial Option, discussed herein.

1.4.2 Pilot Scale Testing

Pilot scale testing is planned to determine/validate/verify the following:

- Performance of selected technologies for sediment removal
- Performance of selected technologies for treatment of sediment
- Performance of selected technologies for treatment of dewatering effluent
- Constructability and suitability of selected methodologies for construction of isolation and separation berms
- Air emissions during sediment removal and treatment (i.e., sediment and water) activities
- Noise emissions during operation of specialized remediation equipment
- Groundwater and surface water inflows into Boat Harbour
- Condition of existing leachate collection system (LCS) in the sludge disposal cell
- Selected vendors offering new/innovative technology solutions

The Pilot Scale Testing will be completed in Cove 1, which was segregated as part of early works completed by NS Lands. Pilot Scale testing is scheduled to run July 2018 to December 2018 with final reporting in early 2019.

1.5 Report Organization

The RODD is organized into the following sections:

- Section 2.0 – Methodology, presents an overview of the methodology for development and identification of Alternative Means, Feasible Concepts, and evaluation process to select the Qualified Remedial Options.
- Sections 3.0 to 7.0 - Identification of Feasible Concepts, Detailed Concept Descriptions for Feasible Concepts carried forward, evaluation of the Feasible Concepts, and identification of the Qualified Remedial Options. The sections are organized as follows:
  - Section 3 - Bridge at Highway 348
  - Section 4 - Waste Management
  - Section 5 - Wetland Management
  - Section 6 - Infrastructure Decommissioning
  - Section 7 - Remediation Methodology and Approach
- Section 8.0 – References, presents a list of documents referred to in this report.

2. Methodology

2.1 Terms and Definitions

The following terms and definitions are provided to identify the specialized terminology used in developing Qualified Remedial Options for the BHRD.

Approach | Overall direction or general concept for implementing the BHRD (e.g., dredging and dewatering of sludge, management in place), described in general terms.

Approaches to be Evaluated | Approaches which pass the first Filter, meaning approaches that conform to the scope of the BHRD and meet Project goals.

Concept | A specific application of an Approach that represents a complete solution including technologies, systems, structures.

Feasible Concepts | Concepts which consist of feasible Alternative Means and Components that have passed the second Filter and are then assembled into single Concept; referring to concepts that are technically and economically sound.

Qualified Remedial Options | Feasible Concepts which have been subjected to a detailed comparative evaluation using the Evaluation Criteria and Weighting Matrix and have been determined to be the most suitable Concept for the BHRD.

Components | Specific engineering methods or systems intended to achieve a specific objective or function. Each Approach to be evaluated consists of one or more Components; each Component is comprised of several Alternative Means.

Design Component | Major design areas or aspects of the remediation for which remedial options have been developed as part of the RODD.

Category | Sub-section of a Design Component with common Approaches, Components, and Alternative Means.

Alternative Means | Different ways or methods in which a particular Component can be implemented.

Filters | Steps in the evaluation process used to reduce the number of approaches or alternatives meriting additional consideration through application of certain criteria. First Filters are applied to Approaches within a specific Design Component, and generally use a "Yes/No" binary test to determine whether an Approach meets a Project goal. Second Filters are applied to Alternative Means to determine whether or not the Alternative Means should be considered as part of a Feasible Concept. The purpose of the second Filter is to eliminate Alternative Means that do not meet Project goals and/or design requirements.

2.2 Process Overview

Using the terms defined previously in Section 2.1, this section presents a high-level overview of the process for developing Qualified Remedial Options for remediation of the BHETF. An overview of the process is shown on Figure 2.1 on the following page.

The methodology for developing remedial options under each Design Component is based on identifying or compiling a list of Approaches, which are described in general terms. Application of a first Filter reduces the number of Approaches to be considered, by selectively ensuring that each Approach conforms to the Project goals. The remaining Approaches are then broken down into specific Components, with one or more Alternative Means identified for implementing each Component. Once general information regarding technical applicability and feasibility of each Alternative Means is compiled, a second Filter is applied to eliminate Alternative Means that are not feasible or appropriate/applicable for implementation in the BHRD. The remaining Alternative Means are re-assembled into Feasible Concepts to be considered as cost effective, viable remedial solutions.

A detailed Concept Description is developed for each Feasible Concept, with supplementary information (i.e., sketches, flow diagrams, preliminary costs) prepared/provided as necessary to facilitate the evaluation process. The Feasible Concepts are then subjected to additional filters and a detailed comparative analysis using the Evaluation Criteria and Weighting Matrix. Using pre-defined scoring and weighting factors, the results of the comparative evaluation are used to determine and select the Qualified Remedial Options. To distinguish between subtle numerical differences in the evaluation process scoring, consideration of Advantages and Disadvantages between Feasible Concepts may be considered to verify the results of the Evaluation Criteria and Weighting Matrix comparison approach, and ultimately identify the Qualified Remedial Option.

Qualified Remedial Options identified through the detailed comparative evaluation process form the basis for each Design Component in the BHRD, namely: Bridge at Highway 348, Waste Management, Wetland Management, Infrastructure Decommissioning, and Remediation Methodology and Approach. These Qualified Remedial Options represent the Feasible Concepts most likely to be successfully implemented as part of the Project, and will be recommended as the preferred options to be carried forward for the BHRD.

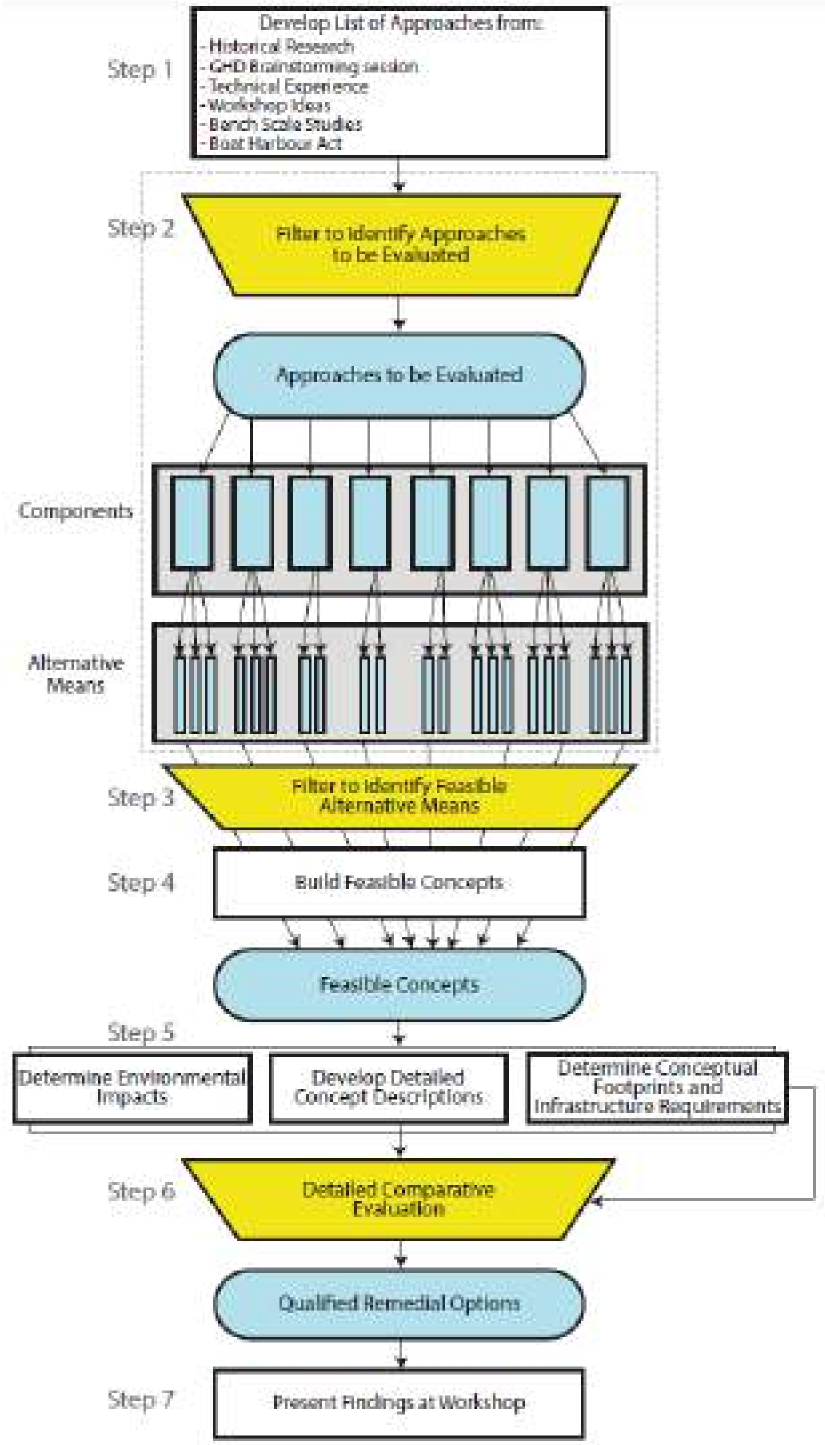

Figure 2.1 Process Overview

2.3 Evaluation Matrix

Evaluation criteria were initially developed by GHD with input and agreement from NS Lands and technical advisors. The evaluation criteria included both qualitative and quantitative components for the various design requirements identified in Design Requirements Document (DR Document) (GHD, September 2017). Establishment of the evaluation and weighting matrix prior to identification of the Feasible Concepts is necessary to ensure that the recommended solution is unbiased, traceable, and best aligns with the Project goals. A copy of the Evaluation Criteria and Weighting Matrix is provided in Appendix B.

Feasible Concepts were pre-screened to confirm that they meet the functional requirements laid out in the DR Document. If the Feasible Concept met all mandatory pre-screening requirements, it was passed and further evaluated using the scoring matrix. In the cases where only one Feasible Concept passed, the scoring matrix was not completed. Feasible Concepts that failed to meet all of the mandatory pre-screening requirements, were not further evaluated.

The scoring matrix includes five indicator categories (i.e., Regulatory, Technical, Environmental, Social, and Economic) which was determined collaboratively during the Evaluation Criteria and Weighting Matrix workshop.

2.4 Alternative Means Process

The identification, evaluation, and selection of suitable Alternative Means is the first step in the remedial options planning development. The process is important technically to ensure that not only are the best possible Alternative Means selected, but also to document and provide transparency in the development of remedial options and allow the opportunity for selected stakeholder input.

The process is presented schematically on Figure 2.1 above, and is outlined in the remainder of this section as Steps 1-7, describing: the methodology for identifying approaches and alternative means; the evaluation procedures; and screening steps and criteria.

2.4.1 Identification of Remedial Approaches

Step 1 – Develop List of Remedial Approaches

The evaluation methodology began with identification of remedial Approaches which were described at a general (i.e., non-detailed) level of information. These remedial Approaches were initially identified at GHD's internal brainstorming sessions. The objectives of the workshop were to identify:

- Approaches for each of the major Design Components
- Mechanisms to filter Approaches
- Components and Alternative Means necessary to implement Approaches
- Pros and Cons associated with each Component/Alternative Means
- Available data or data gaps preventing the further assessment of each Component/Alternative Means

A list of Approaches was developed for each major Design Component (i.e., Bridge at Highway 348, Waste Management, Wetland Management, Infrastructure and Decommissioning, and Remediation Methodology and Approach) based on consultation with subject matter experts in each applicable discipline. The remedial Approaches were compiled from a number of sources, including experience on similar projects, historical research, review of similar projects worldwide, and review of recent technological advancements. The remedial Approaches were evaluated for sludge, sediment, water and dewatering effluent, and infrastructure.

Through a workshop format, the project team was broken down into focus groups, each led by a Discipline Lead, to review the list of Approaches and develop a list of Components and Alternative Means for each Approach. At the outset of each focus group, the design requirements (i.e., the performance, safety, and operational requirements) for each Design Component were reviewed prior to identifying Components and Alternative Means for each Approach. The identification of Components and Alternative Means was largely based on technical expertise of the project team, collaboration with subject matter experts, and research. The focus-groups also identified pros and cons of the various Alternative Means, and developed filters to be applied to both Approaches (i.e., first filters to ensure the Approach complied with Project goals) and Alternative Means (i.e., second filters to eliminate Alternative Means that were not feasible or appropriate/applicable for implementation in the BHRD). Application of Filters was conducted following the workshop, and are discussed in greater detail in Section 2.4.2.1.

In the event that there was insufficient data available to further assess an Alternative Means, follow-up communication with vendors to obtain proof of performance, or to better understand limitations and challenges associated with specific Approaches, was completed.

2.4.2 Development of Alternative Means

2.4.2.1 Application of First Filtering Step (F1)

Step 2 – Filter to Identify Approaches to be Evaluated

The first filtering step was applied to reduce the number of remedial Approaches to those that conformed to Project goals. This initial filtering step typically used a "Yes/No" binary test to determine suitability of the Approach (e.g., Does the Approach meet Functional Requirement X). If the answer for any of the indicators was "No", the Approach was eliminated from further consideration. For an Approach to warrant further evaluation, the answer to all of the indicators must have been "Yes".

Generally speaking, remedial Approaches were not put forward if they did not meet with Project goals. As a result, application of the first Filter eliminated a few but not many Approaches – typically, it was the 'Do Nothing' Approach that was eliminated from each major Design Component (or sub-category), as this Approach was the least likely to the Project goals.

Next, the surviving remedial Approaches were broken down into Components, with Alternative Means identified for implementing each Component. Advantages and disadvantages to each Component (and Alternative Means) were identified previously during the internal brainstorming session, and were documented along with other key considerations and comments from the focus groups at the RODD Workshop. Additional environmental information from past and ongoing technical studies, including bench scale or similar testing completed by others, was also considered during identification of advantages and disadvantages to each Component and Alternative Means.

2.4.2.2 Application of Second Filtering Step (F2)

Step 3 – Filter to Identify Feasible Alternative Means

A second filtering step (F2) was applied to eliminate Alternative Means that were not technically and/or economically feasible or appropriate/applicable for implementation in the BHRD. This second filtering step applied binary filters to eliminate Alternative Means that do not meet Project goals and/or design requirements.

To apply the second filtering step, a matrix was prepared with minimally three criteria listed across the top of the matrix, and the Alternative Means for each Concept summarized down the left side of the matrix. Each matrix square was then completed by insertion of a simple "Y" or "N" response to the question: "Does the Alternative Means meet/satisfy Criterion (A), (B), and (C)"? Only the Alternative Means that had all positive answers survived the second screening, and were carried forward to the next stage of the process. Any Alternative Means having even one "N" answer were screened out.

2.5 Feasible Concepts Process

2.5.1 Development of Feasible Concepts

Step 4 – Build Feasible Concepts

Following application of the second filtering step (F2), each remaining Approach, Component, and Alternative Mean were grouped into logical Feasible Concepts.

2.5.2 Detailed Concept Descriptions for Feasible Concepts

Steps 5 – Develop Detailed Concept Descriptions

Following development of the Feasible Concepts, Detailed Concept Descriptions were prepared to provide additional information for each Feasible Concept. Detailed Concept Descriptions provide a conceptual design level of detail, and at a minimum include: site location map, conceptual footprint, infrastructure requirements, potential environmental impact(s), and a Class D (minus 30 to plus 50 percent) cost estimate used for screening and evaluating each Feasible Concept.

Depending on the degree of complexity of the Feasible Concept, additional details were provided in some Detailed Concept Descriptions, including: preliminary sequencing estimates, construction dewatering requirements, process flow diagrams, sketches and/or diagrams, monitoring requirements, and specific data requirements (e.g., technical performance, removal efficiencies).

2.5.3 Confirmation of Design Requirements

Prior to the detailed comparative evaluation of Feasible Concepts to identify Qualified Remedial Options, a detailed review of each Feasible Concept was required to verify compliance with design requirements identified in the DR Document.

The DR Document identified the parameters that were required to prepare the design and assist in the subsequent identification of remedial options. Factors such as functionality, performance, safety (i.e., worker, public, and environment), applicable codes and standards, environmental and geotechnical/hydrogeological conditions, reliability and maintenance, decommissioning, end use, regulatory compliance, and cost effectiveness were all taken into consideration during the development of the BHRD.

The requirements put forth in the DR Document were developed in collaboration with NS Lands and technical advisors in order to gain consensus on the criteria and requirements to be applied.

Specific requirements for each Design Component were identified in the DR Document. The design requirements for each component were then organized into the following categories:

Functional Requirements | state what the system is required to do what legislation must be met, if any. Functional requirements may be technical details or other specific functionality that define what a system is supposed to accomplish - functional requirements specify particular results of a system.

Non-Function Requirements | state what the system shall be; that is, an overall property of the system as a whole. Non-Functional requirements may identify a required physical characteristic of the system or component (i.e., mass, dimension, volume).

Performance Requirements | state how well the system does what it is required to do; that is, performance is an attribute of the system's function. Performance requirements are a type (or sub-set) of non-functional requirements which impose constraints on the design or implementation.

Safety Requirements | state the means to protect the health and safety of workers and general public.

Operational Requirements | state the requirements of the system during implementation and the post remediation operation and maintenance phase, and the applicable permit requirements.

In addition, the DR Document identified the applicable codes, standards, and classifications that apply to the BHRD, including: applicable Federal and Provincial legislation; applicable Federal, Provincial, and Municipal guidelines, policies, and standards; and other Codes and Standards.

Prior to advancing to the evaluation stage, Feasible Concepts were reviewed to confirm that specific functional, non-functional, performance, safety, and operational requirements identified for each Design Component were/or could be met, and that the proper legislation, codes, and standards could be applied during detailed design.

Feasible Concepts not capable of meeting design requirements were either modified to ensure compliance, eliminated from the evaluation, or identified as subject to verification/future modification.

2.6 Evaluation of Feasible Concepts

Steps 6 – Detailed Comparative Evaluation

The process for comparing Feasible Concepts to identify those which are most suitable for consideration as Qualified Remedial Options was carried out within the following framework:

- Matrix evaluation – Application of the Evaluation Criteria and Weighting Matrix established preference specifically on the basis of numerical rank within a series of pre-defined, weighted criteria applied to Regulatory, Technical, Environmental, Social, and Economic Indicators.
- Advantages and disadvantages – Evaluation of identified advantages and disadvantages associated with each Feasible Concept. Pros and cons rationalized based on professional judgement and experience of the evaluation team.

The numerical evaluation and ranking of the Feasible Concepts was performed using the 'Evaluation Criteria and Weighting Matrix' described previously in Section 2.3.

Scoring within the matrix evaluation was done by assigning a value from 1 to 5 for each sub-indicator question under the five Indicator categories (i.e., Regulatory, Technical, Environmental, Social, and Economic); a value of 5 represents the maximum score, while a value of 1 represents to lowest score based on pre-defined responses to question. Assigned weighting for each the five Indicator categories was then applied to determine total weighted comparative score. The maximum total comparative score a Feasible Concept can receive is 2500; the maximum total weighted comparative score a Feasible Concept can receive is 500. The Feasible Concepts were then ranked based on the total weighted comparative scores.

Non-numerical evaluation was also applied to distinguish between subtle numerical differences in the matrix scoring, and to verify and/or test the results obtained through the mathematical matrix comparison approach. Following evaluation, if the advantage-disadvantage analysis validated matrix conclusions, acceptance of the advantage-disadvantage analysis increased confidence in the matrix-derived ranking of concepts.

2.7 Qualified Remedial Option Descriptions

Step 7 – Identification of Qualified Remedial Options

The comparative evaluation of all of the Feasible Concepts for each major Design Component was undertaken using the data contained in the Detailed Concept Descriptions, and through application of the Evaluation Criteria and Weighting Matrix. The evaluation was initially completed by the discipline lead for each major design component, followed by a discussion with the design team and project leads to gain consensus on the scoring for each Feasible Concept.

2.7.1 Stakeholder Input

A Remedial Options Decision Workshop was held with NS Lands and technical advisors to review and discuss the evaluation of each Feasible Concept. The following key comments were noted during the workshop

- Bridge at Highway 348 |The shoulder width will be reduced from 2.0 m to 1.5 m on both sides and a 1.5 m sidewalk will be added to the upstream side of the bridge providing a sidewalk on both sides.
- Alternative costing carried for waste disposal under Section 4.3.3 Feasible Concept Cost Estimate for disposal of sludge/sediment waste verses disposal of sludge/sediment waste for use as daily cover.

- Confirmation of off-site treatment options for Leachate Management Feasible Concept 4 – Off-Site Management using Conveyance to a Wastewater Treatment Plant.

The results of the comparative evaluation process yield the selected Qualified Remedial Options to be put forward as recommended components for the BHRD.

3. Bridge at Highway 348

3.1 Background

A causeway along Highway 348 crosses Boat Harbour at the downstream end. The causeway is constructed with three 1500 mm diameter concrete culverts and two 3600 x 3000 mm concrete box culverts connecting Boat Harbour to the downstream dam. A water main running from the PLFN well field to the PLFN community is buried within the causeway.

In order to return Boat Harbour to tidal conditions and to allow for boat access to the harbour, the causeway will be removed and replaced with a bridge.

Remediation of Boat Harbour and returning it to tidal state and providing navigation will generally require the following construction activities:

- Removal of the existing causeway and all culverts to accommodate new bridge span
- Construction of a new bridge along Highway 348
- Re-routing the existing water main along the new bridge

3.2 Development and Identification of Feasible Concepts

Figure 3.1 shows the Approaches, Components, and Alternative Means developed for the Bridge at Highway 348 component.

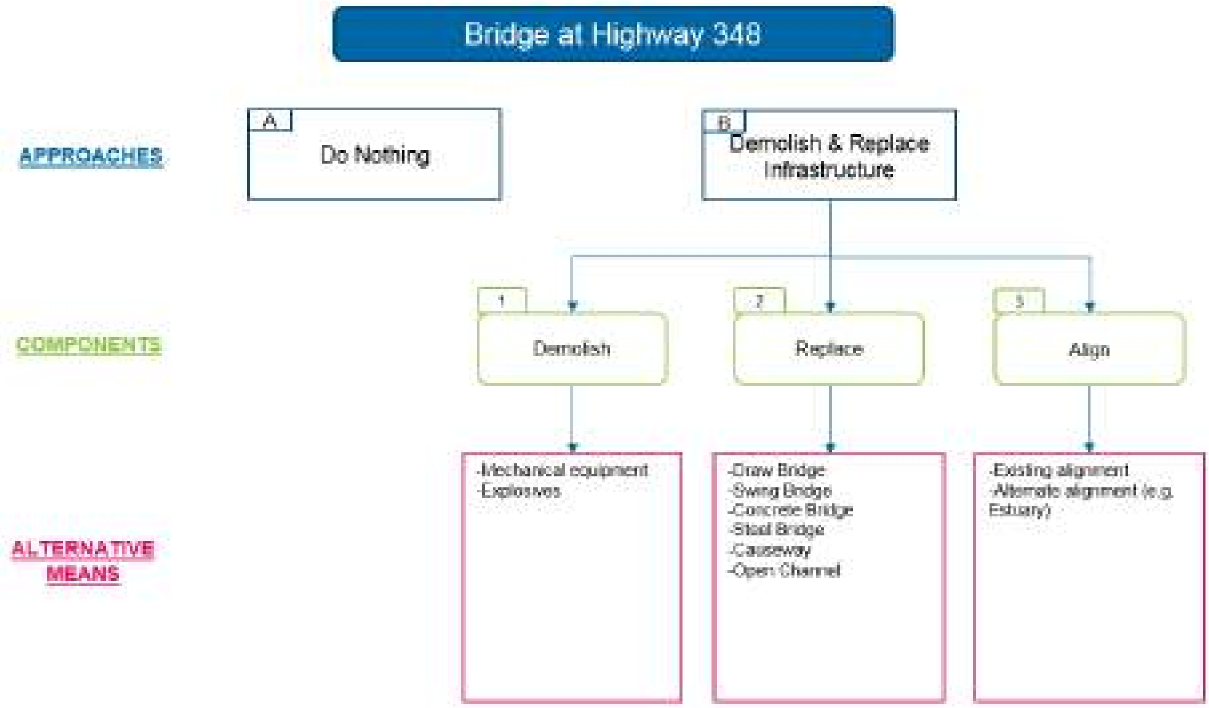

Figure 3.1 Bridge at Highway 348 Approaches, Components, and Alternative Means

3.2.1 Approaches

Two Approaches were identified for the bridge at Highway 348 as part of the BHRD implementation:

A. Do Nothing

B. Demolish and Replace Infrastructure

Approach B considers Alternative Means to demolish the existing causeway at Highway 348 through mechanical demolition and explosives. In addition, Approach B considers Alternative Means to replace the causeway with an open channel or a bridge constructed using various designs (e.g., draw bridge, swing bridge, causeway, etc.), construction materials (e.g., concrete, steel, etc.), and alignments.

3.2.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the water level suitable for end use (e.g., boat passage, return to tidal)?
- F1-2: Are regulatory approvals likely achievable?
- F1-3: Is the approach acceptable to the public?

The results of the F1 application are summarized below in Table 3.1.

Table 3.1 Results of First Filter Step – Bridge at Highway 348

Approaches	F1-1 Functionality	F1-2 Approvability	F1-3 Acceptability	Pass/Fail
A. Do Nothing	No	Yes	No	Fail
B. Demolish and Replace Infrastructure	Yes	Yes	Yes	Pass

Of the two Approaches considered, only Approach B was determined to be an Approach that warranted further evaluation.

The Do Nothing Approach (Approach A) did not meet end use or functionality requirements (i.e., return to tidal conditions), and was also considered unlikely to receive acceptance from the public. As a result, Approach A was removed from further consideration.

3.2.3 Identification of Components and Alternative Means

Approach B consisted of the following three components (with a number of associated Alternative Means).

1. Demolition (two Alternative Means)
2. Bridge Replacement (six Alternative Means)
3. Bridge Alignment (two Alternative Means)

An Alternative Means is defined as a different way in which each Component can be implemented.

3.2.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the Alternative Means technically feasible?
- F2-2: Does the Alternative Means minimize environmental impact?
- F2-3: Is the Alternative Means cost effective?

The results of the F2 application are summarized below in Table 3.2. Of the 10 Alternative Means considered, only four Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 3.2 Results of Second Filter Step – Bridge at Highway 348

Component	Alternative Means	F2-1 Technical	F2-2 Environmental	F2-3 Cost	Pass/Fail
1. Demolish	Mechanical Equipment	Yes	Yes	Yes	Pass
	Explosives	Yes	No	No	Fail
2. Replace	Draw Bridge	No	Yes	No	Fail
	Swing Bridge	No	Yes	No	Fail
	Concrete Bridge	Yes	Yes	Yes	Pass
	Steel Bridge	Yes	Yes	Yes	Pass
	Causeway	No	Yes	No	Fail
	Open Channel	No	Yes	No	Fail
3. Alignment	Existing Alignment	Yes	Yes	Yes	Pass
	Estuary Alignment	Yes	No	No	Fail

3.2.4.1 Demolition

The two Alternative Means that were considered as part of the demolition Component under Approach B included: mechanical equipment (e.g., high reach arm, crane) and collapse using explosives. Only use of the mechanical equipment for demolition passed the F2. The use of explosives to collapse the existing bridge did not minimize potential environmental impact, nor was it considered cost effective.

3.2.4.2 Bridge Replacement

Alternative Means that were considered as part of the bridge replacement Component under Approach B included: draw bridge, swing bridge, concrete bridge, steel bridge, causeway, and open channel. Only construction of a concrete or steel bridge passed F2. A draw bridge or swing bridge were deemed too costly in both construction and operation, plus the added capital cost to bury the water main. The causeway was removed as not being technical feasibility due to the size of a box culvert required to allow for boat access and tidal flow into Boat Harbour[4]. An open channel was deemed unlikely to receive acceptance from the public as it did not provide the transportation connection along Highway 348.

3.2.4.3 Bridge Alignment

The two Alternative Means that were considered as part of the bridge alignment Component under Approach B included: existing alignment and alternate alignment (i.e., re-aligning towards the estuary). Only use of the existing alignment passed F2. The alternate alignment in the estuary represented a significant cost increase and had a greater potential for adverse environmental impacts.

[4] The functional requirements identified in the DR Document and amended through meeting minutes, require that the minimum opening size of the navigable channel must be at least 15 m in width and 4 m in vertical clearance from the high water elevation.

3.3 Feasible Concept Description

Following application of the F2 step, the remaining Approaches, Components, and Alternative Means were grouped into the following Feasible Concepts:

- Feasible Concept 1 – Concrete girder bridge
- Feasible Concept 2 – Steel girder bridge

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix C. Common design criteria for both Feasible Concepts include:

- Structural design in accordance with Canadian Highway Bridge Design Code (CHBDC) S6-14
- 80 km/h design speed
- 3.5 metre lanes, 2.0 metre shoulders, and 1.5 metre wide sidewalk on one side[5]
- Deck structure to be a 225 mm concrete deck, reinforced with glass fiber reinforced polymer (GFRP) reinforcing
- All other concrete reinforcement to be galvanized
- 80 mm thick asphalt wearing surface complete with waterproofing membrane
- Concrete barrier to be designed to a minimum Test Level 2 (TL-2) and a minimum height of 1050 mm
- Abutment design to be integral abutment, if feasible

3.3.1 Feasible Concept 1 – Concrete Girder Bridge

Based on the preliminary general arrangement and required soffit elevation for the bridge, it is expected that the new bridge structure will be approximately a 34 m long single span structure which will provide flow under the structure, but does not require the construction of a center pier. This will provide a better hydraulic condition and improved tidal flow under the structure.

Feasible Concept 1 involves the construction of a precast concrete bulb tee girder superstructure for the bridge. Precast bulb tee girders is a cost-effective solution for a 34 m span, provides a reasonable structure depth and is comparable to the existing structure. For this span length, a concrete superstructure is typically preferred by NS TIR as they are a durable structure with low long-term maintenance costs and easily meet the 75 year design life criteria outlined in the CBHDC.

3.3.2 Feasible Concept 2 – Steel Girder Bridge

Feasible Concept 2 involves the construction of a steel girder superstructure for the bridge. A steel superstructure can consist of either steel plate girders or steel box beams. Steel girders have the

[5] During the Remedial Options Decision Workshop, NS Lands confirmed that a sidewalk will be provided on both sides of the bridge; and NS TIR confirmed that the shoulder width would be reduced to 1.5 m. Changes will be incorporated as part of detailed design.

benefit of potential longer spans and shallower depths, but for shorter span structures such as this bridge, they are typically more costly to construct and maintain compared to concrete girders.

3.3.3 Feasible Concept Cost Estimate

Class D capital and O&M[6] cost estimates for each Feasible Concept is provided in Appendix C, Attachment C1 and summarized on Table 3.3 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost covers the estimated 75-year service life of the bridge.

Table 3.3 Bridge Class D Cost Estimate

Feasible Concept	Capital Cost[7]	Operation and Maintenance Cost
Feasible Concept 1 – Concrete Girder Bridge	$2,980,000	$150,000
Feasible Concept 2 – Steel Girder Bridge	$3,160,000	$280,000

Key assumptions in development of the cost estimate include:

- No rock excavation required for foundation
- Steel piled foundation with 10 m long piles
- No detour structure required during construction
- No allowance for a pedestrian crossing during construction
- Existing water main to be supported by a temporary pipe bridge during construction
- Road reconstruction length of 600 m to improve road grade and super elevation on approaches
- Service life of 75 years

3.4 Evaluation of Feasible Concepts

The Feasible Concepts carried forward for the Bridge at Highway 348 as part of the BHRD were evaluated, compared, and ranked to identify the most suitable concept for consideration as a Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation) included as Appendix B, as well as the identification and comparison of advantages/disadvantages for each Feasible Concept.

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6 Operation and Maintenance cost are post-remediation cost. O&M costs during remediation are considered as part of the capital construction costs

7 Capital costs include a sidewalk on one side and 2.0 m shoulders.

3.4.1 Comparative Evaluation

The completed evaluation and weighting matrix for Bridge at Highway 348 Feasible Concepts is presented in Appendix H. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 3.4 presents a summary of the matrix scores for each Feasible Concept. As demonstrated by the matrix scores, Feasible Concept 1 (concrete girder bridge) was deemed preferable to Feasible Concept 2 (steel girder bridge).

Table 3.4 Summary of Matrix Scores – Bridge at Highway 348

Criteria Category	Weighting Factor	Feasible Concept 1 (Concrete Girder)	Feasible Concept 2 (Steel Girder)
Regulatory	14%	**463**	**463**
Technical	26%	**400**	397
Environmental	24%	**474**	**474**
Social	14%	**463**	**463**
Economic	22%	**500**	250
Total Comparative Score		**2299**	2047
Total Weighted Score		**457**	402
Rank		**1**	2

3.4.1.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Both Feasible Concepts ranked the same based on regulatory indicators (score 463). Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Under both Feasible Concepts, the relative risk to public health and safety upon completion of the bridge was considered to be very low, but not negligible. The only perceived risk was the presence of rip rap or armour stone along the embankments, which would potentially represent a slip/trip/fall hazard. As both Feasible Concepts would include a designated sidewalk along the bridge, there would be no need for pedestrians to walk along the embankments. Accordingly, both Feasible Concept 1 and Feasible Concept 2 received a score of 4.0 for sub-indicator HS1.1.

The potential risks to public health and safety during and following construction of the Bridge at Highway 348 are generally considered to be easily mitigatable, and may include barricades, re-routing of traffic (i.e., detours), and signage. As a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for sub-indicator HS1.2.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Under both Feasible Concepts, the inherent level of risk to worker health and safety associated with constructing a Bridge at Highway 348 was considered to be low. Typical health and safety risks associated with general construction (i.e., working at heights, use of heavy equipment, and slips/trips/falls) are common hazards and were considered to be easily mitigated with proper training and site planning and controls. Since the only significant difference between the Feasible Concepts was the construction material (i.e., concrete vs. steel girders), both Feasible Concepts received identical scores for sub-indicator HS2.1 (3.0) and sub-indicator HS2.2 (5.0).

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

Both Feasible Concepts were considered to have a high level of compliance, going beyond the minimum requirements for ease of Federal/Provincial approvability. Both Feasible Concepts were able to meet functional requirements for navigable channel size, design load, and hydraulic capacity, making the Feasible Concepts readily approvable in accordance with Canadian Highway Bridge Design Code and applicable Navigable Waters Bridges Regulations. As a result, both Feasible Concept 1 and Feasible Concept 2 scored 5.0 for sub-indicator C1.1.

Similarly, both Feasible Concepts were considered to have high levels of public acceptance from the PLFN and surrounding communities. Both options facilitate a return to tidal conditions and no change to traffic flow (with the exception during construction). Regardless of the construction materials selected (i.e., concrete vs. steel girders), it is expected that the Bridge at Highway 348 will be welcomed by PLFN and surrounding communities, and as a result, both Feasible Concept 1 and Feasible Concept 2 scored 5.0 for sub-indicator C1.2.

3.4.1.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project.

Feasible Concept 1 (concrete girder bridge) ranked higher than Feasible Concept 2 (steel girder bridge). Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

Both bridge construction methodologies were considered reliable approaches with extensive track records of successful applications. As a result, both Feasible Concepts received a score of 5.0 for sub-indicator T1.1.

Similarly, the materials and equipment required to implement both Feasible Concepts were considered easily acquired within the Province, as were the vendors and contractors required to implement the construction. While there are limited concrete girder manufacturers in Nova Scotia (compared to several/multiple steel suppliers), all materials required for construction of Feasible Concept 1 and Feasible Concept 2 were considered easily acquirable, and as a result, both Feasible Concepts received scores of 3.0 for sub-indicators T1.2 and T1.3.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criteria discussed in Section 4.4.1.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1 and Feasible Concept 2 with Site size and configuration was identified as an item that needed to be addressed, and was considered an average constraint regardless of the construction material. Both Feasible Concepts were considered compatible for this application, and as a result both Feasible Concepts received a score of 3.0 for sub-indicator T2.1.

There was no perceived difference between the compatibility of either Feasible Concept with all other on-Site features (i.e., site geology, hydrogeology, access, and hydrology). Accordingly, both Feasible Concepts received identical scores of 4.0 or 5.0 for the remaining sub-indicator questions T2.2 to T2.5.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

Regardless of the construction materials selected, there was no perceived difference between the compatibility of either Feasible Concept with existing off-Site features. Both Feasible Concepts required grade adjustment and resurfacing to the approach ramps. Both Feasible Concept 1 and Feasible Concept 2 received a score of 4.0 for sub-indicator T3.3.

Compatibility of the Feasible Concepts with existing off-Site features was considered to be a modest constraint to be addressed, with minimal impact to off-Site conditions (e.g., traffic) or infrastructure (e.g., points of access, roads, power lines) associated with either Feasible Concept. Accordingly, both Feasible Concept 1 and Feasible Concept 2 received identical scores of 4.0 for sub-indicators T3.1 and T3.2.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicator T4.1, the components of each Feasible Concept were not expected to fail, but would show signs of fatigue/wear and tear within the remediation and post-remediation period; as a result both Feasible Concepts received a score of 4.0.

Under sub-indicator T4.2, the relative maintenance requirements associated with each Feasible Concept was considered throughout the anticipated 75-year lifespan of the Bridge at Highway 348. Under Feasible Concept 2, the steel components of the bridge would be subject to corrosion, and would require cleaning and/or painting after a period of approximately 40 years. All other maintenance requirements for both Feasible Concepts were anticipated to be routine (e.g., cleaning, minor repair). As a result, Feasible Concept 1 received a score of 5.0 for sub-indicator T4.2, while Feasible Concept 2 scored 4.0.

Similar to sub-indicator C1.1, both Feasible Concepts were considered to have a high likelihood of compliance, meeting functional requirements (i.e., navigable channel size, design load, and hydraulic capacity) and performance requirements readily. As a result, both Feasible Concept 1 and Feasible Concept 2 scored 5.0 for sub-indicator T4.3.

For sub-indicator T4.4, the resulting impact of the Feasible Concepts not meeting performance criteria was considered moderate, and as a result both Feasible Concepts received a score of 3.0.

For sub-indicator T4.5, the relative ease of implementing a contingency measure during the post-remediation period was considered moderately difficult for both Feasible Concepts, despite the fact that the likelihood of contingency measures being required was considered remote. Both Feasible Concepts received a score of 3.0 for sub-indicator T4.5.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

The anticipated timeframe required to construct the Bridge at Highway 348 under Feasible Concept 1 and Feasible Concept 2 was considered to be approximately 4 months. This estimate included import of fill material and re-grading to adjust the superelevation on the approaches connecting Highway 348. Since the only difference between the two Feasible Concepts was the construction material, both Feasible Concepts were considered to require the same amount of time to construct, and received identical scores (3.0) under sub-indicator T5.1 for moderate timeframe for construction.

Both Feasible Concepts are expected to be implemented in less than 4 years; as a result both Feasible Concepts received a maximum score of 5.0 for sub-indicator T5.2.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

The duration of the remediation and post-remediation phases of the BHRD have no impact on the monitoring and testing of the Bridge at Highway 348; general inspection, operation, and maintenance requirements for both Feasible Concepts will be the same throughout, and is readily accomplished. Accordingly, both Feasible Concepts received identical scores of 5.0 for sub-indicators T6.1 and T.6.2.

Both Feasible Concepts were considered to require similar (i.e., above average, or moderate) amounts of monitoring to validate proper construction and effectiveness, including full time inspection during construction of footings, foundations, concrete pours, etc. As a result, both Feasible Concepts received a score of 2.0 for sub-indicator T6.3.

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase, both Feasible Concepts were considered to generate moderate amounts of general construction and demolition debris. Removal of fill excavated during the process of opening up the channel for construction was not considered, as this volume of material was considered to be the same for both Feasible Concepts. As a result, both Feasible Concepts received a score of 3.0 for sub-indicator T7.1.

During the post-remediation/maintenance phase, neither Feasible Concept was expected to generate any amount of waste; as a result both Feasible Concept 1 and Feasible Concept 2 received a maximum score of 5.0 for sub-indicator T7.2.

Both Feasible Concepts were expected to generate minimal (i.e., negligible) amounts of hazardous/dangerous goods throughout construction and post-construction phases. Both Feasible Concept 1 and Feasible Concept 2 received a maximum score of 5.0 for sub-indicator T7.3.

3.4.1.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events. This criterion has been assigned a total weigh of 24 percent of the overall comparison.

Both Feasible Concepts ranked the same based on environmental indicators. Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1a Atmospheric Environment

EN1.1b Aquatic Environment

EN1.1c Geology and Groundwater

EN1.1d Terrestrial Environment

No environmental impacts to atmosphere, groundwater quality, and soil quality were anticipated during the construction phase. As the bridge is anticipated to be constructed prior to the removal of the dam, minimal risk to the aquatic environment are anticipated due to excavation within water for construction of footings. Similarly, minimal/modest environmental impacts to terrestrial environment were anticipated during construction due to heavy equipment, clean fill stockpiles, and laydown areas. Both Feasible Concepts scored 5.0 for sub-indicator EN1.1a, and 4.0 for sub-indicators EN1.1b and EN1.1d. Overall, Feasible Concept 1 and Feasible Concept 2 received identical scores of 4.3 for sub-indicator EN1.

EN2 – Post-Remediation Phase Effects – 50 Percent of Environmental

Similarly, environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1a Atmospheric Environment

EN2.1b Aquatic Environment

EN2.1c Geology and Groundwater

EN2.1d Terrestrial Environment

During the post-construction phase, no impacts to atmospheric, aquatic, or geologic/terrestrial environmental quality were associated with either Feasible Concept; both Feasible Concepts scored 5.0 for sub-indicators EN2.1a through EN2.1d, resulting in overall scores of 5.0 for sub-indicator EN2.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential susceptibility of each Feasible Concept to inclement and severe weather events during the remediation and post-remediation phase. The sub-indicator questions for these weather effects included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

For sub-indicator EN3.1, both Feasible Concepts were considered to be somewhat susceptible to poor weather conditions during construction. However, the differing construction materials used (i.e., concrete vs. steel) did not have an impact on the susceptibility of the Feasible Concepts to inclement weather as both girders systems are manufacture off-Site. As a result, both Feasible Concepts received a score of 4.0 for sub-indicator EN3.1.

During the post-remediation phase (following construction of the Bridge at Highway 348), both Feasible Concepts were considered to be not susceptible to poor weather conditions, and as a result received identical scores of 5.0 for sub-indicator EN3.2.

Similarly, both Feasible Concepts would be designed and constructed in accordance with CHBDC and applicable Navigable Water Bridges Regulations, ensuring that the bridges would not fail under severe weather events (i.e., 1:100 year design event) during the remediation and post remediation phase. Accordingly, both Feasible Concepts received a score of 5.0 for sub-indicator EN3.3.

3.4.1.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept.

Both Feasible Concepts ranked the same based on social indicators. Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Social indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surroundings community during post remediation phase (i.e., safety, visual, nuisance)?

For sub-indicator S1.1, both Feasible Concepts were considered to have only a moderate level of community acceptance during the remediation phase. While some members of the surrounding community may embrace getting a new bridge, the anticipated short-term response from the surrounding communities may be one of opposition, as road closures and lane reductions during the anticipated 4-month construction period will inconvenience many. Accordingly, both Feasible Concepts received a score of 3.0 under sub-indicator S1.1.

During the post-remediation phase, once the Bridge at Highway 348 has been constructed, it was anticipated that there will be a high level of community acceptance for the new bridge and associated return to tidal conditions under both Feasible Concepts. As a result, both Feasible Concepts received a score of 5.0 under community acceptance sub-indicator S1.2.

During the remediation phase, construction of the Bridge at Highway 348 was considered to have a significant negative impact on the surrounding communities; the resulting road closures during construction present a major inconvenience to the surrounding communities, and will even limit/prohibit pedestrian traffic in the area. Accordingly, both Feasible Concepts received a score of 1.0 under community acceptance sub-indicator S1.3.

Finally, both Feasible Concepts were considered to have positive effect or impact on the surrounding communities during the post-remediation phase and as a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for community acceptance sub-indicator S1.4.

S2 - Community Benefit – 75 Percent of Social

Social indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)

Construction of the Bridge at Highway 348 and return to tidal conditions will have direct and indirect positive social impacts on the surrounding communities, from increased recreational use of Boat Harbour, to allowing the PLFN community to reestablish its relationship with the water and land of A'se'k. From an economic perspective, construction of the Bridge at Highway 348 may increase tourism in the area once the harbor is returned to tidal conditions. No other economic benefits directly attributable to either Feasible Concept were identified. Accordingly, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for community benefit sub-indicator S2.1.

3.4.1.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs for planning and implementation (i.e., capital costs) and for ongoing O&M costs.

Feasible Concept 1 (concrete girder bridge) ranked higher (based on economic indicators) than Feasible Concept 2 (steel girder bridge). Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 1 (concrete girder bridge) was estimated to be $2,980,000, and was the lowest cost of the two Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 1 received a maximum score of 5.0.

The capital cost of Feasible Concept 2 (steel girder bridge) was estimated to be $3,160,000, which is approximately 6 percent higher than Feasible Concept 1. As a result, Feasible Concept 2 received a score of 4.0 for sub-indicator EC1.1.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

Considering the relative maintenance requirements associated with each Feasible Concept throughout the anticipated 75-year lifespan of the Bridge at Highway 348, under Feasible Concept 2 the steel components of the bridge would be subject to corrosion, and would require cleaning and/or painting after a period of approximately 40 years. All other maintenance requirements for both Feasible Concepts were anticipated to be routine (e.g., cleaning, minor repair). Therefore the estimated O&M costs for Feasible Concept 2 ($280,000) were higher than Feasible Concept 1

($150,000). Due to the reduced O&M requirements associated with the concrete bridge, Feasible Concept 1 received a score of 5.0 for sub-indicator T4.2, while Feasible Concept 2 scored 1.0.

3.4.2 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

This section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment
- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

Since the only significant difference between the Feasible Concepts was the construction material (i.e., concrete vs. steel girders), there is nothing separating the two Feasible Concepts in terms of protection of human health and the environment, meeting timelines and milestones, and technical maturity. Based on these key overall Project goals, there are no advantages or disadvantages associated with either Feasible Concept.

Both Feasible Concepts are considered to be economically feasible. The capital costs for construction of either Feasible Concept are relatively close, and while the concrete bridge under Feasible Concept 1 is considered better value and slightly less expensive (i.e., Feasible Concept 2 capital cost is 6 percent higher), this does not represent a significant advantage over the lifetime of the Project. However, when considered in conjunction with anticipated O&M requirements over a 75 year period, Feasible Concept 1 provides the best value to the Province (and taxpayers), and would be preferred based on this economic consideration due to the increased durability of the concrete structure.

Overall, the comparison of advantages and disadvantages generally supports selection of Feasible Concept 1 as the preferred Feasible Concept for the construction of a Bridge at Highway 348.

3.5 Summary of Qualified Remedial Option

Based on the results of the numerical evaluation and ranking, comparative analysis, and review of advantages and disadvantages, Feasible Concept 1 – Concrete Girder Bridge, was selected as the Qualified Remedial Option for the Bridge at Highway 348.

The new bridge structure will be an approximately 34 m long, single-span structure, maximizing the flow beneath the span through elimination of a center pier. A concrete superstructure is preferred by NS TIR due to its durability, longevity, and low long-term maintenance costs. The rail height on the bridge will be a 1050 mm high, concrete barrier system to meet the necessary requirements for pedestrians and architectural enhancements. The bridge design will incorporate a new support system for the water main, including galvanized steel brackets equally spaced at approximately 1.8 to 2.4 m across the bridge.

4. Waste Management

4.1 Background

Remediation of the BHETF will generate the following industrial waste streams:

- Sludge waste generated from cleaning of the pipeline and remediation of the twin settling basins, ASB, BH, wetlands, and estuary
- Construction and demolition (C&D) debris generated from decommissioning/demolition of the BHETF buildings, causeway at Highway 348, dam, and pipeline
- Industrial waste generated from remediation activities (e.g., spent treatment media, remediated sludge, chemicals, etc.)

The anticipated waste quantities that will be generated during decommissioning and remediation activities are provided in Table 4.1 below. A breakdown of the volumes is detailed in Appendix G[8] for sludge/sediment and Appendix F[9] for C&D debris. Industrial waste has not been estimated as it is considered insignificant for the assessment.

Table 4.1 Waste Quantities Summary

Waste Type	In Place Volume (m^3)	Final Disposal Volume (m^3)
Sludge/Sediment	1,224,000	517,700[(1)]
C&D Debris	N/A	1,100
Note: [(1)] Assumes the sludge/sediment is dewatered and volume reduction is achieved as detailed in Appendix G.		

4.2 Development and Identification of Feasible Concepts

Figure 4.1 shows the results Approaches, Components, and Alternative Means developed for Waste Management component.

[8] Remediation Detailed Concept Descriptions
[9] Infrastructure Decommissioning Detailed Concept Descriptions

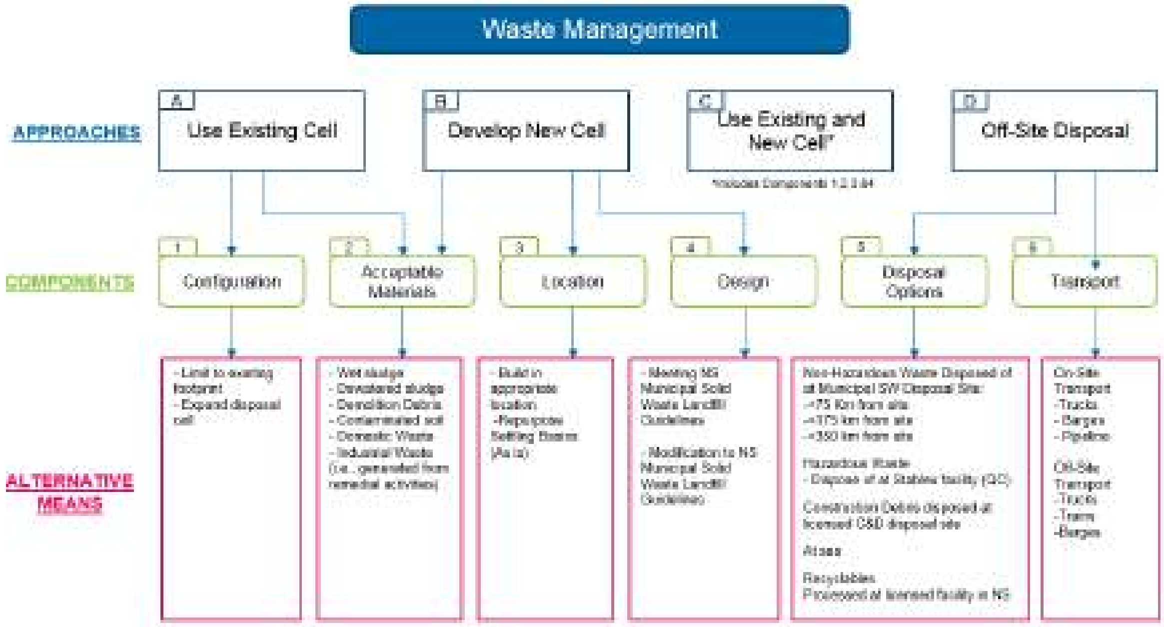


Figure 4.1 Waste Management Approaches, Components, and Alternative Means

4.2.1 Approaches

Four approaches were identified for the management of waste generated as part of the remediation of the BHETF:

A. Use Existing Cell

B. Develop New Cell

C. Use Existing and New Cell

D. Off-Site Disposal

Approach A consists of the use of the existing disposal cell to manage waste generated as part of remediation. The disposal cell has received sludge originating from the BHETF under Industrial Permit (94-032) since 1994. The disposal cell currently operates under a separate approval from the BHETF.

Approach B involves the establishment of a new disposal cell using the existing twin settling basins as the preferred disposal cell location. This proposed location is ideal as it is an already disturbed area on Provincial land and is currently accessible using the BHETF site access road (Simpsons Road).

Approach C was developed to provide the flexibility to manage a potentially greater volume of waste that may be generated as a result of the remediation of Boat Harbour. This approach combines aspects of Approaches A and B through use of the existing disposal cell and development of a new disposal cell within the existing twin settling basins.

Approach D consists of hauling the waste materials to a licensed off-Site facility.

4.2.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Can the Approach accommodate the waste quantities?
- F1-2: Is the Approach likely to be acceptable to the public?
- F1-3: Is the Approach likely to meet applicable regulatory requirements?

The results of the F1 application are summarized below in Table 4.1.

Table 4.2 Results of First Filter Step – Waste Management

Approaches	F1-1 Functionality	F1-2 Acceptability	F1-3 Approvability	Pass/Fail
A. Use Existing Cell	Yes	Yes	Yes	Pass
B. Develop New Cell	Yes	No	Yes	Fail
C. Use Existing and New Cell	Yes	No	Yes	Fail
D. Off-Site Disposal	Yes	Yes	Yes	Pass

Two of the four Approaches passed the F1, including use of the existing cell and off-Site disposal. These Approaches were carried forward for further evaluation in the following sections.

Approaches B and C failed the F1 and were removed from further development and evaluation as a Feasible Concept. Development of a new on-Site disposal cell was common to both Approaches and was considered unlikely to be acceptable by the public due to setback distances from adjacent properties and Boat Harbour; and due to visual appearance (i.e., mound height relative to surrounding grade in center of potentially usable land area).

4.2.3 Identification of Components and Alternative Means

The Approaches A through D identified in Section 4.1.2 consisted of the following Components (with a number of associated Alternative Means):

1. Configuration (two Alternative Means)
2. Acceptable Materials (six Alternative Means)
3. Location (two Alternative Means)
4. Containment Cell Design (two Alternative Means)
5. Disposal Options (five Alternative Means)
6. Transport (two Alternative Means)

4.2.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Can the Alternative Means accommodate the anticipated waste type(s)?
- F2-2: Does the Alternative Means minimize environmental impact?
- F2-3: Is the Alternative Means cost effective?

The results of the application of the F2 are summarized in the following Table 4.2. Of the 24 Alternative Means considered, 16 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 4.3 Results of Second Filter Step – Waste Management

Component	Alternative Means	F2-1 Waste Type	F2-2 Environmental	F2-3 Cost	Pass/Fail
1. Configuration	Limit to existing footprint	Yes	Yes	Yes	Pass
	Expand disposal cell	Yes	Yes	Yes	Pass
2. Acceptable Materials	Wet sludge	Yes	Yes	Yes	Pass
	Dewatered sludge	Yes	Yes	Yes	Pass
	Demolition Debris	Yes	Yes	Yes	Pass
	Contaminated soil	Yes	Yes	Yes	Pass
	Domestic Waste	No	Yes	No	Fail
	Industrial Waste	Yes	Yes	Yes	Pass
3. Location[10]	Establishment of new cell location within study area	N/A	N/A	N/A	N/A
	Repurpose Settling Basins (As is)	N/A	N/A	N/A	N/A
4. New Disposal Cell Design [10]	Meeting NS Municipal Solid Waste Landfill Guidelines	N/A	N/A	N/A	N/A
	Modification to NS Municipal Solid Waste Landfill Guidelines	N/A	N/A	N/A	N/A
5. Disposal Options	Non-Hazardous Waste - disposed of at municipal solid waste disposal site, located:				
	• <75 km from site	Yes	Yes	Yes	Pass
	• <76-175 km from site	Yes	Yes	Yes	Pass
	• <176-350 km from site	Yes	No	No	Fail
	Hazardous Waste - disposed of at the Stablex facility (QC)	Yes	Yes	Yes	Pass
	Construction Debris - disposed of at a licensed C&D disposal site	Yes	Yes	Yes	Pass
	Recyclables - processed at licensed facility in NS	Yes	Yes	Yes	Pass
	Sludge waste disposed of at sea	Yes	No	Yes	Fail

[10] Not evaluated as Approach B and C were eliminated as part of F1

Table 4.3 Results of Second Filter Step – Waste Management

Component	Alternative Means	F2-1 Waste Type	F2-2 Environmental	F2-3 Cost	Pass/Fail
6. Transport Options	On-Site Transport				
	• Trucks	Yes	Yes	Yes	Pass
	• Barges	Yes	Yes	Yes	Pass
	• Pipeline	Yes	Yes	Yes	Pass
	Off-Site Transport				
	• Trucks	Yes	Yes	Yes	Pass
	• Trains	Yes	Yes	No	Fail
	• Barges	Yes	Yes	No	Fail

4.2.4.1 Configuration

Both use of the existing cell and expansion of the existing cell passed the F2. Configuration considers both vertical and horizontal expansion.

4.2.4.2 Acceptable Materials

For Approach A, acceptance of all waste in the disposal cell was deemed acceptable with the exception of domestic waste which is not generally not permitted in industrial landfills, noting there is a provincial landfill ban on select materials including food waste.

4.2.4.3 Disposal Options

For Approach D, several disposal options were considered as Alternative Means for the off-Site disposal of the various types of waste anticipated, including: non-hazardous waste disposed of at a municipal solid waste disposal site located <75 km, <76-175 km, or <176-350 km from Site; hazardous waste disposed of at the Stablex facility (Quebec); construction debris disposed of at a licensed C&D disposal site; recyclables processed at licensed facility in NS; and disposing sludge at sea.

The results of the application of the F2 eliminated transport of non-hazardous waste greater than 176 km from Site due to its potential risk and inability to minimize environmental impact, as well as being cost prohibitive. In addition, application of the F2 also eliminated disposal of sludge waste at sea due to not minimizing environmental impact.

4.2.4.4 Transport

For Approach D, several transport methods were considered as Alternative Means for both on- and off-Site disposal of the various types of waste anticipated during the remediation of Boat Harbour, including: on-Site transport by trucks, barges, or pipeline; and off-Site transport by trucks, trains, or barges.

The results of the application of the F2 eliminated off-Site transport by train as this Alternative Mean is not cost effective. Similarly, off-Site transport of waste by barge was eliminated as an Alternative Mean due to its lack of feasibility and cost effectiveness.

4.3 Feasible Concept Descriptions

Following application of F2 step the remaining Approaches, Components, and Alternative Means were grouped into the following Feasible Concepts:

- Feasible Concept 1 – Use existing disposal cell
- Feasible Concept 2 – Off-Site disposal

Other identified Alternative Means (e.g., limit to existing footprint or expand disposal cell) were deemed to be alternatives that could be evaluated as needed with the development of the Detailed Concept Description for Feasible Concept 1 (e.g., if it was identified that there is a need to expand the disposal cell).

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix D.

4.3.1 Feasible Concept 1 – Use Existing Disposal Cell

In 1994, an Industrial Permit (94-032) was issued by NSE for the construction and operation of the sludge disposal cell. The sludge disposal cell operates under a separate approval from the BHETF, which operates under Approval (2011-076657-R03) issued by NSE for the operation of the Kraft Mill.

The 6.7 ha disposal cell is located southeast of the ASB and has a total capacity of 220,000 m^3 (waste). The sludge disposal cell is located on Provincially-owned lands, and is surrounded by undeveloped mixed woodlands and First Nation reserve lands (including IR37 to the south and IR24G to the east). Access to the sludge disposal cell is via a single lane gravel roadway off the ASB perimeter road. The sludge disposal cell is secured by a perimeter fence with an access gate in the northwest corner.

Feasible Concept 1 involves using the existing disposal cell and placing waste materials in excess of the current design capacity. It is noted that in the Operations and Maintenance Manual[11], the design capacity could be exceeded based on the physical properties of the waste materials and the recommended final elevations could be determined as part of the disposal cell closure plan.

Under Feasible Concept 1, the disposal cell would be modified to enhance the leachate collection layer and facilitate placement and dewatering of the sludge/sediment in a one-step operation, as further detailed in Appendix G – Remediation Detailed Concept Descriptions.

11 Nova Scotia Department of Transportation and Public Works Operational and Maintenance Manual, Boat Harbour Disposal Cell, Boat Harbour Treatment Facility, Boat Harbour, Nova Scotia (Jacques Whitford Environment Limited, September 1999)

The final landfill cover contours will be designed to accommodate the anticipated range of final waste volumes, minimize precipitation infiltration through the cap, control the release of landfill gas, and accommodate end use.

The annual leachate generation rate is estimated to be less than 2,500 m^3 per year based on using a flexible membrane liner and assuming approximately 1,200 mm of rainfall per year[12].

Leachate management is described in Section 7.5 and Appendix G. As noted in Section 7.5, the Qualified Remedial Option for leachate management is disposal at an off-Site licensed municipal wastewater treatment plant (WWTP). Acceptance of the leachate at a WWTP is dependent on the strength and parameters in the leachate, as such leachate may need to be disposed of at an industrial WWTP or treated on-Site. Leachate will be further characterized as part of pilot scale testing.

4.3.2 Feasible Concept 2 – Off-Site Disposal

Feasible Concept 2 consists of trucking waste materials to an off-Site facility located within 175 km of the Site. It is anticipated that the majority of the waste generated as part of the Project will be classified as non-hazardous/ non-dangerous material, and can be accepted at licensed provincial municipal landfills.

It is anticipated that dewatered sludge/sediment waste could be disposed of at a provincial municipal landfill, either as alternative daily cover or as waste, as detailed in Appendix D. There are four provincial municipal landfills located within 175 km of the Site.

It is anticipated that C&D debris would be disposed of at a C&D disposal site. There are three C&D disposal sites in relative (<75 km) close proximity to the Site.

Straight trailers (or similar) pulled by a tractor will be used to haul materials to an off-site disposal facility. All vehicles transporting contaminated materials will be cleaned as needed and inspected prior to leaving site to ensure loads are secured. Manifests will be completed to track the transportation and disposal at licensed provincial facilities.

Assuming a trailer capacity of 35 tonnes (tonnes or metric tonnes (MT)) and based on the anticipated sludge volumes and density of 1.2 MT/m^3, it is estimated that approximately 18,200 loads will be required to transport the treated sludge material off-Site.

4.3.3 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix D, Attachment D1 and summarized on Table 4.4 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in

12 Based on a review of Lyons Brook weather station data for 1981-2010.

overall Project Costing. O&M cost for the estimated 25-year contaminating life span of the disposal cell are covered for Feasible Concept 1.

Three costing scenarios are shown for Feasible Concept 1 – Use Existing Disposal Cell. Feasible Concept 1A represents leachate being transported to a municipal WWTP for disposal, Feasible Concept 1B represents leachate being transport to an industrial WWTP for disposal, and Feasible Concept 1C represents leachate being treated on-Site with treated effluent discharged to Boat Harbour. As detailed in Section 7.5, on-Site treatment scored less than off-Site treatment and as such was not selected as the Qualified Remedial Option, however, it is a viable option should off-Site disposal not be approved.

Two costing scenarios are also shown for Feasible Concept 2 – Off-Site Disposal. Feasible Concept 2A represents a tip fee based on the dewatered sludge/sediment being used as alternative daily cover at a municipal landfill and Feasible Concept 2B represents a tip fee based on the dewatered sludge/sediment being landfilled (i.e., consuming air space available for waste disposal).

Table 4.4 Waste Management Feasible Concepts Class D Cost Estimates

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1A – Use Existing Disposal Cell (Leachate disposed at municipal WWTP)	$6,400,000	$5,500,000
Feasible Concept 1B – Use Existing Disposal Cell (Leachate disposed at industrial WWTP)	$6,400,000	17,000,000
Feasible Concept 1C – Use Existing Disposal Cell (Leachate treated on-Site with treated effluent discharged to Boat Harbour)	$8,740,000	$9,750,000
Feasible Concept 2A – Off-Site Disposal (tip fee of $25/MT based on use as alternative daily cover)	$28,510,000	$0
Feasible Concept 2B – Off-Site Disposal (tip fee of $115/MT based on landfilling waste)	$85,080,000	$0

Key assumptions include:

- For Feasible Concept 1, final cover based on 4(H):1(V) slopes constructed to a maximum elevation of 28 m AMSL
- For Feasible Concept 1, stormwater pond is assumed to be constructed using earthen berms with low permeable clay liner along the inside slope and floor
- For Feasible Concept 1, a 25-year contaminating life span is assumed
- For Feasible Concept 2, sludge is assumed to be disposed of at a landfill that is approximately 55 km away from the Site
- For Feasible Concept 2, landfill can accept volume of sludge/sediment waste over the anticipated remediation duration (i.e., no daily load limits)
- For Feasible Concept 2, C&D waste is assumed to be disposed of at a C&D facility that is approximately 15 km away from the Site

4.4 Evaluation of Feasible Concepts

The Feasible Concepts carried forward for Waste Management were evaluated, compared, and ranked to identify the Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation) included as Appendix B, as well as the identification and comparison of advantages/disadvantages for each Feasible Concept.

4.4.1 Comparative Evaluation

The completed evaluation and weighting matrix for Waste Management Feasible Concepts is presented in Appendix H. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 4.5 presents a summary of the matrix scores for each Feasible Concept. As demonstrated by the matrix scores, Feasible Concept 1 (on-Site disposal) was deemed preferable to Feasible Concept 2 (off-Site disposal).

Table 4.5 Summary of Matrix Scores – Waste Management

Criteria Category	Weighting Factor	Feasible Concept 1 (Existing Disposal Cell)	Feasible Concept 2 (Off-Site Disposal)
Regulatory	14%	**388**	300
Technical	26%	**451**	425
Environmental	24%	455	**472**
Social	14%	**456**	306
Economic	22%	**300**	**300**
Total Comparative Score		**2050**	**1803**
Total Weighted Score		**411**	**375**
Rank		**1**	**2**

4.4.1.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Feasible Concept 1 (existing disposal cell) ranked higher than Feasible Concept 2 (off-Site disposal) based on regulatory indicators. Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Under both Feasible Concepts, an identical volume of waste material will need to be managed, however, the subsequent handling and potential transportation of waste material varies for each. Feasible Concept 2 had a higher level of risk to public health and safety due to the significant increase in truck traffic required, and consequently scored lower than Feasible Concept 1 for sub-indicator HS1.1.

The potential risks to public during waste management are generally considered to be easily mitigatable and may include stopping work during inclement weather, altering or restricting truck routes and travel times to avoid peak traffic areas and times. However due to the significant volume of traffic required to move the treated waste material, there is still an inherent level of risk associated with Feasible Concept 2, despite the ability to implement mitigative measures. As a result, Feasible Concept 2 scored lower than Feasible Concept 1 for sub-indicator HS1.2.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Under both Feasible Concepts, an identical volume of waste material will need to be managed, however, the subsequent handling and potential transportation of waste material varies for each. The level of risk associated with constructing a disposal cell cap and placement of waste in a cell under Feasible Concept 1 was considered to be less than the risk associated with Feasible Concept 2. Feasible Concept 2 had a higher level of risk to worker health and safety due to the significant volume of transportation required, and consequently scored lower than Feasible Concept 1 for sub-indicator HS2.1.

The potential risks to the worker during waste management are generally considered to be easily mitigatable and may include stopping work during inclement weather, altering or restricting truck routes and travel times to avoid peak traffic areas and times, etc. However due to the significant volume of transportation required to move the treated waste material, there is still an inherent level of risk associated with Feasible Concept 2, despite the ability to implement mitigative measures. As a result, Feasible Concept 2 scored lower than Feasible Concept 1 for sub-indicator HS2.2.

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

Acceptance criteria is currently not defined for dioxins and furans (D&F) by NSE for off-Site disposal at a municipal landfill. As such, it is not known at this time if the treated sludge will be acceptable for off-Site disposal. For sub-indicator C1.1, Feasible Concept 2 received a score of 3.0 due to uncertainties associated with off-Site acceptance of treated sludge. As the existing disposal cell is already approved by NSE to accept the sludge waste, Feasible Concept 1 scored 4.0 for sub-indicator C1.1.

With respect to sub-indicator C1.2, both Feasible Concepts were considered to have only a moderate level of public acceptance from the PLFN and surrounding communities. Regardless of which licensed provincial municipal landfill is selected under Feasible Concept 2, it is anticipated that the choice will face public opposition. A typical public response would be "not in my backyard", indicating a reluctance to transport, store, and manage a significant volume of waste within the community. Similarly, it is anticipated that there will be opposition from PLFN to store and manage waste in the existing on-Site disposal cell under Feasible Concept 1. As a result, both Feasible Concept 1 and Feasible Concept 2 scored 3.0 for sub-indicator C1.2.

4.4.1.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project.

Feasible Concept 1 (existing disposal cell) ranked higher than Feasible Concept 2 (off-Site disposal). Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

Both on-Site disposal in the existing cell and off-Site disposal are considered reliable and successful approaches to managing the waste generated by the Project. However, due to the significant volume of waste material and potentially high concentrations of D&F, there were uncertainties whether provincial municipal landfills will be able to accept the sludge waste. As a result, Feasible Concept 2 received a score of 4.0 for sub-indicator T1.1, while Feasible Concept 1 scored 5.0.

Similarly, the materials and equipment required to implement both Feasible Concepts are readily available, as are the vendors and contractors required to implement the remediation. As a result, both Feasible Concepts received a score of 5.0 for remaining sub-indicator questions T1.2 and T1.3.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criteria discussed in Section 4.4.1.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1 and Feasible Concept 2 with current on-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints. While Feasible Concept 2 was expected to be less compatible with existing off-Site features, there was no perceived difference between the compatibility of each Feasible Concept with on-Site features. As a result, both Feasible Concepts received a score of 5.0 for all five sub-indicator questions.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

For sub-indicator T3.1, restrictions due to spring road load restrictions on secondary roads will limit off-Site transport, making Feasible Concept 2 less compatible with existing off-Site features. Historically, restrictions have been implemented between mid-March to mid-May, but restrictions are also dependent on weather conditions and the types of vehicles being used. Accordingly, Feasible Concept 2 received a score of 3.0 for sub-indicator T3.1, while Feasible Concept 1 scored 5.0.

Potential changes or impacts to off-Site conditions due to the anticipated increase in traffic volume under Feasible Concept 2 was considered to be a significant and challenging constraint. The resulting increase in noise, dust (during summer months), wear and tear (e.g., deterioration) on surrounding roads, and impact on traffic volume all contributed to Feasible Concept 2 receiving a score of 2.0 for sub-indicator T3.2. No potential changes or impacts to off-Site conditions were associated with Feasible Concept 1, which as a result received a score of 5.0 for sub-indicator T3.2.

While there was no perceived difference between the two Feasible Concepts in anticipated changes to existing power supply or other municipal infrastructure off-Site, implementation of Feasible Concept 2 was expected to necessitate significant upgrades and repairs to secondary highways surrounding the Site. As a result, Feasible Concept 2 received a score of 3.0 for sub-indicator T3.3, while Feasible Concept 1 received a score of 5.0.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicator T4.1, the components of each Feasible Concept were not expected to fail within the remediation and post-remediation period, and as a result both Feasible Concepts received a score of 5.0.

The relative maintenance requirements associated with Feasible Concept 1, including long-term disposal cell O&M and leachate treatment throughout the remediation and post-remediation period, were considered moderate, and resulted in Feasible Concept 1 receiving a score of 3.0 for sub-indicator T4.2. By comparison, there were little to no long-term maintenance requirements associated with Feasible Concept 2, as these tasks would become the responsibility of the selected licensed provincial municipal landfill. Feasible Concept 2 received a score of 5.0 for sub-indicator T4.2.

Similar to sub-indicator C1.1, uncertainties associated with acceptance criteria for D&F for treated sludge disposal in off-Site landfills constitutes a moderate level of risk under sub-indicator T4.3. As a result of this uncertainty, Feasible Concept 2 received a score of 3.0 for sub-indicator T4.3, while Feasible Concept 1 scored 5.0.

For sub-indicator T4.4, the likelihood and resulting impact of the Feasible Concepts not meeting performance criteria or remediation objectives was considered low for Feasible Concept 1, and as a result Feasible Concept 1 received a score of 5.0. However, due to uncertainties with the criteria for accepting D&F impacted waste at off-Site facilities, Feasible Concept 2 received a score of 1.0.

For sub-indicator T4.5, the relative ease of implementing a contingency measure during the post-remediation period was considered more difficult for an off-Site location than an on-Site location. However, the likelihood of contingency measures being required with treated sediment waste being managed within a licensed provincial municipal landfill was considered un-likely. Feasible Concept 2 received a score of 3.0 for sub-indicator T4.5, while Feasible Concept 1 scored 5.0.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

The anticipated timeframe required to implement Feasible Concept 1 and Feasible Concept 2 was considered to be less than four years; as a result, both Feasible Concepts received a maximum score of 5.0 for sub-indicator T5.2.

While both Feasible Concepts are expected to be implemented in less than four years, it will take longer to construct and prepare the existing disposal cell, place the material, and implement subsequent closure for the on-Site alternative. By comparison, Feasible Concept 2 requires less time to construct and be fully operational. As a result, Feasible Concept 2 received a maximum score of 5.0 under sub-indicator T5.1, while Feasible Concept 1 scored 1.0 for the longest relative time frame to implement.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

During the remediation phase, routine monitoring requirements should be roughly the same for both Feasible Concepts. Feasible Concept 2 was considered to be more difficult to monitor, however, additional testing is unlikely to be required. Additional monitoring and testing would be more readily implementable on-Site under Feasible Concept 1, in the unlikely event that this is required. Accordingly, Feasible Concept 1 received the maximum score of 5.0 for sub-indicator T6.1, while Feasible Concept 2 scored 4.0.

Similarly, during the post-remediation phase, Feasible Concept 2 would be more difficult to monitor in an off-Site location. Additional testing is unlikely to be required, however, these tasks would become the responsibility of the landfill operator at the off-Site facility. Additional monitoring and testing would be more readily implementable on-Site under Feasible Concept 1. As a result, Feasible Concept 1 received the maximum score of 5.0 for sub-indicator T6.2, while Feasible Concept 2 scored 4.0.

Both Feasible Concepts were considered to require similar (i.e., moderate) amounts of monitoring to ensure effectiveness. Accordingly, both Feasible Concepts received a score of 4.0 for sub-indicator T6.3.

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase, both Feasible Concepts were considered to generate minimal amounts of additional waste through implementation, and as a result both Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.1.

During the post-remediation phase, Feasible Concept 1 was considered to generate a moderate amount of waste (in comparison to Feasible Concept 2) due to the additional leachate generated from the on-Site disposal cell which would need to be managed. In comparison, any leachate generated under Feasible Concept 2 at an off-Site landfill would be the responsibility of the facility operator, therefore minimal waste generation was associated with Feasible Concept 2. Accordingly, Feasible Concept 2 received a maximum score of 5.0 for sub-indicator T7.2, while Feasible Concept 1 scored 3.0.

Both Feasible Concepts were considered to generate minimal (i.e., negligible) amounts of hazardous/dangerous goods through implementation during the remediation phase, and as a result both Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.3.

4.4.1.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events.

Feasible Concept 2 (existing disposal cell) ranked higher than Feasible Concept 1 (on-Site disposal) based on environmental indicators. Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1a Atmospheric Environment

EN1.1b Aquatic Environment

EN1.1c Geology and Groundwater

EN1.1d Terrestrial Environment

Very little separated the environmental impact scoring of each Feasible Concept during the remediation phase. Feasible Concept 2 scored less (under sub-indicator EN1.1b) for impacts to air quality (for the protection of public health) due to increased vehicle emissions and dust emissions associated with a significant increase traffic volume during the remediation phase. For sub-indicators EN1, Feasible Concept 1 received a score of 4.7, while Feasible Concept 2 received a score of 4.6.

EN2 – Post-remediation Phase Effects – 50 Percent of Environmental

Similarly, environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1a Atmospheric Environment

EN2.1b Aquatic Environment

EN2.1c Geology and Groundwater

EN2.1d Terrestrial Environment

Very little separated the environmental impact scoring of each Feasible Concept during the post-remediation phases. During the post-remediation phase, Feasible Concept 1 scored slightly less (under sub-indicator EN2.2 and EN2.3) due to potential impacts to aquatic/groundwater quality associated with utilization of the on-Site disposal cell. For sub-indicators EN2, Feasible Concept 1 received a score of 4.8, while Feasible Concept 2 received a score of 5.0.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential susceptibility of each Feasible Concept to inclement and severe weather events during the remediation and post remediation phase. The sub indicator questions for these weather effects included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

For sub-indicator EN3.1, both Feasible Concepts were considered to be somewhat susceptible to poor weather conditions during the management of waste in the remediation phase. In particular, seasonal restrictions or limitations to off-Site transport on secondary highways affected Feasible Concept 2, while inclement weather would hinder use of on-Site access roads under both Feasible Concepts. As a result, both Feasible Concepts received a score of 4.0 for sub-indicator EN3.1.

During the post-remediation phase, Feasible Concept 1 was considered to be somewhat susceptible to inclement weather, as the leachate treatment systems associated with the existing cell could potentially fail. As a result, Feasible Concept 1 received a score of 4.0 for sub-indicator EN3.2. In contrast, Feasible Concept 2 was considered to be not susceptible to poor weather conditions and received a score of 5.0.

For sub-indicator EN3.3, the existing cell under Feasible Concept 1 is unlikely to fail under severe weather events during the remediation and post remediation phase. As part of detailed design, severe weather (e.g., 1:100 design event) will be taken into consideration when designing the disposal cell (e.g., sizing stormwater infrastructure). Similarly, municipal landfills are designed to manage severe weather. Accordingly, both Feasible Concepts received a score of 4.0 for sub-indicator EN3.3.

4.4.1.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept. This criterion has been assigned a total weigh of 14 percent of the overall comparison.

Feasible Concept 1 (existing disposal cell) ranked higher than Feasible Concept 2 (off-Site disposal) with a score of 306. Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Social indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surroundings community during post remediation phase (i.e., safety, visual, nuisance)?

For sub-indicator S1.1, both Feasible Concepts were considered to have only a moderate level of community acceptance during the remediation phase. While some members of the surrounding community may embrace the removal of contaminants from the Site, the anticipated short-term response from the surrounding communities may be one of resistance, and may include: a reluctance to transport, store, and manage a significant volume of waste within the community; opposition to store and manage waste in the existing on-Site disposal cell; and opposition to the significant increase in the volume of truck traffic. Accordingly, both Feasible Concepts received a score of 3.0 under sub-indicator S1.1.

During the post-remediation phase, once the sludge waste has been transported off-Site to a licensed provincial municipal landfill under Feasible Concept 2, it was anticipated that there will be a high level of community acceptance for the remediation of the BHETF[13]. As a result, Feasible Concept 2 received a score of 5.0 for sub-indicator S1.2. In contrast, during the post-remediation phase under Feasible Concept 1 it was anticipated that there will be only a moderate level of community acceptance (initially), as it will take time to prove the closed disposal cell does not pose a risk to human health or the environment. As a result, Feasible Concept 1 received a score of 4.0 for community acceptance sub-indicator S1.2.

During the remediation phase, implementation of Feasible Concept 2 was considered to have a moderately negative impact on the surrounding communities; the increased volume of truck traffic could potentially have an impact on community safety, and may also negatively impact ambient air quality (e.g., increased dust) and noise levels. As a result, Feasible Concept 2 received a score of 2.0 for community acceptance sub-indicator S1.3. Implementation of Feasible Concept 1 was considered to have no net effect (i.e., either positive or negative) or impact on the surrounding communities during the remediation phase. Accordingly, Feasible Concept 1 received a score of 3.0 for community acceptance sub-indicator S1.3.

Finally, both Feasible Concepts were considered to have no net effect (i.e., either positive or negative) or impact on the surrounding communities during the post-remediation phase and as a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 3.0 for community acceptance sub-indicator S1.4.

[13] Community acceptance was focused on the communities adjacent to the Site and not the community in the vicinity of a potential receiving site

S2 - Community Benefit – 75 Percent of Social

Social indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)

The remediation of Boat Harbour and return to tidal conditions will have direct and indirect positive social impacts on the surrounding communities, from increased recreational use of Boat Harbour, to allowing the PLFN community to reestablish its relationship with the water and land of A'se'k. From an economic perspective, remediation of Boat Harbour may increase tourism in the area once the harbor is returned to tidal conditions. Implementation of Feasible Concept 1 has the added benefit of potentially providing long-term employment to the PLFN community through performance of monitoring and O&M for the closed cell. No economic benefits directly attributable to Feasible Concept 2 were identified. Accordingly, Feasible Concept 1 received a score of 5.0 for sub-indicator S2.1, while Feasible Concept 2 scored 3.0.

4.4.1.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs for planning and implementation (i.e., capital costs) and for ongoing O&M costs.

Feasible Concept 1 (existing disposal cell) and Feasible Concept 2 (off-Site disposal) ranked the same based on economic indicators. Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 1 (existing disposal cell) was estimated to be $6,400,000, and was the lowest cost of the two Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 1 received a maximum score of 5.0.

The capital cost of Feasible Concept 2 (off-Site disposal) was estimated to range between $28,510,000 and $85,080,000, depending on the tip fee for dewatered sludge/sediment ($25-$115 per MT) which is 4 to 13 times higher than Feasible Concept 1. As a result, Feasible Concept 2 received a score of 1.0 for sub-indicator EC1.1.

Leachate Management is detailed in Appendix G - Remediation Detailed Concept Descriptions; and the leachate management capital costs have been incorporated with Feasible Concept 1.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

Once the waste has been moved to a licensed provincial landfill under Feasible Concept 2, the anticipated O&M costs are $0, as these tasks would become the responsibility of the landfill operator. For sub-indicator EC2.1, Feasible Concept 2 received a maximum score of 5.0.

In contrast, the anticipated O&M costs under Feasible Concept 1 are considerably greater, requiring post-closure management of the disposal cell for approximately 25 years[14]. The O&M costs are estimated to range from $5,500,000 to $17,000,000 depending on the leachate disposal option implemented. As a result, Feasible Concept 1 received the minimum score of 1.0 for sub-indicator EC2.1.

4.4.2 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

The remainder of this section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment
- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

In accordance with Project goals, both Feasible Concepts are considered protective of human health and the environment (indicators HS1/2 and EN1/2). Due to the significant volume of truck traffic required to move sludge waste (i.e., estimated 18,200 loads), there is an inherent level of risk associated with Feasible Concept 2 that is difficult to mitigate. However, in comparison to Feasible Concept 1, Feasible Concept 2 does offer a greater level of protection to the environment during the remediation and post-remediation phases of the Project, despite the potential for atmospheric nuisances such as noise and dust (during the remediation phase only). There is no clear preference based on the environmental and H&S considerations for this Project goal.

Although both Feasible Concepts are considered to be constructible/implementable within the established timeframe (per indicator T5), the uncertainties associated with acceptance criteria for D&F for treated sludge disposal in off-Site landfills constitutes a moderate level of risk for Feasible

14 It is assumed that the material within the disposal cell will generate leachate that has concentrations above direct discharge criteria for approximately 25 years, based on best practices. Further characterization of the waste once landfilled is needed to calculate the contaminating life span.

Concept 2, and may cause delays for approvals, or ultimately prevent Feasible Concept 2 from meeting performance criteria or remediation objectives. As result, Feasible Concept 1 would be preferred based on this technical consideration.

In accordance with Project goals, both Feasible Concepts are founded on mature, proven technologies. Both approaches are considered reliable and effective means to managing the waste for the Project, such that there is very little risk associated with either Feasible Concept. There is no clear preference based on the technical consideration for this Project goal.

Feasible Concept 2 is not economically feasible relative to Feasible Concept 1. Implementation of Feasible Concept 1 has the added benefit of potentially providing long-term employment to the PLFN community through performance of monitoring and O&M for the closed cell. Feasible Concept 1 provides the best value to the Province (and taxpayers), and would be preferred based on this economic consideration.

Overall, the comparison of advantages and disadvantages supports selection of Feasible Concept 1 (on-Site disposal) as the preferred Feasible Concept for the management of waste for the Project.

4.5 Summary of Qualified Remedial Option

Based on the results of the numerical evaluation and ranking, comparative analysis, and review of advantages and disadvantages, Feasible Concept 1 – Use Existing Disposal Cell, was selected as the Qualified Remedial Option for the management of dewatered sludge and sediment waste.

Under Feasible Concept 1, the 220,000 m^3 (waste) design capacity of the existing 6.7 ha disposal cell will be exceeded based on the physical properties of the waste and recommended final elevations. The disposal cell will be modified to enhance the leachate collection layer and facilitate placement and dewatering of the sludge/sediment in a one-step operation. Final landfill cover contours will be designed to accommodate the anticipated range of final waste volumes, minimize precipitation infiltration through the cap, control the release of landfill gas, and accommodate end use.

5. Wetland Management

5.1 Background

The Site contains wetlands that have been impacted with Kraft Mill effluent. The areas to be managed include the former effluent discharge area and former Settling Ponds 1, 2, and 3, as shown on Figure 1. The impacted wetlands were used as part of the Kraft Mill wastewater management from 1967 to 1972. Changes to the BHEFT resulted in the effluent being routed by pipe to the twin settling basins and eliminated the use of the wetlands for conveyance/treatment.

Wetlands are a diverse group of natural ecosystems that range from salt marshes to prairie potholes to riparian forests and forested swamps. The wetlands associated with the Site have been classified as marsh and swamp wetlands or a combination of the two wetland types. Wetlands serve as nursery areas for many valuable recreational fish species as well as habitat for a numerous wildlife species included federally and provincially listed species at risk. Wetlands are often rich in nutrients and organic matter and are among the most productive ecosystems as they form the base of complex communities, producing the biomass that forms the base of complex food webs.

The delineation of impacted wetland areas is shown in Appendix E. The impacted area is approximately 38 ha and contains approximately 263,000 m^3 of sludge and root mass to be managed. This estimate was based on results and sediment thickness observed during GHD's Phase 2 ESA and assuming 0.3 m of root mass over the entire impacted area will need to managed.

Wetland management activities will require management of sludge that is impacted with COCs including metals, TPH, PAH, polychlorinated biphenyl (PCB), D&F, and volatile organic compounds (VOC) to be managed, treated, or removed. Analytical results for surface water samples collected from the wetland areas identified concentrations of COCs below applicable screening guidelines or similar to background conditions.

5.2 Development and Identification of Feasible Concepts

Figure 5.1 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

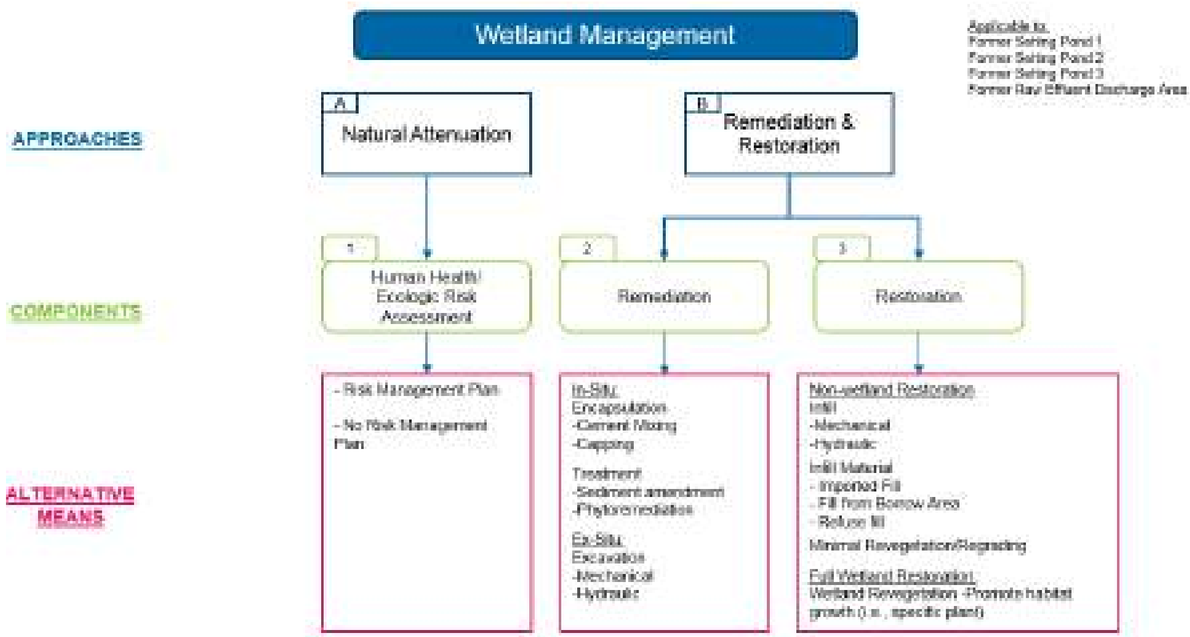


Figure 5.1 Wetland Management Approaches, Components, and Alternative Means

5.2.1 Approaches

Two Approaches were identified for the management of wetlands as part of the BHRD implementation:

A. Natural Attenuation

B. Remediation and Restoration

Approach A involves natural attenuation, which is commonly used as a viable remedial option to address residual impacts to an ecosystem after the contaminant source has been removed or eliminated. As such, with the elimination of the mill effluent to the wetland area, and following planned remediation of other areas of the Site, additional loading of COCs to the wetland area is expected to be significantly reduced or eliminated compared to current conditions and allows for the natural attenuation processes to begin. In association with natural attenuation of COCs in wetlands is the concept of risk assessment. Risk assessment is the process to estimate the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment) now or in the future.

The primary benefit of using the risk-based approach is that it allows for a site-specific evaluation of potential interactions between receptors and contaminants in the environment and focusses future clean-up activities or management programs on the areas of greatest concern. This approach used in conjunction with natural attenuation also has the potential to minimize remedial efforts and unnecessary disturbances to sensitive environments, such as wetlands, that are unlikely to pose an adverse health effect, now or in the future.

Approach B involves remediation of impacted sludge in the wetlands either through in-situ or ex-situ remediation Alternative Means. In-situ remediation refers to techniques to address contamination in place without the removal of the sludge (e.g., encapsulation or treatment); while ex-situ remediation involves direct removal of sludge from the wetlands. Approach B also involves restoration Alternative Means, which include considerations for re-establishing the areas in consideration as either a fully functional wetland area or not (e.g., infilling).

5.2.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the Approach acceptable to the public?
- F1-2: Is the Approach likely to meet applicable regulatory criteria?
- F1-3: Is the Approach likely to meet end-use requirements?

The results of the first Filter application are summarized below in Table 5.1.

Table 5.1 Results of First Filter Step – Wetland Management

Approaches	F1-1 Acceptability	F1-2 Approvability	F1-3 Functionality	Pass/Fail
A. Natural Attenuation	Yes	Yes	Yes	Pass
B. Remediation and Restoration	Yes	Yes	Yes	Pass

Both Approach A and B passed the application of the F1 and were therefore carried for further evaluation.

5.2.3 Identification of Components and Alternative Means

Collectively, the Approaches identified in Section 5.2.1 consisted of the following three components (with a number of associated Alternative Means):

1. Human Health/Ecological Risk Assessment (two Alternative Means)
2. Remediation (six Alternative Means)
3. Restoration (seven Alternative Means)

5.2.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the Alternative Means technically feasible and/or a proven technology?
- F2-2: Is the Alternative Means effective within a reasonable timeframe?
- F2-3: Does the Alternative Means minimize environmental impact and/or is the alternative protective of species at risk?

The results of the application of the F2 are summarized below in Table 5.2. Of the 15 Alternative Means considered, three of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 5.2 Results of Second Filter Step – Wetland Management

Component	Alternative Means	F2-1 Technical	F2-2 Timeframe	F2-3 Environmental	Pass/Fail
1. Human Health/ Ecological Risk Assessment	Risk Management Plan	Yes	Yes	Yes	Pass
	No Risk Management Plan	No	Yes	Yes	Fail
2. Remediation	In-Situ Encapsulation				
	• Cement Mixing	No	Yes	No	Fail
	• Capping	No	Yes	No	Fail
	In-Situ Treatment				
	• Sediment Amendment	No	Yes	No	Fail
	• Phytoremediation	No	No	Yes	Fail
	Ex-Situ Excavation				
	• Mechanical	Yes	Yes	Yes	Pass
	• Hydraulic	No	Yes	Yes	Fail
3. Restoration	Non Wetland Restoration				
	Infill				
	• Mechanical	Yes	Yes	No	Fail

Table 5.2 Results of Second Filter Step – Wetland Management

Component	Alternative Means	F2-1 Technical	F2-2 Timeframe	F2-3 Environmental	Pass/Fail
	• Hydraulic	Yes	Yes	No	Fail
	Infill Material				
	• Imported Fill	Yes	Yes	No	Fail
	• Fill from Borrow Area	Yes	Yes	No	Fail
	• Refuse Fill	Yes	Yes	No	Fail
	Minimal Revegetation/ Regrading	Yes	Yes	No	Fail
	Full Wetland Restoration				
	• Wetland Revegetation to promote habitat growth (i.e., specific plant)	Yes	Yes	Yes	Pass

5.2.4.1 Human Health/Ecological Risk Assessment

The Alternative Means that were considered as part of the human health/ecological risk assessment under Approach A include: development/implementation of a risk management plan, and no development/implementation of a risk management plan. The intent/scope of the risk management plan would include implementation of the findings of the risk assessment (e.g., addressing hot spots, long-term monitoring). It was determined that it would be very unlikely that a risk management plan would not be required (i.e., not technically feasible) due to level of impact.

5.2.4.2 Remediation

The six Alternative Means that were considered as part of wetland remediation under Approach B included: in-situ encapsulation (i.e., cement mixing, capping); in-situ treatment (i.e., sediment amendment, phytoremediation), and ex-situ excavation through mechanical or hydraulic means.

In-situ encapsulation techniques considered included:

- Cement mixing: converts sludge into a less soluble form and prevents leaching by adding Portland cement and bulking agents to solidify the sludge in place.
- Capping: is the process of placing a clean layer of sand, sediment, or other material over the sludge. The cap can incorporate a geotextile to aid in layer separation or geotechnical stability, as well as amendments to enhance level of protection.

In-situ treatment techniques considered included:

- Sediment amendment: Adding chemical binding agents in place such as activated carbon, organoclay, or phosphate salts to immobilize/treat contaminants in the sludge.

- Phytoremediation: Is a bioremediation process that uses various types of plants to uptake, degrade, and immobilize contaminants in water and sediment.

The results of the application of the F2 eliminated all in-situ treatment Alternative Means as the sole solution to remediate the wetlands. The implementation of cement mixing, capping, sediment amendment, or phytoremediation was determined non-feasible due to technical uncertainties around the effectiveness of each Alternatives Means noting that the wetland end use has not been fully defined (e.g., consumption of food). Furthermore, phytoremediation was also considered to require an excessive timeline to implement. Phytoremediation would transfer contaminants to another media (i.e., foliage) that would subsequently require remediation or some form of disposal.

The in-situ Alternative Means, however, could potentially be used as part of a risk management plan to address any identified hot spots to minimize intrusive/destructive activities. Bench and/or pilot scale would be required to further validate the effectiveness of the in-situ treatment approaches.

The results of the application of the F2 also eliminated the use of hydraulic excavation as a means of ex-situ remediation/excavation, due to its lack of technical feasibility. Hydraulic excavation was unlikely to be an effective means of remediation given the depth of water varies and would not facilitate hydraulic dredging equipment which requires a minimum of a 0.8-1.0 m water depth. In addition, this approach is ineffective at removing impacted sediments that are bound by vegetation/root mass hydraulically.

5.2.4.3 Restoration

The seven Alternative Means that were considered as part of wetland restoration under Approach B included means that considered full wetland restoration (e.g., to promote specific or targeted habitat growth and traditional use); or did not consider full wetland restoration: infill by mechanical or hydraulic means; infill of imported, borrow area, or refuse fill; and partial revegetation.

All Alternative Means that did not involve restoring the wetland (i.e., infilling or partial revegetation) were eliminated due to environmental impact considerations including given wetland compensation requirements (i.e., establishing new Site wetlands yielding a minimum net positive environmental benefit at a 2:1 replacement ratio).

Benefits of full wetland restoration include a favourable perception by the public and PLFN, supporting existing natural habitat and traditional uses, and minimizing the need for a wetland compensation plan.

5.3 Feasible Concept Description

Following application of the second Filter (F2) step described in Section 5.2.5, each remaining Approach, Component, and Alternative Means was grouped into the following logical Feasible Concepts:

- Feasible Concept 1 – Natural attenuation
- Feasible Concept 2 – Ex-situ remediation

It is noted that Feasible Concept 1 (natural attenuation) is not considered for any PLFN land including Indian Reserve land. Only full removal of impacted sediments has been assumed for PLFN land.

The remainder of this Section presents descriptions of the Feasible Concepts that were carried forward for Wetland Management as part of the BHRD. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix E.

5.3.1 Feasible Concept 1 – Natural Attenuation

Feasible Concept 1 is based on Approach A discussed in Section 5.2.1. Following the elimination of the mill effluent and the implementation of the planned remediation of other areas of the Site, natural attenuation processes will begin on Site.

In addition to natural attenuation of COCs in wetlands, a human health/ecological risk assessment will be conducted in order to estimate the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment), now or in the future. The risk assessment would include analysis of theoretical models such as bioavailability model in conjunction with field investigation. Sampling of biological tissue such as plants (including fruits and berries), fish, birds, and/or small mammals will be required.

The human health/ecological risk assessment will be followed by development of a risk management plan, which will address the findings of the human health/ecological risk assessment. At first sight, since several of the COCs associated with the Site are potentially bio-accumulative (i.e., D&F, PCBs, mercury), the human health/ecological risk assessment would likely identify hotspots in the wetland areas that require active remediation or risk management measures. As mentioned above in Section 5.2.4.1, it was determined that it would be very unlikely that a risk management plan would not be required (i.e., not technically feasible).

If isolated hotspots exist and risk management is deemed insufficient, active remediation of select areas will be completed. This may include full remediation through ex-situ impact removal (as discussed under Feasible Concept 2 below) or preferably would consist of less destructive in-situ remediation. In-situ techniques include enhanced natural recovery and encapsulation.

Finally, a post-remediation monitoring program up to 5 years will be implemented to monitor the Site and confirm the effectiveness of the natural attenuation.

It is noted that natural attenuation is not applicable to portions of wetlands located on PLFN land including Indian Reserve land. Only full removal of impacted sediments has been assumed for these lands.

5.3.2 Feasible Concept 2 - Ex-Situ Remediation

Feasible Concept 2 consists of the complete removal of the approximately 263,000 m^3 of contaminated sludge/sediment and root mass present in the former effluent discharge area and former Settling Ponds 1, 2, and 3.

The wetlands will be dewatered, as needed, and impacted sediments will be removed through excavation using land-based earthmoving equipment. Dewatering is required for equipment access and will limit re-suspension and dispersion of impacted sediments into surface water downstream of the work area. Installation and continuous operation of a pumping system to maintain a dewatered condition would be accomplished through the establishment of sumps in several locations through out the wetland and pumping the water from bulk dewatering to the selected bulk water treatment area[15]. Sumps could be established in open water first, with additional sumps added as needed. Sumps could be established using a perforated steel chamber filled with clear stone to minimize sedimentation.

Construction of access roads around the wetlands to facilitate dewatering and removal activities would be required. Targeted sediment excavation would be completed to limit level of disturbance. Excavators will remove wetland vegetation and root mass as well as sludge, stockpile it at the base of the dewatered area, and load it into dump trucks (sealed as required) or into a hopper for pumping. Dozers may be used to push and stockpile sludge. Specialized equipment may be required; for example a swamp buggy excavator with pontoon tracks could be used to better travel across soft and wet ground. Confirmatory sampling will be completed post remediation to confirm that the remaining sediment meets the applicable remedial quality standards for all sediment COCs.

Once excavated, sediment will be managed similarly to the sludge removed from the rest of the Site. This will involve pumping or hauling the sediment to a sludge management area for further treatment and/or dewatering prior to disposal.

The implementation of Feasible Concept 2 will require careful consideration as to not negatively impact existing wildlife. During dewatering activities, a wildlife removal plan may be required to trap and relocate fish or other aquatic wildlife species. To limit the impact on any fish and other wildlife populations within the system, water levels in the wetlands would only be lowered to a level sufficient for the removal of contaminated sediment. The requirement to conduct a wildlife removal program should be determined in consultation with Department of Fisheries and Oceans (DFO) and NSE. Secondly, to mitigate potential impacts to waterfowl and other migratory birds as well as breeding or spawning aquatic wildlife such as anurans, the construction activities may be limited to late summer or early winter months. These seasonal periods are typically not considered sensitive spawning/breeding/nesting periods and also generally coincide with dry periods which would limit dewatering requirements.

Feasible Concept 2 will effectively reduce or eliminate the potential for unacceptable risk to ecological receptors by removing the exposure pathway, however, it would cause significant short-term damage to the existing habitat. Following the removal of impacted sediment and infilling and regrading to match the existing hydraulic regime, Feasible Concept 2 will involve restoration of the construction areas including the planting or seeding of native aquatic and terrestrial vegetation. It is important that native species be seeded or planted that are tolerant of the hydrological regimes that would be established following remedial activities. To ensure success of any re-vegetation effort, water budgets that take into account any alteration of inflows and outflows should be developed and used to identify seeding or planting zones within the wetlands. A review of historical

[15] As outlined in Appendix G Remediation Detailed Concept Descriptions

occurrence of species in the region would also be useful in developing a detailed vegetation planting plan to re-establish the Site.

5.3.3 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix E, Attachment E1 and summarized on Table 5.3 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost for an estimated 5-year period have been carried for Feasible Concept 1.

Table 5.3 Class D Cost Estimate – Wetland Management

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – Natural Attenuation	$17,420,000	$830,000
Feasible Concept 2 – Ex-Situ Remediation	$41,590,000	$0

Key assumptions include:

- For Feasible Concept 1, ex-situ remediation will be required on PLFN and IR land
- For Feasible Concept 1, a contingency for active remediation of hotspots identified during risk assessment is carried at 25 percent of the full Feasible Concept 2 ex-situ remediation cost
- For Feasible Concept 1, post remediation monitoring for 5 years with parameter limitations noted in cost table
- For Feasible Concept 2, excavated sludge will be pumped to the sludge management area and dewatered using geotubes and treatment of water required as detailed in Appendix G Remediation Detailed Concept Descriptions
- Wetlands disturbed as part of active remediation will be restored/compensated at a rate of 2:1
- Bulk dewatering required for active remediation accounts for a 1:100 year storm

5.4 Evaluation of Feasible Concepts

The Feasible Concepts carried forward for Wetland Management as part of the BHRD were evaluated, compared, and ranked to identify the most suitable concept for consideration as a Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation), as well as the identification and comparison of advantages/disadvantages for each Feasible Concept.

5.4.1 Comparative Evaluation

The completed evaluation and weighting matrix for wetland management alternatives is presented in Appendix H. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 5.4 presents a summary of the matrix scores for each Feasible Concept. As demonstrated by the matrix scores, Feasible Concept 2 (ex-situ remediation) was deemed preferable to Feasible Concept 1 (natural attenuation).

Table 5.4 Summary of Matrix Scores – Wetland Management

Criteria Category	Weighting Factor	Feasible Concept 1 (Natural Attenuation)	Feasible Concept 2 (Ex-situ Remediation)
Regulatory	14%	**400**	388
Technical	26%	440	**449**
Environmental	24%	**405**	330
Social	14%	200	**394**
Economic	22%	**300**	**300**
Total Comparative Score		1745	**1860**
Total Weighted Score		362	**371**
Rank		2	**1**

5.4.1.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Feasible Concept 1 (natural attenuation) ranked higher than Feasible Concept 2 (ex-situ remediation). Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

The level of risk associated with public health and safety was considered to be very low for both Feasible Concepts. Under Feasible Concept 2, only short-term risks were identified during the removal activities, such as increased vehicle emissions and dust, and potential exposure to air emissions and odors resulting from excavation and removal of contaminated sediment. However, the likelihood of exposure or risk to public health and safety was considered low since removal activities are concentrated in the middle of the Site. In comparison, long-term risks were associated with Feasible Concept 1 due to contamination being left in place, but the risk to public health and safety was minimal since there were no direct exposure pathways. As a result, both Feasible Concepts received a score of 4.0 for sub-indicator HS1.1.

For sub-indicator HS1.2, the potential risks to public health and safety during wetland management were generally considered to be easily mitigatable. However, Feasible Concept 2 scored higher than Feasible Concept 1 since exposure to identified on-site risks during remediation would occur over a shorter period of time and mitigation measures could be implemented (e.g., use of an odour dispersion mister combined with perimeter air monitoring). As a result, Feasible Concept 2 received a score of 5.0 for sub-indicator HS1.2, while Feasible Concept 1 scored 4.0.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

The level of risk to worker health and safety was considered to be very low for both Feasible Concepts.

Feasible Concept 2 required the use of earthmoving equipment, management of 263,000 m^3 of impacted sediment, and dewatering of the impacted wetlands. These removal activities created a direct exposure pathway to COCs, and included several potential risks for workers such as work near open water, and typical health and safety risks associated with general construction (i.e., working at heights, use of heavy equipment, slips/trips/falls, etc.). Feasible Concept 2 received a score of 4.0 for sub-indicator HS2.1.

By comparison, Feasible Concept 1 required significantly less intrusive fieldwork on Site, and less interaction or exposure to COCs. However, there is an inherent level of uncertainty regarding the effectiveness of natural attenuation. As a result, Feasible Concept 1 also received a score of 4.0 for sub-indicator HS2.1.

The potential risks to worker health and safety during wetland management are quite common, and generally considered to be easily mitigatable for both Feasible Concepts. For Feasible Concept 2, the implementation of proper site planning and controls, standard safety methods on a construction site, and use of PPE will mitigate the anticipated risks by adapting to the specific conditions on Site. As a result, both Feasible Concepts received a score of 4.0 for sub-indicator HS2.2.

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

Both Feasible Concepts were considered to have a generally high level of compliance for ease of approvability. Under Feasible Concept 2, the time frame needed to completely restore the wetlands following ex-situ remediation activities is very long, and implementation of a compensation plan may be required to ensure approvability. As a result, Feasible Concept 2 received a score of 4.0 for sub-indicator C1.1, while Feasible Concept 1 received a score of 5.0.

For sub-indicator C1.2, both Feasible Concepts were considered to have only a moderate level of public acceptance from PLFN and the surrounding communities. It is anticipated that both Feasible Concepts will face the same level of public scrutiny. Under Feasible Concept 1, uncertainty regarding the level of impact to existing flora and fauna in the wetland will remain throughout the natural attenuation process. In comparison, the public perception of the intrusive works necessary under Feasible Concept 2 (causing the temporary destruction of functional wetlands) will be negative, despite the fact that the wetlands will eventually regain its ecological functions after approximately 25 years. As a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 3.0 for sub-indicator C1.2.

5.4.1.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project.

Feasible Concept 2 (ex-situ remediation) ranked higher than Feasible Concept 1 (natural attenuation). Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

Both Feasible Concepts were considered reliable and successful approaches for wetland management. Similarly, the materials and equipment required to implement both Feasible Concepts were considered readily available, as were the vendors and contractors required to implement the remediation. As a result, both Feasible Concepts received a score of 5.0 for sub-indicators T1.2 and T1.3.

Despite the fact that Feasible Concept 1 is based on widely-accepted scientific methodology and approach, uncertainty remains because natural attenuation is not as proven, and as a result Feasible Concept 1 requires more effort to document case studies to demonstrate a successful track record. In comparison, Feasible Concept 2 was considered slightly more successful considering the proven or successful track record of ex-situ remediation. As a result, Feasible Concept 1 received a score of 4.0 for sub-indicator T1.1, while Feasible Concept 2 scored 5.0.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criterion discussed in Section 4.4.1.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1 with current on-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints for all five sub-indicators. Site compatibility was one of the strengths of Feasible Concept 1, largely due to significantly less intrusive work as compared to Feasible Concept 2. As a result, Feasible Concept 1 received a score of 5.0 for sub-indicators T2.1 through T2.5.

Under Feasible Concept 2, the compatibility with current on-Site features was also identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints for sub-indicator T.2.1. However, Feasible Concept 2 will impact Site hydrogeology and hydrology due to remedial activities (i.e., dewatering, sludge removal, and restoration). The compatibility of Feasible Concept 2 with these features was considered an average constraint, and as a result Feasible Concept 2 received a score of 3.0 for sub-indicators T2.2 through T2.5.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

The compatibility of Feasible Concept 1 and Feasible Concept 2 with current off-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints for most sub-indicators. Both Feasible Concept 1 and Feasible Concept 2 received scores of 5.0 for sub-indicators T3.1 and T3.3.

Feasible Concept 2 will have a greater impact on off-Site conditions (i.e., traffic) due to general construction for mobilizing and demobilizing equipment and due to the quantity of organic material that will be required to be imported for wetland restoration. As a result, Feasible Concept 2 received a score of 4.0 for sub-indicator question T3.2, while Feasible Concept 1 received a score of 5.0.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicators T4.1 and T4.2, the components of each Feasible Concept were not expected to fail within the remediation and post-remediation period, and the relative maintenance requirements during the remediation and post-remediation period were considered low. As a result, both Feasible Concepts received a score of 5.0 for these two sub-indicators.

Under Feasible Concept 2, performance criteria and remediation objectives were expected to be met readily due to the complete removal of impacted sediments and the confirmatory sampling program implemented during remediation. In comparison, under Feasible Concept 1 performance criteria and remediation objectives were considered only likely to be met, due to the potential uncertainty of complete effectiveness of natural attenuation processes on-Site, and dependence upon the findings identified in the Risk Assessment. As a result, Feasible Concept 2 received scores of 5.0 for sub-indicators T4.3 to T.4.5, while Feasible Concept 1 received moderate scores of 3.0.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

The anticipated timeframe required to implement Feasible Concept 1 and Feasible Concept 2 was considered to be less than four years; as a result, both Feasible Concepts received a maximum score of 5.0 for both sub-indicators.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

During the remediation phase, Feasible Concept 2 was identified as easier to monitor while Feasible Concept 1 needs average monitoring and testing effort. The monitoring program for Feasible Concept 2 consists of confirmatory sampling of sediment, while the Feasible Concept 1 monitoring program includes significant sampling of sediment, invertebrates, pore water, and biological tissue. Following the findings of the risk assessment, some additional monitoring activities might also be required for hotspots. As a result, Feasible Concept 1 received a score of 3.0 for sub-indicator T6.1, while Feasible Concept 2 received a score of 5.0.

During the post-remediation phase, both Feasible Concepts were considered readily monitored and tested. Accordingly, both Feasible Concepts received the maximum score of 5.0 for sub-indicator T6.2.

For sub-indicator T6.3, Feasible Concept 1 was considered to require the maximum amount of monitoring and testing to ensure effectiveness of the method; at a minimum, testing will include sampling of sediment, invertebrates, pore water, and biological tissue; as well as a minimum of 5 years of monitoring post implementation of Feasible Concept 1. In comparison, Feasible Concept 2 will only include confirmatory sampling of sediments after removal. As a result, Feasible Concept 1 received a score of 1.0 while Feasible Concept 2 received a score of 3.0 for sub-indicator T6.3

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase, Feasible Concept 2 will generate a relatively high amount of waste through the dewatering of wetlands and the removal of impacted sediment. It was estimated that approximately 263,000 m^3 of sludge and root mass will have to be managed. In comparison, Feasible Concept 1 was considered to generate a significantly smaller amount of waste; depending on the results of the risk assessment, there may be individual hot-spots that will be addressed with ex-situ remediation during the implementation of natural attenuation. Accordingly, Feasible Concept 1 received a score of 4.0 while Feasible Concept 2 received a score of 2.0 for sub-indicator T7.1.

During the post-remediation phase, both Feasible Concepts were considered to generate a minimal amount of waste generation. However, Feasible Concept 1 was scored lower due to the potential post-remediation activities required if wetland areas do not meet performance criteria and remediation objectives. Accordingly, Feasible Concept 1 received a score of 4.0 while Feasible Concept 2 received a score of 5.0 for sub-indicator T7.2.

Both Feasible Concepts were expected to generate minimal (i.e., negligible) amounts of hazardous/dangerous goods and as a result, both Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.3.

5.4.1.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events.

Feasible Concept 1 (ex-situ remediation) ranked higher than Feasible Concept 2 (natural attenuation). Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1a Atmospheric Environment

EN1.1b Aquatic Environment

EN1.1c Geology and Groundwater

EN1.1d Terrestrial Environment

During the remediation phase, Feasible Concept 2 was identified to have a higher environmental impact than Feasible Concept 1 due to the amount of intrusive work required on Site, which will significantly affect sediment, groundwater, and surface water quality, as well as fish communities and habitats, benthic invertebrate communities, etc.

For sub-indicator EN1.1a, very little separated the atmospheric environmental impact scoring. Moderate adverse effects were identified for air quality under Feasible Concept 2 for workers due to exposed sludge (i.e., under dewatered conditions) and increased vehicle emissions and dust emissions associated with earthmoving equipment. However, impacts to air quality for the public would be limited as emissions would be concentrated in the middle of the Site and would not likely migrate off-Site.

For sub-indicator EN1.1b, Feasible Concept 2 would cause destruction of habitat due to intrusive activities (e.g., dewatering, sediment removal, road construction). In addition, for sub-indicators EN1.1c and EN1.1d for the same reason (intrusive activities), Feasible Concept 2 could potentially cause impact to groundwater, surface water, and soil quality and cause some impact to the terrestrial environment in the vicinity of the impacted wetlands.

For sub-indicators EN1, Feasible Concept 1 received a score of 4.1, while Feasible Concept 2 received a score of 2.4.

EN2 – Post-remediation Phase Effects – 50 Percent of Environmental

Similarly, environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1a Atmospheric Environment

EN2.1b Aquatic Environment

EN2.1c Geology and Groundwater

EN2.1d Terrestrial Environment

During the post-remediation phase, very little separated the environmental impact scoring of each Feasible Concept. Feasible Concept 2 scored higher (under sub-indicator EN2.1c) for impacts to general groundwater and soil quality due to the complete removal of contaminated sediments.

During the post-remediation phase, both Feasible Concepts were considered to cause moderate adverse effects to the aquatic (EN2.1B) and terrestrial (EN2.1D) environments. Under Feasible Concept 1, the potential impacts resulted from the contamination left in place and associated with potential intrusive work required depending on the findings of the risk assessment. Under Feasible Concept 2, the aquatic and terrestrial environments would be impacted due to intrusive work and be moderately effected post-remediation as the wetlands re-establishes.

For sub-indicators EN2, Feasible Concept 1 received a score of 3.6, while Feasible Concept 2 received a score of 3.9.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential susceptibility of each Feasible Concept to inclement and severe weather events during the remediation and post remediation phase. The sub-indicator questions for these weather effects included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

Under Feasible Concept 1, on-Site condition will almost remain steady and therefore weather conditions will not affect the implementation, post-remediation, and the suitability (i.e., during extreme weather events) of Feasible Concept 1. Feasible Concept 2 was identified as moderately susceptible to inclement weather for all three sub-indicators. Under Feasible Concept 2, severe weather events could affect the excavation and restoration work schedule during the remediation phase. As a result, Feasible Concept 1 received scores of 5.0 for sub-indicators EN3.1 to EN3.3, while Feasible Concept 2 received scores of 3.0 for sub-indicators EN3.1 to EN3.3.

5.4.1.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept.

Feasible Concept 2 (in-situ remediation) ranked higher than Feasible Concept 1 (natural attenuation). Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Community Acceptance indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surroundings community during post remediation phase (i.e., safety, visual, nuisance)?

Under Feasible Concept 2 the wetlands will be fully remediated, however, will likely take up to 25 years to regain full ecological function as compared to current conditions. While some members of the surrounding community may embrace the direct removal of contaminants by an intrusive method, others may perceive this approach as the destruction of natural habitat. As a result, Feasible Concept 2 received scores of 3.0 and 4.0 for sub-indicators S1.1 and S1.4 (respectively). Under the more passive approach of Feasible Concept 1, contaminants are being kept in place and as a result, post-remediation monitoring requirements will prevent full use of Boat Harbour until natural attenuation processes have been confirmed effective. This approach is likely to receive minimal community acceptance, despite the fact that the wetlands will remain largely intact. As a result, Feasible Concept 1 received scores of 1.0 for sub-indicators S1.1 and S1.4.

During the remediation phase, both Feasible Concepts were considered to have no effect on the surrounding communities from a safety or nuisance perspective. Since the remediation will be conducted in the middle of the Site, there are no potential receptors nearby to be affected, and impacts due to noise or vehicle traffic will be minimal. As a result, both Feasible Concepts received a score of 3.0 sub-indicator S1.3.

During the post-remediation phase, members of the surrounding community may have a low risk tolerance, and may not be comfortable with contamination left in place even if the risk assessment has determined that current concentrations of COCs in wetland areas do not pose an unacceptable risk to ecological receptors or human health. As a result, Feasible Concept 1 received a score of 3.0 for sub-indicator S1.2 while Feasible Concept 2 received a score of 5.0.

S2 - Community Benefit – 75 Percent of Social

Community Acceptance indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)

The remediation of Boat Harbour and return to tidal conditions will have direct and indirect positive social impacts on the surrounding communities, from increased recreational use of Boat Harbour, to allowing the PLFN community to reestablish its relationship with the water and land of A'se'k. From an economic perspective, remediation of Boat Harbour may also increase tourism in the area once the harbor is returned to tidal conditions.

Implementation of Feasible Concept 2 will provide more positive social impacts by enabling use of the wetlands immediately following remediation. This will provide recreational and human health benefits for PLFN and the surrounding community, and may potentially provide traditional benefits for PLFN. However, there are no direct economic benefits associated with Feasible Concept 2, and the wetland functionally will be impaired and may take up to 25 years to fully recover. Feasible Concept 2 received a score of 4.0 for sub-indicator S2.1.

Under Feasible Concept 1, the post-remediation monitoring requirements may benefit the community through potential involvement in monitoring activities (minimum 5 years). However, post-remediation monitoring requirements will also prevent full use of the wetlands until natural attenuation processes have been confirmed effective. This approach significantly delays any human health or recreational benefits resulting from the remediation of the wetlands. As a result, Feasible Concept 1 received a score of 2.0 for sub-indicator S2.1.

5.4.1.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs for planning and implementation (i.e., capital costs) and for ongoing O&M costs.

Feasible Concept 1 (natural attenuation) and Feasible Concept 2 (ex-situ remediation) ranked the same based on economic indicators. Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 1 was estimated to be $17,420,000 and was the lowest cost of the two Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 1 received a maximum score of 5.0.

The capital cost of Feasible Concept 2 was estimated to be $41,590,000, which is approximately 2.39 times higher than Feasible Concept 1. As a result, Feasible Concept 2 received a score of 1.0 for sub-indicator EC1.1.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

Considering that the impacted sediment will be removed and no further work will be required after the remediation phase, Feasible Concept 2 received a score of 5.0, while the intensive monitoring requirements associated with natural attenuation under Feasible Concept 1 received a score of 1.0 for sub-indicator EC2.1.

5.4.2 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

The remainder of this section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment
- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

In accordance with Project goals, both Feasible Concepts were considered protective of human health (indicators HS1/2). Due to the significant amount of earthmoving equipment needed to remove all impacted sediments (i.e., estimated 263,000 m^3), there was moderate risk associated with Feasible Concept 2 for the workers, but the risk was considered easy to mitigate and therefore did not impact the selection of the Feasible Concept. There was no clear preference based on the H&S considerations.

Regarding the environmental impact during the remediation phase of the Project, Feasible Concept 1 clearly offered a greater level of protection to the environment. Feasible Concept 1 did not required massive modification to the on-Site conditions, as only a few hotspots may need active remediation or ex-situ works. As a result, Feasible Concept 1 was preferred based on this environmental consideration.

During the post-remediation phase of the Project, both Feasible Concepts have some disadvantages. For Feasible Concept 1, there may be public concerns with regards to impacted material being left in place. For Feasible Concept 2, the wetlands require a minimum of 25 years to regain the same functionality as to current conditions. As a result, there was no preference post-remediation.

In accordance with Project goals, both Feasible Concepts were considered to be constructible/implementable within the established timeframe (per indicator T5). There was no clear preference based on timelines and milestones. However, it is noted that there would be a minimum of 5 years of monitoring associated with a risk management plan (Feasible Concept 1).

In accordance with Project goals, both Feasible Concepts were founded on mature, proven technologies. Both approaches were considered reliable and effective approaches to manage impacted wetlands. However, Feasible Concept 2 was considered to have a more successful or proven track record than Feasible Concept 1.

Economically, Feasible Concept 1 provided the best value for to the Province. The capital costs were much higher for Feasible Concept 2 than Feasible Concept 1. However, Feasible Concept 2 will more positively affect the surrounding communities, and cost significantly less during the post-remediation phase.

Overall, the comparison of advantages and disadvantages does not clearly support the selection of one Feasible Concept over another. This result is to be expected considering the comparative evaluation scores were so close. The major difference in the evaluation of Feasible Concepts for wetland management comes down to costs (i.e., capital and O&M costs) and resulting environmental impact during the remediation phase.

5.5 Summary of Qualified Remedial Option

Based on the results of the numerical evaluation and ranking, comparative analysis, and review of advantages and disadvantages, Feasible Concept 2 - Ex-Situ Remediation was selected as the Qualified Remedial Option for the management of wetlands.

Feasible Concept 2 will involve complete removal of the approximately 263,000 m^3 of contaminated sludge/sediment and root mass present in Former Settling Ponds 1, 2 and 3. A continuous pumping system will be established and maintained through the installation of sumps in several locations. Impacted sediments will be removed by excavation using land-based earthmoving equipment, and subsequently managed in the same manner as all other sludge/sediment removed from the rest of the Site. Organic material matching the former hydraulic regime will be brought on-Site as part of wetland restoration activities. The restoration phase will include, in addition to the infilling and regrading of wetlands, planting or seeding of native aquatic and terrestrial vegetation in the construction areas.

6. Infrastructure Decommissioning

6.1 Background

The following sections describe the Feasible Concepts for the infrastructure required to be decommissioned as part of the Project.

Key infrastructure components that will need to be decommissioned include:

- Pipeline: The pipeline includes approximately 2,305 m of 0.915 m diameter fiberglass reinforced plastic pipe (RPP) buried on land; and approximately 1,220 m of 1.1 m diameter high density polyethylene (HDPE) pipe buried at the bottom of the East River.
- Treatment Buildings: There are 10 buildings and several small structures that form part of the BHETF. Buildings are typically slab on grade construction or trailer based. Structures include inlet/outlet weirs, retaining walls, maintenance holes, etc.
- Dam: The dam is located north of the Highway 348 causeway and is designed to allow the levels in the Boat Harbour stabilization lagoon to be controlled while blocking the tidal inflow. The dam is approximately 25 m wide and is connected to the banks of the estuary with earthen berms.

Infrastructure decommissioning has a number of Design Component categories containing common Approaches, Components, and Alternative Means; the categories for this Design Component include:

- Pipeline Decommissioning – On Land
- Pipeline Decommissioning – Under Water
- Treatment Buildings
- Dam

Development of Feasible Concepts for each of these four infrastructure decommissioning categories is described in the following Sections 6.2 to 6.5.

6.2 Pipeline on Land

The pipeline is located on multiple properties including Kraft Mill, residential, Provincial, and First Nation properties. The alignment of the pipeline is shown on Figure 1.

6.2.1 Development and Identification of Feasible Concepts

Figure 6.1 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

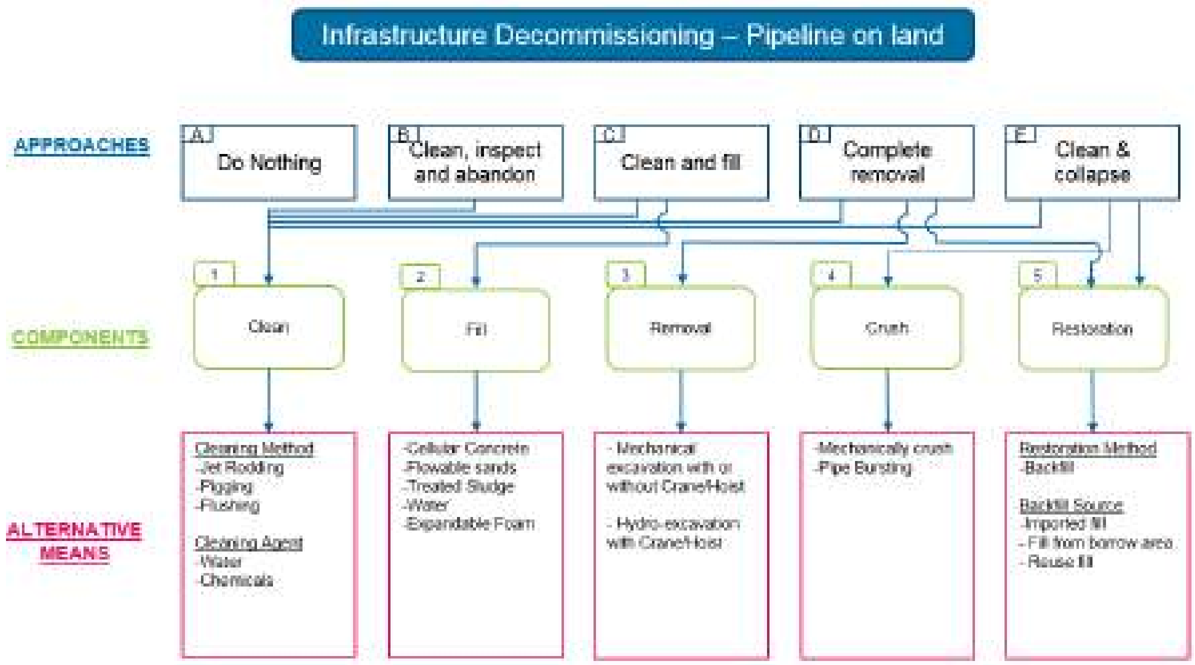


Figure 6.1 Pipeline on Land Decommissioning Approaches, Components, and Alternative Means

6.2.1.1 Approaches

Five Approaches were identified for decommissioning the on land portion of the pipeline as part of the overall infrastructure decommissioning to be conducted during BHRD implementation:

A. Do Nothing

B. Clean, Inspect, and Abandon

C. Clean and Fill

D. Complete Removal

E. Clean and Collapse

With the exception of the Do Nothing alternative (Approach A), common to all Approaches was the cleaning of the pipeline in its entirety, regardless of whether the pipeline is to be removed, filled, or abandoned. Cleaning will remove accumulated solid residue and other liquids that might otherwise be released during decommissioning activities, or pose as an environmental risk/liability should the pipeline be abandoned in place.

The remaining Approaches (B through E) included various methods to decommission the on land portion of the pipeline, including abandonment in place after filling or collapsing the pipe, or removing the pipeline altogether.

6.2.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Are decommissioning requirements likely achievable (e.g., owners, regulatory, end use)?
- F1-2: Is long-term liability minimized?
- F1-3: Does the approach minimize environmental impact?

The results of the F1 application are summarized below in Table 6.1.

Table 6.1 Results of First Filter Step

Approaches	F1-1 Regulatory Approvability	F1-2 Reduced Liability	F1-3 Minimize Env. Impact	Pass/Fail
A. Do Nothing	Yes	No	No	Fail
B. Clean, Inspect and Abandon	Yes	Yes	Yes	Pass
C. Clean and Fill	Yes	Yes	Yes	Pass
D. Complete Removal	Yes	Yes	Yes	Pass
E. Clean and Collapse	Yes	Yes	Yes	Pass

Of the five Approaches considered, only the Do Nothing alternative (Approach A) was removed from further consideration as it failed due to long term liability and potential environmental impact considerations due to potential failure/collapse. This Approach was also unlikely to meet anticipated land owner requirements.

All other Approaches were determined to warrant further evaluation and were therefore carried forward for further evaluation.

6.2.1.3 Identification of Components and Alternative Means

Remaining Approaches B through E consisted of the following components (with a number of associated Alternative Means):

1. Clean (five Alternative Means)
2. Fill (five Alternative Means)

3. Removal (two Alternative Means)
4. Crush (two Alternative Means)
5. Restoration (four Alternative Means)

6.2.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the Alternative Means technically feasible?
- F2-2: Is the Alternative Means acceptable to the public?
- F2-3: Is the Alternative Means cost effective?

The results of the application of the F2 are summarized below in Table 6.2. Of the 18 Alternative Means considered, 11 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 6.2 Results of Second Filter Step

Component	Alternative Means	F2-1 Technical	F2-2 Public	F2-3 Cost	Pass/Fail
1. Clean	Cleaning Method				
	• Jet Rodding	Yes	Yes	Yes	Pass
	• Pigging	Yes	Yes	Yes	Pass
	• Flushing	Yes	Yes	Yes	Pass
	Cleaning Agent				
	• Water	Yes	Yes	Yes	Pass
	• Chemicals	Yes	No	Yes	Fail
2. Fill	• Cellular Concrete	Yes	Yes	Yes	Pass
	• Flowable sands	No	Yes	Yes	Fail
	• Treated Sludge	No	No	Yes	Fail
	• Water	No	Yes	Yes	Fail
	• Expandable Foam	Yes	Yes	Yes	Pass
3. Removal	• Mechanical excavation with or without Crane/Hoist	Yes	Yes	Yes	Pass
	• Hydro-excavation with Crane/Hoist	No	Yes	No	Fail
4. Crush	• Mechanically crush	No	Yes	Yes	Fail
	• Pipe Bursting	No	Yes	Yes	Fail
5. Restoration	Restoration Method				
	• Backfill	Yes	Yes	Yes	Pass
	Backfill Source				
	• Imported fill	Yes	Yes	Yes	Pass

Table 6.2 Results of Second Filter Step

Component	Alternative Means	F2-1 Technical	F2-2 Public	F2-3 Cost	Pass/Fail
	• Fill from borrow area	Yes	Yes	Yes	Pass
	• Reuse fill	Yes	Yes	Yes	Pass

6.2.1.4.1 Clean

Common to all Approaches was the cleaning of the pipeline in its entirety. The three cleaning methods that were considered as part of this Component under Approaches B through E included: flushing, jet rodding, and pigging. All three Alternative Means passed application of the second filter and were considered to be technically feasible and cost effective options.

Application of the second filter eliminated the use of chemicals as a potential cleaning agent, as this Alternative Means was unlikely to meet public acceptability. As a result, water will be used as the cleaning agent in all instances to eliminate public scrutiny and remove any risks to the environment (i.e., unforeseen leaks).

6.2.1.4.2 Fill

The five Alternative Means that were considered as part of the fill Component under Approach C included: cellular concrete, flowable sands, treated sludge, water, and expandable foam. Only cellular concrete and expandable foam passed application of the F2 and were considered technically feasible, cost effective options capable of meeting design requirements.

Flowable sands were determined to be not technically feasible for this particular application due to the limited distance which this material can be pumped.

The use of treated sludge and water as potential fill material were also considered technically unfeasible options. Using treated sludge and water as fill materials were eliminated due to not being foreseen long term at effectively preventing a crushing hazard due to the potential for leaks from the pipeline.

6.2.1.4.3 Removal

The two Alternative Means that were considered as part of the removal Component under Approach D included: mechanical excavation (with or without crane/hoist) and hydro-excavation (with crane/hoist). Only mechanical excavation passed application of the F2, and was considered the only technically feasible, cost effective option capable of meeting design requirements.

Hydro-excavation was considered to be not technically feasible for removal of the on land portion of the pipeline due to the potential presence of boulders in the subsurface, and was also a significantly more costly alternative.

6.2.1.4.4 Crush

The two Alternative Means that were considered as part of the crush in place Component under Approach E included: mechanically crush and pipe bursting. Both Alternative Means were considered to be not technically feasible, as the RPP pipe was expected to deform, but not likely break using these methods.

6.2.1.4.5 Restoration

The four Alternative Means that were considered as part of the restoration Component under Approaches D and E included: backfill (as the single restoration method), and imported fill, fill from the Site borrow area, and reused fill from other Site activities as the potential backfill sources. All Alternative Means under the restoration Component passed application of the F2 and were considered technically feasible, cost effective options capable of meeting design requirements.

6.2.2 Feasible Concept Description

Following application of the F2 step the remaining Approaches, Components, and Alternative Means were grouped into the following logical Feasible Concepts:

- Feasible Concept 1 – Clean, inspect, and abandon in place
- Feasible Concept 2 – Clean, fill, and abandon in place
- Feasible Concept 3 – Complete removal

Other identified Alternative Means (i.e., cleaning method and fill material) were deemed to be alternatives that could potentially be evaluated as needed with the development of the Detailed Concept Description for each Feasible Concept (e.g., identifying the preference between cleaning methods, as needed).

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix F.

6.2.2.1 Feasible Concept 1 – Clean, Inspect, and Abandon in Place

Feasible Concept 1 consists of cleaning the pipeline, performing an inspection, and abandonment of the pipeline in place.

Cleaning the pipeline will remove any accumulated solid residue and other liquids that otherwise could pose an environmental risk/liability, and render the pipeline free of gross process residues. Acceptable cleaning Alternative Means include water flushing, jet rodding, and pigging.

The purpose of inspecting the pipeline will be to ensure that the pipeline has been adequately cleaned and that the integrity of the pipeline is sufficient to minimize differential settlement or ground subsidence due to the pipe collapsing. Corrective action could include additional cleaning and potentially filling or complete removal of segments of the pipeline should imminent collapse be identified through inspection activities. Acceptable inspection approaches include manual visual inspection, PIG inspection, and video inspection.

Abandonment would consist of leaving the cleaned and inspected pipeline in place. The ends of the pipeline will be plugged with an appropriate cap (e.g., concrete plug). Similarly, pipeline ends at each manhole will be cut and plugged with an appropriate cap (e.g., concrete plug). Each manhole will be cut approximately one metre below grade and backfilled (both remaining void space and disturbed area). Disturbed areas will be graded to match existing hard surfaces and to achieve positive drainage.

6.2.2.2 Feasible Concept 2 – Clean, Fill, and Abandon in Place

Feasible Concept 2 consists of cleaning the pipeline, filling the annulus such that the internal void space in the pipeline is solidified, and abandonment of the pipeline in place.

Cleaning of the pipeline is a common element as described in 6.2.2.1 above.

The purpose of filling the pipeline will be to solidify the annulus of the pipe such that any remaining process residues are immobilized and to prevent ground subsidence due to the pipe collapsing. Prior to commencing the filling process, the inspection performed as part of the cleaning phase as noted in Section 6.2.2.1 above.

The filling process will involve using mechanical equipment to mix and pump cellular concrete fill into the pipeline, followed by allowing the fill to solidify/set. It is noted that expandable foam is also a viable material to fill the pipeline, however, is not readily available in Nova Scotia and was therefore assumed to be cost prohibitive.

Abandonment would consist of leaving the cleaned and filled pipeline in place. The ends of the pipeline will be plugged with an appropriate cap (e.g., concrete plug). Similarly, pipeline ends at each manhole will be cut and plugged with an appropriate cap (e.g., concrete plug). Each manhole will be cut approximately one metre below grade and backfilled (both remaining void space and disturbed area). Disturbed areas will be graded to match existing hard surfaces and to achieve positive drainage.

6.2.2.3 Feasible Concept 3 – Complete Removal

Feasible Concept 3 consists of cleaning the pipeline and complete removal by excavating cover material and removal using mechanical equipment such as excavators or cranes (as needed). It is noted that a section of the pipeline is near a PLFN burial ground. Complete removal of this section would require acceptance from PLFN and would require archeological monitoring.

Cleaning of the pipeline is a common element as described in 6.2.2.1 above.

Removal will include excavating the cover material to expose the pipeline such that it can be removed. The cover material will be removed using conventional excavation equipment. Large excavators with buckets will be used to excavate a trench and expose the pipeline. An excavator equipped with a ripper tooth will be used, as needed, to break strong in-situ material.

The excavated material will be stockpiled near the trench and will be reused for backfilling provided there are no soil contamination issues. It is anticipated that approximately a 30 m pipeline section will be exposed at one time followed by pipe removal and backfilling. The pipeline will be removed using mechanical equipment by first cutting the pipeline (e.g., excavator with a shear attachment) followed by removal (e.g., excavator or mobile crane). All manholes will also be removed. Manholes will be removed in sections using mechanical equipment (e.g., excavator or mobile crane).

If high rates of groundwater infiltration are observed, the water table will be lowered using pumps. The water collected from dewatering would be tested and then disposed at an appropriate on or off Site treatment facility. Trenches will be continuously backfilled as the pipe is removed to limit the length of open excavations. Efforts will be made to limit excavations left open at the end of each day. Disturbed areas will be backfilled and graded to match existing hard surfaces and to achieve positive drainage.

6.2.2.4 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix F, Attachment F1 and summarized on Table 6.3 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost for an estimated 25-year period have been carried for Feasible Concept 1.

Table 6.3 Pipeline on Land Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 - Clean, inspect, and abandon in place	$170,000	$130,000
Feasible Concept 2 - Clean, fill, and abandon in place	$1,520,000	$0
Feasible Concept 3 - Complete Removal	$630,000	$0

Key assumptions include:

- Cellular concrete was carried for Feasible Concept 2; expandable foam is not readily available in Nova Scotia and was therefore assumed to be cost prohibitive.
- Video inspection was carried for costing Feasible Concepts 1 and 2, as it was deemed the most likely option to be implemented.
- Pigging was carried for costing cleaning for all Feasible Concepts, as it was deemed the most likely Alternative Mean to be implemented.
- Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.
- For the pipeline on land, Feasible Concept 1 assumes a 25 year inspection and care program will be required.
- Based on published weights of RPP from various manufactures approximately 250 tonnes of pipe to be disposed of for Feasible Concept 3. The capital cost estimate for disposal is included in the costing prepared in Appendix C – Waste Management Detailed Concept Descriptions for Feasible Concepts.

- For Feasible Concept 2, fill can be done by gravity on both sides using portable pumps.

6.2.3 Evaluation of Feasible Concepts

The Feasible Concepts carried forward for pipeline decommissioning (on land) as part of the BHRD were evaluated, compared, and ranked to identify the most suitable concept for consideration as a Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation), as well as the identification and comparison of advantages/disadvantages for each Feasible Concept.

6.2.3.1 Comparative Evaluation

The completed evaluation and weighting matrix for pipeline decommissioning (on land) is presented in Appendix H. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 6.4 presents a summary of the matrix scores for each Feasible Concept. As demonstrated by the matrix scores, Feasible Concept 1 (abandon) was deemed preferable to Feasible Concept 2 (fill) and Feasible Concept 3 (remove).

Table 6.4 Summary of Matrix Scores – Pipeline Decommissioning (on land)

Criteria Category	Weighting Factor	Feasible Concept 1 (Abandon)	Feasible Concept 2 (Fill)	Feasible Concept 3 (Remove)
Regulatory	14%	375	**425**	413
Technical	26%	**479**	435	384
Environmental	24%	**500**	485	446
Social	14%	**306**	300	300
Economic	22%	**450**	300	300
Total Comparative Score		**2110**	1945	1843
Total Weighted Score		**439**	397	373
Rank		**1**	2	3

6.2.3.1.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Feasible Concept 2 (abandon) ranked higher than the other Feasible Concepts based on regulatory indicators. Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

By simply abandoning the on-land portion of the pipeline in place (following cleaning and inspection) under Feasible Concept 1, there was potential for the pipeline to collapse. Under a worse-case scenario, pipe collapse could potentially cause a sinkhole to occur. As a result, Feasible Concept 1 was considered to represent a low risk to public health and safety, and received a score of 3.0 for sub-indicator HS1.1. Feasible Concept 2 (abandon) and Feasible Concept 3 (remove) were both considered to represent no risk to public health during remediation and post-remediation phases, and scored 5.0 for sub-indicator HS1.1.

The potential risks to public during decommissioning of the on-land portion of the pipeline were generally considered to be easily mitigated, with the exception of Feasible Concept 1. Following abandonment of the pipeline, moderate changes to Feasible Concept 1 would be required to mitigate the potential risks to public associated with pipe collapse, including isolating or partial filling of pipe segments. As a result, Feasible Concept 1 received a score of 3.0 for sub-indicator HS1.2, while Feasible Concept 2 and Feasible Concept 3 both received scores of 5.0.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Feasible Concept 3 required a significantly greater level of effort to physically remove the pipeline during decommissioning, and as a result was considered to represent a low level of risk to worker health and safety. In contrast, under Feasible Concept 1 and Feasible Concept 2, the relative risk level to worker safety was considered to be much less since the pipeline was being abandoned in place for both Feasible Concepts, and therefore required significantly less effort. Accordingly, Feasible Concept 3 received a score of 3.0 for sub-indicator HS2.1, while Feasible Concept 1 and Feasible Concept 2 both scored 4.0.

The inherent level of risk to worker health and safety associated with decommissioning of the on-land portion of the pipeline was generally considered to be low, and easily mitigated. Typical health and safety risks associated with general construction (i.e., working at heights, use of heavy equipment, slips/trips/falls, etc.) are quite common, and were considered to be easily mitigated with proper site planning and controls, use of personal protective equipment (PPE), and implementation of proper protective systems during trenching and excavation. As a result, all three Feasible Concepts received a score of 4.0 for sub-indicator HS2.2.

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

All three Feasible Concepts were considered to have a high level of compliance, going beyond the minimum requirements for ease of Federal/Provincial approvability. While there are few applicable criteria that apply to decommissioning of the on-land portion of the pipe, demolition activities may require a permit for portions under public roadways. Disposal of construction waste material from pipeline decommissioning activities will be disposed of in the on-Site disposal cell. These demolition and disposal requirements were considered easily met, and as a result all three Feasible Concepts received a score of 5.0 for sub-indicator C1.1.

With respect to sub-indicator C1.2, all three Feasible Concepts were considered to have only a moderate level of public acceptance from the PLFN and surrounding communities. Under Feasible Concept 3, complete removal of the pipeline will inconvenience the general public for the removal of the portion under Highway 348. While there is much more disturbance along the pipeline corridor under Feasible Concept 3, the surrounding community will likely be more content to have the pipeline (and all associated impacts) removed entirely. Under Feasible Concept 1 and Feasible Concept 2, the public may fear residual contamination will be left in place with the abandoned pipeline, or that the pipeline may get subsequently re-used for another purpose. Due to the mixed range of anticipated public acceptance towards decommissioning of the on-land portion of the pipeline, all three Feasible Concepts received a score of score of 3.0 for sub-indicator C1.2.

It is worth noting that the majority of land along the pipeline corridor is generally wide open and located within an easement. The easement would remain in place under Feasible Concept 1 and 2, but could be removed under Feasible Concept 3. For the pipeline adjacent the PLFN burial ground; complete removal of this section would require acceptance from PLFN and would require archeological monitoring.

6.2.3.1.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project. This criterion has been assigned a total weight of 26 percent of the overall comparison.

Feasible Concept 1 (abandon) ranked higher than Feasible Concept 2 (fill) and Feasible Concept 3 (remove) based on technical indicators. Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

All three pipe decommissioning methodologies were considered reliable approaches with extensive track records of successful applications. As a result, all Feasible Concepts received a score of 5.0 for sub-indicator T1.1.

The materials and equipment required to implement the Feasible Concepts were considered easily acquired within the Province. Similarly, the vendors and contractors required to implement the decommissioning activities were considered readily available within the Province. As a result, all three Feasible Concepts received scores of 4.0 for sub-indicators T1.2 and T1.3.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criterion discussed in Section 4.4.1.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1 with the Site (size and configuration) was identified as an item that needed to be addressed, but one that could be accomplished readily. The cleaning, inspection, and abandonment associated with Feasible Concept 1 was considered the least intrusive, causing minimal disturbance at the Site; Feasible Concept 1 received a score of 5.0 for sub-indicator T2.1. The compatibility of Feasible Concept 2 with the Site was identified as an item that needed to be addressed, and was an average constraint. The cleaning, filling, and abandonment associated with Feasible Concept 2 was considered somewhat intrusive, causing moderate disturbance at the Site; Feasible Concept 2 received a score of 3.0 for sub-indicator T2.1. Finally, the compatibility of Feasible Concept 3 was considered a challenging constraint, with the complete pipe removal causing the most disturbance to site features and noting the potential for space limitations for staging decommissioning activities; Feasible Concept 3 received a score of 1.0 for sub-indicator T2.1.

The compatibility of Feasible Concept 1 with Site geology was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.2. Feasible Concept 2 and Feasible Concept 3 were considered to be less compatible with site geology – disturbances were required at several access points during filling of the pipeline under Feasible Concept 2, and significant disturbance was required along the entire pipeline corridor with the removal under Feasible Concept 3. As a result, Feasible Concept 2 and Feasible Concept 3 received scores of 3.0 for sub-indicator T2.2.

The compatibility of Feasible Concept 1 with Site hydrogeology was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.3. Feasible Concept 2 and Feasible Concept 3 were considered to be less compatible with site hydrogeology, especially along the sections adjacent to East River of Pictou. As a result, Feasible Concept 2 and Feasible Concept 3 received scores of 3.0 for sub-indicator T2.3. It is noted that groundwater quality along the pipeline corridor has not been characterized due to access restrictions while the pipeline is in operation. Scoring for Feasible Concept 2 and Feasible Concept 3 is based the assumption that groundwater quality along the pipeline corridor is not impacted.

The compatibility of Feasible Concept 1 with Site access was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.4. Feasible Concept 2 and Feasible Concept 3 were considered to be less compatible with site access, especially along sections where the pipeline crosses the existing single lane access road. In particular for Feasible Concept 3, the anticipated 2-4 m deep excavation required to remove the pipeline presents a significant challenge to maintain site access. As a result, Feasible Concept 2 and Feasible Concept 3 received scores of 3.0 and 1.0 respectively, for sub-indicator T2.4.

Finally, the compatibility of Feasible Concept 1 with Site hydrology was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.5. Feasible Concept 2 and Feasible Concept 3 were considered to be less compatible with site hydrology due to potential localized impacts to runoff, infiltration, and streamflow. As a result, Feasible Concept 2 and Feasible Concept 3 received scores of 3.0 for sub-indicator T2.5.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

For sub-indicator T3.1, restrictions due to spring load restrictions on secondary roads will limit off-Site transport, making Feasible Concept 3 less compatible with existing off-Site features due to construction traffic (e.g., importing fill for restoration). Historically, load restrictions are implemented between mid-March to mid-May, but load restrictions are also dependent on weather conditions and the types of vehicles being used. Accordingly, Feasible Concept 3 received a score of 1.0 for sub-indicator T3.1, while Feasible Concept 1 and Feasible Concept 2 scored 5.0 and 3.0, respectively.

Potential changes or impacts to off-Site conditions due to the anticipated increase in traffic volume under Feasible Concept 3 was considered to be an average constraint. The resulting increase in noise, dust (during summer months), wear and tear (e.g., deterioration) on surrounding roads, and impact on traffic volume all contributed to Feasible Concept 3 receiving a score of 3.0 for sub-indicator T3.2. No potential changes or impacts to off-Site conditions were associated with Feasible Concept 1, which as a result received a score of 5.0, while Feasible Concept 2 received a score of 4.0.

There was no perceived difference between the three Feasible Concepts in anticipated changes to existing power supply or other municipal infrastructure off-Site, as no upgrades are currently required for implementation of these Feasible Concepts. As a result, all Feasible Concepts received a score of 5.0 for sub-indicator T3.3.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicator T4.1, the components of Feasible Concept 2 and Feasible Concept 3 were not expected to fail within the remediation and post-remediation period, and as a result both Feasible Concepts received a score of 5.0. Due to the small likelihood that the abandoned pipeline may collapse in place during the post-remediation period, Feasible Concept 1 received a score of 4.0 for sub-indicator T4.1.

The relative maintenance requirements associated with Feasible Concept 2 and Feasible Concept 3 were considered low, as no inspection or testing is anticipated during the post-remediation maintenance period; as a result, both Feasible Concept 2 and Feasible Concept 3 received a score of 5.0 for sub-indicator T4.2. By comparison, periodic walks/inspections along the former pipeline corridor may be required following implementation of Feasible Concept 1 to monitor for potential pipe collapse. As a result, Feasible Concept 1 received a score of 4.0 for sub-indicator T4.2.

In the event that existing soils around the pipeline are impacted, there is a slight/modest risk that remediation objectives associated with Feasible Concept 1 and Feasible Concept 2 will not be met as marginally impacted soils may be left in place. As a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 4.0 for sub-indicator T4.3. Under Feasible Concept 3, the level of risk associated with remediation objectives not being met was considered to be lower, since impacted soils (surrounding the pipeline) would be removed along with the pipeline itself as part of decommissioning activities. As a result, Feasible Concept 3 received a score of 5.0 for sub-indicator T4.3.

In the event that marginally impacted soils surrounding the pipeline were left in place under Feasible Concept 1 and Feasible Concept 2, the resulting impact was considered to be slight or modest. Under Feasible Concept 3, the relative impact associated with remediation objectives not being met was considered to be lower, since impacted soils would be removed along with the pipeline itself as part of decommissioning activities. As a result, Feasible Concept 3 received a score of 5.0 for sub-indicator T4.4, while Feasible Concept 1 and Feasible Concept 2 received a score of 4.0.

For sub-indicator T4.5, the relative ease of implementing a contingency measure during the post-remediation period was considered straight forward for all Feasible Concepts, and as a result all Feasible Concepts received an identical score of 5.0.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

The anticipated timeframe required to decommission the pipeline under Feasible Concept 3 was considered to be approximately 6 months (i.e., a single construction season) for complete removal and reinstatement; this timeframe is significantly longer than the time required to implement Feasible Concept 1 and Feasible Concept 2. Feasible Concept 1 had the shortest relative timeframe for implementation, and received a score of 5.0 for sub-indicator T5.1; Feasible Concept 2 had a slightly longer timeframe for implementation, and received a score of 4.0, while Feasible Concept 3 received a 1.0 under sub-indicator T5.1 for the longest timeframe for construction.

All three Feasible Concepts were expected to be implemented in well under four years; as a result all Feasible Concepts received a maximum score of 5.0 for sub-indicator T5.2.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

During the remediation phase, routine monitoring requirements were considered to be roughly the same (i.e., readily monitored and testable) for all Feasible Concepts. For all three Feasible Concepts, inspection will be either through in-situ (e.g., camera) or ex-situ (i.e., visual in the case of complete removal) means. All three Feasible Concepts received a score of 5.0 for sub-indicator T6.1.

Similarly, during the post-remediation phase, there are no anticipated monitoring requirements for Feasible Concept 2 and Feasible Concept 3 following pipe decommissioning activities. As a result, Feasible Concept 2 and Feasible Concept 3 received a score of 5.0 for sub-indicator T6.2. Feasible Concept 1 (abandon) will require some post-remediation inspection for subsidence and therefore received a score of 4.0 for sub-indication T6.2.

Finally, all three Feasible Concepts were considered to require similar (i.e., minimal) amounts of monitoring to ensure effectiveness, and received identical scores of 5.0 for sub-indicator T6.3.

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase, both Feasible Concept 1 and Feasible Concept 2 were considered to generate minimal amounts of additional waste through implementation, and as a result both Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.1. By comparison, Feasible Concept 3 was expected to generate a moderate amount of waste, primarily consisting of pipe and construction/demolition debris to be removed as part of decommissioning activities. As a result, Feasible Concept 3 received a score of 3.0 under sub-indicator T7.1.

During the post-remediation phase, all three Feasible Concepts were considered to generate minimal amounts of additional waste following decommissioning activities, and received a maximum score of 5.0 for sub-indicator T7.2.

All three Feasible Concepts were considered to generate negligible amounts of hazardous/dangerous goods during the remediation phase, and as a result all Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.3.

6.2.3.1.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events.

Feasible Concept 1 (abandon) ranked higher than Feasible Concept 2 (fill) and Feasible Concept 3 (remove) based on environmental indicators. Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1 Atmospheric Environment

EN1.2 Aquatic Environment

EN1.3 Geology and Groundwater

EN1.4 Terrestrial Environment

Very little separated the environmental impact scoring of each Feasible Concept during the remediation phase. Feasible Concept 3 scored less (4.0) under sub-indicator EN1.1b for potential impacts to the aquatic environment (e.g., water quality, fish and benthic communities, etc.) resulting from pipeline removal activities near the East River. Feasible Concept 2 and Feasible Concept 3 scored less (4.0 and 3.0, respectively) under sub-indicator EN1.1d for potential impacts to terrestrial environment (e.g., vegetation, habitat, etc.) resulting from soil disturbances required to create access points or complete pipeline removal during decommissioning activities. All three Feasible Concepts scored 5.0 on the remaining environmental sub-indicators, including EN1.1a (atmospheric environment) and EN1.1c (geology and groundwater).

EN2 – Post-remediation Phase Effects – 50 Percent of Environmental

Environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1 Atmospheric Environment

EN2.2 Aquatic Environment

EN2.3 Geology and Groundwater

EN2.4 Terrestrial Environment

Very little separated the environmental impact scoring of each Feasible Concept during the post-remediation phase. All three Feasible Concepts scored 5.0 under each environmental sub-indicator (i.e., EN2.1a through EN2.1d), indicating that little or no environmental interaction was anticipated, and no resulting adverse effects were expected following pipeline decommissioning activities.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential susceptibility of each Feasible Concept to inclement and severe weather events during the remediation and post remediation phase. The sub indicator questions for these weather effects included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

For sub-indicator EN3.1, both Feasible Concept 1 and Feasible Concept 2 were considered to be not susceptible to poor weather conditions during implementation of pipeline decommissioning activities on land, primarily because these Feasible Concepts required significantly less intrusive work and were implemented under a much shorter time frame. As a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for sub-indicator EN3.1. Feasible Concept 3 was considered to be moderately susceptible to inclement weather due to the six month implementation timeframe and amount of intrusive/open excavation work required during decommissioning. As a result, Feasible Concept 3 received a score of 3.0 for sub-indicator EN3.1.

During the post-remediation phase (following pipeline decommissioning activities), all three Feasible Concepts were considered to be not susceptible to poor weather conditions, and as a result received identical scores of 5.0 for sub-indicator EN3.2.

For sub-indicator EN3.3, Feasible Concept 1 was considered suitable under severe weather events (i.e., 1:100 year design storm), as the Feasible Concept would not fail under a catastrophic event, and received a score of 5.0. Feasible Concept 2 was considered slightly more susceptible to a severe weather event during the remediation/implementation phase due to the increased implementation time and excavation required; Feasible Concept 2 received a score of 4.0 for sub-indicator EN3.3. Finally, Feasible Concept 3 was considered most susceptible to a severe weather event during the remediation/implementation phase due to the significantly increased implementation time and amount of open excavation required; Feasible Concept 3 received a score of 3.0 for sub-indicator EN3.3, indicating the Feasible Concept could be impacted by a catastrophic event but not fail during the remediation/implementation phase.

6.2.3.1.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept. This criterion has been assigned a total weight of 14 percent of the overall comparison.

Feasible Concept 1 (abandon) ranked higher than Feasible Concepts 2 (fill) and 3 (remove) based on social indicators. Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Social indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surroundings community during post remediation phase (i.e., safety, visual, nuisance)?

For sub-indicator S1.1, all three Feasible Concepts were considered to have only a moderate level of community acceptance during the remediation phase. Under Feasible Concept 3, complete removal of the pipeline will inconvenience the public during the removal of the pipeline under Highway 348. While there is much more disturbance along the pipeline corridor under Feasible Concept 3, the surrounding community will likely be more content to have the pipeline (and all associated impacts) removed entirely. Under Feasible Concept 1 and Feasible Concept 2, the public may be concerned that residual contamination will be left in place with the abandoned pipeline, or that the pipeline may get subsequently re-used for another purpose. Due to the mixed range of anticipated community acceptance, all three Feasible Concepts received a score of score of 3.0 for community acceptance sub-indicator S1.1.

During the post-remediation phase, it was anticipated that there will be a high level of community acceptance for the complete pipeline removal under Feasible Concept 3; as a result, Feasible Concept 3 received a score of 5.0 for sub-indicator S1.2. In comparison, abandonment of the pipeline under Feasible Concept 1 and Feasible Concept 2 would likely receive less community support during the post-remediation phase, as there may be concerns of residual contamination in place. Accordingly, Feasible Concept 1 and Feasible Concept 2 received a score of 4.0 for community acceptance sub-indicator S1.2.

During the remediation phase, implementation of Feasible Concept 1 was considered to have no effect (i.e., positive or negative) on the surrounding community, and received a score of 3.0 for sub-indicator S1.3. Similarly, implementation of Feasible Concept 2 was considered to have a slightly negative effect on the surrounding community due to minor inconvenience/nuisance during pipeline filling activities prior to abandonment. Feasible Concept 2 received a score of 2.0 for sub-indicator S1.3. Finally, implementation of Feasible Concept 3 was considered to have a definite negative impact on the surrounding communities due to the disruption and inconvenience caused by pipeline removal, in particular at the Highway 348 crossing. As a result, Feasible Concept 3 received a score of 1.0 for community acceptance sub-indicator S1.3.

Finally, all three Feasible Concepts were considered to have no net effect (i.e., either positive or negative) or impact on the surrounding communities during the post-remediation phase and as a result, all three Feasible Concepts received a score of 3.0 for community acceptance sub-indicator S1.4.

S2 - Community Benefit – 75 Percent of Social

Social indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)

Decommissioning of the on-land portion of the pipeline was considered to have no direct or indirect positive social impacts on the surrounding communities. From an economic perspective, no economic benefits directly attributable to pipeline decommissioning Feasible Concepts were identified. Accordingly, all three Feasible Concepts received a score of 3.0 for community benefit sub-indicator S2.1, indicating no socio-economic effects (i.e., positive or negative) on the surrounding community.

6.2.3.1.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs implementation (i.e., capital costs) and for ongoing O&M costs.

Feasible Concept 1 (abandon) ranked higher than Feasible Concepts 2 (fill) and 3 (remove) based on economic indicators. Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 1 was estimated to be $170,000, and was the lowest cost of the three Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 1 received a maximum score of 5.0.

The capital cost of Feasible Concept 2 was estimated to be $1,520,000, which is approximately 8.9 times higher than Feasible Concept 1. As a result, Feasible Concept 2 received a score of 1.0 for sub-indicator EC1.1.

Similarly, the capital cost of Feasible Concept 3 was estimated to be $630,000, which is approximately 3.7 times higher than Feasible Concept 1. As a result, Feasible Concept 3 also received a score of 1.0 for sub-indicator EC1.1.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

The relative post-remediation O&M requirements associated with Feasible Concept 2 and Feasible Concept 3 were considered low/negligible, as no inspection or testing is anticipated during the post-remediation maintenance period; as a result, both Feasible Concept 2 and Feasible Concept 3 received a score of 5.0 for sub-indicator EC2.1. By comparison, periodic inspections along the pipeline corridor will be required following implementation of Feasible Concept 1 to monitor for pipe collapse. As a result, Feasible Concept 1 received a relative score of 4.0 for sub-indicator EC2.1.

6.2.3.2 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

The remainder of this section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment
- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

In accordance with Project goals, all three Feasible Concepts were considered protective of human health and the environment (indicators HS1/2 and EN1/2). Due to the significant disruption caused by excavating the on-land portion of the pipeline and due to truck traffic (e.g., remove C&D debris, import fill), there was a slight increase in the level of risk to the environment associated with Feasible Concept 3. However, in the event that the soils surrounding the pipeline are impacted, Feasible Concept 3 would likely be the only viable Feasible Concept (assuming excavation and removal of impacted soil is required). All three Feasible Concepts were considered equally protective of the environment in the post-remediation phase. As such, there is no clear preference based on the environmental and H&S considerations for this Project goal.

All three Feasible Concepts were considered to be constructible/implementable within the established timeframe (per indicator T5); the relative incremental timeframe required to implement Feasible Concept 3 is significant when compared to Feasible Concept 1 and Feasible Concept 2, but does not adversely affect the overall Project timeframe. There is no clear preference based on the timeframe/schedule consideration for this Project goal.

In accordance with Project goals, all three Feasible Concepts were founded on mature, proven technologies. All approaches were considered reliable and effective means to decommission the on-land portion of the pipeline, such that there is very little risk associated with the Feasible Concepts. There is no clear preference based on the technical consideration for this Project goal.

All Feasible Concepts were considered to be economically feasible. The capital costs for complete pipeline removal under Feasible Concept 3 were not off-set by the costs for ongoing O&M requirements under Feasible Concept 1 (which are assumed to be minimal). Feasible Concept 2 (fill) was the highest cost option. Feasible Concept 1 (abandon), being the lowest cost option, provides the best value to the Province (and taxpayers), and would be preferred based on this economic consideration.

Overall, the comparison of advantages and disadvantages generally supports selection of Feasible Concept 1 (abandon) as the preferred Feasible Concept for decommissioning of the on-land portion of the pipeline.

6.2.4 Summary of Qualified Remedial Option

Feasible Concept 1 consists of cleaning the pipeline, performing an inspection, and abandonment of the pipeline in place.

Cleaning the pipeline will remove any accumulated solid residue and other liquids that otherwise could pose an environmental risk/liability, and render the pipeline free of gross process residues. Inspecting the pipeline will ensure that the pipeline has been adequately cleaned and that the integrity of the pipeline is sufficient to minimize differential settlement or ground subsidence due to the pipe collapsing. Finally, abandonment will consist of leaving the cleaned and inspected pipeline in place. The ends of the pipeline will be plugged with an appropriate cap (e.g., concrete plug). Similarly, pipeline ends at each manhole will be cut and plugged with an appropriate cap (e.g., concrete plug). Each manhole will be cut approximately one metre below grade and backfilled (both remaining void space and disturbed area). Disturbed areas will be graded to match existing hard surfaces and to achieve positive drainage.

6.3 Pipeline Under Water

The original water portion of the pipeline consisted of 0.915 m diameter RFP that was decommissioned in 2009. The decommissioned pipe was replaced with approximately 1,220 m of HDPE pipe. The newer HDPE pipe was buried under the river bed adjacent to the decommissioned pipe and connected to the older RPP pipe at each end.

6.3.1 Development and Identification of Feasible Concepts

Figure 6.2 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

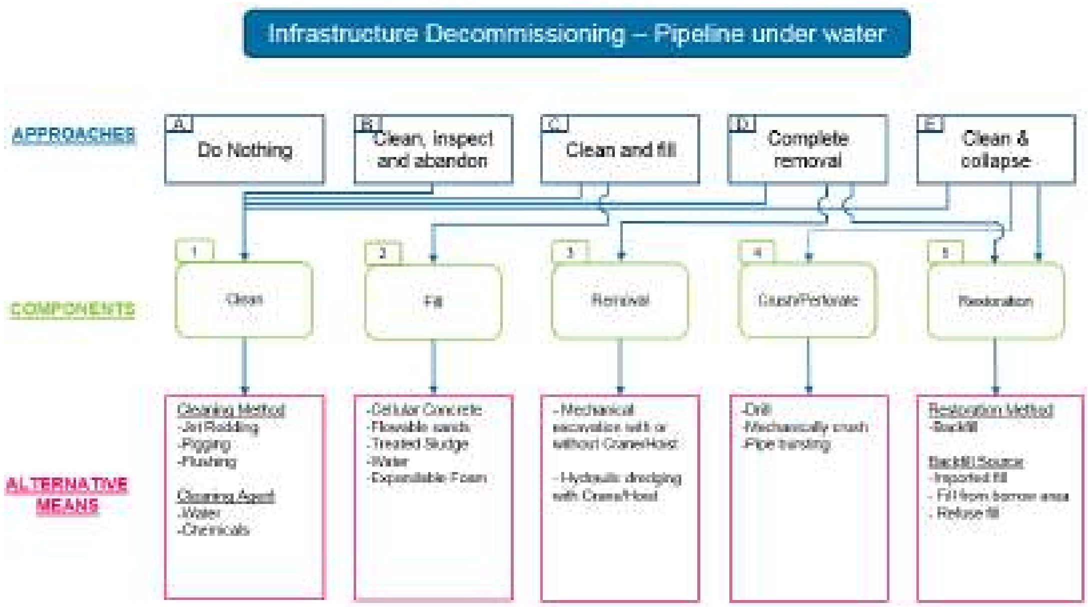


Figure 6.2 Underwater Pipeline Decommissioning Approaches, Components, and Alternative Means

6.3.1.1 Approaches

The same five Approaches were identified for decommissioning the underwater portion of the pipeline as the land portion as part of the overall infrastructure decommissioning to be conducted during BHRD implementation:

A. Do Nothing

B. Clean, Inspect and Abandon

C. Clean and Fill

D. Complete Removal

E. Clean and Collapse

With the exception of the Do Nothing alternative (Approach A), common to all Approaches was the cleaning of the pipeline in its entirety, regardless of whether the pipeline is to be removed, filled, or abandoned. Cleaning will remove accumulated solid residue and other liquids that might otherwise be released during decommissioning activities, or pose as an environmental risk/liability should the pipeline be abandoned in place.

The remaining Approaches (B through E) included various methods to decommission the underwater portion of the pipeline, including abandonment in place after filling or collapsing the pipe, or simply removing the pipeline altogether.

6.3.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Are decommissioning requirements likely achievable (e.g., owners, regulatory, end use)?
- F1-2: Is long-term liability minimized?
- F1-3: Does the approach minimize environmental impact?

The results of the F1 application are summarized below in Table 6.5.

Table 6.5 Results of First Filter Step

Approaches	F1-1 Regulatory Approvability	F1-2 Reduced Liability	F1-3 Minimize Env. Impact	Pass/Fail
A. Do Nothing	No	No	No	Fail
B. Clean, Inspect and Abandon	Yes	Yes	Yes	Pass
C. Clean and Fill	Yes	Yes	Yes	Pass
D. Complete Removal	No	Yes	No	Fail
E. Clean and Collapse	Yes	Yes	Yes	Pass

Of the five Approaches considered, both the Do Nothing alternative (Approach A) and Complete Removal (Approach D) Approach were removed from further consideration, as both failed to minimize long-term environmental impacts and were unlikely to meet regulatory requirements. Complete removal was considered to likely cause substantial disturbance to any established aquatic environments. As a result, Approaches A and D were removed from further consideration.

All other Approaches were determined to warrant further evaluation and were therefore carried forward for further evaluation.

6.3.1.3 Identification of Components and Alternative Means

Approaches B, C and E consisted of the following four common/overlapping components (with a number of associated Alternative Means):

1. Clean (five Alternative Means)
2. Fill (five Alternative Means)
3. Crush or Perforate (three Alternative Means)
4. Restoration (four Alternative Means)

6.3.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the Alternative Means technically feasible?

- F2-2: Is the Alternative Means acceptable to the Public?
- F2-3: Is the Alternative Means cost effective?

The results of the application of the F2 are summarized below in Table 6.6. Of the 17 Alternative Means considered, 6 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 6.6 Results of Second Filter Step

Component	Alternative Means	F2-1 Technical	F2-2 Public	F2-3 Cost	Pass/Fail
1. Clean	Cleaning Method				
	• Jet Rodding	Yes	Yes	Yes	Pass
	• Pigging	Yes	Yes	Yes	Pass
	• Flushing	Yes	Yes	Yes	Pass
	Cleaning Agent				
	• Water	Yes	Yes	Yes	Pass
	• Chemicals	Yes	No	Yes	Fail
2. Fill	• Cellular Concrete	Yes	Yes	Yes	Pass
	• Flowable sands	No	Yes	Yes	Fail
	• Treated Sludge	No	No	Yes	Fail
	• Water	No	Yes	Yes	Fail
	• Expandable Foam	Yes	Yes	Yes	Pass
3. Removal	• Mechanical excavation with or without Crane/Hoist	No	Yes	No	Fail
	• Hydro-excavation with Crane/Hoist	No	Yes	No	Fail
4. Crush/Perforate	• Drill	No	Yes	Yes	Fail
	• Mechanically crush	No	Yes	Yes	Fail
	• Pipe Bursting	No	Yes	Yes	Fail
5. Restoration[16]	Restoration Method				
	• Backfill	N/A	N/A	N/A	N/A
	Backfill Source				
	• Imported fill	N/A	N/A	N/A	N/A
	• Fill from borrow area	N/A	N/A	N/A	N/A
	• Reuse fill	N/A	N/A	N/A	N/A

6.3.1.4.1 Clean

Common to remaining Approaches was the cleaning of the pipeline in its entirety. The three cleaning methods that were considered as part of this Component under Approaches B, C, and E

[16] N/A - Not Applicable. The Alternative Means is not applicable with the elimination of Component D complete removal under F1 and Component E clean and crush under F2.

included: flushing, jet rodding, and pigging. All three Alternative Means passed application of the F2 and were considered to be technically feasible and cost effective options.

Application of the second filter eliminated the use of chemicals as a potential cleaning agent, as this Alternative Means was unlikely to meet public acceptability. As a result, water will be used as the cleaning agent in all instances to eliminate public scrutiny and remove any risks to the environment (i.e., unforeseen leaks).

6.3.1.4.2 Fill

The five Alternative Means that were considered as part of the fill Component under Approach C included: cellular concrete, flowable sands, treated sludge, water, and expandable foam. Only cellular concrete and expandable foam passed application of the F2 and were considered technically feasible, cost effective options capable of meeting design requirements.

Flowable sands were determined to be not technically feasible for this particular application due to the limited distance which this material can be pumped.

Use of treated sludge and water as potential fill material were also considered technically unfeasible options. Using treated sludge and water as fill materials were eliminated due to not being foreseen long term at maintaining a filled pipe condition due to the potential for leaks from the pipeline.

6.3.1.4.3 Crush/Perforate

The three Alternative Means that were considered as part of the crush or perforate in place Component under Approach E included: drill, mechanically crush, and pipe bursting.

As the underwater sections of the pipeline are trenched and covered, use of drilling techniques to perforate the pipeline in place was not considered technically feasible, without fully exposing the pipe and without the use of divers to guide the drill. The remaining two Alternative Means were also not considered to be technically feasible, as certain sections of the pipeline were expected to deform, but not actually break using mechanical crushing or pipe bursting methods. As a result, all three Alternative Means failed the application of the F2.

6.3.2 Feasible Concept Description

Following application of F2 step the remaining Approaches, Components, and Alternative Means were grouped into the following Feasible Concepts:

- Feasible Concept 1 – Clean, inspect, and abandon in place
- Feasible Concept 2 – Clean, fill, and abandon in place

Other identified Alternative Means (i.e., cleaning method and fill material) were deemed to be alternatives that could potentially be evaluated as needed with the development of the Detailed Concept Description for each Feasible Concept (e.g., identifying the preference between cleaning methods, as needed).

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix F.

6.3.2.1 Feasible Concept 1 – Clean, Inspect, and Abandon in Place

Feasible Concept 1 consists of cleaning the pipeline, performing an inspection, and abandonment of the pipeline in place.

Cleaning the pipeline will remove any accumulated solid residue and other liquids that otherwise could pose an environmental risk/liability, and render the pipeline free of gross process residues. Acceptable cleaning Alternative Means include water flushing, jet rodding, and pigging.

The purpose of inspecting the pipeline will be to ensure that the pipeline has been adequately cleaned. Acceptable inspection approaches include manual visual inspection, PIG inspection, and video inspection.

Abandonment would consist of leaving the cleaned and inspected pipeline in place. The ends of the pipeline will be cut at the nearest manhole and plugged with an appropriate cap (e.g., concrete plug).

6.3.2.2 Feasible Concept 2 – Clean, Fill, and Abandon in Place

Feasible Concept 2 consists of cleaning the pipeline, filling the annulus such that the internal void space in the pipeline is solidified, and abandonment of the pipeline in place. Cleaning and filling operations will be completed in sequence with pipeline decommissioning activities for both the land and water portions as described in Section 6.2.2.2.

6.3.2.3 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix F, Attachment F1 and summarized on Table 6.7 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

Table 6.7 Pipeline Under Water Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 - Clean, inspect, and abandon in place	$90,000	$0
Feasible Concept 2 - Clean, fill, and abandon in place	$1,080,000	$0

Key assumptions include:

- Cellular concrete was carried for Feasible Concept 2; expandable foam is not readily available in Nova Scotia and was therefore assumed to be cost prohibitive.
- Video inspection was carried for costing Feasible Concepts 1 and 2, as it was deemed the most likely option to be implemented.

- Pigging was carried for costing cleaning for all Feasible Concepts, as it was deemed the most likely Alternative Mean to be implemented.
- Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.
- For Feasible Concept 2, fill can be done by gravity on both sides using portable pumps.

6.3.3 Evaluation of Feasible Concepts

The Feasible Concepts carried forward for pipeline decommissioning (underwater) as part of the BHRD were evaluated, compared, and ranked to identify the most suitable concept for consideration as a Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation), as well as the identification and comparison of advantages/disadvantages for each Feasible Concept.

6.3.3.1 Comparative Evaluation

The completed evaluation and weighting matrix for pipeline decommissioning (underwater) is presented in Appendix H. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 6.8 presents a summary of the matrix scores for each Feasible Concept. As demonstrated by the weighted matrix scores, Feasible Concept 1 (abandon) was deemed preferable to Feasible Concept 2 (fill).

Table 6.8 Summary of Matrix Scores – Pipeline Decommissioning (Underwater)

Criteria Category	Weighting Factor	Feasible Concept 1 (Abandon)	Feasible Concept 2 (Fill)
Regulatory	14%	**438**	**438**
Technical	26%	**490**	419
Environmental	24%	**500**	485
Social	14%	**306**	300
Economic	22%	**500**	300
Total Comparative Score		2234	1942
Total Weighted Score		**462**	395
Rank		**1**	2

6.3.3.1.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Both Feasible Concepts 1 (abandon) and 2 (fill) ranked the same based on regulatory indicators. Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

By simply abandoning the underwater portion of the pipeline in place (following cleaning and inspection) under Feasible Concept 1, there was potential for the pipeline to collapse. However, due to its location, pipe abandonment did not represent any risk to public health and safety, and as a result Feasible Concept 1 received a score of 5.0 for sub-indicator HS1.1. Feasible Concept 2 was also considered to represent no risk to public health during remediation and post-remediation phases, and scored 5.0 for sub-indicator HS1.1.

The potential risks to public during decommissioning of the underwater portion of the pipeline were generally considered to be easily mitigated. Similarly, post-remediation/implementation no potential risks to public health and safety were identified. As a result, both Feasible Concept 1 and Feasible Concept 2 received scores of 5.0 for sub-indicator HS1.2.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

The inherent level of risk to worker health and safety associated with decommissioning of the underwater portion of the pipeline was generally considered to be quite low, and easily mitigated. Typical health and safety risks associated with general construction (i.e., use of heavy equipment, pressurized equipment, slips/trips/falls, etc.) are quite common, and were considered to be easily mitigated with proper site planning and controls and use of PPE. Since the most common pipe cleaning methods (i.e., water flushing, jet rodding, pigging) are all conducted remotely, there is little need for confined space entry during pipeline decommissioning activities. Similarly, there is no additional risk for decommissioning the pipeline sections under water. As a result, both Feasible Concepts received a score of 4.0 for sub-indicator HS2.1, and scored 5.0 for sub-indicator HS2.2.

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

Both Feasible Concepts were considered to have a high level of compliance, going beyond the minimum requirements for ease of Federal/Provincial approvability. While there are few applicable criteria that apply to decommissioning of the underwater portion of the pipe, decommissioning activities would be conducted in accordance with requirements specified in Nova Scotia Watercourse Alterations Standard, and will be subject to conditions identified in Navigable Waters Protection Act. These decommissioning requirements were considered easily met, and as a result both Feasible Concepts received a score of 5.0 for sub-indicator C1.1.

With respect to sub-indicator C1.2, both Feasible Concepts were considered to have only a moderate level of public acceptance from the PLFN and surrounding communities. Under Feasible Concept 1 and Feasible Concept 2, the public may fear residual contamination will be left in place with the abandoned pipeline, or that the pipeline may get used for another purpose. Conversely, the surrounding community may be more content knowing that the pipeline has been cleaned and filled. Due to the mixed range of anticipated public acceptance towards decommissioning of the underwater portion of the pipeline, both Feasible Concepts received a score of score of 3.0 for sub-indicator C1.2.

6.3.3.1.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project.

Feasible Concept 1 (abandon) ranked higher than Feasible Concept 2 (fill) based on technical indicators. Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

Both pipe decommissioning methodologies were considered reliable approaches with extensive track records of successful applications. As a result, both Feasible Concepts received a score of 5.0 for sub-indicator T1.1.

The materials and equipment required to implement the Feasible Concepts were considered easily acquired within the Province. Similarly, the vendors and contractors required to implement the decommissioning activities were considered readily available locally within the Province. Both Feasible Concept 1 and Feasible Concept 2 received scores of 4.0 for sub-indicators T1.2 and T1.3.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criterion discussed in Section 4.4.1.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1 with the Site (size and configuration) was identified as an item that needed to be addressed, but one that could be accomplished readily. The cleaning, inspection, and abandonment associated with Feasible Concept 1 was considered the least intrusive, causing minimal disturbance at the Site; Feasible Concept 1 received a score of 5.0 for sub-indicator T2.1. The compatibility of Feasible Concept 2 with the Site was identified as an item that needed to be addressed, and was an average constraint. The cleaning, filling, and abandonment associated with Feasible Concept 2 was considered somewhat intrusive, causing moderate disturbances at access points; Feasible Concept 2 received a score of 3.0 for sub-indicator T2.1.

The compatibility of Feasible Concept 1 with Site geology was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.2. Feasible Concept 2 was considered to be less compatible with site geology – disturbances were required at access points during filling of the pipeline under Feasible Concept 2, and as a result, Feasible Concept 2 received a score of 3.0 for sub-indicator T2.2.

The compatibility of Feasible Concept 1 with Site hydrogeology was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.3. Feasible Concept 2 was considered to be less compatible with site hydrogeology due to the placement of cellular concrete fill throughout the underwater sections of pipeline. As a result, Feasible Concept 2 received a score of 3.0 for sub-indicator T2.3.

The compatibility of Feasible Concept 1 with Site access was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.4. Feasible Concept 2 was considered to be less compatible with Site access, as much of the decommissioning work will be initiated from points only accessible from the existing single lane access road. As a result, Feasible Concept 2 received a score of 3.0 for sub-indicator T2.4.

Finally, the compatibility of Feasible Concept 1 with Site hydrology was identified as an item that needed to be addressed, but one that could be accomplished readily, resulting in a score of 5.0 for sub-indicator T2.5. Feasible Concept 2 was considered to be less compatible with site hydrology due to potential localized impacts to runoff, infiltration, and streamflow during the filling activities. As a result, Feasible Concept 2 received a score of 3.0 for sub-indicator T2.5.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

For sub-indicator T3.1, restrictions due to spring load restrictions on secondary roads will hinder off-Site transport, making Feasible Concept 2 slightly less compatible with existing off-Site features due to the amount of cellular concrete (also called foamed concrete) to be imported from off-Site. Historically, load restrictions have been implemented between mid-March to mid-May, but restrictions are dependent on weather conditions and the types of vehicles being used. Accordingly, Feasible Concept 2 received a score of 3.0 for sub-indicator T3.1, while Feasible Concept 1 scored 5.0.

Potential changes or impacts to off-Site conditions due to the slight increase in traffic volume under Feasible Concept 2 was considered to be a minor constraint that could be easily addressed. The resulting increase in noise, dust (during summer months), wear and tear (e.g., deterioration) on surrounding roads, and impact on traffic volume were considered minimal, but contributed to Feasible Concept 2 receiving a score of 4.0 for sub-indicator T3.2. No potential changes or impacts to off-Site conditions were associated with Feasible Concept 1, which as a result received a score of 5.0.

There was no perceived difference between the two Feasible Concepts in anticipated changes to existing power supply or other municipal infrastructure off-Site, as no upgrades are currently required for implementation of these Feasible Concepts. As a result, both Feasible Concepts received a score of 5.0 for sub-indicator T3.3.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicator T4.1, the components of Feasible Concept 1 and Feasible Concept 2 were not expected to fail within the remediation and post-remediation period, and as a result both Feasible Concepts received a score of 5.0. While there was a small likelihood that the abandoned pipeline under Feasible Concept 1 may collapse in place during the post-remediation period, this was not considered a design failure of the Feasible Concept; the pipeline is situated at such a depth that there is no risk for the public to encounter it, and therefore does not pose any risk if it collapses in place.

The relative maintenance requirements associated with Feasible Concept 1 and Feasible Concept 2 were considered low, as no inspection or testing was anticipated during the post-remediation maintenance period; and the level of effort required to inspect the pipeline during decommissioning was the same for both Feasible Concepts. As a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for sub-indicator T4.2.

In the event that existing sediment around the underwater sections of the pipeline are impacted, there is a slight/modest risk that remediation objectives associated with Feasible Concept 1 and Feasible Concept 2 will not be met, as marginally impacted sediment may be left in place. Scoring for this sub-indicator was made under the assumption that soil surrounding the pipeline is not impacted; Feasible Concept 1 and Feasible Concept 2 received a tentative score of 5.0 for sub-indicator T4.3.

In the event that marginally impacted soil surrounding the pipeline was left in place under Feasible Concept 1 and Feasible Concept 2, the resulting impact from not meeting remediation objective was considered to be low as there is no potential receptor for the buried soil. Similar to T4.3 above, the assumption that the soil surrounding the pipeline is not impacted will be confirmed. In the interim, both Feasible Concept 1 and Feasible Concept 2 received a tentative score of 5.0 for sub-indicator T4.4.

For sub-indicator T4.5, the relative ease of implementing a contingency measure during the post-remediation period was considered relatively easy for both Feasible Concepts, and as a result Feasible Concept 1 and Feasible Concept 2 received an identical score of 5.0.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

The anticipated timeframe required to decommission the pipeline under Feasible Concept 1 was considered to be less than one month (i.e., significantly less than a single construction season) for cleaning, inspection, and abandonment; Feasible Concept 1 had the shortest relative timeframe for implementation, and received a score of 5.0 for sub-indicator T5.1; Feasible Concept 2 had a slightly longer timeframe for implementation, and received a score of 1.0 for the longest timeframe for construction.

Both Feasible Concepts were expected to be implemented in well under four years; as a result Feasible Concept 1 and Feasible Concept 2 both received a maximum score of 5.0 for sub-indicator T5.2.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

During the remediation phase, routine monitoring requirements were considered to be similar (i.e., readily monitored and testable) for both Feasible Concepts. Both Feasible Concepts received a score of 5.0 for sub-indicator T6.1.

Similarly, during the post-remediation phase, monitoring requirements were considered to be roughly the same (i.e., readily monitored and testable) for both Feasible Concepts following pipe decommissioning activities, since no post-remediation inspections will be required for either Feasible Concept. As a result, both Feasible Concepts received a score of 5.0 for sub-indicator T6.2.

Finally, both Feasible Concepts were considered to require similar (i.e., minimal) amounts of monitoring to validate effectiveness, and received identical scores of 5.0 for sub-indicator T6.3.

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase, both Feasible Concept 1 and Feasible Concept 2 were considered to generate minimal amounts of additional waste through implementation, and as a result both Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.1. Similarly during the post-remediation phase, both Feasible Concepts were considered to generate minimal amounts of waste following decommissioning activities, and received a maximum score of 5.0 for sub-indicator T7.2.

Both Feasible Concepts were considered to generate negligible amounts of hazardous/dangerous goods through implementation during the remediation phase, and as a result Feasible Concept 1 and Feasible Concept 2 received a maximum score of 5.0 for sub-indicator T7.3.

6.3.3.1.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events.

Feasible Concept 1 (abandon) ranked higher than Feasible Concept 2 (fill) based on environmental indicators. Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1a Atmospheric Environment

EN1.1b Aquatic Environment

EN1.1c Geology and Groundwater

EN1.1d Terrestrial Environment

Very little separated the environmental impact scoring of each Feasible Concept during the remediation phase. Feasible Concept 2 scored less (4.0) under sub-indicator EN1.1d for potential impacts to the terrestrial environment (e.g., vegetation, habitat, etc.) resulting from the additional equipment and pumper trucks required to complete pipeline filling activities. These filling activities were not required under Feasible Concept 1, and as a result Feasible Concept 1 received a score of 5.0 for sub-indicator EN1.1d. Both Feasible Concepts scored 5.0 on all the remaining environmental sub-indicators, including EN1.1a (atmospheric environment), EN1.1b (aquatic environment) and EN1.1c (geology and groundwater).

During the post-remediation phase, both Feasible Concepts scored 5.0 under each environmental sub-indicator (i.e., EN2.1a through EN2.1d), indicating that little or no environmental interaction was anticipated, and no resulting adverse effects were expected following pipeline decommissioning activities.

EN2 – Post-remediation Phase Effects – 50 Percent of Environmental

Similarly, environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1a Atmospheric Environment

EN2.1b Aquatic Environment

EN2.1c Geology and Groundwater

EN2.1d Terrestrial Environment

Very little separated the environmental impact scoring of each Feasible Concept during the post-remediation phase. Both Feasible Concepts scored 5.0 under each environmental sub-indicator (i.e., EN2.1a through EN2.1d), indicating that little or no environmental interaction was anticipated, and no resulting adverse effects were expected following pipeline decommissioning activities.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential susceptibility of each Feasible Concept to inclement and severe weather events during the remediation and post remediation phase. The sub indicator questions for these weather effects included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

For sub-indicator EN3.1, both Feasible Concept 1 and Feasible Concept 2 were considered to be not impacted by poor weather conditions during implementation of underwater pipeline decommissioning activities, primarily because these Feasible Concepts required minimal intrusive work and were implemented under a relatively short time frame. As a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for sub-indicator EN3.1.

During the post-remediation phase (following pipeline decommissioning activities), both Feasible Concepts were not considered to be susceptible to poor weather conditions, and as a result received identical scores of 5.0 for sub-indicator EN3.2.

For sub-indicator EN3.3, Feasible Concept 1 was considered suitable under severe weather events (i.e., 1:100 year design storm), as the Feasible Concept would not fail under a catastrophic event, and received a score of 5.0. Feasible Concept 2 was considered slightly more susceptible to a severe weather event during the remediation/implementation phase due to the slightly increased implementation time required for pipeline filling activities. Feasible Concept 2 received a score of 4.0 for sub-indicator EN3.3, indicating the Feasible Concept could be potentially impacted by a catastrophic event but not fail during the remediation/implementation phase only.

6.3.3.1.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept.

Feasible Concept 1 (abandon) ranked higher than Feasible Concept 2 (fill) based on social indicators. Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Social indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surroundings community during post remediation phase (i.e., safety, visual, nuisance)?

For sub-indicator S1.1, both Feasible Concepts were considered to have only a moderate level of community acceptance during the remediation phase. Under Feasible Concept 1 and Feasible Concept 2, the public may be concerned that residual contamination will be left in place with the abandoned pipeline, or that the pipeline may get used for another purpose. Conversely, PLFN and the surrounding community may be more content knowing that the pipeline has been cleaned and filled. Due to the mixed range of anticipated public acceptance towards decommissioning of the underwater portion of the pipeline, both Feasible Concepts received a score of score of 3.0 for community acceptance sub-indicator S1.1.

During the post-remediation phase, abandonment of the pipeline under Feasible Concept 1 and Feasible Concept 2 would likely receive a moderate amount of community support following cleaning of the pipeline, however there may still be lingering concerns of residual contamination remaining in place. Accordingly, Feasible Concept 1 and Feasible Concept 2 received a score of 4.0 for community acceptance sub-indicator S1.2.

During the remediation phase, implementation of Feasible Concept 1 was considered to have no effect (i.e., positive or negative) on the surrounding community, and received a score of 3.0 for sub-indicator S1.3. Similarly, implementation of Feasible Concept 2 was considered to have a slightly negative effect on PLFN and the surrounding community due to minor inconvenience/nuisance during pipeline filling activities prior to abandonment. Feasible Concept 2 received a score of 2.0 for sub-indicator S1.3.

Finally, both Feasible Concepts were considered to have no net effect (i.e., either positive or negative) or impact on the surrounding communities during the post-remediation phase and as a result, all three Feasible Concepts received a score of 3.0 for community acceptance sub-indicator S1.4.

S2 - Community Benefit – 75 Percent of Social

Social indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)

Decommissioning of the underwater portion of the pipeline was considered to have no direct or indirect positive social impacts on the surrounding communities. From an economic perspective, no economic benefits directly attributable to pipeline decommissioning Feasible Concepts were identified. Accordingly, both Feasible Concepts received a score of 3.0 for community benefit sub-indicator S2.1, indicating no socio-economic effects (i.e., positive or negative) on PLFN or the surrounding community.

6.3.3.1.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs for planning and implementation (i.e., capital costs) and for ongoing O&M costs.

Feasible Concept 1 (abandon) ranked higher than Feasible Concept 2 (fill) based on economic indicators. Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 1 was estimated to be $90,000, and was the lowest cost of the two Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 1 received a maximum score of 5.0.

The capital cost of Feasible Concept 2 was estimated to be $1,080,000, which is approximately 12 times higher than Feasible Concept 1. As a result, Feasible Concept 2 received a score of 1.0 for sub-indicator EC1.1.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

The relative post-remediation O&M requirements associated with Feasible Concept 1 and Feasible Concept 2 were considered low/negligible, as no inspection or testing is anticipated during the post-remediation maintenance period; as a result, both Feasible Concept 1 and Feasible Concept 2 received a score of 5.0 for sub-indicator EC2.1.

6.3.3.2 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

The remainder of this section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment
- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

In accordance with Project goals, both Feasible Concepts were considered protective of human health and the environment (indicators HS1/2 and EN1/2). While there was a slight increase in the level of effort required to fill the pipeline prior to abandonment under Feasible Concept 2, there was no appreciable additional risk to worker health and safety when compared to Feasible Concept 1. In fact, both Feasible Concepts were considered equally protective of human health and the environment on all sub-indicators, with the exception of the terrestrial environment during the remediation/implementation phase. During the remediation phase, Feasible Concept 2 scored less (4.0) under sub-indicator EN1.1d for potential impacts to the terrestrial environment (e.g., vegetation, habitat, etc.) resulting from the additional equipment and pumper trucks required to complete pipeline filling activities from the dry (i.e., on land). Although there is no clear preference based on the environmental and H&S considerations for this Project goal, Feasible Concept 1 may be considered slightly preferable.

Both Feasible Concepts were considered to be constructible/implementable within the established timeframe (per indicator T5); the relative/ incremental timeframe required to implement Feasible Concept 2 is not significant when compared to Feasible Concept 1, or the overall Project timeframe. There is no clear preference based on the timeframe/schedule consideration for this Project goal.

In accordance with Project goals, both Feasible Concepts are founded on mature, proven technologies. Both approaches are considered reliable and effective means to decommission the underwater portion of the pipeline, such that there is very little risk associated with either Feasible Concept. There is no clear preference based on the technical consideration for this Project goal.

Both Feasible Concepts are considered to be economically feasible. The incremental capital costs for importing and placing cellular concrete within the pipeline under Feasible Concept 2 does not appear to provide any additional value in terms of positive benefits to the aquatic environment, or exceeding remediation objectives. Feasible Concept 1 provides the best value to the Province (and taxpayers), and would be preferred based on this economic consideration.

Overall, the comparison of advantages and disadvantages generally supports selection of Feasible Concept 1 as the preferred Feasible Concept for decommissioning of the underwater portion of the pipeline.

6.3.4 Summary of Qualified Remedial Option

Feasible Concept 1 consists of cleaning the pipeline, performing an inspection, and abandonment of the pipeline in place.

Cleaning the pipeline will remove any accumulated solid residue and other liquids that otherwise could pose an environmental risk/liability, and render the pipeline free of gross process residues. Inspection of the pipeline will ensure that the pipeline has been adequately cleaned. Finally, abandonment will consist of leaving the cleaned and inspected pipeline in place. The ends of the pipeline will be cut at the nearest manhole and plugged with an appropriate cap (e.g., concrete plug).

6.4 Treatment Buildings

There are multiple small buildings and structures located throughout the Site that are used in support of the BHETF. The list below provides an inventory of the buildings and structures under consideration for decommissioning/demolition or repurposing as part of the BHRD implementation. Brief descriptions of each building and structures are provided in Appendix F as well as a figure showing each building location.

- Press Building
- Mobile Building Adjacent to Press Building
- Storage Shed
- Air Monitoring Shelter
- Electrical Building
- Mobile Building belonging to CTS Electrical

- Silo
- Electrical Building for Silo
- Point A Building
- Point C Buildings

6.4.1 Development and Identification of Feasible Concepts

Figure 6.3 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

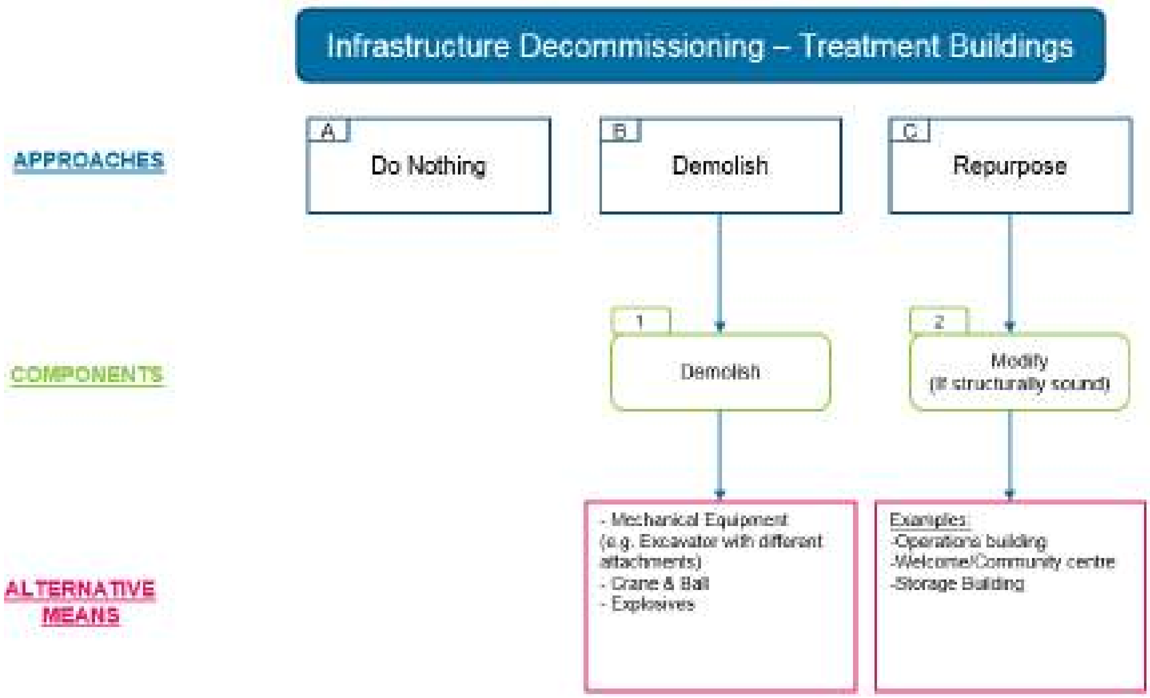


Figure 6.3 Treatment Building Decommissioning Approaches, Components, and Alternative Means

6.4.1.1 Approaches

Three Approaches were identified for decommissioning of the treatment buildings as part of the overall infrastructure decommissioning to be conducted during BHRD implementation:

A. Do Nothing

B. Demolish

C. Repurpose

In accordance with Project objectives, Approach B involves the decommissioning and demolition of multiple BHETF buildings in an environmentally sound manner, and in accordance with acceptable health and safety practices.

Approach C involves repurposing a building consistent with overall Site end use objectives. One building that could be a candidate for re-purposing is the press building as it is the largest on-Site building and is adjacent to the Site access road.

Approach A, the Do Nothing alternative, has been included for comparative purposes only.

6.4.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the solution acceptable to the public?
- F1-2: Are requirements likely achievable (e.g., owners, regulatory, end use)?
- F1-3: Is long-term liability minimized?

The results of the first Filter application are summarized below in Table 6.9.

Table 6.9 Results of First Filter Step

Approaches	F1-1 Acceptability	F1-2 Regulatory Approvability	F1-3 Reduced Liability	Pass/Fail
A. Do Nothing	Yes	No	No	Fail
B. Demolish	Yes	Yes	Yes	Pass
C. Repurpose	Yes	Yes	Yes	Pass

Of the three Approaches considered, only the Do Nothing alternative (Approach A) was removed from further consideration, as it failed to minimize long-term liability and was unlikely to meet anticipated decommissioning requirements. As a result, Approach A was removed from further consideration.

Both remaining Approaches passed the F1and were therefore carried forward for further evaluation.

6.4.1.3 Identification of Components and Alternative Means

Approaches B and C consisted of the following two Components (with a number of associated Alternative Means).

1. Demolition (five Alternative Means)
2. Modification (no Alternative Means)

6.4.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the Alternative Means technically feasible?
- F2-2: Does the Alternative Means minimize environmental impact?

- F2-3: Is the Alternative Means cost effective?
- F2-4: Does the Alternative Means minimize additional risks?

The results of the application of the F2 are summarized in the following Table 6.10. Of the three Alternative Means considered, one of the Alterative Means was considered feasible and suitable for inclusion into a Feasible Concept. Modification to the buildings was not assessed and a potential long term use has not been identified by NS Lands to date.

Table 6.10 Results of Second Filter Step

Component	Alternative Means	F2-1 Technical	F2-2 Environmental	F2-3 Cost	F2-4 Additional Task	Pass/ Fail
1. Demolition	• Mechanical Equipment (e.g., excavator)	Yes	Yes	Yes	Yes	Pass
	• Crane and Wrecking Ball	No	Yes	No	Yes	Fail
	• Explosives	Yes	No	No	No	Fail
2. Modification[17] (if structurally sound)	Examples include:					
	• Operations building	N/A	N/A	N/A	N/A	N/A
	• Welcome/Community Centre	N/A	N/A	N/A	N/A	N/A
	• Storage Building	N/A	N/A	N/A	N/A	N/A

6.4.1.4.1 Demolition

The three Alternative Means that were considered as part of the demolition Component under Approach B included: mechanical equipment (e.g., excavator with hoe ram attachment), crane and wrecking ball, and collapse using explosives.

The results of the application of the F2 eliminated use of the crane and wrecking ball, as this demolition technique was not suitable for a Project of this size/scale, and was considered too costly.

Similarly, use of explosives to demolish/collapse the existing multiple small buildings associated with the BHETF was also considered too expensive, and failed to minimize environmental impact and additional liability risks.

6.4.1.4.2 Modification

No Alternative Means were identified for the Modification/Restoration component under Approach C as end use requirements for the Site have not been fully identified. One building that could be a candidate for re-purposing is the press building as it is the largest on-Site building and is adjacent to the Site access road. Provided that a building inspection is completed to confirm that it is structurally sound, potential repurposing examples include:

- Operational Building

[17] N/A Not Assessed. A potential long term use has not be identified by NS Lands for any of the on-Site buildings.

- Welcome/Community Centre
- Storage Building

6.4.2 Feasible Concept Description

Following application of the F2 step the remaining Approaches, Components, and Alternative Means were grouped into the following logical Feasible Concept:

- Feasible Concept 1 – Decommission and demolition

It is noted that a modification and repurposing of a Site building is considered possible, however, has not been evaluated at this stage as detailed end use Project requirements have not been identified.

The remainder of this Section presents an overview of Feasible Concept. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix F.

6.4.2.1 Feasible Concept 1 – Decommission and Demolition

Feasible Concept 1 consists of decommissioning and demolishing each building/structure and transporting waste materials for disposal or recycling.

Prior to demolition, any hazardous materials will be abated and a chemical sweep and cleaning will be completed. All residual product will be containerized and packaged, transported, and disposed of in accordance with Provincial and Federal regulations. Any non-hazardous waste will be collected and disposed or recycled. Building surfaces will be cleaned, as needed, to remove any residues. Electrical connections will be de-energized and disconnected. Similarly, any buried services will be decommissioned, as needed.

Demolition will commence once each building has been decommissioned and has been released for demolition. Demolition will require the use of an excavator, with a standard bucket or potentially mechanical shears for cutting large structural elements and collapsing the structure for cleanup. For larger structures, such as the silo, demolition will be done with a more methodical process using a crane and taking the structure apart in pieces. Footings and foundations will be removed to a depth of 0.9 m below finished grade.

6.4.2.2 Feasible Concept Cost Estimate

Class D capital cost estimate for Feasible Concept 1is provided in Appendix F, Attachment F1 and summarized on Table 6.11 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

Table 6.11 Treatment Buildings Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – Decommission and Demolish	$150,000	$0

Key assumptions include:

- Foundations will be cut, remain in place, and be buried. Only slabs and aboveground structures will be removed.
- Mobile buildings will be removed with no demolition required.
- Buildings have been de-energized prior to the start of decommissioning.
- Disposal costs are not included (included under Section 5 Waste Management).

6.4.3 Summary of Qualified Remedial Option

As there was only one Feasible Concept that was fully developed, the evaluation and weighting matrix was not applied. Feasible Concept 1 – Decommission and Demolish the treatment building was selected as the Qualified Remedial Option for the management of treatment buildings.

6.5 Dam

The dam is used to regulate the water level in the BHETF and is located north of the bridge at Highway 384. The dam is a flat concrete slab structure with retaining walls supporting the earth embankments at both ends with the bottom elevation of the slab being approximately equivalent to extreme low tide. The water levels are controlled by an adjustable weir/stop log arrangement within the dam structure.

6.5.1 Development and Identification of Feasible Concepts

Figure 6.4 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

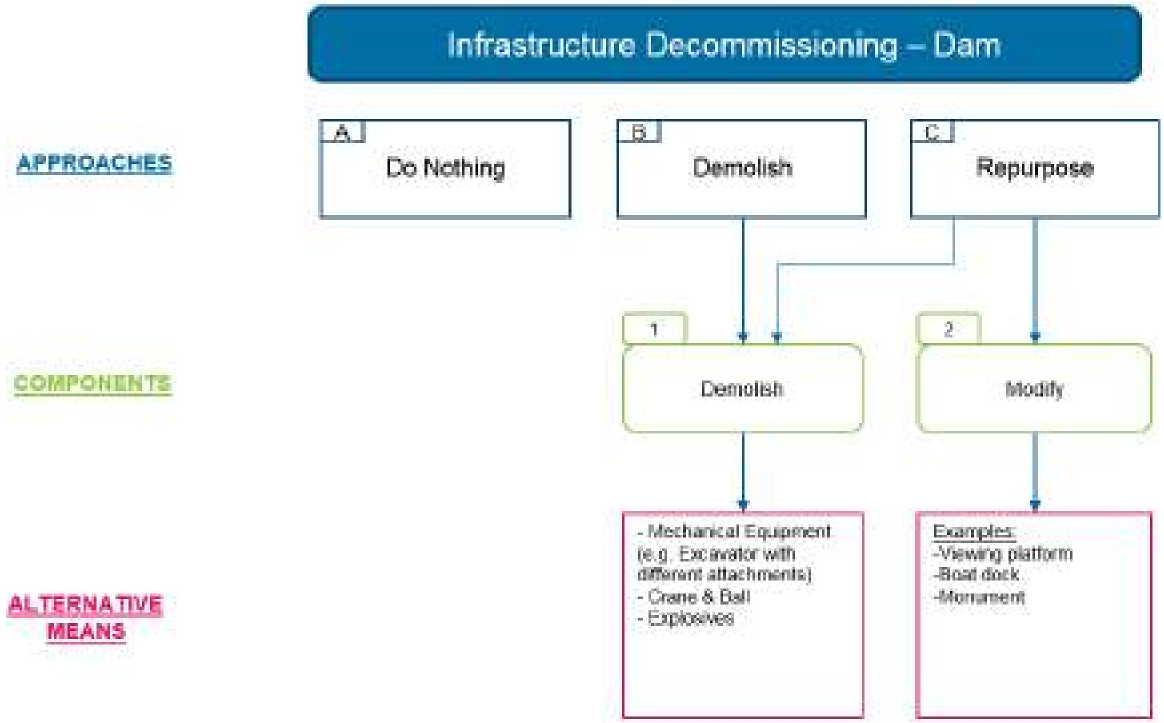


Figure 6.4 Dam Decommissioning Approaches, Components, and Alternative Means

6.5.1.1 Approaches

Three Approaches were identified for decommissioning of the dam as part of the overall infrastructure decommissioning to be conducted during BHRD implementation:

A. Do Nothing

B. Demolition

C. Repurpose

In accordance with Project objectives, Approach B involved full removal and decommissioning of dam structures in an environmentally sound manner, and in accordance with acceptable health and safety practices.

Approach C involved repurposing of the dam structure in accordance with overall Project end use objectives/requirements and applicable Provincial and Federal guidelines.

Approach A, the Do Nothing alternative, has been included for comparative purposes only.

6.5.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the water level suitable for end use (e.g., boat passage, return to tidal)?

- F1-2: Are regulatory approvals likely achievable?
- F1-3: Is the Approach acceptable to the public?

The results of the first Filter application are summarized below in Table 6.12.

Table 6.12 Results of First Filter Step

Approaches	F1-1 Suitability	F1-2 Approvability	F1-3 Acceptability	Pass/Fail
A. Do Nothing	No	No	No	Fail
B. Demolition	Yes	Yes	Yes	Pass
C. Repurpose	Yes	No	Yes	Fail

The Do Nothing alternative (Approach A) was removed from further consideration, as is did not facilitate returning Boat Harbour to tidal conditions, was unlikely to meet anticipated regulatory requirements, and failed to minimize long-term liability.

Repurposing the dam structure in accordance with Project end-use requirements (Approach C) also failed the application of the F1. This Approach was considered unlikely to meet regulatory approvals primarily due to challenges associated with the NS Watercourse Alteration Standard.

Only Approach B, full removal of the dam structure, was determined to be an adequate Approach that warranted further evaluation and was therefore carried forward for further evaluation.

6.5.1.3 Identification of Components and Alternative Means

Approaches B consisted of a single Component (with a number of associated Alternative Means).

1. Demolition (three Alternative Means)

6.5.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the Alternative Means technically feasible?
- F2-2: Does the Alternative Means minimize environmental impact?
- F2-3: Is the Alternative Means cost effective?
- F2-4: Does the Alternative Means minimize additional risks?

The results of the application of the F2 are summarized below in Table 6.13. Of the three Alternative Means considered, only one of the Alterative Means was considered feasible and suitable for inclusion into Feasible Concepts.

Table 6.13 Results of Second Filter Step

Component	Alternative Means	F2-1 Technical	F2-2 Environmental	F2-3 Cost	F2-4 Risk	Pass/ Fail
1. Demolition	• Mechanical Equipment (e.g., excavator)	Yes	Yes	Yes	Yes	Pass
	• Crane and Wrecking Ball	No	Yes	No	Yes	Fail
	• Explosives	Yes	No	No	No	Fail

6.5.1.4.1 Demolition

The three Alternative Means that were considered as part of the demolition Component under Approach B included: mechanical equipment (e.g., excavator with hoe ram attachment), crane and wrecking ball, and use of explosives for full or partial removal of the existing dam structure.

The results of the application of the F2 eliminated use of the crane and wrecking ball, as this demolition technique was not suitable for a Project of this size/scale, and was considered too costly.

Similarly, use of explosives to demolish/collapse the existing dam structures was also considered too expensive, and failed to minimize environmental impact and additional liability risks.

Only one Alternative Means under the demolition Component passed application of the second filter: use of mechanical equipment (e.g., excavator with hoe ram attachment) was considered the only technically feasible and cost effective option capable of meeting design requirements.

6.5.2 Feasible Concept Description

Following application of the F2 step each remaining Approach, Component, and Alternative Mean were grouped into the following logical Feasible Concept:

- Feasible Concept 1: Decommissioning and demolition of the dam

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix F.

6.5.2.1 Feasible Concept 1 – Decommissioning and Demolition of the Dam

Feasible Concept 1 involves the demolition of the dam structure and the rehabilitation of the estuary embankment slopes. The demolition of the dam structure will consist of using mechanical equipment to break the concrete structure into smaller components excavated and dumped into a dump truck for onsite or offsite disposal. The smaller elements of the structure will be demolished by hand, such as the timber screens and fences.

Prior to demolition, any hazardous materials should be abated. In addition, any electrical connections should be fully de-energized.

One of the major items for consideration are the requirements for erosion control during and after construction. Demolition will commence once the remediation is complete and Boat Harbour is ready to be reinstated back to a tidal conditions. The use of silt booms installed in the water upstream and downstream of the dam will be used to control the migration of silt generated as a result of the dam removal. Once the dam structure is removed the channel will be dredged to match the channel shape and depth as the bridge (that will be installed to replace the causeway), to ensure the hydraulics are maintained throughout the channel.

6.5.2.2 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for the Feasible Concept is provided in Appendix F, Attachment F1 and summarized on Table 6.14 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

Table 6.14 Dam Decommissioning Feasible Concept Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 - Decommissioning and Demolition of the Dam	$370,000	$0

Key assumptions include:

- Includes coffer dam and pumping to facilitate works being completed in the dry.
- Includes removing embankments to return open channel to original condition.
- Disposal costs are not included.

6.5.3 Summary of Qualified Remedial Option

As there was only one Feasible Concept that was fully developed, the evaluation and weighting matrix was not applied. Feasible Concept 1 – Decommissioning and Demolition of the Dam was selected as the Qualified Remedial Option.

7. Remediation Methodology and Approach

7.1 Background

Remediation includes addressing Site areas that have been impacted from the operation of the BHETF. Key Site areas that will require remediation include the raw effluent discharge ditch, twin settling basins, ASB, BH, estuary, and wetlands[18].At the core of remediation will be dredging

[18] Wetland remediation is addressed in Section 5

impacted sediments/sludge and managing all associated effluents. Remediation activities must be performed in a manner that is safe and minimizes exposure to humans and the environment.

7.1.1 Categories

Remediation components for the effluent ditch, settling basins, ASB, BH, and estuary have been organized as follows:

- Section 7.2 – Sediment Management, includes sludge/sediment removal, dewatering, and treatment.
- Section 7.3 – Bulk Water Management, includes management and treatment of surface water from the active and historical BHETF components.
- Section 7.4 – Dewatering Effluent Management, includes treatment of effluent generated from dewatering sludge/sediment.
- Section 7.5 – Leachate Management, includes treatment of leachate from the on-Site sludge disposal cell during and post remediation.

Wetland remediation is discussed in Appendix E - Wetland Management Detailed Concept Descriptions, and references sediment and water treatment methodologies and cost from this section where required.

Waste management options are discussed in Appendix D - Waste Management Detailed Concept Descriptions, and reference leachate treatment methodologies and cost from this section where required.

7.2 Sediment Management

Sediment management includes the removal of sludge and impacted sediment, dewatering of sludge/sediment, and treatment of sludge/sediment. Areas requiring remediation are described as follows:

- Raw Effluent Discharge Ditch: It is anticipated that remediation activities will require removal of ditch lining materials[19].
- Twin Settling Basins: Remediation activities will require the removal of sludge/sediment that is impacted with COCs including metals and TPH.
- ASB: Remediation activities will require the removal of sludge that is impacted with COCs including metals, TPH, PAH and D&F. The native marine clay, which underlies the sludge, is not impacted to levels exceeding provincial and federal criteria and is not likely to require remediation. Similarly, surface water will need to be remediated/treated as it is impacted with COCs that include metals, TPH, and cyanide.
- BH: Remediation activities will require the removal of sludge that is impacted with COCs including metals, VOCs, TPH, PAH, and D&F. The underlying native marine clay/sediment is not impacted to levels exceeding provincial and federal criteria and is not likely to require

[19] Due to the flow depth and velocity environmental characterization of the ditch bottom/lining was not practical as part of the Phase 2 ESA.

remediation. Surface water will need to be remediated/treated as it is impacted with COCs including metals, TPH, and cyanide.

- Estuary: Remediation activities will require the removal of sludge that is impacted with COCs including limited metals, TPH, PAH, and D&F. The native marine clay, which underlies the sludge, is not impacted to levels exceeding provincial and federal criteria and is not likely to require remediation. Surface water will need to be remediated/treated as it is impacted with COCs including metals, TPH, and cyanide.
- Sludge Disposal Cell: The disposal cell is currently used for placement of dredged material from the ASB. As noted in Appendix D Waste Management Detailed Concept Descriptions, two Feasible Concepts were developed for waste management including use of existing disposal cell and off-site disposal. As such, the sludge that has been placed in the disposal cell may or may not need to be removed depending on the selected waste management option. Disposal cell sludge COCs include metals, VOCs, TPH, PAH, and D&F. The sludge disposal also contains surface water that is impacted with metals, TPH, and cyanide.

Where sludge is identified to be completely removed, remaining sediment quality is expected to meet standards established in the NSE Tier 1 Environmental Quality Standards (EQSs) for Sediment (Marine Sediment) and CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Probable Effects Level) or risk based criteria that is protective of ecological and human health.

The overall estimate of in-place sludge to be managed from the above noted areas during remediation is approximately 1,244,000 m^3 as further outlined in Appendix G.

7.2.1 Development and Identification of Feasible Concepts

Figure 7.1 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

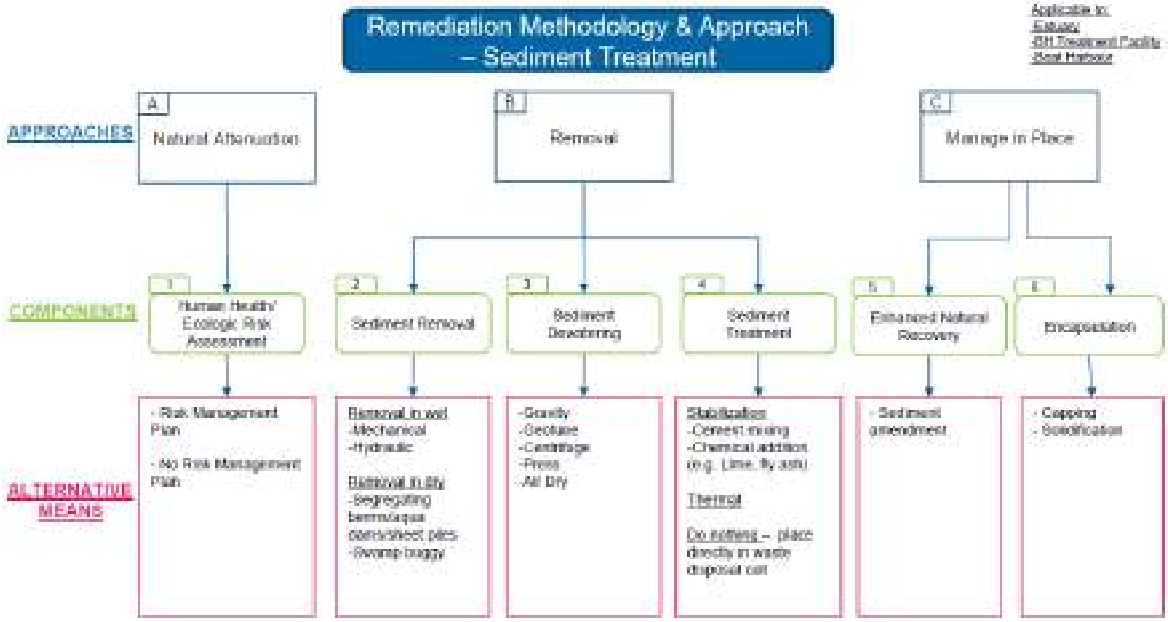


Figure 7.1 Sediment Management Approaches, Components, and Alternative Means

7.2.1.1 Approaches

Three Approaches were identified for the sediment/sludge treatment as part of the BHRD implementation:

A. Natural Attenuation

B. Removal

C. Manage in Place

Approach A involves natural attenuation, which is commonly used as a remedial option to address residual impacts to an ecosystem after the contaminant source has been removed or eliminated (similar to that described in Section 5.2.1 for Wetland Management). As effluent flow to the BHETF ceases, loading of COCs is expected to be significantly reduced or eliminated compared to current conditions. In association with natural attenuation is the concept of risk assessment. Risk assessment is the process to estimate the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment) now or in the future. If the risk assessment identifies isolated hotspots, active remediation or risk management measures may be implemented to accelerate the natural recovery process. Monitoring of the natural attenuation process is critical to ensuring recovery of the system is occurring as anticipated.

Approach B involves sludge removal from impacted areas and ex-situ sludge management. Removal may be completed in wet or dry conditions. This approach ensures effective risk reduction through complete sludge removal. Once removed, the sludge may be further processed to reduce volume and contaminants (e.g., dewatering, treatment).

Approach C involves in-situ remediation approaches to address contamination in place without the removal of the sludge. Manage in place includes enhanced natural recovery (addition of amendments to facilitate contaminants degrading in place) and encapsulation (e.g., capping or solidifying sludge).

7.2.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Are regulatory criteria and end use requirements achievable?
- F1-2: Is residual risk reduced to acceptable levels in an appropriate timeframe?
- F1-3: Is the solution acceptable by the public?

The results of the F1 application are summarized below in Table 7.1.

Table 7.1 Results of First Filter Step – Sediment Management

Approaches	F1-1 Approvability	F1-2 Functionality	F1-3 Acceptability	Pass/Fail
A. Natural Attenuation	Yes	Yes	Potentially for estuary/No for other areas	Pass (for Estuary only)
B. Removal	Yes	Yes	Yes	Pass
C. Manage in Place	No	Yes	No	Fail

For the active BHETF components including the effluent ditches, twin settling basins, ASB, and Boat Harbour, only complete removal (Approach B) of sludge was deemed to be acceptable to the public as reconnection of the community to A'se'k without recreational/traditional use was deemed to be unacceptable.

For the estuary, manage in place failed F1 due to public acceptability as reconnection of the community to A'se'k needs to include the estuary. Although mange in place would provide an environment for recreation, public acceptance is unlikely. Natural attenuation was carried forward for the estuary, even though public acceptability is considered low. However over time, acceptance would likely increase as monitoring proved natural attenuation is occurring.

7.2.1.3 Identification of Components and Alternative Means

Collectively, the Approaches identified in Section 7.2.1.2 consisted of the following six Components (with a number of associated Alternative Means):

1. Human Health/Ecologic Risk Assessment (two Alternative Means)
2. Sediment Removal (four Alternative Means)
3. Sediment Dewatering (five Alternative Means)
4. Sediment Treatment (four Alternative Means)
5. Enhanced Natural Recovery (one Alternative Means)

6. Encapsulation (two Alternative Means)

7.2.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Is the solution acceptable by the public?
- F2-2: Is the Alternative Means technically feasible?
- F2-3: Does the Alternative Means minimize environmental impact?

The results of the application of the F2 are summarized in the following Table 7.2. Of the 18 Alternative Means considered, 11 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 7.2 Results of Second Filter Step – Sediment Management

Component	Alternative Means	F2-1 Public	F2-2 Technical	F2-3 Environmental	Pass/Fail
1. Human Health/Ecologic Risk Assessment (Estuary Only)	Risk Management Plan	Yes	Yes	Yes	Pass
	No Risk Management Plan	Yes	No	Yes	Fail
2. Sediment Removal	Removal in Wet				
	• Mechanical dredging	Yes	Yes	Yes	Pass
	• Hydraulic dredging	Yes	Yes	Yes	Pass
	Excavation in Dry				
	• Segregating berms, Sheet piles, Aqua Dams	Yes	Yes	Yes	Pass
	• Swamp buggy	Yes	Yes	Yes	Pass
3. Sediment Dewatering	Gravity dewatering	Yes	Yes	Yes	Pass
	Geotubes	Yes	Yes	Yes	Pass
	Centrifuge	Yes	Yes	Yes	Pass
	Filtration	Yes	Yes	Yes	Pass
	Air drying	Yes	No	Yes	Fail
4. Sediment Treatment	Stabilization				
	• Cement mixing	Yes	Yes	Yes	Pass
	• Chemical addition	Yes	Yes	Yes	Pass
	Thermal	No	Yes	Yes	Fail
	Do nothing	Yes	Fail	Yes	Fail

Table 7.2 Results of Second Filter Step – Sediment Management

Component	Alternative Means	F2-1 Public	F2-2 Technical	F2-3 Environmental	Pass/Fail
5. Enhanced Natural Recovery[20] (Estuary Only)[20]	Sediment amendment	N/A	N/A	N/A	N/A
6. Encapsulation[20]	Capping	N/A	N/A	N/A	N/A
	In-situ solidification	N/A	N/A	N/A	N/A

7.2.1.4.1 Human Health/Ecologic Risk Assessment (Estuary Only)

The Alternative Means that were considered as part of the human health/ecological risk assessment for the estuary under Approach A include: development/implementation of a risk management plan, and no development/implementation of a risk management plan. If the risk assessment identifies isolated hotspots, active remediation or risk management measures may be implemented to accelerate the natural recovery process. Monitoring of the natural attenuation process is critical to ensuring recovery of the system is occurring as anticipated. As such, it was determined that it would be very unlikely that a risk management plan would not be required (i.e., not technically feasible).

7.2.1.4.2 Sediment Removal

The two Alternative Means that were considered as part of the sediment removal Component under Approach B included: removal in the wet (e.g., mechanical or hydraulic dredging), and removal in the dry using mechanical dredging in combination with segregation methods (e.g., berms, aqua dams, or sheet piles) to facilitate remediation in manageable areas. In addition, removal in the dry also considered the use of a swamp buggy (e.g., amphibious excavator). Both Alternative Means passed application of the F2, and were considered technically feasible and cost effective options capable of meeting design requirements for all areas under consideration. However, further testing is required on the underlying sediment to confirm if low ground pressure equipment can pass on the surface to facilitate removal in the dry. This will be confirmed through geotechnical drilling and potentially pilot scale testing. If not technically achievable, Feasible Concepts using removal in the dry will be eliminated.

7.2.1.4.3 Sediment Dewatering

The five Alternative Means that were considered for the sediment dewatering Component under Approach B included: gravity dewatering, geotubes, centrifuge, filtration (i.e., filter press), and air drying.

The results of the application of the second Filter eliminated air drying, as this dewatering technique was not technically feasible for this particular application due to weather, time, and potential air emissions (odour and dust). The Nova Scotia climate is unsuitable for processing such a large volume of material by air drying.

[20] N/A Not assessed as Approach C was eliminated as part of F1.

All other Alternative Means under the sediment dewatering Component passed application of the second filter, and were considered to have been technically feasible and cost effective options capable of meeting design requirements.

7.2.1.4.4 Sediment Treatment

The three Alternative Means that were considered for the sediment treatment Component under Approach B included: stabilization/solidification via cement mixing, stabilization/solidification via chemical addition, thermal, or do nothing (i.e., place sediment directly into waste disposal cell).

The results of the application of the F2 eliminated incineration (i.e., high temperature thermal treatment) of sludge, as this treatment technique was considered to be not acceptable to the public; public opposition is anticipated based on previous projects completed in Nova Scotia. The high moisture content of the removed sludge would also result in high costs for the application of thermal treatment. As a result, thermal treatment was eliminated from further consideration

Do nothing was eliminated following laboratory treatability testing as gravity dewatering was determine to be not technically feasible.

All other Alternative Means under the sediment treatment Component passed application of the second filter, and were considered to have been technically feasible and cost effective options capable of meeting design requirements.

7.2.2 Feasible Concept Description

Feasible Concepts developed for sediment treatment include the following:

- Feasible Concept 1: Removal in the wet
  - Feasible Concept 1A: With geotube dewatering
  - Feasible Concept 1B: With clay stabilization
- Feasible Concept 2: Removal in the dry
  - Feasible Concept 2A: With geotube dewatering
  - Feasible Concept 2B: With clay stabilization
- Feasible Concept 3 (Estuary Only): Natural attenuation

It is noted that the use of geotubes was found to be the most effective Alternative Mean for dewatering sludge based on Laboratory Treatability Study (Appendix A) and was therefore carried forward as part of Feasible Concept 1A and 2A. Similarly, the use of clay product (Liquasorb 2000) was found to be the most effective Alternative Mean for stabilization of the sludge based on Bench Scale Testing (Appendix A) and was therefore carried forward as part of Feasible Concept 1B and 2B.

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix G.

7.2.2.1 Feasible Concept 1A – Removal in the Wet with Geotube Dewatering

Removal in the wet can be achieved either through mechanical or hydraulic dredging. Mechanical dredging involves material removal using an excavator bucket or clamshell bucket from shore or from a barge. The material is loaded directly into a truck if at shore or if on the water into the barge and subsequently loaded into a truck for transport. Hydraulic dredging equipment is set up on a boat or barge and removes material in a sludge-water mixture (slurry), transferring it via pipe to the desired location.

Removal in the wet will be predominantly completed through hydraulic dredging due to the ease of material transfer (i.e., can be used to a minimum water depth of 0.8 to 1 m), however, limited mechanical dredging may be required to remove sludge in tight and shallow areas. The dredged sludge slurry will be subsequently pumped to a designated sludge management area.

The area (BH, ASB, and estuary) will be sub-divided in eight areas using silt curtains to segregate the areas and to control suspended sediments, with additional silt curtains used within each area, as beneficial, to better control suspended sediment movement. Dredging productivity (using two or more dredges) is anticipated to be 2,000 m^3 of in-place sludge removed per day for both hydraulic dredging and mechanical dredging (based on a 10-hour day). Approximately 0.15 m of materials underlying the sludge (e.g., native marine clay in the BH) will likely be dredged based on the undulating bottom and accuracy of the dredging equipment. Following dredging, confirmatory sampling will be completed to confirm that remaining sediment meets the applicable remedial quality standards for all sediment COCs. As needed, clean up dredging passes and resampling will be completed.

Hydraulically dredged sludge slurry will be pumped through discharge lines to the sludge management area, located in the existing disposal cell. Following some preparation work in the disposal cell, multiple geotubes will be setup as permitted by space. As a geotube dewaters, additional capacity is created to allow for placement of slurry (typically 3 pumping events per geotube). Once the capacity of the geotube is used, empty geotubes will be stacked adjacent or on top (forming a pyramid shape). It is estimated that between 50 and 130 geotubes[21] will be required to manage sludge/sediment generated during remediation.

7.2.2.2 Feasible Concept 1B – Removal in the Wet with Clay Stabilization

Sludge removal activities will be the same as noted above for Feasible Concept 1A.

Hydraulically dredged sludge slurry, as noted in Feasible Concept 1A, will be pumped through discharge lines to the sludge management area located within the existing twin settling basins. Dredged slurry would be pumped to a shear mixer for the addition of Liquasorb 2000 under optimal shear force mixing. Once mixed, the material will be pumped into the sludge management area, where excavators will be used to spread the material out for drying. Once the sludge has stabilized (e.g., solidified) over 1-3 days the material will be loaded and hauled for disposal. As stabilization will increase the sludge volumes, the existing disposal cell would need to be expanded to

21 Assuming a geotube diameter of 5 to 8 m in diameter by 120 m in length

accommodate the treated sludge volume; or some treated sludge would need to be disposed of off-Site. Volume estimates are provided in Appendix G.

7.2.2.3 Feasible Concept 2A – Removal in the Dry with Geotube Dewatering

Removal in the dry will involve dredging sludge/sediment from the twin settling basins, ASB, BH, and estuary under dewatered conditions. Removal in the dry will involve bulk dewatering to achieve dry conditions, mechanical excavation, and transportation of dredged sludge/sediment for dewatering.

For removal, the area (BH, ASB, and esturay) will be sub-divided in eight areas to facilitate bulk dewatering and removal of sludge. Isolation berms or coffer dams will be used to segregate the areas. Within each area, smaller sub-areas will be created with smaller earthen separation berms or water inflated cofferdams, such as an aqua dam, to manage dewatering and maintain dry conditions in an active sub-area. Further testing is required on the underlying sediment to confirm low ground pressure equipment can pass on the surface. This will be confirmed through geotechnical drilling and potentially pilot scale testing.

Excavating in the dry will provide good visual control; to ensure all sludge has been removed. It is estimated that 0.15 m of materials underlying the sludge will be excavated along with the sludge based on undulating bottom and excavation accuracy. Following excavation confirmatory testing will be completed to confirm that the remaining sediment meets the applicable remedial quality standards for all sediment COCs.

Excavated sludge will be placed in a hopper for mixing with water (as needed) to create a slurry such that it can be pumped to the geotubes for dewatering as detailed in Feasbile Concept 1A.

7.2.2.4 Feasible Concept 2B – Removal in the Dry with Clay Stabilization

Sludge removal activities will be the same as detailed above for Feasible Concept 2A and clay stabilization will be the same as detailed for Feasible Concept 2B, as detailed in Appendix G.

7.2.2.5 Feasible Concept 3 (Estuary Only) – Natural Attenuation

Natural attenuation is commonly used as a remedial option to address residual impacts to an ecosystem after the contaminant source has been removed or eliminated. Typical natural attenuation processes involve one or more biological, chemical, or physical processes.

In association with natural attenuation of COCs is the concept of risk assessment. Risk assessment is the process of estimating the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment and surface water) now or in the future. If the risk assessment identifies isolated hotspots, active remediation or risk management measures may be implemented to accelerate the natural recovery process.

Active remediation could include one of the other four sediment management Feasible Concepts (i.e. removal and treatment). Risk management options could include:

- Restrict or reduce future access to the estuary area (potentially create estuary viewing areas and post signs indicating sensitive habitat, do not disturb)
- Restrict future hunting or fishing activities in the estuary
- Enhance ecological habitat in "clean" estuary areas to promote areas for foraging or breeding by wildlife (i.e., construction of bird nesting sites)
- Develop long term monitoring plans including index of biological indicators along with Site-wide risk review to evaluate estuary conditions in conjunction with intrusive remediation of other areas of the Site

Monitoring of the natural attenuation process is critical to ensuring recovery of the system is occurring as anticipated. A post-remediation monitoring program up to 5 years will be implemented to monitor the Site and confirm the effectiveness of the natural attenuation.

Further studies, including environmental assessment baseline studies and hydrologic modelling, are ongoing. The results of these investigations will provide valuable information to determine the viability of natural attenuation in the estuary.

7.2.2.6 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix G, Attachment G1 and summarized on Table 7.3 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost for an estimated 5-year period have been carried for Feasible Concept 3.

Table 7.3 Class D Cost Estimate – Sediment Management

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1A – Removal in the wet with geotube dewatering	$89,090,000	$0
Feasible Concept 1B – Removal in wet with clay stabilization	$117,590,000	$0
Feasible Concept 2A – Removal in dry with geotube dewatering	$113,190,000	$0
Feasible Concept 2B – Removal in dry with clay stabilization	$160,570,000	$0
Feasible Concept 3 (Estuary Only) – Natural attenuation	$290,000	$650,000

Key assumptions include:

- For Feasible Concepts 1A and 1B silt curtains will not be reused.
- For Feasible Concepts 1A and 1B 90 percent of in-place material will be hydraulically dredged, while 10 percent will need to be mechanically dredged.

- For Feasible Concepts 1A, 1B, 2A, and 2B sludge management area improvements (within twin settling basins and existing disposal cell) will not require a low permeable liner due to existing clay liner.
- For Feasible Concepts 1A, 1B, 2A, and 2B conduct confirmatory sampling at a rate of one sample per 1000 m^2.
- For Feasible Concepts 2A and 2B, fill material for isolation and separation berms will not be reused and will constitute clean fill at the completion of remediation.
- For Feasible Concepts 1B and 2B (clay stabilization), no dewatering effluent will be produced.
- See bulk water and dewatering effluent management assumptions in Sections 7.3 and 7.4.
- For Feasible Concept 3 post remediation monitoring for 5 years will be required, with parameter limitations noted in cost table.

7.2.3 Evaluation of Feasible Concepts

The Feasible Concepts carried forward for Sediment Management were evaluated, compared, and ranked to identify the most suitable concept for consideration as a Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation), as well as the identification and comparison of advantages/disadvantages for each Feasible Concept. Feasible Concept 1A, 1B, 2A and 2B were ranked. Feasible Concept 3 (estuary only - natural attenuation) was not ranked and is pending further discussion with stakeholders to determine if it is unacceptable to the public.

7.2.3.1 Comparative Evaluation

The completed evaluation and weighting matrix for Sediment Management Alternatives is presented in Appendix H. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 7.4 presents a summary of the matrix scores for each Feasible Concept.

Table 7.4 Summary of Matrix Scores – Sediment Management

Criteria Category	Weighting Factor	Feasible Concept 1A (Wet & Dewatering)	Feasible Concept 1B (Wet & Stabilization)	Feasible Concept 2A (Dry & Dewatering)	Feasible Concept 2B (Dry & Stabilization)
Regulatory	14%	363	350	**375**	363
Technical	26%	**462**	402	380	339
Environmental	24%	**473**	471	455	453
Social	14%	**400**	**400**	394	394
Economic	22%	**500**	350	350	300
Total Comparative Score		**2197**	1974	1953	1848
Total Weighted Score		**450**	400	392	369
Rank		**1**	2	3	4

7.2.3.1.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Feasible Concept 2A (dry & dewatering) ranked higher than Feasible Concepts 1A (wet & dewatering), 1B (wet & stabilization), and 2B (dry & stabilization). Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Under each of the four Feasible Concepts, sludge will be removed from the effluent ditches, twin settling basins, ASB, BH, and the estuary, however, the handling and transportation of waste material varies for each. There will be some risk due to air quality and odour for all Feasible Concepts, however the concern will be greater for removal in the dry since sludge will be exposed near the property line prior to pumping, whereas material removed in the wet would be directly pumped. Consequently, Feasible Concept 2A and Feasible Concept 2B scored lower (3.0) than Feasible Concept 1A and Feasible Concept 1B (4.0) for sub-indicator HS1.1.

The potential air quality and odour risks to public during sediment management would be moderately difficult to mitigate on such a large Site. In all cases, if odours and/or emissions become an issue, it is likely that work would need to be stopped and procedures altered. As a result of similar mitigative measures, all Feasible Concepts scored equally (3.0) for sub-indicator HS1.2.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

Under all Feasible Concepts, sludge will be removed from effluent ditches, twin settling basins, ASB, BH, and the estuary, however, the subsequent handling of waste material varies for each. The level of risk associated with the extra sludge handling step required for stabilization with clay was considered higher than that for pumping directly to geotubes. The extra sludge handling and exposure to workers associated with Feasible Concept 1B and Feasible Concept 2B scored them lower (3.0) than Feasible Concept 1A and Feasible Concept 2A (4.0) for sub-indicator HS2.1.

The potential risks to the workers during sludge handling and treatment are generally considered to be easily mitigatable through the use of proper PPE and implementation of proper health and safety procedures. All Feasible Concepts were scored the same (4.0) for sub-indicator HS2.2.

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

It is expected that all Feasible Concepts will be readily approvable and that significant monitoring and testing will be required to verify compliance. Sediment quality compliance criteria to confirm sufficient remediation of effluent ditches, twin settling basins, ASB, BH, and the estuary will be based on NSE Tier 1 EQSs for Sediment (Marine) and CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Probable Effects Level) or will be risk-based criteria that is protective of ecological and human health. Based on GHD's Phase 2 ESA results, it is expected that once the sludge is removed, sediment criteria will readily be met. While confirmatory sampling would be completed for all options, it will be easier to demonstrate compliance for removal in the dry as compared to removal in the wet, due to the increased ability to visually confirm and collect representative samples. As a result, Feasible Concept 2A and Feasible Concept 2B scored 5.0 for sub-indicator C1.1, while Feasible Concept 1A and Feasible Concept 1B scored lower at 4.0.

With respect to sub-indicator C1.2, both Feasible Concepts were considered to have only a moderate level of public acceptance from the PLFN and surrounding communities. It will be harder to verify that all sludge has been removed for Feasible Concepts involving removal in the wet compared to removal in the dry. However, removal in the wet will be less disruptive during the remediation process compared to removal in the dry. The public and PLFN would presumably prefer visually verifiable sludge removal, but also minimal disruption during construction. As a result, all Feasible Concepts scored 3.0 for sub-indicator C1.2.

7.2.3.1.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project.

Feasible Concept 1A (wet & dewatering) ranked higher than Feasible Concepts 1B (wet & stabilization), 2A (dry & dewatering), and 2B (dry & stabilization). Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

Both removal in the wet and removal in the dry are considered reliable and successful approaches for sludge removal. However, clay stabilization (Feasible Concept 1B and Feasible Concept 2B) is less proven than geotube dewatering (Feasible Concept 1A and Feasible Concept 2A) for sediment management and treatment. As such, Feasible Concept 1A and Feasible Concept 2A received a score of 5.0, while Feasible Concept 1B and Feasible Concept 2B received a lower score of 3.0 for sub-indicator T1.1.

With regards to sediment removal, hydraulic dredging and pumping equipment, as well as excavators and low ground pressure equipment are all readily available. Removal in the dry (Feasible Concept 2A and Feasible Concept 2B) however, would require significant amounts of material for berm construction, which could be difficult to obtain on such a large scale. Similarly, the clay required for stabilization (Feasible Concept 1B and Feasible Concept 2B) may be difficult to obtain in large quantities, and there are limited vendors who could provide the specific clay product required (other products tested were not successful at stabilizing the sediment). Geotubes, on the other hand, are easily attainable. Consequently, Feasible Concept 1A scored a 5.0, Feasible Concept 2A scored 3.0, and Feasible Concept 1B and Feasible Concept 2B received 2.0 for sub-indicator T1.2.

There are many local contractors who would be available to complete removal in the dry, whereas there would be less dredging and pumping contractors available to complete removal in the wet. At this time it is understood that the clay mixing process for stabilization is specialized and is typically completed by a sole contractor. Based on the relative vendor and contractor availability for the options, Feasible Concept 2A scored the highest at 4.0, Feasible Concept 1A scored 3.0, while Feasible Concept 1B and Feasible Concept 2B received a score of 2.0 for sub-indicator T1.3.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criterion discussed in Section 7.2.1.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1A and Feasible Concept 1B (removal in the wet) with current on-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints. As a result, both Feasible Concept 1A and Feasible Concept 1B received a score of 5.0 for all five sub-indicator questions.

Removal in the dry (Feasible Concept 2A and Feasible Concept 2B) will be a challenge with current Site size and configuration due to the large amount of berms and haul roads to be constructed to get equipment and sludge around the Site. As such, Feasible Concept 2A and Feasible Concept 2B received a score of 2.0 for sub-indicator T2.1. Removal in the dry was also deemed to carry some constraints with respect to the other current Site features, such as the presence of soft marine clay complicating construction, the dewatering requirements to maintain dry conditions, and the amplified impact of a storm event on dry conditions. Therefore, Feasible Concept 2A and Feasible Concept 2B were scored 3.0 for sub-indicators T2.2, T2.3, T2.4, and T2.5.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

Remedial options completed in the dry (Feasible Concept 2A and Feasible Concept 2B) will require importing a large amount of off-Site material for berm construction. Similarly, remedial options involving clay stabilization (Feasible Concept 1B and Feasible Concept 2B) will require substantial amounts of off-Site clay. For sub-indicator T3.1, restrictions due to spring load restrictions on secondary roads will limit material deliveries to the Site, making Feasible Concept 2A and Feasible Concept 2B (and partially Feasible Concept 1B) less compatible with existing off-Site features. Historically, load restrictions have been implemented between mid-March to mid-May, but restrictions are dependent on weather conditions and the types of vehicles being used. Accordingly, Feasible Concept 2A and Feasible Concept 2B received a score of 3.0 for sub-indicator T3.1, while Feasible Concept 1B scored 4.0 and Feasible Concept 1A scored 5.0.

Material deliveries will result in increased traffic, noise, dust, and wear and tear on off-Site roads. As such, Feasible Concept 2A and Feasible Concept 2B scored 3.0, while Feasible Concept 1B scored 4.0 for sub-indicated T3.2. No potential changes or impacts to off-Site conditions were associated with Feasible Concept 1A, which as a result received a score of 5.0 for sub-indicator T3.2.

While there was no perceived difference between the Feasible Concepts in anticipated changes to existing power supply or other municipal infrastructure off-Site, implementation of Feasible

Concept 1B, Feasible Concept 2A, and Feasible Concept 2B were expected to necessitate minor repairs to secondary highways surrounding the Site. As a result, Feasible Concept 1B, Feasible Concept 2A, and Feasible Concept 2B received a score of 4.0 for sub-indicator T3.3, while Feasible Concept 1A received a score of 5.0.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicator T4.1, the components of each Feasible Concept were not expected to fail within the remediation and post-remediation period, and as a result all Feasible Concepts received a score of 5.0.

Maintenance requirements for all options are focused on during remediation, as no major maintenance is expected to be involved post-remediation. The relative maintenance requirements associated with Feasible Concept 2A and Feasible Concept 2B (removal in the dry), including bulk dewatering, water management and treatment, were considered moderate, and resulted in Feasible Concept 2A and Feasible Concept 2B receiving a score of 3.0 for sub-indicator T4.2. By comparison, there were less maintenance requirements associated with Feasible Concept 1A and Feasible Concept 1B (removal in the wet), though there would still be potential for dredge breakdowns and associated maintenance. Feasible Concept 1A and Feasible Concept 1B received a score of 4.0 for sub-indicator T4.2.

There is a high likelihood that remediation completed in the dry (Feasible Concept 2A and Feasible Concept 2B) will achieve sediment criteria due to the high control of removal and visual confirmation. Comparatively, criteria should be met once sediment is removed in wet conditions (Feasible Concept 1A and Feasible Concept 1B), however there will be some uncertainty due to the lack of visual confirmation. Confirmatory sampling will be used to verify satisfactory removal. As a result of this, Feasible Concept 1A and Feasible Concept 1B received a score of 4.0 for sub-indicator T4.3, while Feasible Concept 2A and Feasible Concept 2B scored 5.0.

For sub-indicator T4.4, the likelihood and resulting impact of Feasible Concept 2A and Feasible Concept 2B (removal in the dry) not meeting performance criteria or remediation objectives was considered low, as any isolated residual contaminated sediment could be readily identified and removed. The impact of residual contamination for remediation in the wet (Feasible Concept 1A and Feasible Concept 1B) would be more substantial, as cleanup passes with a hydraulic dredge would not be as targeted as removal of residual sludge in the dry. If residual contamination cannot be fully removed with hydraulic dredging cleanup passes, additional measures may be required (i.e., sand cap). As a result, Feasible Concept 1A and Feasible Concept 2A received a score of 3.0 and Feasible Concept 2A and 2B received a score of 5.0.

Should remaining hotspots need to be addressed following initial sludge removal in the dry, this additional effort would be easily implemented if the area is still dewatered. Comparatively, this task would be more difficult in the wet due to lack of visual confirmation during removal, and inability to accurately delineate discrete hotspots in the wet. Cleanup passes may be sufficient, but additional contingencies may still be required (i.e., sand cap). Contingencies could be implemented with relative ease, but would require more effort in the wet than in the dry. Consequently, Feasible Concept 1A and Feasible Concept 1B received a score of 4.0, while Feasible Concept 2A and Feasible Concept 2B scored 5.0 for sub-indicator T4.5.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

Removal in the wet can be implemented relatively quickly, as it is easy to scale up the operation with the addition of more equipment. This solution may be slightly slower when combined with clay stabilization versus geotubes, due to the extra steps of handling and hauling. As such, Feasible Concept 1A received a score of 5.0 and Feasible Concept 1B received a score of 4.0 for sub-indicator T5.1. Removal in the dry will take longer due to increased weather sensitivity and the time required for berm construction. Again, the clay stabilization process is expected to add to the timeframe as well. Therefore, Feasible Concept 2A received a score of 2.0 and Feasible Concept 2B scored 1.0 for sub-indicator T5.1.

The anticipated timeframe for Feasible Concept 1A and Feasible Concept 1B is less than four years, while Feasible Concept 2A and Feasible Concept 2B are both expected to be implemented in four to seven years; as a result Feasible Concept 1A and Feasible Concept 1B scored 5.0, while Feasible Concept 2A and Feasible Concept 2B scored 3.0 for sub-indicator T5.2.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

During the remediation phase, remediation performance can be readily monitored and tested for all Feasible Concepts through confirmatory sampling in effluent ditches, twin settling basins, ASB, BH, and the estuary following sludge removal and through material testing of dewatered/stabilized sediment. It is not anticipated that any post-remediation monitoring will be required for this portion of the work. Accordingly, all Feasible Concepts received the maximum score of 5.0 for sub-indicator T6.1 and T6.2.

Feasible Concepts involving removal in the wet (Feasible Concept 1A and Feasible Concept 1B) were considered to require slightly more monitoring (confirmatory sampling) during remediation to ensure effectiveness, due to the lack of visual confirmation compared to in the dry. Accordingly, Feasible Concept 1A and Feasible Concept 1B received a score of 4.0 for sub-indicator T6.3, while Feasible Concept 2A and Feasible Concept 2B scored 5.0.

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase, all Feasible Concepts will generate waste as sediment is removed from effluent ditches, twin settling basins, ASB, BH, and the estuary. The Feasible Concepts utilizing geotube dewatering for treatment (Feasible Concept 1A and Feasible Concept 2A) will reduce the volume of sludge through dewatering, whereas clay stabilization for Feasible Concept 1B and Feasible Concept 2B will bulk the material and increase the volume of sludge to be managed. As a result, Feasible Concept 1A and Feasible Concept 2A received a score of 3.0, while Feasible Concept 1B and Feasible Concept 2B scored 1.0 for sub-indicator T7.1.

None of the waste generated (impacted sludge) is expected to be classified as dangerous goods. All Feasible Concepts will effectively remove all impacted sediment during remediation, resulting in no further waste generation post-remediation. Accordingly, all Feasible Concepts received a maximum score of 5.0 for sub-indicator T7.2 and for sub-indicator T7.3.

7.2.3.1.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events.

Feasible Concept 1A (wet & dewatering) ranked higher than Feasible Concepts 1B (wet & stabilization), 2A (dry & dewatering), and 2B (dry & stabilization). Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1a Atmospheric Environment

EN1.1b Aquatic Environment

EN1.1c Geology and Groundwater

EN1.1d Terrestrial Environment

During remediation, under sub-indicator EN1.1a, the risk of air quality effects on workers will be greater for Feasible Concept 1B and Feasible Concept 2B involving clay stabilization, as there will be additional material handling compared to Feasible Concept 1A and Feasible Concept 2A. However, the public will be more exposed under Feasible Concept 2A and Feasible Concept 2B where sediment is removed in the dry and exposed at the surface near the property boundary. For all other sub-indicators (EN1.1b, EN1.1c, and EN1.1d), all Feasible Concepts were considered to have similar and minor effects. Boat Harbour is not currently considered to be high value habitat due to its use as part of the BHETF. Any short-term disruption will result in long-term benefit. For EN1, Feasible Concept 1A received a score of 4.3, Feasible Concept 1B and Feasible Concept 2A both scored 4.2, and Feasible Concept 2B scored 4.1.

EN2 – Post-remediation Phase Effects – 50 Percent of Environmental

Similarly, environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1a Atmospheric Environment

EN2.1b Aquatic Environment

EN2.1c Geology and Groundwater

EN2.1d Terrestrial Environment

During the post-remediation phase, all Feasible Concepts received the maximum score of 5.0 for all sub-indicators (EN2.1a, EN2.1b, EN2.1c, and EN2.1d). This is because all impacted sediment will be removed and areas will have met sediment cleanup criteria. Environmental impacts at this stage will be a positive improvement to the conditions prior to remediation.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential impacts that weather will have on each Feasible Concept during remediation and post-remediation phases. The sub-indicator questions for these environmental impacts included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

During remediation, poor weather or large storm events would impact construction and potentially cause delays. Remediation in the dry is much more susceptible to events like this compared to in the wet, since dewatering and maintaining dry conditions is a major component of Feasible Concept 2A and Feasible Concept 2B. As a result of these potential impacts, Feasible Concept 2A and Feasible Concept 2B scored 2.0 for sub-indicator EN3.1, while Feasible Concept 1A and Feasible Concept 1B scored 4.0.

There will be no potential impacts due to weather post-remediation since all of the related works associated with sediment management will be complete. While Feasible Concept 2A and Feasible Concept 2B are susceptible to poor weather, these Feasible Concepts are still suitable solutions since although they may take longer, they can still be completed successfully. As such, all Feasible Concepts received the maximum score of 5.0 for sub-indicators EN3.2 and EN3.3.

7.2.3.1.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept.

Feasible Concept 1A (wet & dewatering) ranked higher than Feasible Concepts 1B (wet & stabilization), 2A (dry & dewatering), and 2B (dry & stabilization). Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Social indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surrounding community during post remediation phase (i.e., safety, visual, nuisance)?

For sub-indicator S1.1, all Feasible Concepts were considered to have only a moderate level of community acceptance during the remediation phase. While some members of the surrounding community may embrace the removal of contaminants and return of Boat Harbour to tidal conditions, the anticipated short-term response from the surrounding communities may be one of reluctance. The public may have concerns with the long timeframe and potentially increased odour issues during removal in the dry, while they may dislike the lower level of confirmation for sediment removed in the wet. Accordingly, all Feasible Concepts received a score of 3.0 under sub-indicator S1.1.

During the post-remediation phase, once BHETF components have been cleaned up through the removal of impacted sediment, it was anticipated that there will be a high level of community acceptance for the remediation of Boat Harbour and return to tidal conditions. As a result, all Feasible Concepts received a score of 5.0 for sub-indicator S1.2.

During the remediation phase, implementation of Feasible Concept 1A and Feasible Concept 1B (removal in the wet) was considered to have no net effect (i.e., positive or negative) on the surrounding communities; as such, Feasible Concept 1A and Feasible Concept 1B received a score of 3.0 for community acceptance sub-indicator S1.3. Implementation of Feasible Concept 2A and Feasible Concept 2B (removal in the dry) would have a moderately negative impact on the surrounding communities; the increased volume of truck traffic could potentially have an impact on community safety, and may also negatively impact ambient air quality (e.g., increased dust) and noise levels. This remedial option is expected to take longer to implement and will involve exposure of sludge near the property boundary. As a result, Feasible Concept 2A and Feasible Concept 2B received a score of 2.0 for community acceptance sub-indicator S1.3.

Finally, all Feasible Concepts were considered to have positive net effect on the surrounding communities during the post-remediation phase due to the completion of full remediation and sludge removal, and as a result, all Feasible Concepts received the maximum score of 5.0 for community acceptance sub-indicator S1.4.

S2 - Community Benefit – 75 Percent of Social

Social indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)?

The remediation of Boat Harbour and return to tidal conditions will have direct and indirect positive social impacts on the surrounding communities, from increased recreational use of Boat Harbour, to allowing the PLFN community to reestablish its relationship with the water and land of A'se'k. From an economic perspective, remediation of Boat Harbour may increase tourism in the area once the harbor is returned to tidal conditions. Accordingly, all Feasible Concepts received a score of 4.0 for sub-indicator S2.1.

7.2.3.1.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs for planning and implementation (i.e., capital costs) and for ongoing O&M costs.

Feasible Concept 1A (wet & dewatering) ranked higher than Feasible Concepts 1B (wet & stabilization), 2A (dry & dewatering), and 2B (dry & stabilization). Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 1A was estimated to be $89,090,000, and was the lowest cost of all the Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 1A received a maximum score of 5.0.

The capital cost of Feasible Concept 1B was estimated to be $117,590,000, which is approximately 1.3 times higher than Feasible Concept 1A. As a result, Feasible Concept 1B received a score of 2.0 for sub-indicator EC1.1.

The capital cost of Feasible Concept 2A was estimated to be $113,190,000, which is approximately 1.3 times higher than Feasible Concept 1A. As a result, Feasible Concept 2A received a score of 2.0 for sub-indicator EC1.1.

The capital cost of Feasible Concept 2B was estimated to be $160,570,000, which is approximately 1.8 times higher than Feasible Concept 1A. As a result, Feasible Concept 2B received a score of 1.0 for sub-indicator EC1.1.

It is noted that the sediment disposal costs associated with implementing the Feasible Concepts have not been incorporated in these estimates, as these costs have already been included with the Feasible Concepts developed under the Waste Management component presented in Section 4.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

Once the impacted sediment has been removed from effluent ditches, twin settling basins, ASB, BH, and the estuary, and subsequently treated, there would be no post-remediation O&M activities and therefore no cost associated with sediment management. For sub-indicator EC2.1, all Feasible Concepts received a maximum score of 5.0.

7.2.3.2 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

The remainder of this section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment
- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

In accordance with Project goals, all Feasible Concepts are considered protective of human health and the environment (indicators HS1/2 and EN1/2). Due to the significant volume of truck traffic required to import berm material and clay, there is an inherent level of risk associated with Feasible Concept 1B, 2A, and 2B that is difficult to mitigate. Feasible Concept 2A and 2B have a higher relative risk to the public with respect to air quality and odours compared to Feasible Concept 1A and 1B due to handling of sludge near the property boundary. However, in comparison to Feasible Concept 1A and 2A, Feasible Concept 1B and 2B have a higher relative risk to workers, since they involve extra sludge handling and transportation steps. Therefore, Feasible Concept 1A would be preferred based on the environmental and H&S considerations.

It is anticipated that removal in the dry for Feasible Concept 2A and 2B will have a longer implementation timeframe to construct large isolation and separation berms, and to dewater and maintain dry conditions in large areas. These options are also sensitive to extreme weather and could be delayed by precipitation. Clay stabilization may take longer compared to the use of geotubes, since it involves intermediate sludge handling and transportation. As result, Feasible Concept 1A would be preferred based on this technical consideration.

In accordance with Project goals, removal and treatment methods for all Feasible Concepts are founded on proven technologies. All approaches are considered reliable and effective means of managing the waste from the Project, such that there is little risk associated with any Feasible Concept. However, clay stabilization as a sediment treatment method compared to geotube dewatering is less mature and proven. In addition, geotube dewatering will reduce significantly (50-70 percent) the final volume of sludge to be managed; while the use of clay stabilization will increase (~7 percent) the final volume of sludge to be managed. Therefore, Feasible Concept 1A and 2A would be preferred based on the technical consideration for this Project goal.

All Feasible Concepts are considered to be economically feasible. The capital costs for berm construction, bulk dewatering, and water management/treatment under Feasible Concept 2A and Feasible Concept 2B increased the cost substantially as compared to Feasible Concept 1A and Feasible Concept 1B. Treatment via geotubes requires dewatering effluent treatment, whereas treatment via clay stabilization does not, however, the use of geotubes is cheaper than clay. Feasible Concept 1A provides the best value to the Province (and taxpayers), and would be preferred based on this economic consideration.

Overall, the comparison of advantages and disadvantages generally supports selection of Feasible Concept 1A as the preferred feasible concept for the treatment of sediment from BHETF components.

7.2.4 Summary of Qualified Remedial Option

Based on the results of the numerical evaluation and ranking, comparative analysis, and review of advantages and disadvantages, Feasible Concept 1A, removal in the wet with geotube dewatering, was selected as the Qualified Remedial Option for the treatment of sludge and impacted sediment.

Removal in the wet will involve dredging sludge from the ASB, BH, and estuary under wet conditions, and will be predominantly completed through hydraulic dredging (at a rate of 2,000 m^3 of in-place sludge per day) due to the ease of material transfer. Approximately 0.15 m of materials underlying the sludge (e.g., native marine clay in the Boat Harbour stabilization lagoon) will be dredged, followed by confirmatory sampling to confirm that remaining sediment meets the applicable remedial quality standards for all sediment COCs.

Hydraulically dredged sludge slurry will be pumped through discharge lines to the sludge management area, located directly in the disposal cell. Multiple geotubes will be setup as permitted by space. As a geotube dewaters, additional capacity is created to allow for placement of slurry (typically 3 pumping events per geotube). Once the capacity of the geotube is used, empty geotubes will be placed adjacent or stacked on top (forming a pyramid shape). It is estimated that between 50 and 130 geotubes[22] will be required to manage sludge from the effluent ditching, twin settling basins, ASB, Boat Harbour stabilization lagoon, and estuary, however, will vary based on the size of geotube used.

7.3 Bulk Water Management

This section presents a detailed description of the Feasible Concepts developed for the management and treatment of bulk water generated from dewatering the ASB, BH, and estuary. The term bulk water management refers to impacted surface water that will need to be managed prior to, during or post sludge/sediment removal and excludes effluent and leachate from sludge/sediment treatment processes, which are described in Section 7.4 (sludge dewatering

22 Assuming a geotube diameter of 5 to 8 m in diameter by 120 m in length

effluent) and Section 7.5 (leachate from an on-Site disposal cell). Bulk water management has been broken down, for costing purposes, into two categories 1) initial dewatering and 2) ongoing dewatering based on anticipated concentrations and treatment rate.

The overall volume of bulk water to be managed to complete remediation in the dry is approximately 3,500,000 m^3 for initial dewatering, with 1,200,000 m^3 for ongoing dewatering to maintain dry conditions. For removal in the wet, the volume of bulk dewatering post removal of sediment is estimated at 4,000,000 m^3; characterized as initial dewatering. Key treatment parameters include TPH, cyanide, and metals as detailed in Appendix G.

7.3.1 Development and Identification of Feasible Concepts

Figure 7.2 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

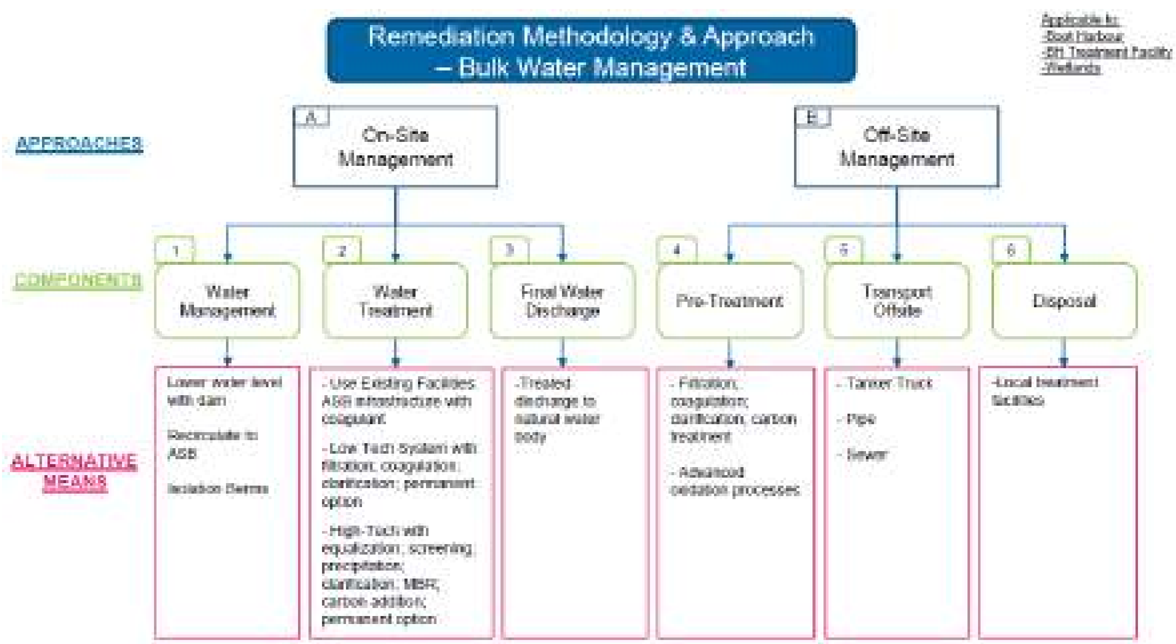


Figure 7.2 Boat Harbour Bulk Water Management Approaches, Components and Alternative Means

7.3.1.1 Approaches

Two common approaches were identified for bulk water management as part of the BHRD implementation. These Approaches included:

A. On-Site Management

B. Off-Site Management

Approach A involves on-Site management using either a low tech or high tech wastewater treatment system prior to discharge to a natural water body.

Approach B involves off-Site management consisting of a conveyance system to a wastewater treatment plant (WWTP), with or without pre-treatment.

7.3.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the Approach acceptable by the public?
- F1-2: Is the Approach technically feasible?
- F1-3: Is the Approach cost effective?

The results of the F1 application are summarized below in Table 7.5.

Table 7.5 Results of First Filter Step

Approaches	F1-1 Acceptability	F1-2 Functionality	F1-3 Cost	Pass/Fail
A. On-Site Management	Yes	Yes	Yes	Pass
B. Off-Site Management	Yes	Yes	No	Fail

Of the two Approaches considered, Approach A (on-Site management) was determined to be warrant further evaluation" (i.e., had "Yes" answers to each filtering question). Approach B (off-Site management) was deemed cost prohibitive and was not carried forward for further evaluation.

7.3.1.3 Identification of Components and Alternative Means

Collectively, the Approaches identified in Section 7.3.1.2 consisted of the following six components (with a number of associated Alternative Means):

1. Water Management (three Alternative Means)
2. Water Treatment (three Alternative Means)
3. Final Water Discharge (one Alternative Means)
4. Pre-Treatment (five Alternative Means)
5. Transport Off-Site (three Alternative Means)
6. Disposal (one Alternative Means)

7.3.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Are the discharge criteria achievable?
- F2-2: Is the Alternative Means technically feasible and cost effective?
- F2-3: Does the Alternative Means minimize environmental impact?

- F2-4: Is the Alternative Means acceptable to the public?

The results of the application of the F2 are summarized in the following Table 7.6. Of the 16 Alternative Means considered, 6 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 7.6 Results of Second Filter Step

Component	Alternative Means	F2-1 Achievable	F2-2 Technical and Cost	F2-3 Environmental	F2-4 Public	Pass/ Fail
1. Water Management	Lower Water Level with Dam	Yes	Yes	Yes	Yes	Pass
	Recirculate to ASB	Yes	Yes	Yes	Yes	Pass
	Isolation Berms	Yes	Yes	Yes	Yes	Pass
2. Water Treatment	Use Existing Facilities	No	No	Yes	Yes	Fail
	Low Tech System	Yes	Yes	Yes	Yes	Pass
	High Tech System	Yes	Yes	Yes	Yes	Pass
3. Final Water Discharge	Treated Discharge to Natural Water Body	Yes	Yes	Yes	Yes	Pass
4. Pre-Treatment[23]	Filtration	N/A	N/A	N/A	N/A	N/A
	Coagulation	N/A	N/A	N/A	N/A	N/A
	Clarification	N/A	N/A	N/A	N/A	N/A
	Carbon Treatment	N/A	N/A	N/A	N/A	N/A
	Advanced Oxidation Process	N/A	N/A	N/A	N/A	N/A
5. Transport Off-Site[23]	Tanker Truck	N/A	N/A	N/A	N/A	N/A
	Pipeline	N/A	N/A	N/A	N/A	N/A
	Sewer	N/A	N/A	N/A	N/A	N/A
6. Disposal[23]	Local Treatment Facilities	N/A	N/A	N/A	N/A	N/A

7.3.1.4.1 Water Management

The three Alternative Means that were considered as part of the water management Component under Approach A included: lower water level with dam, recirculate to ASB, and isolation berms.

All three Alternative Means passed application of the F2, and were considered technically feasible and cost effective options capable of meeting design requirements. The option to lower the water level with the dam requires NSE agreement that the existing discharge criteria stated in the IA for operation of the BHETF will be acceptable criteria for initial lowering of the water elevation in BH.

[23] N/A Not Assessed as Approach B was eliminated as part of F1

Discussion with NSE are ongoing; and if not accepted the water will require treatment prior to being discharged to the estuary.

7.3.1.4.2 Water Treatment

The three Alternative Means that were considered as part of the water treatment Component under Approach A included: use existing facilities, low technology system, and high technology system.

The existing treatment system is a biological treatment system, and as such, use of the on-Site treatment failed filter F2-1 and F2-2 and was eliminated from further consideration. Based on historical Site data, the biological oxygen demand (BOD) to chemical oxygen demand (COD) ratio for Boat Harbour effluent at Point D is approximately 3 percent, which indicates that biological treatment would not be an effective method for removal of organic compounds from bulk water due to the small biologically degradable portion.

On-Site bulk water treatment using a low technology system would include coarse filtration, coagulation, and clarification processes, housed in a temporary facility on-Site. The low technology system passed F2, was deemed suitable for water treatment based on Laboratory Treatability Study results, and was carried forward in the Feasible Concepts.

On-Site bulk water treatment using a high technology system would include the following elements: equalization basin, pre-screening, hydroxide precipitation for metals removal, clarification, membrane bioreactor (MBR), and activated carbon for organics removal and polishing. Although the use of high technology treatment system passed F2 and would adequately treat the water, Laboratory Treatability Study results indicate that this level of treatment is not required based on the COCs present in the water. As such, this Alternative Means was not carried forward in the Feasible Concepts.

7.3.1.4.3 Final Water Discharge

Only one Alternative Means was considered as part of the final water discharge Component under Approach A – discharge of treated effluent to a natural water body. It is envisioned that the discharge point would be immediately downstream of the dam in the estuary.

This Alternative Means passed application of the F2, and was a considered technically feasible and cost effective option capable of meeting design requirements.

7.3.2 Feasible Concept Description

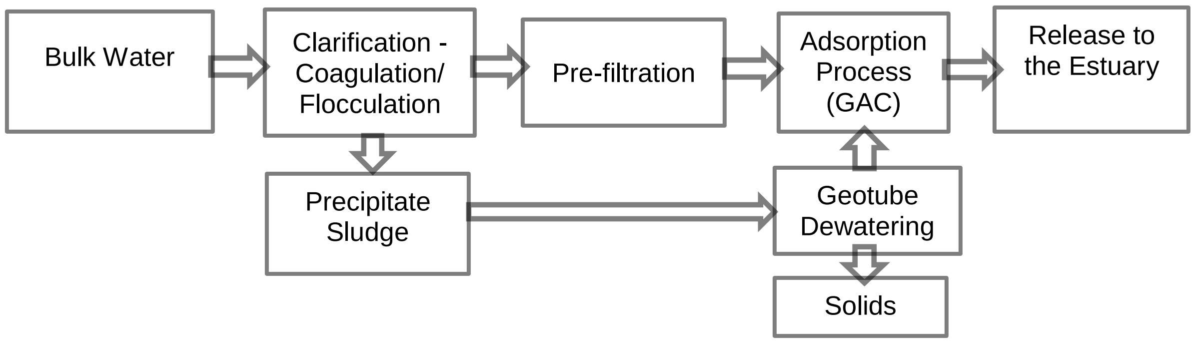
Following application of the F2 step the remaining Approach, Component, and Alternative Means were grouped into the following logical Feasible Concept:

- Feasible Concept 1: On-Site management using low technology treatment system

The remainder of this Section presents an overview of the Feasible Concept. Detailed Concept Descriptions for the Feasible Concept is provided in Appendix G.

7.3.2.1 Feasible Concept 1 – On-Site Management using Low Technology Treatment System

A precipitation, coagulation, and adsorption based process is the most likely treatment method for bulk water management. Bulk water will be treated as depicted in the below diagram:



Coagulation and flocculation (clarification) involve the addition of polymers that conglomerate the small, destabilized particles together into larger particles such that they can be more easily separated from the water. The addition of lime, as well as polymers, will optimize precipitation of COCs. The treatment process will be optimized through pilot scale testing.

Clarification will be completed within a segregated area of BH at the downstream end of the lagoon either immediately upstream or immediately downstream of the causeway along Highway 348. The treatment chemicals will be added upstream via a multistage blending system such as a flocculator. Precipitated material that settles to the bottom of the will be managed by dredging during one of the final stages of the sludge management process.

Following clarification, bulk water is process through granular activated carbon (GAC). Multimedia filtration units (e.g., sand, wood chips) will be required as a pretreatment step to reduce particulate related fouling of the activated carbon beds. Mobile multimedia/GAC contactors could be strategically located to polish the water prior to direct discharge to the estuary.

7.3.2.2 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix G, Attachment G2 and summarized on Table 7.7 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

These costs are incorporated into the overall Sediment Management Feasible Concept cost estimates.

Table 7.7 Class D Cost Estimate – Bulk Water Management

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – On Site management using low technology treatment system (Carried with Sediment Management Feasible Concepts 1A and 1B)	$27,780,000	$0
Feasible Concept 1 – On Site management using low tech treatment system (Carried with Sediment Management Feasible Concepts 2A and 2B)	$40,560,000	$0

Key assumptions include:

- The cost estimate is based on laboratory treatability results; finding to be validated through pilot scale testing.
- The concentration of COCs will be increased as the water level within BH is reduced.
- As concentrations increase, chemical dose may increase but no further advanced treatment will be required.
- Flow rate of 250 m^3/hr.
- 1 percent sludge will be produced.
- 2 percent GAC will be needed and could be backwashed and regenerated in 10 cycles.
- Surface water will flow by gravity to the settling basin.
- Pumping bulk water to maintain dry conditions for removal of sediment in the dry not included (included under Sediment Management costs).
- Utility costs are not included.
- The operation duration is considered to be 9 months (270 days) in each year, since the temperature is assumed to be below the freezing point for the remaining days (3 months).

7.3.3 Summary of Qualified Remedial Option

As there was only one Feasible Concept that was fully developed for management and treatment of BHETF bulk water, the evaluation and weighting matrix was not applied. Feasible Concept 1 – On-Site management using low technology treatment system was selected as the Qualified Remedial Option.

7.4 Dewatering Effluent Management

This section presents the detailed concept descriptions for the Feasible Concept developed for dewatering effluent management. Dewatering effluent is water generated from dewatering sludge/sediment using geotubes as part of sediment treatment Feasible Concept 1A and Feasible Concept 2A. As part of sediment management Feasible Concept 1A (wet & dewatering), a slurry at a 5 percent solids concentration is expected to be pumped to the geotubes established in the existing disposal cell yielding approximately 1,700,000 m^3 of dewatering effluent. As part of sediment management Feasible Concept 2A (dry & dewatering), a slurry at a 10 percent solids concentration is expected to be pumped to the geotubes established in the existing disposal cell yielding approximately 700,000 m^3 of dewatering effluent. Key treatment parameters include TPH, D&F, and metals as is further described in Appendix G.

7.4.1 Development and Identification of Feasible Concepts

Figure 7.3 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

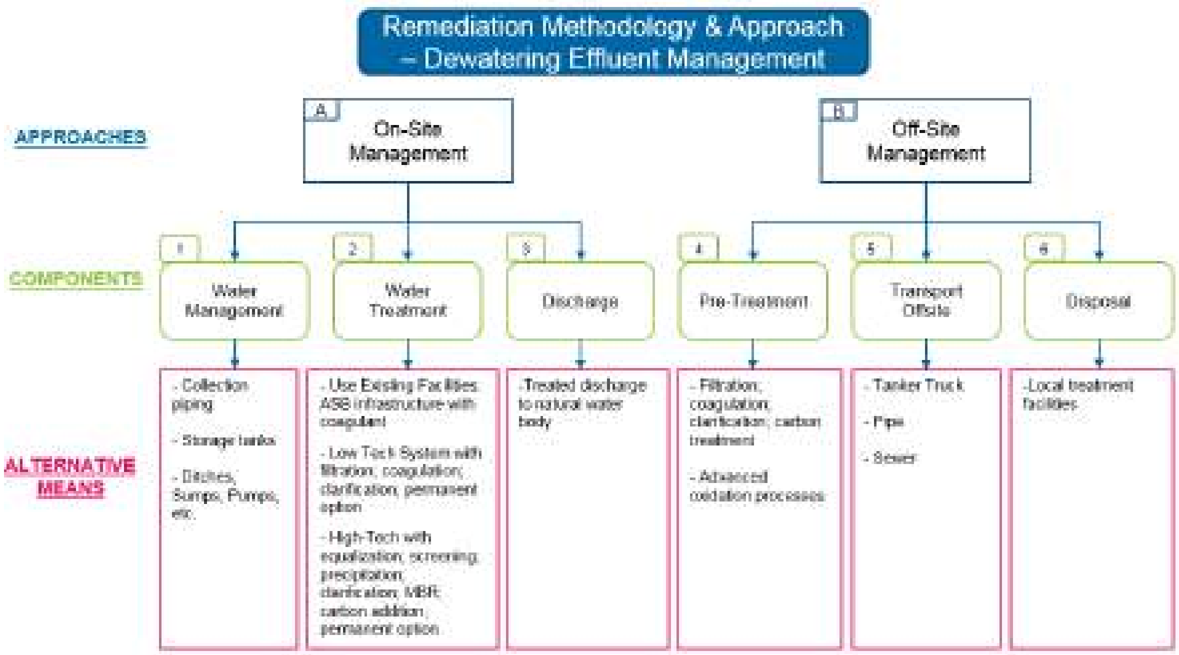


Figure 7.3 Dewatering Effluent Treatment Approaches, Components and Alternative Means

7.4.1.1 Approaches

Two common approaches were identified for the management and treatment of dewatering effluent as part of the BHRD implementation. These Approaches included:

A. On-Site Management

B. Off-Site Management

Approach A involved on-Site management using either a low technology or high technology wastewater treatment systems prior to discharge to natural water body.

Approach B involved off-Site management consisting of a conveyance system to a WWTP, with or without pre-treatment.

7.4.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the Approach acceptable by the public?
- F1-2: Is the Approach technically feasible?
- F1-3: Is the Approach cost effective?

The results of the F1 application are summarized below in Table 7.5.

Table 7.8 Results of First Filter Step

Approaches	F1-1 Acceptability	F1-2 Functionality	F1-3 Cost	Pass/Fail
A. On-Site Management	Yes	Yes	Yes	Pass
B. Off-Site Management	Yes	Yes	No	Fail

Of the two Approaches considered, Approach A (on-Site management) was determined to warrant further evaluation" (i.e., had "Yes" answers to each filtering question). Approach B (off-Site management) was deemed cost prohibitive and was not carried forward for further evaluation.

7.4.1.3 Identification of Components and Alternative Means

Collectively, the Approaches identified in Section 7.4.1.2 consisted of the following six components (with a number of associated Alternative Means):

1. Water Management (three Alternative Means)
2. Water Treatment (three Alternative Means)
3. Final Water Discharge (one Alternative Means)
4. Pre-Treatment (five Alternative Means)
5. Transport Off-Site (three Alternative Means)
6. Disposal (one Alternative Means)

7.4.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Are the discharge criteria achievable?
- F2-2: Is the Alternative Means technically feasible and cost effective?
- F2-3: Does the Alternative Means minimize environmental impact?
- F2-4: Is the Alternative Means acceptable to the public?

To be an Alternative Means that warrants further evaluation, the answer for each of the above filtering questions must be "Yes". A single "No" answer results in the elimination of the Alternative Means from further consideration. The results of the application of the second Filter are summarized in the following Table 7.9. Of the 16 Alternative Means considered, 5 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 7.9 Results of Second Filter Step

Component	Alternative Means	F2-1 Achievable	F2-2 Technical and Cost	F2-3 Environmental	F2-4 Public	Fail/ Pass
1. Water Management	Collection Piping	Yes	Yes	Yes	Yes	Pass
	Storage Tanks	Yes	Yes	Yes	Yes	Pass
	Ditching, Sumps, and Pumps	Yes	Yes	Yes	Yes	Pass
2. Water Treatment	Use Existing Facilities	No	No	Yes	Yes	Fail
	Low Tech System	Yes	Yes	Yes	Yes	Pass
	High Tech System	Yes	No	Yes	Yes	Fail
3. Final Water Discharge	Treated Discharge to Natural Water Body	Yes	Yes	Yes	Yes	Pass
4. Pre-Treatment[24]	Filtration	N/A	N/A	N/A	N/A	N/A
	Coagulation	N/A	N/A	N/A	N/A	N/A
	Clarification	N/A	N/A	N/A	N/A	N/A
	Carbon Treatment	N/A	N/A	N/A	N/A	N/A
	Advanced Oxidation Process	N/A	N/A	N/A	N/A	N/A
5. Transport Off-Site[24]	Tanker Truck	N/A	N/A	N/A	N/A	N/A
	Pipeline	N/A	N/A	N/A	N/A	N/A
	Sewer	N/A	N/A	N/A	N/A	N/A
6. Disposal[24]	Local Treatment Facilities	N/A	N/A	N/A	N/A	N/A

24 N/A Not Assessed as Approach B was eliminated as part of F1

7.4.1.4.1 Water Management

The three Alternative Means that were considered as part of the water management Component under Approach A included the use of collection piping, storage tanks, and ditching/sumps/pumps to manage dewatering effluent.

All three Alternative Means passed application of the F2, and were considered technically feasible and cost effective options capable of meeting design requirements.

7.4.1.4.2 Water Treatment

The three Alternative Means that were considered as part of the water treatment Component under Approach A included: use existing facilities, low tech system, and high tech system.

An on-Site treatment system may take advantage of the existing BHETF with specific emphasis on the existing twin settling basins. The ASB is used for biological treatment, which was not deemed required for treatment of the dewatering effluent. Upon further analysis during the laboratory treatability study, it is anticipated that using the existing BHETF infrastructure will not reduce the COC concentrations significantly. As the dewatering effluent is expected to have a low BOD to COD ratio, further biological treatment would not be effective and other physical/chemical treatment steps will be required. Use of existing facilities is not technically feasible and failed filter F2-1 and F2-2 and was eliminated from further consideration.

On-Site dewatering effluent treatment using a low tech system could include the following elements: coarse filtration, coagulation, and clarification. The low tech treatment system could be housed in a temporary facility on-Site.

On-Site dewatering effluent treatment using a high tech system could include the following elements: equalization basin, pre-screening, hydroxide precipitation for metals removal, clarification, MBR, and activated carbon for organics removal and polishing. The high tech treatment system could be housed in a permanent facility on-Site.

Two Alternative Means (low tech and high tech system) considered as part of the water treatment Component under Approach A passed application of the F2, and were considered technically feasible and cost effective options capable of meeting design requirements.

7.4.1.4.3 Final Water Discharge

Only one Alternative Means was considered as part of the final water discharge Component under Approach A – discharge of treated effluent to a natural water body. It is envisioned that the discharge point would be immediately downstream of the dam in the estuary.

This Alternative Means passed application of the F2, and was a considered technically feasible and cost effective option capable of meeting design requirements.

7.4.2 Feasible Concept Description

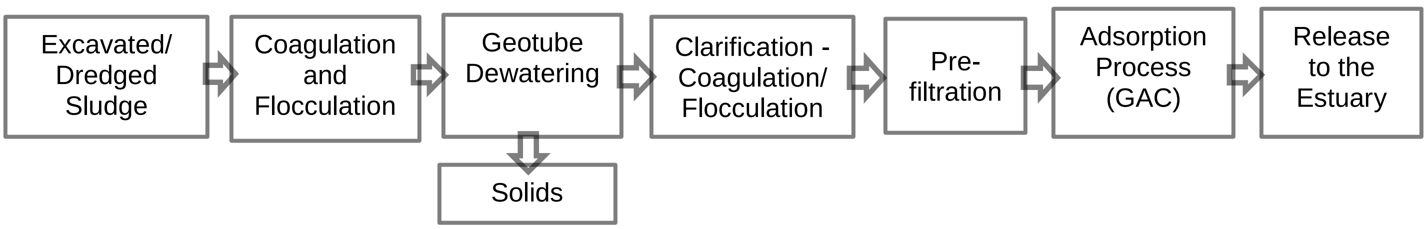
Following application F2 step the remaining Approach, Component, and Alternative Means were grouped into the following logical Feasible Concept:

- Feasible Concept 1: On-Site management using low tech treatment system

The remainder of this Section presents an overview of the Feasible Concept. Detailed Concept Descriptions for this Feasible Concept is provided in Appendix G.

7.4.2.1 Feasible Concept 1: On-Site Management using Low Tech Treatment System

The preliminary results show that coagulation and precipitation coupled with geotube dewatering removes most of the COCs, the remainder of which will be treated through a GAC adsorption column. Dewatering effluent will be treated as depicted in the below diagram:



Following geotube dewatering, dewatering effluent will be conveyed to the dewatering treatment system. The dewatering effluent treatment system will include coagulation and precipitation, followed by a GAC adsorption column.

Polymers/coagulants (and possibly powder activated carbon) will be added to the sludge slurry prior to entering geotubes through an "in-line" dosing system. The optimal doses of chemicals based on laboratory treatability testing will be refined during pilot scale testing, as will the need to add powder activated carbon prior to geotubes.

Following geotube dewatering, dewatering effluent will be pumped to a clarifier where dewatering effluent will be mixed with polymers and lime. Next, the dewatering effluent will go to a dewatering effluent storage basin prior to polishing through GAC. Multimedia filtration units (e.g., sand, wood chips) will be required as a pretreatment step to reduce particulate related fouling of the activated carbon beds. Mobile multimedia/GAC contactors could strategically be located to polish the dewatering effluent prior to direct discharge to the estuary. It is anticipated that these units will be located near the geotubes (located in the existing disposal cell). Once the dewatering effluent has gone through the GAC, the treated water will enter a treated dewatering effluent storage basin and be pumped via a discharge pipeline to the estuary.

7.4.2.2 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix G, Attachment G3 and summarized on Table 7.10 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

These costs are incorporated into the overall Sediment Management Feasible Concept cost estimates.

Table 7.10 Class D Cost Estimate – Dewatering Effluent Management

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – On-Site management using low tech treatment system (Carried with Sediment Management Feasible Concept 1A)	$14,270,000	$0
Feasible Concept 1 – On-Site management using low tech treatment system (Carried with Sediment Management Feasible Concept 2A)	$8,270,000	$0

Key assumptions include:

- The cost estimate is based on the obtained bench scale data and assumes no further treatment processes will be needed on larger scale.
- Dewatering effluent quality will be the same for sediment removed in the wet (5 percent solids) and sediment removed in the dry (10 percent solids).
- Power line and roads will be available to the treatment area.
- Treated dewatering effluent discharge line from sludge management area to estuary has not been included (included under sediment management).
- No utility costs are included.

7.4.3 Summary of Qualified Remedial Option

As there was only one Feasible Concept that was fully developed for management and treatment of dewatering effluent produced from sludge dewatering during remediation, the evaluation and weighting matrix was not applied. Feasible Concept 1 – On-Site management using low tech treatment system was selected as the Qualified Remedial Option.

7.5 Leachate Management

This section presents a detailed description of the Feasible Concepts developed for the management of leachate generated from the use of the on-Site disposal cell for long term disposal of the waste. As noted in Section 4 – Waste Management, the Qualified Remedial Options for waste management is to dispose of sludge/sediment and other waste (e.g., C&D debris and industrial waste) generated as part of remediation in the existing Site disposal cell. Under post-closure conditions (i.e., post capping the landfill with a low permeable final cover), the anticipated leachate generation rate from the disposal cell is expected to be 2,500 m^3 per year. Key leachate parameters include metals, cyanide, TPH, and D&F as outlined in Appendix G.

7.5.1 Development and Identification of Feasible Concepts

Figure 7.4 shows the results of the brainstorming sessions to identify Approaches, Components, and Alternative Means.

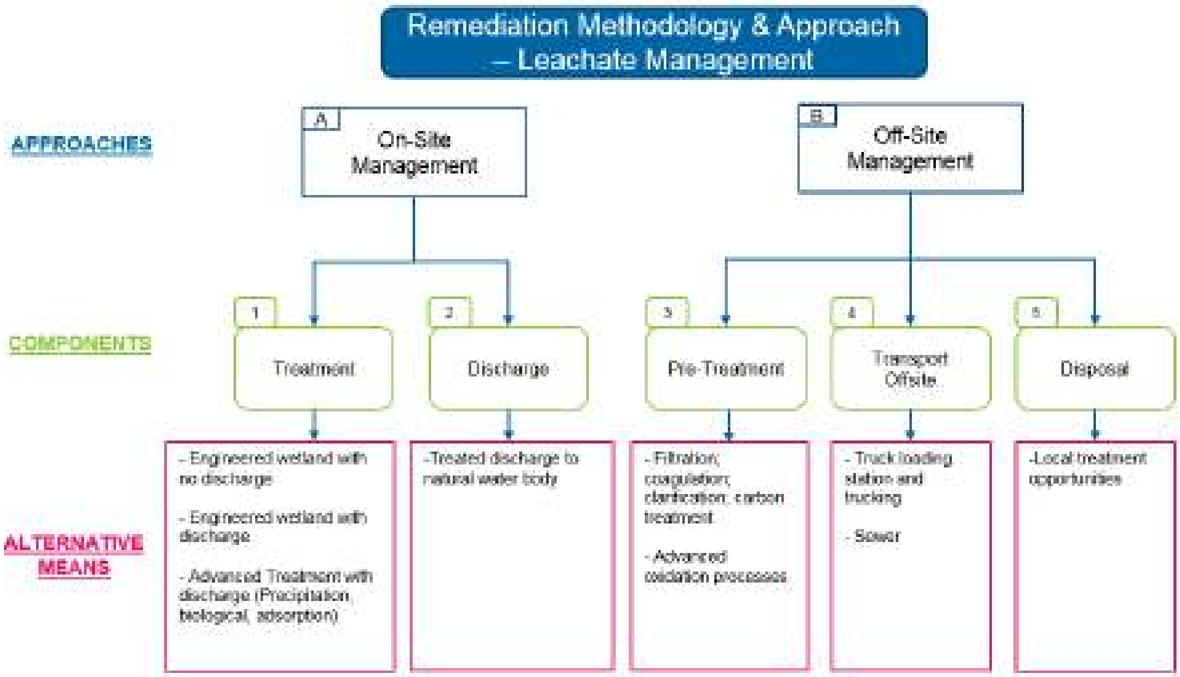


Figure 7.4 Leachate Treatment Approaches, Components and Alternative Means

7.5.1.1 Approaches

Two approaches were identified for the management and treatment leachate from the on-Site sludge disposal cell as part of the BHRD implementation. These Approaches included:

A. On-Site Management

B. Off-Site Management

Approach A involves on-Site management of leachate using an engineered wetland (with or without discharge to a natural water body) or advanced treatment (including precipitation, biological treatment, and adsorption) prior to discharge to a natural water body.

Approach B involved off-Site management of leachate consisting of conveyance off-Site, with or without pre-treatment, and disposal/treatment at a suitable local treatment facility.

7.5.1.2 Filter Approaches

To determine if an Approach met Project goals, the first Filter (F1) consisting of the following questions was applied:

- F1-1: Is the Approach acceptable by the public?

- F1-2: Is the Approach technically feasible?
- F1-3: Is the Approach cost effective?

The results of the F1 application are summarized below in Table 7.7.

Table 7.11 Results of First Filter Step

Approaches	F1-1 Acceptability	F1-2 Functionality	F1-3 Cost	Pass/Fail
A. On-Site Management	Yes	Yes	Yes	Pass
B. Off-Site Management	Yes	Yes	Yes	Pass

Of the two Approaches considered, both (A and B) were determined to be an adequate Approach that warranted further evaluation (i.e., had "Yes" answers to each filtering question). These Approaches were carried forward for further evaluation in the following sections.

7.5.1.3 Identification of Components and Alternative Means

Collectively, the Approaches identified in Section 7.5.1.2 consisted of the following five components (with a number of associated Alternative Means).

1. Water Treatment (three Alternative Means)
2. Discharge (one Alternative Means)
3. Pre-Treatment (five Alternative Means)
4. Transport Off-Site (two Alternative Means)
5. Disposal (one Alternative Means)

7.5.1.4 Filter Alternative Means

The second Filter (F2) was applied to the Alternate Means to eliminate Alternative Means that were not technically or economically feasible, or did not minimize impact to the environment and consisted of the following questions:

- F2-1: Are the discharge criteria achievable?
- F2-2: Is the Alternative Means technically feasible and cost effective?
- F2-3: Does the Alternative Means minimize environmental impact?
- F2-4: Is the Alternative Means acceptable to the public?

The results of the application of the F2 are summarized in the following Table 7.12. Of the 12 Alternative Means considered, 10 of the Alterative Means were considered feasible and suitable for inclusion into Feasible Concepts.

Table 7.12 Results of Second Filter Step

Component	Alternative Means	F2-1 Achievable	F2-2 Technical and Cost	F2-3 Environmental	F2-4 Public	Fail/ Pass
1. Water Treatment	Engineered Wetland	No	No	Yes	Yes	Fail
	Engineered Wetland with Discharge	No	No	Yes	Yes	Fail
	Advanced Treatment	Yes	Yes	Yes	Yes	Pass
2. Discharge	Treated Discharge to Natural Water Body	Yes	Yes	Yes	Yes	Pass
3. Pre-Treatment	Filtration	Yes	Yes	Yes	Yes	Pass
	Coagulation	Yes	Yes	Yes	Yes	Pass
	Clarification	Yes	Yes	Yes	Yes	Pass
	Carbon Treatment	Yes	Yes	Yes	Yes	Pass
	Advanced Oxidation Process	Yes	Yes	Yes	Yes	Pass
4. Transport Off-Site	Truck loading station and transport	Yes	Yes	Yes	Yes	Pass
	Sewer	Yes	No	Yes	Yes	Fail
5. Disposal	Local Treatment Facilities	Yes	Yes	Yes	Yes	Pass

7.5.1.4.1 Water Treatment

The three Alternative Means that were considered as part of the Leachate Management Component under Approach A included: Engineered Wetland, Engineered Wetland with Discharge, and Advanced Treatment.

On-Site treatment of leachate from the on-Site sludge disposal cell could use an engineered wetland to treat the leachate, and may or may not include discharge to a natural water body (e.g., Boat Harbour). Based on anticipated leachate quality, considering historical existing disposal cell leachate data and dewatered sludge leaching data from laboratory testing, wetlands were determined to be insufficient for leachate treatment as some form of pre-treatment or lime precipitation would likely be required. Accordingly, on-Site management using an engineered wetland, both with or without discharge, is not technically viable and failed F2-1 and F2-2 and was not been carried forward. A wetland could however be used as the final discharge step for an advanced treatment system if required.

Advanced treatment would involve application of a simple system including precipitation, biological treatment, and adsorption prior to discharge. This Alternative Means passed application of the F2, and was considered a technically feasible and cost effective option capable of meeting design requirements.

7.5.1.4.2 Discharge

Only one Alternative Mean was considered as part of the discharge component under Approach A for Leachate Management – discharge of treated effluent to a natural water body.

This Alternative Mean passed application of the F2, and was a considered technically feasible and cost effective option capable of meeting design requirements.

7.5.1.4.3 Pre-Treatment

Two Alternative Means were considered as part of the pre-treatment Component prior to transport off-Site under Approach B; these included: low tech system, and high tech system (low tech system plus advanced oxidation).

Prior to transport off-Site, treatment of leachate from the on-Site sludge disposal cell using a low tech pre-treatment system would include the following elements: coarse filtration, coagulation, clarification, and carbon treatment. The low tech pre-treatment system could be housed in a temporary or permanent facility on-Site.

Prior to transport off-Site, treatment of leachate using a high tech pre-treatment system could include the low tech treatment elements plus advanced oxidation processes. The high tech pre-treatment system could be housed in a temporary or permanent facility on-Site.

Both Alternative Means considered as part of the pre-treatment Component prior to transport off-Site under Approach B passed application of the F2, and were considered technically feasible and cost effective options capable of meeting design requirements.

7.5.1.4.4 Transport Off-Site

The two Alternative Means that were considered as part of the off-Site transport Component under Approach B included: truck loading station and transport, and development of a new sewer. Under Approach B, leachate from the on-Site sludge disposal cell would be conveyed off-Site, following pre-treatment (as needed).

Truck loading station and transport Alternative Means considered as part of the off-Site transport Component under Approach B passed application of the F2, however use of a sewer fail F2 as it was deemed to costly.

7.5.1.4.5 Disposal

Only one Alternative Mean was considered as part of the disposal Component under Approach B for Leachate Management – disposal at a local treatment facility.

This Alternative Means passed application of the F2, and was a considered technically feasible and cost effective option capable of meeting design requirements.

7.5.2 Feasible Concept Description

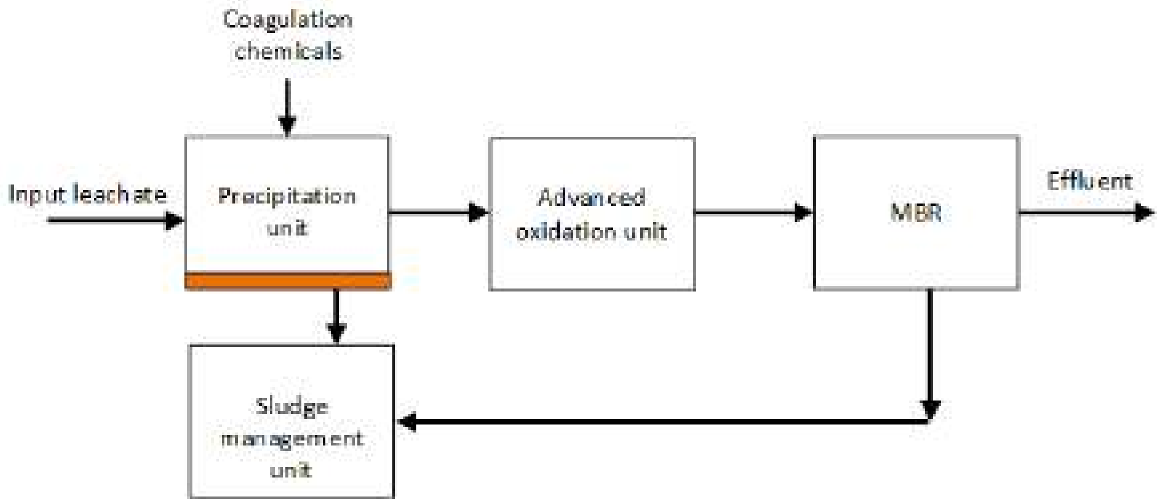
Following application of F2 step the remaining Approach, Component, and Alternative Means were grouped into the following logical Feasible Concepts:

- Feasible Concept 1 – On-Site management using advanced treatment
- Feasible Concept 2 – Off-Site disposal

The remainder of this Section presents an overview of Feasible Concepts. Detailed Concept Descriptions for these Feasible Concepts are provided in Appendix G. It is noted that the Feasible Concepts were developed based on the findings of the Laboratory Treatability Study (Appendix A).

7.5.2.1 Feasible Concept 1 – On-Site Management using Advanced Treatment

As the future generated leachate is expected to contain a high level of toxicity due to high metal concentrations, a three step treatment process was considered for leachate treatment. Leachate will be treated as depicted in the below diagram:



The first step will involve coagulation and precipitation, prior to an advanced oxidation unit. The precipitation and advanced oxidation will be a two stage pretreatment step to reduce toxicity of the leachate prior to the final step of a membrane bioreactor (MBR) unit, such that the MBR biology can effectively polish the leachate prior to discharge. Depending on leachate characteristics an external source of nutrition (e.g., phosphorus, nitrogen, carbon) may be needed prior to the MBR step to maintain a stable biomass and efficient biologic treatment. It is expected that these three treatment steps will reduce the concentration of all COCs below potential discharge criteria and the effluent could be released to Boat Harbour. However, a wetland could be implemented at the end of the treatment process in the event that COC concentrations are higher than expected. An emergency storage tank with a capacity of 20,000 gallons will be incorporated for situations such as higher flow rate and potential system failure.

Solids generated through the leachate treatment process will be managed through the sludge management unit, which may consist of a filter press or centrifuge. Residual solids from the process are expected to be minimal and will be placed in a sludge management area near the disposal cell or disposed of off Site.

7.5.2.2 Feasible Concept 2 – Off-Site Disposal

This Feasible Concept involves disposing of leachate at an off-Site WWTP by tanker.

This Feasible Concept involves a leachate collection storage tank with capacity to store the volume of leachate generated over approximately 3 days. In addition to the storage tank, a larger emergency storage tank was considered in case of higher flow rates or other unpredictable circumstances to provide extra capacity to prevent unauthorized discharges to Boat Harbour. Leachate would drain from the disposal cell to the storage tanks. A truck loading station will facilitate the loading of leachate into a tanker truck. The tanker truck would then transport and dispose of leachate at an off-site WWTP. It has been assumed that all off-Site disposal will be within 175 km of the Site. Leachate quality sampling may be required prior to transportation, depending on the pre-screening requirements of the selected off-Site disposal facility.

7.5.2.3 Feasible Concept Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Appendix G, Attachment G4 and summarized on Table 7.13 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost for the estimated 25-year contaminating life span of the disposal cell are covered for both Feasible Concepts.

Two O&M costs are shown for Feasible Concept 2: Feasible Concept 2A represents leachate being transported to a municipal WWTP; while Feasible Concept 2B represents leachate being transport to an industrial WWTP.

These costs are incorporated into the overall Waste Management Feasible Concept cost estimates.

Table 7.13 Class D Cost Estimate – Leachate Management

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – On-Site Management using Advanced Treatment	$2,770,000	$6,300,000
Feasible Concept 2A – Off-Site disposal (Leachate disposed at municipal WWTP)	$430,000	$2,000,000
Feasible Concept 2B – Off-Site disposal (Leachate disposed at industrial WWTP)	$430,000	$13,500,000

Key assumptions include:

- The generated leachate will meet the off-site discharge criteria.
- The strength of produced leachate will be a mixture of current sludge disposal effluent and the effluent of accumulated sediments in geotubes.
- A constant flow rate of 7 m^3/day was considered in sizing the treatment system.
- The provisional option to add a wetland following on-Site treatment prior to discharge has not been considered in the current cost estimation.

- Power line would be available at the leachate collection area.
- Leachate will be hauled for off-Site disposal within 175 km of the Site – 2 hours per trip has been carried.
- Leachate will need to be managed for 25 years post closure.

7.5.3 Evaluation of Feasible Concepts

7.5.3.1 Comparative Evaluation

The Feasible Concepts carried forward for leachate management as part of the BHRD were evaluated, compared, and ranked to identify the most suitable concept for consideration as a Qualified Remedial Option. The evaluation process involved application of the Evaluation Criteria and Weighting Matrix (i.e., matrix evaluation), as well as the identification and comparison of advantages/disadvantages for each Feasible Concept.

7.5.3.2 Comparative Evaluation

The completed evaluation and weighting matrix for leachate management is presented in Appendix G. A summary of the results for each indicator or criterion, including the rationale for the individual scores contained in the matrix, is discussed below. Table 7.14 presents a summary of the matrix scores for each Feasible Concept. As demonstrated by the weighted matrix scores, Feasible Concept 2 (off-Site) with a score of 454 was deemed preferable to Feasible Concept 1 (on-site advanced) with a score of 340.

Table 7.14 Summary of Matrix Scores – Leachate Management

Criteria Category	Weighting Factor	Feasible Concept 1 (On-Site Advanced)	Feasible Concept 2 (Off-Site)
Regulatory	14%	363	**413**
Technical	26%	411	**465**
Environmental	24%	446	**467**
Social	14%	**381**	**381**
Economic	22%	100	**500**
Total Comparative Score		1702	**2226**
Total Weighted Score		340	**454**
Rank		2	**1**

7.5.3.2.1 Regulatory Indicators – 14 Percent

The regulatory criterion is a measure of the Feasible Concept's ability to meet the safety requirements of the Project, including the protection of the health and safety of both workers and the general public. In addition, this criterion also measures the anticipated approvability of each Feasible Concept.

Feasible Concept 2 (off-Site) ranked higher than Feasible Concept 1 (on-Site advanced) based on regulatory indicators. Individual sub-indicator scoring is as follows:

HS1 – Ability to Protect Health and Safety of Public – 25 Percent of Regulatory

Health and safety indicator HS1 considered the relative risk level to the health and safety of the public under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public included:

HS1.1 What is the relative risk level to public health and safety posed by the Feasible Concept?

HS1.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

There was deemed to be no risk to public health and safety under either of the Feasible Concepts during remediation and post-remediation phases; as a result, both Feasible Concept 1 and Feasible Concept 2 received the highest scores of 5.0 for sub-indicator HS1.1 and HS1.2.

HS2 – Ability to Protect Health and Safety of Workers – 25 Percent of Regulatory

Health and safety indicator HS2 considered the relative risk level to the health and safety of the worker under each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the worker included:

HS2.1 What is the relative risk level to worker health and safety posed by the Feasible Concept?

HS2.2 To what extent can the potential risks be mitigated as part of the Feasible Concept?

The inherent level of risk to worker health and safety associated with leachate management was generally considered to be quite low. In both cases however, there will be some risk such as typical health and safety risks associated with general construction (i.e., use of heavy equipment, slips/trips/falls, etc.) and potential contact with leachate. The risks were considered slightly higher for Feasible Concept 1 working in a leachate treatment plant on an ongoing basis (in terms of potential air quality issues and leachate contact) compared to leachate trucking. As a result, Feasible Concept 1 received a score of 3.0 for sub-indicator HS2.1, while Feasible Concept 2 scored 4.0.

The risks associated with both Feasible Concepts were considered to be easily mitigated with proper planning and controls and use of PPE. Feasible Concept 1 risk may be relatively less mitigatable than Feasible Concept 2 if changes or repairs to leachate treatment system are required. As a result, Feasible Concept 1 received a score of 4.0 for sub-indicator HS2.2, and Feasible Concept 2 scored 5.0 for sub-indicator HS2.2.

C1 – Ease of Obtaining Approvals –50 Percent of Regulatory

Compliance indicator C1 considered the ease of obtaining regulatory approvals under each Feasible Concept. The sub-indicator questions for approvability included:

C1.1 Does the Feasible Concept go beyond the minimum requirements for Federal/Provincial approvability?

C1.2 What is the relative public acceptability of the Feasible Concept?

For Feasible Concept 2, it is anticipated that the leachate will be accepted for off-Site disposal, however, depending on the strength and parameters of concern in the leachate, options for location of off-Site treatment disposal may be limited. The relative approvability of an on-Site leachate treatment system (Feasible Concept 1) may vary depending on the discharge location and is considered to have a moderate level of compliance for ease of approvability. Therefore, Feasible Concept 1 received a 3.0 and Feasible Concept 2 received a 4.0 for sub-indicator C1.1.

With respect to sub-indicator C1.2, both Feasible Concepts were considered to have only a moderate level of public acceptance from the PLFN and surrounding communities. Under Feasible Concept 1, the public may not want a treatment facility remaining and discharging to Boat Harbour. Under Feasible Concept 2, the public may not want the leachate being sent to their municipal WWTP. Due to these anticipated public concerns towards both solutions, each Feasible Concept received a score of score of 3.0 for sub-indicator C1.2.

7.5.3.2.2 Technical Indicators – 26 Percent

The technical criterion is a measure of the Feasible Concept's ability to meet the functional requirements of the Project.

Feasible Concept 2 (off-Site) ranked higher than Feasible Concept 1 (on-Site advanced) based on technical indicators. Individual sub-indicator scoring is as follows:

T1 - Technical Maturity – 14.3 Percent of Technical

Technical indicator T1 considered the "track record" of each Feasible Concept, as well as the ease of implementing each Feasible Concept through consideration of vendor and materials/equipment availability under each Feasible Concept. The sub-indicator questions for technical maturity included:

T1.1 What is the relative successful "track record" for implementing the Feasible Concept?

T1.2 What is the relative availability of the source materials/equipment?

T1.3 What is the relative availability of vendors/contractors for the Feasible Concept?

Both leachate management methodologies were considered reliable approaches with extensive track records of successful applications. As a result, both Feasible Concepts received a score of 5.0 for sub-indicator T1.1.

The materials, equipment, and contractors required to implement Feasible Concept 2 (i.e., for off-loading station construction and trucking) were considered easily acquired within the Province. Materials and equipment required for Feasible Concept 1 (i.e., for leachate treatment facility construction and operation) were considered less accessible than those required for Feasible Concept 2 since they will be more specialized. Similarly, the on-Site leachate treatment facility will require a specialized licensed operator, which may not be available locally. As such, Feasible Concept 1 received a score of 3.0 for sub-indicator T1.2 and a score of 2.0 for sub-indicator T1.3. Feasible Concept 2 scored 5.0 for both sub-indicator T1.2 and T1.3.

T2 - Compatibility with Current Site Features – 14.3 Percent of Technical

Technical indicator T2 considered the compatibility of the size, configuration, and accessibility of each Feasible Concept with current on-Site features, including site geology and hydrology. It is noted that the focus is on compatibility, not environmental impact, which is addressed through the environmental criterion discussed in Section 7.5.3.2.3. The sub-indicator questions for on-Site compatibility included:

T2.1 What is the relative compatibility of the Feasible Concept with site size and configuration?

T2.2 What is the relative compatibility of the Feasible Concept with site geology?

T2.3 What is the relative compatibility of the Feasible Concept with site hydrogeology?

T2.4 What is the relative compatibility of the Feasible Concept with site access?

T2.5 What is the relative compatibility of the Feasible Concept with site hydrology?

The compatibility of Feasible Concept 1 with the Site (size and configuration) was identified as an item that needed to be addressed, but one that could be accomplished readily. An area will need to be dedicated to the on-Site leachate treatment facility, but this should not be an issue due to the Site size and access. As such, Feasible Concept 1 received a score of 4.0 for sub-indicator T2.1. The compatibility of Feasible Concept 1 with the rest of the current on-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints. As a result, Feasible Concept 1 received a score of 5.0 for sub-indicator questions T2.2, T2.3, T2.4, and T2.5.

The compatibility of Feasible Concept 2 with current on-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily without challenges or constraints. As a result, Feasible Concept 2 received a score of 5.0 for all five sub-indicator questions.

T3 - Compatibility with Existing Off-Site Features – 14.3 Percent of Technical

Technical indicator T3 considered the compatibility of the Feasible Concepts with existing off-Site features and infrastructure, and addressed whether or not significant changes/impacts or required upgrades were anticipated under each Feasible Concept. The sub-indicator questions for off-Site compatibility included:

T3.1 What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?

T3.2 Does the Feasible Concept cause significant changes to offsite conditions (e.g., traffic)?

T3.3 Does the Feasible Concept require upgrades or significant changes to the existing offsite infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

The compatibility of Feasible Concept 1 with existing off-Site features was identified as an item that needed to be addressed, but one that could be accomplished readily. As a result, Feasible Concept 1 received a score of 5.0 for all three sub-indicator questions.

Similarly, Feasible Concept 2 is relatively compatible with off-Site features. It is not anticipated that any changes or improvements will be required to off-Site features; although this Feasible Concept involves some off-Site traffic for leachate hauling, the volume is relatively small (2,500 m^3 per year). As a result, Feasible Concept 2 scored 4.0 for sub-indicator T3.1 and received a score of 5.0 for sub-indicators T3.2 and T3.3.

T4 - Reliability/Effectiveness/Durability – 14.3 Percent of Technical

Technical indicator T4 considered the performance and effective service life of each Feasible Concept, as well as the ease of implementing maintenance or contingency measures both during and post-remediation. The sub-indicator questions for reliability, effectiveness, and durability included:

T4.1 What is the relative expected service life of the Feasible Concept components relative to the remediation and post remediation maintenance period?

T4.2 What is the relative maintenance requirements of the Feasible Concept during the remediation and post remediation maintenance period?

T4.3 What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?

T4.4 What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?

T4.5 What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?

For sub-indicator T4.1, Feasible Concept 2 is not expected to fail within the remediation and post-remediation period since leachate will be managed off-Site and it is expected there will always be a location willing to accept the leachate. As such, Feasible Concept 2 received a score of 5.0 for sub-indicator T4.1. The components of Feasible Concept 1 will eventually reach their service life and will need to be replaced; as a result, Feasible Concept 1 received a score of 3.0 for sub-indicator T4.1.

It is anticipated that some maintenance will be required for both Feasible Concepts, however, an on-Site leachate treatment facility would require more maintenance activities (Feasible Concept 1) than a truck loading station (Feasible Concept 2) due to the greater complexity of components. As a result, Feasible Concept 1 received a score of 3.0, while Feasible Concept 2 scored 4.0 for sub-indicator T4.2.

For sub-indicator T4.3, it is likely that Feasible Concept 1 will meet performance criteria (i.e., leachate treatment objectives) since the on-Site leachate treatment system will be designed to treat the Site-specific leachate (with contingencies) and its process could be modified as required if leachate characteristics change slightly. It is expected that leachate will be readily accepted by off-Site facilities, however, there is a greater relative risk that some WWTPs may not be able to accept the leachate based on the actual quality results. Therefore, Feasible Concept 1 received a score of 5.0 and Feasible Concept 2 received a score of 4.0 for sub-indicator T4.3.

In the event that leachate quality is worse than expected and does not meet performance criteria, the process at the on-Site leachate treatment facility (Feasible Concept 1) could be modified as required. For off-Site disposal, however, the leachate could be rejected if it does not meet the performance criteria. Due to this increased impact, Feasible Concept 2 scored 3.0 for sub-indicator T4.4, while Feasible Concept 1 scored 5.0

For sub-indicator T4.5, the relative ease of implementing a contingency measure during the post-remediation period was considered relatively easy for both Feasible Concepts. The contingency for Feasible Concept 2 would involve shipping the leachate to another facility that will accept the leachate; while this may result in a higher cost, it would be easily accomplished. Contingencies for Feasible Concept 1 would be slightly more involved to alter the leachate treatment process, as needed. As a result Feasible Concept 1 received a score of 4.0 and Feasible Concept 2 scored 5.0 for sub-indicator T4.5.

T5 - Remedial Implementation Time – 14.3 Percent of Technical

Technical indicator T5 considered the anticipated timeframe to implement each Feasible Concept, as well as the relative time required to construct/prepare the Feasible Concept to be fully operational. The sub-indicator questions for implementation time included:

T5.1 Can the Feasible Concept be constructed and fully operational within established time frame?

T5.2 Anticipated time frame to implement Feasible Concept?

The anticipated timeframe required to construct a truck loading station is substantially shorter than that to construct a leachate treatment facility. Feasible Concept 2 had the shortest relative timeframe for implementation and received a score of 5.0, while Feasible Concept 1 received a score of 1.0 for the longest timeframe for construction for sub-indicator T5.1.

Both Feasible Concepts were expected to be implemented in well under four years; as a result Feasible Concept 1 and Feasible Concept 2 both received a maximum score of 5.0 for sub-indicator T5.2.

T6 - Readily Monitored and Tested – 14.3 Percent of Technical

Technical indicator T6 considered the relative amount of monitoring and testing required during remediation and post-remediation phases for each Feasible Concept, as well as the relative amount of effort required to validate effectiveness of the Feasible Concept. The sub-indicator questions for monitoring and testing included:

T6.1 How readily can the Feasible Concept be monitored and tested during remediation phase?

T6.2 How readily can the Feasible Concept be monitored and tested during post-remediation phase?

T6.3 What is the relative amount of monitoring required to validate effectiveness?

During the remediation phase, routine monitoring requirements were considered to be roughly the same (i.e., readily monitored and testable) for both Feasible Concepts. Operational checks can be completed during construction to ensure systems are properly installed and leachate samples will be collected to monitor quality in both scenarios to ensure suitability of proposed leachate management strategies. This will remain the case during the post-remediation phase, when system checks may be completed and leachate sampling will be completed to verify compliance with criteria. Both Feasible Concepts received a score of 5.0 for sub-indicator T6.1 and sub-indicator T6.2.

Finally, both Feasible Concepts were considered to require similar (i.e., minimal) amounts of monitoring to validate effectiveness, though there will be ongoing leachate quality sampling required for both. As such, both Feasible Concepts received identical scores of 5.0 for sub-indicator T6.3.

T7 - Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate) – 14.3 Percent of Technical

Technical indicator T7 considered the waste generated through implementation of each Feasible Concept. The sub-indicator questions for waste generation included:

T7.1 What is the ability of the Feasible Concept to minimize waste generation during remediation?

T7.2 What is the ability of the Feasible Concept to minimize waste generation during the post remediation maintenance phase?

T7.3 What is the ability of the Feasible Concept to minimize dangerous goods generation?

During the remediation phase (i.e. construction), both Feasible Concept 1 and Feasible Concept 2 were considered to generate minimal amounts of additional waste through implementation, and as a result both Feasible Concepts received a score of 4.0 for sub-indicator T7.1.

During the post-remediation phase (i.e., operational phase), both Feasible Concepts were considered to generate moderate amounts of additional waste. The on-Site leachate treatment facility would produce waste through the use of disposable materials for the treatment process (e.g. filters), while for off-Site disposal the leachate represents a waste to be managed. Both Feasible Concepts received a score of 3.0 for sub-indicator T7.2.

Both Feasible Concepts were considered to generate minimal amounts of hazardous/dangerous goods through implementation during the remediation phase, and as a result Feasible Concept 1 and Feasible Concept 2 received a maximum score of 5.0 for sub-indicator T7.3.

7.5.3.2.3 Environmental Indicators – 24 Percent

The environmental criterion is a measure of the potential effects to the environment posed by the Feasible Concepts during remediation and post-remediation phases of the Project. In addition, this criterion considers the impact of weather events on the susceptibility and suitability of the Feasible Concepts to severe weather events.

Feasible Concept 2 (off-Site) ranked higher than Feasible Concept 1 (on-Site advanced) based on environmental indicators. Individual sub-indicator scoring is as follows:

EN1 - Remediation Phase Effects – 25 Percent of Environmental

Environmental indicator EN1 considered potential environmental impacts of each Feasible Concept during the remediation phase. The sub-indicator questions for environmental impacts included:

During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN1.1a Atmospheric Environment

EN1.1b Aquatic Environment

EN1.1c Geology and Groundwater

EN1.1d Terrestrial Environment

During remediation (i.e. construction), under sub-indicator EN1.1a, there may be some risk of air quality effects on workers due to construction activities and potential leachate exposure. For all other sub-indicators (EN1.1b, EN1.1c, and EN1.1d), all Feasible Concepts were considered to have similar and minor effects. For EN1, both Feasible Concept 1 and Feasible Concept 2 received a score of 4.9.

EN2 – Post-remediation Phase Effects – 50 Percent of Environmental

Similarly, environmental indicator EN2 considered potential environmental impacts of each Feasible Concept during the post-remediation phase. The sub-indicator questions for these environmental impacts included:

During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on:

EN2.1a Atmospheric Environment

EN2.1b Aquatic Environment

EN2.1c Geology and Groundwater

EN2.1d Terrestrial Environment

Similar to during remediation, post remediation under sub-indicator EN1.1a, there may be some risk of air quality effects on workers during operations activities (from either equipment or potential leachate exposure). The risk of air quality effects to the public will be very minor, though the trucking operations for off-Site disposal will generate some emissions.

For all other sub-indicators (EN2.1b, EN2.1c, and EN2.1d), all Feasible Concepts were considered to have similar and minor effects. However for EN2.1b, depending on leachate discharge location, Feasible Concept 1 could have relatively more of an impact the aquatic environment compared to Feasible Concept 2. For EN2, Feasible Concept 1 scored 4.6, while Feasible Concept 2 received a score of 4.9.

EN3 - Weather Effects – 25 Percent of Environmental

Environmental indicator EN3 considered potential susceptibility of each Feasible Concept to inclement and severe weather events during the remediation and post remediation phase. The sub indicator questions for these weather effects included:

EN3.1 What is the potential impact of weather on the implementation of the Feasible Concept?

EN3.2 What is the potential impact of weather on the Feasible Concept during the post remediation period?

EN3.3 What is the suitability of the Feasible Concept under severe weather events during remediation and post remediation phase (e.g., 1:100 design event)?

For sub-indicator EN3.1, weather was considered to have little effect on both Feasible Concept 1 and Feasible Concept 2, outside of typical weather-related construction delays during the remediation (or construction) phase. As a result, both Feasible Concepts received a score of 4.0 for sub-indicator EN3.1.

During the post-remediation phase (operation and maintenance phase), poor weather conditions were considered to have minimal effects on hauling leachate off-Site. Poor weather could have moderate effects on an on-Site leachate treatment facility if the facility were to experience a power outage. As a result, Feasible Concept 1 received a score of 3.0, while Feasible Concept 2 received a score of 4.0 for sub-indicator EN3.2.

For sub-indicator EN3.3, both Feasible Concepts were considered suitable under severe weather events (i.e., 1:100 year design storm). There may be some effects from severe weather (e.g. power outages, work stoppages, increased leachate generation, etc.); as a result, both Feasible Concepts received a score of 4.0.

7.5.3.2.4 Social Indicators – 14 Percent

The social criterion is a measure of the acceptability and compatibility of the Feasible Concept to the immediately affected surrounding community during remediation and post-remediation phases of the Project. In addition, this social criterion considers the potential socio-economic benefit to the surrounding community as a result of implementation of the Feasible Concept.

Both Feasible Concept 1 (on-Site advanced) and Feasible Concept 2 (off-Site) received the same score for social indicators. Individual sub-indicator scoring is as follows:

S1 - Community Acceptance – 25 Percent of Social

Social indicator S1 considered the acceptance of, and potential impacts to, the surrounding communities during remediation and post-remediation phases for each Feasible Concept. The sub-indicator questions for community acceptance included:

S1.1 How acceptable is the Feasible Concept to the surrounding communities during remediation phase?

S1.2 How acceptable is the Feasible Concept to the surrounding communities during the post remediation phase?

S1.3 Does the Feasible Concept impact the surroundings community during remediation phase (i.e., safety, visual, nuisance)?

S1.4 Does the Feasible Concept impact the surroundings community during post remediation phase (i.e., safety, visual, nuisance)?

For sub-indicator S1.1, both Feasible Concepts were considered to have a high level of community acceptance during the remediation phase. It is not expected that the public will have an issue with construction of either leachate management solution, since it would be one component of a larger construction project. Therefore, both Feasible Concepts received a score of 5.0 for community acceptance sub-indicator S1.1.

During the post-remediation (or operational) phase, both Feasible Concepts were expected to receive only a moderate amount of community support. Though the leachate will be managed, the public may not be happy to have remaining leachate treatment or conveyance infrastructure on Site. They may be resistant to discharging effluent from the on-Site leachate treatment facility to Boat Harbour, and similarly to sending leachate to a WWTP. Accordingly, Feasible Concept 1 and Feasible Concept 2 received a score of 3.0 for community acceptance sub-indicator S1.2.

During the construction phase, implementation of both Feasible Concepts were considered to have no effect (i.e., positive or negative) on the surrounding community, and received a score of 3.0 for sub-indicator S1.3.

Finally, both Feasible Concepts were considered to have a slightly negative effect on PLFN and the surrounding community due to the leachate management operation remaining post remediation. Accordingly, both Feasible Concepts received a score of 2.0 for community acceptance sub-indicator S1.4.

S2 - Community Benefit – 75 Percent of Social

Social indicator S2 considered the potential social and economic benefits to the surrounding communities associated with each Feasible Concept. The sub-indicator question for community acceptance included:

S2.1 Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (human health and recreational enjoyment)?

Both leachate management Feasible Concepts will have direct and indirect positive social impacts on the surrounding communities. Leachate management activities will provide a public safeguard against any leachate impacts. Both Feasible Concepts could provide local employment opportunities; an on-Site leachate treatment facility operator would be required, or truck drivers and maintenance staff for the off-Site disposal option. Accordingly, both Feasible Concepts received a score of 4.0 for community benefit sub-indicator S2.1, indicating that there is some net positive socio-economic effects for PLFN or the surrounding community.

7.5.3.2.5 Economic Indicators – 22 Percent

The economic criterion is a measure of the relative costs associated with the implementation of the Feasible Concepts. Consideration is given to costs for planning and implementation (i.e., capital costs) and for ongoing O&M (O&M) costs.

Feasible Concept 2 (off-Site) ranked higher than Feasible Concept 1 (on-Site advanced) based on economic indicators. Individual sub-indicator scoring is as follows:

EC1 - Remediation Capital Costs – 50 Percent of Economic

Economic indicator EC1 considered the relative remediation capital costs of each Feasible Concept; the sub-indicator question was simply:

EC1.1 What is the capital cost of the Feasible Concept?

The capital cost of Feasible Concept 2 was estimated to be $430,000, and was the lowest cost of the two Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 2 received a maximum score of 5.0.

The capital cost of Feasible Concept 1 was estimated to be $2,770,000, which is approximately 6.44 times higher than Feasible Concept 2. As a result, Feasible Concept 1 received a score of 1.0 for sub-indicator EC1.1.

EC2 - Post-Remediation Operations & Maintenance Costs – 50 Percent of Economic

Economic indicator EC2 considered the post-remediation O&M costs of each Feasible Concept; the sub-indicator question was simply:

EC2.1 What are the typical annual post-remediation O&M costs for the Feasible Concept?

The O&M cost of Feasible Concept 2 was estimated to range from $2,000,000 to $13,500,000 depending on whether a municipal or industrial WWTP would accept the leachate (respectively). As it is anticipated that a municipal WWTP will be able to accept the leachate, Feasible Concept 2 was considered to be the lowest cost of the two Feasible Concepts being considered. For sub-indicator EC1.1, Feasible Concept 2 received a maximum score of 5.0.

The O&M cost of Feasible Concept 1 was estimated to be $6,300,000, which is approximately 3.15 times higher than Feasible Concept 2 (for a municipal WWTP). As a result, Feasible Concept 1 received a score of 1.0 for sub-indicator EC1.1.

7.5.3.3 Advantages and Disadvantages

Evaluation of identified advantages and disadvantages associated with each Feasible Concept rationalized the pros and cons of the concepts in context of the professional judgement and experience of the evaluation team. Ideally, the discussion of advantages and disadvantages among the concepts should support the preference rank based on the numerical matrix evaluation.

The remainder of this section examines the advantages and disadvantages of the Feasible Concepts in context of the following key overall Project goals of the BHRD:

- Protective of human health and the environment

- Meet established timelines and milestones
- Founded on proven technologies
- Provide the best value to the Province

In accordance with Project goals, both Feasible Concepts were considered protective of human health and the environment (indicators HS1/2 and EN1/2). Neither Feasible Concept contains an inherent risk to the public or worker health and safety. Though there is added traffic for Feasible Concept 2, it is minimal and conversely there may be some minor potential risks for an operator of the on-Site leachate treatment facility. During the post-remediation operational phase, Feasible Concept 1 scored less for potential impacts to the aquatic environment (e.g., water quality) resulting from the discharge of treated effluent from the leachate treatment facility. Although there is no clear preference based on the environmental and H&S considerations for this Project goal, Feasible Concept 2 may be considered slightly preferable.

Both Feasible Concepts were considered to be constructible/implementable within the established timeframe (per indicator T5). Although the relative timeframe required to implement Feasible Concept 1 is longer when compared to Feasible Concept 2, it is not significant when compared to the overall Project timeframe and can readily be implemented prior to the need for leachate management. There is no clear preference based on the technical considerations for this Project goal, though Feasible Concept 2 may be considered slightly preferable due to its shorter timeframe.

In accordance with Project goals, both Feasible Concepts are founded on mature, proven technologies. Both approaches are considered reliable and effective means to manage leachate, such that there is very little risk associated with either Feasible Concept. There is no clear preference based on the technical consideration for this Project goal.

Both Feasible Concepts are considered to be economically feasible. The capital costs for leachate treatment facility construction under Feasible Concept 1 are substantially higher than Feasible Concept 2. The ongoing O&M costs to continually operate and maintain an on-Site leachate treatment facility are much higher than the cost to continually haul leachate off-Site (assuming the leachate can be disposed of at a municipal WWTP). Feasible Concept 2 provides the best value to the Province (and taxpayers), and would be preferred based on this economic consideration.

Overall, the comparison of advantages and disadvantages generally supports selection of Feasible Concept 2 as the preferred Feasible Concept for leachate management.

7.5.4 Summary of Qualified Remedial Option

Based on the results of the numerical evaluation and ranking, comparative analysis, and review of advantages and disadvantages, Feasible Concept 2, off-Site disposal, was selected as the Qualified Remedial Option for post remediation leachate treatment.

This Feasible Concept involves disposing of leachate at an off-Site WWTP by tanker. Leachate will drain from the sludge disposal cell to the storage tanks. A truck loading station will facilitate the loading of leachate into a tanker truck. The tanker truck would then transport and dispose of leachate at an off-site WWTP. It has been assumed that all off-Site disposal will be within 175 km of the Site.

All of Which is Respectfully Submitted,

GHD

Eric Farquhar, P.Eng.

Andrew Philopoulos, P.Eng.

Christine Skirth, C.E.T., PMP

Source: Imagery @2017 Google CNES / Airbus, DigitalGlobe, Landsat / Copernicus

0 200 400 600

Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
REMEDIAL OPTIONS DECISION DOCUMENT

11148275-09
Mar 15, 2018

STUDY AREA

FIGURE 1

GIS File: \\HAL-S1\Shared\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA002.mxd

Appendices

Appendix A
Laboratory Treatability Study

Laboratory Treatability Study

Boat Harbour Remediation Planning and Design
Pictou Landing, Nova Scotia

Nova Scotia Lands Inc.

GHD | 45 Akerley Boulevard Dartmouth, Nova Scotia B3B 1J7 Canada

11148275 **|** Report No 10 **|** April 9 2018

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1. Introduction

The Boat Harbour Effluent Treatment Facility (BHETF) consists of the wastewater effluent pipeline, twin settling basins, aeration stabilization basin (ASB), and the Boat Harbour stabilization lagoon (BH). Effluent from Boat Harbour discharges through a dam into the estuary before being released to the Northumberland Strait. Prior to the construction of the twin settling basins and ASB, effluent was routed by open ditch from the pipeline on the east side of Highway 348 to a natural wetland area (Former Ponds 1, 2, and 3) before being discharged into the stabilization lagoon.

Remediation includes addressing Site areas that have been impacted from the operation of the BHETF. At the core of remediation will be removal of impacted sludge/sediment and managing all associated effluents including treatment prior to disposal or discharge. A Laboratory Treatability Study (Study) was performed to identify the optimum technologies for treatment of sediment, surface water, and dewater water from the BHETF. Treatment strategies tested included:

- Removal of sediments in the wet
- Excavation of sediments in the dry
- Do nothing

Under each strategy, the following testing was performed:

- Removal of sediments in the wet
  - Testing of geotubes for dewatering of sediment (dewatering study would also be applicable to filter press or centrifuge dewatering)
  - Testing for determination of required treatment for dewater water
  - Leach testing of dewatered sediment
  - Stabilization of non-dewatered sediment
- Excavation of sediments in the dry
  - Testing for determination of required treatment for surface water pumped off
  - Dewatering of sediment
  - Stabilization and leach testing of dewatered and non-dewatered sediment
- Do nothing
  - Leach testing on untreated sediment

This report presents the objectives and methodology and findings from the Study.

2. Laboratory Treatability Study

2.1 Objectives

The primary objectives of the Study were to gather the data necessary to:

1. Determine the optimum treatments for removal of sediments in the wet including dewatering and required treatment of dewater water and dewatered sediment.
2. Determine the optimum treatments for excavation in the dry including treatment of surface water, dewatering of excavated sediment, and treatment of excavated sediment.
3. Determine whether untreated sediment can be landfilled without treatment.

2.2 Sample Acquisition

The Study was performed using sediment (sludge/sediment) and surface water samples collected from three distinct areas of the Site; a sample from the ASB, a sample from the Boat Harbour stabilization lagoon (BH), and a sample from the estuary (EST). A total of 30 gallons (~115 litres) of sediment and 110 gallons (~420 litres) of water was collected per sample. The samples were shipped to GHD's laboratory in Niagara Falls, New York under the terms specified in GHD's United States Department of Agriculture (USDA) soil permit and received at the laboratory on November 28, 2017.

2.3 Standards Used

Laboratory analytical results were compared to provincial criteria. For parameters where provincial criteria were not available, federal criteria were referenced.

Analytical results for surface water (including dewater water generated by the testing) were compared to the Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQSs) for Surface Water (Marine Water Values) as referenced in the 2013 NSE Contaminated Site Regulations (CSRs). In the absence of a surface water Tier 1 EQS for the dioxins and furans toxicity equivalent (TEQ), the groundwater Tier 1 EQS for this parameter has been applied as a screening level to evaluate human health exposure via the potable drinking water pathway. Similarly, in the absence of a Tier 1 EQS for chromium, the Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (Marine Value) for trivalent chromium has been applied to evaluate total and dissolved chromium levels.

The analytical results for the initial sediment characterization were compared to the NSE Tier 1 EQSs for Sediment (Marine Sediment Values) as referenced in the 2013 NSE CSRs. The CCME Sediment Quality Guidelines for the Protection of Aquatic Life (Marine Values) have also been referenced, however it is noted that these values are the same as the NSE Tier 1 EQSs for sediment. In the absence of applicable Tier 1 EQS or CCME guidelines for organic compounds, applicable guidelines were developed based on the 2003 United States Environmental Protection Agency (USEPA) Equilibrium Partitioning Sediment Benchmarks (ESBs) Approach for the Protection of Benthic Organisms. ESB calculation assumed a fraction of organic carbon content of 0.01 (1 percent) and fraction of solids being 0.5 (50 percent).

For evaluation of suitability of off-site landfill disposal, analytical results for sediment (solids and leachate) were compared to the Acceptance Parameters for Contaminated Soil as referenced in the 1992 NSE Guidelines for Disposal of Contaminated Solids in Landfills (Attachment B for Total Analysis and Attachment C for Leachate Results). It is noted that since this document does not reference an applicable guideline for dioxins and furans, therefore:

- For sediment solids the NSE Tier 1 EQS for soil has been carried as a screening level to evaluate acceptance criteria for the dioxins and furans TEQ results.
- For sediment leachate, the criteria for dioxins and furans (TEQ) was carried based on Schedule 6 Hazardous Constituents Controlled Under Leachate Test and Regulated Limits from the Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2005-149).

2.4 Task 1 | Initial Characterization

The untreated sediment and surface water for each area was analyzed to determine the level of treatment required.

Surface water samples were analyzed for:

1. pH
2. Total Cyanide
3. Volatile organic compounds (VOC)
4. Semi-volatile organic compounds (SVOC)
5. Petroleum hydrocarbon fractions
6. Total and dissolved metals
7. Total Polychlorinated biphenyls (PCB)
8. Polychlorinated dibenzodioxins/Polychlorinated dibenzofurans (PCDD/PCDF)

Sediment samples were analyzed for:

1. pH
2. Percent Solids
3. VOC
4. SVOC
5. Petroleum hydrocarbon fractions
6. Total metals
7. Total PCB
8. PCDD/PCDF
9. Toxicity Characteristic Leaching Procedure (TCLP) SVOC
10. TCLP petroleum hydrocarbons

11. TCLP metals

12. Synthetic precipitation leaching procedure (SPLP) SVOC

13. SPLP petroleum hydrocarbons

14. SPLP metals

2.4.1 Initial Surface Water Sample Characterization

For the surface water sample collected from the EST, the pH was neutral at 7.19 standard units (S.U.). Concentrations above the NSE Tier 1 EQSs were observed for total cyanide at 15 micrograms per liter (µg/L), total petroleum hydrocarbons at 0.514 milligrams per liter (mg/L), total zinc at 51.9 µg/L and dissolved zinc at 30.8 ug/L. The metals were generally observed in their particulate forms with dissolved concentrations being lower than the total metals values. The toxicity equivalent (TEQ) for PCDD/PCDF was 1.41 picograms per liter (pg/L). No VOCs, SVOCs, or PCBs were detected in this sample.

For the surface water sample collected from BH, the pH was neutral at 7.19 S.U. Concentrations above the NSE Tier 1 EQSs were observed for total cyanide at 21 µg/L, total petroleum hydrocarbons at 0.335 mg/L, total zinc at 64.4 µg/L and dissolved zinc at 53.4 ug/L. The metals were generally observed in their particulate forms with dissolved concentrations being lower than the total metals values. The TEQ for PCDD/PCDF was 0.257 pg/L. No VOCs, SVOCs, or PCBs were detected in this sample.

For the surface water sample collected from the ASB, the pH was neutral at 6.68 S.U. Concentrations above the NSE Tier 1 EQSs were observed for total cyanide at 19 µg/L, total petroleum hydrocarbons at 0.202 mg/L, total zinc at 97.9 µg/L and dissolved zinc at 60.7 ug/L. The metals were generally observed in their particulate forms with dissolved concentrations being lower than the total metals values. The TEQ for PCDD/PCDF was 0.329 pg/L. No VOCs, SVOCs, or PCBs were detected in this sample. The initial surface water sample characterization results are shown in Table 1.

2.4.2 Initial Sediment Sample Characterization

For the sediment sample collected from the EST, the pH was neutral at 7.19 S.U. and percent solids were at 21.9 percent weight per weight (w/w). Concentrations of all parameters were within the applicable criteria. The TEQ for PCDD/PCDF was 2.73 pg/g. No VOCs, SVOCs, or PCBs were detected in this sample. Leach testing was performed for PAHs, petroleum hydrocarbons and metals and no exceedances of the landfill disposal criteria were observed.

For the sediment sample collected from BH, the pH was neutral at 6.86 S.U. and percent solids were at 10.1 percent (w/w). Concentrations above the applicable criteria were observed for total cadmium at 11.3 mg/kg, total silver at 4.17 mg/kg, total zinc at 1230 mg/kg, petroleum hydrocarbons at 221 mg/kg and the TEQ for PCDD/PCDF at 170 pg/g. No VOCs, SVOCs, or PCBs were detected in this sample. Leach testing was performed for PAHs, petroleum hydrocarbons, and metals and no exceedances of the landfill disposal criteria were observed.

For the sediment sample collected from the ASB, the pH was neutral at 6.93 S.U. and the percent solids were at 11.3 percent (w/w). Concentrations above the applicable criteria were observed for total cadmium at 12.6 mg/kg, total mercury at 0.82 mg/kg, total silver at 3.35 mg/kg, total zinc at 955 mg/kg, petroleum hydrocarbons at 259 mg/kg and the TEQ for PCDD/PCDF at 402 pg/g. No VOCs, SVOCs, or PCBs were detected in this sample. Leach testing was performed for PAHs, petroleum hydrocarbons, and metals and no exceedances of the landfill disposal criteria were observed. The initial sediment sample characterization data are shown in Table 2.

These initial characterization data were used as baseline conditions for the treatability study.

2.5 Task 2 | Removal of Sediments in the Wet

2.5.1 Geotube Testing

Bench scale geotubes were used to assess the effectiveness of geotubes for dewatering of sediment removed in the wet (i.e., dredged sediment). The results from the geotube dewatering tests are also applicable to dewatering by filter press or centrifuge.

For each sample, surface water and sediment were mixed to make a slurry containing 5 percent solids (w/w). This slurry was assumed to be representative of what will be removed during dredging. Test tube and jar testing were performed on the slurry prior to placing the slurry in geotubes to determine the optimum polymer and/or coagulant additives to enhance dewatering of the sediments. Polymers and coagulants were mixed with the slurry in test tubes and then examined visually for floc formation and settling of the floc. The reagents tested are listed below:

Polymers

- Nalco Core Shell 71301
- Nalco Nalclear 7768

Coagulants

- Ferric Chloride
- Polyaluminum Chloride
- Nalco Ultraion 8186 (clarification agent)

2.5.1.1 Polymer Screening

A 10 milliliter (mL) aliquot of the 5 percent solids mixture of each sample was placed in each of four test tubes for each reagent to be screened. Three different doses of each reagent were tested along with a control tube containing the mixture only which was used as a reference. A stock solution for each of the polymers was prepared using distilled water. The solutions of the polymer were prepared at a concentration of 5,000 milligrams (mg) of coagulant for per liter (L) of distilled water.

Each solution was added to three test tubes containing the water/sediment mixture and at concentrations between 10 mg/L and 2,000 mg/L. The control test tube was left untreated. These concentrations were selected as a starting point based on previous experience with settling sludge. Following addition of the reagents, the tubes were capped and inverted gently repeatedly for

60 seconds to mix the samples. Once the samples were mixed, they were allowed to settle, and the settling rate was observed. The reagents producing the most effective settling, as determined by visual observation of settling rate, clearness of the supernatant, and volume of solids produced, were noted. This process was repeated for each of the polymers. One polymer was tested at a time. If sufficient settling was not observed after 1 minute, it is unlikely that the polymer dose is effective and testing of that polymer/dose was discontinued.

2.5.1.2 Coagulant Screening

Coagulant screening followed the same procedure as the polymer screening. A 5,000 mg/L stock solution of each polymer was prepared, and added to the test tubes containing the samples at concentrations between 10 mg/L and 2,000 mg/L.

2.5.1.3 Combined Testing

After testing the coagulants and polymers individually, the most effective coagulant was mixed with the most effective polymer doses and tested as specified above to determine whether addition of both a polymer and coagulant produced a faster settling rate or clearer supernatant than treatment with a single reagent. If any coagulant/polymer combinations appeared to produce better settling than either the polymer or coagulant alone, then the ratios of polymer and coagulant were varied to determine the most effective ratio to enhance settling.

2.5.1.4 Jar Testing

The reagents and doses showing the best flocculation and settling in the test tube tests were scaled up to jar tests for dose optimization. The selected reagents/doses/combinations were retested using 500 mL jar tests. Five-hundred milliliters of the 5 percent solids sediment/surface water mixture was placed in each jar, and doses of coagulants and/or polymers as determined in the screening tests were added to the jars. The jars were mixed for 2 minutes using a Phipps and Bird Model 7790-400 mechanical mixer with paddle attachments at 100 revolutions per minute (rpm) for mixtures with coagulant(s) and at 50 rpm for mixtures with a polymer only. For mixtures containing coagulant(s) and polymer, the coagulant was added and mixed at 100 rpm for 2 minutes, and the mixing was reduced to 50 rpm, and the polymer was added and mixed for 2 minutes. The mixtures was allowed to settle for 5 minutes.[1]

The optimum combinations of polymers and/or coagulants for each of the sediment mixtures were as follows:

- EST: 600 parts per million (ppm) of Nalco 71301
- BH: 1,000 ppm Nalco 8186 and 150 ppm Nalco 7768
- ASB: 1,250 ppm Nalco 8186 and 100 ppm Nalco 7768

[1] Standard procedures for jar testing of polymers and coagulants vary the mixing speeds to enhance mixing of the water soluble coagulants while avoiding shearing of the larger polymer materials.

2.5.1.5 Geotube Testing

Once the optimum polymer/coagulant doses were determined, geotubes were set up using the following treatments:

Table 2.1 Geotube Treatments

Estuary (EST)	Boat Harbour (BH)	ASB
Control (no additions)	Control (no additions)	Control (no additions)
Polymer only:600 ppm of Nalco 71301	Polymers/Coagulant only: 1,000 ppm Nalco 8186 and 150 ppm Nalco 7768	Polymers/Coagulant only:1,250 ppm Nalco 8186 and 100 ppm Nalco 7768
Polymer + Lime: 600 ppm of Nalco 71301 and 4 grams (g) of Lime to pH 8 – 8.5 S.U.	Polymers/Coagulant + Lime and powdered activated carbon (PAC):1,000 ppm Nalco 8186; 150 ppm Nalco 7768, 12 g of Lime to pH 8 – 8.5 S.U., and 2 percent PAC	Polymers/Coagulant + Lime and PAC: 1,250 ppm Nalco 8186 and 100 ppm Nalco 7768, 82 g of Lime to pH 8 – 8.5 S.U., and 2 percent PAC
	Polymers/Coagulant + Lime and RemBind: 1,000 ppm Nalco 8186 and 150 ppm Nalco 7768, 12 g of Lime to pH 8 – 8.5 S.U., and 2 percent RemBind	Polymers/Coagulant + Lime and RemBind:1,250 ppm Nalco 8186 and 100 ppm Nalco 7768, 82 g of Lime to pH 8 – 8.5 S.U., and 2 percent RemBind

The 5 percent solids sediment slurries and reagents were mixed in 5-gallon (~19 L) buckets using an IKA RW 20 Digital Laboratory Stirrer at 300 rpm. The mixing speed was determined visually as a speed that was able to move the entire volume of the bucket without splashing the material out of the bucket. Once all of the reagents were homogenized (approximately 30 minutes of mixing) in the buckets, the mixture was poured through a funnel attached to the geotube. This process was repeated for all geotubes.

2.5.1.6 Geotube Dewatering Rate

The rates of geotube dewatering were recorded and are shown in Table 3. For the EST samples, dewatering was complete within the first 24 hours. For the BH samples, dewatering was largely complete after 48 hours, and for the ASB samples, dewatering occurred over a 72 hour period. Samples of the dewater water from each geotube were collected and analyzed as described below.

2.5.2 Quality of Dewater Water

Dewater water was collected and analyzed for pH, total and dissolved metals, petroleum hydrocarbons, PCDD/PCDF, and cyanide. Analytical results were compared to the NSE Tier 1 EQSs for Surface Water (Marine Water Values) and supplemental criteria as noted in Section 2.3, which best represents the post remediation environment. The EST samples contained cyanide, mercury and zinc concentrations above the applicable criteria in the control test. For the EST geotubes that received polymer or lime and polymer, total cyanide exceeded the applicable criteria. Concentrations of petroleum hydrocarbons in the water from all EST geotubes exceeded the applicable criteria. TEQ values were within the applicable criteria.

For the BH geotubes, petroleum hydrocarbons, total cyanide and total zinc exceeded applicable criteria in all four samples. The control sample also contained a total vanadium concentration that exceeded the applicable criteria. The control sample and the polymer only sample also exceeded applicable criteria for total mercury and TEQ. It is noted that geotubes that received PAC and RemBind, which are both activated carbon based products that bind large organic molecules, did not exceed the applicable criteria for TEQ or total mercury.

For the ASB samples, petroleum hydrocarbons, total cyanide and total zinc exceeded applicable criteria in all four samples. The control sample also contained total chromium, total copper and total vanadium concentrations that exceeded the applicable criteria. The control sample and the polymer only sample also exceeded applicable criteria for total mercury and TEQ. It is noted that geotubes that received PAC and RemBind, which are both activated carbon based products that bind large organic molecules, did not exceed the applicable criteria for TEQ or total mercury. The sample that received lime, polymer and RemBind also contained a copper concentration above applicable criteria.

The geotube dewater water data are shown in Table 4.

2.5.3 Quality of Geotube Solids

Toxicity Characteristic Leaching Procedure (TCLP) and Synthetic Precipitation Leaching Procedure (SPLP) leaches were performed on the dewatered geotube solids, and the leachate was analyzed for metals, cyanide and petroleum hydrocarbons. Total PCDD/PCDF was analyzed in the dewatered solids with TCLP and SPLP PCDD/PCDF performed on one selected sample.

Leaching above landfill disposal standards was not observed for metals, petroleum hydrocarbons, or cyanide for any of the geotube solids from any of the areas. TCLP and SPLP PCDD/PCDF analysis was performed on the ASB control geotube solids which would represent the "worst case" leaching of PCDD/PCDF. The TCLP and SPLP TEQ values were below the applicable criteria.

For total PCDD/PCDF TEQ concentrations (i.e., solids), results for the EST geotubes were within applicable criteria; however, the PCDD/PCDF TEQ concentrations exceeded applicable criteria for all of the BH and ASB geotubes.

The geotube solids analyses are shown in Table 5.

2.5.4 Dewater Water Treatment Testing

Treatment of dewater water was performed on dewater water from the BH and ASB geotubes that received lime, polymer, and 2 percent PAC. The water from these geotubes was selected because these geotube amendments were the most effective in decreasing concentrations of metals, petroleum hydrocarbons and PCDD/PCDF in the dewater water. One litre of the dewater water from the geotubes was mixed with 2 percent PAC for 30 minutes. After the mixing, samples were filtered through a 1.5 micron glass fiber filter and then bottled for sample analyses. The samples were analyzed for chemical oxygen demand (COD), total cyanide, total petroleum hydrocarbons, total metals, and dissolved metals. COD for both samples was found to be low (less than 20 mg/L) and both samples were non-detect for total cyanide. Total and dissolved metals data for both samples were below the applicable criteria. The water from the BH geotube was slightly above the applicable criteria for total petroleum hydrocarbons at 0.178 mg/L while the ASB geotube sample was below the applicable criteria. The analytical results are shown in Table 6.

Since the quality of the dewater water was weak enough that treatment through a simple treatment process reduced all parameters to below Tier 1 standards and leach testing of the geotube did not show leaching above landfill disposal standards, further stabilization of the geotube solids was not required and was not tested.

2.5.5 Stabilization of Non-Dewatered Sediment

Stabilization testing of material removed "in the wet" without dewatering was tested using Cetco clay products, distributed by Claytech Services Inc. The vendor recommended a dose of 4.5 percent Liquisorb 2000 for a 5 percent solids mixture. Since the ASB sediment had the highest concentration of chemicals of concern and was the most difficult to dewater using geotubes, this sample was selected for testing as it would represent "worst case" conditions. Treatment of a slurry of ASB sediment and surface water containing 5 percent solids with 4.5 percent Liquisorb 2000 was tested. After 24 hours, the stabilized material was tested for paint filter test, percent solids, bulking, TCLP metals, TCLP petroleum hydrocarbons, and TCLP PCDD/PCDF. The material passed the paint filter test and contained 12.8 percent solids (w/w). Bulking was not observed in this sample. TCLP metals, TCLP cyanide, and TCLP PCDD/PCDF were below landfill disposal standards, however, TCLP total petroleum hydrocarbons were above the standard at 6.5 mg/L. These data are shown in Table 7.

2.6 Task 3 | Excavation of Sediments in the Dry

Stabilization of sediments "in the dry" was tested. Excavation of sediments in the dry would involve bulk dewatering prior to excavation. The surface water that was removed may require treatment prior to discharge therefore treatment of the surface water was tested.

2.6.1 Treatment of Surface Water

Surface water treatment testing was performed on BH and ASB surface water samples as received. One-litre of each sample was pH adjusted to greater than 10 S.U. using lime. After pH adjustment, the samples were mixed for 2 minutes. Suspended solids were observed which did not appear to settle within a short period of time. Ferric chloride (250 ppm) and Nalco polymer 7768 (1 ppm) were added to each of the samples and mixed for 2 minutes to enhance the settling of suspended solids. After mixing, both samples were allowed to settle for 5 minutes. The supernatant from each test was analyzed for COD, total cyanide, total petroleum hydrocarbons, and total and dissolved metals. The COD for both samples were greater than that of the dewater water from the geotube testing. Both samples exceeded the applicable criteria for total petroleum hydrocarbons, total lead, and total zinc.

The supernatant from the lime tests was mixed with 2 percent PAC for 30 minutes. After mixing, both samples were filtered through a 1.5 micron glass fiber filter. These samples were again analyzed for COD, total cyanide, total petroleum hydrocarbons, and total and dissolved metals. The results from the analyses showed that the COD had been reduced by 78-90 percent by the PAC treatment. The total cyanide remained below detection limit. The total petroleum hydrocarbons and total and dissolved metal concentrations were all reduced to levels within applicable criteria. The data are shown in Table 8.

2.6.2 Treatment of Sediment

The sediment as received was used for these tests as it is expected to represent sediments that would be excavated in the dry. As shown in Table 2, the EST sediment had a percent solids content of 21.9 percent (w/w), while the BH and ASB sediments contained percent solids contents of 10.1 and 11.3 percent (w/w) respectively. Initial stabilization testing involved mixing of the sediments with combinations of Portland cement (up to 15 percent w/w), PAC (2 percent w/w), and agricultural lime (20 percent w/w). Free water was observed on the top of all solidified sediment treatments. The tests were left to stand for 72 hours to determine whether the free water would be absorbed as the cement became hydrated, however the free water remained. Further doses of up to 20 percent Portland cement and 60 percent lime were then tested. This resulted in less standing water, however an approximate 50 percent bulking of the samples was observed. Bulking of 50 percent is considered unacceptable from a waste management perspective. Based on these findings, it was determined that the moisture content of the sediments was too high for stabilization using Portland cement and lime alone without excessive bulking.

Therefore, the following alternate options were tested:

1. Gravity dewatering
2. Geotube dewatering

Additional polymer testing was performed to refine the polymer doses determined for the mixture containing 5 percent solids during the geotube testing. Since these mixtures contained more solids than the "in the wet" mixtures, a slightly different polymer dose was found to be optimal. The same procedures were followed for screening tests and combined tests as described above in the Section 2.5.1. Based on the testing, the following doses were determined:

- EST 2,000 ppm of Nalco 71301
- BH 2,000 ppm Nalco 8186 and 1,000 ppm Nalco 7768
- ASB 2,500 ppm Nalco 8186 and 1,500 ppm Nalco 7768

The sediments were mixed with these polymer doses. For gravity dewatering, the mixed sediment was placed in a beaker, and free water rising to the top of the sediment was pipetted off. After 72 hours, none of the samples passed the paint filter test. Therefore, it was determined that dewatering by settling of solids and removal of free water from the top of the material was not a viable dewatering mechanism.

For geotube dewatering, the sediment mixed with polymer/coagulant at the doses listed above were placed on filter fabric obtained from the geotube vendor and allowed to dewater. The rate of dewatering was noted and is shown in Table 9. The dewatered sediment from all three areas passed the paint filter test.

Solidification tests were set up on the dewatered sediment. The following treatments were set up for each of the three areas:

- Control
- Lime, 2 percent PAC
- Lime, 2 percent RemBind
- 5 percent Portland cement, 2 percent PAC

Stabilized sediments were tested for percent solids, TCLP metals, and TCLP petroleum hydrocarbons. For all samples in all tests, the TCLP metals and TCLP petroleum hydrocarbons were below the applicable standard. Bulking of the material for all tests was observed to be less than 11 percent. For all areas the percent solids were greatest with 5 percent Portland cement with 2 percent PAC at 38.7 percent for EST, 19.4 percent for BH, and 19.6 for ASB. These data are shown in Table 10.

Cetco clay products were again tested for stabilization of material removed "in the dry". Initial stabilization screening testing involved mixing of the sediments with clay products at 1 percent, 1.5 percent, and 3 percent at a fast mixing rate and then placed in molds. The clay products tested were Liquisorb 1000, Liquisorb 2000, and X-Dry 1000 OES. After 24 hours, the 3 percent Liquisorb 2000 dose passed paint filter testing with less than 7 percent bulking. The other clay products did not pass paint filter testing after 24 hours. The following larger scale stabilization tests were set up for each area:

- 3 percent Liquisorb 2000 alone
- 3 percent Liquisorb 2000, 2 percent PAC

After the stabilization tests were allowed to set up for at least 24 hours, the stabilized sediment was tested for percent solids, TCLP cyanide, TCLP metals, and TCLP petroleum hydrocarbons. For all areas the percent solids increased slightly over the untreated sediment. The TCLP testing did not show leaching of any metals or cyanide above landfill disposal standards. TCLP petroleum hydrocarbons exceeded landfill disposal standards for all areas except for EST and BH samples that received 3 percent Liquisorb 2000 with 2 percent PAC. In addition, the BH sample that received 3 percent Liquisorb 2000 was analyzed for TCLP PCDD/PCDF and had a TCLP TEQ of 2.64 pg/L which is below applicable criteria. These data are shown in Table 11.

3. Discussion

3.1 Removal of Sediments in the Wet

Options for dewatering of sediments removed in the wet include:

- Geotube
- Centrifuge
- Gravity

- Stabilization without Dewatering

3.1.1 Geotube

The Study has shown that geotube treatment would be effective for dewatering of sediments removed in the wet. Polymer and/or coagulant doses have been developed for all three sediments that cause "clumping" of the fine particulate and allow the sediment to be retained by the geotube while water runs out. After 2 weeks percent solids in geotubes treated with polymer averaged approximately 35 percent solids for the EST, 28 percent solids for the BH and 20 percent solids for the ASB. Geotube solids did not leach metals, cyanide or petroleum hydrocarbons in excess of landfill disposal criteria. The initial sediment and surface water samples did not contain VOC or PAH, therefore these compounds would not be present in the leachate from these samples. The solids contained PCDD/PCDF such that the TEQ was higher than the applicable criteria, however leaching of PCDD/PCDF was below the applicable leachate criteria for hazardous materials. At this time, it is not clear which standard would apply to this material. Geotube dewater water would require treatment for TPH, metals and cyanide. If carbon or RemBind are not added to the geotube, dewater water would also require treatment for PCDD/PCDF. Testing showed that a relatively simple process consisting of pH adjustment with lime and filtration through activated carbon would be sufficient for treatment.

3.1.2 Gravity

Laboratory results for gravity dewatering showed that BH and ASB sediments did not settle or dewater by gravity while EST sediments settled quickly when treated with a polymer. Therefore gravity dewatering would not be effective for the BH and ASB sediments removed in the wet but may be effective for EST sediments removed in the wet.

3.1.3 Centrifuge

Centrifugation applies a greater force of gravity to the material, however since gravity settling was not effective for BH or ASB sediments collected in the wet, it is unlikely that centrifugation would be effective for these sediments. Centrifugation may be effective for EST sediments collected in the wet.

3.1.4 Stabilization

Stabilization was performed using Cetco clay products distributed by Claytech Services Inc. The use of Liquisorb 2000 at a dose of 4.5 percent by weight resulted in a material that was workable and would pass paint filter. No significant bulking was observed using this dose. The stabilized material did not leach metals in excess of landfill disposal criteria or PCDD/PCDF TEQ in excess of applicable leachate criteria, however leaching of TPH in excess of landfill criteria was observed. Therefore stabilization using Cetco clay would be a viable option for sediment excavated in the wet without dewatering, however a binding agent such as activated carbon would need to be mixed in to prevent leaching of petroleum hydrocarbons.

3.2 Excavation of Sediments in the Dry

3.2.1 Treatment of Surface Water

The Study indicates that the BH and ASB surface water would need to be treated to decrease total petroleum hydrocarbons and metals. Testing showed that a relatively simple process consisting of pH adjustment with lime and filtration through activated carbon would be sufficient for treatment.

3.2.2 Geotube

The laboratory study has shown that geotube treatment would be effective for dewatering of sediments excavated in the dry. Polymer and/or coagulant doses similar to those used for geotube treatment "in the wet" were developed for all three sediments. Geotube dewatering for all three sediments produced a material that would pass the paint filter test. Percent solids for solids treated with polymer and dewatered with geotubes averaged approximately 34 percent solids (w/w) for the EST, 16 percent solids (w/w) for BH and 17 percent solids for the ASB. The dewatered solids did not leach metals, cyanide or petroleum hydrocarbons in excess of landfill disposal criteria.

3.2.3 Gravity

Gravity dewatering would not be effective for any of the three sediments removed in the dry. Testing showed that although a small amount of free water was produced when sediments were treated with polymers, the settled solids would not pass a paint filter test.

3.2.4 Centrifuge

Based on the gravity dewatering tests, centrifugation would not be effective for sediments removed in the dry from either the EST, BH, or ASB areas.

3.2.5 Stabilization

Stabilization using Portland cement with lime as a bulking agent was not effective for the stabilization of sediments removed in the dry. The water content of these sediments was too high and stabilization such that a material was obtained that would pass the paint filter test could not be obtained using Portland cement and lime without bulking the sediment by over 50 percent.

Stabilization was also performed using Cetco clay products distributed by Claytech Services Inc. The use of Liquisorb 2000 at a dose of 3 percent by weight resulted in a material that was workable and would pass paint filter. Seven percent bulking was observed using this dose. The stabilized material did not leach metals in excess of landfill disposal criteria or PCDD/PCDF TEQ in excess of federal criteria, however leaching of TPH in excess of landfill criteria was observed for EST, BH, and ASB sediments. The addition of powdered activated carbon eliminated leaching of TPH for the EST and BH sediments but not for the ASB sediments. A higher activated carbon dose would be required for the ASB sediments. Therefore stabilization using Cetco clay would be a viable option for sediment excavated in the dry without dewatering, however a binding agent such as activated carbon would need to be mixed in to prevent leaching of petroleum hydrocarbons.

The stabilization testing showed that stabilization of sediments removed in the dry with Portland cement and lime is not viable without excessive bulking, however stabilization using a clay product is a viable option.

Stabilization testing was also performed on sediment collected in the dry but dewatered using geotubes. Stabilization of the dewatered sediment was not required.

3.3 Geotube Dewatering Rates

3.3.1 Removal in the Wet

The geotubes were filled with 40 L (0.04 cubic metres (m^3)) of a sediment/water mixture containing 5 percent solids.

For the EST a total of 26.5 L of water was recovered from each of the geotubes. This volume was recovered during the first 24 hours after the geotube was filled. The rate of dewatering decreased over the 24 hour period. If linear rates are fitted to the different time ranges than the dewatering rate over the first 6 hours was 2.7 liters per hour, the second 6 hours was 0.54 liters per hour and over the following 12 hours was 0.3 liters per hour. Since 40 L (0.04 m^3) of sludge was placed in the geotube the dewatering rate during the first 6 hours can be converted to 67.5 L/m^3 of sludge; the dewatering rate during the second 6 hours was 13.5 L/m^3 and the dewatering rate during the following 12 hours was 7.5 L/m^3 of sludge.

A full size geotube 100 m long and 5 m in diameter would hold 1,964 m^3 of sediment so during the first 6 hours 132,570 L of water per hour would be recovered from the geotube so over the first 6 hours 795,420 L (795 cubic m) of water would be recovered. This means that 40 percent of the volume of the geotube would dewater within the first 6 hours and additional 795 m^3 could be pumped into the geotube.

The corresponding numbers for the BH and ASB geotubes are shown in the table below:

Table 3.1 Geotube Dewatering Rates in the Wet

Geotube	Dewater Rate for first 6 hours; second 6 hours; following 12 hours	Percent reduction in Geotube Volume	Dewater Rate per Cubic Meter of Soil for first 6 hours; second 6 hours; following 12 hours	Dewater Rate for 1,964 m^3 geotube for first 6 hours; second 6 hours; following 12 hours	Volume of water recovered from 1,964 m^3 geotube during first 6 hours; second 6 hours; following 12 hours
EST (all three geotubes)	2.7 L/h; 0.54 L/h; 0.3 L/h	66.25%	67.5 L/h; 13.5 L/h; 7.5 L/h	133 m^3/h; 26.5 m^3/h; 14.7 m^3/h	795 m^3; 159 m^3; 177 m^3
BH Control	1.35 L/h; 0.29 L/h; 0.13 L/h	39.4%	33.7 L/h; 7.27 L/h; 3.24 L/h	66.3 m^3/h; 14.3 m^3/h; 6.4 m^3/h	398 m^3; 85.6 m^3; 76.5 m^3
BH Polymer/ CoagulantOnly	2.01 L/h; 0.43 L/h; 0.19 L/h	56.8%	50.3 L/h; 10.8 L/h; 4.8 L/h	98.8 m^3/h; 21.3 m^3/h; 9.5 m^3/h	593 m^3; 128 m^3; 114 m^3

Table 3.1 Geotube Dewatering Rates in the Wet

Geotube	Dewater Rate for first 6 hours; second 6 hours; following 12 hours	Percent reduction in Geotube Volume	Dewater Rate per Cubic Meter of Soil for first 6 hours; second 6 hours; following 12 hours	Dewater Rate for 1,964 m^3 geotube for first 6 hours; second 6 hours; following 12 hours	Volume of water recovered from 1,964 m^3 geotube during first 6 hours; second 6 hours; following 12 hours
BH Polymer/Coag, Lime + PAC	2.5 L/h; 0.54 L/h; 0.24 L/h	53.2%	62.8 L/h; 13.5 L/h; 6.03 L/h	123 m^3/h; 26.5 m^3/h; 11.8 m^3/h	739 m^3; 159 m^3; 142 m^3
BH Polymer/Coag, Lime + RemBind	1.79 L/h; 0.39 L/h; 0.17 L/h	51.0%	44.7 L/h; 9.6 L/h; 4.3 L/h	87.8 m^3/h; 18.9 m^3/h; 8.4 m^3/h	527 m^3; 113 m^3; 101 m^3
ASB Control	0.6 L/h; 0.15 L/h; 0.098 L/h	32.0%	15.1 L/h; 3.77 L/h; 2.45 L/h	29.6 m^3/h; 7.4 m^3/h; 4.8 m^3/h	178 m^3 44.4 m^3; 57.8 m^3
ASB Polymer/Coag Only	1.5 L/h; 0.38 L/h 0.24 L/h	43.2%	37.6 L/h; 9.39 L/h; 6.10 L/h	73.8 m^3/h; 18.4 m^3/h; 12.0 m^3/h	443 m^3; 111 m^3; 144 m^3
ASB Polymer/Coag, Lime + PAC	1.4 L/h; 0.35 L/h; 0.23 L/h	40.9%	34.9 L/h; 8.73 L/h; 5.67 L/h	68.6 m^3/h; 17.1 m^3/h; 11.1 m^3/h	412 m^3; 103 m^3; 134 m^3
ASB Polymer/Coag, Lime + RemBind	1.0 L/h; 0.25 L/h; 0.16 L/h	37.7%	25.1 L/h; 6.28 L/h; 4.08 L/h	45.4 m^3/h; 12,3 m^3/h; 8.0 m^3/h	296 m^3; 74.0 m^3; 96.2 m^3

Notes:

- Dewatering occurred in the ASB and BH geotubes after the first 24 hours, however the amounts were fairly negligible so only the volumes for the first 24 hours were used in the calculations above
- Calculation parameters:
  - Volume of sediment mixture placed in bench scale geotubes: approximately 40 L (0.04 m^3)
  - Surface area of bench scale geotubes: approximately 4,100 square cm (0.21 m^2)
  - Ratio of surface area to volume of the bench scale geotube was 5.25 m^2/m^3

3.3.2 Removal in the Dry

Geotubes were not set up for the removal in the dry option, however sediment was placed on geotube filter fabric and the rates at which water was recovered from the sediment mixture were measured. Dewatering of all three sediments was complete after 150 minutes. Similar to the "in the wet" geotubes, the greatest amount of dewatering was observed immediately after the sediment was placed on the filter fabric – in this case in the first 20 minutes. When dewatering rates for "in the dry" are graphed over time the curve as a similar shape to those for "in the wet" above therefore it appears it would be valid to use the rates in the table above that were developed for the "in the wet" geotubes for "in the dry". For the ASB and the BH, the "in the dry" material contains 10 percent solids and the "in the wet" material contains 5 percent solids therefore the similarity is expected.

Only dewatering using polymer was performed for the "in the dry" tests. In the table below an attempt has been made to scale the rates observed during the 150 minutes filtration to what would be seen in geotubes based on the fact that 2 L of sediment were used in the filters compared with 40 L in the getubes. The numbers are similar to the "in the wet" numbers in part because the "in the wet" rates were used in the scale up calculation.

Table 3.2 Geotube Dewatering Rates in the Dry

Geotube	Dewater Rate for first 6 hours; second 6 hours; following 12 hours	Dewater Rate per Cubic Meter of Soil for first 6 hours; second 6 hours; following 12 hours	Dewater Rate for 1,964 m^3 geotube for first 6 hours; second 6 hours; following 12 hours	Volume of water recovered from 1,964 m^3 geotube during first 6 hours; second 6 hours; following 12 hours
EST (all three geotubes)	2.5 L/h; 0.5 L/h; 0.28 L/h	64 L/h; 13 L/h; 7 L/h	125 m^3/h; 25 m^3/h; 14 m^3/h	750 m^3; 150 m^3; 170 m^3
BH Polymer/Coag Only	2 L/h; 0.4 L/h; 0.18 L/h	48 L/h; 10 L/h; 4.5 L/h	94 m^3/h; 20 m^3/h; 9 m^3/h	560 m^3; 120 m^3; 108 m^3
ASB Polymer/Coag Only	1.4 L/h; 0.36 L/h; 0.23 L/h	36 L/h; 9 L/h; 6 L/h	70 m^3/h; 17 m^3/h; 11 m^3/h	420 m^3; 105 m^3; 136 m^3

4. Conclusion and Recommendation

Based on this testing removal in the wet and removal in the dry are both viable options for treatment of the EST, BH, and ASB areas of the Site. Pilot testing of these technologies is recommended.

4.1 Removal in the Wet

For removal in the wet viable options for management of the dredged material are treatment using geotubes and stabilization without dewatering using Cetco clay and activated carbon.

4.1.1 Geotube Treatment

For geotube treatment the sediment would be mixed with polymer and/or coagulant as follows:

- EST: 600 ppm of Nalco 71301
- BH: 1,000 ppm Nalco 8186 and 150 ppm Nalco 7768
- ASB: 1,250 ppm Nalco 8186 and 100 ppm Nalco 7768

The addition of lime or activated carbon is not required to prevent leaching of metals, cyanide or organics from the geotube solids, however the addition of lime and PAC to the geotubes produces dewater water that requires less treatment. Therefore the addition of lime to pH 10 and 2 percent PAC may be considered, however it may be more feasible to do some additional treatment of the dewater water than add additional solids to the geotubes. Dewater water would be treated using lime and activated carbon.

4.1.2 Stabilization

For stabilization the non-dewatered dredged material would be mixed with Cetco Liquisorb 2000 at a concentrations of 4.5 percent by weight. Samples from the BH area would also be mixed with 2 percent activated carbon and samples from the ASB area would be mixed with 4 percent activated carbon.

4.2 Excavation in the Dry

For removal in the dry viable options for management of the excavated material are also geotubes and stabilization without dewatering using Cetco clay and activated carbon.

Surface water would be removed from the treatment areas and treated using lime and activated carbon.

4.2.1 Geotube Treatment

For geotube treatment the sediment would be mixed with polymer and/or coagulant as follows:

- EST 2,000 ppm of Nalco 71301
- BH 2,000 ppm Nalco 8186 and 1,000 ppm Nalco 7768
- ASB 2,500 ppm Nalco 8186 and 1,500 ppm Nalco 7768

The addition of lime or activated carbon is not required to prevent leaching of metals, cyanide or organics from the geotube solids, however the dewater water will be similar to that produced "in the wet" therefore the addition of lime and PAC to the geotubes will produce dewater water that requires less treatment. Therefore the addition of lime to pH 10 and 2 percent PAC may be considered however it may be more feasible to do some additional treatment of the dewater water than add additional solids to the geotubes. No stabilization of the dewatered solids is necessary.

4.2.2 Stabilization

For stabilization the non-dewatered dredged material would be mixed with Cetco Liquisorb 2000 at a concentration of 3 percent by weight. Samples from the BH area would also be mixed with 2 percent activated carbon and samples from the ASB area would be mixed with 4 percent activated carbon.

All of Which is Respectfully Submitted,

GHD

for Sophia Dore

Sophia Dore, Ph.D.

Christine Skirth, C.E.T., PMP

Table 1

Initial Surface Water Sample Characterization Results
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST	BH	ASB
General Chemistry					
pH	S.U.	b	7.19	7.19	6.68
Total Cyanide	µg/L	1	15	21	19
Volatile Organic Compounds (VOCs)					
2-Butanone	µg/L		ND (5)	ND (5)	ND (5)
2-Hexanone	µg/L		ND (5)	ND (5)	ND (5)
4-Methyl-2-pentanone	µg/L		ND (5)	ND (5)	ND (5)
1,2-Dibromo-3-chloropropane	µg/L		ND (2)	ND (2)	ND (2)
1,2-Dibromoethane	µg/L		ND (2)	ND (2)	ND (2)
1,2-Dichlorobenzene	µg/L	42	ND (2)	ND (2)	ND (2)
1,3-Dichlorobenzene	µg/L	19.7	ND (2)	ND (2)	ND (2)
1,4-Dichlorobenzene	µg/L	19.7	ND (2)	ND (2)	ND (2)
1,1-Dichloroethane	µg/L	1130	ND (2)	ND (2)	ND (2)
1,1-Dichloroethene	µg/L	2240	ND (2)	ND (2)	ND (2)
1,2-Dichloroethane	µg/L	1130	ND (2)	ND (2)	ND (2)
1,2-Dichloropropane	µg/L	3040	ND (2)	ND (2)	ND (2)
1,1,2,2-Tetrachloroethane	µg/L	90.2	ND (2)	ND (2)	ND (2)
1,2,4-Trichlorobenzene	µg/L		ND (2)	ND (2)	ND (2)
1,1,1-Trichloroethane	µg/L	312	ND (2)	ND (2)	ND (2)
1,1,2-Trichloroethane	µg/L	312	ND (2)	ND (2)	ND (2)
1,1,2-Trichloro-1,2,2-trifluoroethane	µg/L		ND (2)	ND (2)	ND (2)
Acetone	µg/L		ND (5)	ND (5)	ND (5)
Benzene	µg/L	2100	ND (2)	ND (2)	ND (2)
Bromochloromethane	µg/L		ND (2)	ND (2)	ND (2)
Bromodichloromethane	µg/L	6400	ND (2)	ND (2)	ND (2)
Bromoform	µg/L	6400	ND (2)	ND (2)	ND (2)
Bromomethane (Methyl bromide)	µg/L	6400	ND (2)	ND (2)	ND (2)
Carbon disulfide	µg/L		ND (2)	ND (2)	ND (2)
Carbon tetrachloride	µg/L	500	ND (2)	ND (2)	ND (2)
Chlorobenzene	µg/L	25	ND (2)	ND (2)	ND (2)
Chloroethane	µg/L		ND (2)	ND (2)	ND (2)
Chloroform (Trichloromethane)	µg/L	6400	ND (2)	ND (2)	ND (2)
Chloromethane (Methyl chloride)	µg/L	6400	ND (2)	ND (2)	ND (2)
cis-1,2-Dichloroethene	µg/L	2240	ND (2)	ND (2)	ND (2)
cis-1,3-Dichloropropene	µg/L		ND (2)	ND (2)	ND (2)
Cyclohexane	µg/L		ND (2)	ND (2)	ND (2)
Dibromochloromethane	µg/L	6400	ND (2)	ND (2)	ND (2)
Dichlorodifluoromethane	µg/L		ND (2)	ND (2)	ND (2)
Ethylbenzene	µg/L	320	ND (2)	ND (2)	ND (2)
Isopropylbenzene	µg/L		ND (2)	ND (2)	ND (2)
Methyl acetate	µg/L		ND (2)	ND (2)	ND (2)
Methylcyclohexane	µg/L		ND (2)	ND (2)	ND (2)
Methylene chloride	µg/L	6400	ND (2)	ND (2)	ND (2)
Methyl tert-butyl ether	µg/L	5000	ND (2)	ND (2)	ND (2)
Styrene	µg/L		ND (2)	ND (2)	ND (2)
Tetrachloroethene	µg/L	450	ND (2)	ND (2)	ND (2)
Toluene	µg/L	770	ND (2)	ND (2)	ND (2)
trans-1,2-Dichloroethene	µg/L	2240	ND (2)	ND (2)	ND (2)
trans-1,3-Dichloropropene	µg/L		ND (2)	ND (2)	ND (2)

Table 1

Initial Surface Water Sample Characterization Results
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST	BH	ASB
VOCs-Continued					
Trichlorofluoromethane	µg/L		ND (2)	ND (2)	ND (2)
Trichloroethene	µg/L	20	ND (2)	ND (2)	ND (2)
m/p-Xylenes	µg/L	330	ND (2)	ND (2)	ND (2)
o-Xylene	µg/L	330	ND (2)	ND (2)	ND (2)
Vinyl chloride	µg/L		ND (2)	ND (2)	ND (2)
Semi-volatile Organic Compounds (SVOCs)					
1-Methylnaphthalene	µg/L	1	ND (2)	ND (2)	ND (2)
2-Methylnaphthalene	µg/L	2	ND (2)	ND (2)	ND (2)
Acenaphthene	µg/L	6	ND (2)	ND (2)	ND (2)
Acenaphthylene	µg/L	6	ND (2)	ND (2)	ND (2)
Anthracene	µg/L		ND (2)	ND (2)	ND (2)
Benzo(a)anthracene	µg/L		ND (2)	ND (2)	ND (2)
Benzo(b)fluoranthene	µg/L		ND (2)	ND (2)	ND (2)
Benzo(k)fluoranthene	µg/L		ND (2)	ND (2)	ND (2)
Benzo(g,h,i)perylene	µg/L		ND (2)	ND (2)	ND (2)
Benzo(a)pyrene	µg/L	0.01	ND (2)	ND (2)	ND (2)
Chrysene	µg/L	0.1	ND (2)	ND (2)	ND (2)
Dibenz(a,h)anthracene	µg/L		ND (2)	ND (2)	ND (2)
Fluoranthene	µg/L	11	ND (2)	ND (2)	ND (2)
Fluorene	µg/L	12	ND (2)	ND (2)	ND (2)
Indeno(1,2,3-cd)pyrene	µg/L		ND (2)	ND (2)	ND (2)
Naphthalene	µg/L	1.4	ND (2)	ND (2)	ND (2)
Phenanthrene	µg/L	4.6	ND (2)	ND (2)	ND (2)
Pyrene	µg/L	0.02	ND (2)	ND (2)	ND (2)
Total Petroleum Hydrocarbons					
Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)
Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	ND (0.02)	0.016 J
Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.051	0.046	0.023
Total Petroleum Hydrocarbons (>C21-C32)	mg/L		0.463	0.288	0.163
Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	0.1	0.514	0.335	0.202
Polychlorinated Biphenyls (PCBs)					
Total PCBs	µg/L		ND (0.06)	ND (0.06)	ND (0.06)
Dioxins and Furans					
2,3,7,8-TCDD	pg/L		ND (9.5)	ND (9.5)	ND (13)
1,2,3,7,8-PeCDD	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,4,7,8-HxCDD	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,6,7,8-HxCDD	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,7,8,9-HxCDD	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,4,6,7,8-HpCDD	pg/L		89	ND (48)	ND (48)
OCDD	pg/L		2900 B	30 JB	40 JB
2,3,7,8-TCDF	pg/L		ND (9.5)	ND (11)	ND (15)
1,2,3,7,8-PeCDF	pg/L		ND (47)	ND (48)	ND (48)
2,3,4,7,8-PeCDF	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,4,7,8-HxCDF	pg/L		ND (47)	ND (48)	ND (48)
Dioxins and Furans-Continued					
1,2,3,6,7,8-HxCDF	pg/L		ND (47)	ND (48)	ND (48)
2,3,4,6,7,8-HxCDF	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,7,8,9-HxCDF	pg/L		ND (47)	ND (48)	ND (48)
1,2,3,4,6,7,8-HpCDF	pg/L		22 J B	25 JB	32 JBq
1,2,3,4,7,8,9-HpCDF	pg/L		ND (47)	ND (48)	ND (48)
OCDF	pg/L		71 Jq B	39 JB	47 JB
TEQ	pg/L	120 [2]	1.4071	0.2569	0.3287

Table 1

Initial Surface Water Sample Characterization Results
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria (1)	EST	BH	ASB
Total Metals					
Total Aluminum	µg/L		977	1220	1320
Total Antimony	µg/L	500	ND (50)	ND (50)	ND (50)
Total Arsenic	µg/L	12.5	ND (50)	ND (50)	ND (50)
Total Barium	µg/L	500	168	208	210
Total Beryllium	µg/L	100	ND (25)	ND (25)	ND (25)
Total Cadmium	µg/L	0.12	ND (25)	ND (25)	ND (25)
Total Calcium	µg/L		77600	29800	33700
Total Chromium	µg/L	56 (trivalent) (3)	ND (25)	ND (25)	ND (25)
Total Cobalt	µg/L		ND (50)	ND (50)	ND (50)
Total Copper	µg/L	2	ND (50)	ND (50)	ND (50)
Total Iron	µg/L		345	395	461
Total Lead	µg/L	2	ND (50)	ND (50)	ND (50)
Total Magnesium	µg/L		154000	5240	4460
Total Manganese	µg/L		1030	1480	2020
Total Mercury	µg/L	0.016	ND (0.2)	ND (0.2)	ND (0.2)
Total Nickel	µg/L	8.3	ND (50)	ND (50)	ND (50)
Total Potassium	µg/L		57900	22600	86800
Total Selenium	µg/L	2	ND (100)	ND (100)	ND (100)
Total Silver	µg/L	1.5	ND (50)	ND (50)	ND (50)
Total Sodium	µg/L		1370000 E	312000	284000
Total Thallium	µg/L	21.3	ND (100)	ND (100)	7.10 J
Total Vanadium	µg/L	50	ND (50)	ND (50)	ND (50)
Total Zinc	µg/L	10	51.9	64.4	97.9

Table 1

Initial Surface Water Sample Characterization Results
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
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Parameters	Units	Criteria [1]	EST	BH	ASB
Dissolved Metals					
Dissolved Aluminum	µg/L		746	1070	1110
Dissolved Antimony	µg/L	500	ND (50)	ND (50)	1.68 J
Dissolved Arsenic	µg/L	12.5	ND (50)	ND (50)	ND (50)
Dissolved Barium	µg/L	500	164	190	207
Dissolved Beryllium	µg/L	100	ND (25)	ND (25)	ND (25)
Dissolved Cadmium	µg/L	0.12	ND (25)	ND (25)	ND (25)
Dissolved Calcium	µg/L		75900	3100	20300
Dissolved Chromium	µg/L	56 (trivalent) [3]	ND (25)	ND (25)	ND (25)
Dissolved Cobalt	µg/L		ND (50)	ND (50)	ND (50)
Dissolved Copper	µg/L	2	ND (50)	ND (50)	ND (50)
Dissolved Iron	µg/L		215	290	308
Dissolved Lead	µg/L	2	ND (50)	ND (50)	ND (50)
Dissolved Magnesium	µg/L		167000	5310	4490
Dissolved Manganese	µg/L		794	1270	2010
Dissolved Mercury	µg/L	0.016	ND (0.2)	ND (0.2)	ND (0.2)
Dissolved Nickel	µg/L	8.3	ND (50)	ND (50)	ND (50)
Dissolved Potassium	µg/L		76400	74800	23900
Dissolved Selenium	µg/L	2	ND (100)	ND (100)	ND (100)
Dissolved Silver	µg/L	1.5	ND (50)	ND (50)	ND (50)
Dissolved Sodium	µg/L		1490000 E	30900	285000
Dissolved Thallium	µg/L	21.3	ND (100)	ND (100)	ND (100)
Dissolved Vanadium	µg/L	50	ND (50)	ND (50)	ND (50)
Dissolved Zinc	µg/L	10	30.8	53.4	60.7

Notes:
[1] Nova Scotia Environment (NSE) 2013 Tier 1 Environmental Quality Standards (EQSs) for Surface Water (Marine Water Values), Table 3, July 6, 2013.
[2] NSE 2013 Tier 1 EQSs for Groundwater (Potable Groundwater Values), Table 4, July 6, 2013.
[3] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (Marine
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above calibration range
 - Exceeds Applicable Criteria
S.U. - Standard Units
q - Possible interference
B - Compound detected in blank
CN - Cyanide

Table 2

Initial Sediment Sample Characterization Results
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria (1)	Criteria (3)	Criteria (4)	EST	BH	ASB
General Chemistry							
pH	S.U.				7.19	6.86	6.93
Percent Solids	%				21.9	10.1	11.3
Volatile Organic Compounds (VOCs)							
2-Butanone	µg/kg				ND (125)	ND (125)	ND (125)
2-Hexanone	µg/kg				ND (125)	ND (125)	ND (125)
4-Methyl-2-pentanone	µg/kg				ND (125)	ND (125)	ND (125)
1,2-Dibromo-3-chloropropane	µg/kg				ND (50)	ND (50)	ND (50)
1,2-Dibromoethane	µg/kg				ND (50)	ND (50)	ND (50)
1,2-Dichlorobenzene	µg/kg	10000	50	50	ND (50)	ND (50)	ND (50)
1,3-Dichlorobenzene	µg/kg	10000	50	50	ND (50)	ND (50)	ND (50)
1,4-Dichlorobenzene	µg/kg	10000	90		ND (50)	ND (50)	ND (50)
1,1-Dichloroethane	µg/kg	50000		7910 (5)	ND (50)	ND (50)	ND (50)
1,1-Dichloroethene	µg/kg	50000		6340 (5)	ND (50)	ND (50)	ND (50)
1,2-Dichloroethane	µg/kg	50000		23000 (5)	ND (50)	ND (50)	ND (50)
1,2-Dichloropropane	µg/kg	50000		13100 (5)	ND (50)	ND (50)	ND (50)
1,1,2,2-Tetrachloroethane	µg/kg	50000			ND (50)	ND (50)	ND (50)
1,2,4-Trichlorobenzene	µg/kg	10000			ND (50)	ND (50)	ND (50)
1,1,1-Trichloroethane	µg/kg	50000	170		ND (50)	ND (50)	ND (50)
1,1,2-Trichloroethane	µg/kg	50000	170		ND (50)	ND (50)	ND (50)
1,1,2-Trichloro-1,2,2-trifluoroethane	µg/kg	50000			ND (50)	ND (50)	ND (50)
Acetone	µg/kg				ND (50)	ND (50)	ND (50)
Benzene	µg/kg	5000	1200		ND (50)	ND (50)	ND (50)
Bromochloromethane	µg/kg	50000		8210 (5)	ND (50)	ND (50)	ND (50)
Bromodichloromethane	µg/kg	50000			ND (50)	ND (50)	ND (50)
Bromoform	µg/kg		650		ND (50)	ND (50)	ND (50)
Bromomethane (Methyl bromide)	µg/kg			54700 (5)	ND (50)	ND (50)	ND (50)
Carbon disulfide	µg/kg				ND (50)	ND (50)	ND (50)
Carbon tetrachloride	µg/kg	50000	1200		ND (50)	ND (50)	ND (50)
Chlorobenzene	µg/kg	10000			ND (50)	ND (50)	ND (50)
Chloroethane	µg/kg	50000		13300 (5)	ND (50)	ND (50)	ND (50)
Chloroform (Trichloromethane)	µg/kg	50000		13300 (5)	ND (50)	ND (50)	ND (50)
Chloromethane (Methyl chloride)	µg/kg	50000		29300 (5)	ND (50)	ND (50)	ND (50)
cis-1,2-Dichloroethene	µg/kg	50000		7960 (5)	ND (50)	ND (50)	ND (50)
cis-1,3-Dichloropropene	µg/kg	50000			ND (50)	ND (50)	ND (50)
Cyclohexane	µg/kg				ND (50)	ND (50)	ND (50)
Dibromochloromethane	µg/kg	50000		29500 (5)	ND (50)	ND (50)	ND (50)
Dichlorodifluoromethane	µg/kg	50000			ND (50)	ND (50)	ND (50)
Ethylbenzene	µg/kg	50000	1200		ND (50)	ND (50)	ND (50)
Isopropylbenzene	µg/kg				ND (50)	ND (50)	ND (50)
Methyl acetate	µg/kg				ND (50)	ND (50)	ND (50)
Methylcyclohexane	µg/kg				ND (50)	ND (50)	ND (50)
Methylene chloride	µg/kg			29500 (5)	ND (50)	ND (50)	ND (50)
Methyl tert-butyl ether	µg/kg				ND (50)	ND (50)	ND (50)
Styrene	µg/kg	50000			ND (50)	ND (50)	ND (50)
Tetrachloroethene	µg/kg	50000	530		ND (50)	ND (50)	ND (50)
Toluene	µg/kg	30000	1400		ND (50)	ND (50)	ND (50)
trans-1,2-Dichloroethene	µg/kg	50000		10340 (5)	ND (50)	ND (50)	ND (50)
trans-1,3-Dichloropropene	µg/kg	50000			ND (50)	ND (50)	ND (50)
Trichlorofluoromethane	µg/kg	50000		5610 (5)	ND (50)	ND (50)	ND (50)
Trichloroethene	µg/kg	50000			ND (50)	ND (50)	ND (50)
m/p-Xylenes	µg/kg	50000	1300		ND (50)	ND (50)	ND (50)
o-Xylene	µg/kg	50000	1300		ND (50)	ND (50)	ND (50)
Vinyl chloride	µg/kg	50000		16000 (5)	ND (50)	ND (50)	ND (50)

Table 2

Initial Sediment Sample Characterization Results
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Nova Scotia Lands

Parameters	Units	Criteria (1)	Criteria (3)	Criteria (4)	EST	BH	ASB
Semi-volatile Organic Compounds (SVOCs)							
1-Methylnaphthalene	µg/kg	10000	201	201	ND (100)	ND (100)	ND (100)
2-Methylnaphthalene	µg/kg	10000	201	201	ND (100)	ND (100)	ND (100)
Acenaphthene	µg/kg	10000	88.9	88.9	ND (100)	ND (100)	ND (100)
Acenaphthylene	µg/kg	10000	128	128	ND (100)	ND (100)	ND (100)
Anthracene	µg/kg	10000	245	245	ND (100)	ND (100)	ND (100)
Benzo(a)anthracene	µg/kg	10000	693	693	ND (100)	ND (100)	ND (100)
Benzo(b)fluoranthene	µg/kg	10000	4500		ND (100)	ND (100)	ND (100)
Benzo(k)fluoranthene	µg/kg	10000	4500		ND (100)	ND (100)	ND (100)
Benzo(g,h,i)perylene	µg/kg	10000	3200		ND (100)	ND (100)	ND (100)
Benzo(a)pyrene	µg/kg	10000	763	763	ND (100)	ND (100)	ND (100)
Chrysene	µg/kg	10000	846	846	ND (100)	ND (100)	ND (100)
Dibenz(a,h)anthracene	µg/kg	10000	135	135	ND (100)	ND (100)	ND (100)
Fluoranthene	µg/kg	10000	1494	1494	ND (100)	ND (100)	ND (100)
Fluorene	µg/kg	10000	144	144	ND (100)	ND (100)	ND (100)
Indeno(1,2,3-cd)pyrene	µg/kg	10000	880		ND (100)	ND (100)	ND (100)
Naphthalene	µg/kg	10000	391	391	ND (100)	ND (100)	ND (100)
Phenanthrene	µg/kg	10000	544	544	ND (100)	ND (100)	ND (100)
Pyrene	µg/kg	10000	1398	1398	ND (100)	ND (100)	ND (100)
Total Petroleum Hydrocarbons							
Total Petroleum Hydrocarbons (C6-C10)	mg/kg		15-500		ND (0.25)	ND (0.25)	ND (0.25)
Total Petroleum Hydrocarbons (>C10-C16)	mg/kg		25-500		ND (1)	ND (1)	ND (1)
Total Petroleum Hydrocarbons (>C16-C21)	mg/kg		43-500		4.39	27.9	38.7
Total Petroleum Hydrocarbons (>C21-C32)	mg/kg		43-500		28.5	193	220
Total Petroleum Hydrocarbons - Modified - Tier 1	mg/kg	150	500		32.9	221	259
Polychlorinated Biphenyls (PCBs)							
Total PCBs	µg/kg	50000	189		ND (3)	ND (3)	ND (3)
Dioxins and Furans							
2,3,7,8-TCDD	pg/g				1.1 J	94	93
1,2,3,7,8-PeCDD	pg/g				.13 Jq	5.7 Jq	6.4 J
1,2,3,4,7,8-HxCDD	pg/g				ND (9.4)	2 J	2.3 J
1,2,3,6,7,8-HxCDD	pg/g				0.78 Jq	25 J	9.1 Jq
1,2,3,7,8,9-HxCDD	pg/g				0.6 Jq	15 J	9.1 J
1,2,3,4,6,7,8-HpCDD	pg/g				12	52	92
OCDD	pg/g				220 B	630 B	910 B
2,3,7,8-TCDF	pg/g				12	610	2800
1,2,3,7,8-PeCDF	pg/g				ND (9.4)	12 J	25
2,3,4,7,8-PeCDF	pg/g				ND (9.4)	7.3 J	35
1,2,3,4,7,8-HxCDF	pg/g				ND (9.4)	2.5 Jq	4.3 Jq
1,2,3,6,7,8-HxCDF	pg/g				ND (9.4)	ND (26)	1.6 Jl
2,3,4,6,7,8-HxCDF	pg/g				ND (9.4)	ND (26)	2.2 J
1,2,3,7,8,9-HxCDF	pg/g				ND (9.4)	ND (26)	ND (21)
1,2,3,4,6,7,8-HpCDF	pg/g				1.5 J B	7 JB	11 JB
1,2,3,4,7,8,9-HpCDF	pg/g				ND (9.4)	ND (26)	2.0 J
OCDF	pg/g				3 J B	12 JB	21 JB
TEQ	pg/g	4 (2)	21.5	21.5	2.73	170	402

Table 2

Initial Sediment Sample Characterization Results
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Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria (1)	Criteria (3)	Criteria (4)	EST	BH	ASB
Total Metals							
Total Aluminum	mg/kg				8550	9070	8220
Total Antimony	mg/kg	40			ND (5)	ND (5)	ND (5)
Total Arsenic	mg/kg	50	41.6	41.6	3.46 J	7.25	2.86 J
Total Barium	mg/kg	2000			76	40.4	44.3
Total Beryllium	mg/kg	8			ND (2.5)	ND (2.5)	ND (2.5)
Total Cadmium	mg/kg	20	4.2	4.2	3.46	11.3	12.6
Total Calcium	mg/kg				4710	24000	36200
Total Chromium	mg/kg	800	160	160	14.7	19.9	78.2
Total Cobalt	mg/kg	300			10.5	6.64	6.42
Total Copper	mg/kg	500	108	108	17.4	91.1	90
Total Iron	mg/kg				19200	11400	12100
Total Lead	mg/kg	1000	112	112	63.6	72.7	86.1
Total Magnesium	mg/kg				6860	7470	3980
Total Manganese	mg/kg				426	1540	2010
Total Mercury	mg/kg	10	0.7	0.7	0.035 J	0.59	0.82
Total Nickel	mg/kg	500			18	27.4	28.2
Total Potassium	mg/kg				1540	1030	860
Total Selenium	mg/kg	10			ND (10)	ND (10)	ND (10)
Total Silver	mg/kg	40	2.2		ND (5)	4.17 J	3.35 J
Total Sodium	mg/kg				18700	17900	8140
Total Thallium	mg/kg	1			ND (10)	ND (10)	ND (10)
Total Vanadium	mg/kg	200			23.4	74.5	70.5
Total Zinc	mg/kg	1500	271	271	148	1230	955
TCLP-Total Petroleum Hydrocarbons							
TCLP-Total Petroleum Hydrocarbons (C6-C10)	mg/L				NA	NA	NA
TCLP-Total Petroleum Hydrocarbons (>C10-C16)	mg/L				ND (0.02)	ND (0.02)	ND (0.02)
TCLP-Total Petroleum Hydrocarbons (>C16-C21)	mg/L				0.0377	0.0816	0.1575
TCLP-Total Petroleum Hydrocarbons (>C21-C32)	mg/L				ND (0.02)	0.080	0.109
TCLP-Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5			0.0377	0.162	0.266
SPLP-Total Petroleum Hydrocarbons							
SPLP-Total Petroleum Hydrocarbons (C6-C10)	mg/L				NA	NA	NA
SPLP-Total Petroleum Hydrocarbons (>C10-C16)	mg/L				ND (0.02)	ND (0.02)	ND (0.02)
SPLP-Total Petroleum Hydrocarbons (>C16-C21)	mg/L				0.0348	0.550	0.420
SPLP-Total Petroleum Hydrocarbons (>C21-C32)	mg/L				0.0295	1.36	2.10
SPLP-Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L				0.0643	1.91	2.52
TCLP Semi-volatile Organic Compounds							
TCLP 1-Methylnaphthalene	µg/L				ND (2)	ND (2)	ND (2)
TCLP 2-Methylnaphthalene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Acenaphthene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Acenaphthylene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Anthracene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Benzo(a)anthracene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Benzo(b)fluoranthene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Benzo(k)fluoranthene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Benzo(g,h,i)perylene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Benzo(a)pyrene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Chrysene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Dibenz(a,h)anthracene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Fluoranthene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Fluorene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Indeno(1,2,3-cd)pyrene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Naphthalene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Phenanthrene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Pyrene	µg/L				ND (2)	ND (2)	ND (2)
PAHs (total)	µg/L	10			ND (2)	ND (2)	ND (2)

Table 2

Initial Sediment Sample Characterization Results
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Parameters	Units	Criteria (1)	Criteria (3)	Criteria (4)	EST	BH	ASB
SPLP Semi-volatile Organic Compounds							
SPLP 1-Methylnaphthalene	µg/L				ND (2)	ND (2)	ND (2)
SPLP 2-Methylnaphthalene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Acenaphthene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Acenaphthylene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Anthracene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Benzo(a)anthracene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Benzo(b)fluoranthene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Benzo(k)fluoranthene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Benzo(g,h,i)perylene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Benzo(a)pyrene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Chrysene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Dibenz(a,h)anthracene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Fluoranthene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Fluorene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Indeno(1,2,3-cd)pyrene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Naphthalene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Phenanthrene	µg/L				ND (2)	ND (2)	ND (2)
SPLP Pyrene	µg/L				ND (2)	ND (2)	ND (2)
TCLP Metals							
TCLP Aluminum	µg/L	500000			522	489	290
TCLP Antimony	µg/L				4.55 J	1.51 J	ND (50)
TCLP Arsenic	µg/L	5000			10.3 J	15.7 J	ND (50)
TCLP Barium	µg/L	100000			436	670	483
TCLP Beryllium	µg/L	10000			ND (25)	ND (25)	ND (25)
TCLP Cadmium	µg/L	500			ND (25)	ND (25)	ND (25)
TCLP Calcium	µg/L				41600 E	69400 E	106000 E
TCLP Chromium	µg/L	5000			ND (50)	ND (50)	0.0369 J
TCLP Cobalt	µg/L	5000			2.27 J	ND (50)	ND (500
TCLP Copper	µg/L	100000			ND (50)	ND (50)	ND (50)
TCLP Iron	µg/L				27100	1320	1810
TCLP Lead	µg/L	5000			41.0 J	ND (50)	ND (50)
TCLP Magnesium	µg/L				34200	17500	9080
TCLP Manganese	µg/L				1730	3130	5440
TCLP Mercury	µg/L	100			ND (0.2)	ND (0.2)	ND (0.2)
TCLP Nickel	µg/L	20000			ND (50)	ND (50)	ND (50)
TCLP Potassium	µg/L				12200	4610	3720
TCLP Selenium	µg/L	1000			4.55 J	ND (100)	ND (100)
TCLP Silver	µg/L	5000			ND (50)	ND (50)	ND (50)
TCLP Sodium	µg/L				1230000 E	1200000 E	1090000 E
TCLP Thallium	µg/L				ND (100)	ND (100)	ND (100)
TCLP Vanadium	µg/L	10000			ND (50)	ND (50)	ND (50)
TCLP Zinc	µg/L	500000			431	1410	1210
SPLP Metals							
SPLP Aluminum	µg/L	500000			126	263	725
SPLP Antimony	µg/L				ND (50)	ND (50)	ND (50)
SPLP Arsenic	µg/L	5000			ND (50)	ND (50)	ND (50)
SPLP Barium	µg/L	100000			182	149	241
SPLP Beryllium	µg/L	10000			ND (25)	ND (25)	ND (25)
SPLP Cadmium	µg/L	500			ND (25)	ND (25)	ND (25)
SPLP Calcium	µg/L				12900 E	17200 E	20800 E
SPLP Chromium	µg/L	5000			ND (50)	ND (50)	ND (50)
SPLP Cobalt	µg/L	5000			ND (50)	ND (50)	ND (50)
SPLP Copper	µg/L	100000			ND (50)	ND (50)	0.967 J
SPLP Iron	µg/L				538	378	781
SPLP Lead	µg/L	5000			ND (50)	ND (50)	ND (50)
SPLP Magnesium	µg/L				21300	10400	5240
SPLP Manganese	µg/L				182	150	721
SPLP Mercury	µg/L	100			ND (0.2)	0.097J	0.065 J
SPLP Nickel	µg/L	20000			ND (50)	ND (50)	ND (50)
SPLP Potassium	µg/L				9980	3800	3640
SPLP Selenium	µg/L	1000			ND (100)	ND (100)	ND (100)
SPLP Silver	µg/L	5000			ND (50)	ND (50)	ND (50)
SPLP Metals-Continued							
SPLP Sodium	µg/L				215000 E	80300 E	44300 E
SPLP Thallium	µg/L				ND (100)	ND (100)	ND (100)

Table 2

Initial Sediment Sample Characterization Results
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	Criteria [3]	Criteria [4]	EST	BH	ASB
SPLP Vanadium	µg/L	10000			ND (50)	ND (50)	ND (50)
SPLP Zinc	µg/L	500000			65.1	111	180

Notes:
[1] Nova Scotia Environment and Labour Guidelines for Disposal of Contaminated Solids in Landfills, Acceptance Parameters for Contaminated Soil (Attachment B for Total Analysis and Attachment C for Leachate Results), 1992.
[2] Nova Scotia Environment (NSE) 2013 Tier 1 Environmental Quality Standards (EQSs) for Soil, Table 1A/1B, July 6, 2013.
[3] NSE 2013 Tier 1 EQSs for Sediment (Marine Sediment Values), Table 2, July 6, 2013.
[4] Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines for the Protection of Aquatic Life (Marine Probable Effect Levels) (http://www.ccme.ca/ - Online, 2018).
[5] Equilibrium Partitioning Sediment Benchmarks (ESBs) Approach for the Protection of Benthic Organisms (USEPA, 2003; DiToro et al., 2000; van Leeuwen and Vermeir, 2007). ESB calculation assumed a fraction of organic carbon content of 0.01 (1%) and fraction of solids being 0.5 (50%).
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
S.U. - Standard Units
TCLP - Toxicity Characteristic Leaching Procedure
SPLP - Synthetic Precipitation Leaching Procedure
q - Possible interference
B - Compound detected in blank
I - Estimated maximum possible concentration
- Exceeds Applicable Criteria

Table 3

Geotube Dewatering Rates - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Geotube Treatment	Date Setup	Volume in Geotube (L)	Volume after 24 hours (L)	Volume after 48 hours (L) (Cumulative)	Volume after 72 hours (L) (Cumulative)	Volume after 96 hours (L) (Cumulative)	Volume after 1 week (L) (Cumulative)
EST - 5% Solids-Lime and Polymer	1/5/2018	40	26.5				
EST - 5% Solids-Polymer Only	1/4/2018	40	26.5				
EST - 5% Solids-Control	1/4/2018	40	26.5				
BH - 5% Solids-Lime, Polymer, and 2% PAC	1/16/2018	40	21.2	21.3			
BH - 5% Solids-Lime, Polymer, and 2% RemBind Plus	1/15/2018	40	15.1	20	20.4		
BH - 5% Solids-Polymer Only	1/10/2018	40	17	22.7			
BH - 5% Solids-Control	1/10/2018	38.1	11.4				15
ASB - 5% Solids-Lime, Polymer, and 2% PAC	1/16/2018	39.1	13.2	15.2	16		
ASB - 5% Solids-Lime, Polymer, and 2% RemBind Plus	1/16/2018	35.3	9.5	12.1	13.3		
ASB - 5% Solids-Polymer Only	1/16/2018	40	14.2	16.4	17.3		
ASB - 5% Solids-Control	1/15/2018	37.2	5.7	9.5	11.1	11.9	

Notes:
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units
EST Polymer - 71301 at 600 ppm
BH Polymer - 8186 at 1000 ppm and 7768 at 150 ppm
ASB Polymer - 8186 at 1250 ppm and 7768 at 100 ppm

Table 4

Geotube Dewater Water Analyses - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST - 5% Solids Control	EST - 5% Solids Polymer Only	EST - 5% Solids Lime and Polymer	BH - 5% Solids Control	BH - 5% Solids Polymer Only	BH - 5% Solids Lime, Polymer, and 2% PAC	BH - 5% Solids Lime, Polymer, and 2% RemBind Plus	ASB - 5% Solids Control	ASB - 5% Solids Polymer Only	ASB - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% RemBind Plus
pH	S.U.		7.7	7.19	6.68	8.15	7.89	8.47	8.25	8.57	8.41	8.84	8.44
Total Cyanide	µg/L	1	6.7 J	11	31	19	43	5.2 J	7.5 J	6.0 J	6.8 J	4.1 J	4.1 J
Total Petroleum Hydrocarbons													
Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	5.7	4.7	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.602	0.042	0.043	3.61	0.843	0.303	1.57	1.26	1.36	0.198	0.715
Total Petroleum Hydrocarbons (>C21-C32)	mg/L		7.21	0.044	ND (0.02)	19.9	4.67	1.64	9.34	8.71	8.69	1.4	4.62
Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	0.1	7.81	5.79	4.74	23.5	5.51	1.94	10.9	9.97	10.1	1.6	5.34
Total Metals													
Total Aluminum	µg/L		7250	131	105	10800	2160	434	1670	9850	2650	848	2260
Total Antimony	µg/L	500	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Total Arsenic	µg/L	12.5	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Total Barium	µg/L	500	387	175	165	390	187	154	202	246	143	39.6	73.5
Total Beryllium	µg/L	100	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
Total Cadmium	µg/L	0.12	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
Total Calcium	µg/L		68300 E	67600 E	77500 E	55400 E	44800	49000 E	63900 E	67700 E	61900 E	49000 E	63800 E
Total Chromium	µg/L	56 (trivalent) [2]	ND (25)	ND (25)	ND (25)	21.7 J	ND (25)	ND (25)	ND (25)	74.6	25.8	ND (25)	ND (25)
Total Cobalt	µg/L		ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Total Copper	µg/L	2	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	50	ND (50)	ND (50)	22.6 J
Total Iron	µg/L		6230	157	ND (100)	9150	2860	210	1180	8140	2350	410	1110
Total Lead	µg/L	2	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Total Magnesium	µg/L		123000 E	125000 E	122000 E	69700 E	41100 E	53900 E	40800 E	25700 E	23300 E	11600 E	11900 E
Total Manganese	µg/L		972	845	526	2675	1890	882	1330	3320	2890	402	484
Total Mercury	µg/L	0.016	0.15 J	ND (0.2)	ND (0.2)	0.58	0.23	ND (0.2)	ND (0.2)	0.47	0.15 J	ND (0.2)	ND (0.2)
Total Nickel	µg/L	8.3	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Total Potassium	µg/L		86700 E	85300 E	82800 E	42400 E	26800 E	34500 E	26400 E	35300	31300 E	27000 E	27000 E
Total Selenium	µg/L	2	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
Total Silver	µg/L	1.5	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Total Sodium	µg/L		1790000 E	1820000 E	1790000 E	886000 E	531000 E	737000 E	513000 E	572000 E	516000 E	481000 E	473000 E
Total Thallium	µg/L	21.3	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
Total Vanadium	µg/L	50	24 J	ND (50)	ND (50)	101	20 J	ND (50)	21.4 J	79.5	34.7 J	26.4 J	27.9 J
Total Zinc	µg/L	10	187	ND (50)	ND (50)	729	90.8	31.4 J	82.8	528	197	41.1 J	87.8
Dissolved Metals													
Dissolved Aluminum	µg/L		423	62.8	82.5	206	72.4	82.9	70.3	559	153	228	501
Dissolved Antimony	µg/L	500	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Arsenic	µg/L	12.5	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Barium	µg/L	500	211	169	165	131	147	127	136	37.1	48.9	26	27
Dissolved Beryllium	µg/L	100	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
Dissolved Cadmium	µg/L	0.12	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
Dissolved Calcium	µg/L		70900 E	68900 E	78300 E	42800 E	43400 E	47700 E	60300 E	54400 E	57200 E	52010 E	49800 E
Dissolved Chromium	µg/L	56 (trivalent) [2]	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)	ND (25)
Dissolved Cobalt	µg/L		ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Copper	µg/L	2	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Iron	µg/L		784	ND (100)	ND (100)	280	ND (100)	ND (100)	ND (100)	404	ND (100)	ND (100)	ND (100)
Dissolved Lead	µg/L	2	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Magnesium	µg/L		128000 E	124000 E	124000 E	64500 E	40600 E	51500 E	39100 E	23200 E	22700 E	11600 E	12200 E
Dissolved Manganese	µg/L		790	827	534	1390	1440	690	890	1675	2060	290	273
Dissolved Mercury	µg/L	0.016	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)
Dissolved Nickel	µg/L	8.3	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Potassium	µg/L		92000 E	84300 E	82100 E	39300 E	26800 E	32100 E	25100 E	32400 E	22700 E	26800 E	28100 E
Dissolved Selenium	µg/L	2	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
Dissolved Silver	µg/L	1.5	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Metals-Continued													
Dissolved Sodium	µg/L		1900000 E	1820000 E	1780000 E	875000 E	539000 E	696000 E	498100 E	549000 E	505000 E	480000 E	496000 E
Dissolved Thallium	µg/L	21.3	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)
Dissolved Vanadium	µg/L	50	ND (50)	ND (50)	ND (50)	43.4 J	ND (50)	ND (50)	ND (50)	42.7	18.7	23.8 J	20.3 J
Dissolved Zinc	µg/L	10	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)	ND (50)

Table 4

Geotube Dewater Water Analyses - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST - 5% Solids Control	EST - 5% Solids Polymer Only	EST - 5% Solids Lime and Polymer	BH - 5% Solids Control	BH - 5% Solids Polymer Only	BH - 5% Solids Lime, Polymer, and 2% PAC	BH - 5% Solids Lime, Polymer, and 2% RemBind Plus	ASB - 5% Solids Control	ASB - 5% Solids Polymer Only	ASB - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% RemBind Plus
Dioxins and Furans													
2,3,7,8-TCDD	pg/L		ND (9.5)	ND (9.4)	ND (9.5)	110	25	2.0 Jq	15	120	29	5.1 J	14
1,2,3,7,8-PeCDD	pg/L		ND (47)	1.1 Jq	ND (47)	12 J	1.3 Jq	ND (47)	3.0 J	7.1 Jq	2.3 Jq	3.1 J	8.5 J
1,2,3,4,7,8-HxCDD	pg/L		ND (47)	ND (47)	ND (47)	1.9 J	1.1 Jq	ND (47) I	1.2 Jq	3.4 Jq	0.79 Jq	ND (47)	2.5 J
1,2,3,6,7,8-HxCDD	pg/L		ND (47)	ND (47)	ND (47)	35 J	6.3 J	1.1 J	4.2 J	12 Jq	3.7 Jq	0.66 Jq	7.5 J
1,2,3,7,8,9-HxCDD	pg/L		ND (47)	ND (47)	ND (47)	22 J	3.0 Jq	0.68 J	6.2 J	9.5 J	3.2 Jq	0.84 Jq	5.0 Jq
1,2,3,4,6,7,8-HpCDD	pg/L		ND (47)	ND (47)	ND (47)	44 J	14 Jq	2.6 J	23 J	92	30 J	6,4 J	15 Jq
OCDD	pg/L		1.1 JB	9.1 JqB	2.0 JBq	520 B	280 B	28 JB	62 JB	820	250 B	46 JB	150 B
2,3,7,8-TCDF	pg/L		ND (9.5)	ND (9.4)	ND (9.5)	1400	890	40	260	4900	1100	170	590
1,2,3,7,8-PeCDF	pg/L		ND (47)	ND (47)	ND (47)	14 J	7.1 J	ND (47)	ND (47)	24 J	4.8 J	ND (47)	2.8 Jq
2,3,4,7,8-PeCDF	pg/L		ND (47)	ND (47)	ND (47)	12 J	7.5 J	0.36 Jq	2.8 J	40 J	8.9 J	1.2 Jq	3.5 Jq
1,2,3,4,7,8-HxCDF	pg/L		ND (47)	ND (47)	ND (47)	ND (48)	ND (47)	ND (47)	ND (47)	5.3 J	ND (47)	ND (47)	ND (47)
1,2,3,6,7,8-HxCDF	pg/L		ND (47)	ND (47)	ND (47)	ND (48)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)
2,3,4,6,7,8-HxCDF	pg/L		ND (47)	ND (47)	ND (47)	ND (48)	ND (47)	ND (47)	ND (47)	3.5 J	ND (47)	ND (47)	ND (47)
1,2,3,7,8,9-HxCDF	pg/L		ND (47)	ND (47)	ND (47)	ND (48)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)
1,2,3,4,6,7,8-HpCDF	pg/L		ND (47)	ND (47)	ND (47)	6.1 JBq	2.8 JBq	ND (47)	1.5 JB	9.8 J	3.4 JB	1.8 JqB	4.0 JB
1,2,3,4,7,8,9-HpCDF	pg/L		ND (47)	ND (47)	ND (47)	ND (48)	ND (47)	ND (47)	ND (47)	ND (47)	ND (47)	1.7 JqB	ND (47)
OCDF	pg/L		ND (95)	2.2 JB	ND (95)	15 JB	5.0 JB	1.1 JSBq	ND (95)	24 JB	6.1 J1SB	6.0 JB	11 JB
TEQ	pg/L	120 [3]	0.00011	1.10	0.0002	275	121	6.39	46.8	643	147	26.1	85.1

Notes:
[1] Nova Scotia Environment (NSE) 2013 Tier 1 Environmental Quality Standards (EQSs) for Surface Water (Marine Water Values), Table 3, July 6, 2013.
[2] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (Marine Values)
[3] NSE 2013 Tier 1 EQSs for Groundwater (Potable Groundwater Values), Table 4, July 6, 2013.
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units
(shaded) - Exceeds Applicable Criteria
S.U. - Standard Units
EST Polymer - 71301 at 600 ppm
BH Polymer - 8186 at 1000 ppm and 7768 at 150 ppm
ASB Polymer - 8186 at 1250 ppm and 7768 at 100 ppm

Table 5

Geotube Solids Analyses - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST - 5% Solids Control	EST - 5% Solids Polymer Only	EST - 5% Solids Lime and Polymer	BH - 5% Solids Control	BH - 5% Solids Polymer Only	BH - 5% Solids Lime, Polymer, and 2% PAC	BH - 5% Solids Lime, Polymer, and 2% RemBind Plus	ASB - 5% Solids Control	ASB - 5% Solids Polymer Only	ASB - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% RemBind Plus
Percent Solids	%		47.7	36.5	34.8	16.4	34.0	24.6	25.9	10.0	18.5	20.2	19.9
TCLP Cyanide	mg/L	20	ND (0.01)	ND (0.01)	ND (0.01)	0.0089 J	ND (0.01)	ND (0.01)	0.0039 J	ND (0.01)	ND (0.01)	ND (0.01)	0.0046 J
TCLP Metals													
TCLP Aluminum	mg/L	500	0.538	0.521	0.48	0.412	0.532	0.645	0.37	0.233	0.285	0.481	0.216
TCLP Antimony	mg/L		ND (0.05)	ND (0.05)	ND (0.05)	0.00303 J	ND (0.05)	0.0045 J	0.00618 J	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Arsenic	mg/L	5	ND (0.05)	ND (0.05)	0.00951 J	0.00407 J	ND (0.05)	0.00464 J	ND (0.05)	ND (0.05)	ND (0.05)	0.0108	0.00122
TCLP Barium	mg/L	100	0.230	0.305	0.293	0.784	0.656	0.803	0.943	0.626	0.667	0.765	0.718
TCLP Berylium	mg/L	10	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)
TCLP Cadmium	mg/L	0.5	0.000933 J	0.000897 J	0.000967 J	0.00363 J	0.00113 J	0.00343 J	0.00311 J	0.00102 J	ND (0.025)	0.00184 J	ND (0.025)
TCLP Calcium	mg/L		11.7 E	8.87	114 E	95.8	355 E	224 E	216 E	218 E	221 E	259 E	161 E
TCLP Chromium	mg/L	5	0.000106 J	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	0.000171 J	ND (0.025)	ND (0.025)	ND (0.025)
TCLP Cobalt	mg/L	5	0.00922 J	0.0114 J	0.00905 J	ND (0.05)	0.00261 J	0.000761 J	0.00219 J	ND (0.05)	ND (0.05)	ND (0.05)	0.0013 J
TCLP Copper	mg/L	100	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	0.0238	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Iron	mg/L		1.04	15.5	10.6	4.02	8.72	0.538	0.150	0.749	1.7	0.422	0.101
TCLP Lead	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	0.00971 J	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	0.00815 J	ND (0.05)
TCLP Magnesium	mg/L		51.9	44.4	38.3	19.4	16.7	23.5	25.9	7.62	8.34	8.86	8.42
TCLP Manganese	mg/L		4.49	4.29	4.78	4.66	8.41	4.81	5.31	6.1364	7.48512	6.46514	7.11874
TCLP Mercury	mg/L	0.1	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
TCLP Nickel	mg/L	20	0.00826 J	0.011 J	0.00888 J	0.00848 J	0.0141 J	0.00551 J	0.00846 J	0.00558 J	0.00606 J	0.00296 J	0.00218 J
TCLP Potassium	mg/L		12.4	11.4	10.2	4.37	4.03	4.56	4.52	3.88	3.54	3.57	3.52
TCLP Selenium	mg/L	1	ND (0.1)	ND (0.1)	0.00442 J	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.0131 J	ND (0.1)	0.000487 J
TCLP Silver	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Sodium	mg/L		1470	1490	1480	1480 E	1440 E	1400 E	1500 E	1420 E	1370 E	1360 E	1440 E
TCLP Thallium	mg/L		0.0113 J	0.00204 J	0.0116 J	0.00686 J	0.00872 J	0.0254 J	ND (0.1)	0.0044 J	0.00503 J	0.0212 J	0.00177 J
TCLP Vanadium	mg/L	10	0.000351 J	0.000885 J	0.000654 J	0.0219 J	0.00155 J	0.00604 J	0.0103 J	0.0121 J	0.00857 J	0.00879 J	0.00584 J
TCLP Zinc	mg/L	500	0.908	0.512	0.788	1.94	1.52	1.64	2.38	1.42	1.07	1.52	0.964
TCLP Total Petroleum Hydrocarbons													
TCLP Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TCLP Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.0128 J	0.0190	0.0129 J	0.0476	0.005 J	ND (0.02)	ND (0.02)	0.062	0.05	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C21-C32)	mg/L		0.027	ND (0.02)	ND (0.02)	0.293	ND (0.02)	ND (0.02)	ND (0.02)	0.09	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5	0.0398	0.0190	0.0129 J	0.341	0.005 J	ND (0.02)	ND (0.02)	0.152	0.05	ND (0.02)	ND (0.02)
Dioxins and Furans													
2,3,7,8-TCDD	pg/g		0.55 Jq	0.76 Jq	0.92 J	81	72	33	39	100	90	46	62
1,2,3,7,8-PeCDD	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	7.0 J	4.7 J	2.1 Jq	3.0 J	6.2 Jq	5.9 J	2.7 J	3.9 J
1,2,3,4,7,8-HxCDD	pg/g		0.25 J	ND (5.9)	0.23 Jq	1.6 Jq	0.90 Jq	0.60 Jq	0.89 Jq	3.3 Jq	2.9 J	0.65 Jq	1.5 J
1,2,3,6,7,8-HxCDD	pg/g		0.67 Jq	0.61 Jq	0.77 Jq	26	15	8.0 Jq	8.1 Jq	9.8 J	13 J	4.6 Jq	5.6 J
1,2,3,7,8,9-HxCDD	pg/g		0.54 Jq	0.66 J	0.53 Jq	18 J	9.2 J	4.2 Jq	5.6 J	10 J	10 J	3.7 J	5.0 J
1,2,3,4,6,7,8-HpCDD	pg/g		12	12	12	46	38	12	30	95	95	27	45
OCDD	pg/g		260 B	250 B	240 B	680 B	860 B	150 B	630	830	730 B	160 B	450 B
2,3,7,8-TCDF	pg/g		12	15	14	1300	2500	700	1100	3800	2600	2100	2400
1,2,3,7,8-PeCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	13 J	16	4.0 Jq	8.4 J	22 J	19	11 J	14
2,3,4,7,8-PeCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	12 J	24	5.4 J	11	35	25	18	21
1,2,3,4,7,8-HxCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	2.7 Jq	4.3 J	1.1 J	1.5 Jq	5.7 J	5.2 J	2.3 J	3.5 J
1,2,3,6,7,8-HxCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	ND (20)	0.88 Jq	ND (11)	ND (10)	ND (24)	ND (16)	0.76 Jq	ND (14)
2,3,4,6,7,8-HxCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	ND (20)	1.8 J	ND (11)	ND (10)	ND (24)	ND (16)	1.5 J	ND (14)
1,2,3,7,8,9-HxCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	ND (20)	ND (11)	ND (11)	ND (10)	ND (24)	ND (16)	ND (14)	ND (14)
1,2,3,4,6,7,8-HpCDF	pg/g		2.5 JB	1.9 JB	1.5 JBq	7.0 JB	7.1 JB	1.5 JBq	3.8 JB	11 JB	10 JB	2.6 JqB	6.0 JB
1,2,3,4,7,8,9-HpCDF	pg/g		ND (4.9)	ND (5.9)	ND (6.5)	ND (20)	ND (11)	ND (11)	ND (10)	ND (24)	ND (16)	ND (14)	ND (14)
OCDF	pg/g		4.3 JB	2.9 JB	3.3 JB	9.8 JBq	13 JB	3.1 JB	5.4 JBq	20 JB	18 JB	5.7 JB	10 JqB
TEQ	pg/g	4 [2]	2.07	2.55	2.63	230	343	110	160	509	374	270	319

Table 5

Geotube Solids Analyses - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST - 5% Solids Control	EST - 5% Solids Polymer Only	EST - 5% Solids Lime and Polymer	BH - 5% Solids Control	BH - 5% Solids Polymer Only	BH - 5% Solids Lime, Polymer, and 2% PAC	BH - 5% Solids Lime, Polymer, and 2% RemBind Plus	ASB - 5% Solids Control	ASB - 5% Solids Polymer Only	ASB - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% RemBind Plus
TCLP Dioxins and Furans													
TCLP 2,3,7,8-TCDD	pg/L									ND (9.5)			
TCLP 1,2,3,7,8-PeCDD	pg/L									ND (47)			
TCLP 1,2,3,4,7,8-HxCDD	pg/L									ND (47)			
TCLP 1,2,3,6,7,8-HxCDD	pg/L									ND (47)			
TCLP 1,2,3,7,8,9-HxCDD	pg/L									ND (47)			
TCLP 1,2,3,4,6,7,8-HpCDD	pg/L									54			
TCLP OCDD	pg/L									1200			
TCLP 2,3,7,8-TCDF	pg/L									8.9			
TCLP 1,2,3,7,8-PeCDF	pg/L									ND (47)			
TCLP 2,3,4,7,8-PeCDF	pg/L									ND (47)			
TCLP 1,2,3,4,7,8-HxCDF	pg/L									ND (47)			
TCLP 1,2,3,6,7,8-HxCDF	pg/L									ND (47)			
TCLP 2,3,4,6,7,8-HxCDF	pg/L									ND (47)			
TCLP 1,2,3,7,8,9-HxCDF	pg/L									ND (47)			
TCLP 1,2,3,4,6,7,8-HpCDF	pg/L									7.9			
TCLP 1,2,3,4,7,8,9-HpCDF	pg/L									ND (47)			
TCLP OCDF	pg/L									39			
TCLP TEQ	pg/L	1500 [3]								1.63			
SPLP Cyanide	mg/L	20	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	0.0042 J	0.0032 J	ND (0.01)	0.0036 J	ND (0.01)	ND (0.01)
SPLP Metals													
SPLP Aluminum	mg/L	500	0.211	0.252	0.0736	0.613	0.0505	0.221	0.121	0.686	0.256	1.26	0.352
SPLP Antimony	mg/L		0.00614 J	ND (0.05)	0.00484 J	0.00372 J	0.0111 J	0.0116 J	0.0177 J	0.00279 J	0.0182 J	0.00179 J	0.00722 J
SPLP Arsenic	mg/L	5	0.00406 J	0.0178 J	0.00989 J	0.00985 J	0.0154 J	0.00958 J	0.00139 J	0.00437 J	0.00190 J	0.0161 J	0.00317 J
SPLP Barium	mg/L	100	0.100	0.098	0.0882	0.203	0.117	0.171	0.101	0.185	0.145	0.224	0.206
SPLP Berylium	mg/L	10	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)
SPLP Cadmium	mg/L	0.5	ND (0.025)	ND (0.025)	ND (0.025)	0.000122 J	ND (0.025)	ND (0.025)	ND (0.025)	0.000296 J	ND (0.025)	0.000149	ND (0.025)
SPLP Calcium	mg/L		69.9	66.9	72.2	20.4 E	49.3 E	9.77	32.4 E	14.3 E	22.8 E	6.13	15.1 E
SPLP Chromium	mg/L	5	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	ND (0.025)	0.00785 J	0.00105 J	0.00345 J	0.00212 J
SPLP Cobalt	mg/L	5	ND (0.05)	0.00249 J	0.0024 J	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
SPLP Copper	mg/L	100	ND (0.05)	0.0130 J	ND (0.05)	0.00830 J	ND (0.05)	ND (0.05)	ND (0.05)	0.0121 J	ND (0.05)	0.0188 J	0.0258 J
SPLP Iron	mg/L		0.363	1.04	0.114	1.00	0.0759 J	0.149	0.109	0.891	0.317	0.659	0.381
SPLP Lead	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	0.0208 J	0.0121 J	0.0113 J	ND (0.05)	0.0167 J	0.00397 J	0.0233 J	0.0206 J
SPLP Magnesium	mg/L		52.3	45.1	25.5	9.13	8.66	5.47	10.6	2.65	3.51	1.07	2.44
SPLP Manganese	mg/L		1.87	2.64	2.03	0.288	0.675	0.0	0.107	0.456	0.671	0.14	0.237
SPLP Mercury	mg/L	0.1	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
SPLP Nickel	mg/L	20	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
SPLP Potassium	mg/L		16.9	12.3	7.88	3.02	2.75	3.32	3.36	2.96	3.47	3.21	3.34
SPLP Selenium	mg/L	1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.00668 J	ND (0.1)	ND (0.1)	ND (0.1)	0.00164 J	0.00346 J
SPLP Silver	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
SPLP Sodium	mg/L		229	179	93.6	52.5 E	20.6 E	52.1 E	41.7 E	33.6 E	36.3 E	34.6 E	37.6 E
SPLP Thallium	mg/L		ND (0.1)	ND (0.1)	0.00514 J	ND (0.1)	ND (0.1)	0.00337 J	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
SPLP Vanadium	mg/L	10	0.00233 J	0.00191 J	0.00192 J	0.0144 J	0.00244 J	0.0135 J	0.00321 J	0.0187 J	0.0133 J	0.0621	0.0128 J
SPLP Zinc	mg/L	500	0.115	0.222	0.167	167	0.0247 J	0.0363 J	0.0341 J	0.149	0.0995	0.136	0.108
SPLP Total Petroleum Hydrocarbons													
SPLP Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
SPLP Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
SPLP Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.0240	ND (0.02)	ND (0.02)	0.899	0.03	0.022	ND (0.02)	0.314	0.253	0.157	0.097
SPLP Total Petroleum Hydrocarbons (>C21-C32)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	5.56	0.075	0.221	0.101	1.81	1.49	1.46	0.889
SPLP Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5	0.0240	ND (0.02)	ND (0.02)	6.46	0.105	0.243	0.101	2.12	1.74	1.62	0.986

Table 5

Geotube Solids Analyses - In the Wet
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Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST - 5% Solids Control	EST - 5% Solids Polymer Only	EST - 5% Solids Lime and Polymer	BH - 5% Solids Control	BH - 5% Solids Polymer Only	BH - 5% Solids Lime, Polymer, and 2% PAC	BH - 5% Solids Lime, Polymer, and 2% RemBind Plus	ASB - 5% Solids Control	ASB - 5% Solids Polymer Only	ASB - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% RemBind Plus
SPLP Dioxins and Furans													
SPLP 2,3,7,8-TCDD	pg/L									ND (9.5)			
SPLP 1,2,3,7,8-PeCDD	pg/L									ND (47)			
SPLP 1,2,3,4,7,8-HxCDD	pg/L									ND (47)			
SPLP 1,2,3,6,7,8-HxCDD	pg/L									ND (47)			
SPLP 1,2,3,7,8,9-HxCDD	pg/L									ND (47)			
SPLP 1,2,3,4,6,7,8-HpCDD	pg/L									16 JBq			
SPLP OCDD	pg/L									290 B			
SPLP 2,3,7,8-TCDF	pg/L									170			
SPLP 1,2,3,7,8-PeCDF	pg/L									ND (47)			
SPLP 2,3,4,7,8-PeCDF	pg/L									ND (47)			
SPLP 1,2,3,4,7,8-HxCDF	pg/L									ND (47)			
SPLP 1,2,3,6,7,8-HxCDF	pg/L									ND (47)			
SPLP 2,3,4,6,7,8-HxCDF	pg/L									ND (47)			
SPLP 1,2,3,7,8,9-HxCDF	pg/L									ND (47)			
SPLP 1,2,3,4,6,7,8-HpCDF	pg/L									ND (47)			
SPLP 1,2,3,4,7,8,9-HpCDF	pg/L									ND (47)			
SPLP OCDF	pg/L									9.7 HBq			
SPLP TEQ	pg/L	1500 [3]								17.2			

Notes:
[1] Nova Scotia Environment and Labour Guidelines for Disposal of Contaminated Solids in Landfills, Acceptance Parameters for Contaminated Soil (Attachment C for Leachate Results), 1992.
[2] Nova Scotia Environment (NSE) 2013 Tier 1 Environmental Quality Standards (EQSs) for Soil, Table 1A/1B, July 6, 2013.
[3] Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2005-149), Schedule 6 Hazardous Constituents Controlled Under Leachate Test and Regulated Limits
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units
S.U. - Standard Units
EST Polymer - 71301 at 600 ppm
BH Polymer - 8186 at 1000 ppm and 7768 at 150 ppm
ASB Polymer - 8186 at 1250 ppm and 7768 at 100 ppm
- Exceeds Applicable Criteria

Table 6

Dewater Water Treatment Testing Analyses - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria (1)	BH - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% PAC
General Chemistry				
COD	mg/L		16	18
Total Cyanide	µg/L	1	ND (10)	ND (10)
Total Petroleum Hydrocarbons				
Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)
Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	ND (0.02)
Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.023	ND (0.02)
Total Petroleum Hydrocarbons (>C21-C32)	mg/L		0.155	ND (0.02)
Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	0.1	0.178	ND (0.02)
Total Metals				
Total Aluminum	µg/L		125	236
Total Antimony	µg/L	500	ND (50)	ND (50)
Total Arsenic	µg/L	12.5	ND (50)	ND (50)
Total Barium	µg/L	500	89.8	27.5 J
Total Beryllium	µg/L	100	ND (25)	ND (25)
Total Cadmium	µg/L	0.12	ND (25)	ND (25)
Total Calcium	µg/L		46300	41300
Total Chromium	µg/L	56 (trivalent) (2)	ND (25)	ND (25)
Total Cobalt	µg/L		ND (50)	ND (50)
Total Copper	µg/L	2	ND (50)	ND (50)
Total Iron	µg/L		ND (100)	ND (100)
Total Lead	µg/L	2	ND (50)	ND (50)
Total Magnesium	µg/L		63900	9520
Total Manganese	µg/L		458	73.0
Total Mercury	µg/L	0.016	ND (0.2)	ND (0.2)
Total Nickel	µg/L	8.3	ND (50)	ND (50)
Total Potassium	µg/L		32000	26800
Total Selenium	µg/L	2	ND (100)	ND (100)
Total Silver	µg/L	1.5	ND (50)	ND (50)
Total Sodium	µg/L		798000	528000
Total Thallium	µg/L	21.3	ND (100)	ND (100)
Total Vanadium	µg/L	50	ND (50)	ND (50)
Total Zinc	µg/L	10	ND (50)	ND (50)
Dissolved Metals				
Dissolved Aluminum	µg/L		107	224
Dissolved Antimony	µg/L	500	ND (50)	ND (50)
Dissolved Arsenic	µg/L	12.5	ND (50)	ND (50)
Dissolved Barium	µg/L	500	84.7	ND (50)
Dissolved Beryllium	µg/L	100	ND (50)	ND (25)
Dissolved Cadmium	µg/L	0.12	ND (25)	ND (25)
Dissolved Calcium	µg/L		51800	52500
Dissolved Chromium	µg/L	56 (trivalent) (2)	ND (25)	ND (25)
Dissolved Metals-Continued				
Dissolved Cobalt	µg/L		ND (50)	ND (50)
Dissolved Copper	µg/L	2	ND (50)	ND (50)
Dissolved Iron	µg/L		ND (100)	ND (100)

Table 6

Dewater Water Treatment Testing Analyses - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria (1)	BH - 5% Solids Lime, Polymer, and 2% PAC	ASB - 5% Solids Lime, Polymer, and 2% PAC
Dissolved Lead	µg/L	2	ND (50)	ND (50)
Dissolved Magnesium	µg/L		67100	9970
Dissolved Manganese	µg/L		486	75.2
Dissolved Mercury	µg/L	0.016	ND (0.2)	ND (0.2)
Dissolved Nickel	µg/L	8.3	ND (50)	ND (50)
Dissolved Potassium	µg/L		36000	33000
Dissolved Selenium	µg/L	2	ND (100)	ND (100)
Dissolved Silver	µg/L	1.5	ND (50)	ND (50)
Dissolved Sodium	µg/L		835000	629000
Dissolved Thallium	µg/L	21.3	9.58 J	ND (100)
Dissolved Vanadium	µg/L	50	ND (50)	ND (50)
Dissolved Zinc	µg/L	10	ND (50)	ND (50)

Notes:

(1) Nova Scotia Environment (NSE) 2013 Tier 1 Environmental Quality Standards (EQSs) for Surface Water (Marine Water Values), Table 3, July 6, 2013.

(2) Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (Marine Values) (http://www.ccme.ca/ - Online, 2018).

ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units
- Exceeds Applicable Criteria
S.U. - Standard Units
BH Polymer - 8186 at 1000 ppm and 7768 at 150 ppm
ASB Polymer - 8186 at 1250 ppm and 7768 at 100 ppm

Table 7

Stabilization of Non-Dewatered Sediment - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [(1)]	ASB - 4.5% Liquisorb 2000
Percent Solids	%		12.8
Bulking	%		0
Density	g/mL		1.05
TCLP Cyanide	mg/L	20	ND (0.01)
TCLP Metals			
TCLP Aluminum	mg/L	500	8.64
TCLP Antimony	mg/L		ND (0.05)
TCLP Arsenic	mg/L	5	0.0111 J
TCLP Barium	mg/L	100	0.582
TCLP Berylium	mg/L	10	0.000128 J
TCLP Cadmium	mg/L	0.5	0.00659 J
TCLP Calcium	mg/L		77.3
TCLP Chromium	mg/L	5	0.0539
TCLP Cobalt	mg/L	5	0.00156 J
TCLP Copper	mg/L	100	0.0145 J
TCLP Iron	mg/L		22.2
TCLP Lead	mg/L	5	0.204
TCLP Magnesium	mg/L		6.10
TCLP Manganese	mg/L		3.67
TCLP Mercury	mg/L	0.1	0.00016 JB
TCLP Nickel	mg/L	20	ND (0.05)
TCLP Potassium	mg/L		4.20
TCLP Selenium	mg/L	1	ND (0.1)
TCLP Silver	mg/L	5	ND (0.05)
TCLP Sodium	mg/L		158
TCLP Thallium	mg/L		0.00733 J
TCLP Vanadium	mg/L	10	0.0363 J
TCLP Zinc	mg/L	500	1.36
TCLP Total Petroleum Hydrocarbons			
TCLP Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)
TCLP Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.952
TCLP Total Petroleum Hydrocarbons (>C21-C32)	mg/L		5.57
TCLP Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5	6.52
TCLP Dioxins and Furans			
TCLP 2,3,7,8-TCDD	pg/L		2.70
TCLP 1,2,3,7,8-PeCDD	pg/L		ND (51)
TCLP 1,2,3,4,7,8-HxCDD	pg/L		ND (51)
TCLP Dioxins and Furans - Continued			
TCLP 1,2,3,6,7,8-HxCDD	pg/L		ND (51)
TCLP 1,2,3,7,8,9-HxCDD	pg/L		ND (51)
TCLP 1,2,3,4,6,7,8-HpCDD	pg/L		5.3 J

Table 7

Stabilization of Non-Dewatered Sediment - In the Wet
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	ASB - 4.5% Liquisorb 2000
TCLP OCDD	pg/L		37 JB
TCLP 2,3,7,8-TCDF	pg/L		110.00
TCLP 1,2,3,7,8-PeCDF	pg/L		ND (51)
TCLP 2,3,4,7,8-PeCDF	pg/L		ND (51)
TCLP 1,2,3,4,7,8-HxCDF	pg/L		ND (51)
TCLP 1,2,3,6,7,8-HxCDF	pg/L		ND (51)
TCLP 2,3,4,6,7,8-HxCDF	pg/L		ND (51)
TCLP 1,2,3,7,8,9-HxCDF	pg/L		ND (51)
TCLP 1,2,3,4,6,7,8-HpCDF	pg/L		ND (51)
TCLP 1,2,3,4,7,8,9-HpCDF	pg/L		ND (51)
TCLP OCDF	pg/L		11 JB
TCLP TEQ	pg/L	1500 [2]	13.8

Notes:

[1] Nova Scotia Environment and Labour Guidelines for Disposal of Contaminated Solids in Landfills, Acceptance Parameters for Contaminated Soil (Attachment C for Leachate Results), 1992.

[2] Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2005-149), Schedule 6 Hazardous Constituents Controlled Under Leachate Test and Regulated Limits

ND (x) - Not detected at reporting limit

J - Estimated value

E - Above Calibration Range

PAC - Powdered Activated Carbon

Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units

- Exceeds Applicable Criteria

Table 8

Surface Water Treatment Testing Analyses
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [(1)]	BH - pH>10 with Lime	BH - pH>10 with Lime 2% PAC	ASB - pH>10 with Lime	ASB - pH>10 with Lime 2% PAC
General Chemistry						
COD	mg/L		170	16	140	31
Total Cyanide	µg/L	1	ND (10)	ND (10)	ND (10)	ND (10)
Total Petroleum Hydrocarbons						
Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	0.028	ND (0.02)	ND (0.02)
Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.025	0.0107	0.0104	ND (0.02)
Total Petroleum Hydrocarbons (>C21-C32)	mg/L		0.539	0.057	0.183	ND (0.02)
Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	0.1	0.564	0.068	0.193	ND (0.02)
Total Metals						
Total Aluminum	µg/L		786	280	944	399
Total Antimony	µg/L	500	ND (50)	ND (50)	ND (50)	ND (50)
Total Arsenic	µg/L	12.5	ND (50)	ND (50)	ND (50)	5.14 J
Total Barium	µg/L	500	40.6 J	46.6 J	23.9 J	61.3
Total Beryllium	µg/L	100	ND (25)	ND (25)	ND (25)	ND (25)
Total Cadmium	µg/L	0.12	ND (25)	ND (25)	ND (25)	ND (25)
Total Calcium	µg/L		38600	13600	29200	15900
Total Chromium	µg/L	56 (trivalent) [(2)]	23.0 J	ND (25)	22.5 J	ND (25)
Total Cobalt	µg/L		ND (50)	ND (50)	ND (50)	ND (50)
Total Copper	µg/L	2	ND (50)	ND (50)	1.96 J	ND (50)
Total Iron	µg/L		3000	3000	39900	5050
Total Lead	µg/L	2	93.3	ND (50)	103	ND (50)
Total Magnesium	µg/L		3740	2700	3410	2550
Total Manganese	µg/L		566	38.8	915	114
Total Mercury	µg/L	0.016	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)
Total Nickel	µg/L	8.3	ND (50)	ND (50)	ND (50)	ND (50)
Total Potassium	µg/L		14300	12800	12600	13500
Total Selenium	µg/L	2	ND (100)	ND (100)	ND (100)	ND (100)
Total Silver	µg/L	1.5	ND (50)	ND (50)	ND (50)	ND (50)
Total Sodium	µg/L		275000	263000	246000	263000
Total Thallium	µg/L	21.3	ND (100)	ND (100)	ND (100)	ND (100)
Total Vanadium	µg/L	50	ND (50)	ND (50)	ND (50)	ND (50)
Total Zinc	µg/L	10	32.7 J	ND (50)	27.2 J	ND (50)

Table 8

Surface Water Treatment Testing Analyses
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	BH - pH>10 with Lime	BH - pH>10 with Lime 2% PAC	ASB - pH>10 with Lime	ASB - pH>10 with Lime 2% PAC
Dissolved Metals						
Dissolved Aluminum	µg/L		146	192	155	248
Dissolved Antimony	µg/L	500	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Arsenic	µg/L	12.5	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Barium	µg/L	500	79.0	ND (50)	72.1	ND (50)
Dissolved Beryllium	µg/L	100	ND (25)	ND (25)	ND (25)	ND (25)
Dissolved Cadmium	µg/L	0.12	ND (25)	ND (25)	ND (25)	ND (25)
Dissolved Calcium	µg/L		29500	31000	24400	31000
Dissolved Chromium	µg/L	56 (trivalent) [2]	41.9	ND (25)	ND (25)	ND (25)
Dissolved Cobalt	µg/L		ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Copper	µg/L	2	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Iron	µg/L		3530	ND (100)	3340	ND (100)
Dissolved Lead	µg/L	2	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Magnesium	µg/L		3240	3060	3240	2570
Dissolved Manganese	µg/L		280	ND (25)	280	ND (25)
Dissolved Mercury	µg/L	0.016	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)
Dissolved Nickel	µg/L	8.3	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Potassium	µg/L		15300	17300	15600	16300
Dissolved Selenium	µg/L	2	ND (100)	ND (100)	ND (100)	ND (100)
Dissolved Silver	µg/L	1.5	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Sodium	µg/L		337000	347000	275000	250000
Dissolved Thallium	µg/L	21.3	ND (100)	ND (100)	ND (100)	ND (100)
Dissolved Vanadium	µg/L	50	ND (50)	ND (50)	ND (50)	ND (50)
Dissolved Zinc	µg/L	10	ND (50)	ND (50)	ND (50)	ND (50)

Notes:
[1] Nova Scotia Environment (NSE) 2013 Tier 1 Environmental Quality Standards (EQSs) for Surface Water (Marine Water Values), Table 3, July 6, 2013.
[2] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (Marine Values) (http://www.ccme.ca/ -
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
S.U. - Standard Units
- Exceeds Applicable Criteria

Table 9

Geotube Fabric Dewatering Rates - In the Dry
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Time	Volume for EST (L) Polymer 71301 at 2000 mg/kg	Volume for BH (L) Polymer 8186 at 2000 mg/kg Polymer 7768 at 1000 mg/kg	Volume for ASB (L) Polymer 8186 at 2500 mg/kg Polymer 7768 at 1500 mg/kg
10 min	100	192	140
20 min	150	234	175
30 min	175	260	200
40 min	190	280	220
50 min	200	300	240
60 min	210	316	250
90 min	255	346	276
120 min	275	366	292
150 min	285	-	315

Notes:
Volumes are cumulative

Table 10

Solidification Tests on Dewatered Sediment - In the Dry
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST Control	EST - 2% PAC 5% PC	EST - 2% RemBind Lime	EST - 2% PAC Lime	BH Control	BH - 2% PAC 5% PC	BH - 2% RemBind Lime	BH - 2% PAC Lime
Percent Solids	%		30.4	38.7	32.3	32.3	12.8	19.4	13.8	14.9
Bulking	%		-	0	3.4	10.3	-	2.9	2.4	7.4
Density	g/mL		1.24	1.30	1.20	1.13	1.06	1.12	1.04	1.00
TCLP Cyanide	mg/L	20	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TCLP Metals										
TCLP Aluminum	mg/L	500	0.381	5.08	0.306	0.506	0.409	5.92	0.618	0.314
TCLP Antimony	mg/L		0.0302 J	0.0164 J	ND (0.05)	ND (0.05)	0.00805 J	0.0159 J	0.00760 J	0.00213 J
TCLP Arsenic	mg/L	5	ND (0.05)	0.00985 J	ND (0.05)	ND (0.05)	0.00198 J	0.0117 J	ND (0.05)	0.00166 J
TCLP Barium	mg/L	100	0.247	0.814	0.596	0.699	0.600	1.16	0.709	0.748
TCLP Berylium	mg/L	10	ND (0.025)	0.000806 J	ND (0.025)	ND (0.025)	ND (0.025)	0.00116 J	ND (0.025)	ND (0.025)
TCLP Cadmium	mg/L	0.5	0.000567 J	0.00737 J	0.005.25 J	0.00715 J	0.00168 J	0.00813 J	0.00241 J	0.00200 J
TCLP Calcium	mg/L		45.7	981	73.5	69.1	88.3	976	110	97.7
TCLP Chromium	mg/L	5	ND (0.025)	0.0.0129 J	ND (0.025)	ND (0.025)	ND (0.025)	0.0110 J	ND (0.025)	ND (0.025)
TCLP Cobalt	mg/L	5	0.00429 J	0.0159 J	0.00411 J	0.00611 J	ND (0.05)	0.0107 J	ND (0.05)	0.000364 J
TCLP Copper	mg/L	100	ND (0.05)	0.0193 J	ND (0.05)	ND (0.05)	ND (0.05)	0.00449 J	ND (0.05)	ND (0.05)
TCLP Iron	mg/L		11.6	41.6	49.8	68.2	4.88	3.49	3.99	0.769
TCLP Lead	mg/L	5	ND (0.05)	0.00556 J	0.0805 J	0.144	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Magnesium	mg/L		35.3	83.5	42.5	42.9	19.1	58.2	21.0	20.2
TCLP Manganese	mg/L		2.61	4.64	3.08	3.22	4.46	6.78	4.83	4.65
TCLP Mercury	mg/L	0.1	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
TCLP Nickel	mg/L	20	0.00775 J	ND (0.05)	ND (0.05)	0.00951 J	0.00505 J	ND (0.05)	0.00346 J	0.00523 J
TCLP Potassium	mg/L		14.2	25.7	14.9	15.2	3.66	14.8	3.94	4.11
TCLP Selenium	mg/L	1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	0.00356 J
TCLP Silver	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Sodium	mg/L		1350 E	212	1540 E	1580 E	1370 E	79.3	1530 E	1380 E
TCLP Thallium	mg/L		0.00408 J	ND (0.1)	ND (0.1)	0.00540 J	0.00213 J	ND (0.1)	ND (0.1)	0.00579 J
TCLP Vanadium	mg/L	10	0.0000853 J	0.0244 J	0.00470 J	0.00770 J	0.0178 J	0.0497 J	0.0177 J	0.0135 J
TCLP Zinc	mg/L	500	0.544	1.34	0.352	0.226	1.44	3.18	1.66	1.92
TCLP Total Petroleum Hydrocarbons										
TCLP Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TCLP Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C16-C21)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	0.11	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C21-C32)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	0.599	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	0.709	ND (0.02)	ND (0.02)	ND (0.02)

Notes:
[1] Nova Scotia Environment and Labour Guidelines for Disposal of Contaminated Solids in Landfills, Acceptance Parameters for Contaminated Soil (Attachment C for Leachate Results), 1992.
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units

Table 10

Solidification Tests on Dewatered Sediment - In the Dry
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria (1)	ASB Control	ASB - 2% PAC 5% PC	ASB - 2% RemBind Lime	ASB - 2% PAC Lime
Percent Solids	%		12.5	19.6	13.4	19.0
Bulking	%		-	0.0	1.0	2.3
Density	g/mL		1.02	1.05	1.02	0.97
TCLP Cyanide	mg/L	20	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TCLP Metals						
TCLP Aluminum	mg/L	500	0.164	5.24	0.43	0.875
TCLP Antimony	mg/L		0.00920 J	0.0214 J	0.00302 J	0.000274 J
TCLP Arsenic	mg/L	5	ND (0.05)	0.00389 J	ND (0.05)	ND (0.05)
TCLP Barium	mg/L	100	0.415	0.914	0.532	0.464
TCLP Berylium	mg/L	10	ND (0.025)	0.000139 J	ND (0.025)	ND (0.025)
TCLP Cadmium	mg/L	0.5	ND (0.025)	0.00360 J	0.000604 J	ND (0.025)
TCLP Calcium	mg/L		142	1020	169	145
TCLP Chromium	mg/L	5	0.000680 J	0.187	0.000815 J	0.0637
TCLP Cobalt	mg/L	5	0.00101 J	0.00820 J	0.000921 J	ND (0.05)
TCLP Copper	mg/L	100	ND (0.05)	0.186	ND (0.05)	0.0395 J
TCLP Iron	mg/L		5.63	5.76	3.04	1.63
TCLP Lead	mg/L	5	0.0124 J	0.0596	0.0151 J	0.0104 J
TCLP Magnesium	mg/L		8.54	49.0	10.9	8.86
TCLP Manganese	mg/L		6.09	8.58	7.37	6.19
TCLP Mercury	mg/L	0.1	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
TCLP Nickel	mg/L	20	0.00367 J	ND (0.05)	0.00481 J	0.0199 J
TCLP Potassium	mg/L		3.30	15.9	4.29	3.62
TCLP Selenium	mg/L	1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
TCLP Silver	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Sodium	mg/L		1310 E	54.2	1570 E	1410 E
TCLP Thallium	mg/L		0.00593 J	ND (0.1)	0.00647 J	0.00287 J
TCLP Vanadium	mg/L	10	0.00396 J	0.0244 J	0.00914 J	0.00389 J
TCLP Zinc	mg/L	500	0.796	2.30	1.28	0.811
TCLP Total Petroleum Hydrocarbons						
TCLP Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TCLP Total Petroleum Hydrocarbons (>C10-C16)	mg/L		ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.03	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C21-C32)	mg/L		0.16	ND (0.02)	0.071	ND (0.02)
TCLP Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5	0.19	ND (0.02)	0.071	ND (0.02)

Notes:
(1) Nova Scotia Environment and Labour Guidelines for Disposal of Contaminated Solids in
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units

Table 11

Solidification Tests on Sediment as Received - In the Dry
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	Units	Criteria [1]	EST - 3% Liquisorb 2000	EST - 3% Liquisorb 2000 2% PAC	BH - 3% Liquisorb 2000	BH - 3% Liquisorb 2001 2% PAC	ASB - 3% Liquisorb 2000	ASB - 3% Liquisorb 2000 2% PAC
Percent Solids	%		29.6	31.4	15.4	27.8	16.0	17.2
Bulking	%		0	1	0	3	6	11.0
Density	g/mL		1.18	1.18	1.02	1.10	0.97	0.99
TCLP Cyanide	mg/L	20	ND (0.01)	ND (0.01)	ND (0.01)	0.00041 J	0.00049 J	0.00042 J
TCLP Metals								
TCLP Aluminum	mg/L	500	4.33	4.89	8.66	7.33	5.62	4.44
TCLP Antimony	mg/L		0.00721 J	0.0345 J	0.00978 J	0.00196 J	0.00138 J	0.00335 J
TCLP Arsenic	mg/L	5	ND (0.05)	ND (0.05)	0.0193 J	0.0351 J	ND (0.05)	ND (0.05)
TCLP Barium	mg/L	100	0.639	0.564	0.612	0.509	0.485	0.397
TCLP Berylium	mg/L	10	ND (0.025)	ND (0.025)	0.000346 J	0.000298 J	ND (0.025)	ND (0.025)
TCLP Cadmium	mg/L	0.5	0.00985 J	0.00971 J	0.00522 J	ND (0.025)	0.00439 J	0.00346 J
TCLP Calcium	mg/L		50.0	42.7	97.6	169	187.0	141
TCLP Chromium	mg/L	5	0.00562 J	0.00368 J	0.0102 J	ND (0.025)	0.0277 J	0.0181 J
TCLP Cobalt	mg/L	5	0.00158 J	0.000921 J	0.00373 J	ND (0.05)	0.00260 J	0.00150 J
TCLP Copper	mg/L	100	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Iron	mg/L		84.6	75.3	35.7	429	0.941	38.4
TCLP Lead	mg/L	5	0.176	0.156	0.129	0.153	0.125	0.106
TCLP Magnesium	mg/L		41.2	38.6	23.3	13.4	10.8	8.35
TCLP Manganese	mg/L		2.10	2.05	4.33	5.20	6.90	5.30
TCLP Mercury	mg/L	0.1	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)	ND (0.2)
TCLP Nickel	mg/L	20	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Potassium	mg/L		14.9	15.1	5.20	3.88	5.23	4.03
TCLP Selenium	mg/L	1	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)	ND (0.1)
TCLP Silver	mg/L	5	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)	ND (0.05)
TCLP Sodium	mg/L		17120 E	1650 E	1670 E	1420 E	1620 E	1370 E
TCLP Thallium	mg/L		ND (0.1)	ND (0.1)	0.00769 J	0.0136 J	ND (0.1)	0.00447 J
TCLP Vanadium	mg/L	10	0.0356 J	0.0200 J	0.0479 J	0.0248 J	0.0206 J	0.008672 J
TCLP Zinc	mg/L	500	0.156	0.148	1.12	0.607	0.800	0.830
TCLP Total Petroleum Hydrocarbons								
TCLP Total Petroleum Hydrocarbons (C6-C10)	mg/L		ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)	ND (0.01)
TCLP Total Petroleum Hydrocarbons (>C10-C16)	mg/L		1.2	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
TCLP Total Petroleum Hydrocarbons (>C16-C21)	mg/L		0.062	0.065	1.29	0.164	0.35	0.227
TCLP Total Petroleum Hydrocarbons (>C21-C32)	mg/L		1.05	0.94	6.74	1.01	2.25	1.68
TCLP Total Petroleum Hydrocarbons - Modified - Tier 1	mg/L	1.5	2.31	1.01	8.03	1.17	2.6	1.91
TCLP Dioxins and Furans								
TCLP 2,3,7,8-TCDD	pg/L				ND (10)			
TCLP 1,2,3,7,8-PeCDD	pg/L				ND (50)			
TCLP 1,2,3,4,7,8-HxCDD	pg/L				ND (50)			
TCLP 1,2,3,6,7,8-HxCDD	pg/L				ND (50)			
TCLP 1,2,3,7,8,9-HxCDD	pg/L				ND (50)			
TCLP 1,2,3,4,6,7,8-HpCDD	pg/L				3.6 J			
TCLP OCDD	pg/L				16 JqB			
TCLP 2,3,7,8-TCDF	pg/L				26			
TCLP 1,2,3,7,8-PeCDF	pg/L				ND (50)			
TCLP 2,3,4,7,8-PeCDF	pg/L				ND (50)			

Table 11

Solidification Tests on Sediment as Received - In the Dry
Laboratory Treatability Study
Boat Harbour Remediation Planning and Design
Nova Scotia Lands

Parameters	**Units**	**Criteria [1]**	**EST - 3% Liquisorb 2000**	**EST - 3% Liquisorb 2000 2% PAC**	**BH - 3% Liquisorb 2000**	**BH - 3% Liquisorb 2001 2% PAC**	**ASB - 3% Liquisorb 2000**	**ASB - 3% Liquisorb 2000 2% PAC**
Percent Solids	%		29.6	31.4	15.4	27.8	16.0	17.2
Bulking	%		0	1	0	3	6	11.0
Density	g/mL		1.18	1.18	1.02	1.10	0.97	0.99
TCLP Cyanide	mg/L	20	ND (0.01)	ND (0.01)	ND (0.01)	0.00041 J	0.00049 J	0.00042 J
TCLP 1,2,3,4,7,8-HxCDF	pg/L				ND (50)			
TCLP 1,2,3,6,7,8-HxCDF	pg/L				ND (50)			
TCLP 2,3,4,6,7,8-HxCDF	pg/L				ND (50)			
TCLP 1,2,3,7,8,9-HxCDF	pg/L				ND (50)			
TCLP 1,2,3,4,6,7,8-HpCDF	pg/L				ND (50)			
TCLP 1,2,3,4,7,8,9-HpCDF	pg/L				ND (50)			
TCLP OCDF	pg/L				2.6 JqB			
TCLP TEQ	pg/L	1500 [2]			2.64			

Notes:
[1] Nova Scotia Environment and Labour Guidelines for Disposal of Contaminated Solids in Landfills, Acceptance Parameters for Contaminated Soil (Attachment C for Leachate Results), 1992.
(2) Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations (SOR/2005-149), Schedule 6 Hazardous Constituents Controlled Under Leachate Test and Regulated Limits
ND (x) - Not detected at reporting limit
J - Estimated value
E - Above Calibration Range
PAC - Powdered Activated Carbon
Lime - Calcium Hydroxide added to reach pH 8-8.5 Standard Units
- Exceeds Applicable Criteria

Appendices

Appendix A
Treatability Testing Photographs

Photo 1: Mixing of sample with amendments for geotube

Photo 2: Geotube filling

Treatability Testing Photographs

Photo 3: Geotube filling

Photo 4: Geotube dewatering

Treatability Testing Photographs

Photo 5: Geotube dewatering

Photo 6: Geotube dewatering

Treatability Testing Photographs

Photo 7: Water clarity before (right) and after (left) geotube

Photo 8: Dewatered geotubes

Treatability Testing Photographs

Photo 9: Dewatered solids from geotube

Photo 10: Dewatered solids from geotube

Treatability Testing Photographs

Photo 11: Samples after gravity dewatering

Photo 12: Samples after gravity dewatering

Photo 13: Samples after fabric dewatering

Photo 14: Samples after fabric dewatering

Photo 15: Sample before Liquisorb 2000

Photo 16: Sample after Liquisorb 2000

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Appendix B
Evaluation Criteria and Scoring Matrix Technical Memorandum (GHD, September 26, 2017)

Memorandum

September 26, 2017

To:	Angela Swaine (NS Lands)	Ref. No.:	11148275
From:	Eric Farquhar/ Andrew Philopoulos/Christine Skirth/al/007	Tel:	613-288-1708
CC:	Ken Swaine, Donnie Burke		
Subject:	**Evaluation Criteria and Weighting Matrix**		

1. Introduction

The purpose of this memorandum is to define the evaluation criteria and weighting matrix to be used in evaluating Feasible Concepts for the remediation of Boat Harbour in Pictou Landing, Nova Scotia (Site). The Boat Harbour Remediation Design (BHRD) includes: decommissioning of the Boat Harbour Treatment Facility (BHTF); remediating impacted soil, sediment, surface water, and groundwater; and returning Boat Harbour (A'se'k) to tidal conditions.

The evaluation criteria and weighting matrix includes both qualitative and quantitative components and serves to establish project priorities. The intent is to establish the criteria and weighting matrix in advance of developing Feasible Concepts to ensure that the recommended remediation approach is unbiased, traceable, and best aligns with projects goals.

2. Evaluation Criteria

This section presents a description of the evaluation criteria which have been developed by GHD with input and agreement from NS Lands and stakeholders. The evaluation criteria have been grouped into five Indicator categories: Regulatory, Technical, Environmental, Social, and Economic Indicators and will be used to evaluate Feasible Concepts. Sample Evaluation Criteria and Weighting Matrix forms have been provided in Attachment A and include rating (i.e., scoring) definitions for each criterion.

2.1 Pass/Fail/Pre-Screening Requirements

Feasible Concepts will be pre-screened to confirm that they meet the functional requirements laid out in the Design Requirements Document for Boat Harbour Remediation Planning and Design (GHD, September 2017).

If the Feasible Concept meets all mandatory pre-screening requirements, it will pass and be evaluated under the criteria discussed in this memorandum and assigned a weighted score and rank. If the Feasible Concept fails to meet all of the mandatory pre-screening requirements, it will fail and not be evaluated further. The pre-screening criteria are as follows:

Public Acceptability

Mandatory pre-screening requirement indicator M1 considers the public acceptability of the Feasible Concept on a pass or fail basis. The sub-indicator question is as follows:

- M1.1 - Are there any components of the Feasible Concept that are clearly unacceptable to the public?

Return to Tidal

Mandatory pre-screening requirement indicator M2 considers whether the Feasible Concept can facilitate returning Boat Harbour/A'se'k to tidal conditions. The sub-indicator question is as follows:

- M2.1 - Does the Feasible Concept facilitate returning A'se'k to tidal conditions?

Intended End Use

Mandatory pre-screening requirement indicator M3 considers whether the Feasible Concept will meet the intended end use. The sub-indicator question is as follows:

- M3.1 - Does the Feasible Concept restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?

Approvability

Mandatory pre-screening requirement indicator M4 considers the approvability of the Feasible Concept. Although regulatory compliance is also an evaluation criteria, the pre-screening considers whether there are any clear violations of Federal or Provincial regulatory requirements. The sub-indicator question is as follows:

- M4.1 - Is the Feasible Concept readily approvable?

Landowner Requirements

Mandatory pre-screening requirement indicator M5 considers whether the landowner requirements will be met, considering the various landowners within the boundary of the site. The sub-indicator question is as follows:

- M5.1 - Does the Feasible Concept meet landowner requirements?

Procurement Requirements

Mandatory pre-screening requirement indicator M6 considers whether the NS Lands' procurement requirements will be met, ensuring that the Feasible Concept cannot be sole-sourced to a specific Contractor, and that fair and competitive procurement practices are attainable. The sub-indicator question is as follows:

- M6.1 - Does the FC allow for the implementation of the NS Procurement Strategy?

2.2 Regulatory Indicators

The regulatory evaluation includes two performance measures to evaluate the ability of each Feasible Concept to achieve compliance with regulatory requirements. Successful feasible concepts must comply with health and safety requirements and compliance requirements, as identified below.

Health and Safety

This evaluation criterion measures the ability of a Feasible Concept to comply with health and safety requirements, specifically the ability to protect the health and safety of public, and the ability to protect the health and safety of workers both during and post-remediation.

Health and safety indicator HS1 considers the relative risk level to the health and safety of the public for each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the public include:

- HS1.1 - What is the relative risk level to public health and safety posed by the Feasible Concept?
- HS1.2 - To what extent can the potential risks be mitigated as part of the Feasible Concept?

Health and safety indicator HS2 considers the relative risk level to the health and safety of the workers for each Feasible Concept. The sub-indicator questions for the risk level to the health and safety of the workers include:

- HS2.1 - What is the relative risk level to worker health and safety posed by the Feasible Concept?
- HS2.2 - To what extent can the potential risks be mitigated as part of the Feasible Concept?

Compliance

This evaluation criterion C1 measures the ability of a Feasible Concept to comply with approval requirements and relative public acceptability. The sub-indicator questions for compliance are as follows:

- C1.1 - Does the Feasible Concept go beyond the minimum requirements for approvability?
- C1.2 - What is the relative public acceptability of the Feasible Concept?

2.3 Technical Criteria

This technical criteria includes performance measures to evaluate the ability of each Feasible Concept to meet the requirements of the project. Successful Feasible Concepts must exhibit technical maturity, compatibility with current site features, compatibility with existing offsite features, have long-term reliability/effectiveness/durability, have a reasonable remedial implementation time, be readily monitored and tested, and have minimal waste generation.

Technical Maturity (e.g., remedial technology)

Technical indicator T1 considers the demonstrated experience of the Feasible Concepts. The sub-indicator questions for proven experience with implementation include:

- T1.1 - What is the relative successful "track record" for implementing the Feasible Concept?

- T1.2 - What is the relative availability of the source materials?
- T1.3 - What is the relative availability of contractors/vendors for the Feasible Concept?

Compatibility with Current Site Features (e.g., disposal cell location, remedial technology, bridge)

Technical indicator T2 considers the compatibility of the Feasible Concepts with current site features. The sub-indicator questions for compatibility with current site features include:

- T2.1 - What is the relative compatibility of the Feasible Concept with site size and configuration?
- T2.2 - What is the relative compatibility of the Feasible Concept with site geology?
- T2.3 - What is the relative compatibility of the Feasible Concept with site hydrogeology?
- T2.4 - What is the relative compatibility of the Feasible Concept with site access?
- T2.5 - What is the relative compatibility of the Feasible Concept with site hydrology?

Compatibility with Existing Off-site Features

Technical indicator T3 considers the compatibility of the Feasible Concepts with existing off-site features. The sub-indicator questions include:

- T3.1 - What is the relative compatibility of the Feasible Concept with existing features and infrastructure surrounding the site (e.g., points of access, roads, power lines)?
- T3.2 - Does the Feasible Concept cause significant changes to off-Site conditions (e.g., traffic)?
- T3.3 - Does the Feasible Concept require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?

Reliability/Effectiveness/Durability

Technical indicator T4 considers the relative long-term reliability, effectiveness, and durability of the Feasible Concepts. The sub-indicator questions for long-term reliability, effectiveness, and durability include:

- T4.1 - What is the relative expected service life of the Feasible Concept components relative to the remediation and post-remediation maintenance period?
- T4.2 - What are the relative maintenance requirements of the Feasible Concept during the remediation and post-remediation maintenance period?
- T4.3 - What is the likelihood the Feasible Concept will meet performance criteria or remediation objectives?
- T4.4 - What is the relative impact of the Feasible Concept not meeting performance criteria or remediation objectives?
- T4.5 - What is the relative ease of implementation of contingency measures during the remediation and post-remediation maintenance period?

Remedial Implementation Time

Technical indicator T5 considers the implementation time for the Feasible Concepts. The sub-indicator questions for remedial implementation time include:

- T5.1 - Can the Feasible Concept be constructed and fully operational in an established time frame?
- T5.2 – What is the anticipated time frame to implement the Feasible Concept?

Readily Monitored and Tested

Technical indicator T6 considers how readily the Feasible Concepts can be monitored and tested. The sub-indicator questions for readily monitored and tested include:

- T6.1 - How readily can the Feasible Concept be monitored and tested during the remediation phase?
- T6.2 - How readily can the Feasible Concept be monitored and tested during post-remediation phase?
- T6.3 - What is the relative amount of monitoring required to validate effectiveness?

Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)

Technical indicator T7 considers the ability of the Feasible Concepts to minimize waste generation. The sub-indicator questions for minimizing waste generation include:

- T7.1 - What is the ability of the Feasible Concept to minimize waste generation during remediation?
- T7.2 - What is the ability of the Feasible Concept to minimize waste generation during the post-remediation maintenance phase?
- T7.3 - What is the ability of the Feasible Concept to minimize dangerous goods (i.e., hazardous waste) generation?

2.4 Environmental Indicators (During and Post Remediation)

This performance aspect includes three performance measures to evaluate the extent of the Feasible Concept to cause measurable effects on the environment. Successful Feasible Concepts will minimize environmental impact during both the remediation phase and the post-remediation phase. The sub-indicator questions for environmental indicators include:

- EN1 - During the remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on the environment (i.e., atmospheric, aquatic, and terrestrial environments)?
- EN2 - During the post-remediation phase, to what extent is the Feasible Concept likely to cause an adverse effect on the environment (i.e., atmospheric, aquatic, and terrestrial environments)?

Sub-indicators for both EN1 and EN2 are divided into four categories: atmospheric environment (air quality for protection of workers and for protection of public health), aquatic environment (water quality, sediment quality, fish communities and habitats, benthic invertebrate communities, contaminants in aquatic biota tissue), geology and groundwater (groundwater flow, groundwater/surface water interaction, general groundwater quality, seismicity, soil quality), and terrestrial environment (vegetation, communities, and species, wildlife habitat, wildlife communities and species, and significant species).

Weather Effects

The third performance measure in the Environmental Indicator category considers the susceptibility of the Feasible Concept to weather events during the remediation phase and post-remediation phase. The sub-indicator questions for evaluating weather effects include:

- EN3.1 - What is the potential impact of weather on the implementation of the Feasible Concept?
- EN3.2 - What is the potential impact of weather on the Feasible Concept during the post-remediation phase?
- EN3.3 - What is the suitability of the Feasible Concept under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?

2.5 Social Indicators

This performance aspect includes two performance measures to evaluate community acceptance and the potential socio-economic benefits of the Feasible Concept during the remediation phase and post-remediation phase. Successful Feasible Concepts will foster a high level of acceptability by the PLFN and other surrounding communities, and minimize negative impacts to the surrounding communities during both the remediation phase and the post-remediation phase.

Community Acceptance

Community Acceptance indicator S1 considers the acceptance of the Feasible Concepts by the surrounding (i.e., PLFN and other) communities. The sub-indicator questions include:

- S1.1 - How acceptable is the Feasible Concept to the surrounding communities during remediation phase?
- S1.2 - How acceptable is the Feasible Concept to the surrounding communities during the post-remediation phase?
- S1.3 - Does the Feasible Concept impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?
- S1.4 - Does the Feasible Concept impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?

Community Benefit

Community Benefit indicator S2 considers the community benefit of the Feasible Concepts. The sub-indicator question includes:

- S2.1 - Does the Feasible Concept affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?

2.6 Economic Indicators

The final evaluation criterion considers the capital and operation and maintenance (O&M) costs of the Feasible Concepts.

Cost accuracy is based on Class D cost estimates, which is typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Typical accuracy ranges for Class D estimates are -30 percent to -50 percent on the low side, and +30 percent to +100 percent on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination.

Remediation Capital Costs

Economic indicator EC1 considers remediation capital costs of the Feasible Concepts. The sub-indicator question for EC1 includes:

- EC1.1 - What is the capital cost of the Feasible Concept?

Post-Remediation O&M Costs

Economic indicator EC2 considers annual post-remediation O&M costs for the Feasible Concepts. The sub-indicator question for EC2 includes:

- EC2.1 - What are the typical annual post-remediation O&M costs for the Feasible Concept?

3. Criteria Weighting

Criteria weighting for the five Indicator categories (i.e., Regulatory, Technical, Environmental, Social, and Economic) was determined collaboratively during the Evaluation Criteria and Weighting Matrix workshop held on September 20, 2017.

Following discussions on the rationale for assigned weighting for each the five Indicator categories, initial weighting distributions were submitted individually by NS Lands stakeholders and GHD subject matter experts. The weighting distributions assessed, and subsequently averaged following removal of the highest and lowest assigned weighting for each Indicator category. Based on the results, the weighting distribution to be applied during the evaluation of Feasible Concepts is as follows:

- Regulatory Indicator Weighting – 14 percent
- Technical Indicator Weighting – 26 percent
- Environmental Indicator Weighting – 24 percent
- Social Indicator Weighting – 14 percent
- Economic Indicator Weighting – 22 percent

The assigned weighting for each category is identified on the Evaluation Criteria and Weighting Matrix provided in Attachment A.

In general, the weighting within each Indicator category (i.e., sub-categories) was evenly distributed across each evaluation criterion on the Feasible Concept scoring sheet. Two exceptions to this approach were noted, as follows:

- Within the Environmental Indicator category, sub-indicator EN2 (Environmental Effects During Post-Remediation Phase, 50 percent) was assigned a higher weighting than sub-indicators EN1 (Environmental Effects During Remediation Phase, 25 percent) and EN3 (Weather Effects, 25 percent).
- Within the Social Indicator category, sub-indicator S2 (Community Benefit, 75 percent) was assigned a higher weighting than sub-indicator S1 (Community Acceptance, 25 percent).

Attachment A
Sample Evaluation Criteria and Weighting Matrix Form

EVALUATION CRITERIA AND WEIGHTING MATRIX

Boat Harbour Remediation Design (BHRD)

Remedial Component: ________________________________

			Feasible Concept 1	Feasible Concept 2	Feasible Concept 3	Feasible Concept 4	Feasible Concept 5
Pre-screening Requirements							
M1	Public Acceptability	Pass/Fail	0.0	0.0	0.0	0.0	0.0
M2	Return to Tidal	Pass/Fail	0.0	0.0	0.0	0.0	0.0
M3	Intended End Use	Pass/Fail	0.0	0.0	0.0	0.0	0.0
M4	Approvability	Pass/Fail	0.0	0.0	0.0	0.0	0.0
M5	Landowner Requirements	Pass/Fail	0.0	0.0	0.0	0.0	0.0
M6	Procurement Requirements	Pass/Fail	0.0	0.0	0.0	0.0	0.0
			Pass	Pass	Pass	Pass	Pass
Regulatory Indicators							
Health & Safety		**Weighting**					
HS1	Ability to Protect Health & Safety of Public	0.25	0.0	0.0	0.0	0.0	0.0
HS2	Ability to Protect Health & Safety of Workers	0.25	0.0	0.0	0.0	0.0	0.0
Compliance							
C1	Ease of Obtaining Approvals	0.50	0.0	0.0	0.0	0.0	0.0
14%	**Regulatory Indicator Weighting**		0	0	0	0	0
Technical Indicators							
T1	Technical Maturity	0.14	0.0	0.0	0.0	0.0	0.0
T2	Compatibility with Current Site Features	0.14	0.0	0.0	0.0	0.0	0.0
T3	Compatibility with Existing Offsite Features	0.14	0.0	0.0	0.0	0.0	0.0
T4	Reliability/ Effectiveness/Durability	0.14	0.0	0.0	0.0	0.0	0.0
T5	Remedial Implementation Time	0.14	0.0	0.0	0.0	0.0	0.0
T6	Readily Monitored and Tested	0.14	0.0	0.0	0.0	0.0	0.0
T7	Minimal Waste Generation	0.14	0.0	0.0	0.0	0.0	0.0
26%	**Technical Indicator Weighting**		0	0	0	0	0
Environmental Indicators							
EN1	Environmental Effects During Remediation Phase	0.25	0.0	0.0	0.0	0.0	0.0
EN2	Environmental Effects During Post-Remediation Phase	0.50	0.0	0.0	0.0	0.0	0.0
EN3	Weather Effects	0.25	0.0	0.0	0.0	0.0	0.0
24%	**Environmental Indicator Weighting**		0	0	0	0	0
Social Indicators							
S1	Community Acceptance	0.25	0.0	0.0	0.0	0.0	0.0
S2	Community Benefit	0.75	0.0	0.0	0.0	0.0	0.0
14%	**Social Indicator Weighting**		0	0	0	0	0
Economic Indicators							
EC1	Remediation Capital Costs	0.50	0.0	0.0	0.0	0.0	0.0
EC2	Post-Remediation Operations & Maintenance Costs	0.50	0.0	0.0	0.0	0.0	0.0
22%	**Economic Indicator Weighting**		0	0	0	0	0
Total Comparative Score			0	0	0	0	0
Total Weighted Comparative Score			0	0	0	0	0
Rank							

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
Remedial Component: ________________________________

		FEASIBLE CONCEPT (FC) 1	2	3	4	5	Scoring 1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements											
M1	**Public Acceptability**										
1	Are there any components of the FC that are clearly unacceptable to the public?						Fail		<-->		Pass
M2	**Return to Tidal**										
1	Does the FC facilitate returning A'se'k to tidal conditions?						Fail		<-->		Pass
M3	**Intended End Use**										
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?						Fail		<-->		Pass
M4	**Approvability**										
1	Is the FC readily approvable?						Fail		<-->		Pass
M5	**Landowner Requirements**										
1	Does the FC meet landowner requirements?						Fail		<-->		Pass
M6	**Procurement Requirements**										
1	Does the FC allow for the implementation of the NS Procurement Strategy?						Fail		<-->		Pass
Regulatory Indicators											
Health and Safety Indicators											
HS1	**Ability to Protect Health and Safety of Public**										
1	What is the relative risk level to public health and safety posed by the FC?						High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?						Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**										
1	What is the relative risk level to worker health and safety posed by the FC?						High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?						Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance											
C1	**Ease of Obtaining Approvals**										
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?						Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?						Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators											
T1	**Technical Maturity**										
1	What is the relative successful "track record" for implementing the FC?						Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?						Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?						Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**										
1	What is the relative compatibility of the FC with site size and configuration?						Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?										
3	What is the relative compatibility of the FC with site hydrogeology?										
4	What is the relative compatibility of the FC with site access?										
5	What is the relative compatibility of the FC with site hydrology?										
T3	**Compatibility with Existing Off-Site Features**										
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?						Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?										
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?										
T4	**Reliability/Effectiveness/Durability**										
1	What is the relative expected service life of the FC components relative to the remediation and post-remediation maintenance period?						Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post-remediation maintenance period?						Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?						High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?						High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post-remediation maintenance period?						Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures

DRAFT EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
Remedial Component: ______________________________

		FEASIBLE CONCEPT (FC)					Scoring				
		1	**2**	**3**	**4**	**5**	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**
Technical Indicators - *continued*											
T5	**Remedial Implementation Time**										
1	Can the FC be constructed and fully operational within established time frame?						Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?						>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**										
1	How readily can the FC be monitored and tested during remediation phase?						Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?						Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?						Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**										
1	What is the ability of the FC to minimize waste generation during remediation?						High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?						High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?						High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
Environmental Indicators											
EN1	**Remediation Phase Effects**										
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:						Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment										
	Air Quality for the Protection of Workers										
	Air Quality for the Protection of Public Health										
b	Aquatic Environment										
	Water quality										
	Sediment quality										
	Fish communities and habitats										
	Benthic invertebrate communities										
	Contaminants in aquatic biota tissue										
c	Geology and Groundwater										
	Groundwater flow										
	GW/SW interaction										
	General groundwater quality										
	Seismicity										
	Soil quality										
d	Terrestrial Environment										
	Vegetation, Communities and Species										
	Wildlife habitat										
	Wildlife communities and Species										
	Significant Species										
EN2	**Post-Remediation Phase Effects**										
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:						Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment										
	Air Quality for the Protection of Workers										
	Air Quality for the Protection of Public Health										
b	Aquatic Environment										
	Water quality										
	Sediment quality										
	Fish communities and habitats										
	Benthic invertebrate communities										
	Contaminants in aquatic biota tissue										
c	Geology and Groundwater										
	Groundwater flow										
	GW/SW interaction										
	General groundwater quality										
	Seismicity										
	Soil quality										
d	Terrestrial Environment										
	Vegetation, Communities and Species										
	Wildlife habitat										
	Wildlife communities and Species										
	Significant Species										
EN3	**Weather Effects**										
1	What is the potential impact of weather on the implementation of the FC?						FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?						FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?						Design fails under catastrophic event		<-->		Design does not fail under catastrophic event

DRAFT EVALUATION CRITERIA AND WEIGHTING MATRIX

Boat Harbour Remediation Design (BHRD)
Remedial Component: ______________________________

		FEASIBLE CONCEPT (FC)					Scoring				
		1	2	3	4	5	1.0	2.0	3.0	4.0	5.0
Social Indicators											
S1	**Community Acceptance**										
1	How acceptable is the FC to the surrounding communities during remediation phase?						Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?						Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?						Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?						Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**										
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?						Negative effect	<-->	No effect	<-->	Positive effect
Economic Indicators											
EC1	**Remediation Capital Costs**										
1	What is the capital cost of the FC?						FC costs >40% above lowest	<-->	FC costs 20% above lowest	<-->	Lowest FC cost
EC2	**Post-Remediation Operation & Maintenance Costs**										
1	What are the typical annual post-remediation O&M costs for the FC?						FC costs >40% above lowest	<-->	FC costs 20% above lowest	<-->	Lowest FC cost

Appendix C
Bridge Detailed Concept Descriptions

Appendix C Bridge Detailed Concept Descriptions

1. Overview

Remediation of the Boat Harbour Effluent Treatment Facility (BHETF) and returning A'se'k to tidal state will generally require the following:

- Excavation of the existing causeway at Highway 348 to allow for a sufficient opening width to permit navigation of the design vessel
- Construction of a new bridge on Highway 348 with adequate vertical clearance to permit navigation of the design vessel
- Removal and reinstatement of the buried water main and support for the water main on the bridge

The following two Feasible Concepts for construction of the bridge were developed:

1. Feasible Concept 1: Concrete girder bridge
2. Feasible Concept 2: Steel girder bridge

The following sections describe the bridge construction objectives, common design elements, and detailed concept description for the Feasible Concepts.

2. Objectives

The objectives for construction of a new bridge at Highway 348 are as follows:

- Provide for navigation in and out of Boat Harbour from the Northumberland Strait
- Provide adequate hydraulic capacity to allow for tidal flow under the structure based on a maximum surface water velocity of 1.8 m/sec, facilitate the 1 in 100 year storm event, and consider the sea level rise to the year 2100
- Construct a structure that minimizes long-term maintenance costs
- Ensure the structure has a 75 year design life as per the requirements of the Canadian Highway Bridge Design Code

3. Common Design Elements

3.1 Design Criteria

Nova Scotia Transportation and Infrastructure Renewal (NS TIR) has developed typical requirements for provincially owned structures that will apply to this project. Based on discussions with TIR and past experience, common design criteria for the Feasible Concepts are as follows:

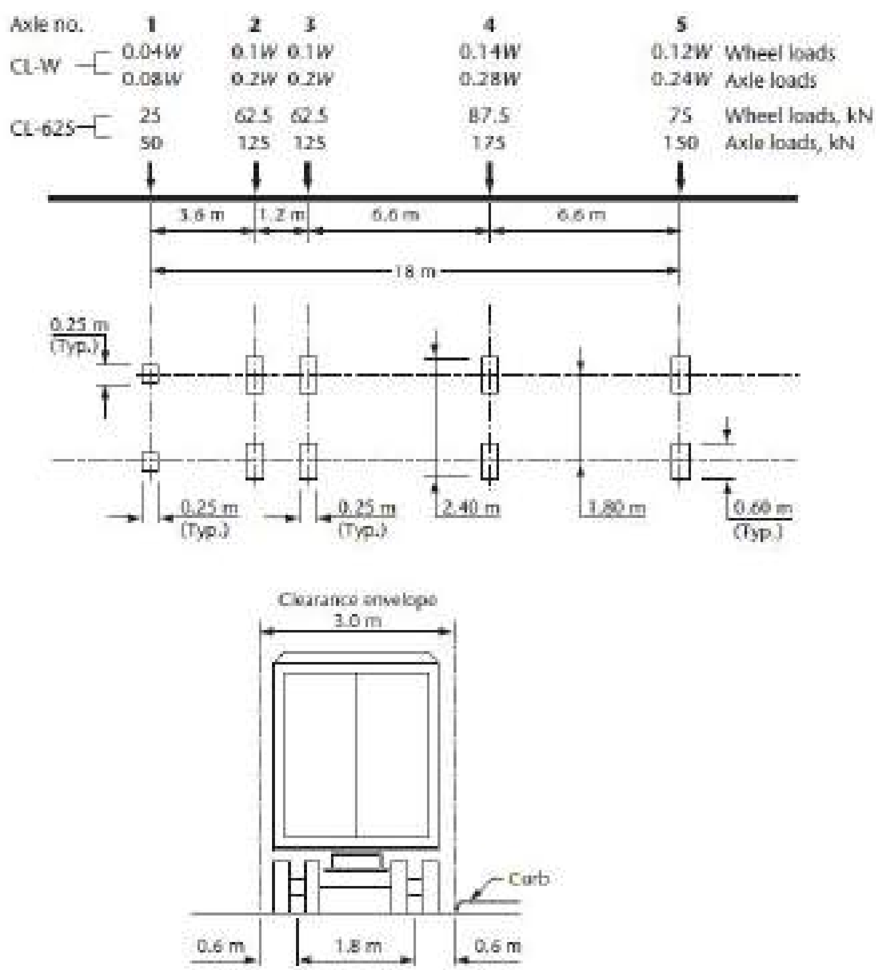
- Structural design in accordance with CHBDC S6-14, Canadian Highway Bridge Design Code
- 80 km/h design speed

- 3.5 m lanes, 2.0 m shoulders, and 1.5 m wide sidewalk on one side[1]
- Deck structure to be a 225 mm concrete deck, reinforced with glass fiber reinforced polymer (GFRP) reinforcing
- All other concrete reinforcement to be galvanized
- 80 mm thick asphalt wearing surface complete with waterproofing membrane
- Concrete barrier to be designed to a minimum Test Level 2 (TL-2) and a minimum height of 1050 mm
- Abutment design to be integral abutment, if feasible

3.2 Design Vehicle

Typically the design vehicle for a new bridge constructed in Canada is defined as a CL-625 vehicle load in accordance with the Canadian Highway Bridge Design Code (CHBDC). As per the CHBDC, the design vehicle is defined in the following two figures:

CL-W Truck



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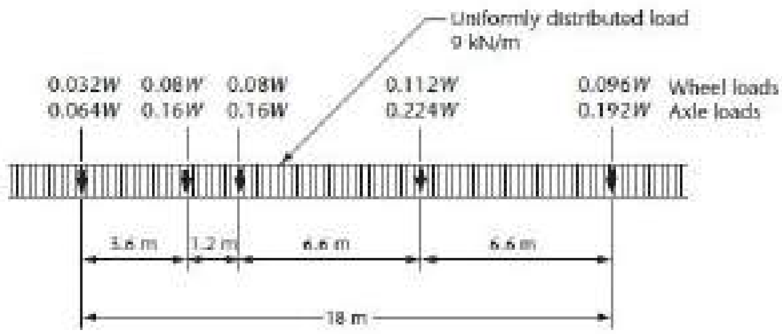
1 During the Remedial Options Decision Workshop, NS Lands confirmed that a sidewalk will be provided on both sides of the bridge; and NS TIR confirmed that the shoulder width would be reduced to 1.5 m. Changes will be incorporated as part of detailed design.

CI-W Lane Load



3.3 Materials

Materials specified will be appropriate for the structure in accordance with CSA S6. The materials identified below represent possible options, but all may not be used in the design. If they are used, they will be specified as follows:

- Prestressed Concrete: 55 MPa high performance concrete to CAN/CSA A23.1 requirements
- Concrete for Abutments and Wingwalls: 45 MPa high performance concrete to CAN/CSA A23.1 requirements
- Concrete for Mud Slabs: 30 MPa
- Prestressing Strands (if used): 12.7 mm diameter, 7 wire extra high strength grade 1860 MPa, stabilized strand to ASTM A416M-06
- Rebar: 400W, galvanized to CAN/CSA G30.18
- GFRP (if used): Grade III to CAN/CSA S6, S806-12 and S087-10
- Steel Girders: 350W or 350AT to CSA G40.21. Should steel girders be selected, further discussion will be held to determine to appropriate coating system for the bridge, or if weathering steel should be considered.
- Steel Piles: 350W to CSA G40

3.4 General Arrangement

The preliminary bridge site plan and profile are shown of Figures C1 and C2 respectively. Based on estimated post remediation grades, hydraulic analysis, and navigation requirements, it is expected that the bridge structure will be approximately 34 m long single span structure. The use of a single span provides a better hydraulic condition and improved tidal flow under the structure.

3.5 Bridge Foundation

It is expected that bedrock depths will be sufficient to allow for the construction of an integral abutment, which is preferred by NS TIR. Should the final geotechnical investigation show that bedrock is at shallow depths, abutment foundations including a semi-integral abutment with spread footings cast directly on bedrock, or an integral abutment with steel piles installed in pre-drilled pipe casings or a backfilled rock trench will be considered.

3.6 Barrier Selection

Barrier options for the bridge include concrete barriers and horizontal steel rail systems. Preliminary discussions with NS TIR indicate that a concrete barrier system is the preferred option. The rail system will be a TL-5 barrier system that has been crash tested as per CHBDC requirements. The rail height will be 1050 mm high to meet the necessary requirements for pedestrians and architectural enhancements can be made to the barrier system.

3.7 Water Main Support

A water main is constructed within the existing causeway embankment and provides water supply from the nearby well field to PLFN. During construction, a temporary water main will need to be constructed adjacent to the new bridge. This temporary water main would be supported by a temporary pipe bridge or rerouted across the dam structure.

Incorporated into the bridge design will be a new support system for the water main as shown in the figure for each of the Feasible Concepts. The line will be rerouted within the embankment to be adjacent to the new bridge foundations and be supported under the exterior concrete deck of the bridge. The water main will be supported by galvanized steel brackets that are equally spaced at approximately 1.8 to 2.4 m across the bridge.

3.8 Detour

A typical construction schedule for this size and type of structure from removal of the existing culverts to completion of the new bridge ready for traffic is approximately three months. During this time, Highway 348 will be closed at the bridge location and a detour route around the site will be required.

4. Bridge Feasible Concept 1 – Concrete Girder Bridge

Feasible Concept 1 involves the construction of a precast concrete bulb tee girder superstructure for the bridge. Precast bulb tee girders is a cost-effective solution for a 34 m span, provides a reasonable structure depth, and is comparable to the existing structure. For this span length, a concrete superstructure is typically preferred by NS TIR as they are a durable structure with low long-term maintenance costs and easily meet the 75 year design life criteria outlined in the CBHDC.

A preliminary cross-section of the concrete superstructure option is provided on Figure C3.

5. Feasible Concept 2 – Steel Girder Bridge

Feasible Concept 2 involves the construction of a steel girder superstructure for the bridge. A steel superstructure can consist of either steel plate girders or steel box beams. Steel girders have the benefit of potential longer spans and shallower depths, but for shorter span structures such as this bridge, they are typically more costly to construct and maintain compared to concrete girders.

A preliminary cross-section of a steel (steel plate) girder option with a concrete superstructure is shown on Figure C4.

6. Feasible Concepts Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Attachment C1 and summarized on Table C.1 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost covers the estimated 75-year service life of the bridge.

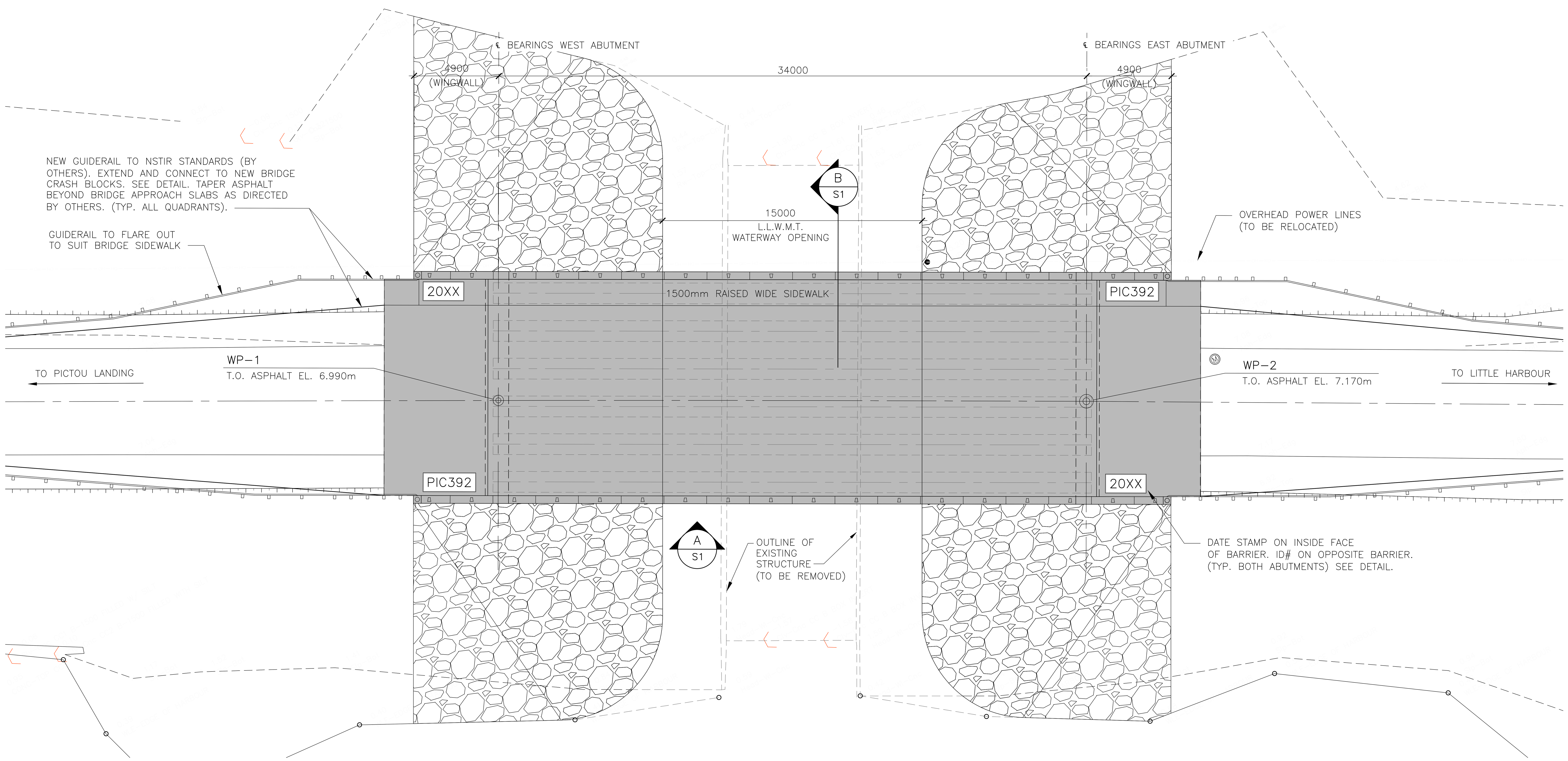
Table C.1 Bridge Class D Cost Estimate

Feasible Concept	Capital Cost[2]	Operation and Maintenance Cost
Feasible Concept 1 – Concrete Girder Bridge	$2,980,000	$150,000
Feasible Concept 2 – Steel Girder Bridge	$3,160,000	$280,000

Key assumptions in development of the cost estimate include:

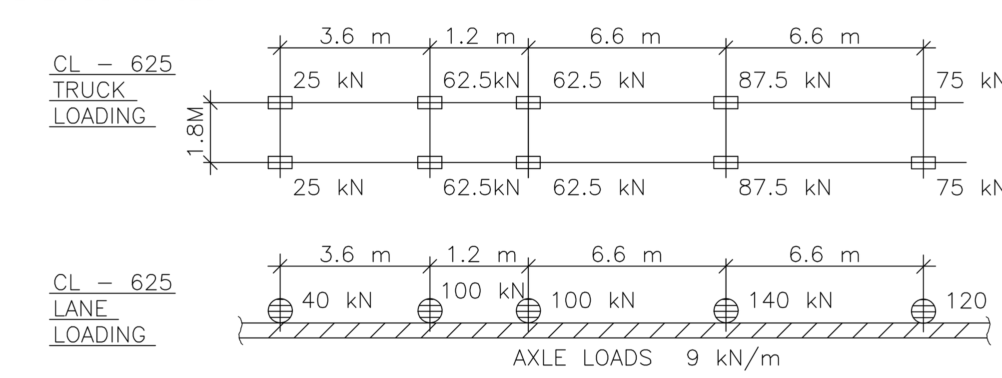
- No rock excavation required for foundation
- Steel piled foundation with 10 m long piles
- No detour structure required during construction
- No allowance for a pedestrian crossing during construction
- Existing water main to be supported by a temporary pipe bridge during construction
- Road reconstruction length of 600 m to improve road grade and super elevation on approaches
- Service life of 75 years

[2] Capital costs include a sidewalk on one side and 2.0 m shoulders.



GENERAL NOTES:

1. GENERAL REQUIREMENTS GOVERNING DESIGN, MATERIALS, AND CONSTRUCTION ARE AS FOLLOWS:
   A) LOADING AND GENERAL DESIGN TO CAN/CSA-S6-14, WITH LATEST REVISIONS
   B) NOVA SCOTIA TRANSPORTATION AND INFRASTRUCTURE RENEWAL (NSTIR), STANDARD SPECIFICATION
   C) CONCRETE MATERIALS AND METHODS OF CONSTRUCTION TO CSA – A23.1, AND METHODS OF TEST FOR CONCRETE TO CSA – A23.2
   D) CONCRETE (MINIMUM 28 DAY COMP. STRENGTH)
      I. PRECAST GIRDERS: HPC AS PER DIV. 5, SECTION 18 OF STD. SPEC., f'c = 55 MPa, AIR CONTENT 6%,±1% (AIR VOID SPACING REQUIREMENTS STD. SPEC.), W/C = 0.35 MAX.
      II. DECK, BARRIERS, ABUTMENTS, & APPROACH SLABS: HPC AS PER DIV. 5, SECTION 18 OF STD. SPEC., f'c = 45 MPa, AIR CONTENT 6%, ±1% (AIR VOID SPACING REQUIREMENTS STD. SPEC.), W/C = 0.35 MAX.
   E) REINFORCING STEEL TO NSTIR STD. SPECIFICATIONS WITH YIELD STRENGTH OF 400 MPa (WELDABLE).
2. ALL DIMENSIONS SHOWN IN MILLIMETRES (mm) UNLESS NOTED OTHERWISE.
3. ALL SPECIFICATION NOTES TO REFLECT THE "LATEST EDITION" AT TIME OF TENDER.
4. LIVE LOADS CL-625



5. FOUNDATION DESIGN BASED ON INFORMATION PROVIDED IN GEOTECHNICAL REPORT.
6. LAYOUT INFORMATION AND SURVEY INFORMATION PROVIDED BY NSTIR. COORDINATES ARE BASED ON THE NOVA SCOTIA COORDINATE SYSTEM AND ELEVATIONS ARE TO CANADIAN GEODETIC DATUM.
7. ALL STANDARDS TO REFLECT "LATEST EDITION".
8. REFERENCE WSP DRAWING 171-10478-520 NAD 83 UTM 20. DWG FOR ROAD ALIGNMENT OVER BRIDGE STRUCTURE.
9. CONSTRUCTION SHALL BE CARRIED OUT AS PER CAN/CSA-S6-14.
10. CONTRACTOR TO COORDINATE WITH UTILITY OWNERS AND THE ENGINEER.
11. CONTRACTOR IS RESPONSIBLE FOR VERIFYING ALL EXISTING DIMENSIONS AND ELEVATIONS. ANY DISCREPANCIES BETWEEN DRAWINGS AND THE FIELD CONDITIONS SHALL BE BROUGHT TO THE ATTENTION OF THE ENGINEER PRIOR TO PROCEEDING WITH CONSTRUCTION.
12. CONTRACTOR SHALL DESIGN, INSTALL AND MAINTAIN TEMPORARY BRACING, SHORING AND FORMWORK OF ALL STRUCTURAL ELEMENTS FOR STABILITY AND SAFETY WHERE REQUIRED DURING CONSTRUCTION.
13. CONTRACTOR IS TO ENSURE THAT ALL WORK IS CARRIED OUT IN ACCORDANCE WITH NOVA SCOTIA OCCUPATIONAL HEALTH AND SAFETY REGULATIONS.

0 2.5m 5.0m

SCALE: 1:150

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
BRIDGE AT HIGHWAY 348

PROPOSED BRIDGE SITE PLAN

11148275-5

Mar 13, 2018

FIGURE C1

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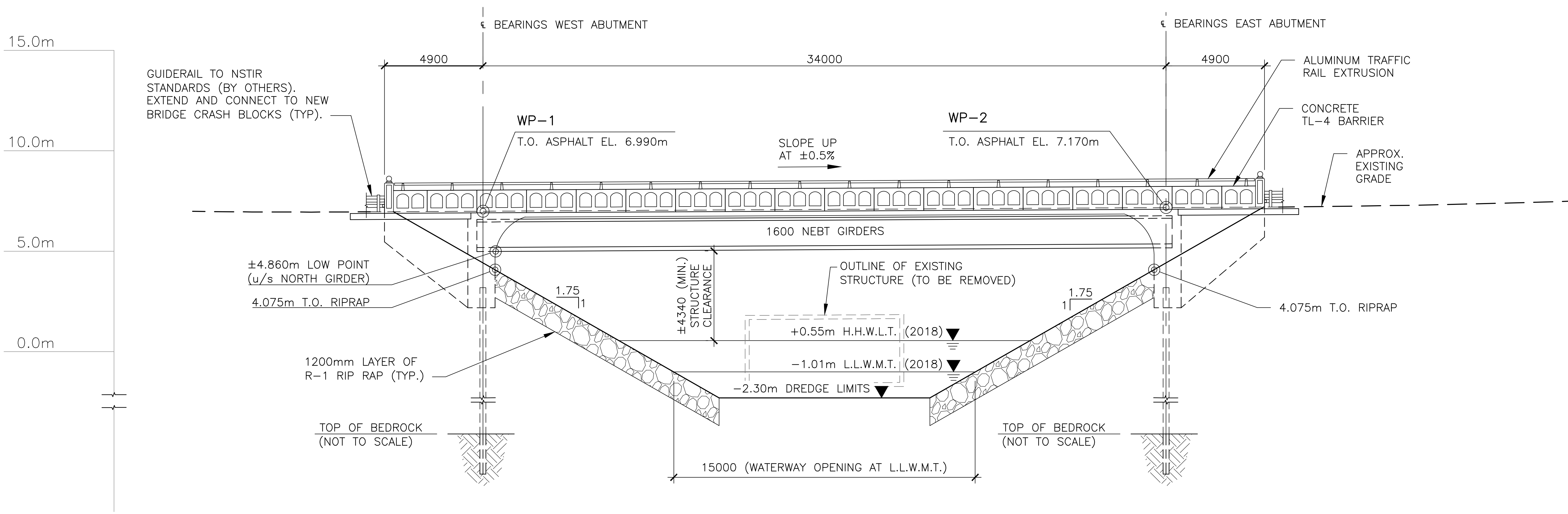

A / S1 ELEVATION BRIDGE PROFILE LOOKING NORTH

1 : 200

0 2 4 6m

N

GHD

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
BRIDGE AT HIGHWAY 348

PROPOSED BRIDGE PROFILE

11148275-5

Mar 13, 2018

FIGURE C2

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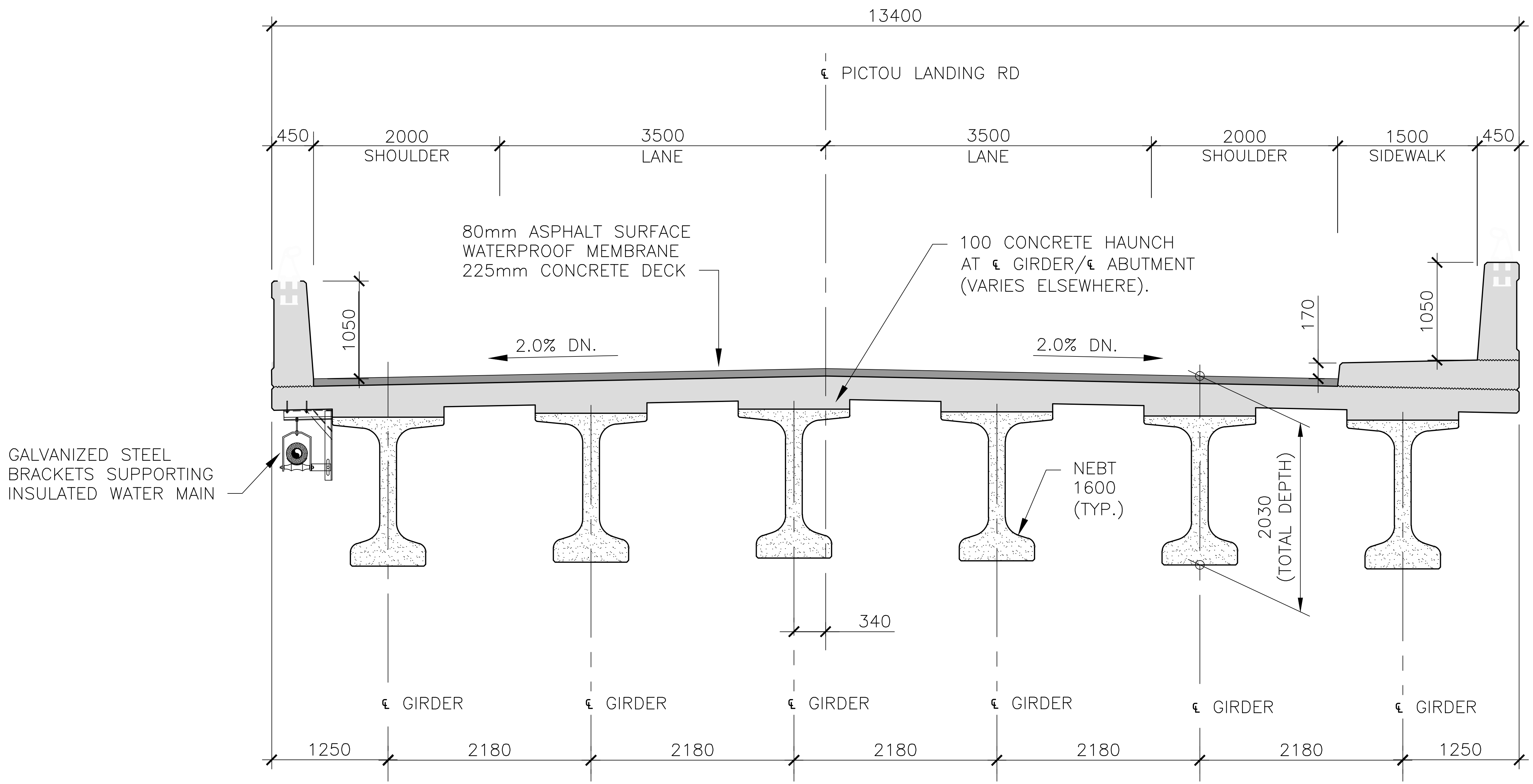

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NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
BRIDGE AT HIGHWAY 348

CONCRETE SUPERSTRUCTURE OPTION

11148275-5
Mar 13, 2018

FIGURE C3

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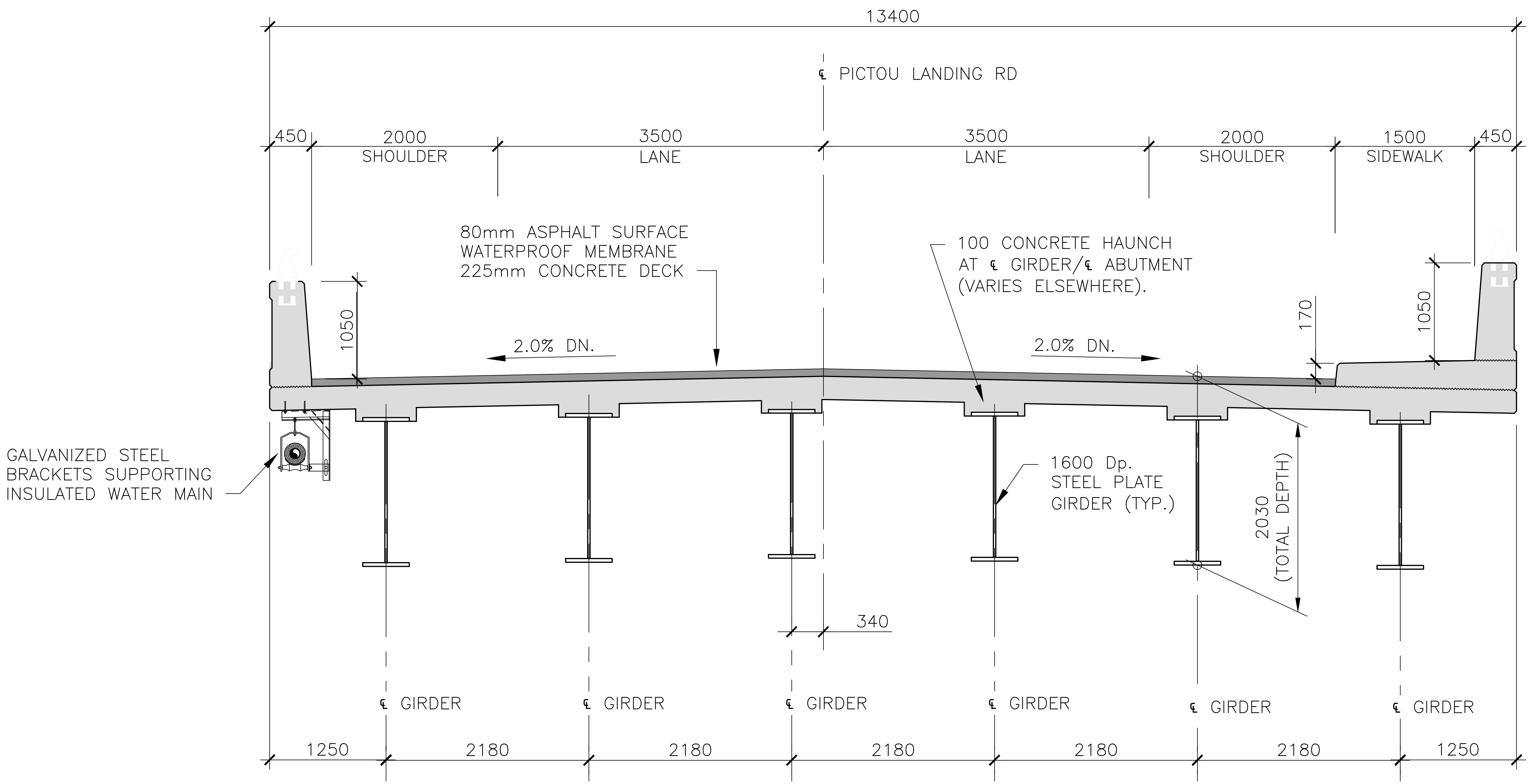

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NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
BRIDGE AT HIGHWAY 348

STEEL SUPERSTRUCTURE OPTION

11148275-5
Mar 13, 2018

FIGURE C4

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Attachment C1

Attachement C1

Class D Cost Estimate
Feasible Concept 1 - Concrete Girder Bridge
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Excavation	LS	-	-	$ 50,000
2	H-Piles (Supply and Install)	M	300	$ 1,200	$ 360,000
3	Fill Against Structure	T	500	$ 35	$ 17,500
4	Prestressed Concrete Girders	M	210	$ 2,500	$ 525,000
5	Cast in Place Concrete	M3	700	$ 2,200	$ 1,540,000
6	Waterproofing	M2	400	$ 40	$ 16,000
7	Water Main Supports	LS	-	-	$ 25,000
8	Armour Stone	T	500	$ 60	$ 25,000
9	Road Reconstruction	M2	4,200	$ 100	$ 420,000
				Total Class D Estimate	$ 2,978,500
				Total Class D Subtotal (Rounded, -4)	**$ 2,980,000**
Part B - Operations and Maintenance Over Service Life					
10	Operation and Maintenance	LS			$ 150,000
				Total Class D O&M Cost Estimate	$ 150,000
				Total Class D Cost Estimate (Rounded, -4)	**$ 150,000**

1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -20 to +50%.
   - Capital cost estimate does not include cost associated with general requirements (e.g., bonds, insurance,
   - O&M costs are total cost for a maintenance period over the lifespan of the bridge (approximately 75 years) and does not consider the time value of money (e.g., net present value).
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions Include:
   - No rock excavation required
   - Steel piled foundation with bedrock elevation approximately 15 metres below grade (10 m long piles)
   - No detour structure required during construction and no allowance for pedestrian corssing during construction
   - Existing water main to be supported by a temporary pipe bridge during construction
   - Road reconstruction required over a length of 600 m

Attachment C1

Class D Cost Estimate
Feasible Concept 2 - Steel Girder Bridge
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Excavation	LS	-	-	$ 50,000
2	H-Piles (Supply and Install)	M	300	$ 1,200	$ 360,000
3	Fill Against Structure	T	500	$ 35	$ 17,500
4	Steel Plate Girders	T	100	$ 7,000	$ 700,000
5	Cast in Place Concrete	M3	700	$ 2,200	$ 1,540,000
6	Waterproofing	M2	400	$ 40	$ 16,000
7	Water Main Supports	LS	-	-	$ 25,000
8	Armour Stone	T	500	$ 60	$ 25,000
9	Road Reconstruction	M2	4,200	$ 100	$ 420,000
				Total Class D Cost Estimate	$ 3,153,500
				Total Class D Cost Estimate (Rounded, -4)	**$ 3,160,000**
Part B - Operations and Maintenance Over Service Life					
10	Operation and Maintenance	LS			$ 275,000
				Total Class D O&M Cost Estimate	$ 275,000
				Total Class D Cost Estimate (Rounded, -4)	**$ 280,000**

Notes:

1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -20 to +50%.
   - Capital cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
   - O&M costs are total cost for a maintenance period over the lifespan of the bridge (approximately 75 years) and does not consider the time value of money (e.g., net present value).
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
3. Key - Standard Supplier Price List
3. Key assumptions Include:
   - No rock excavation required
   - Steel piled foundation with bedrock elevation approximately 15 metres below grade (10 m long piles)
   - No detour structure required during construction and no allowance for pedestrian corssing during construction
   - Existing water main to be supported by a temporary pipe bridge during construction
   - Road reconstruction required over a length of 600 m

Appendix D
Waste Management Detailed Concept Descriptions

Appendix D Waste Management Detailed Concept Descriptions

1. Overview

The Boat Harbour Effluent Treatment Facility (BHETF) consists of the wastewater effluent pipeline, twin settling basins, aeration stabilization basin (ASB), and the Boat Harbour stabilization lagoon (BH). Effluent from Boat Harbour discharges through a dam into the estuary before being released to the Northumberland Strait. Prior to the construction of the twin settling basins and ASB, effluent was routed by open ditch from the pipeline on the east side of Highway 348 to a natural wetland area (Former Ponds 1, 2, and 3) before being discharged into the stabilization lagoon. An overall site plan identifying key infrastructure is presented on Figure D1.

Remediation of the BHETF will generate the following industrial waste streams:

- Sludge waste generated from cleaning of the pipeline and remediation of the twin settling basins, aeration stabilization basin (ASB), stabilization lagoon, wetlands, and estuary
- Construction and demolition (C&D) debris generated from decommissioning/demolition of the BHETF buildings, causeway at Highway 348, dam, and pipeline
- Industrial waste generated from remediation activities (e.g., spent treatment media, remediated sludge, chemicals, etc.)

The following two Feasible Concepts were developed for management of industrial waste stream:

1. Feasible Concept 1: Use existing disposal cell
2. Feasible Concept 2: Off-Site disposal

The following sections describe waste management objectives, common design elements, and detailed concept descriptions for the Feasible Concepts.

2. Objectives

The objectives for managing waste generated as part of decommissioning and remediation the BHETF are to:

- Minimize the quantity of waste that needs to be managed by diverting material from the landfill (e.g., reuse, recycle), where possible
- Remove, transport, and dispose of waste in a manner that is protective of human health and the environment, and minimizes long-term monitoring and care
- Minimize total waste management costs (i.e., capital and operational expenditures)

3. Common Design Elements

3.1 Waste Quantities

Table D.1 below presents a summary of the anticipated waste quantities that will be generated during decommissioning and remediation activities. A breakdown of the volumes is detailed in Appendix G[1] for sludge/sediment and Appendix F[2] for C&D debris. Industrial waste has not been estimated as it is considered insignificant for the assessment.

Table D.1 Waste Quantities Summary

Waste Type	In Place Volume (m^3)	Final Disposal Volume (m^3)
Sludge/Sediment	1,224,000	517,700[(1)]
C&D Debris	N/A	1,100
Note: [(1)] Assumes the sludge is dewatered (see Appendix G)		

The predominant waste stream to be managed is the sludge/sediment waste. The sludge/sediment is concentrated in the twin settling basins, ASB, stabilization lagoon, estuary, and historical discharge areas (e.g., Former Settling Ponds 1, 2 and 3).

4. Waste Management Feasible Concept 1 – Use Existing Disposal Cell

4.1 Background

In 1994, an Industrial Permit (94-032) was issued by Nova Scotia Environment (NSE) for the construction and operation of the sludge disposal cell.

The 6.7 ha sludge disposal cell is located southeast of the ASB and has a total capacity of 220,000 m^3 (waste). As shown on Figure D2, the sludge disposal cell is located on provincially-owned lands, and is surrounded by undeveloped mixed woodlands and Indian Reserve Lands (including IR37 to the south and IR24G to the east). Access to the sludge disposal cell is via a single lane gravel roadway off the ASB perimeter road. The sludge disposal cell is secured by a perimeter fence with an access gate in the northwest corner.

Hydraulically dredged sludge from the ASB is directly discharged as a slurry into the sludge disposal cell on a routine basis, typically annually. In addition, dewatered sludge from the twin settling basins was reportedly transferred to the disposal cell from 1996 to 1998. It is understood that prior to 2004, sludge material in the disposal cell was pushed/dozed into a mound on the western portion of the disposal cell which currently forms a solid mass. Hydraulically dredged sludge is placed in the eastern portion of the disposal cell, which is currently under wet conditions. Based on a survey completed by GHD in 2016[3], the disposal cell contains approximately 180,000 m^3 of waste; including approximately 51,000 m^3 of sludge forming the western solid portion of the cell, and approximately 129,000 m^3 of sludge/water in the eastern wet portion of the cell.

1 Remediation Detailed Concept Descriptions for Feasible Concepts

2 Detailed Concept Descriptions for Feasible Concepts for Infrastructure Decommissioning

3 Sampling and Analysis of Dredge Spoils Report - Final Boat Harbour Effluent Treatment Facility Disposal Cell, Pictou Landing, Nova Scotia (GHD, February 2016)

The 1994 design drawings for the disposal cell are presented as Figures D3 and D4. The disposal cell was designed as a single cell with a total capacity of 220,000 m^3 (waste) to facilitate placement of sludge to the top of the perimeter berm (elevation 12 m AMSL). The disposal cell is lined with 0.6 m of clay-till, with a hydraulic conductivity of approximately $1x10^{-6}$ cm/s.

The disposal cell includes leak detection, leachate, and decanting collection systems. All collection systems are connected by a 0.3 m diameter PVC pipe gravity pipe and manhole system that discharges to the ASB.

Key features of these systems include:

- Leak Detection System: The system consists of an underdrain pipe network (i.e., 0.15 m and 0.10 m diameter perforated PVC pipe) underlying the 0.6 m clay-till liner and connected to manholes located on the eastern external side of the disposal cell.
- Leachate Collection System: A 20 m x 0.4 m filter bed is located above the 0.6 m clay-till liner on the eastern side of the cell that includes a pipe collection network (i.e., 0.15 m perforated PVC pipe) connected to manholes located on the eastern external side of the disposal cell.
- Decant System: The decant structure is used to manage the water level in the disposal cell and facilitates gravity dewatering of supernatant. The decant structure consists of a concrete base, steel structure, and stop log cladding and is approximately 4.5 m high and 1.2 m wide. A 0.2 m PVC pipe connects the base of the decant structure to MH 2 located on the eastern external side of the disposal cell.

An overflow pond is located immediately east of the disposal cell. The eastern berm of the disposal cell includes two emergency overflow spillways to discharge excess surface water from the disposal cell to the overflow pond. A catch basin, located within the overflow pond, discharges surface water from the pond to MH 4 and ultimately to the ASB.

4.2 Detailed Concept Description

Feasible Concept 1 involves using the existing disposal cell and placing waste materials in excess of the current design capacity of 220,000 m^3 (waste only). It is noted that in the Operations and Maintenance Manual[4], the design capacity could be exceeded based on the physical properties of the waste materials and the recommended final elevations could be determined as part of the disposal cell closure plan. To illustrate potential disposal cell waste volumes, Table D.2 shows the waste capacity available using a range of final cover elevations, 4H:1V and 10H:1V side slopes, and 20H:1V top slope. Figure D5 shows a cross section through the landfill with 4H:1V side slopes to a top of final cover elevation of 23 m, assuming 0.75 m thick cap.

Table D.2 Available Capacity (Waste)

Cover Elevation	Total Capacity (m^3) Based on 10:1 Slope	Total Capacity (m^3) Based on 4:1 Slope
18 m AMSL	350,000	440,000
20 m AMSL	360,000	505,000
23 m AMSL	N/A	580,000
28 m AMSL	N/A	660,000

4 Nova Scotia Department of Transportation and Public Works Operational and Maintenance Manual, Boat Harbour Disposal Cell, Boat Harbour Treatment Facility, Boat Harbour, Nova Scotia (Jacques Whitford Environment Limited, September 1999)

In support of detailed design, the following investigations should be completed to confirm the integrity of the disposal cell and suitability for use without modifications:

- Geotechnical investigation to confirm integrity of perimeter berms and slope stability of the berms during rapid filling and post closure under various design scenarios.
- Inspection of the existing leak detection, leachate collection, and decanting systems to confirm system performance.

It is noted that the most recent annual groundwater monitoring reports[5,6] for the disposal cell show no impairment to groundwater, which indicates that the base liner is performing as intended.

4.2.1 Disposal Cell Development

Under Feasible Concept 1, the disposal cell would be modified to enhance the leachate collection layer and facilitate placement and dewatering of the sludge/sediment in a one-step operation. As detailed in Appendix G sludge/sediment would be managed as follows:

- The majority of the sludge will be pumped into geotubes located in the disposal cell and allowed to dewater by gravity over time, with dewatering effluent being collected and conveyed using the decant and leachate collection systems.
- Mechanically excavated sludge would be placed in a dump truck and end dumped into the disposal cell. End dumped sludge would be developed in lifts of approximately 1-3 m, followed by compaction to maximize disposal cell air space, and used to fill the gaps between the filled geotube bags. Leachate would be managed via the leachate collection system.

Other waste materials generated as part of remediation would be placed in the disposal cell similar to the mechanically excavated sludge.

4.2.2 Final Cover

The final landfill cover contours will be designed to accommodate the anticipated range of final waste volumes, minimize precipitation infiltration through the cap, control the release of landfill gas, and accommodate end use. A 0.75 m thick low permeable final cover consisting of a sand/grading layer, flexible membrane liner, sand drainage layer, and vegetated topsoil would be constructed to minimize infiltration and leachate generation as shown on Figure D6. The final cover material will be modified to accommodate intended plantings such as short shrubs that would tie the landfill visually into the surrounding tree line.

4.2.3 Leachate Management

Under Feasible Concept 1, dewatering effluent and leachate will be collected and conveyed through existing decant and leachate collection systems, and transferred to the temporary wastewater management system.

The annual leachate generation rate is estimated to be less than 2,500 m^3 per year based on using a flexible membrane liner and assuming approximately 1,200 mm of rainfall per year[7]. A leachate management area will need to be established for managing leachate post-closure. As shown on

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5 Sludge Disposal Cell – Boat Harbour Effluent Treatment Facility, 2015 Monitoring Report (Dillon Consulting Limited, March 2016)

6 Sludge Disposal Cell – Boat Harbour Effluent Treatment Facility, 2016 Monitoring Report (Stantec, March 2017)

7 Based on a review of Lyons Brook weather station data for 1981-2010.

Figure D5, an ideal location would be in the vicinity of MH 6, which is part of the existing sewer infrastructure and adjacent to the ASB.

Options for the leachate management system are discussed and detailed in Appendix G. The recommended leachate management option is off-site disposal. As such, a storage tank and truck loading station would be constructed to facilitate off site disposal at a licenced facility. The cost estimates for the recommended leachate management system are carried under this feasible concept for comparative purposes.

4.2.4 Surface Water Management

During remediation, clean surface water runoff in the vicinity of the disposal cell will continue to be diverted away from the disposal cell and controlled by infiltration and overland flow. Water that comes in contact with the waste will be managed as leachate and conveyed by gravity to the decant and leachate collection systems.

Under post-closure conditions the primary objectives of surface water management are to:

- Convey and direct surface water runoff from the closed disposal cell
- Preserve the natural hydrologic cycle
- Minimize the potential for on-Site erosion and sediment loading to downstream water courses and water bodies

Under post-closure conditions, surface water runoff from the disposal cell will be conveyed via integrated perimeter ditches, through culverts on the eastern end of cell, and discharged into the overflow pond, which will be converted to a lined stormwater management pond. Ultimately, clean surface water that is discharged from the overflow pond will be conveyed by gravity to Boat Harbour.

As part of detailed design, a hydrological model will be developed to calculate peak flows and runoff volumes from the disposal cell under various storm event conditions, and evaluate the size of perimeter ditches, culverts, the stormwater management pond, and any other stormwater infrastructure. Surface water conveyance infrastructure will be designed to accommodate a 25-year storm event, and the stormwater management pond will be designed to accommodate a 100-year storm event.

It is noted that the proposed location of the stormwater management pond is in the existing overflow pond area. This area may need to be remediated and therefore disturbed prior to the construction of the lined pond.

4.2.5 Landfill Gas Management

Landfill Gas (LFG) is produced by the biological decomposition of waste placed in a landfill. LFG composition is highly variable and depends upon a number of site-specific conditions including waste composition, density, moisture content, and age. LFG is typically comprised of methane (approximately 50 percent by volume) and carbon dioxide (approximately 50 percent by volume). LFG may also contain nitrogen, oxygen, and trace quantities of other gases (such as hydrogen sulphide and mercaptans).

Due to its composition, the presence of LFG may create explosive, suffocating, and toxic conditions. LFG management may be required to control potential impacts relating to the release of LFG to the atmosphere and migration of LFG through the soil surrounding the Site.

The release of LFG into the air may contribute to odours in the vicinity of the Site, and the addition of "greenhouse gases" into the atmosphere. LFG odours are primarily a result of the presence of hydrogen sulphide and mercaptans. These compounds may be detected by sense of smell at very low concentrations (0.005 and 0.001 parts per million for hydrogen sulphide and mercaptans, respectively). It is generally recognized that the impacts related to these compounds are nuisance odours.

LFG produced by the disposal cell are anticipated to be predominantly methane and carbon dioxide as a result of the anaerobic decomposition of the organic fraction of the waste. The LFG production will be evaluated as part of the detailed design, and is expected to be small as compared to municipal solid waste due to the organic material being degraded and not readily biodegradable.

LFG will be managed using a passive venting system which allows the release of pressure build up within the closed cell. Installation of vents through the final cover of the cell will provide pressure release points; the location and depths will be confirmed using a calculated gas production rate determined during the detailed design phase. If required, the vents will be fitted with turbines to assist in venting.

4.2.6 Site Facilities

Vehicle access to the disposal cell will need to be improved to facilitate cell improvements, waste placement, construction of final cover, and post-closure monitoring and care. The access road will be designed to accommodate two lane heavy vehicle traffic during construction. The existing perimeter fence will also need to be upgraded/extended to prevent public access to the disposal cell and supporting infrastructure. Signage will need to be posted along the access road, perimeter fence, and all access gates.

5. Waste Management Feasible Concept 2 - Off-Site Disposal

Feasible Concept 2 consists of trucking waste materials to an off-Site facility located within 175 km of the study area.

5.1 Off-Site Disposal Locations

5.1.1 Licensed Provincial Facilities

It is anticipated that the majority of the waste generated as part of the project will be classified as non-hazardous/ non-dangerous material, and can be accepted at licensed provincial municipal landfills, either as alternative daily cover or as a waste, with Nova Scotia Environment (NSE) approval. A summary of potential licensed provincial municipal landfills within 175 km of the Site are shown in Table D.3 and presented on Figure D7. In addition, several soil management facilities that are relatively close to the Site are also shown. The soil management facilities could potentially be used for off-site processing of sludge/sediment prior to being shipped to a municipal landfill for disposal, with NSE approval.

Table D.3 Non-Hazardous Waste Facility Summary

Landfill or Soil Management Facility	Location	Distance from Site (km one way)
Atlantic Soils	Mount Williams, Pictou County	13
Groundfix Remediation	Truro, NS	52.5
Colchester Balefill Facility	Truro, NS	52.5
Guysborough County Landfill Site	Guysborough, NS	133
West Hants Landfill	Scotch Village, NS	157
Cumberland Central Landfill	Amherst, NS	164

5.1.2 Licensed Construction and Demolition Debris Facilities

C&D debris generated as part of decommissioning and demolition activities would be transported to licensed C&D disposal sites that are relatively close to the Site. A summary of potential licensed C&D disposal sites located in Pictou, Antigonish, and Guysborough regions are shown in Table D.4 and presented on Figure D7.

Table D.4 C&D Waste Facility Summary

Facility	Location	Distance from Site (km one way)
Pictou County Solid Waste Management Facility	Mount William, Pictou County	14.8
Atlantic Supermarket Contractors	Broadway, Pictou County	36.6
Beech Hill Landfill	Beech Hill, Antigonish County	70.8

5.2 Hauling

Straight trailers (or similar) pulled by a tractor will be used to haul contaminated materials to an off-site disposal facility. All vehicles transporting contaminated materials will be cleaned as needed and inspected prior to leaving site to ensure loads are secured. Manifests will be completed to track the transportation and disposal at licensed provincial facilities. Assuming a trailer capacity of 35 tonnes and based on the sludge volumes presented in Table D.1 and density of 1.2 tonnes/m^3, it is estimated that approximately 18,200 loads will be required to transport the treated (dewatered) sludge material off-site.

5.3 Off-Site Disposal Requirements

To determine if waste can be accepted at off-Site facilities, analytical results will be reviewed in detail and compared to the NSE 2005 Guidelines for Disposal of Contaminated Solids in Landfills (Landfill Disposal Guidelines); target contaminants will be compared to Attachment B – Acceptance Parameters for Contaminated Soils (Total Analysis) and Attachment C – Acceptance Parameters for Contaminated Soil (Leachate Results), as applicable.

It is GHD's understanding that impacted materials must be in solid form to be accepted at the facilities under consideration. Though there are no specific requirements (e.g., slump test), materials transported in liquid containers (e.g., vacuum trucks or tanker) will not be accepted.

5.3.1 Off-Site Disposal Assessment

GHD conducted bench scale testing to identify the optimum technologies for treatment of sludge from the Site; the results of this study were considered in the evaluation of potential disposal options for the treated sludge material. The results are included in Appendix A.

Based on the analysis of solids captured using geotubes (with varying polymer and/or coagulant doses applied), the treated sludge was well below applicable Landfill Disposal Guidelines leachate criteria (Attachment C). In accordance with the Landfill Disposal Guidelines, with contaminant levels less than Attachment C criteria the treated sludge material is considered acceptable for disposal in landfills. However, dioxins and furans are well-documented contaminants of concern to which there is no criteria identified in the Landfill Disposal Guidelines. As part of the bench scale testing, concentrations of dioxins and furans in the treated sludge collected from the estuary, stabilization lagoon, and ASB were compared to NSE Tier 1 EQSs[8]. All treated sludge samples collected from the stabilization lagoon and ASB exceeded Tier 1 EQS for dioxins and furans (4 pg/g). As acceptance criteria is currently not defined for dioxins and furans by NSE, it is not known at this time if the treated sludge will be acceptable for off-Site disposal at a licensed provincial municipal landfill.

6. Feasible Concepts Cost Estimate

Class D capital and operation and maintenance cost estimates for each Feasible Concept is provided in Attachment D1 and summarized on Table D.5 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

Three costing scenarios are shown for Feasible Concept 1 – Use Existing Disposal Cell. Feasible Concept 1A represents leachate being transported to a municipal wastewater treatment plant (WWTP) for disposal, Feasible Concept 1B represents leachate being transport to an industrial WWTP for disposal, and Feasible Concept 1C represents leachate being treated on-Site with treated effluent discharged to Boat Harbour.

Two costing scenarios are also shown for Feasible Concept 2 – Off-Site Disposal. Feasible Concept 2A represents a tip fee based on the dewatered sludge/sediment being used as alternative daily cover at a municipal landfill and Feasible Concept 2B represents a tip fee based on the dewatered sludge/sediment being landfilled (i.e., consuming air space available for waste disposal).

Table D.5 Waste Management Feasible Concepts Class D Cost Estimates

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1A – Use Existing Disposal Cell (Leachate disposed at municipal WWTP)	$6,400,000	$5,500,000
Feasible Concept 1B – Use Existing Disposal Cell (Leachate disposed at industrial WWTP)	$6,400,000	17,000,000
Feasible Concept 1C – Use Existing Disposal Cell (Leachate treated on-Site with treated effluent discharged to Boat Harbour)	$8,740,000	$9,750,000
Feasible Concept 2A – Off-Site Disposal (tip fee of $25/MT based on use as alternative daily cover)	$28,510,000	$0
Feasible Concept 2B – Off-Site Disposal (tip fee of $115/MT based on landfilling waste)	$85,080,000	$0

Key assumptions include:

- For Feasible Concept 1, final cover based on 4(H):1(V) slopes constructed to a maximum elevation of 28 m AMSL
- For Feasible Concept 1, the stormwater pond is assumed to be constructed using earthen berms with low permeable clay liner along the inside slope and floor

8 Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQSs) for Soil (Non Potable Site, Fine Grained Soil, Commercial Land Use) as outlined in Table 1B of the NSE 2013 Contaminated Site Regulations. This criteria is sometimes used in Nova Scotia for assessing landfill acceptance of contaminated soil.

- For Feasible Concept 1, a 25-year contaminating life span is assumed
- For Feasible Concept 2, sludge is assumed to be disposed of at a landfill that is approximately 55 km away from the Site
- For Feasible Concept 2, landfill can accept volume of sludge waste over the anticipated remediation duration (i.e., no daily load limits)
- For Feasible Concept 2, C&D waste is assumed to be disposed of at a C&D facility that is approximately 15 km away from the Site

Source: Imagery @2017 Google CNES / Airbus, DigitalGlobe, Landsat / Copernicus

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
WASTE MANAGEMENT

OVERALL SITE PLAN

11148275-09
Jan 12, 2018

FIGURE D1

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA00D1.mxd

Source: Service Nova Scotia

0 100 200 300
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

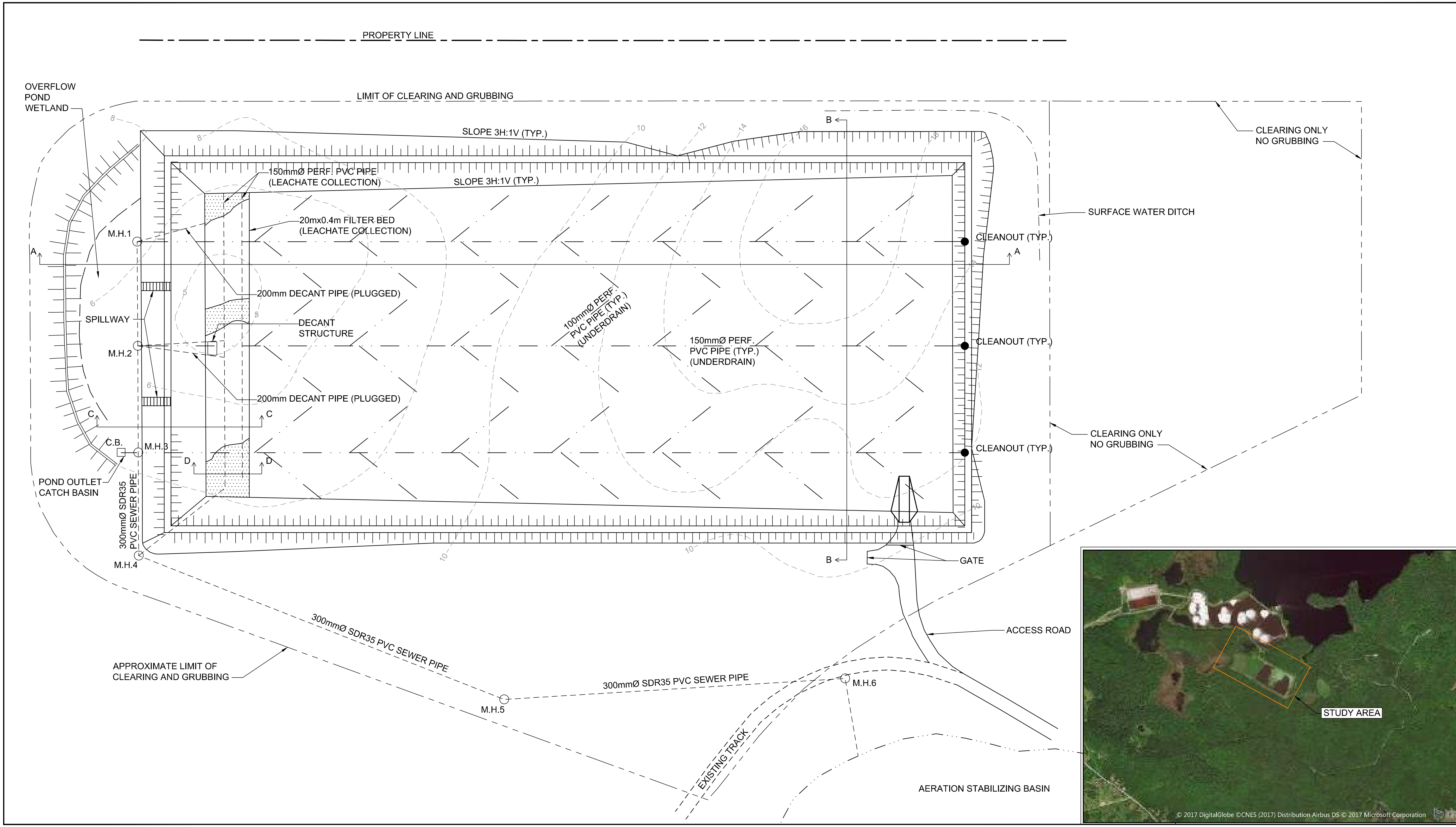
NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
WASTE MANAGEMENT

EXISTING CONDITIONS

11148275-09
Mar 9, 2018

FIGURE D2

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA00D2.mxd



Source: NS Department of Supply and Services/JWEL, Tender No. 1994-000519, Drawing No. 9383-6-1, August 1994

0 17.5 35 52.5m

Coordinate System:
UTM ZONE 20 NAD83 (CSRS)

Note: Elevations Assumed to be Based on CGVD 28 Datum

GHD

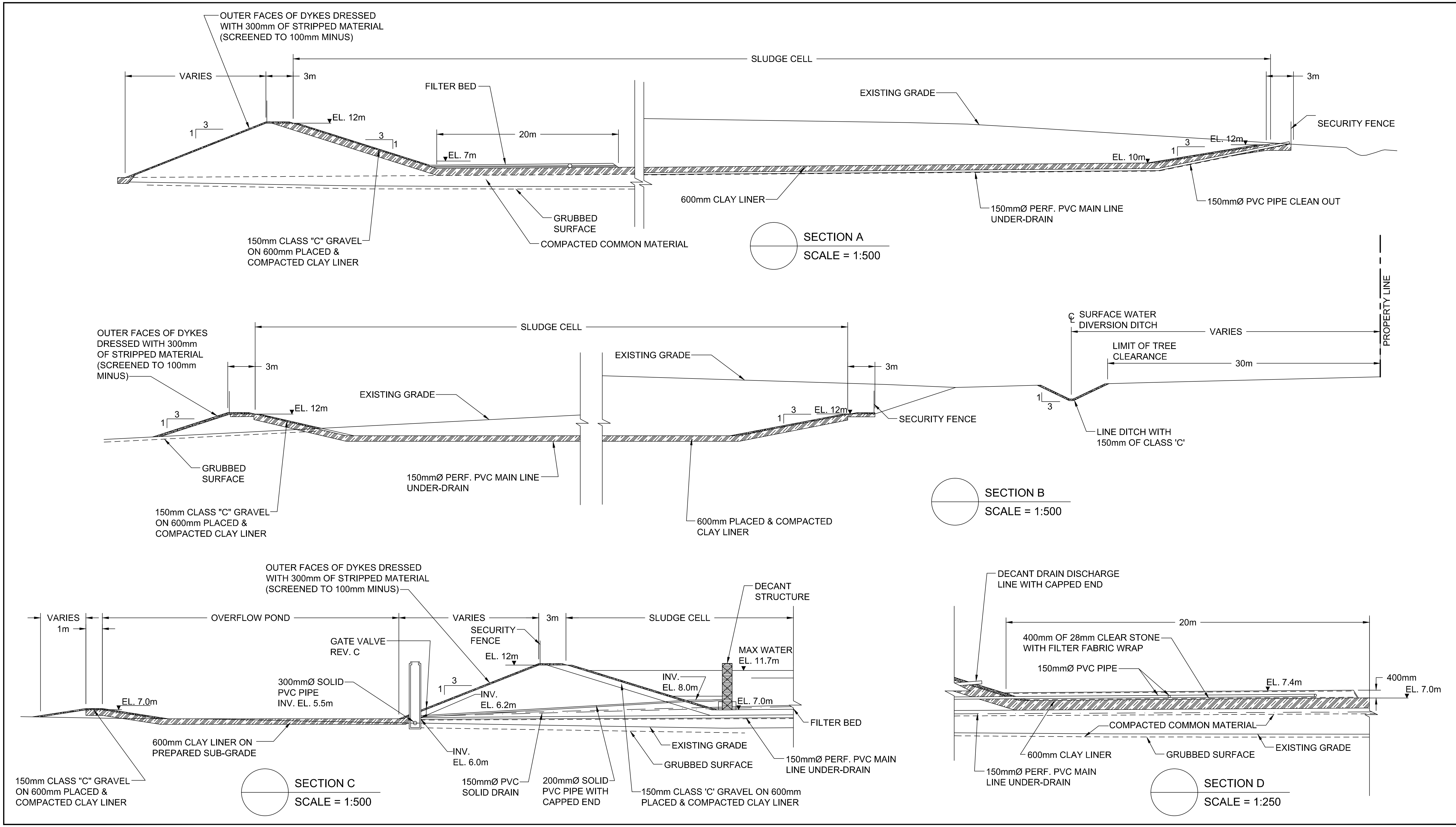
NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
WASTE MANAGEMENT

EXISTING DISPOSAL CELL LAYOUT
(1994 AS-BUILT)

11148275-09
Jan 12, 2018

FIGURE D3

CAD File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GN-DA00D3.dwg



Source: NS Department of Supply and Services/JWEL, Tender No. 1994-000519, Drawing No. 9383-6-2, August 1994

Note: Elevations Assumed to be Based on CGVD 28 Datum

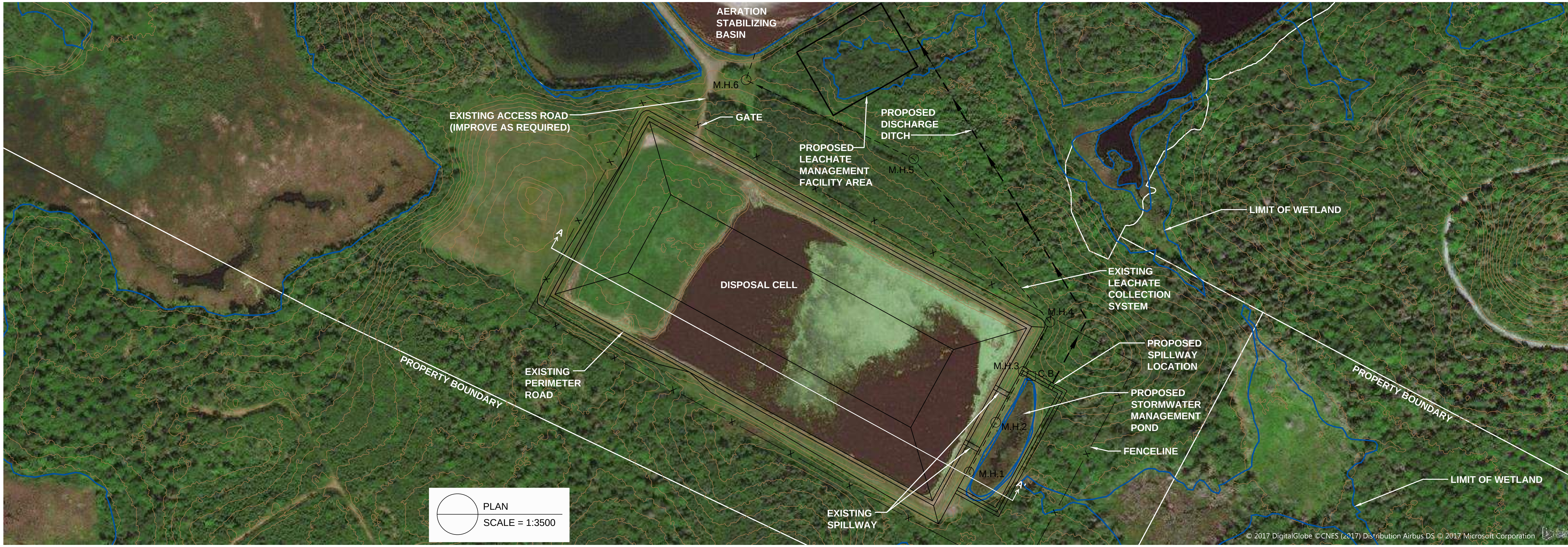
NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
WASTE MANAGEMENT

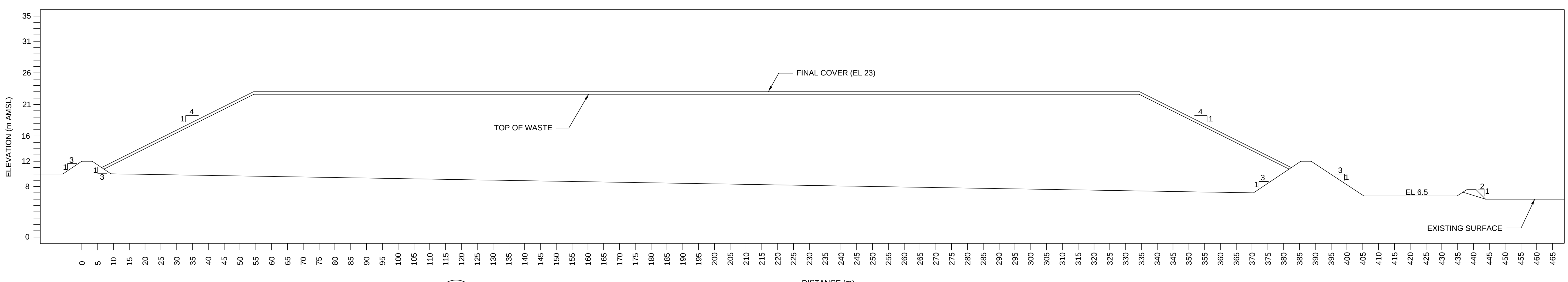
EXISTING DISPOSAL CELL CROSS SECTIONS
(1994 AS-BUILT)

11148275-09
Jan 12, 2018

FIGURE D4

CAD File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GN-DA00D4.dwg





0 30 60 90m

Coordinate System:
UTM ZONE 20 NAD83 (CSRS)

Note: Elevations Assumed to be Based on CGVD 28 Datum

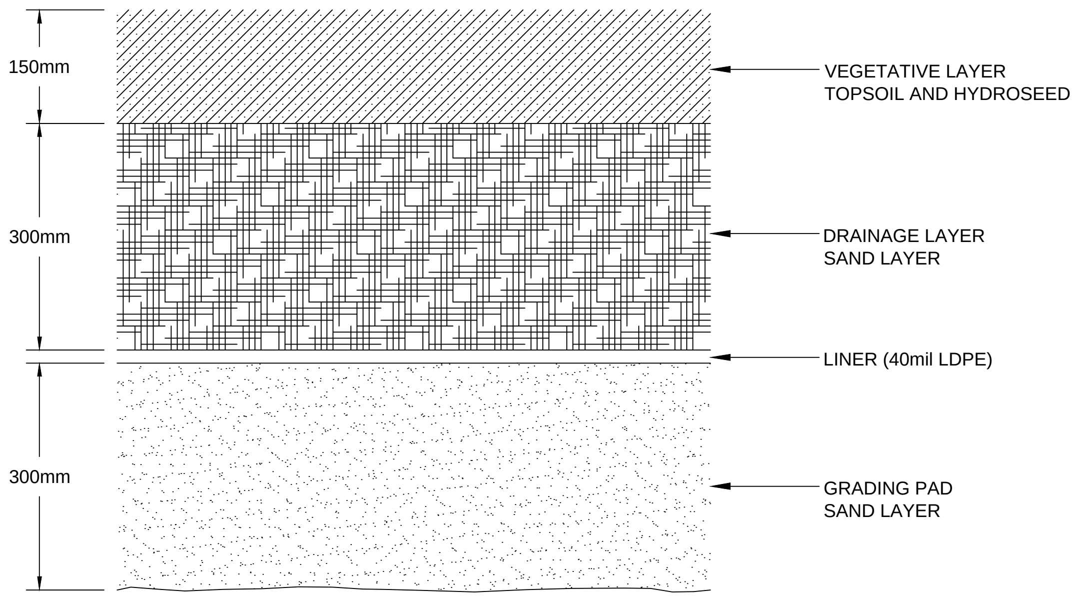
NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
WASTE MANAGEMENT

EXISTING DISPOSAL CELL - PROPOSED FINAL PROFILE SECTION A - A'

11148275-09
Mar 26, 2018

FIGURE D5

CAD File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GN-DA00D5.dwg



SCALE = 1:10

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
WASTE MANAGEMENT

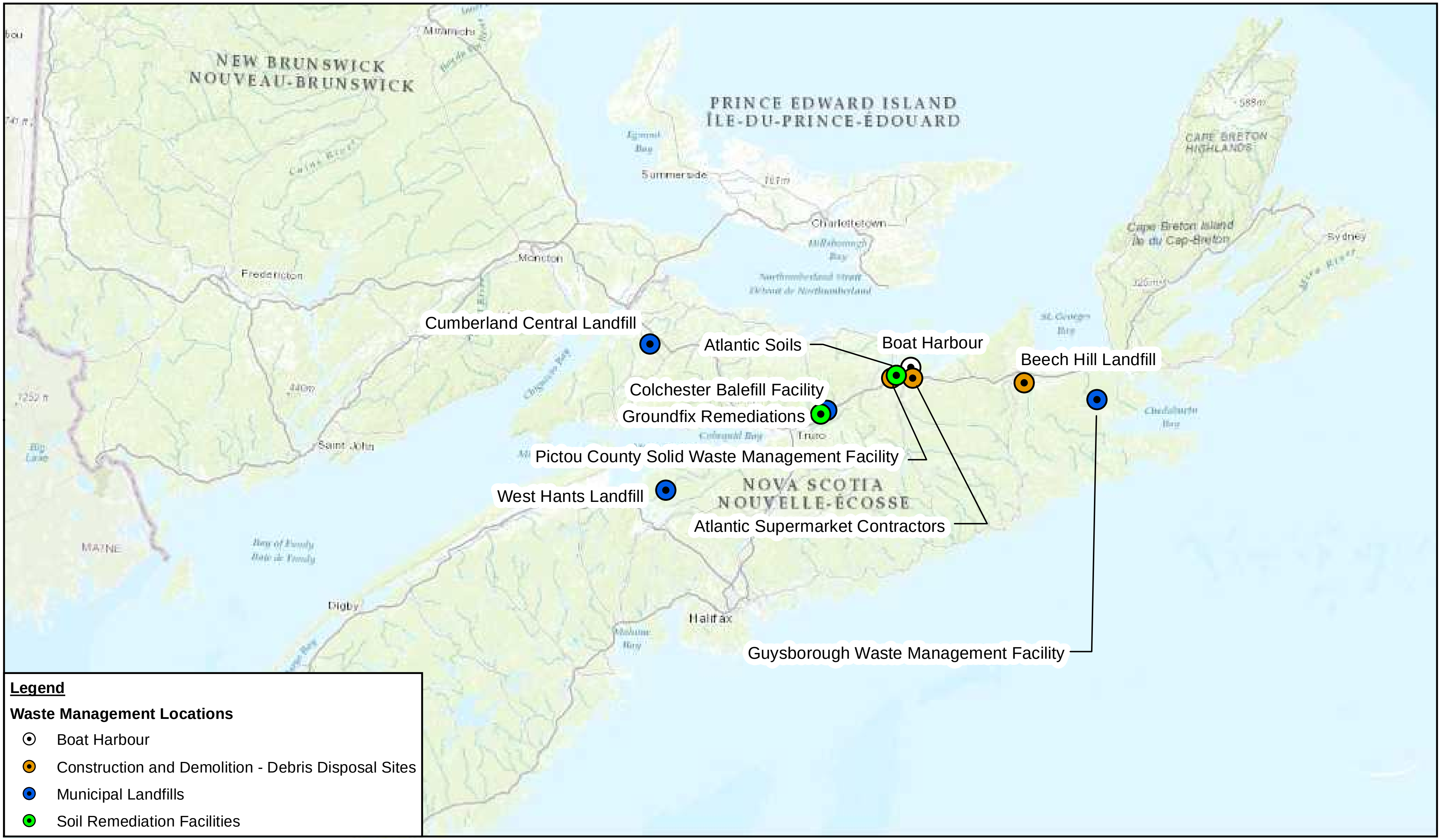
EXISTING DISPOSAL CELL - PROPOSED COVER DESIGN

11148275-09

Jan 25, 2018

FIGURE D6

CAD File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GN-DA00D6.dwg



Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

0 25 50 75
Kilometres

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
WASTE MANAGEMENT

11148275-09
Jan 25, 2018

OFFSITE DISPOSAL LOCATION PLAN

FIGURE D7

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA00D7.mxd

Attachment D1

Attachement D1

Class D Cost Estimate
Feasible Concept 1A - Use Existing Disposal Cell
Leachate Disposed at Municpal Facility
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Allowance for Improvements to Base Liner	LS	-	-	$ 1,000,000
2	Shaping of Disposal Cell Prior to Final Cover Placement	M2	61,500	$ 5	$ 307,500
3	**Final Cover Construction**				$ -
3.1	Grading Pad Sand Layer (300 mm)	M2	61,500	$ 19	$ 1,168,500
3.2	40 mil LDPE Liner	M2	61,500	$ 14	$ 861,000
3.3	Drainage Sand Layer (300 mm)	M2	61,500	$ 19	$ 1,168,500
3.4	Vegetative Layer Topsoil (150 mm) and Hydroseed	M2	61,500	$ 9	$ 553,500
3.5	Erosion Control Blanket	M2	61,500	$ 3	$ 184,500
4	**Stormwater Management**				
4.1	Clear and Grub Pond Area	M2	6,000	$ 4	$ 24,000
4.2	Low Permeable Fill for Pond Berms and Floor	M3	1,000	$ 80	$ 80,000
4.3	Select Fill for Pond Berms	M3	2,600	$ 40	$ 104,000
4.4	Allowance for Culverts and Rip Rap	LS	-	-	$ 30,000
4.5	Vegetative Layer Topsoil (150 mm) and Hydroseed for Pond	M2	1,100	$ 9	$ 9,900
4.6	Clear and Grub Ditch	M2	3,500	$ 4	$ 14,000
4.7	Vegetative Layer Topsoil (150 mm) and Hydroseed for Ditch	M2	3,500	$ 9	$ 31,500
4.8	Erosion Control Blanket for Ditch	M2	3,500	$ 3	$ 10,500
5	**Leachate Management**	LS	-	-	$ 430,000
6	**Site Upgrades**				
6.1	Allowance to Upgrade Existing Road	LS	-	-	$ 150,000
6.2	Remove and Replace Chain Link Fence (1.8 m)	LM	1,700	$ 120	$ 204,000
6.3	New Swing Gate (6 m wide)	EA	1	$ 7,500	$ 7,500
6.4	Allowance for Signage	LS	-	-	$ 6,000
6.5	Allowance for Placement of Trees and Shrubs	LS	-	-	$ 50,000
				Total Class D Cost Estimate	$ 6,394,900
				Total Class D Cost Estimate (Rounded, -4)	**$ 6,400,000**
Part B - Long Term Operations and Maintenance (O&M)					
7	Annual Monitoring and Reporting	Y	25	$ 120,000	$ 3,000,000
8	Post Closure Care	Y	25	$ 20,000	$ 500,000
9	Leachate Management	Y	25	$ 80,000	$ 2,000,000
				Total Class D O&M Cost Estimate	$ 5,500,000
				Total Class D O&M Cost Estimate (Rounded, -4)	**$ 5,500,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Final cover based on 4(H):1(V) slopes constructed to a maximum elevation of 28 m AMSL
   - Stormwater pond constructed using earthen berms with low permeable clay liner along the inside slope and floor
   - Leachate will be disposed at an off-Site licensed municipal wastewater treatment facility (capital costs include a truck loadin
   - 25 year contaminating life span

Attachement D1

Class D Cost Estimate
Feasible Concept 1B - Use Existing Disposal Cell
Leachate Disposed at Industrial Facility
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Allowance for Improvements to Base Liner	LS	-	-	$ 1,000,000
2	Shaping of Disposal Cell Prior to Final Cover Placement	M2	61,500	$ 5	$ 307,500
3	**Final Cover Construction**				$ -
3.1	Grading Pad Sand Layer (300 mm)	M2	61,500	$ 19	$ 1,168,500
3.2	40 mil LDPE Liner	M2	61,500	$ 14	$ 861,000
3.3	Drainage Sand Layer (300 mm)	M2	61,500	$ 19	$ 1,168,500
3.4	Vegetative Layer Topsoil (150 mm) and Hydroseed	M2	61,500	$ 9	$ 553,500
3.5	Erosion Control Blanket	M2	61,500	$ 3	$ 184,500
4	**Stormwater Management**				
4.1	Clear and Grub Pond Area	M2	6,000	$ 4	$ 24,000
4.2	Low Permeable Fill for Pond Berms and Floor	M3	1,000	$ 80	$ 80,000
4.3	Select Fill for Pond Berms	M3	2,600	$ 40	$ 104,000
4.4	Allowance for Culverts and Rip Rap	LS	-	-	$ 30,000
4.5	Vegetative Layer Topsoil (150 mm) and Hydroseed for Pond	M2	1,100	$ 9	$ 9,900
4.6	Clear and Grub Ditch	M2	3,500	$ 4	$ 14,000
4.7	Vegetative Layer Topsoil (150 mm) and Hydroseed for Ditch	M2	3,500	$ 9	$ 31,500
4.8	Erosion Control Blanket for Ditch	M2	3,500	$ 3	$ 10,500
5	**Leachate Management**	LS	-	-	$ 430,000
6	**Site Upgrades**				
6.1	Allowance to Upgrade Existing Road	LS	-	-	$ 150,000
6.2	Remove and Replace Chain Link Fence (1.8 m)	LM	1,700	$ 120	$ 204,000
6.3	New Swing Gate (6 m wide)	EA	1	$ 7,500	$ 7,500
6.4	Allowance for Signage	LS	-	-	$ 6,000
6.5	Allowance for Placement of Trees and Shrubs	LS	-	-	$ 50,000
				Total Class D Cost Estimate	$ 6,394,900
				Total Class D Cost Estimate (Rounded, -4)	**$ 6,400,000**
Part B - Long Term Operations and Maintenance (O&M)					
7	Annual Monitoring and Reporting	Y	25	$ 120,000	$ 3,000,000
8	Post Closure Care	Y	25	$ 20,000	$ 500,000
9	Leachate Management	Y	25	$ 540,000	$ 13,500,000
				Total Class D O&M Cost Estimate	$ 17,000,000
				Total Class D O&M Cost Estimate (Rounded, -4)	**$ 17,000,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Final cover based on 4(H):1(V) slopes constructed to a maximum elevation of 28 m AMSL
   - Stormwater pond constructed using earthen berms with low permeable clay liner along the inside slope and floor
   - Leachate will be disposed at an off-Site licensed industrial wastewater treatment facility (capital costs include a truck loading
   - 25 year contaminating life span

Attachement D1

Class D Cost Estimate
Feasible Concept 1C - Use Existing Disposal Cell
Leachate Treated On-Site
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Capital Costs							
1	Allowance for Improvements to Base Liner	LS	-		-	$	1,000,000
2	Shaping of Disposal Cell Prior to Final Cover Placement	M2	61,500	$	5	$	307,500
3	**Final Cover Construction**					$	-
3.1	Grading Pad Sand Layer (300 mm)	M2	61,500	$	19	$	1,168,500
3.2	40 mil LDPE Liner	M2	61,500	$	14	$	861,000
3.3	Drainage Sand Layer (300 mm)	M2	61,500	$	19	$	1,168,500
3.4	Vegetative Layer Topsoil (150 mm) and Hydroseed	M2	61,500	$	9	$	553,500
3.5	Erosion Control Blanket	M2	61,500	$	3	$	184,500
4	**Stormwater Management**						
4.1	Clear and Grub Pond Area	M2	6,000	$	4	$	24,000
4.2	Low Permeable Fill for Pond Berms and Floor	M3	1,000	$	80	$	80,000
4.3	Select Fill for Pond Berms	M3	2,600	$	40	$	104,000
4.4	Allowance for Culverts and Rip Rap	LS	-		-	$	30,000
4.5	Vegetative Layer Topsoil (150 mm) and Hydroseed for Pond	M2	1,100	$	9	$	9,900
4.6	Clear and Grub Ditch	M2	3,500	$	4	$	14,000
4.7	Vegetative Layer Topsoil (150 mm) and Hydroseed for Ditch	M2	3,500	$	9	$	31,500
4.8	Erosion Control Blanket for Ditch	M2	3,500	$	3	$	10,500
5	**Leachate Management**	LS	-		-	$	2,770,000
6	**Site Upgrades**						
6.1	Allowance to Upgrade Existing Road	LS	-		-	$	150,000
6.2	Remove and Replace Chain Link Fence (1.8 m)	LM	1,700	$	120	$	204,000
6.3	New Swing Gate (6 m wide)	EA	1	$	7,500	$	7,500
6.4	Allowance for Signage	LS	-		-	$	6,000
6.5	Allowance for Placement of Trees and Shrubs	LS	-		-	$	50,000
					Total Class D Cost Estimate	$	8,734,900
					Total Class D Cost Estimate (Rounded, -4)	**$**	**8,740,000**
Part B - Long Term Operations and Maintenance (O&M)							
7	Annual Monitoring and Reporting	Y	25	$	120,000	$	3,000,000
8	Post Closure Care	Y	25	$	20,000	$	500,000
9	Leachate Management	Y	25	$	250,000	$	6,250,000
					Total Class D O&M Cost Estimate	$	9,750,000
					Total Class D O&M Cost Estimate (Rounded, -4)	**$**	**9,750,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Final cover based on 4(H):1(V) slopes constructed to a maximum elevation of 28 m AMSL
   - Stormwater pond constructed using earthen berms with low permeable clay liner along the inside slope and floor
   - Leachate will be treated on-Site
   - 25 year contaminating life span

Attachement D1

Class D Cost Estimate
Feasible Concept 2A - Off-Site Disposal
Sludge/Sediment Disposal Tip Fee of $25 per Tonne
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	**Sludge/Sediment Waste**				
1.1	Loading Sludge	T	628,590	$ 5	$ 3,142,950
1.2	Trucking of Sludge Material To Landfill	T	628,590	$ 15	$ 9,428,850
1.3	Tip Fee For Sludge Material	T	628,590	$ 25	$ 15,714,750
2	**C&D Debris**				
2.1	Loading C&D Debris	T	1,400	$ 8	$ 11,200
2.2	Trucking C&D Debris to Disposal Facility	T	1,400	$ 17	$ 23,800
2.3	Tip Fee for C&D Debris	T	1,400	$ 130	$ 182,000
				Total Class D Cost Estimate	**$ 28,503,550**
				Total Class D Cost Estimate (Rounded, -4)	**$ 28,510,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
   - Bottom up estimation
3. Key assumptions include:
   - Sludge is assumed to be disposed of at a landfill that is approximately 55 km from the site
   - Landfill tip fee for sludge assumes that material can be used as daily cover soil
   - Landfill can accept volume of sludge waste over the anticipated remediation duration (i.e., no daily load limits)
   - C&D waste is assumed to be disposed of at a C&D facility that is approximately 15 km from the site

Attachement D1

Class D Cost Estimate
Feasible Concept 2B - Off-Site Disposal
Sludge/Sediment Disposal Tip Fee of $115 per Tonne
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	**Sludge/Sediment Waste**				
1.1	Loading Sludge	T	628,590	$ 5	$ 3,142,950
1.2	Trucking of Sludge Material To Landfill	T	628,590	$ 15	$ 9,428,850
1.3	Tip Fee For Sludge Material	T	628,590	$ 115	$ 72,287,850
2	**C&D Debris**				
2.1	Loading C&D Debris	T	1,400	$ 8	$ 11,200
2.2	Trucking C&D Debris to Disposal Facility	T	1,400	$ 17	$ 23,800
2.3	Tip Fee for C&D Debris	T	1,400	$ 130	$ 182,000
				Total Class D Cost Estimate	**$ 85,076,650**
				Total Class D Cost Estimate (Rounded, -4)	**$ 85,080,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
   - Bottom up estimation
3. Key assumptions include:
   - Sludge is assumed to be disposed of at a landfill that is approximately 55 km from the site
   - Landfill tip fee for sludge assumes that material cannot be used as daily cover soil
   - Landfill can accept volume of sludge waste over the anticipated remediation duration (i.e., no daily load limits)
   - C&D waste is assumed to be disposed of at a C&D facility that is approximately 15 km from the site

Appendix E
Wetland Management Detailed Concept Descriptions

Appendix E Wetland Management Detailed Concept Descriptions

1. Overview

The Boat Harbour Effluent Treatment Facility (BHETF) consists of the wastewater effluent pipeline, twin settling basins, aeration stabilization basin (ASB), and the Boat Harbour stabilization lagoon. Effluent from Boat Harbour discharges through a dam into the estuary before being released to the Northumberland Strait. Between 1967 and 1972, prior to the construction of the twin settling basins and ASB, effluent was routed by open ditch from the pipeline on the east side of Highway 348 to a natural wetland area (Former Ponds 1, 2, and 3) before being discharged into the stabilization lagoon.

The delineation of impacted wetland areas is shown on Figure E1. The impacted area is approximately 38 ha and contains approximately 260,000 m^3 of sludge and root mass to be managed. This estimate assumes 0.3 m of root mass over the entire impacted area will need to be managed.

Wetland management activities will require management of sludge that is impacted with contaminants of concern (COCs) including metals, total petroleum hydrocarbons (TPH), polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyl (PCB), dioxins and furans (D&F), and volatile organic compounds (VOC) to be managed, treated, or removed. Analytical results for surface water samples collected from the wetland areas identified concentrations of COCs below applicable screening guidelines or similar to background conditions.

Three Feasible Concepts for wetland management were developed as follows:

1. Feasible Concept 1: Natural attenuation
2. Feasible Concept 2: Ex-situ remediation

It is noted that Feasible Concept 1 (natural attenuation) is not considered for any Pictou Landing First Nation (PLFN) land including Indian Reserve Land. Only full removal of impacted sediments has been assumed for these lands based on objectives discussed with the Department of Indigenous Services Canada and PLFN.

2. Objectives

The objectives for managing impacted wetlands as part of remediation of the Site are:

- Supporting return of Boat Harbour to tidal conditions, including protection of ecological and human health
- Limit wetland destruction where possible to support a wetland compensation plan yielding a minimum net positive environmental benefit of 2:1 replacement
- Utilizing technologies that are proven at a commercial scale
- If sludge is to be completely removed, remaining sediments will meet sediment quality standards established as outlined in the Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQSs) for Sediment (Freshwater Sediment) and Canadian Council of Ministers of the Environment (CCME) Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Freshwater Probable Effects Level) or risk-based criteria that is protective of ecological and human health.

- Where in-situ techniques are employed, ensuring that risk to the environment and human health is minimized with appropriate monitoring to ensure early implementation of any mitigative measures, as needed.
- Minimize remediation costs

3. Feasible Concept 1 – Natural Attenuation

3.1 Overview

Wetlands are a diverse group of natural ecosystems that range from salt marshes to prairie potholes to riparian forests and forested swamps. The wetlands associated with the Site have been classified as marsh and swamp wetlands or a combination of the two wetland types. Wetlands serve as nursery areas for many fish species as well as habitat for a numerous wildlife species included federally and provincially listed species at risk. Wetlands are often rich in nutrients and organic matter and are among the most productive ecosystems as they form the base of complex producing the biomass that forms the base of complex food webs.

Although there is an abundance of scientific literature on the use of wetlands as water treatment systems, there is relatively little that addresses remediation and risk reduction in wetlands containing contaminants. The paucity of this literature is due in part to the priority given by regulators and the regulated community to conventional remedial measures, such as excavation to address contamination in wetlands. Unfortunately, these conventional remediation approaches often destroy the integrity of the wetlands ecosystem by removing vegetation and hydric soils, altering hydrology, and displacing wildlife and other biota that use the wetlands. Because wetlands systems represent a delicate balance of hydrology, soils, and vegetation, it may be impossible to fully, or even partially, re-create wetland functions following remediation. Moreover, even under the best of conditions and the most optimistic scenarios, restoring ecological structure and functions, such as habitat for wildlife, to "remediated" marsh or swamp wetlands can be very long term (decades). Conventional methods of remediation are also problematic because even if basic functions can be restored, the resulting wetlands may vary significantly from natural wetlands. Recognizing the adverse impacts associated with active remediation, natural attenuation and risk assessment in wetlands has become an increasingly important risk management consideration in the evaluation of remedial alternatives.

The primary advantage of this remedial approach is that minimal intrusive construction activities are required and the habitat and wildlife receptors currently utilizing this habitat are not disturbed and are allowed to naturally evolve to the current environmental conditions. Undertaking any intrusive remedial construction activities would alter or destroy the current ecological functions that the habitat currently provides, as well as displace the wildlife species utilizing the habitat.

3.2 Natural Attenuation Processes

Natural attenuation is commonly used as a viable remedial option to address residual impacts to an ecosystem after the contaminant source has been removed or eliminated. As such, with the elimination of the mill effluent to the wetland area, and following planned remediation of other areas of the Site, additional loading of COCs to the wetland area is expected to be significantly reduced or eliminated compared to current conditions and allows for the natural attenuation processes to begin. In association with natural attenuation of COCs in wetlands is the concept of risk assessment. Risk assessment is the process to estimate the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment) now or in the future.

Typical natural attenuation processes in wetlands involve one or more biological, chemical or physical processes. One specific process that is likely to have significant potential to reduce risk to human health and ecological receptors in wetland is the reduction in the bioavailability of organic and inorganic COCs in sediment, of which adsorption, biodegradation, cation and anion exchange are the most common. Given the predominantly anaerobic environment of wetlands leads to the formation and accumulation of soil that can be very rich in organic carbon. Many chemicals, especially hydrophobic organic chemicals (e.g., dioxins/furans, PCBs, petroleum hydrocarbons, PAHs, etc.) and many heavy metals, bind strongly to organic matter making them effectively unavailable for uptake into tissue. This is specifically true for the Site wetland areas which have total organic carbon in the sediment ranging from approximately 1 percent to >20 percent[1]. Given the high organic carbon content of wetland sediment at the site, adsorption is likely a significant on-going mechanism for reducing bioavailability of site related COCs.

Deposition and burial of sediments can be significant mechanisms of natural attenuation in wetlands. Deposition occurs when the velocity of water in wetlands is slowed to the point where the water can no longer hold particles in suspension. The suspended particles settle out of the water column and become trapped in wetlands. Contaminants that are adsorbed to these particles are also deposited and trapped. Accordingly, wetlands are commonly referred to as nutrient and sediment "sinks". Burial occurs when multiple depositional events occur over time, with each subsequent event depositing a layer of sediments or particulate matter over previously deposited layers. The tandem processes of deposition and burial can provide a mechanism for natural attenuation if future sediments deposition is of "clean" material. Although the buried COCs may persist, deposition and burial can be effective mechanisms for reducing risk by eliminating the exposure pathway.

3.3 Risk Assessment

The risk-based approach is a widely-accepted scientific method to evaluate potential environmental impacts and to estimate if these impacts are likely to cause adverse health effects to humans or ecological receptors. The risk assessment process requires thorough evaluation of potential contaminants associated with a specific site or property, identification of human and ecological receptors that may use the property, and ways these receptors may be exposed to potential contaminants (e.g., direct exposure to soil, consumption of plants/wildlife, consumption of water, etc.). The primary benefit of using the risk-based approach is that it allows for a site-specific evaluation of potential interactions between receptors and contaminants in the environment and focusses future clean-up activities or management programs on the areas of greatest concern. This approach used in conjunction with natural attenuation also has the potential to minimize remedial efforts and unnecessary disturbances to sensitive environments, such as wetlands, that are unlikely to pose an adverse health effect, now or in the future.

The Canadian Council of Ministers of the Environment (CCME) has developed guidelines for screening substances in soil, sediment and water on Federal lands across Canada. The majority of these guidelines have also been adopted by Nova Scotia Environment for use at properties in Nova Scotia. However, these nation-wide guidelines are only intended for general guidance purposes and may not be appropriate in all locations or for use as remediation criteria. For instance, natural levels of some metals in soils of Nova Scotia (e.g., arsenic) are actually higher than the CCME guideline. Therefore, local conditions must be considered when applying these values. In addition, these screening guidelines, specifically sediment quality guidelines, do not account for potential effects to upper trophic level receptors or human health

[1] GHD, 2018. Phase 2 Environmental Site Assessment for Boat Harbour Project. To be submitted in June 2018.

from exposure to bioaccumulative COCs such as dioxin/furans. Risk assessment requirements are further discussed in the following sections specific to ecological and human health consideration.

3.3.1 Ecological Risk Assessment

Preliminary screening of COCs in sediment of the wetland area against CCME or NSE guidelines identified concentrations of several organic contaminants (specifically dioxins/furans, petroleum hydrocarbons, PAHs and PCBs) as well as several metals as exceeding these generic criteria. However, the majority of these COCs have a strong affinity to organic carbon which renders them relatively immobile and not bioavailable. The guidelines used for screening COCs in sediment are primarily based on protection of benthic invertebrates but the bioavailability or toxicity of these contaminants is linked to the organic carbon content of the sediment (higher the organic carbon, lower the bioavailabilty or toxicity). Bioavailability models developed by the United States Environmental Protection Agency (USEPA) (i.e., equilibrium partitioning) and endorsed by various Canadian jurisdictions including Environment Canada (EC) are commonly used in risk assessments to evaluate potential risk to invertebrates. These theoretical models along with field investigations can provide multiple lines of evidence to determine if concentrations of COCs in sediment are likely to pose an adverse risk to benthic invertebrate communities. In addition, the recent industry trend is to include analysis of sediment pore water as another line of evidence to determine if organic and inorganic contaminants are bioavailable. As toxicity to benthic organisms is a function of the concentrations of chemical constituents in water in the interstitial spaces, chemical analysis of pore water provides a direct measurement of the bioavailability of chemicals detected in bulk sediment.

Given the high organic carbon content in wetland sediment at the site, it is reasonable to assume that concentrations of COCs exceeding generic screening guidelines does not necessarily indicate a potential for risk to ecological receptors, specifically invertebrates. It is expected that development of site-specific risk assessment models and additional sampling (such as pore water) would provide multiple lines of evidence indicating that the concentrations of COCs in the majority of wetland sediment do not pose an unacceptable risk to benthic invertebrates.

As indicated in the preceding paragraphs, sediment screening guidelines are based on potential affects to benthic invertebrates as these organisms are in direct contact with COCs in sediment. However, several of the COCs associated with the site are potentially bioaccumulative (i.e., dioxins/furans, PCBs, mercury). As such, the natural attenuation and risk assessment remedial option must ensure protection of upper trophic level organisms that may use the wetland for breeding habitat or for foraging. Therefore, the first step in the risk assessment process will be to develop a conceptual site model (CSM) to determine potential ecological receptors for inclusion in the risk assessment and potential contaminant exposure pathways. Food chain models can then be developed to quantitatively evaluate potential risks to wildlife receptors from exposure to bioaccumulative COCs in wetland sediment or from consumption of COCs in food items. A key component in developing future site-specific ecological risk assessment models will be development of site-specific uptake factors. There are uptake factors and regression equations available in literature which estimate the concentration of COCs in biological tissue from exposure to sediment (i.e., sediment-to-invertebrates, sediment-to-fish, sediment-to-plants, etc.). However, these "book values" are highly conservative and do not accommodate for the concentration of organic carbon in sediment or the bioavailability of the contaminant. Future risk assessment models will, therefore, require sampling of biological tissue such as plants (including fruits and berries), invertebrates, fish, birds, and/or small mammals and the data obtained incorporated into the risk assessment models.

The primary benefit to completing a detailed ecological risk assessment model is to identify the most sensitive site-specific receptor such that benchmarks can be developed to guide future remediation activities. As a best case scenario, the risk assessment would provide multiple lines of evidence indicating that current conditions of the wetland areas do not pose an unacceptable risk to ecological receptors and natural attenuation processes will continue to meet remedial objectives. The worst case scenario is likely to be that the risk assessment identifies isolated hotspots in the wetland areas that require active remediation or risk management measures.

3.3.2 Human Health Risk Assessment

Health Canada recently released guidance on evaluating human health exposure to COCs in sediment (Health Canada, Supplemental Guidance on Human Health Risk Assessment of Contaminated Sediments: Direct Contact Pathway, March 2017). The guidance document indicates that soil screening guidelines protective of human health should also be used for screening of sediment if there is the potential for humans to be in direct contact with the sediment. A preliminary review of the analytical data available for the wetland areas[2] indicate that the concentrations of COCs in the majority of wetland sediment samples collected in 2017 are below human health screening levels for direct contact. The exception would be total concentrations of dioxin and furans using total equivalency factors (TEF) for mammals. The dioxin/furan TEF guideline for the protection of humans for direct contact and ingestion is 4 ng/g. Several of the sediment samples collected from the wetland areas have total concentrations of dioxin/furans significantly exceeding this screening value. However, the NSE and CCME screening values are based on ambient background concentrations of these chemicals across Canada and are not specifically based on protection of humans or risks to human health.

If the natural attenuation and risk assessment remedial option is selected as a viable option, future evaluations must include the development of a human health CSM including exposure estimates to ensure current and future concentrations of COCs, specifically bioaccumulative COCs, do not pose an unacceptable risk to human health. In addition, the wetland areas have the potential for future use as a food source by local citizens or traditional land uses by Pictou Landing First Nation (PLFN). Future evaluation of risk to human health must consider all potential pathways of exposure and receptors, not just the direct exposure pathway. Examples of potential exposure pathways that would require review as part of future human health risk assessment include (but are not limited to) the following:

- Use of the wetland as a recreational fishery by local citizens or traditional fishery area by PLFN
- Consumption of plants, berries, fruit, nuts collected from the wetland by local citizens or PLFN
- Consumption of birds (waterfowl) harvested in the wetland by local citizens or PLFN

It is anticipated that the critical driver for risk to human health and the requirement for remediation or risk management in the wetland areas will be related to human exposure to dioxin/furans in sediment or food items. Similar to the ecological considerations, future risk assessment models will, therefore, require sampling of biological tissue such as plants (including fruits and berries), fish, birds and/or small mammals that may provide a food source for humans and the data obtained incorporated into the risk assessment models. The future human health risk assessment will also likely require additional assessment of dioxin/furans (as well as other COCs) in other media in the area (soil, drinking water, etc.), to evaluate potential cumulative exposure effects related to human health.

3.4 Wetland Area Functions and Values

As the site wetland areas likely provide habitat for a variety of wildlife receptors, the goal of any remedial work will be the maintenance of the ecological function that the wetlands provide or has the potential to

[2] GHD, 2018. Phase II Environmental Site Assessment for Boat Harbour Project. To be submitted in June 2018.

provide to wildlife. In addition, the wetlands have the potential to be used as a recreational resources by local citizens or traditional land uses by PLFN. Wetland ecological functions are natural physical, biological and chemical processes that are associated with wetlands, independent of how wetlands benefit humans. Unlike functions, wetland values reflect ecosystem services provided from the wetland that benefits humans. The Federal Policy on Wetland Conservation indicates that the objective of the Federal Government is to promote the conservation of Canada's wetlands to sustain their ecological and socio-economic functions and have also identified policy goal of "no-net loss" of wetland function.

Historically, the wetland evaluation guide developed jointly by EC and Wildlife Habitat Canada (Bond et al, 1992) was commonly used as the guiding document for identifying wetland functions and values in the project planning decision process. However, more recent publications prepared by EC (2008) provide an overview of potential approaches used in Wetland Functionality Assessment (WFA) and recommends methods used in Ohio, Minnesota, Wisconsin and Washington. EC acknowledges that there is no one specific methodology that will meet every assessment need but discourages the use of Bond et al. (1992) to evaluate wetland functions. The Province of Nova Scotia has also adopted a process of evaluating wetland functions through a method called NovaWET. This method is designed to assess the condition and functions of Nova Scotia wetlands and is intended to provide NSE with basic information for Wetland Alteration or Environmental Assessment Applications.

Therefore, in an effort to evaluate the functions and values that the site wetland areas provide, completion of a WFA in general accordance with the procedures and guidance provided in the EC 2008 document will likely be required as part of the natural attenuation and risk assessment remedial options implementation. The guidance document has identified WFA as a tiered approach consisting of the following:

- Level 1: Landscape Level, identifies the importance of the wetland within in the broader landscape.
- Level 2: Rapid Assessments, utilizes assessment techniques that suit the project's needs and are appropriate for the region. Some jurisdictions have proposed the use of wetland functions rapid assessment methods which are also recommended and outlined in the EC 2008 document.
- Level 3: Detailed Assessments, uses different assessment methodologies that focus on specific wetland functions or information requirements and may combine the utilization of detailed field observations, flora and fauna evaluations and Index of Biological Integrity (IBI) among other techniques.

Using this tiered approach, each level can be used to validate and inform the others. For the purpose of this management plan, it is assumed that a Level 1 Landscape Level evaluation has been completed for the wetland as previous assessments have specifically documented drainage patterns for the subject wetland and associated watercourses. The WFA likely required in the future include Level 2 - Rapid Assessment and Level 3 - Detailed Assessment. Rapid assessment methods are considered specifically important as they can provide sound, quantitative information on the status of the wetland resource and establish a baseline for future monitoring. Detailed Assessments are used to calibrate or validate the rapid methods and better understand cause and environmental effect relationships.

Specific requirements included in the rapid assessment include but are not limited to:

- Wetland description and class based on published inventories
- Wetland Size estimated using aerial photographs (a field wetland delineation is not included as part of this investigation)
- Hydrological Setting
- Dominant Vegetation Communities

- Soils
- Anthropogenic Influences and Surrounding Land Area Uses
- Evaluation of Specific Wetland Functions Present (i.e., salmonid habitat)

To supplement Rapid Assessments, the USEPA has created a series of reports on assessing wetland conditions using IBIs for invertebrates, algae, nutrients, amphibians, birds, vegetation and land use. These methods are considered Detailed Assessments and are termed Biological Assessments due to their focus on biota. As part of the WFA, it is expected that a detailed inventory of the wetland plant community would be completed to assess species richness/diversity, types of plants present (i.e., percent free floating versus emergent), and to document the presence/absence of invasive species or plant species that are chemical tolerant. As described in the USEPA wetland conditions reports, plants are considered excellent indicators of wetland condition for many reasons including their relatively high levels of species richness, rapid growth rates, and direct response to environmental change. Many human-related alterations to the environment that act to degrade wetland ecosystems cause shifts in plant community composition that can be quantified easily. For comparison purposes, a reference wetland of similar type and size would be selected to establish background floral assemblages in the area. The comparison of the wetland plant community in the wetland areas to a reference area will facilitate the development of IBIs for the wetland areas as well as developing potential gradients of human or chemical disturbances (if any).

Similar to developing IBIs based on wetland plant assemblages, a quantitative evaluation could also be completed specific to anurans (frogs and toads) and/or benthic invertebrates in the wetland areas and compared to a similar reference wetland(s). Frogs and invertebrates are frequently used as indicators of environmental health of an aquatic ecosystem as they complete at least a portion of their life cycle in water and are sensitive to anthropogenic inputs in aquatic environments. The presence of a diverse anuran or invertebrate assemblage (or similar bio-indicator) in the wetland areas would provide quantitative and qualitative information that contaminants of concern in sediment are not adversely affecting sensitive wildlife populations or communities. These bio-indicators could also be used as indices for post-remediation monitoring success to ensure active remediation in other areas of the site have not adversely affected habitat in the wetland areas.

3.5 Risk Management

As indicated in the preceding sections, there is the potential that the natural attenuation and risk assessment remedial option would determine that current concentrations of COCs in the wetland areas do not pose an unacceptable risk to ecological receptors or human health and additional remediation or risk management is not required. However, there is the potential that the risk assessment identifies isolated hotspots in the wetland areas that require active remediation or implementation of risk management measures. There are several non-intrusive risk management options that could be implemented to reduce risk to human health or ecological receptors including (but not limited to) the following:

- Restrict or reduce future access to the wetland area (potentially create wetland viewing areas and post signs indicating sensitive habitat, do not disturb)
- Restrict future hunting or fishing activities in the wetland
- Enhance ecological habitat in "clean" wetland areas to promote areas for foraging or breeding by wildlife (i.e., construction of bird nesting sites, planting of preferred native wetland food such as wild rice, etc.)
- Develop a long term monitoring plans including IBIs along with site-wide risk review to evaluate wetland conditions in conjunction with intrusive remediation of other areas of the site.

Active remedial options for the wetland areas are discussed further in the following sections.

3.6 Active Remediation

If isolated hotspots exist and risk management is deemed insufficient, active remediation of select areas will be completed. This may include full remediation through ex-situ impact removal, as discussed under Feasible Concept 2 below or preferably would consist of less destructive in-situ remediation. In-situ techniques include enhanced natural recovery and encapsulation.

Enhanced natural recovery, or sediment amendment, is a remedial approach that relies on natural subsurface mechanisms that are classified as either destructive or non-destructive. Biodegradation is the most important in-situ destructive mechanism, while non-destructive mechanisms include sorption, dispersion, dilution, and volatilization. Enhanced natural recovery applies materials or amendments to enhance these natural recovery processes such as the addition of a biological stimulant or a carbon amendment. Sediment amendment speeds the development of a surface layer of cleaner sediment, which results in the reduction of surface chemical concentrations.

Encapsulation, or stabilization, is the addition of chemicals to encapsulate contaminated sediments into a solidified mass that reduces contaminant mobility and bioavailability. The solid matrix created by the sediment, water, and solidifying agent encapsulates any contaminants present within the solid matrix such that they are no longer available and cannot leach out. Chemical binding agents may include activated carbon, organo clay for organics, or phosphate salts for metals.

Wetlands' high capacity for biodegradation enhanced with the addition of an electron acceptor such as sulfate should degrade TPH, PAH, and VOC. PCB and dioxins and furans are bound to wetland sediments and will not leach, however colloidal organic carbon could be injected to provide additional assurance that these compounds are irreversibly bound and will not leach out of the wetland. Metals could be precipitated as insoluble metal sulfides either biologically with the enhancement of sulfate injection or chemically by the injection of a sulfur-containing reducing agent. Alternatively, metals could be bound to colloidal activated carbon. Metals bound to carbon or precipitated as sulfides will not leach.

Placement and mixing of the amendments/solidifying agents can occur in subaqueous or dry conditions with heavy equipment, though mixing is typically more successful and requires less reagent in dry conditions compared to wet conditions. Care should be taken during mixing to limit impact to and destruction of wetland features.

4. Feasible Concept 2 – Ex-Situ Remediation

4.1 Removal

This Feasible Concept proposes dewatering the wetlands, as needed, and removing impacted sediments through excavation using land-based earthmoving equipment. Dewatering is required for equipment access and will limit re-suspension and dispersion of impacted sediments into surface water downstream of the work area. Installation and continuous operation of a pumping system to maintain a dewatered condition would be accomplished through the establishment of sumps in several locations through out the wetland and pumping the water from bulk dewatering to a water management area[3]. Sumps could be established in open water first, with additional sumps added as needed. Sumps could be established using a perforated steel chamber filled with clear stone to minimize sedimentation.

[3] As outlined in Appendix G Remediation Detailed Concept Descriptions

Construction of access roads around the wetlands to facilitate dewatering and removal activities would be required. Targeted sediment excavation would be completed to limit level of disturbance. Excavators will remove wetland vegetation and root mass as well as sludge, stockpile it at the base of the dewatered area, and load it into dump trucks (sealed as required) or into a hopper for pumping. Dozers may be used to push and stockpile sludge. Specialized equipment may be required; for example a swamp buggy excavator with pontoon tracks could be used to better travel across soft and wet ground. Confirmatory sampling will be completed post remediation to confirm that the remaining sediment meets the applicable remedial quality standards for all sediment COCs.

Once excavated, sediment will be managed similarly to the sludge removed from the rest of the Site[4]. This will involve pumping or hauling the sediment to a sludge management area for further treatment and/or dewatering prior to disposal as shown on Figure E2.

The implementation of this Feasible Concept would require careful consideration as to not negatively impact existing wildlife. During dewatering activities, a wildlife removal plan may be required to trap and relocate fish or other aquatic wildlife species. To limit the impact on any fish and other wildlife populations within the system, water levels in the wetlands would only be lowered to a level sufficient for the removal of contaminated sediment. The requirement to conduct a wildlife removal program should be determined in consultation with Department of Fisheries and Oceans (DFO) and NSE. Secondly, to mitigate potential impacts to waterfowl and other migratory birds as well as breeding or spawning aquatic wildlife such as anurans, the construction activities may be limited to late summer or early winter months. These seasonal periods are typically not considered sensitive spawning/breeding/nesting periods and also generally coincide with dry periods which would limit dewatering requirements.

4.2 Restoration

This remedial option would effectively reduce or eliminate the potential for unacceptable risk to ecological receptors by removing the exposure pathway, however it would cause significant short-term damage to the existing habitat. Following the removal of impacted sediment and infilling and regrading to match the existing hydraulic regime, this Feasible Concept would involve restoration of the construction areas including the planting or seeding of native aquatic and terrestrial vegetation. It is important that native species be seeded or planted that are tolerant of the hydrological regimes that would be established following remedial activities. To ensure success of any re-vegetation effort, water budgets that take into account any alteration of inflows and outflows should be developed and used to identify seeding or planting zones within the wetlands. A review of historical occurrence of species in the region would also be useful in developing a detailed vegetation planting plan to re-establish the Site. There may be opportunity to improve the wetland area by removing any invasive species that may be present in the wetland either during or after sediment removal. Either biodegradable erosion control blankets or other methods would be used to eliminate soil erosion until the vegetation has re-established.

5. Feasible Concepts Cost Estimate

Class D capital and O&M cost estimates for each Feasible Concept is provided in Attachment E1 and summarized on Table E.1 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with

[4] As outlined in Appendix G Remediation Detailed Concept Descriptions

general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost for an estimated 5-year period have been carried for Feasible Concept 1.

Table E.1 Wetlands Management Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – Natural Attenuation	$17,420,000	$830,000
Feasible Concept 2 – Ex-Situ Remediation	$41,590,000	$0

Key assumptions include:

- For Feasible Concept 1, ex-situ remediation will be required on PLFN and IR land
- For Feasible Concept 1, a contingency for active remediation of hotspots identified during risk assessment is carried at 25 percent of the full Feasible Concept 2 ex-situ remediation cost
- For Feasible Concept 1, post remediation monitoring for 5 years with parameter limitations noted in cost table
- For Feasible Concept 2, excavated sludge will be pumped to the sludge management area and dewatered using geotubes and treatment of water required as detailed in Appendix G Remediation Detailed Concept Descriptions
- Wetlands disturbed as part of active remediation will be restored/compensated at a rate of 2:1
- Bulk dewatering required for active remediation accounts for a 1:100 year storm

Source: ESRI Imagery; Vivid - Canada, DigitalGlobe, 7/31/2016

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
WETLAND MANAGEMENT

SITE LAYOUT

11148275-09
Mar 15, 2018

FIGURE E1

GIS File: Q:\GIS\PROJECTS\11148000s\11148275\Layouts\005\11148275-09(005)GIS-OT005.mxd

Source: ESRI Imagery; Vivid - Canada, DigitalGlobe, 7/31/2016

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
WETLAND MANAGEMENT

11148275-09
Mar 15, 2018

SITE LAYOUT - ACTIVE REMEDIATION

FIGURE E2

GIS File: Q:\GIS\PROJECTS\11148000s\11148275\Layouts\005\11148275-09(005)GIS-OT006.mxd

Attachment E1

Attachment E1

Class D Cost Estimate
Wetland Management - Feasible Concept 1 Natural Attenuation
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Prepare Work Plan, Field Program Prep and CSM	LS	-	-	$ 30,000
2	Additional Data Collection (Field)	LS	-	-	$ 40,000
3	Human Health and Ecological Risk Assessment	LS	-	-	$ 50,000
4	Wetland Functionality Assessment and IBI Development	LS	-	-	$ 40,000
5	Hydrologic Modeling	LS	-	-	$ 15,000
6	Report Preparation	LS	-	-	$ 140,000
7	Expenses	LS	-	-	$ 10,000
8	Laboratory Fees	LS	-	-	$ 100,000
9	Remediation of IR and PLFN Lands	LS	-	-	$ 6,660,000
10	Contingency for Active Remediation	LS	-	-	$ 10,397,500
	Total Class D Capital Cost Estimate				$ 17,412,500
	Total Class D Capital Cost Estimate (Rounded, -4)				**$ 17,420,000**
Part B - Long Term Operations and Maintenance (O&M)					
11	**Post Remedition Monitoring**				
11.1	Professional Fees and Expenses	$/year	5	$ 65,000.00	$ 325,000
11.2	Laboratory Fees	$/year	5	$ 100,000.00	$ 500,000
	Total Class D O&M Cost Estimate				$ 825,000
	Total Class D O&M Cost Estimate (Rounded, -4)				**$ 830,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -20 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Standard Supplier Price List
3. Key assumptions include:
   - 5-years of post-remediation monitoring will be required (monitoring may not be in consecutive years).
   - Various biological media (tissue, pore water, etc.) will be required in addition to sediment characterization pre and post-remediation to validate the NA approach.
   - Costs do not include surface water sampling for D/F as guidelines currently not available from CCME or NSE.
   - Costs do not include invertebrate or fish toxicity testing (i.e. LC50 testing) as these test are considered unlikely to be required at this time.
   - Remediation will be required on PLFN land, including Indian Reserve land (approximately 16% of the impacted wetland area
   - Contingency for active remediation of hotspots identified during risk assessment is carried at 25% of the full Feasible Concept 2 ex-situ remediation cost.
   - Wetlands disturbed as part of active remediation will be restored/compensated at a rate of 2:1.
   - Bulk dewatering required for active remediation accounts for a 1:100 year storm.

Attachment E1

Class D Cost Estimate
Wetland Management - Feasible Concept 2 Ex-Situ Remediation
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
1	**Site Improvements**				
1.1	Access Road Improvements	LM	2,800	$ 550	$ 1,540,000
2	**Sludge Removal**				
2.1	Bulk Water Management (Initial)	M3	600,000	$ 6	$ 3,600,000
2.2	Bulk Water Management (Ongoing)	M3	269,000	$ 10	$ 2,690,000
2.3	Excavation and Dewatering	M3	263,000	$ 50	$ 13,150,000
2.4	Dewatering Effluent Treatment	M3	60,000	$ 7	$ 420,000
3	**Confirmatory Sampling**				
3.1	Analytical	Sample	392	$ 1,500	$ 588,000
4	**Restoration**				
4.1	Topsoil	M2	392,000	$ 20	$ 7,840,000
4.2	Wetland Revegetation	M2	392,000	$ 5	$ 1,960,000
5	Wetland Compensation (2:1)	M2	392,000	$ 25	$ 9,800,000
				Total Class D Cost Estimate	$ 41,588,000
				Total Class D Capital Cost Estimate (Rounded, -4)	**$ 41,590,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -20 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Access road assumed to be 8 m wide and 1 m above existing grade.
   - Excavated sludge will be pumped to the sludge management area and dewatered using geotubes.
   - Approximately 2,000 m^3 of in place sludge/sediment can be removed and processed daily.
   - Wetlands disturbed as part of active remediation will be restored/compensated at a rate of 2:1.
   - Bulk dewatering required for remediation accounts for a 1:100 year storm.

Appendix F
Infrastructure Decommissioning Detailed Concept Descriptions

Appendix F Infrastructure Decommissioning Detailed Concept Descriptions

1. General

The Boat Harbour Effluent Treatment Facility (BHETF) consists of the wastewater effluent pipeline, twin settling basins, aeration stabilization basin (ASB), and the Boat Harbour stabilization lagoon (Site). Effluent from Boat Harbour discharges through a dam into an estuary before being released to the Northumberland Strait. Prior to the construction of the twin settling basins and ASB, effluent was routed by open ditch from the pipeline on the east side of Highway 348 to a natural wetland area (Former Settling Ponds 1, 2, and 3) before being discharged into the stabilization lagoon. A Site Plan showing key infrastructure is shown on Figure F1.

Key infrastructure components that will need to be decommissioned include:

- Pipeline: The pipeline includes approximately 2,305 m of 0.915 m diameter fiberglass reinforced plastic pipe (RPP) buried on land; and approximately 1,220 m of 1.1 m diameter high density polyethylene (HDPE) pipe buried at the bottom of the East River.
- Treatment Buildings: There are 10 buildings and several small structures that form part of the BHETF. Buildings are typically slab on grade construction or trailer based. Structures include inlet/outlet weirs, retaining walls, maintenance holes, etc.
- Dam: The dam is located north of the Highway 348 causeway and is designed to allow the levels in the Boat Harbour stabilization lagoon to be controlled while blocking the tidal inflow. The dam is approximately 25 m wide and is connected to the banks of the estuary with earthen berms.

1.1 Pipeline

The Feasible Concepts for decommissioning the land portion of the pipeline include:

- Feasible Concept 1: Clean, inspect, and abandon in place
- Feasible Concept 2: Clean, fill, and abandon in place
- Feasible Concept 3: Complete removal

Feasible Concept 3 does not apply to the pipeline under water as this was eliminated during the first Filter (F1) step.

1.2 Treatment Buildings

The Feasible Concepts for decommissioning of the buildings include:

- Feasible Concept 1: Decommission and demolition
- Feasible Concept 2: Repurpose and upgrade

1.3 Dam

The Feasible Concept considered for decommissioning of the dam include:

- Feasible Concept 1: Decommissioning and demolition of the dam

The following sections describe decommissioning objectives, common design elements, and detailed concept descriptions for the Feasible Concepts.

2. Objectives

2.1 Pipeline

The objectives for pipeline decommissioning are to:

- Eliminate potential for environmental contamination from any residuals located in the pipeline
- Minimize the potential for substantial differential settlement or ground subsidence (e.g., due to the pipeline collapsing)
- Eliminating health and safety concerns associated with the pipeline
- Minimize long term maintenance requirements

2.2 Buildings and Structures

The objectives for building and structure decommissioning include the following:

- Ensure that any decommissioning and demolition activities are completed in an environmentally sound manner and following acceptable health and safety practices
- Minimize waste disposal through maximizing opportunities for reuse and recycling of materials
- Any repurposing of Site buildings is consistent with overall project end use objectives/requirements

2.3 Dam

The objectives of the dam decommissioning is to:

- Return Boat Harbour back to the natural tidal conditions
- Prevent the migration of any demolition debris or sedimentation into the estuary or Boat Harbour

3. Common Design Elements

3.1 Pipeline

Cleaning of the pipe will be completed to remove accumulated solid residue and other liquids that otherwise may be released during decommissioning activities or pose as an environmental risk/liability should the pipeline be abandoned in place. Cleaning will render the pipeline free of gross process residues, enabling abandonment of a clean pipeline in place or the shipment of salvageable materials. An inspection (visual or video) and/or water sampling of the flushed water will be performed following cleaning to confirm the pipeline is clean.

The cleaning process will use one or a combination of the processes described below.

- Water flushing would involve filling and pressurizing the pipeline with sea water pumped from the East River using a portable pump.
- Jet rodding would involve inserting a nozzle into the pipeline to scour the inner wall of the pipe using high pressure jets. The nozzle would have a rotating head or a spray pattern to remove built up debris

and ensure the entire inside surface of the pipeline is clean. The operation would involve pumping sea water from the East River nearby using a portable pump.

- Pigging would involve inserting a "PIG" into the pipeline to scour the inner wall of the pipe. The "PIG" would be pushed using fresh water imported in tanks using a portable pump. The "PIG" would be launched from the surface and pushed to the other side.

In each case, spent cleaning water will be discharged into the twin settling basins and managed in accordance with the recommended remedial option for wastewater management, as detailed in Appendix G.

3.2 Building and Structures

Common design elements for buildings/structure decommissioning include: de-energizing facilities and equipment; chemical sweep to remove all chemical and products; cleaning to remove chemical and waste residuals; hazardous material abatement, if any; and disposal of waste and waste products. Any hazardous waste encountered will be disposed of of-Site in accordance with applicable provincial and federal regulations.

4. Pipeline Decommissioning Feasible Concepts

4.1 Background

The pipeline is located on multiple properties including Kraft Mill, residential, provincial, and First Nation properties. The alignment of the pipeline including property ownership information is shown on Figure F2. A summary of the pipeline sections on land is shown in Table F.1 below.

Table F.1 Pipeline on Land Summary

Property ID	Owner	Pipeline Type	Depth (m) From Surface	Pipe Length (m)	Comments
West Shore					
864538	Northern Pulp Nova Scotia Corporation	915 mm ID FRP*	1 – 3 m	320	Includes one access manhole
65103798	Road Parcel Owner Undetermined	915 mm ID FRP*	1 – 3 m	23	Across Granton Abercrombie Branch Road
961284	NS Environment (Province)	915 mm ID FRP*	1 – 5 m	422	Commercial, Part of Pipeline Corridor; Approximately 30 m in width
East Shore					
801241	PLFN - Chief Andrea Paul	915 mm ID FRP*	1 – 3 m	325	Undeveloped, Part of Pipeline Corridor; Pipeline Easement Dated 1966

Table F.1 Pipeline on Land Summary

Property ID	Owner	Pipeline Type	Depth (m) From Surface	Pipe Length (m)	Comments
801282	William James Palmer and Susan Mary Palmer	915 mm ID FRP*	1 – 3 m	563	Residential, Undeveloped, Part of Pipeline Corridor; Pipeline Easement Dated 1966
65098188	Road Parcel Owner Undetermined	915 mm ID FRP*	1 – 3 m	20	Pictou Landing Road
801308	David Ross Rector	915 mm ID FRP*	1 – 3 m	121	Undeveloped, Part of Pipeline Corridor; No Pipeline Leasing Information Available
65098378	Road Parcel Owner Undetermined	915 mm ID FRP*	1 – 3 m	37	
801316	County of Pictou	915 mm ID FRP*	1 – 3 m	25	Undeveloped, Part of Pipeline Corridor; No Pipeline Leasing Information Available
961367	NS Supply and Services (Province)	915 mm ID FRP*	1 – 3 m	425	Undeveloped, Part of Pipeline Corridor; No Pipeline Leasing Information Available
801407	Bernice Evelyn Pace	915 mm ID FRP*	1 – 3 m	51	Undeveloped, Part of Pipeline Corridor; No Pipeline Leasing Information Available

Note:
* FRP = Fiberglass Reinforced Plastic Pipe

The pipeline plan and profile is shown on Figure F3.

4.2 Pipeline Decommissioning Feasible Concept 1 – Clean, Inspect, and Abandon in Place

Feasible Concept 1 consists of cleaning the pipeline, performing an inspection, and abandonment of the pipeline in place. This applies to all portions of the pipeline with exception of the pipeline beneath Highway 348, which should be decommissioned by filling or full removal in accordance with Feasible Concept 2 or 3, respectively.

Cleaning of the pipeline is a common design element described in Section 3.1 above.

Following inspection to render the pipeline clean, the integrity of the pipeline will be evaluated to determine if the pipe integrity is sufficient to minimize differential settlement or ground subsidence due to the pipe collapsing. Corrective action could include additional cleaning and potentially filling or complete removal of segments of the pipeline should imminent collapse be identified through inspection activities.

Integrity inspection could be completed by any of the following options, all of which will meet the intended purpose:

- Manual visual inspection – consists of having experienced personnel go inside the pipeline and manually perform the inspection. This method is currently performed on a yearly basis as part of the Kraft Mill operation.
- "PIG" inspection – consist of sending an inspection "PIG" in the pipeline to perform an automatically recorded inspection. The inspection "PIG" will record the waste thickness and the pipeline conditions using magnetic or ultrasonic tools.
- Video inspection – consists of lowering a camera tractor into the pipeline. The camera is connected to a service truck and records the interior of the pipe. The recording can be assessed in real time and can be recoded and saved for review.

Abandonment would consist of leaving the cleaned and inspected pipeline in place. The ends of the pipeline will be capped. Similarly, pipeline ends at each manhole will be cut capped. Each manhole will be removed to 1 m below grade and backfilled. Disturbed areas will be graded to match existing conditions and drainage patterns.

4.3 Pipeline Decommissioning Feasible Concept 2 – Clean, Fill, and Abandon in Place

Feasible Concept 2 consists of cleaning the pipeline, filling the annulus such that the internal void space in the pipeline is solidified, and abandonment of the pipeline in place.

Cleaning of the pipeline is a common design element described in Section 3.1 above.

The purpose of filling the pipeline is to solidify the annulus of the pipe to prevent ground subsidence due to the pipe collapsing. Prior to commencing the filling process, the inspection performed as part of the cleaning phase will be assessed to check for potential breaks in the pipe using manual, pig, or video inspection methods. If pipe breaks are present the pipe will be repaired prior to filling. The filling process will involve using mechanical equipment to mix and pump a flowable fill into the pipeline.

Flowable fill Alternative Means include the following material types:

- Cellular concrete/foamed concrete: Cellular concrete (also called foamed concrete) is a type of lightweight concrete. The primary characteristic of foamed concrete is that instead of aggregate such as stone and sand, foamed concrete contains small air bubbles. These air bubbles reduce the weight of the material (making it a lightweight concrete), but they also lower the strength. This type of material can easily be pumped long distances at low pressures with no segregation issues. Cellular concrete fills pipes over much longer runs per access hole than flowable fill making it more economical and efficient due to the ability to use low density materials that are effectively self-leveling and highly pumpable. This allows for abandonments of long structures with minimal pumping points, while still ensuring complete fill. The fill will be poured or pumped into the pipeline by using the manholes as access points. Additional access points may be excavated along the pipeline to aid in the filling of potential difficult sections (e.g., high points or bends). A tremmie pipe will be lowered down the pipeline to reach the lowest point where the filling process will start. While filling the pipe the tremmie pipe will be retracted towards the access point.
- Expandable foam: This process would involve injecting a single component expansive foam chemical grout into the pipeline. The foam will be injected from manhole to manhole or excavated openings. The expansive foam is pressure injected from a remote pumping system sitting on the surface. The liquid foam (with appropriate amount of catalyst) is pressurized directly into the void space, when the chemical grout comes into contact with moisture within the pipe, the chemical grout expands and fills the space to complete the reaction. The chemicals predictably react in minutes, but the reaction times

can be increased by adding additional catalysts to the resin. This process is relatively fast and efficient.

It is estimated that a volume of approximately 1,600 m^3 of fill will be required to fill the annulus of the land portion of the pipeline. Overall both materials are deemed acceptable for filling the land portion of the pipeline.

Abandonment would consist of leaving the cleaned inspected, and filled pipeline in place. The ends of the pipeline will be capped. Similarly, pipeline ends at each manhole will be cut capped. Each manhole will be removed to 1 m below grade and backfilled. Disturbed areas will be graded to match existing conditions and drainage patterns.

4.4 Pipeline Decommissioning Feasible Concept 3 – Complete Removal

Feasible Concept 3 consists of cleaning the pipeline and complete removal by mechanical excavation. This Feasible Concept does not apply to the underwater portion of the pipeline as this was eliminated under the first Filter (F1) step.

It is noted that a section of the pipeline is near a Pictou Landing First Nation (PLFN) burial ground. Complete removal of this section would require acceptance from PLFN and would require archeological monitoring.

Removal will include excavating to expose and remove the pipe. Clean soils will be stockpiled for reuse as backfill. Impacted soils, if any, will be managed in accordance with the recommended remedial and waste management option.

It is anticipated that approximately a 30 m pipeline section will be exposed at one time followed by pipe removal and backfilling. The pipe will be removed using mechanical equipment by first cutting the pipeline (e.g., excavator with a shear attachment) followed by removal (e.g., excavator or mobile crane).

Manholes will be removed in sections using mechanical equipment (e.g., excavator or mobile crane) and disposed of at a licensed construction and demolition debris facility or crushed on Site and used as clean fill.

If high rates of groundwater infiltration are observed, the water table will be lowered using pumps. The water collected from dewatering would be tested and then disposed at an appropriate on or off Site treatment facility. Trenches will be continuously backfilled as the pipe is removed to limit the length of open excavations. Efforts will be made to limit excavations left open at the end of each day. Approximately 38,750 m^3 of cover material will need to be removed, with approximately 40,425 m^3 being required for backfilling.

Disturbed areas will be graded to match existing conditions and drainage patterns.

4.5 Feasible Concepts Cost Estimate

Capital and operation and maintenance cost estimates for each Feasible Concept is provided in Attachment F1 and summarized on Table F.2 for pipeline on land and Table F.3 for pipeline under water below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing. O&M cost for decommissioning the pipeline on-lands were carried for 25 years post remediation.

Table F.2 Pipeline on Land Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 - Clean, inspect, and abandon in place	$170,000	$130,000
Feasible Concept 2 - Clean, fill, and abandon in place	$1,520,000	$0
Feasible Concept 3 - Complete removal	$630,000	$0

Table F.3 Pipeline Under Water Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 - Clean, inspect, and abandon in place	$90,000	$0
Feasible Concept 2 - Clean, fill, and abandon in place	$1,080,000	$0

Key assumptions include:

- Cellular concrete was carried for Feasible Concept 2; expandable foam is not readily available in Nova Scotia and was therefore assumed to be cost prohibitive.
- Video inspection was carried for costing Feasible Concepts 1 and 2, as it was deemed the most likely option to be implemented.
- Pigging was carried for costing cleaning for all Feasible Concepts, as it was deemed the most likely Alternative Mean to be implemented.
- Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.
- For the pipeline on land, Feasible Concept 1 assumes a 25-year inspection and care program will be required.
- Based on published weights of RPP from various manufactures approximately 250 tonnes of pipe to be disposed of for Feasible Concept 3. The capital cost estimate for disposal is included in the costing prepared in Appendix C – Waste Management Detailed Concept Descriptions for Feasible Concepts.
- For Feasible Concept 2, fill can be done by gravity on both sides using portable pumps.

5. Treatment Buildings

5.1 Background

The buildings under consideration for decommissioning/demolition or repurposing are shown of Figure F4 and described as follows:

Press Building

The press building is approximately 15 x 20 m in area and is located northwest of the twin setting basins. The press is used as an office and maintenance area. Historically the building housed the filter press used for sludge dewatering. The building is a typical 'Butler Building' with a concrete foundation, steel structure and siding, fiberglass insulation, and an asphalt shingle roof. The interior office area is constructed with wooden studs, drywall, and a tile floor.

Mobile Building Adjacent to Press Building

The mobile building is 12 x 3 m in area. The building is used for storage, but it is mostly vacant and unused. The building is wood frame construction with metal siding and roofing. The interior of the building was finished with wood panel walls, vinyl floor tiles, and dropped ceiling tiles.

Storage Shed

A 2 x 2 m storage shed located southwest of the press building and is used for storing a spill kit, booms, spare pipe, and empty 19 L buckets. The storage shed is wooden construction and has an asphalt shingle roof.

Air Monitoring Shelter

The 2 x 3 m air monitoring shelter is located north of the twin settling basins and is currently unused and empty. The air monitoring shed is wooden construction with an asphalt shingle roof.

Electrical Building

The 15 x 10 m electrical building is located north of the ASB along Simpsons Road. The main function of the electrical building is to house the electrical equipment that powers the aerators. In addition to the interior electrical equipment, there are two exterior transformers west of the building and a backup generator on a trailer immediately south of the building. Within the building there is a vehicle bay that contains a boat with an outboard motor as well as supplies and tools for maintaining the aerators. Waste oil is stored in a 1,000 L plastic tote within the vehicle bay and there is a checkplate aluminum tank with pump that fits the back of a pick-up truck, used for transporting fuel from the Kraft Mill in the event the generator is required. A fenced-in area at the east side of the electrical building is used for storage of a plow, silt curtains, parts and wire, and a storage compound within the fenced area contains small parts (rubber seals, gaskets, and bolts), supplies, and 19 L buckets of waste oil.

The original electrical building is concrete block construction. The ASB electrical system is housed within a newer 'Butler Building' addition. The building is not insulated and has prefinished metal siding.

Mobile Building belonging to CTS Electrical

The 3.5 x 20 m CTS Electrical-owned mobile building is a one story mobile structure that was used by an electrical contractor who formerly worked at the Site. The building has extensive water damage. Currently there are some miscellaneous items stored in the building, but it is mostly vacant and unused. The building is wood frame construction with metal siding and roofing. The interior of the building was finished with wood panel walls, vinyl floor tiles, and dropped ceiling tiles with fiberglass insulation.

Silo

The 2.7 m diameter silo contains urea that is used in the treatment process. The silo is constructed of metal and is located on a concrete base.

Electrical Building for Silo

In addition to housing the electrical equipment for the silo, this 2.5 x 2.5 m building contains a small scale that is used for weighing urea so that flow rates can be calibrated. The building is wood frame construction with metal siding and an asphalt shingle roof. The interior of the building was finished with gyprock and vinyl floor tiles.

Point A Building

The 2.5 x 3 m Point A structure contains the valves and electrical equipment for isolating the settling basins as well as a fridge used for storing samples. The structure is wood frame construction with vinyl siding and an asphalt shingle roof. The structure rests on a concrete slab over the raw effluent discharge ditch.

Point C Building

One 2.5 x 3 m building contains electrical equipment and the other 2.5 x 3 m building contains a sampler, fridge, and a supply of sampling containers. The Point C electrical building is wood frame construction with metal siding and a flat roof. The interior of the building was finished with wall board, vinyl floor tiles, and dropped ceiling tiles. The Point C sampling building is wood frame construction with wood siding. The interior of the building was finished with wood wall panels and wood floor.

5.2 Treatment Buildings Feasible Concept 1 – Decommission and Demolition

Feasible Concept 1 consists of decommissioning and demolishing each building/structure and transporting waste materials for disposal or recycling.

Prior to demolition, the facilities will be decommissioned as noted in Section 3.2.

Demolition will require the use of an excavator, with a standard bucket or potentially mechanical shears for cutting large structural elements and collapsing the structure for cleanup. For larger structures, such as the silo, demolition in a methodical process using potentially using a crane and taking the structure apart in pieces is required. Footings and foundations will be removed to a depth of 0.9 m below finished grade.

5.3 Treatment Buildings Feasible Concept 2 – Repurpose and Upgrade

Feasible Concept 2 consists of potentially repurposing a building consistent with overall Site end use objectives. One building that could be a candidate for re-purposing is the press building as it is the largest on-Site building and is adjacent to the Site access road. Provided that a building inspection is completed to confirm that it is structurally sound, potential repurposing examples include:

- Operational Building
- Welcome/Community Centre
- Storage Building

Repurposing could include building modifications to improve/upgrade siding, roofing, building layout, and mechanical/electrical equipment.

5.4 Feasible Concept Cost Estimate

Capital and operation and maintenance cost estimates for the Feasible Concept is provided in Attachment F1 and summarized on Table F.3 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. The cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

Table F.3 Treatment Buildings Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – Decommission and Demolish	$150,000	$0

Key assumptions include:

- Foundations will be cut, remain in place, and be buried. Only slabs and aboveground structures will be removed.
- Mobile buildings will be removed with no demolition required.
- Buildings have been de-energized prior to the start of decommissioning.
- Construction and demolition debris (C&D) estimates are shown in Table F.4 below. Disposal costs are included as part of the cost estimate under Appendix C – Waste Management Detailed Concept Descriptions for Feasible Concepts.

Table F.4 C&D Debris Quantity Estimate

Materials	Weight (tonnes)	Volume (cubic metres)
Asphalt shingles	4.4	-
Ceiling tile	0.6	-
Concrete	-	100
Drywall	1.2	-
Fiberglass insulation	0.1	-
Metal	19.2	-
Tile	6.9	-
Vinyl flooring	0.6	-
Wood framing	0.8	-

6. Dam

6.1 Background

The dam is used to regulate the water level in the Boat Harbour stabilization lagoon and is located north of the causeway at Highway 384 at the mouth of the estuary. The dam is a flat concrete slab structure with retaining walls supporting the earth embankments at both ends, the bottom elevation of the slab is approximately at -0.92 m AMSL[1] which is about the equivalent of low low tide. The water levels are controlled by an adjustable weir/stop log arrangement within the dam structure.

This section presents the detailed descriptions of the Feasible Concept developed for the dam.

6.2 Dam Feasible Concept 1 – Decommissioning and Demolition of the Dam

Feasible Concept 1 involves the demolition of the dam structure and the rehabilitation of the estuary embankment slopes. The demolition of the dam structure will consist of using mechanical equipment to break the concrete structure into smaller components excavated and dumped into a dump truck for onsite

[1] Average Mean Sea Level (AMSL); Based on CGVD26 Datum

or offsite disposal. The smaller elements of the structure will be demolished by hand, such as the timber screens and fences.

Prior to demolition, any hazardous materials should be abated. In addition, any electrical connections should be fully de-energized.

One of the major items for consideration are the requirements for erosion control during and after construction. Demolition will commence once the remediation is complete and Boat Harbour is ready to be reinstated back to a tidal conditions. The use of silt booms installed in the water upstream and downstream of the dam will be used to control the migration of silt generated as a result of the dam removal. Once the dam structure is removed the channel will be dredged to match the channel shape and depth as the bridge (that will be installed to replace the causeway), to ensure the hydraulics are maintained throughout the channel.

6.3 Feasible Concepts Cost Estimate

Capital and operation and maintenance cost estimates for the Feasible Concept is provided in Attachment F1 and summarized on Table F.5 below. The cost estimate represent Class D cost estimated in accordance with the Treasury Board of the Canadian Federal Government and is considered to have an accuracy of minus 30 to plus 50 percent. It is noted that the cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.

Table F.5 Dam Decommissioning Feasible Concept Class D Cost Estimate

Feasible Concept	Cost	Operation and Maintenance Cost
Feasible Concept 1 - Decommissioning and Demolition of the Dam	$370,000	$0

Key assumptions include:

- Includes cofferdam and pumping to facilitate working in the dry.
- Includes removing embankments to return open channel to original condition.
- C&D debris quantities include approximate 270 m^3 of concrete; disposal costs are included as part of the cost estimate under Appendix C – Waste Management Detailed Concept Descriptions.

Source: Imagery @2017 Google CNES / Airbus, DigitalGlobe, Landsat / Copernicus

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

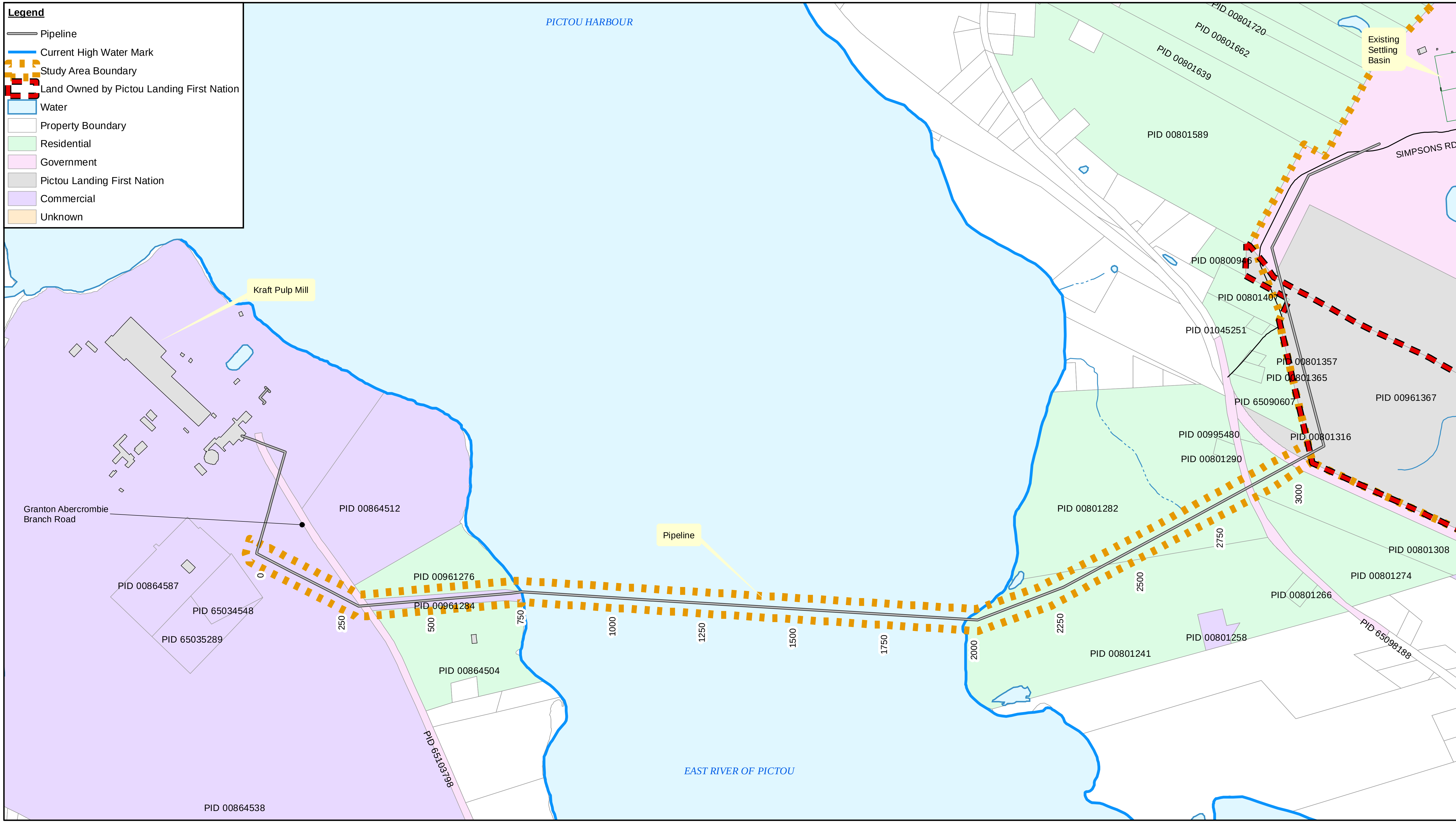
NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
INFRASTRUCTURE DECOMMISSIONING

11148275-09
Mar 15, 2018

SITE PLAN

FIGURE F1

GIS File: \\HAL-S1\Shared\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA004.mxd



Source: Insert source text here.

0 100 200 300
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

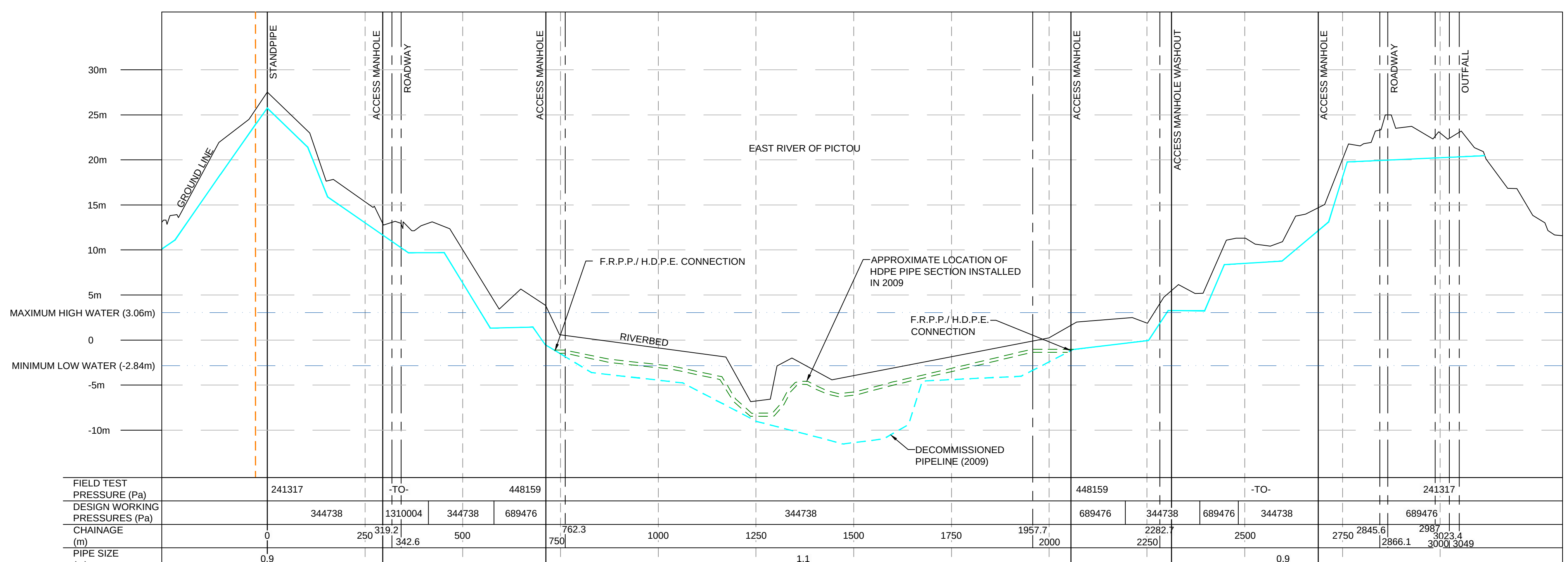
NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
INFRASTRUCTURE DECOMMISSIONING

11148275-09
May 1, 2018

PROPERTY OWNERSHIP ALONG PIPELINE

FIGURE F2

GIS File: \\HAL-S1\Shared\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA003.mxd



LEGEND:

- STUDY AREA
- PROPERTY BOUNDARY
- HDPE PIPELINE
- FIBRE REINFORCED PLASTIC PIPELINE

NOTES:

1. ELEVATIONS ASSUMED TO BE BASED ON CGVD28 DATUM

HORIZONTAL SCALE = 1:15000
VERTICAL SCALE = 1:86250

Source: Kimberley-Clark Nova Scotia Inc., DWG. No.2502-MTL-9-4012, April 26, 2001

0 150 300 450m

Coordinate System:
UTM ZONE 20 NAD83 (CSRS)

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
INFRASTRUCTURE DECOMMISSIONING

PIPELINE PLAN AND PROFILE

11148275-09
Mar 7, 2018

FIGURE F3

CAD File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148725-09(005)GN-DA00F3a.dwg

Source: Imagery @2017 Google CNES / Airbus, DigitalGlobe, Landsat / Copernicus

0 40 80 120
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

NOVA SCOTIA LANDS INC.
BOAT HARBOUR, NOVA SCOTIA
INFRASTRUCTURE DECOMMISSIONING

BOAT HARBOUR EFFLUENT TREATMENT FACILITY
SITE PLAN

11148275-09
Dec 19, 2017

FIGURE F4

GIS File: I:\GIS_DATA\Projects\8-chars\1114----\11148275 Boat Harbour\11148275-REPORTS\11148275-Rpt-5\11148275-09(005)GIS-DA00F4.mxd

Attachment F1

Class D Cost Estimate
Pipeine (On-Land) Decommissioning Feasible Concept 1- Clean, Inspect, and Abandon In Place
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Capital Costs							
1	Cleaning	M	2,300	$	60	$	138,000
2	Inspection	M	2,300	$	5	$	11,500
3	Access Pits	EA	8	$	2,000	$	16,000
					Total Class D Cost Estimate	$	165,500
					Total Class D Cost Estimate (Rounded, -4)	**$**	**170,000**
Part B - Long Term Operations and Maintenance (O&M)							
4	Allowance for Inspection and Care	Y	25	$	5,000	$	125,000
					Total Class D O&M Cost Estimate	$	125,000
					Total Class D O&M Cost Estimate (Rounded, -4)	**$**	**130,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Video inspection was carried for costing as it was deemed the most likely alternative mean to be implemented.
   - Pigging was carried for costing cleaning as it was deemed the most likely alternative mean to be implemented.
   - Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.
   - O&M allowance for 25 years of inspection and repair as needed (e.g., due to subsidence).

Attachment F1

Class D Cost Estimate
Pipeline (On Land) Decommissioning Feasible Concept 2 - Clean, Fill, and Abandon In Place
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Cleaning	M	2,300	$ 60	$ 138,000
2	Inspection	M	2,300	$ 5	$ 11,500
3	Access Pits	EA	8	$ 2,000	$ 16,000
4	Flowable Fill	M3	1,500	$ 900	$ 1,350,000
				Total Class D Cost Estimate	$ 1,515,500
				Total Class D Cost Estimate (Rounded, -4)	**$ 1,520,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Video inspection was carried for costing as it was deemed the most likely alternative mean to be implemented.
   - Pigging was carried for costing cleaning as it was deemed the most likely alternative mean to be implemented.
   - Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.
   - Cellular concrete was carried for costing; expandable foam is not readily available in Nova Scotia and was therefore assumed to be cost prohibitive.
   - Fill can be done by gravity on both sides using portable pumps.

Class D Cost Estimate
Pipeline (On Land) Decommissioning Feasible Concept 3 - Complete Removal
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1.01	Cleaning	M	2,300	$ 60	$ 138,000
1.02	Excavation (Shear pipe and remove in sections)	M3	10,500	$ 26	$ 273,000
1.03	Backfill	M3	12,000	$ 15	$ 180,000
1.04	Restoration	M2	10,000	$ 3	$ 30,000
				Total Class D Cost Estimate	$ 621,000
				Total Class D Cost Estimate (Rounded, -4)	**$ 630,000**

Notes:

1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Video inspection was carried for costing as it was deemed the most likely alternative mean to be implemented.
   - Pigging was carried for costing cleaning as it was deemed the most likely alternative mean to be implemented.
   - Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to
   - Pipeline is 2,300m long and 2.6 m deep to the invert on average.
   - The pipe will be cut using shears on an excavator.
   - Approximately 1,500 m3 of imported backfill will be required.
   - Existing tosoil will be reused; restoration will include hydroseed.
   - Based on published weights of RPP from various manufactures approximately 250 tonnes of pipe to be disposed of for Feasible Concept 3. The capital cost estimate for disposal is included in the costing prepared in Appendix C – Waste Management Detailed Concept Descriptions for Feasible Concepts.

Attachment F1

Class D Cost Estimate
Pipeline (in Water) Decommissioning Feasible Concept 1 - Clean, Inspect, and Abandon In Place
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1.01	Cleaning	M	1,200	$ 60	$ 72,000
1.02	Inspection	M	1,200	$ 5	$ 6,000
1.03	Access Pits	EA	2	$ 2,000	$ 4,000
				Total Class D Cost Estimate	$ 82,000
				Total Class D Cost Estimate (Rounded, -4)	**$ 90,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Video inspection was carried for costing as it was deemed the most likely alternative mean to be implemented.
   - Pigging was carried for costing cleaning as it was deemed the most likely alternative mean to be implemented.
   - Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.

Class D Cost Estimate
Pipeline (In Water) Decommissioning Feasible Concept 2 - Clean, Fill, and Abandon In Place
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Cleaning	M	1,200	$ 60	$ 72,000
2	Inspection	M	1,200	$ 5	$ 6,000
3	Access Pits	EA	2	$ 2,000	$ 4,000
4	Flowable Fill	M3	1,100	$ 900	$ 990,000
				Total Class D Cost Estimate	$ 1,072,000
				Total Class D Cost Estimate (Rounded, -4)	**$ 1,080,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Video inspection was carried for costing as it was deemed the most likely alternative mean to be implemented.
   - Pigging was carried for costing cleaning as it was deemed the most likely alternative mean to be implemented.
   - Cleaning costs were determined for the total length of the pipeline and divided into a cost per metre and applied to the on land and water portion of the pipeline.
   - Cellular concrete was carried for costing; expandable foam is not readily available in Nova Scotia and was therefore assumed to be cost prohibitive.
   - Fill can be done by gravity on both sides using portable pumps.

Attachment F1

Class D Cost Estimate
Treatment Building Decommissioning Feasible Concept 1 - Decommission and Demolish
Remdial Options Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Hazmat Abatement	LS	-	-	$ 50,000
2	Chemical Sweep and Cleaning	LS			$ 50,000
3	Press Building (15m x 20m)	LS	-	-	$ 10,000
4	Mobile Building (12mx 3m)	LS	-	-	$ 3,000
5	Storage Shed (2m x 2m)	LS	-	-	$ 2,000
6	Air Monitoring Shelter (2m x 3m)	LS	-	-	$ 2,000
7	Electrical Building (15m x 10m)	LS	-	-	$ 5,000
8	Mobile Building belonging to CTS Electrical (3.5 m x 20 m)	LS	-	-	$ 2,000
9	Annual Allowance for Inspection and Care	LS	-	-	$ 8,000
10	Electrical Building for Silo (2.5m x 2.5m)	LS	-	-	$ 2,000
11	Point A Building (2.5m x 3m)	LS	-	-	$ 2,000
12	Point C Buildings				
12.1	Electrical Equipment Building (2.5m x 3m)	LS	-	-	$ 2,000
12.2	Sampling Building (2.5m x 3m)	LS	-	-	$ 2,000
13	Restoration	M2	610	$ 15.00	$ 9,150
				Total Class D Cost Estimate	$ 149,150
				Total Class D Cost Estimate (Rounded, -4)	**$ 150,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - The foundations will be cut, remain in place and be buried. Only slabs and above ground structure will be removed.
   - Mobile buildings will be removed with no demolition required.
   - Buildings have been deenergised prior to the start of decommissioning.
   - Disposal costs are included under Appendix C - Waste Management.

Class D Cost Estimate
Dam Decommissioning Feasible Concept 1 - Decommissioning and Demolition of the Dam
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Capital Costs							
1	Coffer Dam and Pumping	LS	-		-	$	50,000
2	Excavation	M3	11,200	$	25	$	280,000
3	Concrete Removal	M3	270	$	120	$	32,400
					Total Class D Cost Estimate	$	362,400
					Total Class D Cost Estimate (Rounded, -4)	**$**	**370,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/ demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Includes cofferdam and pumping to facilitate working in the dry.
   - Excavation includes removing embankments to return open channel to original condition.
   - Disposal costs are included under Appendix C - Waste Management

Appendix G
Remediation Detailed Concept Descriptions

Appendix G Remediation Detailed Concept Descriptions

1. General

The Boat Harbour Effluent Treatment Facility (BHETF) consists of the wastewater effluent pipeline, twin settling basins, aeration stabilization basin (ASB), and the Boat Harbour stabilization lagoon (BH). Effluent from Boat Harbour discharges through a dam into an estuary before being released to the Northumberland Strait. Prior to the construction of the twin settling basins and ASB, effluent was routed by open ditch from the pipeline on the east side of Highway 348 to a natural wetland area (Former Ponds 1, 2, and 3) before being discharged into the stabilization lagoon. An overall site plan identifying key infrastructure is presented on Figure G1.

Remediation includes addressing Site areas that have been impacted from the operation of the BHETF. At the core of remediation will be removal of impacted sludge/sediment and managing all associated effluents including treatment prior to disposal or discharge. Wetland remediation is discussed in Appendix E - Wetland Management Detailed Concept Descriptions, and references sediment and water treatment methodologies and cost from this section where required.

Remediation Feasible Concepts for the effluent ditch, settling basins, ASB, BH, and estuary have been organized as follows:

- Section 2 – Sediment Management, includes sludge/sediment removal, dewatering, and treatment.
- Section 3 – Bulk Water Management, includes management and treatment of surface water from the active and historical BHETF components.
- Section 4 – Dewatering Effluent Management, includes treatment of effluent generated from dewatering sludge/sediment.
- Section 5 – Leachate Management, includes treatment of leachate from the on-Site sludge disposal cell during and post remediation. Waste management options are discussed in Appendix D - Waste Management Detailed Concept Descriptions, and references leachate treatment methodologies and cost from this section where required.

2. Sediment Management

2.1 Overview

Sediment management includes the removal of sludge and impacted sediment, dewatering of sludge/sediment, and treatment of sludge/sediment.

The Feasible Concepts for sediment treatment were grouped by Site area. Areas requiring remediation are shown on Figures G2 and G3 and described as follows:

- Raw Effluent Discharge Ditch: Raw effluent is conveyed by a lined open ditch from the end of the pipe line to the twin settling basins and from the twin settling basins to the ASB. It is anticipated that remediation activities will require removal of ditch lining materials[1].

[1] Due to the flow depth and velocity environmental characterization of the ditch bottom/lining was not practical as part of the Phase 2 ESA.

- Twin Settling Basins: The twin settling basins are used to remove suspended solids from the effluent. They are approximately 4.3 ha in size, have a capacity of 114,000 m^3, and are lined with a low permeable material (likely clay/till). From the settling basins, the effluent is conveyed by a ditch to the ASB. Remediation activities will require the removal of sludge/sediment that is impacted with contaminants of concern (COCs) including metals and total petroleum hydrocarbons (TPH).
- ASB: The ASB is 18.3 ha in size and has a capacity of 567,750 m^3. Floating aerators are used to aerobically treat the effluent prior to discharge into the BH. Three silt curtains divide the ASB into four cells to improve mixing and reduce areas of sludge build up. An automated nutrient addition system adds urea and diammonium phosphate[2] to the effluent before it discharges to the ASB. Remediation activities will require the removal of sludge that is impacted with COCs including metals, TPH, polycyclic aromatic hydrocarbons (PAH) and dioxins and furans (D&F). The native marine clay, which underlies the sludge, is not impacted to levels exceeding provincial and federal criteria and is not likely to require remediation. Similarly, surface water will need to be remediated/treated as it is impacted with COCs that include metals, TPH, and cyanide.
- BH: Effluent from the ASB is discharged into the BH, which is approximately 140 ha in size and has a capacity of 2,458,545 m^3 based on average water elevation of 0.78 m AMSL[3] and using bathymetry data provided by Acadia University[4]. The effluent from the BH is discharged via a dam located north of Highway 348 into the tidal estuary and ultimately to the Northumberland Strait. Remediation activities will require the removal of sludge that is impacted with COCs including metals, volatile organic compounds (VOCs), TPH, PAH, and D&F. The underlying native marine clay/sediment is not impacted to levels exceeding provincial and federal criteria and is not likely to require remediation. Surface water will need to be remediated/treated as it is impacted with COCs including metals, TPH, and cyanide.
- Estuary: The estuary area is approximately 7.6 ha in size and is located north of Highway 348 and the dam. The estuary is delineated to the south by the dam and to the north by the Northumberland Strait. Remediation activities will require the removal of sludge that is impacted with COCs including limited metals, TPH, PAH, and D&F. The native marine clay, which underlies the sludge, is not impacted to levels exceeding provincial and federal criteria and is not likely to require remediation. Surface water will need to be remediated/treated as it is impacted with COCs including metals, TPH, and cyanide.
- Sludge Disposal Cell: The sludge disposal cell is approximately 6.7 ha in size and has a minimum capacity of approximately 220,000 m^3 (waste). The disposal cell is currently used for placement of dredged material from the ASB. As noted in Appendix D Waste Management Detailed Concept Descriptions, two Feasible Concepts were developed for waste management including use of existing disposal cell and off-site disposal. As such, the sludge that has been placed in the disposal cell may or may not need to be removed depending on the selected waste management option. Disposal cell sludge COCs include metals, VOCs, TPH, PAH, and D&F. The sludge disposal also contains surface water that is impacted with metals, TPH, and cyanide.

For the active BHETF components including the effluent ditches, twin settling basins, ASB, and BH it was deemed unacceptable to the public and potentially not technically feasible to use in-situ approaches such as natural attenuation or encapsulation. For the estuary, which has lower levels of contamination in-situ approaches to manage impacted sediments were also carried forward for evaluation.

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2 Other fertilizers may also be used or historically used.

3 Based on Canadian Geodetic Vertical Datum CGVD2013

4 200 khz sonar bathymetry survey completed in October and November 2016

Feasible Concepts developed for sediment treatment include the following:

- Feasible Concept 1: Removal in the wet
  - Feasible Concept 1A: With geotube dewatering
  - Feasible Concept 1B: With clay stabilization
- Feasible Concept 2: Removal in the dry
  - Feasible Concept 2A: With geotube dewatering
  - Feasible Concept 2B: With clay stabilization
- Feasible Concept 3 (Estuary Only): Natural attenuation

2.2 Objectives

The objectives for sludge removal and treatment include:

- Support return of Boat Harbour to tidal conditions
- Facilitate reconnection of the community to A'se'k by creating a site that is protection of human and ecological health and suitable for recreational purposes
- Utilize technologies that are proven at a commercial scale
- Meet sediment quality standards established as outlined in the Nova Scotia Environment (NSE) Tier 1 Environmental Quality Standards (EQSs) for Sediment (Marine Sediment) and Canadian Council of Ministers of the Environment (CCME) Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Probable Effects Level) or risk-based criteria that is protective of ecological and human health.
- The best value to the province in terms of schedule and cost

2.3 Common Design Elements

This section describes the common design elements for the Feasible Concepts including sludge/sediment volumes and methodologies for sludge/sediment removal, dewatering, ex-situ treatment, and in-situ treatment.

2.3.1 Sediment Quantities

The overall estimate of sludge/sediment to be managed during remediation ranges from 516,500 m^3 to 1,233,400 m^3 depending on the selected remedial option. Table G.1 below provides a summary of sludge/sediment quantities for each area to be remediated. Sludge/sediment volumes for the twin settling basins, ASB, BH, and estuary assume 0.15 m of the underlying marine clay will be removed as part of the remediation process. The estimated reduction and/or bulking in volume was determined based on the results of the laboratory treatability testing. The Laboratory Treatability Testing Report is provided in Appendix A.

Table G.1 Sludge/Sediment Quantities

Area	In-Place Volume (m^3)(1)	Dewatering			Stabilization	
		Estimated Reduction in Volume (%)	Final Disposal Volume(2) (m^3)	Final Disposal Weight(3) (MT)	Estimated Bulking (%)	Final Disposal Volume(4) (m^3)
Raw Effluent Discharge Ditches	1,000	50	500	600	7	1,100
Twin Settling Basins	25,000	50	12,500	15,000	7	26,800
Aeration Stabilization Basin	129,000	55	58,100	69,800	7	138,100
Boat Harbour Stabilization Lagoon	577,000	70	173,100	225,100	7	617,400
Existing Disposal Cell	180,000	36	116,000	139,200	NA	116,000
Estuary	49,000	48	25,500	30,600	7	52,500
Wetland Areas(5)	263,000	50	132,000	158,400	7	281,500
Total	1,244,000		517,700	638,700		1,233,400

Notes:

(1) Values for BH, ASB, and estuary include an additional 0.15 m marine clay

(2) All values assume a percent volume reduction due to dewatering and consolidation based on laboratory treatability testing results, 50% where material was not tested in the laboratory (raw effluent ditches, twin settling basins and wet portion of existing disposal cell) and 0% for consolidated waste in the existing disposal cell

(3) All values assume a density of 1.2 metric tonnes (MT)/m^3, with the exception of the BH which was carried at 1.3 MT/m^3 on laboratory treatability results

(4) All values assume a percent bulking due to stabilization (based on laboratory treatability testing)

(5) Wetland remediation is addressed in Appendix E

The estimated sludge volume in BH was determined based on:

- Sediment core sample data collected from 39 locations throughout BH by Acadia University in 2016 and 2017.
- Sediment core data collected from five locations by GHD as part of the Phase 2 Environmental Site Assessment (ESA) in 2017
- End area calculations

Other estimated sludge volumes were based on:

- ASB: Assumed average sludge thickness of 0.56 m based on the one sludge sample collected from the ASB as part of Phase 2 ESA (ASB-SED-1; sludge thickness of 0.45 m) and the average thickness determined from Jacques Whitford Environmental Limited's 1992 sediment characteristic investigation[5] (average thickness of 0.66 m).
- Twin Settling Basins: The Site contains two settling basins; one of the twin settling basins is in use at any given time, while the other basin acts as an emergency storage pond. The solids in the unused

5 An Investigation of Sediment Characteristics at Boat Harbour Treatment Facilities (Jacques Whitford Environment Limited and Beak Consultants Limited, November 1992).

settling basin are typically allowed to dry for six months, and are subsequently transported and disposed of in an off-Site disposal cell. Each settling basin has a volume of 57,000 m^3 with a maximum volume of solids in each basin of 20,000 to 25,000 m^3. It was assumed that since only one basin is typically operational at a time, that remediation will involve management of 25,000 m^3 of sludge from the settling basins (i.e., half of the solids capacity).

- Disposal Cell: Based on survey completed by GHD in 2016[6] identifying approximately 180,000 m^3 of sludge comprised of 51,000 m^3 of sludge forming the western solid portion of the cell and approximately 129,000 m^3 of sludge/water in the eastern wet portion of the cell. It is noted that the final disposal volume in Table G.1 assumes no volume reduction in the already consolidated western portion of the cell and a 50 percent reduction in volume of the eastern portion due to dewatering and consolidation during remediation.
- Estuary: Based on four core samples collected as part of the Phase 2 ESA ranging from no sludge to a sludge thickness of 0.8 m; and end area calculations.
- Wetlands: The estimated volume of sludge in the wetlands (including the former raw effluent discharge area and former settling ponds 1, 2, and 3) was calculated based on six core samples collected as part of the Phase 2 ESA; and end area calculations.

2.3.2 Sediment Removal

Sediment removal in the wet is achieved either through mechanical or hydraulic dredging. Mechanical dredging involves material removal using an excavator bucket or clamshell bucket from shore or from a barge. The material is loaded directly into a truck if at shore or if on the water into the barge and subsequently loaded into a truck for transport. Hydraulic dredging equipment is set up on a boat or barge and removes material in a sludge-water mixture (slurry), transferring it via pipe to the desired location.

Sediment removal in the dry is achieved through mechanical excavation following dewatering of an area. Sludge is mechanically excavated using heavy equipment such as excavators and dozers and is placed in a truck and transported. It is also possible that mechanically excavated material is loaded into a hopper for transport as a slurry via pipe to the desired location. Specialized equipment (low ground pressure or pontoon-based equipment) is likely required to operate on the native marine sediment underlying the sludge.

2.3.3 Sediment Dewatering

Gravity dewatering (or thickening) allows water to drain naturally over time from the sludge under the force of gravity. Gravity thickening concentrates solids in a tank similar to a conventional sedimentation tank or clarifier, on a concrete pad, or in a lined basin. It may be used for dredged material slurries of any grain size, at nearly any flow rate, and produces a solids concentration ranging from 2 to 15 percent. Thickened material can then be dewatered further using other methods to reduce the hydraulic load on subsequent process stages. Settling of solid material can also be enhanced by coagulants and/or polymers. The optimal concentration of polymer utilized is determined by screening tests.

Geotubes dewatering consist of bags made of permeable, soil-tight geotextiles that are filled with dredged sludge slurry through pipe inlet ports. They are designed to allow effluent water to escape through the pores of the fabric, while retaining fine-grained flocculated solids. A polymer may be added to the slurry prior to entering the geotube to improve dewatering performance. Geotubes' large volume

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6 Sampling and Analysis of Dredge Spoils Report – Final, Boat Harbour Effluent Treatment Facility Disposal Cell, Pictou Landfill, Nova Scotia (GHD, February 2016).

allows for high flow rates from the dredging process. The use of geotubes can result in material containing greater than 30 percent solids by weight.

Centrifugal dewatering uses the force developed by rapid rotation of a cylindrical drum or bowl. Solids and liquids separate by density differences under the influence of centrifugal force. Centrifuges are relatively compact and are therefore well suited to areas with space limitations. They are unsuitable for streams containing tars, small particle sizes, low density particles, large objects, or fibrous materials, thereby possibly limiting their application for the BHETF.

Filtration (press, vacuum, and pressure) dewatering are physical processes in which liquid is forced through a permeable medium, retaining solids on the membrane. Filtration dewaters fine-grained sediment over a wide range of solids concentrations. Effectiveness depends on the type of filter, the particle size, and the solids concentration in the influent. Three commonly used types of filter systems are belt press filtration, vacuum filtration, and pressure filtration. Belt presses process slurries from 1 to 40 percent solids by weight, and generate solid streams with 12 to 50 percent solids by weight. Vacuum filters can process streams of 10 to 20 percent solids by weight, and capture 85 to 99 percent of the solids material.

2.3.4 Ex-Situ Sediment Treatment

Stabilization/solidification (S/S) involves the conversion of sludge into solid form and binds the contamination to the solids creating a less soluble form. The solidification process reduces the leaching of contaminant by adding solidifying agents and bulking agents to treat sludge. The agents may include pozzolanic materials such as Portland cement or cement kiln dust, or may be chemical binding agents such as activated carbon, organoclay for organics, or phosphate salts for metals. The S/S process may be enhanced through hydration of the pozzolanic S/S reagent(s). When water is added to the solidifying reagent, it forms a slurry or gel that coats the surfaces of the sludge particles and fills the voids. Soon after sludge, water, and S/S agents are combined, the mixture begins to cure. While curing, a node forms on the surface of each solidifying agent particle and continues to expand until it links up with adjacently forming nodes from other solidifying agent particles or adheres to adjacent soil particles. The solid matrix encapsulates any contaminants present within the solid matrix such that they are no longer available and cannot leach out. The contaminants are immobilized and are no longer considered a risk if leaching concentrations are within respective regulatory limits. Chemical binding agents do not require hydration but must make contact with contaminants within the soil matrix.

2.3.5 Natural Attenuation

Natural attenuation is commonly used as a viable remedial option to address residual impacts to an ecosystem after the contaminant source has been removed or eliminated. Typical natural attenuation processes involve one or more biological, chemical, or physical processes. In association with natural attenuation of COCs is the concept of risk assessment. Risk assessment is the process of estimating the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment and surface water) now or in the future. If the risk assessment identifies isolated hotspots, active remediation or risk management measures may be implemented to accelerate the natural recovery process. Monitoring of the natural attenuation process is critical to ensuring recovery of the system is occurring as anticipated.

2.4 Feasible Concept 1 – Removal in the Wet

Removal in the wet will involve dredging sludge/sediment from the ASB, BH, and estuary under wet conditions, as well as excavating sludge from the twin settling basins under dry conditions. It is noted that the twin settling basins are not part of a water body and will be allowed to dewater by gravity before removal.

Removal in the wet will be predominantly completed through hydraulic dredging. The dredged sludge slurry will be subsequently pumped to a designated sludge management area. Possible locations include the existing disposal cell, twin settling basins, and ASB. The preference would be for the sludge management area to be located within the existing disposal cell to minimize material handling, should on-site disposal be the selected option for waste management.

Sludge/sediment dewatering and treatment alternatives include:

- Feasible Concept 1A – Removal in the wet with geotube dewatering
- Feasible Concept 1B – Removal in the wet with clay stabilization

It is anticipated that the existing Site access roads may be used for this Feasible Concept. Access near the ASB and BH may need to be extended to create additional access roads and boat ramps to get dredging equipment in and out of the water. The exact location for access will be selected to minimize any impacts to sensitive areas (e.g., wetlands). Site electrical service may need to be temporarily extended for dewatering operations.

2.4.1 Removal

Sludge removal Alternative Means consist of mechanical dredging or hydraulic dredging. It is expected that hydraulic dredging will be the primary method of removal due to the ease of material transfer. Hydraulic dredging required a minimum water depth of approximately 1 m. Limited mechanical dredging may be required to remove sludge in shallow areas.

It is envisioned that the BH, ASB, and estuary will be sub-divided in eight areas, as depicted on Figure G2. Silt curtains will be anchored to the base and used to segregate the areas and to control migration of suspended sediments. Additional silt curtains may be used within the active dredging area, as needed to further control re-suspended sediment during dredging. One or more dredges may be used, however, it is anticipated that the dewatering process (including dewatering effluent treatment) will be the limiting step on productivity. Dredging productivity is anticipated to be 2,000 m^3 of in-place sludge removed per day for both hydraulic dredging and mechanical dredging (based on a 10-hour day).

It is anticipated that approximately 0.15 m of materials underlying the sludge (e.g., native marine clay in the BH) will be dredged due to tolerances of the equipment being used and variability in the marine clay topography, and to ensure the sludge is removed. The dredge will complete production passes, followed by cleanup passes to attempt to remove residuals. Confirmatory sampling will be completed post remediation to confirm that the remaining sediment meets the applicable remedial quality standards for all sediment COCs.

Hydraulically dredged sludge/sediment slurry will be pumped through discharge lines to the sludge management area. Mechanically dredged material will be placed in a hopper for mixing with water (as needed) to create a slurry such that it can be pumped to the sludge management area. Some mechanically dredged sludge/sediment may be placed in dump trucks and transported to the sludge management area.

As the twin settling basins and effluent ditching will be dry with the cessation of the Kraft Mill effluent, sludge will be removed from these areas in the dry. Excavators will be used to directly load sludge into dump trucks and transported to the sludge management area.

2.4.2 Feasible Concept 1A – Removal in the Wet with Geotube Dewatering

Based on Laboratory treatability testing results (Appendix A), the use of geotubes was deemed viable to dewater BHETF sludge/sediment. It is also noted that the use of mechanical dewatering (e.g., centrifuge) and gravity dewatering was also deemed viable for the estuary sludge due to it being coarser in nature as compared to ASB and BH.

Dredged sludge/sediment slurry containing approximately five percent solids will be pumped to the sludge management area. As distance between the dredge and the sludge management area increases, a booster pump (water or land based) will be used to pump the slurry through the floating discharge line. Polymers and/or coagulants will be added to the slurry prior to entering geotubes to produce flocculation of the fine grained sediments and to promote dewatering. Optimum dosing for polymer and/or coagulant additions are presented in the Laboratory Treatability Testing Report.

The sludge management area would be located in the existing disposal cell as the filled geotubes would be ultimately landfilled based on recommended option for waste management. Some preparation work would be required, including dewatering wet portions of the disposal cell and shaping the existing placed sludge to facilitate dewatering operations. In addition a clear stone drainage layer will likely be required in the disposal cell to reduce the potential for sludge to foul the existing dewatering/leachate collection infrastructure.

Multiple geotubes will be setup as permitted by space. As the geotubes are filled, additional geotubes will be stacked on top of the existing ones essentially forming a pyramid shape. The geotubes will be stacked such that all dewatering effluent is contained within the within the disposal cell.

The filling of geotubes with slurry is an iterative process. Generally, as each geotube is filled, another partially filled or an empty geotube will be added to accept the slurry. As a filled geotube dewaters, additional capacity is created to allow for additional placement of slurry until the geotube becomes completely full. Sludge addition is typically done through a header system, making it easy to switch between geotubes.

Based on the volume of dewatered sludge presented in Table G.1 and geotube bags being filled to 90 percent capacity, it is estimated that between 50 and 130 geotubes[7] will be required to manage sludge/sediment.

Sludge excavated from the settling basins is expected to have a higher solids content than sludge from other Site areas, and is therefore anticipated to be placed directly in the disposal cell.

All dewatering effluent collected from the designated sludge management area will be managed as outlined in Section 4.

2.4.3 Feasible Concept 1B – Removal in the Wet with Clay Stabilization

Laboratory treatability testing included stabilization using a Cetco clay product (Liquasorb 2000), which was found to be effective at absorbing water and stabilizing/solidifying the sludge.

The dredged sludge slurry with a solids content of approximately 5 percent would be pumped to the sludge management area. The sludge management area would be located within the twin settling basins or the ASB and would consist of 2-3 containment areas. Each containment area would be approximately

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[7] Assuming a geotube diameter of 5 to 8 m in diameter by 120 m in length; actual in-place sludge/sediment volume, contribution from the wetlands; and actual volume reduction achieved.

100 x 50 m in size consisting of earthen berms and low permeable fill material liner (e.g., 1×10^{-6} cm/sec). The existing twin settling basins is an ideal location as it could likely be used with minimal modifications.

Shear mixing equipment would be setup adjacent to the sludge management area. Dredged slurry would be pumped to the mixer for the addition of the clay product. Optimal shear force mixing is important to ensure that clay stabilization is effective, while preventing clumping and segregation of material. It is anticipated that the sludge slurry will be processed at a rate of approximately 135 m^3/hr at the optimum clay dosing.

Once mixed, the material will be pumped into the sludge management area. Excavators will be used to spread the material out for drying. Once the sludge has stabilized (e.g., solidified) over 1-3 days the material will be loaded and hauled for disposal. Stabilization will result in an increase in sludge volumes as shown in Table G.1 as a result of material bulking. Should this Feasible Concept be selected, the existing disposal cell would need to be expanded to accommodate the treated sludge volume; or some treated sludge would need to be disposed of off-Site.

2.5 Feasible Concept 2 – Removal in the Dry

Removal in the dry will involve dredging sludge/sediment from the twin settling basins, ASB, BH, and estuary under dewatered conditions. Removal in the dry will involve bulk dewatering to achieve dry conditions, mechanical excavation, and transportation of dredged sludge/sediment for dewatering to a designated sludge management area. Possible locations include the existing disposal cell, twin settling basins, and ASB. The preference would be for the sludge management area to be located within the existing disposal cell to minimize material handling should on site disposal of waste be selected.

Sludge dewatering and treatment alternatives include:

- Feasible Concept 2A – Removal in the dry with geotube dewatering
- Feasible Concept 2B – Removal in the dry with clay stabilization

2.5.1 Removal

As shown on Figure G3, the ASB, BH, and estuary will be sub-divided in eight areas to facilitate bulk dewatering and removal of sludge. Isolation berms or coffer dams will be used to segregate the eight areas. Isolation berms will be reinforced earth berms incorporating geotextiles and/or geo-grids with toe supports. Berms will be 6 m wide by approximately 3 m high with 2:1 H:V side slopes, with a target permeability of 1×10^{-6} cm/s. Coffer dams would involve driving sheet piles into till or to bedrock.

Remediation would likely progress from upstream to downstream and would generally be focused on one area at a time. Dewatering would consist initially of bulk dewatering to render the area dry, followed by daily dewatering to maintain dry conditions (i.e., due to rainfall and groundwater infiltration). Within each area, smaller sub-areas (e.g., 2 to 3 ha.) will be created with smaller earthen separation berms to manage dewatering and maintain dry conditions in an active sub-area, while other sub-areas will maintain some level of dewatering. Separation berms will be 3.5 m wide by approximately 3 m high with 2:1 H:V side slopes, with a target permeability of 1×10^{-6} cm/s. These separation berms could also be used by sludge-moving equipment as lagoon roads. Alternatively, water inflated cofferdams, such as an aqua dam, could be used to separate sub-areas.

Table G.2 summarizes the dewatering quantities to initially dewater each of the eight areas on Figure G3, as well as to maintain dry conditions and to account for the volume generated from design storm events.

Table G.2 Estimated Dewatering Quantities

Cell No.	Initial Dewatering Volume[(1)]	On-Going Dewatering[(2)]	Additional Volume of Water to be Managed as a Result of Storm Event (m^3) [(3)]					
	(m^3)	(m^3/day)	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr
1	567,750	520	10,151	12,346	13,791	15,638	16,991	18,345
2	242,784	313	6,116	7,439	8,309	9,422	10,238	11,053
3	553,856	2,911	12,754	15,512	17,327	19,648	21,348	23,049
4	237,357	1,320	7,925	9,639	10,767	12,209	13,266	14,323
5	595,110	785	15,346	18,664	20,848	23,641	25,687	27,733
6	578,072	1,507	17,499	21,283	23,774	26,958	29,291	31,625
7	355,126	1,055	12,099	14,715	16,437	18,639	20,252	21,865
8	unknown	374	4,024	4,894	5,467	6,199	6,735	7,272

Notes:

(1) Based on 200 khz sonar bathymetry survey completed in October and November 2016 by Acadia University.

(2) Based on total volume of groundwater discharged as outlined in Section 6.1 of "2016 Boat Harbour Hydrogeology Final" (AECOM, 2016) and average daily discharge from streams from GHD's hydrologic model.

(3) Rainfall depths are from Environment Canada IDF curves for Caribou Point climate station.

Once an area is dewatered, temporary ramps and roads will be constructed, with mud mats used to provide access to sludge to be excavated as needed. Perimeter roads will be constructed on land around Boat Harbour to haul sludge from dewatered areas to the sludge management area. Figure G3 shows examples of proposed locations of planned temporary access ramps and roads. The exact location for access will be selected to minimize impact to sensitive areas (e.g., wetlands). Site electrical service may need to be temporarily extended for dewatering operations.

Excavators will remove sludge/sediment, stockpile it at the base of the dewatered area, and load it into dump trucks (sealed as required). Dozers may be used to push and stockpile sludge. Specialized equipment will likely be required; for example a swamp buggy excavator with pontoon tracks could be used to better travel across soft and wet ground. Excavating in the dry will provide good visual control to ensure all sludge has been removed. It is anticipated that a minimum of 0.15 m of materials underlying the sludge (e.g., native marine clay in the BH, ASB, and estuary) will be excavated due to tolerances of the equipment being used. Confirmatory sampling will be completed post remediation to confirm that the remaining sediment meets the applicable remedial quality standards for all sediment COCs.

Excavated sludge will be placed in a hopper for mixing with water (as needed) to create a slurry such that it can be pumped to the sludge management area. The excavated sludge will have a solids content of approximately 10-20 percent, and may be pumpable with limited water addition. Some excavated sludge may be placed in dump trucks and transported to the sludge management area.

As the twin settling basins and effluent ditching will be dry with the cessation of the Kraft Mill effluent, sludge will be removed from these areas in the dry. Excavators will be used to directly load sludge into dump trucks and transported to the sludge management area.

2.5.2 Feasible Concept 2A – Removal in the Dry with Geotube Dewatering

Results of laboratory treatability testing has deemed use of geotubes as a viable option to dewater sludge/sediment.

Dredged sludge slurry containing approximately 10-20 percent solids will be pumped to the sludge management area. As distance between the dredge and the sludge management area increases, a booster pump will be used to pump the slurry through the discharge line. Polymers and/or coagulants will be added to the slurry prior to entering geotubes to produce flocculation of the fine grained sediments and to promote dewatering. Optimum dosing for polymer and/or coagulant additions are presented in Appendix A.

The sludge management area would be located directly in the disposal cell as the filled geotubes would be ultimately landfilled. Some preparation work would be required, including dewatering wet portions of the disposal cell and shaping the existing placed sludge to facilitate dewatering operations. In addition, the addition of a clear stone drainage layer will likely be required in the disposal cell to reduce the potential for sludge to foul the existing dewatering/leachate collection infrastructure.

The geotubes will be filled in a similar fashion as described above for removal in the wet. Based on the volume of dewatered sludge presented in Table G.1 and geotube bags being filled to 90 percent capacity, it is estimated that between 50 and 130 geotubes will be required to manage sludge/sediment.

Sludge excavated from the settling basins is expected to have a higher solids content than sludge from other Site areas, and is therefore anticipated to be placed directly in the disposal cell.

All dewatering effluent collected from the designated sludge management area will be managed as outlined in Section 3.

2.5.3 Feasible Concept 2B – Removal in the Dry with Clay Stabilization

As part of GHD's bench scale testing (Appendix A), a Cetco clay product (Liquasorb 2000) was found to be effective at absorbing water and stabilizing/solidifying the sludge.

The sludge slurry with a solids content of approximately 10-20 percent would be pumped to the sludge management area. The sludge management area would be located within the twin settling basins or the ASB and would consist of 2-3 containment areas. Each containment area would be approximately 100 x 50 m in size consisting of earthen berms and lined through the use of low permeable fill material (e.g., 1×10^{-6} cm/sec). The existing twin settling basins is an ideal location as it could likely be used with minimal modifications.

Shear mixing equipment would be setup adjacent to the sludge management area. Dredged slurry would be pumped to the mixer for the addition of the clay product. Optimal shear force mixing is important to ensure that clay stabilization is effective, while preventing clumping and segregation of material. It is anticipated that the sludge slurry will be processed at a rate of approximately 135 m^3/hr. Optimum dosing for clay addition is presented in Appendix A.

Once mixed, the material will be pumped into the sludge management area. Excavators will be used to spread the material out for drying. Once the sludge has stabilized (e.g., solidified) over 1-3 days the material will be loaded and hauled for disposal. Stabilization will result in an increase in sludge volumes as shown in Table G.1 (as compared to in place volumes) due to bulking of the material. Should this Feasible Concept be selected, the existing disposal cell would need to be expanded to accommodate the treated sludge volume; or some treated sludge would need to be disposed of off-Site.

2.6 Feasible Concept 3 – Natural Attenuation (Estuary Only)

Natural attenuation has only been deemed acceptable for the estuary. The estuary area associated with the Site has been classified as marsh and salt marsh complex covering an approximate area of 10 ha.

Salt water marshes serve as nursery areas for many valuable recreational fish species as well as habitat for a numerous wildlife species including federally and provincially listed species at risk. As previously discussed for the wetland areas in Appendix E, natural attenuation is commonly used as a viable remedial option to address residual impacts to an ecosystem after the contaminant source has been removed or eliminated. As such, following planned remediation of other areas of the Site, additional loading of COCs to the estuary area is expected to be significantly reduced or eliminated compared to current conditions and will allow for the natural attenuation processes to begin. In association with natural attenuation of COCs is the concept of risk assessment. Risk assessment is the process to estimate the nature and probability of adverse health effects to humans or ecological receptors that may be exposed to chemicals in contaminated environmental media (including sediment and surface water) now or in the future.

Typical natural attenuation processes involve one or more biological, chemical or physical processes. The major biological natural attenuation processes in estuary areas that have the potential to reduce risks associated with contaminants are transformations (or biodegradation) of COCs by microbes and uptake by plants. One specific chemical process that is likely to have significant potential to reduce risk to human health and ecological receptors at the Site is the reduction in the bioavailability of organic and inorganic COCs in sediment, of which adsorption, biodegradation, cation and anion exchange are the most common. A physical process that is also likely to be a significant mechanism of natural attenuation related to the Site estuary is deposition and burial of sediments. This physical process is considered to be potentially significant given that the Boat Harbour stabilization lagoon area is intended to be returned to a natural tidal regime. Deposition occurs when the velocity of water in the estuary is slowed to the point where the water can no longer hold particles in suspension. The suspended particles settle out of the water column and become trapped in the estuary. Contaminants that are adsorbed to these particles are also deposited and trapped. Burial occurs when multiple depositional events occur over time, with each subsequent event depositing a layer of sediments or particulate matter over previously deposited layers. The tandem processes of deposition and burial can provide a mechanism for natural attenuation if future sediment deposition is of "clean" material. Although the buried COCs persist, deposition and burial can be effective mechanisms for reducing risk by eliminating the exposure pathway.

The primary advantage of the natural attenuation remedial approach is that minimal intrusive construction activities are required and the habitat and the wildlife receptors currently utilizing this habitat are not disturbed and are allowed to naturally evolve to the current environmental conditions. Undertaking any intrusive remedial construction activities would alter or destroy the current ecological functions that the habitat currently provides, as well as displace the wildlife species utilizing the habitat.

2.6.1 Risk Assessment

The risk-based approach is a widely-accepted scientific method to evaluate potential environmental impacts and to estimate if these impacts are likely to cause adverse health effects to humans or ecological receptors. The risk assessment process will require thorough evaluation of potential contaminants associated with the Site, identification of human and ecological receptors that may use the property, and ways these receptors may be exposed to potential contaminants (e.g., direct exposure to soil, consumption of plants/wildlife, consumption of water, etc.). The primary benefit of using the risk-based approach is that it allows for a Site-specific evaluation of potential interactions between receptors and contaminants in the environment and focusses future clean-up activities or management programs on the areas of greatest concern. This approach used in conjunction with natural attenuation also has the potential to minimize remedial efforts and unnecessary disturbances to sensitive environments, such as the estuary, that are unlikely to pose an adverse health effect, now or in the future.

The CCME has developed guidelines for screening substances in soil, sediment and water on Federal lands across Canada. The majority of these guidelines have also been adopted by Nova Scotia Environment for use at properties in Nova Scotia. However, these nation-wide guidelines are only intended for general guidance purposes and may not be appropriate in all locations or for use as remediation criteria. For instance, natural levels of some metals in soils of Nova Scotia (e.g., arsenic) are actually higher than the CCME guideline. Therefore, local conditions must be considered when applying these values. In addition, these screening guidelines, specifically sediment quality guidelines, do not account for potential effects to upper trophic level receptors or human health from exposure to bioaccumulative COCs such as D&F. The primary benefit to completing a detailed human health and ecological risk assessment model is to identify the most sensitive Site-specific receptor such that benchmarks can be developed to guide future remediation activities. As a best case scenario, the risk assessment would provide multiple lines of evidence indicating that current conditions of the estuary do not pose an unacceptable risk to human health or ecological receptors and natural attenuation processes will continue to meet remedial objectives. The worst case scenario is likely to be that the risk assessment identifies isolated hotspots in the estuary that require active remediation or risk management measures.

2.6.2 Additional Assessment

It is anticipated that the critical driver for risk at the Site, including the estuary area, will likely be related to potential human and wildlife exposure to dioxin/furans in sediment or food items. Development of a conceptual Site model to determine potential exposure pathways and Site-specific receptors will therefore be a critical step for completion of future risk assessments. However, for the purposes of this preliminary review, it is anticipated that the inputs for future risk assessment models will require sampling and chemical analysis of biological tissue such as plants (including fruits and berries), fish, birds and/or small mammals that may provide a food source for humans or wildlife. The future human health risk assessment will also likely require additional assessment of D&F (as well as other COCs) in other media in the area (soil, drinking water, etc.), to evaluate potential cumulative exposure effects related to human health. In addition to the chemical analysis identified above, it is anticipated that several biological and physical processes studies will be required to validate the natural attenuation remedial alternative. These additional studies are likely to include:

- Evaluation of the benthic invertebrate community and fish population in the estuary compared to a reference location
- Evaluation of COC bioavailability in soil/sediment of the estuary
- Completion of a Wetland Functionality Assessment in accordance with Environment Canada (EC) protocols including development of index of biological indicators (IBIs) to monitor success of the natural attenuation process
- Development of a hydrodynamic model to evaluate the potential for future sediment loading (or mobility) in the estuary

2.6.3 Risk Management

As indicated in the previous sections, there is the potential that the natural attenuation and risk assessment remedial option would determine that current concentrations of COCs in the estuary do not pose an unacceptable risk to ecological receptors or human health and that additional remediation or risk management is not required. However, there is also the potential that the risk assessment identifies isolated hotspots in the estuary that require active remediation or implementation of risk management measures. Active remedial options for the estuary are discussed above. However, there are several non-intrusive risk management options that could also be implemented to reduce risk to human health or ecological receptors including (but not limited to) the following:

- Restrict or reduce future access to the estuary area (potentially create estuary viewing areas and post signs indicating sensitive habitat, do not disturb)
- Restrict future hunting or fishing activities in the estuary
- Enhance ecological habitat in "clean" estuary areas to promote areas for foraging or breeding by wildlife (i.e. construction of bird nesting sites)
- Develop long term monitoring plans including IBIs along with Site-wide risk review to evaluate estuary conditions in conjunction with intrusive remediation of other areas of the Site

2.7 Sediment Treatment Feasible Concepts Cost Estimate

Capital and operation and maintenance cost estimates for each Feasible Concept is provided in Attachment G1 and summarized on Table G.3 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. It is noted that the cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall Project costing.

Table G.3 Sediment Treatment Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1A – Removal in the wet with geotube dewatering	$89,090,000	$0
Feasible Concept 1B – Removal in the wet with clay stabilization	$117,590,000	$0
Feasible Concept 2A – Removal in the dry with geotube dewatering	$113,190,000	$0
Feasible Concept 2B – Removal in the dry with clay stabilization	$160,570,000	$0
Feasible Concept 3 (Estuary Only) – Natural attenuation	$290,000	$650,000

Key assumptions include:

- For Feasible Concepts 1A and 1B silt curtains will not be reused
- For Feasible Concepts 1A and 1B 90 percent of in-place material will be hydraulically dredged, while 10 percent will need to be mechanically dredged
- For Feasible Concepts 1A, 1B, 2A, and 2B sludge management area improvements (within twin settling basins and existing disposal cell) will not require a low permeable liner due to existing clay liner
- For Feasible Concepts 1A, 1B, 2A, and 2B conduct confirmatory sampling at a rate of one sample per 1000 m^2
- For Feasible Concepts 2A and 2B, fill material for isolation and separation berms will not be reused and will constitute clean fill at the completion of remediation
- For Feasible Concepts 1B and 2B (clay stabilization), no dewatering effluent will be produced

- See bulk water and dewatering effluent management assumptions in Sections 3 and 4
- For Feasible Concept 3 post remediation monitoring for 5 years will be required, with parameter limitations noted in cost table

3. Bulk Water Management

3.1 Overview

This section presents a detailed concept descriptions of the Feasible Concept developed for bulk water management. Bulk water refers to impacted surface water that will need to be managed prior to, during or post sludge/sediment removal and excludes dewatering effluent from sludge/sediment treatment processes and leachate generated from the on-Site disposal cellUnder bulk water management, one Feasible Concept was carried forward for evaluation:

- Feasible Concept 1 – On-Site management using low technology treatment system

3.2 Objectives

The objective for bulk water management is to treat COCs to meet applicable criteria to facilitate discharge into the estuary (downstream of the dam) by applying the most cost effective treatment methods. This concept includes the worst case scenario that the discharge would need to meet provincial/federal guidelines and current effluent discharge criteria is not accepted by NSE for bulk dewatering. Discussion with NSE are ongoing to determine if the existing Industrial Approval discharge criteria may be applied through remediation.

3.3 Design Elements

3.3.1 Water Quantity

Table G.2 presented in Section 2.5.1 summarizes the dewatering quantities to initially dewater each of the eight areas shown Figure G3, as well as to maintain dry conditions for sediment treatment Feasible Concept 2. The overall volume to initially dewater the eight areas is approximately 3,500,000 m^3, with an additional 1,200,000[8] m^3 to maintain dry conditions. While removal in the wet (sediment treatment Feasible Concept 1) is expected to require the treatment of 4,000,000 m^3 of surface water post removal of sludge/sediment.

It is noted that it may be possible to lower the water level in the BHETF using the existing dam structure by adjusting the height of the existing stop logs. This could be implemented on the basis that the water quality is similar to what is currently discharged at Point D, with NSE approval.

3.3.2 Water Quality

As part of laboratory treatability and the Phase 2 ESA, characterization of bulk water samples collected from the ASB, BH, and estuary was completed. The surface water quality in each of these areas is comparable. Table G.4 includes a summary of key parameters for treatment based on a review of the analytical results including a comparison to the NSE Tier 1 EQSs for Surface Water (Marine Water) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine).

[8] This includes an average of the Ongoing Dewatering presented in Table G.2 to account for groundwater infiltration and stormwater flow, as well as precipitation and one 100-year design storm event over a period of approximately 630 days.

Table G.4 Bulk Water Management Key Parameters

Parameter	Unit	Criteria[1]	Concentration		
			Estuary	BH	ASB
Total Petroleum Hydrocarbons	mg/l	0.1	0.514	0.335	0.202
Total Cyanide	µg/l	1	15	21	19
Total Cadmium	µg/l	0.12	0.28	0.65	n/a
Total Copper	µg/l	2	2.5	3.8	n/a
Total Mercury	µg/l	0.016	0.03	0.03	n/a
Total Zinc	µg/l	10	51.9	64.4	97.9

Notes:
[1] Criteria is most stringent value of NSE Tier 1 EQSs for Surface Water (Marine) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine).

Metal content in the water will need to be addressed during treatment, to meet the criteria for release into the estuary. The analysis of BH surface water showed that the concentration of zinc is more than five times the criteria. Total cyanide and total petroleum hydrocarbons also exceed criteria. The laboratory treatability testing results show that the concentration of zinc, total cyanide, and total petroleum hydrocarbons can be treated to below discharge criteria with a lime precipitation, coagulation, and adsorption based treatment.

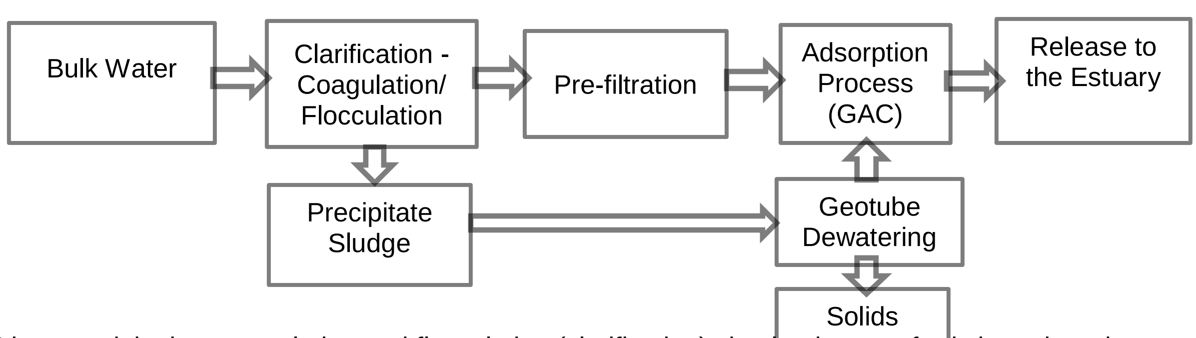
3.3.3 Water Treatment Objectives

Bulk water treatment objectives will include one or more of the following:

- Current Kraft Mill Approval (No 2001-076657-A01) specifies discharge criteria for the BHETF at Point C.
- Surface water quality standards established as outlined in the NSE Tier 1 EQSs for Surface Water (Marine Water) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine).
- Risk based criteria that is protective of ecological and human health.

3.4 Feasible Concept 1 – On-Site Management using Low Technology Treatment System

A precipitation, coagulation, and adsorption based process is the most likely treatment method for bulk water management. Bulk water will be treated as depicted in the below diagram:



Lime precipitation, coagulation and flocculation (clarification) via aluminum or ferric based products, and adsorption by activated carbon are among the most applicable low technology treatment systems. Lime precipitation is a proven technique for lowering the total suspended solids (TSS) (which will aid in reducing metals concentrations), chemical oxygen demand (COD), and toxicity. Coagulation and flocculation involve the addition of coagulants/polymers that conglomerate the small, destabilized particles together into larger particles such that they can be more easily separated from the water. Iron and aluminum salts are among the most widely used coagulants. Coagulant aid polymers and/or acid may also be added to enhance the coagulation process. During laboratory treatability testing, it was determined that the addition of lime optimized precipitation of COCs and the addition of polymers further accelerated the sedimentation process. Further testing needs to be conducted as part of pilot scale testing to optimize the required dosages of treatment chemicals such as polymers, activated carbon, and lime.

Two potential settling areas for the clarification process during the bulk water management process are shown on Figure G4. Area 1 is between Highway 348 and the dam. This area could be converted into a settling basin with the treatment chemicals being added upstream (near the culverts) via a multistage blending system such as a flocculator. Area 2 is a newly created settling basin in BH directly south of Highway 348. Similar to the area 1, treatment chemicals could be added prior to the water entering the basin via a flocculator. For area 2, it is estimated that a 100 m isolation berm will be needed to separate this settling basin from the rest of BH; this will also be the chemical mixing point. Both of these areas could accommodate an assumed flow rate of 250 m^3/hr, however, area 2 could allow for a larger flow rate if needed, since water would have a greater holding time to permit settling of particles as compared to area 1.

Precipitated material that settles to the bottom of the settling basin can be managed by dredging during one of the final stages of the sludge management process. Depending on the sequencing of sludge management activities, this material could be pumped directly to the proposed sludge management area or could be relocated to a provisional temporary precipitated sludge storage area, as shown on Figure G4, for temporary storage and subsequent pumping to the sludge management area.

The last step of the bulk water treatment process following lime precipitation with the aid of appropriate flocculants is treatment by activated carbon. Mobile multimedia/granular activated carbon (GAC) contactors could be strategically located to polish the water prior to direct discharge to the estuary. Multimedia filtration units (e.g., sand, wood chips) will be required as a pretreatment step to reduce particulate related fouling of the activated carbon beds. This alternative is advantageous in that the units are mobile and can be repositioned on Site such that pumping is minimized. Activated carbon has proved successful in the removal of cyanide and metals from the BH surface water. Laboratory treatability testing results showed the concentrations of total petroleum hydrocarbons, cyanide, and zinc dropping below the most stringent discharge criteria after this prescribed treatment process.

Confirmatory sampling will be completed post bulk/surface water treatment to confirm that the water meets the applicable water quality standards for all COCs prior to discharge in the estuary.

3.5 Bulk Water Management Feasible Concept Cost Estimate

Capital cost estimate for the Feasible Concept is provided in Attachment G2 and summarized on Table G.5 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. It is noted that the cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing. A significant portion of the cost is associated with chemical consumptions, which will be verified though pilot scale testing.

Table G.5 Bulk Water Management Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – On-Site management using low technology treatment system (Carried with Sediment Management Feasible Concepts 1A and 1B)	$27,780,000	$0
Feasible Concept 1 – On-Site management using low technology treatment system (Carried with Sediment Management Feasible Concepts 2A and 2B)	$40,560,000	$0

Key assumptions include:

- The cost estimate is based on laboratory treatability results; finding to be validated through pilot scale testing
- The concentration of COCs will be increased as the water level within BH is reduced
- As concentrations increase, chemical dose may increase but no further advanced treatment will be required
- Flow rate of 250 m^3/hr
- 1 percent sludge will be produced
- 2 percent GAC will be needed and could be backwashed and regenerated in 10 cycles.
- Surface water will flow by gravity to the settling basin
- Pumping bulk water to maintain dry conditions for removal of sediment in the dry not included (included under sediment treatment costs)
- No utility cost is included
- The operation duration is considered to be 9 months (270 days) in each year, since the temperature is assumed to be below the freezing point for the remaining days (3 months)

4. Dewatering Effluent Management

4.1 Overview

This section presents the detailed concept descriptions for the Feasible Concept developed for dewatering effluent management. Dewatering effluent is water generated from dewatering sludge/sediment using geotubes as part of sediment treatment Feasible Concept 1A and Feasible Concept 2A. Under dewatering effluent management, one Feasible Concept was developed as follows:

- Feasible Concept 1 – On-Site management using low technology treatment system

4.2 Objectives

The objective for effluent management is to treat COCs to meet applicable criteria to facilitate discharge into the estuary (downstream of the dam) by applying the most cost effective treatment methods. This concept includes the worst case scenario that the discharge would need to meet provincial/federal guidelines and current effluent discharge criteria is not accepted by NSE for bulk dewatering. Discussion with NSE are ongoing to determine if the existing Industrial Approval discharge criteria may be applied through remediation.

4.3 Design Elements

4.3.1 Water Quantity

The quantity of dewatering effluent is anticipated to range between 700,000 to 1,700,000 m^3 as shown in Table G.6 below. For sediment treatment Feasible Concept 1A, it was assumed that a slurry with a solids content of approximately 5 percent would be pumped to the geotubes; while for Feasible Concept 2A it was assumed that a slurry with a solids content of approximately 10 percent would be pumped to the geotubes. Based on laboratory treatability testing, the resulting dewatered solids content is anticipated to range from 20-35 percent.

Table G.6 Dewatering Effluent Water Quantities

Sediment Treatment Feasible Concept	Dewatering Effluent Volume (m^3)
Feasible Concept 1A –Sludge removal in the wet with ex situ dewatering	1,700,000
Feasible Concept 2A – Sludge removal in the dry with ex situ dewatering	700,000

4.3.2 Water Quality

Table G.7 below provides a summary of key parameters for treatment based on laboratory treatability testing analytical results compared to the NSE Tier 1 EQSs for Surface Water (Marine Water) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine). This table presents dewatering effluent concentrations without the addition of any chemicals.

Table G.7 Dewatering Effluent Management Key Parameters

Parameter	Units	Criteria(1)	Concentration		
			Estuary	BH	ASB
Total Petroleum Hydrocarbons	mg/l	0.1	7.81	23.5	9.97
Toxic Equivalent (TEQ) (dioxins and furans)	pg/l	120	0.00011	275	643
Total Cyanide	µg/l	1	6.7	19	6
Total Chromium	µg/l	56 (trivalent)	ND (25)	21.7	74.6
Total Copper	µg/l	2	ND (50)	ND (50)	50
Total Mercury	µg/l	0.016	0.15	0.58	0.47
Total Vanadium	µg/l	50	24	101	79.5
Total Zinc	µg/l	10	187	729	528

Notes:
(1) Criteria is most stringent value of NSE Tier 1 EQSs for Surface Water (Marine) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine). For TEQ (dioxins and furans) based on NSE Tier 1 EQS for Groundwater (Potable Groundwater Values).
ND – not detected at reporting limit.

The dewatering effluent generated from a laboratory scale geotube using a 5 percent solids slurry from ASB, BH, and estuary sludge/sediments without the addition of any chemicals was analyzed for COCs. The results showed that the concentration of total petroleum hydrocarbons, cyanide copper, mercury, and zinc are higher than the potential discharge criteria for all three tested areas. Furthermore, the concentrations of chromium in the ASB and D&F and vanadium in BH and ASB sludge/sediment dewatering effluent are higher than the potential discharge criteria.

It is assumed that the dewatering effluent for sludge removed in both the wet and the dry (sediment treatment Feasible Concept 1A and Feasible Concept 2A) will have similar concentrations of COCs. However, there is a high probability that the concentrations of COCs may be higher in Feasible Concept 2A since the solids content is higher at 10 percent versus the value in the wet of 5 percent solids.

During the laboratory treatability testing, different types of polymers and flocculants, as well as lime and powder activated carbon were added to the sludge prior to geotube dewatering. The optimum combinations of polymer and coagulants for sediment from each tested area are presented in Appendix A. The analysis of the dewatering effluent showed that geotube dewatering with the addition of the optimum polymer/coagulant dosage and 2 percent powder activated carbon produced the best results. This mixture was found to substantially lower COC concentrations in the dewatering effluent, however, the concentration of zinc, cyanide, and total petroleum hydrocarbons remained higher than discharge criteria; therefore the geotube dewatering effluent requires additional treatment.

Adsorption using GAC was selected as the best treatment option for remediation of remaining COCs from the geotube dewatering effluent. The initial laboratory testing results showed a favourable reduction of remaining COC in sediment dewatering effluent following GAC adsorption.

The testing results illustrate that the adsorption process using commercial activated carbon could reduce the concentration of COCs under potential discharge concentrations, which should be validated during pilot scale testing to calculate the kinetic and adsorption capacity of activated carbon. Similarly, since the geotube dewatering test was conducted under atmospheric pressure, and feeding only the 5 percent solids slurry (i.e., removal in the wet), any pressurized dewatering or higher solids content in real application may increase the concentration COCs in the geotube dewatering effluent and could potentially require advanced treatment.

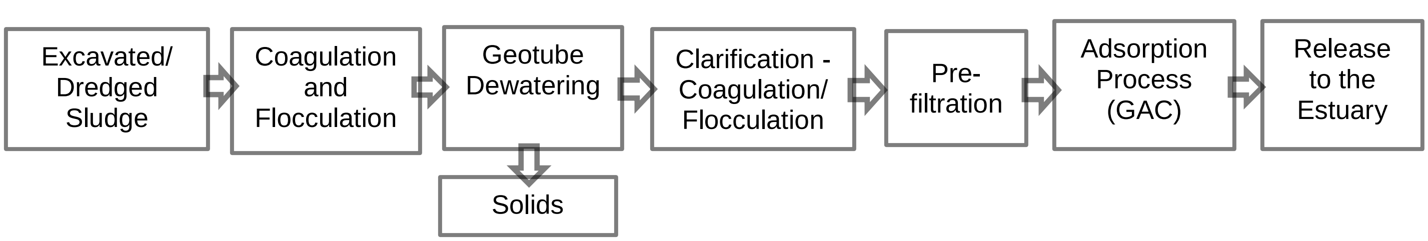
4.3.3 Water Treatment Objectives

Dewatering effluent treatment objectives will include one or more of the following:

- Current Kraft Mill Approval (No. 2001-076657-A01) specifies discharge criteria for the BHETF at Point C.
- Surface water quality standards established as outlined in the NSE Tier 1 EQSs for Surface Water (Marine Water) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine).
- Risk based criteria that is protective of ecological and human health.

4.4 Feasible Concept 1 – On-Site Management using Low Technology Treatment System

The preliminary results show that coagulation and precipitation coupled with geotube dewatering removes most of the COCs, the remainder of which will be treated through a GAC adsorption column. Dewatering effluent will be treated as depicted in the below diagram:



A coagulation and flocculation process with optimum polymer/coagulant and powder activated carbon prior to geotube dewatering resulted in the most significant reduction in metal and D&F concentrations. There are different methods for adding polymer/coagulant and powder activated carbon to the dredged slurry prior to entering geotubes. However, an "in-line" dosing system is the most practical method given its reduced capital and operational costs. In this method, chemicals will be mixed and prepared on Site and will be injected into the dredging transportation pipe prior to entering geotubes. This would be completed near the sludge management area, as shown on Figure G4. As discussed in Section 2 Sediment Treatment, the optimal doses of chemicals based on laboratory treatability testing are presented in Appendix A, as well as the optimal doses of powder activated carbon. During pilot scale testing these doses will be refined. Testing will also be completed to confirm whether the powder activated carbon addition prior to geotubes can be eliminated (if the final GAC adsorption polishing is sufficient), as this would reduce the final sludge volume to remain in the geotubes.

Following geotube dewatering, dewatering effluent will be pumped to a clarifier for mixing with polymers and lime, and then to a dewatering effluent storage basin. Next will be an additional polishing step using GAC adsorption columns, which is expected to capture the remaining metal content in the dewatering effluent water. The bench scale results showed a promising reduction in remaining metals, total petroleum hydrocarbons, and total cyanide from dewatering effluent and indicated that geotube dewatering effluent treated with GAC should be able to be released to the marine environment without further treatment. Mobile multimedia/GAC contactors could strategically be located to polish the dewatering effluent prior to direct discharge to the estuary. Multimedia filtration units (e.g., sand, wood chips) will be required as a pretreatment step to reduce particulate related fouling of the activated carbon beds. Typical trailerized units can treat significant volumes of water depending on the required empty bed contact time. Waste backwash water produced by the units can be recycled to the geotube feed slurry. Mobility of these units is a significant advantage as they can be moved and reoriented to suit sludge management operations. It is anticipated that these units will be located near the geotubes/sludge management area. As shown on Figure G.4, once the dewatering effluent has gone through the GAC adsorption columns, the treated water will enter a treated dewatering effluent storage basin and will then be pumped via a discharge pipeline to the estuary for discharge. Confirmatory sampling will be completed prior to discharge to confirm that the water meets the applicable water quality standards for all COCs.

The applicability of this proposed treatment process will need to be evaluated during pilot testing, to test its performance with geotube dewatering effluent produced under higher pressure and from slurries of varying percent solids.

4.5 Dewatering Effluent Management Cost Estimate

Capital cost estimate for the Feasible Concept is provided in Attachment G3 and summarized on Table G.8 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. It is noted that the cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.

Table G.8 Dewatering Effluent Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – On-Site management using low technology treatment system (Carried with Sediment Management Feasible Concept 1A)	$14,270,000	$0
Feasible Concept 1 – On-Site management using low technology treatment system (Carried with Sediment Management Feasible Concept 2A)	$8,270,000	$0

Key assumptions include:

- The cost estimate is based on the obtained bench scale data and assumes no further treatment processes will be needed on larger scale.
- Dewatering effluent quality will be the same for sediment removed in the wet (5 percent solids) and sediment removed in the dry (10 percent solids).
- Power line and roads will be available to the treatment area.
- Treated dewatering effluent discharge line from sludge management area to estuary has not been included (included under sediment treatment).
- No utility costs are included.

5. Leachate Management

5.1 Overview

This section presents a detailed concept description of the Feasible Concepts developed for the management of leachate from the on-Site sludge disposal cell. Waste Management Feasible Concept 1 (Appendix D) consists of using the existing disposal cell for long term management of waste generated from the remedial activities. The following sections outline Feasible Concepts for the management of leachate generated from the disposal cell post closure.

The following two Feasible Concepts were developed for leachate management:

- Feasible Concept 1 – On-Site management using advanced treatment
- Feasible Concept 2 –Off-Site disposal

5.2 Objectives

The leachate management objectives are to:

- Reduce the volume, toxicity, and mobility of leachate in a cost-effective manner
- Reduce the risk of groundwater and surface water contamination

5.3 Common Design Elements

5.3.1 Leachate Quantity

It is estimated that the volume of leachate would be less than 2500 m^3 per year based on using a flexible membrane liner and assuming approximately 1,200 mm of rainfall per year[9].

5.3.2 Leachate Quality

To simulate the quality of leachate post closure Toxicity Characteristic Leaching Procedure (TCLP) test and Synthetic Precipitation Leaching Procedure (SPLP) test were conducted on the dewatered sludge as part of the laboratory treatability testing. Table G.9 below provides a summary of key parameters for leachate treatment based on a review of the analytical results of the TCLP and SPLP test results and leachate quality results from the existing disposal cell and compares the results to the more stringent of the NSE Tier 1 EQSs for Surface Water (Marine Water) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine). The results are for dewatered sludge following the addition of polymer.

Table G.9 Leachate Management Key Parameters

Parameter	Units	Criteria(1)	TCLP Results BH Dewatered Sludge	SPLP Results BH Dewatered Sludge	Concentration of Leachate in Existing Sludge Disposal Cell2
Barium	µg/l	500	656	117	844
Cadmium	µg/l	0.12	1.13	ND (25)	13.2
Chromium	µg/l	1.5	ND (25)	ND (25)	-
Copper	µg/l	2	ND (50)	ND (50)	67
Lead	µg/l	2	9.71	12.1	43.9
Mercury	µg/l	0.016	ND (0.2)	ND (0.2)	-
Nickel	µg/l	8.3	14.1	ND (50)	26
Selenium	µg/l	2	ND (100)	ND (100)	3
Silver	µg/l	1.5	ND (50)	ND (50)	3.1
Zinc	µg/l	10	1520	24.7	1410
Total Cyanide	µg/l	1	ND (10)	ND (10)	-
Total Petroleum Hydrocarbons	mg/l	0.1	0.005	0.105	-
Toxic Equivalent (TEQ) (dioxins and furans)	pg/l	120	< 1.6	< 17.2	-

Notes:
(1) Criteria is most stringent value of NSE Tier 1 EQSs for Surface Water (Marine) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine). For TEQ (dioxins and furans) based on NSE Tier 1 EQS for Groundwater (Potable Groundwater Values).
(2) Sludge Disposal Cell – Boat Harbour Effluent Treatment Facility, 2015 Monitoring Report, March 2016
ND – not detected at reporting limit

It is expected that the existing sludge in the sludge disposal cell will affect the quality of the combined leachate. Furthermore, the pressure that will be imposed on the lower sludge layers in the disposal cell has the potential to elevate the COCs in the leachate. The leachate treatment system that has been proposed has considered this possibility.

5.3.3 Leachate Treatment Objectives

Potential leachate treatment objectives for on-Site leachate treatment include:

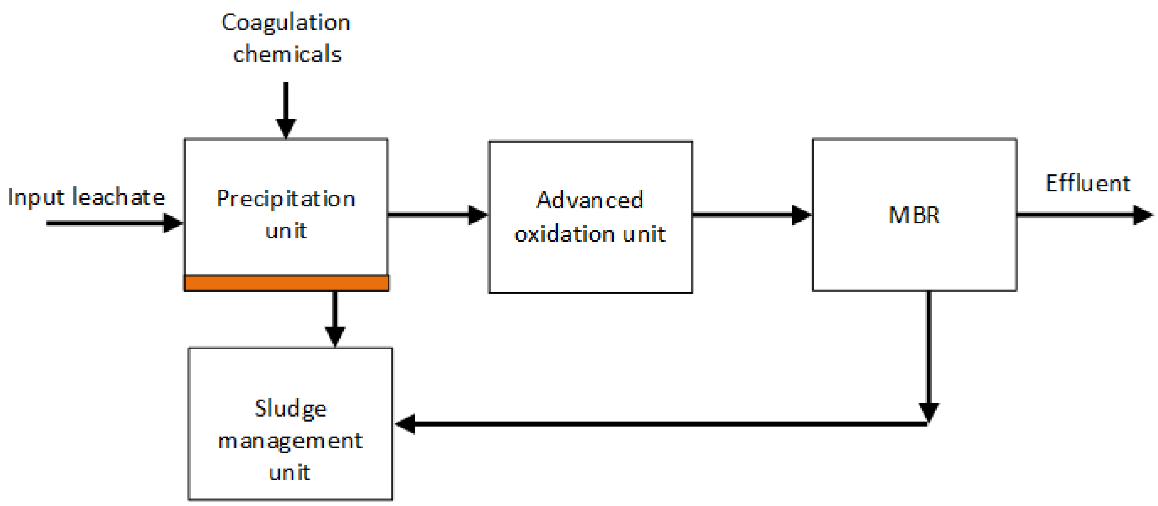
- Surface water quality standards established as outlined in the NSE Tier 1 EQSs for Surface Water (Marine Water) and CCME Water Quality Guidelines for the Protection of Aquatic Life (Marine)
- Risk based criteria that is protective of ecological and human health

Leachate objectives for off-Site leachate disposal include:

- Water treatment facility requirements

5.4 Feasible Concept 1 - On-Site Management Using Advanced Treatment

As the future generated leachate is expected to contain a high level of toxicity due to high metal concentrations, a three step treatment process was considered for leachate treatment. Leachate will be treated as depicted in the below diagram:



In the first step, coagulation and precipitation will reduce the concentration of metals and TSS. The effluent from the first step will enter an advanced oxidation unit to break down possible toxic compounds prior to a membrane bioreactor (MBR) unit. The precipitation and advanced oxidation will be a two stage pretreatment step to reduce toxicity of the leachate such that the MBR biology can effectively polish the leachate prior to discharge. Depending on leachate characteristics an external source of nutrition (e.g., phosphorus, nitrogen, carbon) may be needed prior to the MBR step to maintain a stable biomass and efficient biologic treatment. It is expected that these three treatment steps will reduce the concentration of all COCs below potential discharge criteria and the effluent could be released to Boat Harbour. However, a wetland could be implemented at the end of the treatment process in the event that COC concentrations are higher than expected. In the proposed treatment concept an emergency storage tank with a capacity of 20,000 gallons has been considered for situations such as higher flow rate and potential system failure.

Solids generated through the leachate treatment process will be managed through the sludge management unit, which may consist of a filter press or centrifuge. Residual solids from the process are expected to be minimal and will be placed in a sludge management area near the disposal cell or disposed of off Site.

5.5 Feasible Concept 2 - Off-Site Disposal

Based on the estimated annual leachate volume of less than 2,500 m^3 off-Site leachate management is a viable option.

This treatment concept involves a leachate collection storage tank with a capacity of approximately 20 m^3, which provides sufficient storage to collect leachate generated for approximately 3 days. In addition to the storage tank, a larger emergency storage tank was considered in case of higher flow rates or other unpredictable circumstances to provide extra capacity to prevent unauthorized discharges to Boat Harbour.

Leachate would drain from the sludge disposal cell to the storage tanks. A truck loading station has been carried for the subsequent transfer of leachate to trucks. The haul trucks would load leachate from the tanks for off-Site disposal at a wastewater treatment plant. It is estimated that one 10 m^3 load would need to be removed per day to manage leachate that is generated. It has been assumed that all off-Site disposal will be within 175 km of the Site. Leachate quality sampling may be required prior to transportation, depending on the pre-screening requirements of the selected off-Site disposal facility.

5.6 Leachate Management Cost Estimate

Capital and operation and maintenance cost estimates for the Feasible Concepts are provided in Attachment G4 and summarized on Table G.10 below. The Class D cost estimate was completed in accordance with the Treasury Board of the Canadian Federal Government cost classification system, and is presented in 2018 Dollars without consideration of the time value of money. The cost estimate is considered to have an accuracy of minus 30 to plus 50 percent. It is noted that the cost estimate does not include costs associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing. O&M cost for the estimated 25-year contaminating life span of the disposal cell are covered for both Feasible Concepts. Two O&M costs are shown for Feasible Concept 2: Feasible Concept 2A represents leachate being transported to a municipal wastewater treatment facility; while Feasible Concept 2B represents leachate being transport to an industrial wastewater treatment facility.

Table G.10 Leachate Management Class D Cost Estimate

Feasible Concept	Capital Cost	Operation and Maintenance Cost
Feasible Concept 1 – On-Site management using advanced treatment	$2,770,000	$6,300,000
Feasible Concept 2A – Off-Site disposal (Leachate disposed at municipal wastewater treatment facility)	$430,000	$2,000,000
Feasible Concept 2B – Off-Site disposal (Leachate disposed at industrial wastewater treatment facility)	$430,000	$13,500,000

Key assumptions include:

- The generated leachate will meet the off-site landfill discharge criteria.
- The strength of produced leachate will be a mixture of current sludge disposal effluent and the effluent of accumulated sediments in geotubes.
- A constant flow rate of 7 m^3/day was considered in sizing the treatment system.
- The provisional option to add a wetland following on-Site treatment prior to discharge has not been considered in the current cost estimation.
- Power line would be available at the leachate collection area.
- Leachate will be hauled for off-Site disposal within 175 km of the Site – 2 hours per trip has been carried.
- Leachate will need to be managed for 25 years post closure

Source: ESRI Imagery; Vivid - Canada, DigitalGlobe, 7/31/2016

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
REMEDIATION

SITE LAYOUT

11148275-09
Mar 15, 2018

FIGURE G1

GIS File: Q:\GIS\PROJECTS\11148000s\11148275\Layouts\005\11148275-09(005)GIS-OT008.mxd

Source: ESRI Imagery; Vivid - Canada, DigitalGlobe, 7/31/2016

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
REMEDIATION

11148275-09
Mar 15, 2018

SITE LAYOUT - REMOVAL IN THE WET

FIGURE G2

GIS File: Q:\GIS\PROJECTS\11148000s\11148275\Layouts\005\11148275-09(005)GIS-OT002.mxd

Source: ESRI Imagery; Vivid - Canada, DigitalGlobe, 7/31/2016

0 200 400 600
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

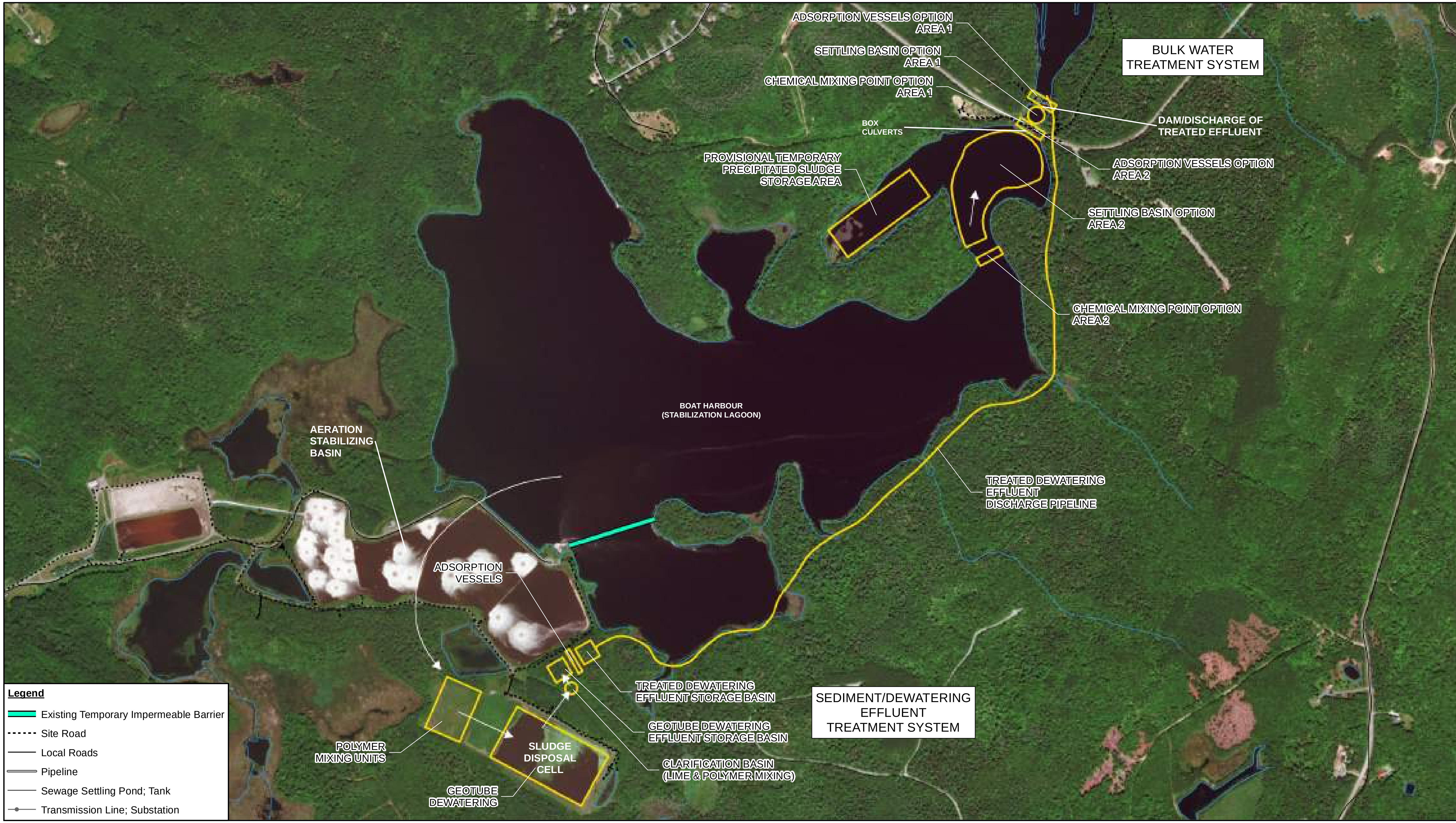
NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
REMEDIATION

SITE LAYOUT - REMOVAL IN THE DRY

11148275-09
Mar 15, 2018

FIGURE G3

GIS File: Q:\GIS\PROJECTS\11148000s\11148275\Layouts\005\11148275-09(005)GIS-OT003.mxd



Source: ESRI Imagery; Vivid - Canada, DigitalGlobe, 7/31/2016

0 100 200 300
Meters

Coordinate System:
NAD 1983 CSRS UTM Zone 20N

N

GHD

NOVA SCOTIA LANDS INC
BOAT HARBOUR, NS
REMEDIATION

DEWATERING EFFLUENT & BULK WATER MANAGEMENT
SITE LAYOUT

11148275-09
Mar 21, 2018

FIGURE G4

GIS File: Q:\GIS\PROJECTS\11148000s\11148275\Layouts\005\11148275-09(005)GIS-OT007.mxd

Attachment G1

Class D Cost Estimate
Sediment Management Feasible Concept 1A - Removal in the Wet with Geotube Dewatering
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Capital Costs							
1	Access Road Improvements	LM	2,000	$	550	$	1,100,000
2	Silt Curtains	LM	2,700	$	185	$	499,500
3	Hydraulic Dredging and Dewatering	M3	702,900	$	50	$	35,145,000
4	Mechanical Dredging and Dewatering	M3	78,100	$	65	$	5,076,500
5	Dewatering Effluent Management	LS	-	-		$	14,264,000
6	Bulk Water Management	LS	-	-		$	27,771,000
7	Discharge Line To Estuary	LM	2,500	$	690	$	1,725,000
8	Sludge Management Area Preparation	LS	-	-		$	1,400,000
9	Confirmatory Sampling Analytical	EA	1,400	$	1,500	$	2,100,000
					Total Class D Cost Estimate	$	89,081,000
					Total Class D Cost Estimate (Rounded, -4)	**$**	**89,090,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Silt curtains will not be reused.
   - 90 percent of in-place material will be hydraulically dredged and 10 percent will mechanically dredged.
   - Assumes treated effluent is discharged into the estuary downstream of the dam.
   - Sludge management area improvements will not require a low permeable liner due to existing clay liner.
   - Confirmatory sampling will be completed at a rate of one sample per 1000 m^2
   - Bulk water and dewatering effluent management detailed in Attachments G2 and G3

Attachment G1

Class D Cost Estimate
Sediment Management Feasible Concept 1B - Removal in the Wet with Clay Stabilization
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Capital Costs							
1	Access Road Improvements	LM	2,000	$	550	$	1,100,000
2	Silt Curtains	LM	2,700	$	185	$	499,500
3	Hydraulic Dredging and Stabilization	M3	702,900	$	110	$	77,319,000
4	Mechanical Dredging and Stabilization	M3	78,100	$	110	$	8,591,000
5	Sludge Management Area Preparation	LS	-		-	$	200,000
6	Bulk Water Management	LS	-	-		$	27,771,000
7	Confirmatory Sampling Analytical	EA	1,400	$	1,500	$	2,100,000
					Total Class D Cost Estimate	$	117,580,500
					Total Class D Cost Estimate (Rounded, -4)	**$**	**117,590,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Silt curtains will not be reused.
   - 90 percent of in-place material will be hydraulically dredged and 10 percent will mechanically dredged.
   - Assumes treated effluent is discharged into the estuary downstream of the dam.
   - Sludge management area improvements will not require a low permeable liner due to existing clay liner.
   - Confirmatory sampling will be completed at a rate of one sample per 1000 m^2
   - Clay stabilization will not produce dewatering effluent
   - Bulk water management detailed in Attachment G2

Class D Cost Estimate
Sediment Managment Feasible Concept 2A - Removal in the Dry with Geotube Dewatering
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price		Total Price	
Part A - Capital Costs							
1	Access Road Improvements	LM	4,000	$	550	$	2,200,000
2	Bulk Water Management (Initial)	LS	-	-		$	24,771,000
3	Bulk Water Management (Ongoing)	LS	-	-		$	15,771,000
4	Isolation Berms	LM	2,000	$	3,000	$	6,000,000
5	Separation Berms	LM	14,000	$	850	$	11,900,000
6	Excavation and Dewatering	M3	781,000	$	50	$	39,050,000
7	Dewatering Effluent Management	LS	-	-		$	8,264,000
8	Discharge Line To Estuary	LM	2,500	$	690	$	1,725,000
9	Sludge Management Area Preparation	LS	-		-	$	1,400,000
10	Confirmatory Sampling Analytical	EA	1,400	$	1,500	$	2,100,000
				Total Class D Cost Estimate		$	113,181,000
				Total Class D Cost Estimate (Rounded, -4)		**$**	**113,190,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Assumes treated effluent is discharged into the estuary downstream of the dam.
   - Sludge management area improvements will not require a low permeable liner due to existing clay liner.
   - Confirmatory sampling will be completed at a rate of one sample per 1000 m^2
   - Fill material for isolation and separation berms will not be reused and will be clean fill at the completion of remediation
   - Bulk water and dewatering effluent management detailed in Attachments G2 and G3

Attachment G1

Class D Cost Estimate
Sediment Managment Feasible Concept 2B - Removal in the Dry with Clay Stabilization
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Capital Costs							
1	Access Road Improvements	LM	4,000	$	550	$	2,200,000
2	Bulk Water Management (Initial)	LS	-		-	$	24,771,000
3	Bulk Water Management (Ongoing)	LS	-		-	$	15,771,000
4	Isolation Berms	LM	2,000	$	3,000	$	6,000,000
5	Separation Berms	LM	14,000	$	850	$	11,900,000
6	Excavation and Stabilization	M3	781,000	$	125	$	97,625,000
7	Sludge Management Area Preparation	LS	-		-	$	200,000
8	Confirmatory Sampling Analytical	EA	1,400	$	1,500	$	2,100,000
					Total Class D Cost Estimate	$	160,567,000
					Total Class D Cost Estimate (Rounded, -4)	**$**	**160,570,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Assumes treated effluent is discharged into the estuary downstream of the dam.
   - Sludge management area improvements will not require a low permeable liner due to existing clay liner.
   - Confirmatory sampling will be completed at a rate of one sample per 1000 m^2
   - Fill material for isolation and separation berms will not be reused and will be clean fill at the completion of remediation
   - Bulk water management detailed in Attachment G2

Class D Cost Estimate
Sediment Managment Feasible Concept 3 (Estuary Only) - Natural Attenuation
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Prepare Work Plan and Conceptual Site Model	LS	-	-	$ 30,000
2	Additional Data Collection (Field)	LS	-	-	$ 30,000
3	Human Health and Ecological Risk Assessment	LS	-	-	$ 50,000
4	Wetland Functionality Assessment and Index of Biological Indicators Development	LS	-	-	$ 40,000
5	Hydrologic Modeling	LS	-	-	$ 15,000
6	Report Preparation	LS	-	-	$ 30,000
7	Expenses	LS	-	-	$ 7,500
8	Laboratory Fees	LS	-	-	$ 80,000
	Total Class D Capital Cost Estimate				$ 282,500
	Total Class D Capital Cost Estimate (Rounded, -4)				**$ 290,000**
Part B - Long Term Operations and Maintenance (O&M)					
9	**Post Remediation Monitoring**				
9.1	Professional Fees and Expenses	Y	5	$ 50,000	$ 250,000
9.2	Laboratory Fees	Y	5	$ 80,000	$ 400,000
	Total Class D O&M Cost Estimate				$ 650,000
	Total Class D O&M Cost Estimate (Rounded, -4)				**$ 650,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Costs assume 5-years of post-remediation monitoring will be required (monitoring may not be in consecutive years)
   - Costs assume various biological media (tissue, pore water, etc.) will be required in addition to sediment characterization pre and post-remediation to validate the NA approach
   - Costs do not include surface water sampling for D/F as guidelines currently not available from CCME or NSE
   - Costs do not include invertebrate or fish toxicity testing (i.e. LC50 testing) as these test are considered unlikely to be required at this time

Attachment G2

Attachment G2

Class D Cost Estimate
Bulk Water Management Feasible Concept 1 - On-Site Management Using Low Tech Treatment System
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity		Unit Price		Total Price
Part A - Base Capital Costs							
1	Isolation Berms	M	100	$	3,000	$	300,000
2	Civil Work for Settling Basin Preparation	LS	-		-	$	500,000
3	Adsorption Column Pumps	EA	7	$	5,750	$	40,300
4	Polymer Storage Tank and Dosing System	EA	1	$	287,500	$	287,500
5	Lime Mixing Tank and Injection Pump	EA	1	$	172,500	$	172,500
6	Valves and Piping	LS	-		-	$	500,000
7	Mechanicals	LS	-		-	$	300,100
8	Installation	LS	-		-	$	650,200
9	Maintenance and Labour	Y	4	$	130,100	$	520,400
10	Sampling	LS	-		-	$	499,500
					Subtotal	**$**	**3,771,000**
Part B - Bulk Water Management (Sediment Management Feasible Concepts 1A and 1B)							
11	Chemicals and Consumables	M3	4,000,000	$	6	$	24,000,000
					Total Class D Cost Estimate	$	27,771,000
					Total Class D Cost Estimate (Rounded,-4)	**$**	**27,780,000**
Part C - Bulk Water Manaagement (Initial) (Sediment Management Feasible Concepts 2A and 2B)							
12	Chemicals and Consumables	M3	3,500,000	$	6	$	21,000,000
					Total Class D Cost Estimate	$	24,771,000
					Total Class D Cost Estimate (Rounded,-4)	**$**	**24,780,000**
Part D - Bulk Water Management (Ongoing)(Sediment Management Feasible Concepts 2A and 2B)							
13	Chemicals and Consumables	M3	1,200,000	$	10	$	12,000,000
					Total Class D Cost Estimate	$	15,771,000
					Total Class D Cost Estimate (Rounded,-4)	**$**	**15,780,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Based on laboratory treatability testing; findings to be validated during pilot scale testing.
   - Concentration of COCs will increase as the water level within BH is reduced
   - As concentrations increase, chemical dose may increase but no further advanced treatment will be required
   - Flow rate of 250 m3/hr
   - 1 percent sludge will be produced.
   - 2 percent GAC will be needed and could be backwashed and regenerated in 10 cycles.
   - Surface water will flow by gravity to the clarification cell.
   - Pumping bulk water to maintain dry conditions for removal of sediment in the dry not included (included under Sediment Manag
   - Utility cost not included.
   - Operation is 9 or 12 months, no winter operation.

Attachment G3

Class D Cost Estimate
Dewatering Effluent Management Feasible Concept 1 - On-Site Low Tech Treatment System
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Base Capital Costs					
1	Site Preparation	M2	400	$ 80	$ 32,000
2	Chemical Dosing System (Mixing Tank, Injection Pump, Mechanicals)	EA	3	$ 172,500	$ 517,500
3	Clarification Basin (Including Civil Work)	LS	-	-	$ 350,000
4	Adsorption Column Pumps	EA	7	$ 5,750	$ 40,300
5	Dewatering Effluent Storage Basins	M3	250	$ 88	$ 22,000
6	Valves and Piping	LS	-	-	$ 500,000
7	Mechanicals	LS	-	-	$ 429,000
8	Installation	LS	-	-	$ 929,400
9	Maintenance and Labour	Y	4	$ 185,880	$ 743,600
10	Water Sampling Analytical	LS	-	-	$ 499,500
				Subtotal	**$ 4,064,000**
Part B - Dewatering Effluent Management (Sediment Management Feasible Concept 1A)					
11	Chemicals and Consumables	M3	1,700,000	$ 6	$ 10,200,000
				Total Class D Cost Estimate	$ 14,264,000
				Total Class D Cost Estimate (Rounded,-4)	**$ 14,270,000**
Part C - Dewatering Effluent Management (Sediment Management Feasible Concept 2A)					
12	Chemicals and Consumables	M3	700,000	$ 6	$ 4,200,000
				Total Class D Cost Estimate	$ 8,264,000
				Total Class D Cost Estimate (Rounded,-4)	**$ 8,270,000**

Notes:

1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
    - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
    - Historical Project Information
    - Quotations from industry experts
    - Standard Supplier Price List
3. Key assumptions include:
    - Based on laboratory treatability testing; findings to be validated during pilot scale testing.
    - Dewatering effluent quality will be the same for sediment removed in the wet and dry.
    - Power lines and road will be available to the treatment area.
    - The cost of treated water's transportation line from sludge disposal cell to estuary area has not been included.
    - Utility cost not included.

Attachment G4

Attachement G4

Class D Cost Estimate
Feasible Concept 1 - On-Site Management using Advanced Treatment
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price		Total Price	
Part A - Capital Costs							
1	Building	M3	300	$	3,100	$	930,000
2	Emergency storage tank (for higher flow rates or system shut dow	M3	75	$	2,250	$	168,750
3	Advanced oxidation reactor	LS	1			$	172,500
4	Memberane bioreactor with blowers, control system	LS	1			$	172,500
5	Chemical storage tanks, pumps, mixers	LS	1			$	172,500
6	Solid waste management (filter press, centrifuge, etc.)	LS	1			$	57,500
7	Mechanicals such as piping and instrumentation, connections, sensors (40% of total equipment cost)	LS	1			$	258,750
8	Installation (100% of equipment cost)	LS	1			$	833,750
				Total Class D Cost Estimate		$	2,766,250
				Total Class D Cost Estimate (Rounded, -4)		**$**	**2,770,000**
Part B - Annual Operations and Maintenance (O&M)							
9	Consumable Chemicals (H2O2, oxidation reagents, biological nutritions, acid and base for pH adjustment, GAC)	M3	2,500	$	18	$	45,000
10	Utilities, solids management, labour	Y	1	$	120,000	$	120,000
11	Maintenance and Repair (assume 3% of capital cost/year)	Y	1	$	83,100	$	83,100
				Total Class D Annual O&M Cost Estimate		$	248,100
				Total Class D Annual O&M Cost Estimate (Rounded, -4)		**$**	**250,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project costing.
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Flow rate of 7 m^3/day.
   - Wetland add on not included.
   - Power line available at leachate collection area.
   - 25 year operational period.
   - Leachate strength will be a mixture of current sludge disposal effluent and the effluent of accumulated sediments in geotubes

Attachement G4

Class D Cost Estimate
Feasible Concept 2A - Off-Site Disposal
Leachate Disposed at Municipal Facility
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Storage Tank	M3	20	$ 2,250	$ 45,000
2	Emergency Collection Basin	M3	75	$ 2,250	$ 168,750
3	Building	M3	60	$ 3,100	$ 186,000
4	Truck Loading Station		1		$ 30,000
				Total Class D Cost Estimate	$ 429,750
				Total Class D Cost Estimate (Rounded, -4)	**$ 430,000**
Part B - Annual Operations and Maintenance (O&M)					
5	Transportation (Truck and operator)	HR	440	$ 144	$ 63,250
6	Disposal Fee	M3	2,500	$ 3	$ 7,500
				Total Class D Annual O&M Cost Estimate	$ 70,750
				Total Class D Annual O&M Cost Estimate (Rounded, -4)	**$ 80,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Flow rate of 7 m^3/day.
   - Power line available at leachate collection area.
   - 25 year operational period.
   - Generated leachate will meet the landfill discharge criteria.
   - Disposal at municipal facility within 175 km.
   - Leachate strength will be a mixture of current sludge disposal effluent and the effluent of accumulated sediments in g

Attachement G4

Class D Cost Estimate
Feasible Concept 2B - Off-Site Disposal
Leachate Disposed at Industrial Facility
Remedial Option Decision Document
Boat Harbour Remediation Planning and Design

Item	Description	Unit	Estimated Quantity	Unit Price	Total Price
Part A - Capital Costs					
1	Storage Tank	M3	20	$ 2,250	$ 45,000
2	Emergency Collection Basin	M3	75	$ 2,250	$ 168,750
3	Building	M3	60	$ 3,100	$ 186,000
4	Truck Loading Station		1		$ 30,000
				Total Class D Cost Estimate	$ 429,750
				Total Class D Cost Estimate (Rounded, -4)	**$ 430,000**
Part B - Annual Operations and Maintenance (O&M)					
5	Transportation (Truck and operator)	HR	440	$ 144	$ 63,250
6	Disposal Fee	M3	2,500	$ 190	$ 475,000
				Total Class D Annual O&M Cost Estimate	$ 538,250
				Total Class D Annual O&M Cost Estimate (Rounded, -4)	**$ 540,000**

Notes:
1. Class D Cost Estimate in accordance with the Treasury Board of the Canadian Federal Government; accuracy -30 to +50%.
   - Cost estimate does not include cost associated with general requirements (e.g., bonds, insurance, mobilization/demobilization, temporary facilities and controls) and contingency, which are carried in overall project
2. Pricing was based on:
   - Historical Project Information
   - Quotations from industry experts
   - Standard Supplier Price List
3. Key assumptions include:
   - Flow rate of 7 m^3/day.
   - Power line available at leachate collection area.
   - 25 year operational period.
   - Generated leachate will meet the landfill discharge criteria.
   - Disposal at industrial facility within 175 km.
   - Leachate strength will be a mixture of current sludge disposal effluent and the effluent of accumulated sediments in

Appendix H
Evaluation and Scoring Matrix for each Feasible Concept and Screening Matrix Evaluation Forms for each Feasible Concept

EVALUATION CRITERIA AND WEIGHTING MATRIX

Boat Harbour Remediation Design (BHRD)

1. BRIDGE AT HIGHWAY 348

			FC1 CONCRETE GIRDER	FC2 STEEL GIRDER	Maximum Score
Pre-screening Requirements					
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass
			Pass	Pass	Pass
Regulatory Indicators					
Health & Safety		**Weighting**			
HS1	Ability to Protect Health & Safety of Public	25.00	4.5	4.5	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	4.0	4.0	5.0
Compliance					
C1	Ease of Obtaining Approvals	50.00	5.0	5.0	5.0
14%	**Regulatory Indicator Weighting**		463	463	500
Technical Indicators					
T1	Technical Maturity	14.29	3.7	3.7	5.0
T2	Compatibility with Current Site Features	14.29	4.0	4.0	5.0
T3	Compatibility with Existing Offsite Features	14.29	4.0	4.0	5.0
T4	Reliability/ Effectiveness/Durability	14.29	4.0	3.8	5.0
T5	Remedial Implementation Time	14.29	4.0	4.0	5.0
T6	Readily Monitored and Tested	14.29	4.0	4.0	5.0
T7	Minimal Waste Generation	14.29	4.3	4.3	5.0
26%	**Technical Indicator Weighting**		400	397	500
Environmental Indicators					
EN1	Environmental Effects During Remediation Phase	25.00	4.3	4.3	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	5.0	5.0	5.0
EN3	Weather Effects	25.00	4.7	4.7	5.0
24%	**Environmental Indicator Weighting**		474	474	500
Social Indicators					
S1	Community Acceptance	25.00	3.5	3.5	5.0
S2	Community Benefit	75.00	5.0	5.0	5.0
14%	**Social Indicator Weighting**		463	463	500
Economic Indicators					
EC1	Remediation Capital Costs	50.00	5.0	4.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	5.0	1.0	5.0
22%	**Economic Indicator Weighting**		500	250	500
Total Comparative Score			2299	2047	2500
Total Weighted Comparative Score			**457**	402	500
Rank			**1**	**2**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
1. BRIDGE AT HIGHWAY 348

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0

Pass/Fail Pre-screening Requirements

M1	**Public Acceptability**								
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**								
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**								
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**								
1	Is the FC readily approvable?	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**								
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**								
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	Fail		<-->		Pass

Regulatory Indicators

Health and Safety Indicators

HS1	**Ability to Protect Health and Safety of Public**								
1	What is the relative risk level to public health and safety posed by the FC?	4.0	4.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	5.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**								
1	What is the relative risk level to worker health and safety posed by the FC?	3.0	3.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	5.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process

Compliance

C1	**Ease of Obtaining Approvals**								
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	5.0	5.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	5.0	5.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance

Technical Indicators

T1	**Technical Maturity**								
1	What is the relative successful "track record" for implementing the FC?	5.0	5.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	3.0	3.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	3.0	3.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**								
1	What is the relative compatibility of the FC with site size and configuration?	3.0	3.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	4.0	4.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	5.0	5.0					
4	What is the relative compatibility of the FC with site access?	4.0	4.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	4.0	4.0	5.0					
T3	**Compatibility with Existing Off-Site Features**								
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	4.0	4.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	4.0	4.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	4.0	4.0	5.0					
T4	**Reliability/Effectiveness/Durability**								
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	4.0	4.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	5.0	4.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	5.0	5.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	3.0	3.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	3.0	3.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**								
1	Can the FC be constructed and fully operational within established time frame?	3.0	3.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**								
1	How readily can the FC be monitored and tested during remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	2.0	2.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
1. BRIDGE AT HIGHWAY 348

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**								
1	What is the ability of the FC to minimize waste generation during remediation?	3.0	3.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation

Environmental Indicators

		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
EN1	**Remediation Phase Effects**								
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	4.0	4.0	5.0					
	Sediment quality	4.0	4.0	5.0					
	Fish communities and habitats	4.0	4.0	5.0					
	Benthic invertebrate communities	4.0	4.0	5.0					
	Contaminants in aquatic biota tissue	4.0	4.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	4.0	4.0	5.0					
	GW/SW interaction	4.0	4.0	5.0					
	General groundwater quality	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	4.0	4.0	5.0					
	Wildlife habitat	4.0	4.0	5.0					
	Wildlife communities and Species	4.0	4.0	5.0					
	Significant Species	4.0	4.0	5.0					
EN2	**Post-Remediation Phase Effects**								
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	5.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0					
EN3	**Weather Effects**								
1	What is the potential impact of weather on the implementation of the FC?	4.0	4.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	5.0	5.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	5.0	5.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event

Social Indicators

		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
S1	**Community Acceptance**								
1	How acceptable is the FC to the surrounding communities during remediation phase?	3.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	5.0	5.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	1.0	1.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	5.0	5.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**								
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	5.0	5.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect

Economic Indicators

		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
EC1	**Remediation Capital Costs**								
1	What is the capital cost of the FC?	5.0	4.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**								
1	What are the typical annual post-remediation O&M costs for the FC?	5.0	1.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

EVALUATION CRITERIA AND WEIGHTING MATRIX

Boat Harbour Remediation Design (BHRD)

2. WASTE MANAGEMENT

			FC1 EXISTING DISPOSAL CELL	FC2 OFF-SITE DISPOSAL	Maximum Score
Pre-screening Requirements					
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass
			Pass	Pass	Pass
Regulatory Indicators					
Health & Safety		**Weighting**			
HS1	Ability to Protect Health & Safety of Public	25.00	4.5	3.0	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	4.0	3.0	5.0
Compliance					
C1	Ease of Obtaining Approvals	50.00	3.5	3.0	5.0
14%	**Regulatory Indicator Weighting**		388	300	500
Technical Indicators					
T1	Technical Maturity	14.29	5.0	4.7	5.0
T2	Compatibility with Current Site Features	14.29	5.0	5.0	5.0
T3	Compatibility with Existing Offsite Features	14.29	5.0	2.7	5.0
T4	Reliability/ Effectiveness/Durability	14.29	4.6	3.4	5.0
T5	Remedial Implementation Time	14.29	3.0	5.0	5.0
T6	Readily Monitored and Tested	14.29	4.7	4.0	5.0
T7	Minimal Waste Generation	14.29	4.3	5.0	5.0
26%	**Technical Indicator Weighting**		451	425	500
Environmental Indicators					
EN1	Environmental Effects During Remediation Phase	25.00	4.7	4.6	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	4.8	5.0	5.0
EN3	Weather Effects	25.00	4.0	4.3	5.0
24%	**Environmental Indicator Weighting**		455	472	500
Social Indicators					
S1	Community Acceptance	25.00	3.3	3.3	5.0
S2	Community Benefit	75.00	5.0	3.0	5.0
14%	**Social Indicator Weighting**		456	306	500
Economic Indicators					
EC1	Remediation Capital Costs	50.00	5.0	1.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	1.0	5.0	5.0
22%	**Economic Indicator Weighting**		300	300	500
Total Comparative Score			2050	1803	2500
Total Weighted Comparative Score			**411**	375	500
Rank			**1**	**2**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
2. WASTE MANAGEMENT

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements									
M1	**Public Acceptability**								
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**								
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**								
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**								
1	Is the FC readily approvable?	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**								
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**								
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	Fail		<-->		Pass
Regulatory Indicators									
Health and Safety Indicators									
HS1	**Ability to Protect Health and Safety of Public**								
1	What is the relative risk level to public health and safety posed by the FC?	4.0	3.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	5.0	3.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**								
1	What is the relative risk level to worker health and safety posed by the FC?	4.0	3.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	4.0	3.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance									
C1	**Ease of Obtaining Approvals**								
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	4.0	3.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	3.0	3.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators									
T1	**Technical Maturity**								
1	What is the relative successful "track record" for implementing the FC?	5.0	4.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	5.0	5.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	5.0	5.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**								
1	What is the relative compatibility of the FC with site size and configuration?	5.0	5.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	5.0	5.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	5.0	5.0					
4	What is the relative compatibility of the FC with site access?	5.0	5.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	5.0	5.0	5.0					
T3	**Compatibility with Existing Off-Site Features**								
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	5.0	3.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	5.0	2.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	5.0	3.0	5.0					
T4	**Reliability/Effectiveness/Durability**								
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	5.0	5.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	3.0	5.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	5.0	3.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	5.0	1.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	5.0	3.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**								
1	Can the FC be constructed and fully operational within established time frame?	1.0	5.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
T6	**Readily Monitored and Tested**								
1	How readily can the FC be monitored and tested during remediation phase?	5.0	4.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	4.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	4.0	4.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**								
1	What is the ability of the FC to minimize waste generation during remediation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	3.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation

Environmental Indicators

		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
EN1	**Remediation Phase Effects**								
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	4.0	4.0	5.0					
	Air Quality for the Protection of Public Health	5.0	3.0	5.0					
b	Aquatic Environment								
	Water quality	4.0	4.0	5.0					
	Sediment quality	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	4.0	4.0	5.0					
	GW/SW interaction	4.0	4.0	5.0					
	General groundwater quality	4.0	4.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0					
EN2	**Post-Remediation Phase Effects**								
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	4.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	4.0	5.0	5.0					
	GW/SW interaction	4.0	5.0	5.0					
	General groundwater quality	4.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0					
EN3	**Weather Effects**								
1	What is the potential impact of weather on the implementation of the FC?	4.0	4.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	4.0	5.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	4.0	4.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event

Social Indicators

		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
S1	**Community Acceptance**								
1	How acceptable is the FC to the surrounding communities during remediation phase?	3.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	4.0	5.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	3.0	2.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**								
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	5.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect

Economic Indicators

		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
EC1	**Remediation Capital Costs**								
1	What is the capital cost of the FC?	5.0	1.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**								
1	What are the typical annual post-remediation O&M costs for the FC?	1.0	5.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
3. WETLAND MANAGEMENT

			FC1 N.A.	FC2 EX-SITU	Maximum Score
Pre-screening Requirements					
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass
			Pass	Pass	Pass
Regulatory Indicators					
Health & Safety		**Weighting**			
HS1	Ability to Protect Health & Safety of Public	25.00	4.0	4.5	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	4.0	4.0	5.0
Compliance					
C1	Ease of Obtaining Approvals	50.00	4.0	3.5	5.0
14%	**Regulatory Indicator Weighting**		400	388	500
Technical Indicators					
T1	Technical Maturity	14.29	4.7	5.0	5.0
T2	Compatibility with Current Site Features	14.29	5.0	3.4	5.0
T3	Compatibility with Existing Offsite Features	14.29	5.0	4.7	5.0
T4	Reliability/ Effectiveness/Durability	14.29	3.8	5.0	5.0
T5	Remedial Implementation Time	14.29	5.0	5.0	5.0
T6	Readily Monitored and Tested	14.29	3.0	4.3	5.0
T7	Minimal Waste Generation	14.29	4.3	4.0	5.0
26%	**Technical Indicator Weighting**		440	449	500
Environmental Indicators					
EN1	Environmental Effects During Remediation Phase	25.00	4.1	2.4	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	3.6	3.9	5.0
EN3	Weather Effects	25.00	5.0	3.0	5.0
24%	**Environmental Indicator Weighting**		405	330	500
Social Indicators					
S1	Community Acceptance	25.00	2.0	3.8	5.0
S2	Community Benefit	75.00	2.0	4.0	5.0
14%	**Social Indicator Weighting**		200	394	500
Economic Indicators					
EC1	Remediation Capital Costs	50.00	5.0	1.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	1.0	5.0	5.0
22%	**Economic Indicator Weighting**		300	300	500
Total Comparative Score			1745	1860	2500
Total Weighted Comparative Score			362	**371**	500
Rank			**2**	**1**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
3. WETLAND MANAGEMENT

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements									
M1	**Public Acceptability**								
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**								
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**								
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**								
1	Is the FC readily approvable?	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**								
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**								
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	Fail		<-->		Pass
Regulatory Indicators									
Health and Safety Indicators									
HS1	**Ability to Protect Health and Safety of Public**								
1	What is the relative risk level to public health and safety posed by the FC?	4.0	4.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	4.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**								
1	What is the relative risk level to worker health and safety posed by the FC?	4.0	4.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	4.0	4.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance									
C1	**Ease of Obtaining Approvals**								
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	5.0	4.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	3.0	3.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators									
T1	**Technical Maturity**								
1	What is the relative successful "track record" for implementing the FC?	4.0	5.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	5.0	5.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	5.0	5.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**								
1	What is the relative compatibility of the FC with site size and configuration?	5.0	5.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	5.0	3.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	3.0	5.0					
4	What is the relative compatibility of the FC with site access?	5.0	3.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	5.0	3.0	5.0					
T3	**Compatibility with Existing Off-Site Features**								
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	5.0	5.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	5.0	4.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	5.0	5.0	5.0					
T4	**Reliability/Effectiveness/Durability**								
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	5.0	5.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	5.0	5.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	3.0	5.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	3.0	5.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	3.0	5.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**								
1	Can the FC be constructed and fully operational within established time frame?	5.0	5.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**								
1	How readily can the FC be monitored and tested during remediation phase?	3.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	1.0	3.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
3. WETLAND MANAGEMENT

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**								
1	What is the ability of the FC to minimize waste generation during remediation?	4.0	2.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	4.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
	Environmental Indicators								
EN1	**Remediation Phase Effects**								
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	4.0	3.0	5.0					
	Air Quality for the Protection of Public Health	5.0	4.0	5.0					
b	Aquatic Environment								
	Water quality	3.0	1.0	5.0					
	Sediment quality	3.0	1.0	5.0					
	Fish communities and habitats	3.0	1.0	5.0					
	Benthic invertebrate communities	3.0	1.0	5.0					
	Contaminants in aquatic biota tissue	3.0	1.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	1.0	5.0					
	GW/SW interaction	5.0	1.0	5.0					
	General groundwater quality	3.0	1.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	3.0	3.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	4.0	5.0					
	Wildlife habitat	5.0	4.0	5.0					
	Wildlife communities and Species	5.0	4.0	5.0					
	Significant Species	5.0	4.0	5.0					
EN2	**Post-Remediation Phase Effects**								
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	4.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	3.0	3.0	5.0					
	Sediment quality	3.0	3.0	5.0					
	Fish communities and habitats	3.0	3.0	5.0					
	Benthic invertebrate communities	3.0	3.0	5.0					
	Contaminants in aquatic biota tissue	3.0	3.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0					
	General groundwater quality	3.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	3.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	3.0	3.0	5.0					
	Wildlife habitat	3.0	3.0	5.0					
	Wildlife communities and Species	3.0	3.0	5.0					
	Significant Species	3.0	3.0	5.0					
EN3	**Weather Effects**								
1	What is the potential impact of weather on the implementation of the FC?	5.0	3.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	5.0	3.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	5.0	3.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event
	Social Indicators								
S1	**Community Acceptance**								
1	How acceptable is the FC to the surrounding communities during remediation phase?	1.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	3.0	5.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	1.0	4.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**								
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	2.0	4.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
	Economic Indicators								
EC1	**Remediation Capital Costs**								
1	What is the capital cost of the FC?	5.0	1.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**								
1	What are the typical annual post-remediation O&M costs for the FC?	1.0	5.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
4.1 PIPE DECOMMISSIONING ON LAND

			FC1 ABANDON	FC2 FILL	FC3 REMOVE	Maximum Score
Pre-screening Requirements						
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass	Pass
			Pass	Pass	Pass	Pass
Regulatory Indicators						
Health & Safety		**Weighting**				
HS1	Ability to Protect Health & Safety of Public	25.00	3.0	5.0	5.0	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	4.0	4.0	3.5	5.0
Compliance						
C1	Ease of Obtaining Approvals	50.00	4.0	4.0	4.0	5.0
14%	**Regulatory Indicator Weighting**		375	425	413	500
Technical Indicators						
T1	Technical Maturity	14.29	4.3	4.3	4.3	5.0
T2	Compatibility with Current Site Features	14.29	5.0	3.0	2.2	5.0
T3	Compatibility with Existing Offsite Features	14.29	5.0	4.0	3.0	5.0
T4	Reliability/ Effectiveness/Durability	14.29	4.2	4.6	5.0	5.0
T5	Remedial Implementation Time	14.29	5.0	4.5	3.0	5.0
T6	Readily Monitored and Tested	14.29	5.0	5.0	5.0	5.0
T7	Minimal Waste Generation	14.29	5.0	5.0	4.3	5.0
26%	**Technical Indicator Weighting**		479	435	384	500
Environmental Indicators						
EN1	Environmental Effects During Remediation Phase	25.00	5.0	4.8	4.2	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	5.0	5.0	5.0	5.0
EN3	Weather Effects	25.00	5.0	4.7	3.7	5.0
24%	**Environmental Indicator Weighting**		500	485	446	500
Social Indicators						
S1	Community Acceptance	25.00	3.3	3.0	3.0	5.0
S2	Community Benefit	75.00	3.0	3.0	3.0	5.0
14%	**Social Indicator Weighting**		306	300	300	500
Economic Indicators						
EC1	Remediation Capital Costs	50.00	5.0	1.0	1.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	4.0	5.0	5.0	5.0
22%	**Economic Indicator Weighting**		450	300	300	500
Total Comparative Score			2110	1945	1843	2500
Total Weighted Comparative Score			**439**	397	373	500
Rank			**1**	**2**	**3**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
4.1 PIPE DECOMMISSIONING ON LAND

		FEASIBLE CONCEPT (FC)				Scoring				
		FC1	FC2	FC3	Maximum Score	1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements										
M1	**Public Acceptability**									
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**									
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**									
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**									
1	Is the FC readily approvable?	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**									
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**									
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	5.0	Fail		<-->		Pass
Regulatory Indicators										
Health and Safety Indicators										
HS1	**Ability to Protect Health and Safety of Public**									
1	What is the relative risk level to public health and safety posed by the FC?	3.0	5.0	5.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	3.0	5.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**									
1	What is the relative risk level to worker health and safety posed by the FC?	4.0	4.0	3.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	4.0	4.0	4.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance										
C1	**Ease of Obtaining Approvals**									
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	5.0	5.0	5.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	3.0	3.0	3.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators										
T1	**Technical Maturity**									
1	What is the relative successful "track record" for implementing the FC?	5.0	5.0	5.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	4.0	4.0	4.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	4.0	4.0	4.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**									
1	What is the relative compatibility of the FC with site size and configuration?	5.0	3.0	1.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	5.0	3.0	3.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	3.0	3.0	5.0					
4	What is the relative compatibility of the FC with site access?	5.0	3.0	1.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	5.0	3.0	3.0	5.0					
T3	**Compatibility with Existing Off-Site Features**									
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	5.0	3.0	1.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	5.0	4.0	3.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	5.0	5.0	5.0	5.0					
T4	**Reliability/Effectiveness/Durability**									
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	4.0	5.0	5.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	4.0	5.0	5.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	4.0	4.0	5.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	4.0	4.0	5.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	5.0	5.0	5.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**									
1	Can the FC be constructed and fully operational within established time frame?	5.0	4.0	1.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	5.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**									
1	How readily can the FC be monitored and tested during remediation phase?	5.0	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	5.0	5.0	5.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
4.1 PIPE DECOMMISSIONING ON LAND

		FEASIBLE CONCEPT (FC)				Scoring				
		FC1	FC2	FC3	Maximum Score	1.0	2.0	3.0	4.0	5.0
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**									
1	What is the ability of the FC to minimize waste generation during remediation?	5.0	5.0	3.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	5.0	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation

Environmental Indicators

		FC1	FC2	FC3	Maximum Score	1.0	2.0	3.0	4.0	5.0
EN1	**Remediation Phase Effects**									
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:					Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment									
	Air Quality for the Protection of Workers	5.0	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0	5.0					
b	Aquatic Environment									
	Water quality	5.0	5.0	4.0	5.0					
	Sediment quality	5.0	5.0	4.0	5.0					
	Fish communities and habitats	5.0	5.0	4.0	5.0					
	Benthic invertebrate communities	5.0	5.0	4.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	4.0	5.0					
c	Geology and Groundwater									
	Groundwater flow	5.0	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0	5.0					
d	Terrestrial Environment									
	Vegetation, Communities and Species	5.0	4.0	3.0	5.0					
	Wildlife habitat	5.0	4.0	3.0	5.0					
	Wildlife communities and Species	5.0	4.0	3.0	5.0					
	Significant Species	5.0	4.0	3.0	5.0					
EN2	**Post-Remediation Phase Effects**									
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:					Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment									
	Air Quality for the Protection of Workers	5.0	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0	5.0					
b	Aquatic Environment									
	Water quality	5.0	5.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0	5.0					
c	Geology and Groundwater									
	Groundwater flow	5.0	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0	5.0					
d	Terrestrial Environment									
	Vegetation, Communities and Species	5.0	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0	5.0					
EN3	**Weather Effects**									
1	What is the potential impact of weather on the implementation of the FC?	5.0	5.0	3.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	5.0	5.0	5.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	5.0	4.0	3.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event

Social Indicators

		FC1	FC2	FC3	Maximum Score	1.0	2.0	3.0	4.0	5.0
S1	**Community Acceptance**									
1	How acceptable is the FC to the surrounding communities during remediation phase?	3.0	3.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	4.0	4.0	5.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	3.0	2.0	1.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	3.0	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**									
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	3.0	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect

Economic Indicators

		FC1	FC2	FC3	Maximum Score	1.0	2.0	3.0	4.0	5.0
EC1	**Remediation Capital Costs**									
1	What is the capital cost of the FC?	5.0	1.0	1.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**									
1	What are the typical annual post-remediation O&M costs for the FC?	4.0	5.0	5.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
4.2 PIPE DECOMMISSIONING UNDER WATER

			FC1 ABANDON	FC2 FILL	Maximum Score
Pre-screening Requirements					
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass
			Pass	Pass	Pass
Regulatory Indicators					
Health & Safety		**Weighting**			
HS1	Ability to Protect Health & Safety of Public	25.00	5.0	5.0	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	4.5	4.5	5.0
Compliance					
C1	Ease of Obtaining Approvals	50.00	4.0	4.0	5.0
14%	**Regulatory Indicator Weighting**		438	438	500
Technical Indicators					
T1	Technical Maturity	14.29	4.3	4.3	5.0
T2	Compatibility with Current Site Features	14.29	5.0	3.0	5.0
T3	Compatibility with Existing Offsite Features	14.29	5.0	4.0	5.0
T4	Reliability/ Effectiveness/Durability	14.29	5.0	5.0	5.0
T5	Remedial Implementation Time	14.29	5.0	3.0	5.0
T6	Readily Monitored and Tested	14.29	5.0	5.0	5.0
T7	Minimal Waste Generation	14.29	5.0	5.0	5.0
26%	**Technical Indicator Weighting**		490	419	500
Environmental Indicators					
EN1	Environmental Effects During Remediation Phase	25.00	5.0	4.8	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	5.0	5.0	5.0
EN3	Weather Effects	25.00	5.0	4.7	5.0
24%	**Environmental Indicator Weighting**		500	485	500
Social Indicators					
S1	Community Acceptance	25.00	3.3	3.0	5.0
S2	Community Benefit	75.00	3.0	3.0	5.0
14%	**Social Indicator Weighting**		306	300	500
Economic Indicators					
EC1	Remediation Capital Costs	50.00	5.0	1.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	5.0	5.0	5.0
22%	**Economic Indicator Weighting**		500	300	500
Total Comparative Score			2234	1942	2500
Total Weighted Comparative Score			**462**	395	500
Rank			**1**	**2**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
4.2 PIPE DECOMMISSIONING UNDER WATER

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements									
M1	**Public Acceptability**								
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**								
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**								
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**								
1	Is the FC readily approvable?	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**								
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**								
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	Fail		<-->		Pass
Regulatory Indicators									
Health and Safety Indicators									
HS1	**Ability to Protect Health and Safety of Public**								
1	What is the relative risk level to public health and safety posed by the FC?	5.0	5.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	5.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**								
1	What is the relative risk level to worker health and safety posed by the FC?	4.0	4.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	5.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance									
C1	**Ease of Obtaining Approvals**								
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	5.0	5.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	3.0	3.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators									
T1	**Technical Maturity**								
1	What is the relative successful "track record" for implementing the FC?	5.0	5.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	4.0	4.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	4.0	4.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**								
1	What is the relative compatibility of the FC with site size and configuration?	5.0	3.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	5.0	3.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	3.0	5.0					
4	What is the relative compatibility of the FC with site access?	5.0	3.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	5.0	3.0	5.0					
T3	**Compatibility with Existing Off-Site Features**								
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	5.0	3.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	5.0	4.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	5.0	5.0	5.0					
T4	**Reliability/Effectiveness/Durability**								
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	5.0	5.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	5.0	5.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	5.0	5.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	5.0	5.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	5.0	5.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**								
1	Can the FC be constructed and fully operational within established time frame?	5.0	1.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**								
1	How readily can the FC be monitored and tested during remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	5.0	5.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
4.2 PIPE DECOMMISSIONING UNDER WATER

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**								
1	What is the ability of the FC to minimize waste generation during remediation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
Environmental Indicators									
EN1	**Remediation Phase Effects**								
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	5.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	4.0	5.0					
	Wildlife habitat	5.0	4.0	5.0					
	Wildlife communities and Species	5.0	4.0	5.0					
	Significant Species	5.0	4.0	5.0					
EN2	**Post-Remediation Phase Effects**								
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	5.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0					
EN3	**Weather Effects**								
1	What is the potential impact of weather on the implementation of the FC?	5.0	5.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	5.0	5.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	5.0	4.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event
Social Indicators									
S1	**Community Acceptance**								
1	How acceptable is the FC to the surrounding communities during remediation phase?	3.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	4.0	4.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	3.0	2.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**								
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
Economic Indicators									
EC1	**Remediation Capital Costs**								
1	What is the capital cost of the FC?	5.0	1.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**								
1	What are the typical annual post-remediation O&M costs for the FC?	5.0	5.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

EVALUATION CRITERIA AND WEIGHTING MATRIX

Boat Harbour Remediation Design (BHRD)

5.1 SEDIMENT

			FC1A WET GEO	FC1B WET CLAY	FC2A DRY GEO	FC2B DRY CLAY	Maximum Score
Pre-screening Requirements							
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass	Pass	Pass
			Pass	**Pass**	**Pass**	**Pass**	Pass
Regulatory Indicators							
Health & Safety		**Weighting**					
HS1	Ability to Protect Health & Safety of Public	25.00	3.5	3.5	3.0	3.0	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	4.0	3.5	4.0	3.5	5.0
Compliance							
C1	Ease of Obtaining Approvals	50.00	3.5	3.5	4.0	4.0	5.0
14%	**Regulatory Indicator Weighting**		363	350	**375**	363	500
Technical Indicators							
T1	Technical Maturity	14.29	4.3	2.3	4.0	2.3	5.0
T2	Compatibility with Current Site Features	14.29	5.0	5.0	2.8	2.8	5.0
T3	Compatibility with Existing Offsite Features	14.29	5.0	4.0	3.3	3.3	5.0
T4	Reliability/ Effectiveness/Durability	14.29	4.0	4.0	4.6	4.6	5.0
T5	Remedial Implementation Time	14.29	5.0	4.5	2.5	2.0	5.0
T6	Readily Monitored and Tested	14.29	4.7	4.7	5.0	5.0	5.0
T7	Minimal Waste Generation	14.29	4.3	3.7	4.3	3.7	5.0
26%	**Technical Indicator Weighting**		**462**	402	380	339	500
Environmental Indicators							
EN1	Environmental Effects During Remediation Phase	25.00	4.3	4.2	4.2	4.1	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	5.0	5.0	5.0	5.0	5.0
EN3	Weather Effects	25.00	4.7	4.7	4.0	4.0	5.0
24%	**Environmental Indicator Weighting**		**473**	471	455	453	500
Social Indicators							
S1	Community Acceptance	25.00	4.0	4.0	3.8	3.8	5.0
S2	Community Benefit	75.00	4.0	4.0	4.0	4.0	5.0
14%	**Social Indicator Weighting**		**400**	**400**	394	394	500
Economic Indicators							
EC1	Remediation Capital Costs	50.00	5.0	2.0	2.0	1.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	5.0	5.0	5.0	5.0	5.0
22%	**Economic Indicator Weighting**		**500**	350	350	300	500
Total Comparative Score			2197	1974	1953	1848	2500
Total Weighted Comparative Score			**450**	400	392	369	500
Rank			**1**	**2**	**3**	**4**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
5.1 SEDIMENT

		FEASIBLE CONCEPT (FC)					Scoring				
		FC1A	FC1B	FC2A	FC2B	Maximum Score	1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements											
M1	**Public Acceptability**										
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**										
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**										
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**										
1	Is the FC readily approvable?	5.0	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**										
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**										
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	5.0	5.0	Fail		<-->		Pass
Regulatory Indicators											
Health and Safety Indicators											
HS1	**Ability to Protect Health and Safety of Public**										
1	What is the relative risk level to public health and safety posed by the FC?	4.0	4.0	3.0	3.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	3.0	3.0	3.0	3.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**										
1	What is the relative risk level to worker health and safety posed by the FC?	4.0	3.0	4.0	3.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	4.0	4.0	4.0	4.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance											
C1	**Ease of Obtaining Approvals**										
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	4.0	4.0	5.0	5.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	3.0	3.0	3.0	3.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators											
T1	**Technical Maturity**										
1	What is the relative successful "track record" for implementing the FC?	5.0	3.0	5.0	3.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	5.0	2.0	3.0	2.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	3.0	2.0	4.0	2.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**										
1	What is the relative compatibility of the FC with site size and configuration?	5.0	5.0	2.0	2.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	5.0	5.0	3.0	3.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	5.0	3.0	3.0	5.0					
4	What is the relative compatibility of the FC with site access?	5.0	5.0	3.0	3.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	5.0	5.0	3.0	3.0	5.0					
T3	**Compatibility with Existing Off-Site Features**										
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	5.0	4.0	3.0	3.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	5.0	4.0	3.0	3.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	5.0	4.0	4.0	4.0	5.0					
T4	**Reliability/Effectiveness/Durability**										
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	5.0	5.0	5.0	5.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	4.0	4.0	3.0	3.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	4.0	4.0	5.0	5.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	3.0	3.0	5.0	5.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	4.0	4.0	5.0	5.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**										
1	Can the FC be constructed and fully operational within established time frame?	5.0	4.0	2.0	1.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	3.0	3.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**										
1	How readily can the FC be monitored and tested during remediation phase?	5.0	5.0	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	5.0	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	4.0	4.0	5.0	5.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**										
1	What is the ability of the FC to minimize waste generation during remediation?	3.0	1.0	3.0	1.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	5.0	5.0	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
5.1 SEDIMENT

		FEASIBLE CONCEPT (FC)					Scoring				
		FC1A	FC1B	FC2A	FC2B	Maximum Score	1.0	2.0	3.0	4.0	5.0
Environmental Indicators											
EN1	**Remediation Phase Effects**										
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:						Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment										
	Air Quality for the Protection of Workers	4.0	3.0	4.0	3.0	5.0					
	Air Quality for the Protection of Public Health	4.0	4.0	3.0	3.0	5.0					
b	Aquatic Environment										
	Water quality	4.0	4.0	4.0	4.0	5.0					
	Sediment quality	4.0	4.0	4.0	4.0	5.0					
	Fish communities and habitats	4.0	4.0	4.0	4.0	5.0					
	Benthic invertebrate communities	4.0	4.0	4.0	4.0	5.0					
	Contaminants in aquatic biota tissue	4.0	4.0	4.0	4.0	5.0					
c	Geology and Groundwater										
	Groundwater flow	5.0	5.0	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0	5.0	5.0					
	Soil quality	4.0	4.0	4.0	4.0	5.0					
d	Terrestrial Environment										
	Vegetation, Communities and Species	4.0	4.0	4.0	4.0	5.0					
	Wildlife habitat	4.0	4.0	4.0	4.0	5.0					
	Wildlife communities and Species	4.0	4.0	4.0	4.0	5.0					
	Significant Species	4.0	4.0	4.0	4.0	5.0					
EN2	**Post-Remediation Phase Effects**										
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:						Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment										
	Air Quality for the Protection of Workers	5.0	5.0	5.0	5.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0	5.0	5.0					
b	Aquatic Environment										
	Water quality	5.0	5.0	5.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0	5.0	5.0					
c	Geology and Groundwater										
	Groundwater flow	5.0	5.0	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0	5.0	5.0					
d	Terrestrial Environment										
	Vegetation, Communities and Species	5.0	5.0	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0	5.0	5.0					
EN3	**Weather Effects**										
1	What is the potential impact of weather on the implementation of the FC?	4.0	4.0	2.0	2.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	5.0	5.0	5.0	5.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	5.0	5.0	5.0	5.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event
Social Indicators											
S1	**Community Acceptance**										
1	How acceptable is the FC to the surrounding communities during remediation phase?	3.0	3.0	3.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	5.0	5.0	5.0	5.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	3.0	3.0	2.0	2.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	5.0	5.0	5.0	5.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**										
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	4.0	4.0	4.0	4.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
Economic Indicators											
EC1	**Remediation Capital Costs**										
1	What is the capital cost of the FC?	5.0	2.0	2.0	1.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**										
1	What are the typical annual post-remediation O&M costs for the FC?	5.0	5.0	5.0	5.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
5.4 LEACHATE MANAGEMENT

			FC1 TREAT	FC2 OFF-SITE	Maximum Score
Pre-screening Requirements					
M1	Public Acceptability	Pass/Fail	Pass	Pass	Pass
M2	Return to Tidal	Pass/Fail	Pass	Pass	Pass
M3	Intended End Use	Pass/Fail	Pass	Pass	Pass
M4	Approvability	Pass/Fail	Pass	Pass	Pass
M5	Landowner Requirements	Pass/Fail	Pass	Pass	Pass
M6	Procurement Requirements	Pass/Fail	Pass	Pass	Pass
			Pass	Pass	Pass
Regulatory Indicators					
Health & Safety		**Weighting**			
HS1	Ability to Protect Health & Safety of Public	25.00	5.0	5.0	5.0
HS2	Ability to Protect Health & Safety of Workers	25.00	3.5	4.5	5.0
Compliance					
C1	Ease of Obtaining Approvals	50.00	3.0	3.5	5.0
14%	**Regulatory Indicator Weighting**		363	413	500
Technical Indicators					
T1	Technical Maturity	14.29	3.3	5.0	5.0
T2	Compatibility with Current Site Features	14.29	4.8	5.0	5.0
T3	Compatibility with Existing Offsite Features	14.29	5.0	4.7	5.0
T4	Reliability/ Effectiveness/Durability	14.29	4.0	4.2	5.0
T5	Remedial Implementation Time	14.29	3.0	5.0	5.0
T6	Readily Monitored and Tested	14.29	4.7	4.7	5.0
T7	Minimal Waste Generation	14.29	4.0	4.0	5.0
26%	**Technical Indicator Weighting**		411	465	500
Environmental Indicators					
EN1	Environmental Effects During Remediation Phase	25.00	4.9	4.9	5.0
EN2	Environmental Effects During Post-Remediation Phase	50.00	4.6	4.9	5.0
EN3	Weather Effects	25.00	3.7	4.0	5.0
24%	**Environmental Indicator Weighting**		446	467	500
Social Indicators					
S1	Community Acceptance	25.00	3.3	3.3	5.0
S2	Community Benefit	75.00	4.0	4.0	5.0
14%	**Social Indicator Weighting**		381	381	500
Economic Indicators					
EC1	Remediation Capital Costs	50.00	1.0	5.0	5.0
EC2	Post-Remediation Operations & Maintenance Costs	50.00	1.0	5.0	4.0
22%	**Economic Indicator Weighting**		100	500	450
Total Comparative Score			1702	2226	2450
Total Weighted Comparative Score			340	**454**	489
Rank			**2**	**1**	

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
5.4 LEACHATE MANAGEMENT

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
Pass/Fail Pre-screening Requirements									
M1	**Public Acceptability**								
1	Are there any components of the FC that are clearly unacceptable to the public?	5.0	5.0	5.0	Fail		<-->		Pass
M2	**Return to Tidal**								
1	Does the FC facilitate returning A'se'k to tidal conditions?	5.0	5.0	5.0	Fail		<-->		Pass
M3	**Intended End Use**								
1	Does the FC restore/remediate A'se'k to conditions that will facilitate traditional Mi'kmaq use for recreation, fishing, hunting and gathering, as well as for physical, mental, spiritual, and emotional purposes?	5.0	5.0	5.0	Fail		<-->		Pass
M4	**Approvability**								
1	Is the FC readily approvable?	5.0	5.0	5.0	Fail		<-->		Pass
M5	**Landowner Requirements**								
1	Does the FC meet landowner requirements?	5.0	5.0	5.0	Fail		<-->		Pass
M6	**Procurement Requirements**								
1	Does the FC allow for the implementation of the NS Procurement Strategy?	5.0	5.0	5.0	Fail		<-->		Pass
Regulatory Indicators									
Health and Safety Indicators									
HS1	**Ability to Protect Health and Safety of Public**								
1	What is the relative risk level to public health and safety posed by the FC?	5.0	5.0	5.0	High risk to public health and safety	<-->	Low risk to public health and safety	<-->	No risk to public health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	5.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
HS2	**Ability to Protect Health and Safety of Workers**								
1	What is the relative risk level to worker health and safety posed by the FC?	3.0	4.0	5.0	High risk to worker health and safety	<-->	Low risk to worker health and safety	<-->	No risk to worker health and safety
2	To what extent can the potential risks be mitigated as part of the FC?	4.0	5.0	5.0	Difficult to mitigate with changes to process	<-->	Moderate changes to process will likely mitigate the effects	<-->	Easily mitigated by changes to process
Compliance									
C1	**Ease of Obtaining Approvals**								
1	Does the FC go beyond the minimum requirements for Federal/Provincial approvability?	3.0	4.0	5.0	Minimal level of compliance for ease of approvability	<-->	Moderate level of compliance for ease of approvability	<-->	High level of compliance for ease of approvability
2	What is the relative public acceptability of the FC?	3.0	3.0	5.0	Minimal level of public acceptance	<-->	Moderate level of public acceptance	<-->	High level of public acceptance
Technical Indicators									
T1	**Technical Maturity**								
1	What is the relative successful "track record" for implementing the FC?	5.0	5.0	5.0	Minimal experience	Limited experience	Average experience	Good experience, usually successful	Extensive successful experience
2	What is the relative availability of the source materials/equipment?	3.0	5.0	5.0	Materials can be difficult to attain	<-->	Materials can be acquired easily	<-->	Readily available, most can be found on site
3	What is the relative availability of vendors/contractors for the FC?	2.0	5.0	5.0	Contractors and vendors are rare and far away	<-->	Contractors and vendors common and relatively nearby	<-->	Contractors and vendors abundant and local
T2	**Compatibility with Current Site Features**								
1	What is the relative compatibility of the FC with site size and configuration?	4.0	5.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	What is the relative compatibility of the FC with site geology?	5.0	5.0	5.0					
3	What is the relative compatibility of the FC with site hydrogeology?	5.0	5.0	5.0					
4	What is the relative compatibility of the FC with site access?	5.0	5.0	5.0					
5	What is the relative compatibility of the FC with site hydrology?	5.0	5.0	5.0					
T3	**Compatibility with Existing Off-Site Features**								
1	What is the relative compatibility of the FC with existing features and infrastructure surrounding the Site (e.g., points of access, roads, power lines)?	5.0	4.0	5.0	Needs to be addressed and is a challenging constraint	<-->	Needs to be addressed but is an average constraint	<-->	Needs to be addressed but can be accomplished readily
2	Does the FC cause significant changes to off-Site conditions (e.g., traffic)?	5.0	5.0	5.0					
3	Does the FC require upgrades or significant changes to the existing off-Site infrastructure (e.g., upgrades to roads, power supply, municipal infrastructure)?	5.0	5.0	5.0					
T4	**Reliability/Effectiveness/Durability**								
1	What is the relative expected service life of the FC components relative to the remediation and post remediation maintenance period?	3.0	5.0	5.0	Components not expected to last the control period	<-->	Components expected to last half of the control period	<-->	Components not expected to fail during the control period
2	What is the relative maintenance requirements of the FC during the remediation and post remediation maintenance period?	3.0	4.0	5.0	Long-term maintenance requirements high	<-->	Long-term maintenance requirements moderate	<-->	Long-term maintenance requirements low
3	What is the likelihood the FC will meet performance criteria or remediation objectives?	5.0	4.0	5.0	High risk; criteria may not be met	<-->	Moderate risk; criteria likely met	<-->	Low risk; criteria expected to be met
4	What is the relative impact of the FC not meeting performance criteria or remediation objectives?	5.0	3.0	5.0	High impact if criteria not met	<-->	Moderate impact if criteria not met	<-->	Low impact if criteria not met
5	What is the relative ease of implementation of contingency measures during the remediation and post remediation maintenance period?	4.0	5.0	5.0	Difficult to implement contingency measures	<-->	Moderately difficult to implement contingency measures	<-->	Easy to implement contingency measures
T5	**Remedial Implementation Time**								
1	Can the FC be constructed and fully operational within established time frame?	1.0	5.0	5.0	Longest Time Frame	<-->	Moderate Time Frame	<-->	Shortest Time Frame
2	What is the anticipated time frame to implement FC?	5.0	5.0	5.0	>7 years	<-->	4-7 years	<-->	<4 years
T6	**Readily Monitored and Tested**								
1	How readily can the FC be monitored and tested during remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
2	How readily can the FC be monitored and tested during post-remediation phase?	5.0	5.0	5.0	Difficult to monitor and test	<-->	Average effort to monitor and test	<-->	Readily monitored and tested
3	What is the relative amount of monitoring required to validate effectiveness?	4.0	4.0	5.0	Maximum amount of monitoring and testing required to ensure effectiveness	<-->	Average amount of monitoring and testing to ensure effectiveness	<-->	Minimal amount of monitoring to ensure effectiveness

EVALUATION CRITERIA AND WEIGHTING MATRIX
Boat Harbour Remediation Design (BHRD)
5.4 LEACHATE MANAGEMENT

		FEASIBLE CONCEPT (FC)			Scoring				
		FC1	FC2	Maximum Score	1.0	2.0	3.0	4.0	5.0
T7	**Minimal Waste Generation (e.g., dewatering effluent, dredged sediments, leachate)**								
1	What is the ability of the FC to minimize waste generation during remediation?	4.0	4.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
2	What is the ability of the FC to minimize waste generation during the post-remediation maintenance phase?	3.0	3.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
3	What is the ability of the FC to minimize dangerous goods generation?	5.0	5.0	5.0	High waste generation	<-->	Moderate waste generation	<-->	Minimal waste generation
Environmental Indicators									
EN1	**Remediation Phase Effects**								
1	During the remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	4.0	4.0	5.0					
	Air Quality for the Protection of Public Health	5.0	5.0	5.0					
b	Aquatic Environment								
	Water quality	5.0	5.0	5.0					
	Sediment quality	5.0	5.0	5.0					
	Fish communities and habitats	5.0	5.0	5.0					
	Benthic invertebrate communities	5.0	5.0	5.0					
	Contaminants in aquatic biota tissue	5.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0					
EN2	**Post-Remediation Phase Effects**								
1	During the post-remediation phase, to what extent is the FC likely to cause an adverse effect on:				Project / environmental interaction likely with potential for associated major adverse effect	<-->	Project / environmental interaction likely with potential for associated moderate adverse effect	<-->	No or little project environmental interaction with no effect (or beneficial effect) expected
a	Atmospheric Environment								
	Air Quality for the Protection of Workers	4.0	4.0	5.0					
	Air Quality for the Protection of Public Health	5.0	4.0	5.0					
b	Aquatic Environment								
	Water quality	4.0	5.0	5.0					
	Sediment quality	4.0	5.0	5.0					
	Fish communities and habitats	4.0	5.0	5.0					
	Benthic invertebrate communities	4.0	5.0	5.0					
	Contaminants in aquatic biota tissue	4.0	5.0	5.0					
c	Geology and Groundwater								
	Groundwater flow	5.0	5.0	5.0					
	GW/SW interaction	5.0	5.0	5.0					
	General groundwater quality	5.0	5.0	5.0					
	Seismicity	5.0	5.0	5.0					
	Soil quality	5.0	5.0	5.0					
d	Terrestrial Environment								
	Vegetation, Communities and Species	5.0	5.0	5.0					
	Wildlife habitat	5.0	5.0	5.0					
	Wildlife communities and Species	5.0	5.0	5.0					
	Significant Species	5.0	5.0	5.0					
EN3	**Weather Effects**								
1	What is the potential impact of weather on the implementation of the FC?	4.0	4.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
2	What is the potential impact of weather on the FC during the post-remediation phase?	3.0	4.0	5.0	FC susceptible to poor weather	<-->	FC moderately susceptible to poor weather	<-->	FC not susceptible to poor weather
3	What is the suitability of the FC under severe weather events during remediation and post-remediation phases (e.g., 1:100 design event)?	4.0	4.0	5.0	Design fails under catastrophic event	<-->		<-->	Design does not fail under catastrophic event
Social Indicators									
S1	**Community Acceptance**								
1	How acceptable is the FC to the surrounding communities during remediation phase?	5.0	5.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
2	How acceptable is the FC to the surrounding communities during the post-remediation phase?	3.0	3.0	5.0	Minimal level of community acceptance	<-->	Moderate level of community acceptance	<-->	High level of community acceptance
3	Does the FC impact the surroundings community during remediation phase (e.g., safety, visual, nuisance)?	3.0	3.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
4	Does the FC impact the surroundings community during post-remediation phase (e.g., safety, visual, nuisance)?	2.0	2.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
S2	**Community Benefit**								
1	Does the FC affect the socio-economic environment including direct and indirect economic benefit impacts and social impacts (e.g., human health and recreational enjoyment)?	4.0	4.0	5.0	Negative effect	<-->	No effect	<-->	Positive effect
Economic Indicators									
EC1	**Remediation Capital Costs**								
1	What is the capital cost of the FC?	1.0	5.0	5.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost
EC2	**Post-Remediation Operation & Maintenance Costs**								
1	What are the typical annual post-remediation O&M costs for the FC?	1.0	5.0	4.0	costs>40% above lowest	<-->	costs 20% above lowest	<-->	Lowest cost

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