Government of Nunavut

Hall Beach Sewage Lagoon Design Brief

Type of Document
Final

Project Name
Hall Beach Sewage Lagoon Upgrade

Project Number
OTT-00220382-A0

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Date Submitted
December 5, 2014

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1 Introduction

Exp Services Inc. (**exp**) were retained by the Department of Community and Government Services (CGS), Government of Nunavut (GN) to provide detailed planning design and construction administration services for the upgrades to the existing sewage lagoon facility in the Hamlet of Hall Beach (Hamlet), Nunavut.

The Hamlet's existing sewage treatment facility is located approximately 1km north of the community on the western shore of the Foxe Basin situated in the Arctic Ocean as seen in Figure 1-1. The existing lagoon system consists of two adjacent cells. The southernmost cell, referred to as Cell 1, has a reported capacity of 15,295 m^3, and the northernmost cell, referred to as Cell 2, has a reported capacity of 15,462 m^3. Currently both of these existing cells are unlined, and Cell 2 exfiltrates through the berm wall into a wetland area receiving secondary treatment, and then into the Foxe Basin. The existing lagoon system encountered problems with leakage under and through the southern berm of Cell 1 between 2008 and the spring of 2013. Several remedial measures were taken in attempt to rectify the leaking as a short term solution. It was determined by CGS that in order to meet the Hamlet's long term needs, a more permanent solution was required.

1.1 General

The following report is presented as the Design Brief for the development of a permanent wastewater facility to service the Hamlet.

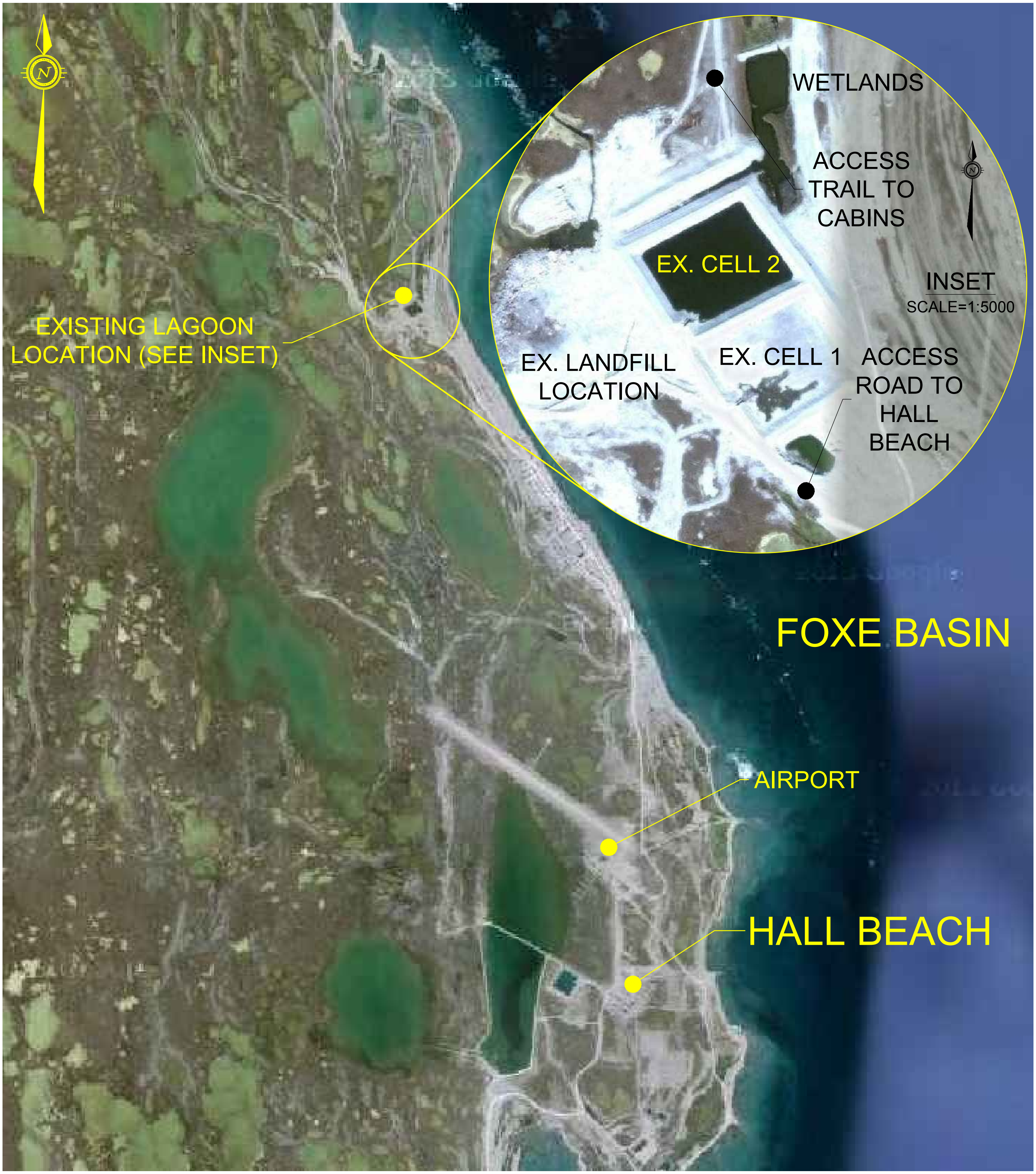
1.2 Community Description

The Hamlet is located on the east shore of the Melville Peninsula, on the western shore of the Foxe Basin. It is in a zone of continuous permafrost and is located on sand and gravel raised beaches, with flat to gently rolling terrain surrounded by numerous lakes and ponds. The population was reported to be 546 according to the 2011 census.

1.3 Scope of Services

The scope of services to be undertaken as part of the detail planning and design for the expansion and/or rehabilitation of the Hamlet's sewage treatment facility includes the following:

1. Initiation Services including a project initiation meeting and a background review
2. Schematic Design Services: Provide a wetlands hydrology study (Additional Service), a wetlands field assessment, waste water quality analysis and a wetlands study report
3. Environmental Assessment (Additional Service)
4. Geotechnical Report, including a geotechnical investigation
5. Schematic Design Report
6. Community Consultation (Additional Service)
7. Design Development
8. Construction Documents
9. Regulatory Approvals (Additional Service)
10. Bidding and Negotiation Services
11. Construction Services including: Construction Administration, Field Review Services, Operational and Maintenance Manuals (Additional Service), a Spill Response Plan, Quality Assurance and Quality Control plan.
12. Post Construction Services including: Record drawings (Additional Service), Project Records and Operator Training (Additional Service)



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drawn by I.P.C.	TITLE: LOCATION PLAN–HALL BEACH SEWAGE LAGOONS	FIG. 1–1

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2 Topographic Survey

A topographic survey was completed at the sewage lagoon site during the period of November 9th 2013, to November 10th, 2013 by Whyte, McElmon and Associates Ltd. The survey plan is included in this report in Appendix A. The site benchmark used for this survey is shown on the survey plan and derived from a single, non-differential GPS measurement with a set project elevation of 9.43 m above local datum.

Seasonal conditions and wildlife activity did not allow the delineation of lakes, streams, and landscape features beyond the berms. At the time of the survey there was approximately 15 cm of hard packed snow and ice with areas of drifting snow in excess of 1m.

The location of lakes and watercourses was derived from aerial mapping for the purposes of this report and are subject to field survey.

3 Description of Alternatives

3.1 Design Alternative Descriptions

Exp was previously retained by CGS to undertake a Feasibility Study (2014) to determine the most financially and technically viable alternative for the development of a permanent wastewater facility to service the Hamlet for the next 20 years. As part of the Feasibility Study five lagoon construction alternatives were examined, four of which were defined by CGS, one of which was defined by **exp**. All of the alternatives for expansion or the construction of new sewage lagoons incorporated impervious lagoon systems. An evaluation of all of the alternatives based on criteria examined within the study resulted in Alternative 4, rehabilitating the existing Cell 1 and expanding to accommodate eight months of active storage, as the highest scoring alternative. Alternative 1, rehabilitating and expanding Cell 1 to accommodate eleven months of active storage was the second highest scoring alternative. The descriptions for the alternatives are listed below.

3.2 Alternative 4 Description

Alternative 4 included the rehabilitation and expansion of existing Cell 1, such that the lagoon system (rehabilitated and expanded Cell 1 and existing Cell 2) would accommodate 8 months of active storage (for 20 years) as opposed to 11 months of active storage with the other four alternatives**.** An overflow weir would be provided for this alternative, to allow the sewage to flow from Cell 1 to Cell 2, and ultimately the effluent from the lagoon to flow from Cell 2 to the wetlands. Expansion in this scenario would involve raising the existing berm height for existing Cell 1 to accommodate the additional active storage requirements. The berm height of existing Cell 1 will be required to be raised from approximately 8.0 m to 9.54 m to accommodate a 1 m of dead zone in the lagoon, 2.0 m of active storage, and 1.0 m of freeboard. The existing access road to Hall Beach must also be raised in this area as it acts as the western berm wall. The sides and bottom of Cell 1 will be fully lined as part of the cell rehabilitation. Alternative 4 is seen in Figure 3-1.

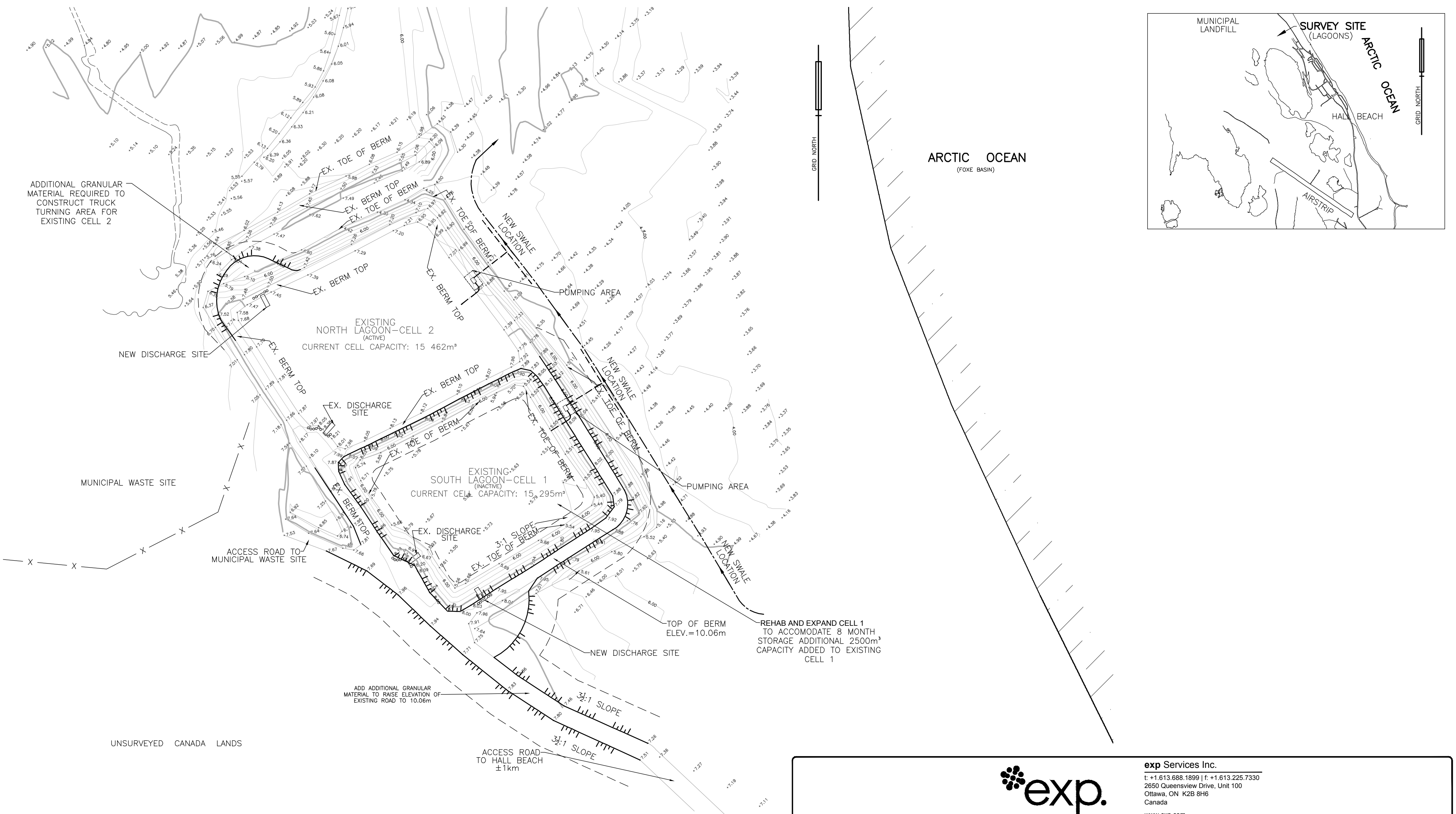
The proposed rehabilitated cell will be designed as an impervious cell and will incorporate a full liner in its design. Additional truck discharge sites for both Cell 1, and Cell 2 would be included in this alternative.

Alternative 4 has the lowest capital cost estimate of all alternatives defined, the lowest estimated operating and maintenance costs, as well as has minimal to no estimated impact on the surrounding lands, no estimated impact on leachate runoff from the existing landfill, no estimated impact to the existing trail system to northern cabins, and no impact on existing water courses.

Conversely, Alternative 4 does not provide the typical 11 months of storage, and it is anticipated that it would not be able to treat the sewage to meet the levels required by the water licence without further treatment from the wetlands. Therefore it was recommended that a full wetlands assessment be conducted prior to the approval of this construction alternative to determine if the wetlands could be provide sufficient treatment to ensure the effluent released from the wetlands met the water licence effluent criteria. A summary of the wetlands assessment, recommendations and conclusions are listed in Section 4.

3.3 Alternative 1 Description

Alternative 1 included expanding and rehabilitating existing Cell 1. As part of this alternative, Cell 2 would be maintained as part of the sewage lagoon system. The combined storage capacity of the sewage lagoon system (rehabilitate and expanded Cell 1 and existing Cell 2) would accommodate an eleven month storage capacity at the 20 year design horizon requirement of the Hamlet. In order to accommodate the storage capacity, while providing a 1m of dead zone in the lagoon, 2.0 m of active storage, and 1.0 m of freeboard, the existing berm height must be raised from approximately 8.0 m to 9.54 m, and the footprint of the existing lagoon will require expansion. The existing access road to Hall Beach must also be raised in this area as it acts as the western berm wall. The proposed rehabilitated Cell 1 will be designed as an impervious cell and will incorporate a full liner in its design. Alternative 1 is seen in Figure 3-2.



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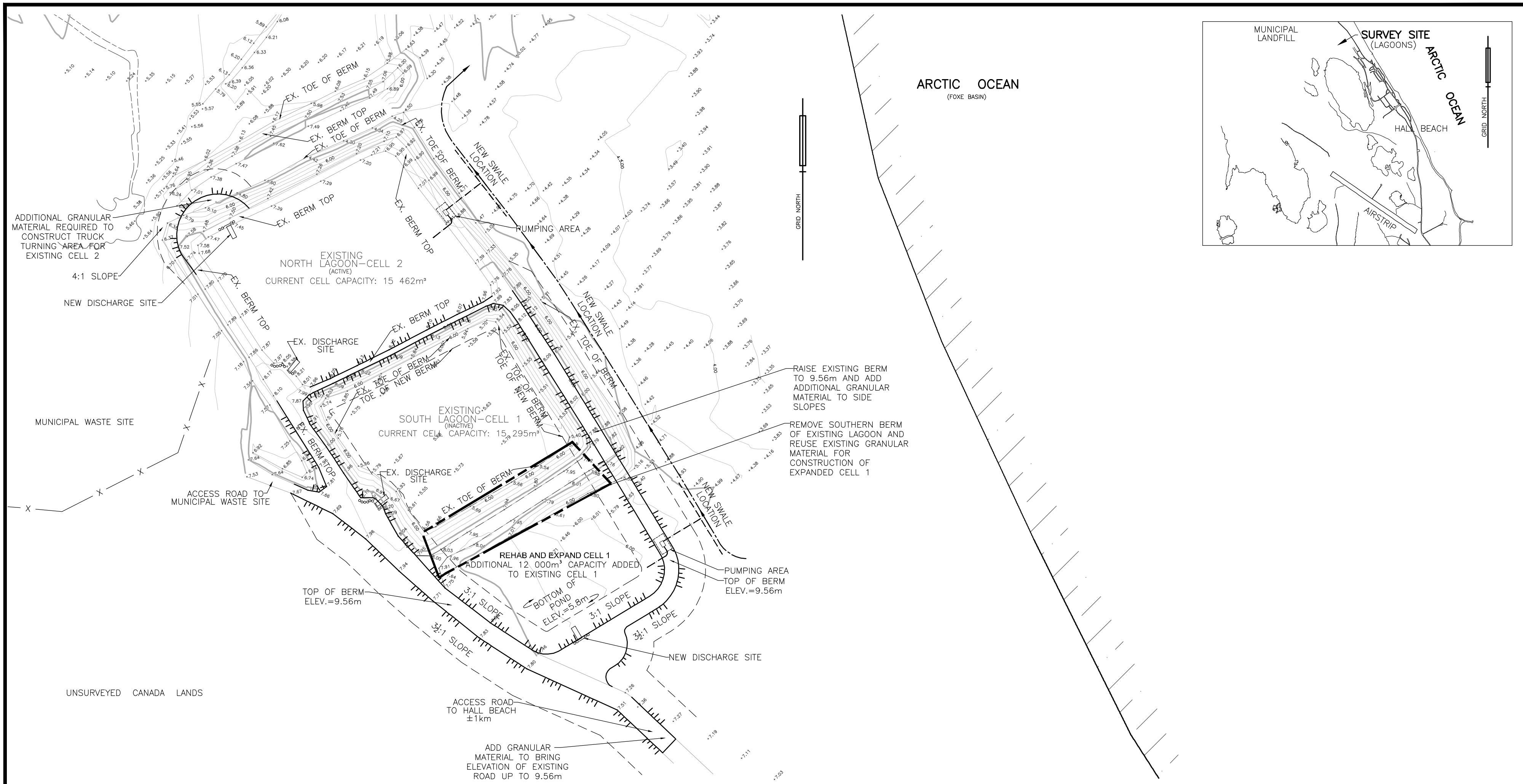
date: DEC. 2014	TITLE:	
drawn by: I.P.C.	ALTERNATIVE 4–REHAB CELL 1 AND EXPAND TO ACCOMMODATE 8 MONTH STORAGE	FIG. 3–1



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date: DEC. 2014	TITLE:	
drawn by: I.P.C.	ALTERNATIVE 1–REHAB AND EXPAND CELL 1	FIG. 3–2

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As per the existing sewage lagoon system, it is intended that this alternative will incorporate the existing wetlands to the north as part of the treatment system to achieve further polishing.

Two truck discharge sites will be constructed at different wind directions at Cell 1 to meet the stipulations set forth by the GN. In addition, a second truck discharge site will be constructed at the existing Cell 2 in a different wind direction.

4 Wetlands Assessment

The Wetlands Assessment Report is issued under a separate cover entitled "Wetlands Assessment, Sewage Treatment Wetlands, Hamlet of Hall Beach, NU."

The purpose of the Wetlands Assessment is to:

- To determine if the Hamlet's existing wetland sewage treatment area is in compliance with the requirements of the Nunavut Water Board, water licence number 3BM-HAL0810 – Hamlet of Hall Beach.
- To determine if Alternative 4, as presented in **exp**'s Feasibility Study (2014), will be the best suited for design of the lagoon system. (As it relies on treatment from the existing wetlands system)

The objective of the Wetlands Assessment is to evaluate the efficiency of the existing sewage treatment wetlands area, and its ability to effectively reduce contaminants and pathogens of effluent waters being released from the wetlands before discharging into Foxe Basin. This assessment will be used to determine if the truck discharged influent into the lagoon from Alternative 4 (eight month storage) will receive sufficient treatment to ensure the effluent release out of the wetlands into the environment will meet the criteria set in the Hamlet's water licence. It is assumed that since Alternative 1 incorporates 11 months of storage, very little, if any additional treatment would be required from the surrounding wetlands. In essence, the wetlands assessment will determine which of the two alternatives is suitable for meeting the requirements of the Hamlet's water licence.

4.1 Conclusions

The Wetlands Assessment revealed that the existing sewage treatment system may not reduce the contaminants and/or pathogens present within effluent before discharging into Foxe Basin in the long-term. The Hamlet's existing sewage treatment system is not in compliance with the requirements of the Sewage Disposal Facility licence (3BM-HAL0810); two parameters (BOD and coliforms) were outside their acceptable criteria at monitoring station HAL-4. HAL-4 is a pond located approximately 30m to the north east of Cell 2. Furthermore, a number of seepage areas were observed east/northeast of the sewage lagoons, some of which were located within 10 m of the ocean shoreline. These areas displayed evidence of untreated wastewater.

As such, various contaminants may be a concern beyond the boundaries of the sewage treatment system. Therefore if the sewage treatment facility is dependent on treatment from the wetland, mitigation measures are recommended for the site to increase the removal of contaminants, and to improve the performance of the sewage treatment wetlands in the long-term. The mitigation measures may include the redirection of effluent from the lagoon towards the northwest, as opposed to the current direction toward the northeast, which will allow for better filtration through the natural wetland system.

4.2 Recommendations

The current wetlands arrangement should not be relied on for achieving significant sewage treatment due to the fact there are current and potential areas of seepage that result in effluent not flowing through the entire wetlands prior to their release into the environment. The recommendation of Alternative 4 in the Feasibility Report (2014) was dependent on the wetlands to achieve significant treatment of the effluent after being discharged from the lagoon system. After completing the wetland assessment, it is evident that the wetlands currently do not achieve the appropriate level of treatment, and as such, the alternative which provides the greatest level of treatment is recommended at this time (Alternative 1), unless significant upgrades to the wetlands are undertaken.

5 Geotechnical Findings

At the time of the initial investigation, undertaken as part of the Feasibility Study, a total of five alternatives were being explored to rehabilitate and expand the existing sewage lagoon. Based on the direction of the GN, two of the five alternatives were carried forward for further investigation. As described in Section 3, Alternative 1 included rehabilitation and expansion of Cell 1 to the south and into an area reportedly previously used as a local dump. Buried debris was reported to be present throughout the expansion area and surficial debris was visible during both of the above noted site visits. Therefore, it was recommended that additional investigative work (test pits) be carried out when the active layer is at or near its maximum depth to evaluate the extent of garbage present if Alternative 1 was selected for final design. Based on the conclusions presented in the wetlands assessment submitted under a different cover, and summarized in this design brief, it is now understood that Alternative 1 is the recommended alternative; therefore, the additional geotechnical investigation discussed herein focused on the proposed expansion footprint to the south. The findings and recommendations from our initial geotechnical investigation (November, 2013) are repeated herein for information and completeness. Our previous recommendations have not been altered, and the full Geotechnical report titled "Additional Geotechnical Investigation, (September 29, 2014)" has been submitted under a different cover.

Many of the test pits excavated throughout the current base of Cell 1 encountered less sand and silt in the gravel layer at depth. A layer of debris (pieces of metal, wood, plastic, glass, etc.) intermixed with organic materials and brown to black silty sandy gravel was observed outside the lagoon. The debris was generally encountered throughout the east half of the proposed expansion area footprint and to the south; however, it is possible that debris may also be present throughout the west half of the footprint, between our test pit locations. Based on the test pit findings, the layer of debris is also present directly adjacent to and beneath portions of the existing outside slope of the south berm of Cell 1. However, it does not appear to extend inside the lagoon.

Bedrock was confirmed in the center of existing Cell 1 during the previous investigation at 2.9 m depth below current grade. Based on previous nearby geotechnical investigations, it is anticipated that bedrock is at a similar depth throughout the entire area of interest to this investigation, likely at about 3 m to 5 m below original grade. The overburden soils were observed to contain very little to no excess ice. Groundwater (primarily comprised of sewage water) was encountered at depths ranging from 1.2 m to 2.3 m in the borehole and most of the test pits located throughout the existing base of Cell 1.

The berm embankments are to be constructed using locally available sand and gravel. It is recommended that the entire zone of influence for the berm expansions and/or liner installations should be stripped of any existing sludge, garbage, surficial organic/peat layer and/or any other soft saturated materials encountered to expose a structurally stable subgrade of either unfrozen or frozen well-graded soils. Where the existing berms of Cell 1 are to be re-used/raised, any sections of the berms known to have experienced slope failures and/or undermining, should be removed to approved material/subgrade and reconstructed. Any over-excavation should be backfilled to pre-existing grades within one day of the excavation to limit the time of exposure of the underlying permafrost soils. Embankment fill should be placed in maximum 300 mm thick lifts and compacted to at least 95 percent Standard Proctor maximum dry density. The synthetic liner should be provided with a suitable bedding (such as sand) as specified by the manufacturer. The upper end of the liner (at the crest of the berm) should be buried in an approximately 0.6 m deep trench and backfilled with well-compacted embankment fill.

Permafrost degradation is expected beneath the lagoon cells and will result in differential thaw settlements of the lagoon and the berms. However, the site soils encountered during our investigation were not observed to be ice-rich, were primarily coarse grained and bedrock is anticipated to be within 3 m to 5 m of the current site grades. Therefore, the use of fully lined lagoon cells is considered feasible at the site.

A slope stability analysis was performed in order to determine if the proposed berm heights and slopes would be stable. For slope stability analysis, the most critical proposed cross-section of the berms was used. It is considered that the results for this location will also be applicable to the other proposed berm cross-sections. The analysis was performed for static as well as seismic loading. It revealed that the required factors of safety of 1.5 in the case of static loading and 1.1 the case of seismic loading will be satisfied with upstream slopes of 3H:1V and downstream slopes of 3.5H:1V for the reservoir. A slope stability analysis for the rapid drawdown condition was also undertaken. The analysis revealed that the berm slopes will be stable (factor of safety of 1.1) provided that the lagoon is drained in 5 or more days. The slope stability results assume that sufficiently sized toe drains would be provided to prevent the phreatic surface from day lighting at the downstream face of the berms and that over topping of the berms will not occur.

The above and other related considerations have been discussed in greater detail in the Geotechnical report distributed under a separate cover.

6 Sewage Lagoon Capacity

6.1 General

The proposed sewage lagoon rehabilitation alternative must have the capacity to meet the Hamlet's needs for the next 20 years, as well as fulfill the current water licence requirements. As per the scope of work provided by CGS, the design horizon for this project will be 20 years, until the year 2035.

6.2 Population

Population projections for Hall Beach were retrieved from the Nunavut, Regional and Community Population Projections 2009 to 2036, distributed by the Nunavut Bureau of Statistics viewed in Appendix B. This document provides projected populations from 2009 to 2036 inclusive, including a projected total population in the Hamlet of Hall Beach of 1042 people in the year 2035.

6.3 Water Use and Wastewater Production

In order to determine the volume of sewage the lagoon must meet, the sewage generation rate for the community must be determined. It is a generally accepted practice to assume sewage generation rates are equal to water consumption rates. The residential water usage for a community is based on the method of water delivery and sewage collection in the community. The Water and Sewage Facility Capital Program Standards and Criteria (GNWT) provide the following design values and formulae for estimating the water consumption and therefore the sewage generation rates for communities.

Table 6.1 - Residential Water Usage

Service Method	Residential Water Usage (RWU)
Trucked water and sewage	90 lpcd
Piped water and sewage	225 lpcd
Piped water supply and truck sewage pump out	110 lpcd
Trucked water delivery and individual septic fields	100 lpcd

Hall Beach utilizes a trucked water and sewage system, therefore, the RWU is equal to 90 lpcd for the community.

The non-residential water usage by a community tends to increase with increases in the population. To determine the Total Community Water Usage the Residential Water Usage is adjusted based on population to provide a Total Water Usage per Capital. The Total Water Usage per Capital, including residential and non-residential activities are estimated based on the equations in Table 6.2.

Table 6.2 - Total Community Water Usage

Community Population	Total Water Use Per Capita
0 – 2000	RWU x (1.0 + 0.00023 x Population)
2000 – 10,000	RWU x [-1.0 + {0.323 x Ln(Population)}]
Over 10,000	RWU x 2.0

Given the projected population of Hall Beach at the design horizon is less than 2000 the following equation was used to calculate total per capita water consumption rate.

Water Consumption (litres per person, per day) = 90 (litres per person, per day) * (1+0.00023 x population)

The factors of ***0.00023 x population*** represents the commercial and industrial water use in the above equation.

Based on the design population of 1042 people for the year 2035, and a total water usage per capita rate of 112 lpcd, the daily sewage generation rate is equal to 116,740 lpd *(112 lpcd x 1042 people).* This is equal to a yearly sewage generation rate of 42,610 m^3 in the year 2035 *(116,740 lpd converted into cubic meters x 365 days).*

Projected sewage generation rates through to the year 2035 for a 335 day supply (11 month storage, 1 month pumping), are calculated in Appendix C.

6.4 Sludge Storage

One of the main mechanisms of treatment in a sewage lagoon is the settlement of solids. The accumulation of solids is referred to as sludge. To ensure that sludge is not released to the environment, the design of the sewage lagoon must allow for storage of the sludge (settled solids).

There is very limited data regarding the operational behaviour of lagoons in arctic environments. Due to this lack of data, various assumptions were used to develop an estimate of sludge accumulation rates and are summarized as follows:

1. Individual suspended solids contribution is assumed to be 90 grams/capita/day. This is based upon the rate of suspended solids typically found in municipal sewage. (Ontario MOE Guidelines for the Design of Sewage Treatment Works, 2008)
2. A complex set of mechanisms is responsible for the removal of contaminants in a lagoon. These mechanisms include sedimentation, aerobic oxidation and anaerobic sludge volume reduction, which reduce the solids contribution from truck discharged influent sewage into the lagoon. The biological processes also create solids in the forms of bio-mass (bio-solids). It has been assumed that the net outcome of the various biological processes that both create and reduce solids leads to a rate of sludge contribution at the same rate as the individual suspended solids contribution.
3. The sludge that accumulates in the lagoon is made up of sedimented suspended solids and a large amount of water. These solids remain undisturbed in the bottom of the lagoon for several years. This provides the opportunity for gravity thickening of these solids over a protracted period of time. For the purposes of these calculations it has been assumed that an ultimate sludge density of 10% will be achieved.
4. The suspended solids, which accumulate in the lagoon cell, have a very low density and these solids are easily re-suspended. Thus, localized areas of high velocity should be avoided to reduce the risk of re-suspension of accumulated sludge.

The preceding assumptions lead to an annual per capita rate of sludge accumulation of 32.85 kg that represents a per capita volume of 0.329 m^3. Therefore o ver a typical 20 year life of a lagoon, there is a requirement for approximately 6.6 m^3 of sludge storage capacity per person. The ratio of sludge accumulation and active storage varies based on the population being served. For a typical northern community with a design population of 1,000, the per capita water consumption would be 110.7 lpcd. For a storage lagoon providing 335 days of storage this would require 37.1.2 m^3 (110.7 l/day x 335 days) of active storage for the sewage per person. Therefore the typical percentage of the volume of active storage required for sludge storage is 18% (6.6m^3/37.1m^3). Sewage lagoons typically have an active storage depth of between 2.0 to 2.5 m. Therefore the sludge accumulation over the 20 year life of the lagoon can be expected to be in the range of 0.36 to 0.45 m.

The depth of sludge accumulation is based on an ultimate sludge density of 10% (assumption #3 listed above). Thickening of the sludge to this density by gravity will occur over a protracted time period; therefore the storage zone within the lagoon must be greater than the estimated 0.36 m to 0.45 m to account for the un-thickened sludge.

That portion of the lagoon, which is described as the dead zone, also serves to separate accumulated sludge from the general contents of the lagoon. During the process of decanting of the lagoon contents, the target is removal of the treated wastewater while retaining the stored sludge in the lagoon cell. Thus, a buffer should be provided below the decanting pipe to insure that localized high velocities do not re-suspend the settled suspended solids. Placing the inlet of the decanting structure a suitable distance above the sludge will ensure that the decanting process does not disturb the settling sludge.

To allow for these factors, it is recommended that an allowance of 0.4 m greater than the calculated thickened sludge be provide for sludge storage. For the purpose of this study a dead zone of 0.76m will be assumed.

6.5 Precipitation

Precipitation normals were used from Environment Canada data to determine the quantity of precipitation that the lagoon would be required to store per year and is shown in Appendix D. This information was used in conjunction with water and wastewater production to calculate the size of the cell. In addition to the 335 day total demand volume of 38,946m^3 in the year 2035, it was determined that 6,400 m^3 of precipitation [217mm (precipitation) x area of lagoons (30,000m^2)] would need to be accounted for in sizing the lagoon.

6.6 Evaporation

Standard texts provide methods for the estimation of evaporation. These techniques, both analytical and empirical, require substantial assumptions and input data. This data includes parameters from a long list that can include solar radiation, fraction of radiation reflected and reflected long wave radiation. Confirmation of any methods of estimating evaporation is very challenging. Any estimates of evaporation must be treated in the most cautious of fashions, and it should be accepted that any computation is, at best, an approximation.

Introduction to Hydrology (Viessman et al, 1972) presents one simplistic method based upon temperature, vapour pressure and wind speed which is data generally available for locations such as Hall Beach. This takes the form:

$$E = C(e_0 - e_a)(1 + W/10)$$

Where:

E = evaporation (in/day)

e_0 and e_a = vapour pressure at water surface and air (in Hg)

W = wind speed (mph), and

C is a constant (typically 0.36)

The Climate Normals for Hall Beach indicate an average temperature for July of 6.1°C and 4.7˚C for August. Wind speed is reported as 16.2 and 18.7 kph for that same period. If the following conditions are assumed:

Air temperature 5.4°C (41.72°F)

Water temperature 3°C (37°F)

Wind Speed 17.4 kph (10.8 mph)

Substituting into the relationship provides:

E = 0.36(0.26 – 0.22)(1 + 10.8/10)
= 0.026 in/day or
= 0.7 mm/day

On this basis evaporation could total 21 mm per month. Evaporation over the period of June through August will reduce the stored volume in the lagoon by a total of 63 mm or approximately 3,600 m^3.

Therefore, the total 11 month volume of storage to be provided by the sewage lagoons is equal to the volume of effluent, plus precipitation minus the evaporation for a total of approximately 41,746m^3 (38,946 m^3 + 6,400 m^3 - 3,600 m^3).

7 Sewage Lagoon Detail Design

7.1 Lagoon Design

The two sewage lagoon design configurations examined in this report will utilize the following construction methods:

- Berms will be constructed of granular material
- Newly constructed berms for storage cell will have an **interior** side slope of 3H:1V
- Newly constructed berms for storage cell will have an **exterior** side slope of 3.5H:1V
- Newly constructed storage cell to be impervious
- Storage cells shall have maintenance vehicle access on top of berms
- Newly constructed storage cell shall be designed to account for 1 m of freeboard
- Newly constructed storage cell shall be designed to account for 1 m of "dead zone" for sludge accrual
- Two truck discharge locations per cell constructed at different wind directions

The design of the earth berms for the rehabilitation of the existing sewage lagoon, and the newly constructed lagoon are based on the recommendations from the geotechnical report issued under a separate cover, and are summarized in Section 5.

7.1.1 Capacity of Existing Lagoons

The existing lagoons have the following capacities:

- Existing Cell 1 has a current cell capacity of approximately 15,295m^3
- Existing Cell 2 has a current cell capacity of approximately 15,462m^3

As stated in Section 6, the anticipated total 11 month volume of storage to be provided by the sewage lagoons in the year 2035 is 41,746m^3 which means the capacity of the lagoon system would need to be expanded to accommodate an additional 11,000m^3 total volume of storage to meet the 20 year design horizon.

7.1.2 Berm Design

Based on the Geotechnical investigation the following conclusions and recommendations were put forward.

The proposed design for the new lagoon cell is for an impervious cell. The options for the creation of an impervious structure are:

- A fully lined lagoon
- A liner installed in the berms keyed into the permafrost

The fully lined lagoon is the traditional approach to making a sewage lagoon impervious. The disadvantages to this approach are liner integrity, if the liner experiences an unstable base, and the possibility of uplift forces due to buoyancy caused by pore pressures under the liner.

Keying the liner into the permafrost is an alternative that makes use of the impervious characteristic of the permafrost to form the impervious boundary along the bottom of the lagoon, and the liner to form the imperious boundary in the berms. This system is dependent on being able to key the liner into the permafrost. The system is generally the most attractive when a fully lined system is not feasible due to ice rich soils or high buoyancy forces.

As the soils conditions are not ice rich and adverse buoyancy forces will not be present, it is recommended that the entire lagoon be fully lined with an appropriate impermeable layer satisfying the geotechnical recommendations.

The berms will be constructed with a liner on the upstream slope to provide an impermeable boundary. The typical berm sections are shown in Figure 7-1.

7.1.3 Lagoon Decanting

As per the Terms of Reference (TOR) established by the GN in the initial Feasibility Study, the option of decanting the sewage lagoons via piping through the berm was not permitted. The TOR allowed for decanting the lagoon by natural exfiltration through the berm walls and berm floor, or through pumping.

Although many lagoons in the north depend on the permeability of their berms to allow for sewage to seep or leak out during the summer (natural exfiltration) this method does not allow for control of the time or rate of decanting. In addition, these berms are more prone to experience partial failure due to erosion piping or settlement from permafrost degradation of the subgrade. Decanting via natural exfiltration was dismissed as the lagoon is designed to be lined both on the berm walls and the bottom of the cells. This scenario would make natural exfiltration in these locations impossible; hence pumping is the chosen method of decanting.

Typically, the decanting of the lagoons occurs annually in the late summer or early fall. Pumping allows the best control over release time, and release rate.

7.1.4 Influent and Effluent Quality

The Hamlet's water and sewer system is comprised of holding tanks and a trucked delivery and collections system. The waste generated from this scenario is described as *moderately diluted wastewater* as defined in the Cold Climate Utilities Manual (D.W. Smith et.al, 1986). Table 7.1 below is an excerpt from the Cold Climate Utilities Manual summarizing the characteristics of *moderately diluted wastewater*.

Table 7.1 - Characteristics of Wastewater

Parameter	Units	Moderately Diluted
BOD_5	mg/L	460
Suspended Solids	mg/L	490

Sedimentation and bio-chemical oxidization are the primary removal systems used for all designed sewage lagoon systems outlined in this report. Sedimentation removes BOD_5 (Biochemical Oxygen Demand-5 day) and suspended solids through settling. An annual detention lagoon provides the opportunity for sedimentation due to the large volume and long detention time. Without chemical addition sedimentation provides typical removals of 35% of BOD_5 and 65% of suspended solids. (Ministry of Environment of Ontario Design Guidelines for Sewage Works-2008.)

The remaining BOD_5 and suspended solids remain in a dissolved or colloidal form, and the natural process within the lagoon will result in bio-chemical removal of the dissolved and colloidal fraction. The level of treatment through bio-chemical treatment can be estimated using the following first order relationship:

$$C_e = C_i e^{-Kt}$$

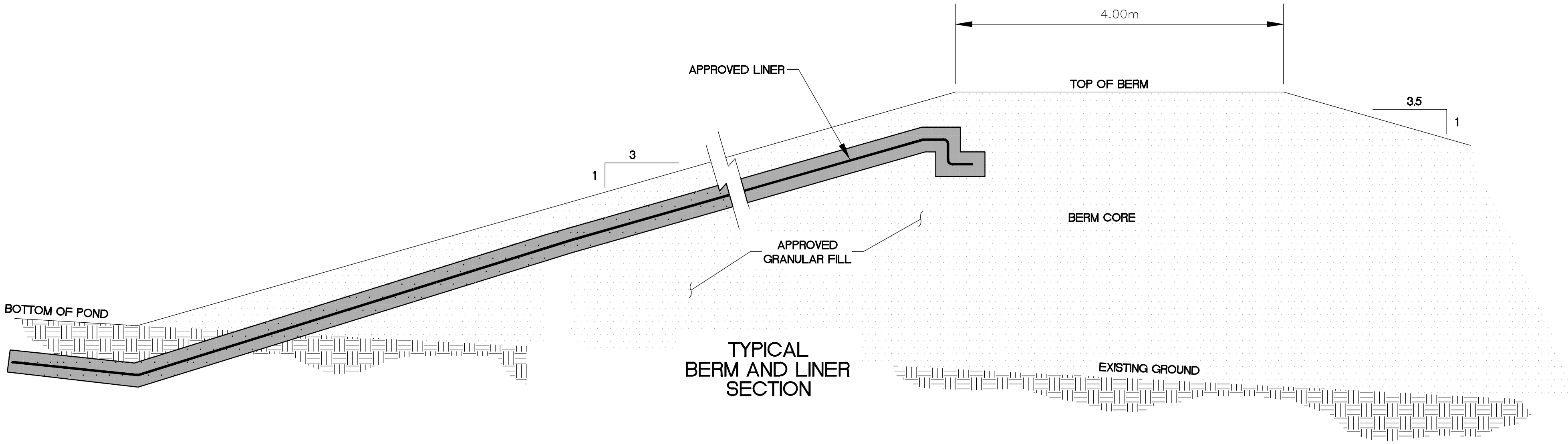
Where:

C_e = Effluent concentration (mg/L)

C_1 = Influent concentration (mg/L)

K = BOD_5 removal rate constant (day^{-1})

t = Residence time in lagoon (days)



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scale 1:80	CLIENT: HAMLET OF HALL BEACH	project no. OTT-00220382
date DEC. 2014		
drawn by MJT	TITLE: TYPICAL BERM SECTION	FIG. 7-1

The rate constant is temperature dependent. The impact of temperature is estimated using the following relationship:

$K = K_{20}\Theta^{T-20}$

Where:

K = Rate constant at stipulated temperature (day^{-1})

K_{20} = Rate constant at 20˚C (day^{-1})

Θ = Temperature activity coefficient (assumed value of 1.08)

T = Temperature (˚C)

Due to the extended periods of low activity due to low temperatures, the BOD_5 removal rate coefficient of 0.10 was assumed for this analysis. This is between 20 and 40% of the typical values typically assumed in southern Canada.

Assuming the truck discharged influent sewage into the lagoon strength of 460mg/L BOD_5, and the 35% removal through sedimentation, the following Table 7.2 summarizes treatment levels based on various assumptions based on the first order relationship.

Table 7.2 - Effluent BOD_5 Following Bio-Chemical Oxidation

Treatment Time (Days)	Temperatures		
	1°C	**2°C**	**4°C**
30	149	141	125
45	105	97	80
60	74	67	52

For the purposes of estimating the levels of suspended solids at the time of release, the levels will be assumed to be 20% higher than the levels of BOD_5 as per the general performance of lagoons in southern Canada. The quality of the effluent released from the sewage lagoon can therefore be summarized in the following table:

Table 7.3 - Effluent Quality from the Lagoon

Parameter	Units	Effluent from Lagoon
BOD_5	mg/L	97
Total Suspended Solids (TSS)	mg/L	116

The proposed sewage treatment lagoon alternatives examined in this study must meet the effluent quality standards as set out in the Hamlet's latest water licence (Licence No. 3BMHAL0810). The effluent quality standards set out in the water licence are summarized in Table 7.4 below.

Table 7.4 - Effluent Quality Standards

Parameters	Maximum Average Concentration
BOD_5	120 mg/l
Total suspended solids (TSS)	180 mg/l
Faecal coliforms	1 x 10^6 CFU/100mL
Oil and grease	No visible sheen
pH	Between 6 and 9

The predicted level of treatment provided by the proposed lagoon treatment system meets or exceeds the requirements for the Hamlet's water licence and can be summarized in the following table:

Table 7.5 - Summary of Treatment Levels

Parameters	Units	Criteria	Influent	Effluent from Lagoon
BOD_5	mg/L	120	460	97
Total suspended solids (TSS)	mg/L	180	490	172* 116**
Faecal coliforms	#100ml	$1x10^6$	$1x10^7$	< or = $1x10^6$

*Based solely on reductions from sedimentation
**Includes removal of colloidal fraction of TSS through bio-chemical oxidation

It should be noted that further polishing of effluent from the lagoon will be achieved after decanting occurs in the surrounding wetlands. As the predicted level of treatment meets or exceeds the requirements of the water licence within the lagoon, the extent of polishing achieved by the effluent through the wetlands has not been estimated for the purposes of this design brief.

8 Cost Estimate

8.1 Class C Cost Estimate

A Class C Capital Cost Estimate has been prepared for the Hall Beach Lagoon upgrade. The works included in the cost estimate include the following:

- Construction of a new storage lagoon (including the liner and granular material)
- Excavation of contaminated areas and replace with new granular material
- Remove of existing berms and dispose if material is unsuitable
- Re-use existing berm material if material is suitable
- Upgrades to the existing, and construction of new discharge locations
- Supply, deliver, and install pumping requirements
- Construction of a new swale

A detailed breakdown of the cost estimate is included in Appendix E and includes a 20% contingency allowance. The estimated capital cost for the Hall Beach Lagoon upgrade is $4,112,520.00.

8.2 Operating and Maintenance Costs

One of the characteristics of a sewage lagoon which makes its use in the arctic attractive is the relatively lower operator requirements. For the lagoon system proposed, other than the decanting of the lagoon, regular inspections of the berms, and sampling and testing of the effluent are the main annual operating and maintenance (O&M) costs. For the purpose of analysis, the O&M costs for the proposed lagoon will be assumed to be 1% of the capital cost, not including the cost for decanting the lagoon. The annual O&M costs are estimated to be approximately $47,825 as detailed in Appendix F.

8.3 Life Cycle Costing

The Life Cycle Cost of the proposed facility based on the Capital and O&M costs presented above, as well as being based on a 20 year economic life as per the "Water and Sewage Facilities Capital Program: Standards and Criteria" and an interest rate of 8%, "General Terms of Reference for a Community Water and Sanitation Service Study, Appendix A MACA 1986", is summarized in Table 9.1, and can be viewed in Appendix F.

Table 8.1- Life Cycle Cost Summary

Capital Cost	$4,112,520
Present Value of O&M Costs over 20 Years	$469,553
Life Cycle Costs	$4,582,073

9 Conclusions and Recommendations

The following summarizes the conclusions and recommendations for the design brief for the Hamlet's sewage lagoon upgrades.

- The existing sewage lagoon in Hall Beach does not meet the long term needs of the Hamlet, nor does it meet the treatment requirements of the existing water licence.
- Between 2008 and the spring of 2013, leaks through and under the southern berm of Cell 1 persisted. Several short term remedial actions were taken to repair the berm, but as these actions did not meet the long term needs of the Hamlet, a permanent solution is required to provide the Hamlet with reliable wastewater treatment for the next 20 years.
- The Hall Beach Sewage Lagoon Feasibility Study completed by **exp** in April 2014 identified a preferred Alternative 4 that would provide an eight month storage capacity for the sewage lagoon system. This system is intended to provide storage to facilitate over winter storage. As such, limited bio-chemical treatment of the sewage will be accomplished prior to the start of the decanting, and it is anticipated that the sewage lagoon will not be able to meet the water licence effluent criteria. Hence, subsequent treatment through a wetland is required in order to satisfy the requirements of the existing water licence. Therefore, a full wetland analysis is required to determine if sufficient treatment through the wetlands is achievable.
- The Wetlands Assessment, Sewage Treatment Wetlands, Hamlet of Hall beach completed by **exp** on October 20, 2014 concluded that the existing wetlands have areas of seepage that currently do, or has the potential to, lead to sewage not flowing through the entire site prior to releasing into the environment. Because of this, the current wetlands arrangement should not be counted on for achieving significant sewage treatment. Therefore, Alternative 4 could not be used, and the second highest scoring design Alternative 1 in the feasibility report would be implemented.
- Alternative 1 incorporates 11 months of storage, and 1 month of decanting. This alternative includes rehabilitation and expansion of existing Cell 1. As part of this alternative, Cell 2 would be maintained as part of the sewage lagoon system.
- The project population for the year 2035 is 1042 people.
- Based on the projected population, the project sewage generation rate is 112 lpcd.
- The total 11 month volume of storage to be provided by the sewage lagoons is equal to the volume of effluent from the lagoon, plus precipitation minus the evaporation for a total of approximately 41,746m^3. It is calculated that an additional approximate 11,000m^3 of storage would be required to fulfill the requirements of the 20 year storage capacity requirement for the Hamlet. This additional volume will be achieved by rehabilitating and expanding the footprint of existing Cell 1.
- The site soils encountered during the investigation were not observed to be ice-rich, were primarily coarse grained, and bedrock is anticipated to be within 3 m to 5 m of the current site grades. Therefore, the use of fully lined lagoon cells is considered feasible at the site.
- It is recommended that the new sewage treatment facility utilize the wetlands between the proposed facility and Foxe Basin to provide additional polishing of the effluent before it is released into the environment.
- It is recommended that the entire zone of influence for the berm expansions and/or liner installations should be stripped of any existing sludge, garbage, surficial organic/peat layer and/or any other soft saturated materials encountered to expose a structurally stable subgrade of either unfrozen or frozen well-graded soils.

10 References

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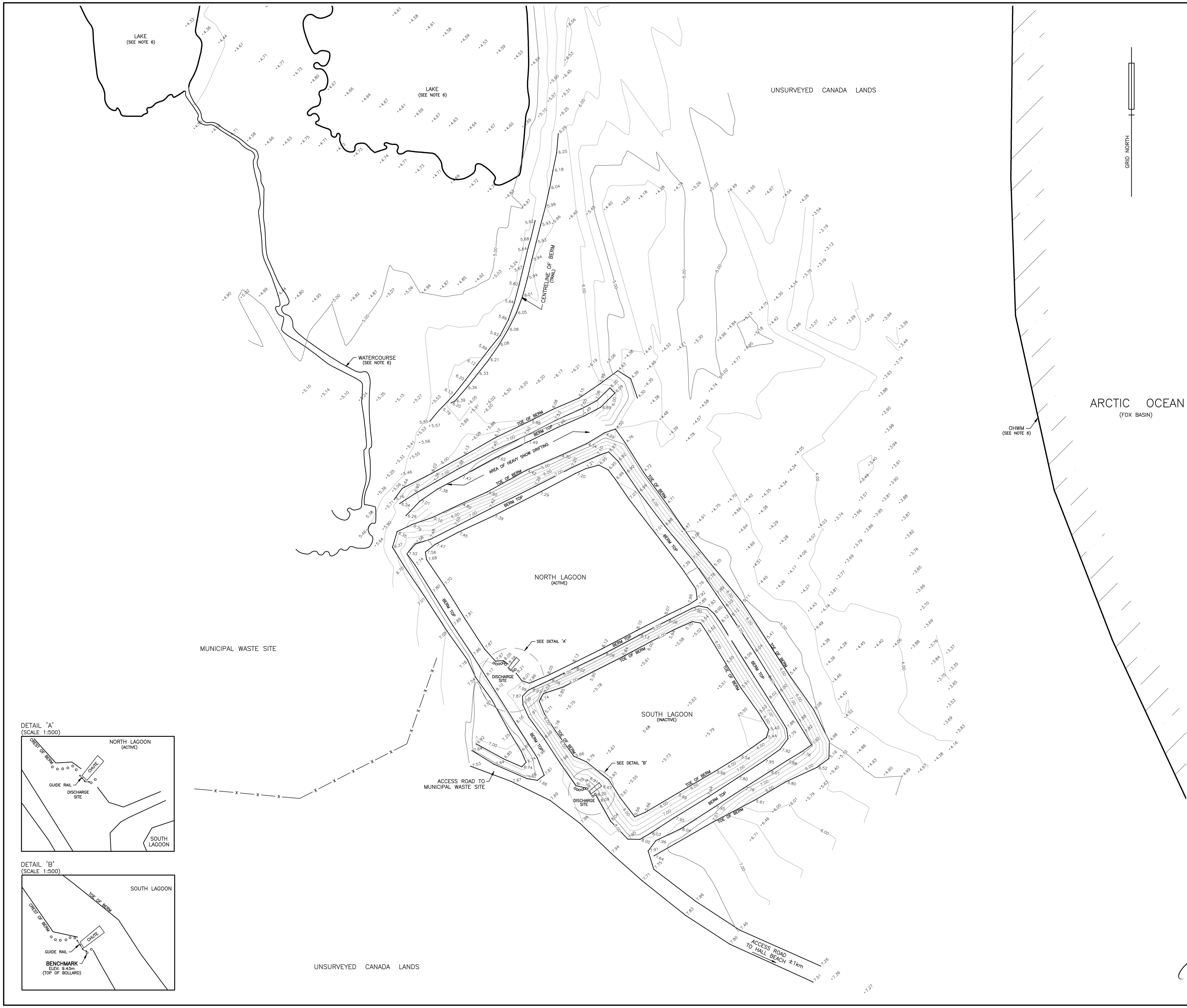
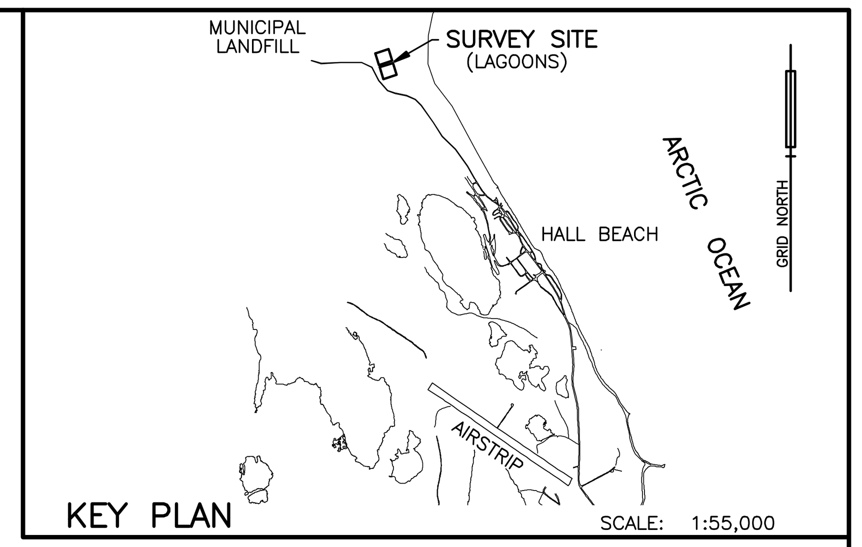
Appendix A – Topographic Survey





KEY PLAN SCALE: 1:55,000

LEGEND

- —G— · · · · · · · · · · GUIDE RAIL
- —X— · · · · · · · · · · CHAIN LINK FENCE
- o · · · · · · · · · · BOLLARD
- OHWM · · · · · · · · · · ORDINARY HIGH WATER MARK
- +3.39 · · · · · · · · · · EXISTING GROUND ELEVATION

NOTES

1) SCALE FACTOR NOT APPLIED
2) FIELD SURVEYS WERE CARRIED OUT DURING THE PERIOD OF NOVEMBER 9TH TO NOVEMBER 10TH, 2013.
3) CONTOUR INTERVAL IS 0.5 METRES
4) THE SITE BENCHMARK IS SET ON TOP OF SHOWN BOLLARD AND DERIVED FROM A SINGLE, NON–DIFFERENTIAL, GPS MEASUREMENT WITH A SET PROJECT ELEVATION OF 9.43m ABOVE LOCAL DATUM.
5) SEASONAL CONDITIONS AND WILDLIFE ACTIVITY DID NOT ALLOW THE DELINEATION OF LAKES, STREAMS, AND LANDSCAPE FEATURES BEYOND THE BERMS. AT THE TIME OF THE SURVEY THERE WAS APPROXIMATELY 15 CENTIMETERS OF HARD PACKED SNOW AND ICE. WITH AREAS OF DRIFTING SNOW IN EXCESS OF ONE METRE.
6) THE LOCATION OF LAKES AND WATERCOURSES ARE DERIVED THROUGH AERIAL MAPPING AND ARE SUBJECT TO FIELD SURVEY.

TOPOGRAPHIC SURVEY OF THE

SEWAGE LAGOON FACILITY

HALL BEACH, NUNAVUT

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FOUNDED 1951
DAVID J. WHYTE
523
MEMBER

SCALE : 1:1000
FILE No. : 3892
PLAN DATE : DECEMBER 3, 2013
DRAWN BY : MB
PLAN No. : 47A–15–1

Appendix B – Population Projections

Baffin Community Projections, 2009 to 2036

Total	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Baffin Region	**17,194**	**17,414**	**17,644**	**17,873**	**18,100**	**18,329**	**18,562**	**18,796**	**19,029**	**19,257**	**19,482**	**19,701**	**19,916**	**20,125**	**20,336**	**20,545**	**20,756**	**20,967**	**21,181**	**21,398**	**21,618**	**21,843**	**22,072**	**22,306**	**22,543**	**22,784**	**23,025**	**23,269**
Arctic Bay	728	737	746	756	766	777	787	798	808	819	830	840	851	861	870	879	888	897	906	915	925	935	945	956	967	978	989	1,000
Baffin unorganized[3]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Cape Dorset	1,366	1,386	1,407	1,429	1,451	1,473	1,496	1,520	1,545	1,569	1,592	1,615	1,638	1,660	1,683	1,705	1,726	1,747	1,768	1,788	1,808	1,829	1,852	1,874	1,896	1,919	1,943	1,968
Clyde River	895	908	922	935	949	963	977	991	1,004	1,017	1,031	1,044	1,056	1,068	1,080	1,093	1,107	1,120	1,135	1,149	1,163	1,178	1,193	1,209	1,225	1,240	1,256	1,272
Grise Fiord	150	152	154	156	158	160	163	166	169	172	175	178	181	184	187	189	191	193	195	197	198	199	200	201	202	203	204	205
Hall Beach	702	710	718	727	736	747	759	771	784	798	812	827	843	859	875	890	905	920	934	949	962	976	990	1,003	1,016	1,029	1,042	1,056
Igloolik	1,639	1,662	1,686	1,711	1,736	1,760	1,784	1,811	1,839	1,867	1,894	1,922	1,949	1,976	2,005	2,035	2,067	2,098	2,129	2,161	2,193	2,226	2,260	2,294	2,329	2,364	2,397	2,431
Iqaluit	6,832	6,920	7,010	7,095	7,176	7,254	7,332	7,405	7,476	7,543	7,608	7,666	7,722	7,775	7,826	7,874	7,919	7,967	8,017	8,069	8,123	8,178	8,237	8,297	8,359	8,423	8,487	8,551
Kimmirut	444	449	455	461	467	473	479	485	491	497	504	511	517	524	530	536	542	548	554	559	565	570	575	580	585	591	597	603
Pangnirtung	1,443	1,459	1,476	1,494	1,512	1,530	1,550	1,571	1,592	1,613	1,634	1,654	1,675	1,695	1,716	1,737	1,760	1,783	1,805	1,828	1,851	1,875	1,898	1,922	1,946	1,971	1,996	2,022
Pond Inlet	1,424	1,444	1,465	1,486	1,507	1,529	1,551	1,572	1,592	1,612	1,632	1,653	1,672	1,691	1,710	1,730	1,752	1,774	1,795	1,817	1,840	1,864	1,888	1,914	1,940	1,966	1,992	2,017
Qikiqtarjuaq	521	527	534	540	547	554	561	567	573	578	583	588	593	598	604	610	615	620	626	632	638	643	647	652	657	662	668	672
Resolute	250	252	255	257	259	262	265	269	273	276	279	282	285	288	291	294	297	299	302	305	308	311	313	316	319	322	324	327
Sanikiluaq	794	802	810	820	830	841	852	864	877	890	902	915	928	940	953	967	981	995	1,009	1,023	1,038	1,053	1,068	1,082	1,096	1,110	1,124	1,139
Male	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Baffin Region	**8,970**	**9,066**	**9,170**	**9,271**	**9,370**	**9,472**	**9,576**	**9,679**	**9,782**	**9,884**	**9,986**	**10,084**	**10,179**	**10,272**	**10,365**	**10,455**	**10,546**	**10,638**	**10,731**	**10,828**	**10,925**	**11,026**	**11,128**	**11,235**	**11,344**	**11,454**	**11,564**	**11,676**
Arctic Bay	418	421	424	427	430	434	437	441	444	448	452	455	459	463	466	469	472	475	478	481	484	487	490	494	498	502	506	510
Baffin unorganized[3]	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Cape Dorset	688	697	707	718	728	738	749	760	772	783	794	804	814	824	834	844	854	864	873	882	891	901	911	921	931	941	953	965
Clyde River	476	481	487	492	498	504	511	518	524	530	537	543	548	553	558	564	570	576	583	590	597	604	611	619	627	634	641	648
Grise Fiord	77	78	79	80	81	82	84	86	88	90	92	94	96	98	100	101	102	103	104	105	106	107	108	109	110	111	112	113
Hall Beach	366	370	374	379	384	390	396	402	409	416	423	431	440	449	458	466	474	482	489	497	504	511	518	525	532	539	546	554
Igloolik	869	878	888	898	908	918	928	939	951	964	976	989	1,001	1,013	1,026	1,039	1,053	1,067	1,081	1,096	1,110	1,125	1,140	1,155	1,171	1,187	1,203	1,219
Iqaluit	3,543	3,581	3,622	3,659	3,694	3,728	3,761	3,792	3,821	3,848	3,874	3,897	3,919	3,939	3,958	3,975	3,991	4,008	4,026	4,045	4,065	4,086	4,109	4,133	4,158	4,184	4,209	4,234
Kimmirut	242	245	248	251	254	257	260	263	266	269	273	277	280	284	287	290	293	296	299	302	305	308	311	314	317	320	323	326
Pangnirtung	727	734	742	750	758	766	775	784	794	804	814	823	832	841	850	859	869	879	889	899	909	920	931	942	953	965	977	989
Pond Inlet	755	764	773	782	791	801	811	820	829	838	847	856	864	872	880	888	897	906	915	925	935	946	956	968	980	992	1,004	1,016
Qikiqtarjuaq	264	268	272	276	280	284	288	291	294	297	300	303	306	309	313	317	320	323	327	331	335	338	341	344	347	350	353	356
Resolute	129	130	132	133	134	136	138	140	142	144	146	148	150	152	154	156	158	160	162	164	166	168	170	172	174	176	177	179
Sanikiluaq	410	413	416	420	424	428	432	437	442	447	452	458	464	469	475	481	487	493	499	505	512	519	526	533	540	547	554	561
Female	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
Baffin Region	**8,224**	**8,348**	**8,474**	**8,602**	**8,730**	**8,857**	**8,986**	**9,117**	**9,247**	**9,373**	**9,496**	**9,617**	**9,737**	**9,853**	**9,971**	**10,090**	**10,210**	**10,329**	**10,450**	**10,570**	**10,693**	**10,817**	**10,944**	**11,071**	**11,199**	**11,330**	**11,461**	**11,593**
Arctic Bay	310	316	322	329	336	343	350	357	364	371	378	385	392	398	404	410	416	422	428	434	441	448	455	462	469	476	483	490
Baffin unorganized[3]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape Dorset	678	689	700	711	723	735	747	760	773	786	798	811	824	836	849	861	872	883	895	906	917	928	941	953	965	978	990	1,003
Clyde River	419	427	435	443	451	459	466	473	480	487	494	501	508	515	522	529	537	544	552	559	566	574	582	590	598	606	615	624
Grise Fiord	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	92	92	92	92	92	92	92	92
Hall Beach	336	340	344	348	352	357	363	369	375	382	389	396	403	410	417	424	431	438	445	452	458	465	472	478	484	490	496	502
Igloolik	770	784	798	813	828	842	856	872	888	903	918	933	948	963	979	996	1,014	1,031	1,048	1,065	1,083	1,101	1,120	1,139	1,158	1,177	1,194	1,212
Iqaluit	3,289	3,339	3,388	3,436	3,482	3,526	3,571	3,613	3,655	3,695	3,734	3,769	3,803	3,836	3,868	3,899	3,928	3,959	3,991	4,024	4,058	4,092	4,128	4,164	4,201	4,239	4,278	4,317
Kimmirut	202	204	207	210	213	216	219	222	225	228	231	234	237	240	243	246	249	252	255	257	260	262	264	266	268	271	274	277
Pangnirtung	716	725	734	744	754	764	775	787	798	809	820	831	843	854	866	878	891	904	916	929	942	955	967	980	993	1,006	1,019	1,033
Pond Inlet	669	680	692	704	716	728	740	752	763	774	785	797	808	819	830	842	855	868	880	892	905	918	932	946	960	974	988	1,001
Qikiqtarjuaq	257	259	262	264	267	270	273	276	279	281	283	285	287	289	291	293	295	297	299	301	303	305	306	308	310	312	315	316
Resolute	121	122	123	124	125	126	127	129	131	132	133	134	135	136	137	138	139	139	140	141	142	143	143	144	145	146	147	148
Sanikiluaq	384	389	394	400	406	413	420	427	435	443	450	457	464	471	478	486	494	502	510	518	526	534	542	549	556	563	570	578

Notes: *1) Based on a total fertility rate of 2.9 for the the Baffin Region.*
2) The 2009 population is estimated.
3) Baffin unorganized areas includes outpost camps.

Source: Nunavut Bureau of Statistics
Prepared by: Nunavut Bureau of Statistics, June 24, 2010

Appendix C – Projected Sewage Generated

PROJECTED SEWAGE GENERATED AND CELL CAPACITY CALCULATIONS
HALL BEACH

Planning Year	Year	Population	Water Consumption	335 Day Supply (11 month store, 1 month pump)
	2013	736	105.2	25,560
	2014	747	105.5	25,998
1	2015	759	105.7	26,879
2	2016	771	106.0	27,368
3	2017	784	106.2	27,900
4	2018	798	106.5	28,476
5	2019	812	106.8	29,054
6	2020	827	107.1	29,677
7	2021	843	107.5	30,344
8	2022	859	107.8	31,016
9	2023	875	108.1	31,690
10	2024	890	108.4	32,326
11	2025	905	108.7	32,965
12	2026	920	109.0	33,607
13	2027	934	109.3	34,209
14	2028	949	109.6	34,858
15	2029	962	109.9	35,422
16	2030	976	110.2	36,032
17	2031	990	110.5	36,645
18	2032	1,003	110.8	37,217
19	2033	1,016	111.0	37,791
20	2034	1,029	111.3	38,367
21	2035	1,042	111.6	38,946
22	2036	1,056	111.9	39,571

EXISTING CAPACITY CELL 1:	**15295**
EXISTING CAPACITY CELL 2:	**15462**
TOTAL **EXISTING** CAPACITY BOTH CELLS	**30757**

exp.

Appendix D – Precipitation Normals

PRECIPITATION NORMALS
HALL BEACH

Precipitation:														
Rainfall (mm)	0	0	0	0.2	1.1	13.6	28.1	41.2	17	1	0.1	0	102.3	A
Snowfall (cm)	7.3	4.1	9.8	13.5	15.8	7.1	0.2	3.7	13	22.7	16.5	10.4	124	A
Precipitation (mm)	7	3.9	9.1	12.4	15.4	20.6	28.4	44.6	30.1	20.9	15	9.5	216.7	A
Average Snow Depth (cm)	31	33	37	41	42	20	0	0	1	10	22	28	22	A
Median Snow Depth (cm)	31	32	36	41	42	20	0	0	0	10	22	27	22	A
Snow Depth at Month-end (cm)	32	34	39	43	37	3	0	0	3	17	27	31	22	A
Extreme Daily Rainfall (mm)	0.5	0	0	3.2	16.4	33	35.3	**52.6**	22.2	5.6	0.8	0.2		
Date (yyyy/dd)	1960/ 18	1957/ 01	1957/ 01	1984/ 18	2001/ 22	1976/ 23	1976/ 07	**1980/ 27**	1994/ 11	1998/ 05	1987/ 05	1998/ 05		
Extreme Daily Snowfall (cm)	8	15.5	15.2	16.6	**17.8**	9.8	2.8	14	8.6	15.2	16.8	14.6		
Date (yyyy/dd)	1977/ 19	1964/ 11	1968/ 02	2001/ 30	**1964/ 07**	1993/ 16	1978/ 21	1990/ 21	1960/ 20	1963/ 18	2000/ 12	1977/ 17		
Extreme Daily Precipitation (mm)	8	15.5	10.9	16	17.8	35.1	35.3	**52.6**	22.2	15.2	16.8	10.4		
Date (yyyy/dd)	1977/ 19	1964/ 11	1977/ 07	2001/ 30	1964/ 07	1976/ 23	1976/ 07	**1980/ 27**	1994/ 11	1963/ 18	2000/ 12	1977/ 17		
Extreme Snow Depth (cm)	71	74	81	81	**84**	74	33	5	15	41	60	64		
Date (yyyy/dd)	1962/ 22	1962/ 09	1962/ 12	1968/ 27	**1968/ 12**	1968/ 01	1968/ 01	1993/ 29	1967/ 25	1967/ 18	1988/ 26	1961/ 31		

*Canadian Climate Normals 1971-2000, Canadian Climate Normals Station Data, Retrieved January 6, 2014

Appendix E – ‘Class C’ Cost Estimate

Sewage Treatment Facility
Hall Beach
OTT-00220382-A0

Class "C" Cost Estimate
December 2014

ITEM	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
1	**Mobilization / Demobilization Option 1**	L.S.	1	$750,000.00	$750,000.00
2	Supply, deliver and place granular material to construct new berms	cu.m	13120	$50.00	$656,000.00
3	Excavation of contaminated areas and replace with granular materal	cu.m	5200	$60.00	$312,000.00
4	Remove existing berm and dispose	cu.m	3900	$20.00	$78,000.00
5	Supply, deliver and place granular material to stabilize existing berms	cu.m	590	$70.00	$41,300.00
6	Supply, deliver, and install liner for proposed berm	cu. m	13870	$40.00	$554,800.00
7	Supply, deliver and place granular material to bring existing access road to specified grade matching new berm height	cu. m	5600	$50.00	$280,000.00
8	Supply, deliver and place granular material to construct truck turning pad on existing berm	cu. m	4650	$50.00	$232,500.00
9	Supply deliver and install all piping for outlet structure, inlet structure, and nestable pipe	m	200	$800.00	$160,000.00
10	Supply Deliver and install Truck discharge stations	ea.	4	$65,000.00	$260,000.00
12	Supply deliver and install all requirements for pumping	ea.	1	$90,000.00	$90,000.00
13	New swale	m	250	$50.00	$12,500.00

SUBTOTAL	**$3,427,100.00**
20% CONTINGENCY	**$685,420.00**
TOTAL	**$4,112,520.00**

Appendix F – Operation and Maintenance and Life Cycle Costs

OPERATING AND MAINTENANCE COSTS
HALL BEACH

	OPTION 1
CAPITAL COSTS (WITH 20% CONTINGENCY)	$4,112,520.00
1% OF CAPITAL COSTS	$41,125
DECANTING COSTS	
FUEL (80 liters @ $1.45)	$125
OPERATOR (2 hours/day @ $80/hr)	$160
MISCELLANEOUS	$50
TOTAL	$335
PUMPING 20 DAYS (Total Decanting Costs)	$6,700
TOTAL OPERATING AND MAINTENANCE COST PER YEAR (EST.)	**$47,825**
ONE TIME COST-REPLACEMENT PUMP (**as required**, after 10 years including estimated shipping, not including GST)	$82,054

exp.

Life Cycle Cost of O&M Costs

@ 8% Discount Rate

Year	Year Cost	Present Value
1	$47,825	$44,282
2	$47,825	$41,002
3	$47,825	$37,965
4	$47,825	$35,153
5	$47,825	$32,549
6	$47,825	$30,138
7	$47,825	$27,905
8	$47,825	$25,838
9	$47,825	$23,924
10	$47,825	$22,152
11	$47,825	$20,511
12	$47,825	$18,992
13	$47,825	$17,585
14	$47,825	$16,283
15	$47,825	$15,076
16	$47,825	$13,960
17	$47,825	$12,926
18	$47,825	$11,968
19	$47,825	$11,082
20	$47,825	$10,261
Total		**$469,553**

exp.