Trow

Design Brief
Rehabilitation and Expansion of Existing Sewage Lagoon for the Hamlet of Kimmirut

Prepared for:

Department of Community Government and Services
Government of Nunavut

Trow Associates Inc.

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Telephone: (613) 225-9940
Facsimile: (613) 225-7337
E-mail: ottawa@trow.com
Web Site: www.trow.com

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Executive Summary

Trow Associates Inc. were retained by the Department of Community and Government Services, Government of Nunavut, to review the existing sewage lagoon and wetlands in the Hamlet of Kimmirut, Nunavut. The assessment of the lagoon and wetlands was to determine if the facility could met the needs of the Hamlet and Regulatory Agencies, and if not recommend upgrades to the facilities.

The Hamlet of Kimmirut currently discharges its untreated wastewater directly into the sea adjacent to the existing solid waste disposal site, approximately 750 m south of the community. In 2001 a new sewage lagoon was constructed approximately 1.5 km to the west of the community but has never been operated and is not currently licensed through the Hamlet's water licence issued by the Nunavut Water Board. Details regarding the construction of the new sewage lagoon are not available, however, it is believed that the facility was constructed based in principle on the report prepared by Dillon Consulting Limited, entitled Sewage and Solid Waste Site Selection Kimmirut, NT – Final Report, dated February 11, 1999.

The assessment of the existing facility determined that the existing lagoon did not have sufficient capacity to meet the over winter storage requirements of the Hamlet. Thus much of the over winter sewage would accumulate in the form of an ice pack in the gulch downstream of the sewage lagoon. The sewage in the ice pack would be released uncontrolled and without treatment during the spring melt.

The assessment of the wetlands potential for treatment determined the large wetlands, which the sewage would ultimately drain into below the sewage lagoon and gulch, provided potential for meeting the treatment requirements of the Hamlet.

The geotechnical investigation of the existing lagoon recommended that the existing earth berm which forms the lagoon be upgraded to provide slope stability and to prevent overtopping and erosion.

To meet the requirements of the wetlands assessment that the sewage not be released to the wetlands until approximately mid June, at which time the wetlands would be active, it is proposed that a second lagoon at the bottom of the gulch be constructed to capture and retain the runoff from the ice pack. The two lagoons will work in series with each other to provide a pre-treatment prior to the sewage being released to the wetlands. The wetlands assessment determined that given the sewage is released at a time when the wetlands are capable of providing treatment and that there is a level of pre-treatment as projected from the sewage lagoons, the wetlands will provide sufficient treatment to meet and exceed the requirements of the water licence.

The estimated capital cost to construct the new sewage lagoon and upgrade the existing lagoon is $1,133,000.00. The annual operating cost for the facility, including general operation and maintenance costs including sampling and testing, as well as the operation of the decanting process is estimated to be $22,000.00 annually.

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1.0 Introduction

Trow Associates Inc. (Trow) were retained by the Department of Community & Government Services (CG&S), Government of Nunavut (GN) to review the existing sewage lagoon and wetlands and recommend upgrades as required for the Hamlet of Kimmirut (Hamlet), Nunavut.

The Hamlet is currently discharging untreated wastewater directly into the sea adjacent to the existing solid waste disposal site located next to the PPD station located approximately 750 m south of the community. In 2000-2001, a new sewage lagoon was constructed approximately 1.5 km to the west of the end of the airport runway. The location of the existing site and the proposed site relative to the community is shown in Figure 1. This facility has never been used and is not currently licensed through the Nunavut Water Board (NWB). Details regarding the construction of the new lagoon are unavailable, however, it is believed the facility was constructed based in principle on a report prepared by Dillon Consulting Ltd. entitled *Sewage & Solid Waste Site Selection Kimmirut, NT – Final Report*: Dated February 11, 1999.

The intent of this project is to assess the existing facility and determine its suitability for use as a sewage lagoon system for the Hamlet and, if required, recommend necessary upgrades to ensure the facility would meet the long term requirements of the Hamlet and the requirements of the regulatory agencies, through the water licensing process as administered by the Nunavut Water Board (NWB).

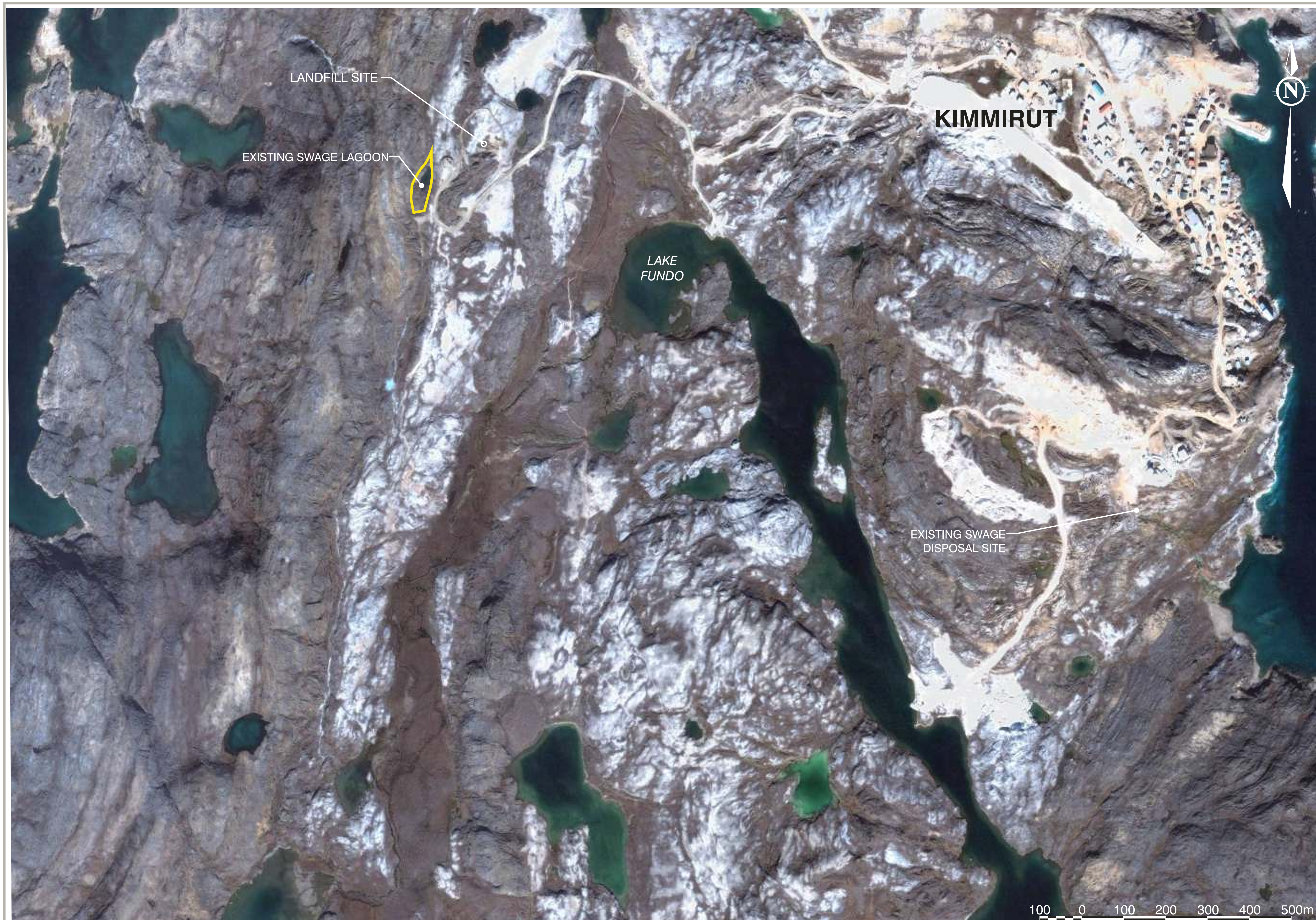
1.1. Background Reports

The reference documentation provided by the GN for this project included three reports. The findings, recommendation and conclusions of the reports are as follows:

1.1.1. Sewage & Solid Waste Site Selection Kimmirut, NT – Final Report

The "Sewage & Solid Waste Site Selection Kimmirut, NT – Final Report", prepared by Dillon Consulting Limited and dated February 11, 1999 was provided as background information. The report was the completion of the third phase of the sanitary site planning study for the community of Kimmirut. The process began in 1994 when Dillon was retained by the Department of Municipal and Community Affairs (MACA) of the Government of the Northwest Territories (GNWT) to complete the sanitary site planning study for the community of Kimmirut, then called Lake Harbour. This study was later designated Phase 1. At the time the requirement for a new sanitary site was due to pressures for new residential housing areas, with the community plan dated 1994 showing the expansion of the community around the existing sanitation site.

The original study looked at four sites and three treatment options generating six different alternatives for consideration. The report concluded *"the best balanced choice would negate the*



Trow Associates Inc.
154 Colonnade Road South, Ottawa, Ontario K2E 7J5
Tel: (613) 225-9940
Fax: (613) 225-7337

GOVERNMENT OF NUNAVUT

LOCATION PLAN - KIMMIRUT WASTE FACILITIES

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FIG 1

community's planned housing subdivision expansion". The draft report was used to stimulate discussions within the community and was never finalized.

In July 1995, MACA again retained Dillon to completed Phase 2 of the sanitary site planning study with the purpose of the work defined as the examination of sites and options that did not impact on the community plan. Two additional sites to those developed in phase 1 were identified and included in the study. These provided five more options when combined with the three technologies, resulting in a total of eleven options.

In 1998, Public Works and Services (PWS), GNWT, again retained Dillon to investigate an additional two sites for the community for solid waste and sewage treatment disposal. The additional two sites, and an access road alignment were provided by PWS. This work was referred to as phase 3 and resulted in the 1999 report.

Overall, a total of eight sites and ten options were evaluated as part of the third phase of the sanitary site planning study. The report concluded that development of Site 3 as a wetlands sewage disposal facility was the recommended choice. The report recognized that the use of Site 3 as a sanitary disposal site would impact the then current community plan and put forth Site 8 as an alternate site which will allow the community more flexibility in growth and development.

Site 8 is the location of the new sewage lagoon cell to be investigated as part of this project.

1.1.2. Kimmirut Sewage Treatment Site Assessment

The "Kimmirut Sewage Treatment Site Assessment" prepared by Dillon Consulting Limited and dated October 22, 2001, was provided as background information. As noted in the cover letter of the report:

"*the purpose of the following report is to provide the reader with background project information, summarize previous government assessments of the proposed construction activities and to report on the site assessment that was carried out by Dillon.*

In summary, our habitat assessment concluded that construction and operation of the proposed sewage treatment lagoon in Kimmirut, NT will not have adverse effects on local fish or fish habitat. Furthermore, the proposed project will likely improve on current environmental conditions that exist in Kimmirut with respect to the existing sewage treatment operations". The report again discussed site eight as per the 1999 report and identified the treatment alternative to be wetlands treatment requiring the construction of two berms, one near the existing pond at the upper end of the valley and a second berm at the bottom of the valley, the purpose being to promote water pooling, decreased drainage velocities and minimize transport of materials downstream."

The report also stated that construction of the berms was scheduled to be completed during the low flow period of 2002.

1.1.3. Sewage and Solid Waste Sites Assessment. Water Licence Application – Kimmirut NU

A draft copy of the "Sewage and Solid Waste Sites Assessment. Water Licence Application – Kimmirut NU" prepared by Dillon Consulting Limited and dated December 14, 2006 was provided as background information by the GN.

The scope of work as detailed in the report includes:

1. Review of relevant documentation available at the GN office, Dillon and other data sources.

2. Twenty-year population projections on sewage and solid waste projections.

3. Assess existing facilities for compliance to the current NWB guidelines for sewage and solid waste.

4. The report required upgrades to address deficiencies as identified.

1.2. Scope of Services

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

1. A community visit and site investigation.
2. Completion of a topographic survey.
3. Completion of a geotechnical investigation and report.
4. Complete an assessment of wetlands system.
5. Develop a plan and design for the rehabilitation of the existing sewage lagoon.
6. Develop a plan and design for expansion of the existing system if required to meet the long term requirements of the Hamlet.

2.0 System Requirements

2.1. General

The requirements for the proposed sewage treatment facility for the Hamlet must meet the long term needs of the Hamlet, as well as the regulatory requirements of the Hamlet's water licence. The Water and Sewage's Facility Capital Program Standards and Criteria as provided by the CG&S indicate the design horizon for sewage lagoons is to be between 15 - 20. As per the direction of the CG&S, the design horizon for this project shall be 20 years, to the year 2028.

2.2. Population Projections

The Nunavut Bureau of Statistics population projections provide projected populations of the Nunavut communities to the year 2020. As a planning horizon for this project is past the current population projections available form the Nunavut Bureau of Statistics, the population projection from 2020 to 2028 was estimated using the average growth rate for the Hamlet between the year 2000 and 2020 of 2.28%. The table below summarizes the population projections over the life of the proposed facility.

Table 2.1 - Population Projections

Planning Year	Year	Population	Planning Year	Year	Population
	2000	450	7	2015	636
	2001	461	8	2016	649
	2002	474	9	2017	662
	2003	485	10	2018	675
	2004	496	11	2019	688
	2005	506	12	2020	706
	2006	519	13	2021	722
	2007	530	14	2022	739
0	2008	546	15	2023	755
1	2009	560	16	2024	773
2	2010	573	17	2025	790
3	2011	589	18	2026	808
4	2012	601	19	2027	827
5	2013	612	20	2028	846
6	2014	624			

The design population for the end of the design horizon, 2028, is projected to be 846 persons.

2.3. Sewage Generation

To determine the volume of sewage the facility must treat, the sewage generation rate for the community must be determined. Sewage generation rates are generally assumed to be equal to the water consumption rates for a community, with the water consumption rate being the total of the residential and non-residential water consumption. The Water and Sewage Facility Capital Program Standards and Criteria provide the following design values and formulae for estimating the water consumption and therefore the sewage generation rates for communities.

The residential water usage (RWU) for a community is based on the method of water delivery and sewage collection in the community. The per capita water usage rates for the different methods of water delivery and sewage collection are summarized in the Table 2.2.

Table 2.2 - 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

The Hamlet of Kimmirut has a trucked water and sewage system, therefore the RWU for the community from table 2.2 is equal to 90 lpcd.

Non-residential water usage by a community tends to increase with increases in the population. To determine the Total Community Water Usage (TCWU, the Residential Water Usage is adjusted based on population to provide a Total Water Usage Per Capital. The daily water consumption by the community is equal to the population multiplied by the 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 2.3 – Total Community Water Usage.

For a population of 846, from equation in Table 2.3, the total sewage generated per capita is 107.5 lpcd. For the design population of 846 and a sewage generation rate of 107.5 lpcd, the daily sewage generation is equal to 90,945 lpd and a yearly sewage generation rate for the year 2028 is 33,195 m^3.

Table 2.3 - 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

2.4. Regulatory Requirements

The proposed sewage treatment facility will be required to meet the effluent quality standards as set out in the Hamlet's water licence. The Hamlet is operating under a valid water license, licence #NWB3KIM0207 issued on September 1, 2002 by the Nunavut Water Board, as required under the Nunavut Lands Claim Agreement and the Nunavut Waters Act. The effluent quality standards set out in the water licence are summarized in the Table 2.4 - Effluent Quality Standards.

Table 2.4 – 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/dl
Oil and grease	No visible sheen
pH	6 and 9

3.0 Site Investigation

In July 2007 a site investigation was undertaken, including the following:

1. Site inspection
2. Topographic survey
3. Geotechnical investigation
4. Wetlands assessment

3.1. Site Inspection

As part of the site investigation, a site inspection of the existing facility was undertaken. This inspection noted the following:

1. The existing lagoon was created through the construction of an earth berm at the southern end of a small valley.
2. The truck discharge for the sewage lagoon is a metal chute located towards the southern end of the lagoon close to the earth berm.
3. Downstream of the existing lagoon there is a 400 m long gulch with limited vegetation and a slope of approximately 7% (as determined from the topographic survey).
4. The outlet of the truck discharge chute should have erosion protection due to the drop from the end of the chute to the existing ground.
5. The gulch opens into a flat area of approximately 5½ ha which includes a small, shallow pond.
6. The flat area drains over a relatively steep slope of approximately 25% and drains to a flat valley floor below.
7. A small diversionary berm has been built near the top of the drop-off in an attempt to change the direction of flow from an easterly to south easterly direction.
8. The floor of the valley is a wetlands area with a meandering (braided channel) and comprises an area in excess of 20 ha.
9. The wetlands area discharges to a series of small lakes to the south and ultimately drains into Tulsit Lake.
10. The wetland is also an overflow or outlet for the Hamlet's water supply. The Hamlet's water supply, Lake Fundo, is hydraulically uphill of the wetlands area. The elevation of Lake Fundo is 33m and the elevation of the wetlands where the sewage would enter is 22m. Therefore, this is no potential of contamination of the Hamlet's water supply from use of this area for sewage treatment.

3.2. Topographic Survey

The topographic survey of the sewage treatment facility included the existing lagoon, the gulch at the outlet of the lagoon, the flat area at the outlet of the gulch and the diversionary berm as shown in Figure 2. From the topographic survey it was determined that the existing sewage lagoon has a total capacity of approximately 7,300 m^3, with no allowance for freeboard. The existing earth berm has a crest width of 2 m to 2.5 m with upstream (inside) and downstream (outside) slopes of 3H:1V and 2.5H:1V respectively . Downstream of the lagoon, sewage would flow through a gulch with a 7% slope for approximately 400 m to a small relatively flat area of approximately 5 ½ ha, prior to discharging over a steep slope of approximately 25 % over 200 m to a flat valley floor which includes a wetlands area with meandering (braided) channels.

3.3. Geotechnical Investigation

The purpose of the geotechnical investigation was to assess the stability of the existing lagoon berm slopes and develop an appreciation of the geotechnical conditions present in the lagoon, and at the location of the diversion berm. The investigation consisted of drilling eleven boreholes at the sewage lagoon site and two boreholes on the diversion berm. The Geotechnical Report generated from the investigation has been issued under a separate cover.

The investigation revealed that the sewage lagoon berm consists of sand and gravel fill which extends to 2.2 m to 2.8 m depth. The predominant natural soil at the site is silty sand and gravel with some cobbles and it extends to a depth of 0.3 m to 2.7 m. The silty sand and gravel in the lagoon area is underlain by highly fractured gneiss bedrock.

The overburden in the bottom of the lagoon also comprises of silty sand and gravel and extends to 1.6 m to 2.7 m depth. It is underlain by a layer of topsoil or clayey silty sand to 1.85 m to 2.9 m depth beneath which fractured gneiss bedrock was encountered.

The two boreholes drilled at the diversion berm revealed that the overburden comprises of 1.1 m to 1.2 m of sand and gravel fill. It is underlain by micaceous marble bedrock.

The stability of the lagoon berm was investigated. The berm has a crest width of 2 m to 2.5 m approximately and upstream (inside) and downstream (outside) slopes of 3H:1V and 2.5:1V approximately. The stability of slope analysis revealed that the upstream slope has an acceptable factor of safety under completely submerged conditions under static as well as seismic loading. The slope is expected to be stable provided that the berm is not over topped and it is not subjected to a rapid drawdown condition. The downstream slope with its present inclination of 2.5H:1V does not have adequate factor of safety against potential slope failure. It is therefore recommended that this slope should also be flattened to an inclination of 3H:1V.

It is noted that potential for extensive erosion and/or failure of the berm exists if subjected to rapid drawdown condition or allowed to over top. It is recommended that a spillway should be incorporated in the berm to prevent its over topping.

Trow Associates Inc.
154 COLONNADE ROAD SOUTH PHONE (613) 225-9940
OTTAWA, ONTARIO K2E 7J5 FAX (613) 225-7337

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drawn by MEB	TITLE: TOPOGRAPHIC SURVEY	FIGURE 2

3.4. Wetlands Assessment

An assessment of the potential for wetlands treatment was carried out, as part of the site investigation, by Dr. Robert Kadlek for Earth Tech Canada. The assessment of the sites potential from the site investigation included the following comments and conclusions.

The existing lagoon is located near the upper end of a small valley. Downstream of the existing sewage lagoon sewage would flow through the 400 m gulch which has limited vegetation. The slope (7%) and rocky surface of the gulch would provide some cascade oxygenation. The gulch opens into a small flat area which could provide limited wetlands treatment. Its relatively small size (½ ha) limits the amount of treatment possible from this area.

From this area, the sewage would flow down a relatively steep slope 25% which would provide an excellent source of cascade oxygenation. At the bottom of the steep slope, sewage would enter into a flat valley floor with a wetlands area of approximately 20 hectares. The wetlands are braided and therefore only a portion of the entire wetlands would contribute to the treatment. It was concluded that the wetlands would provide an excellent opportunity to treat the sewage.

It was noted that the current arrangement would allow sewage to be released to the wetlands during the spring melt when the wetlands are potentially still dormant. To best utilize the potential of the wetlands, the sewage should be retained and only released to the wetlands over the optimal period for treatment, mid June to late September. The areas of potential wetlands treatment are shown in Figure 3 – Potential Wetlands

3.5. Assessment of Sewage Treatment Facility

The existing sewage lagoon's capacity of 7,300 m^3 is not sufficient not meet over winter storage requirements of the Hamlet. Therefore operating the existing lagoon would result in the lagoon overflowing and formation of an ice pack in the gulch below the lagoon during the winter months. During spring melt, the sewage from the ice pack would be release to the wetlands without any pre-treatment and at a time when the wetlands would not be capable of providing sufficient treatment. Therefore some of the sewage released during the spring melt would receive negligible or limited treatment and therefore would not meet the requirements of the regulatory agencies.

To ensure the sewage receives treatment from the wetlands, the sewage must be retained as recommended by the wetlands assessment until the optimal time for treatment by the wetlands, i.e. mid June. The areas of potential wetlands treatment are shown in Figure 3 – Potential Wetlands.

Trow Associates Inc.
154 Colonnade Road South, Ottawa, Ontario K2E 7J5
Tel: (613) 225-9940
Fax: (613) 225-7337

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4.0 Detailed Design

4.1. Design Philosophy

The current sewage treatment arrangement would allow for the release of sewage during spring runoff. The wetlands assessment recommended that if the wetlands were to be used as a treatment process, the sewage should be retained until mid May, when the wetlands were no longer dormant. Alternative arrangements were reviewed, including the creation of a storage lagoon with 365 days storage, expanding the existing lagoon to provide over winter storage and methods to retain the runoff.

A review of the existing site and surrounding topography reveal that the site is not suitable for the construction of a storage lagoon with 365 days storage (33,195 m^3) as a main treatment method. In addition, the topography around the existing lagoon did not lend itself to expanding the lagoon from its current capacity to 20,750 m^3 to provide over the winter storage (sewage generated over 7 ½ months). Therefore, a system to retain the early spring runoff is required.

To provide a system to retain the spring melt until the wetlands are more capable to provide treatment, it is proposed that second lagoon be created in the flat area at the bottom of the gulch through the construction of an earth. The lagoon (Lower Lagoon) would provide containment during spring runoff to ensure the sewage is released to the wetlands at optimal time. Operation of the two retention cells will require more operator involvement than a traditional annual detention cell system. The operation of the proposed system is described in the Proposed Operations Plan.

As the two lagoons are constructed in a natural valley, design of the lagoons will have to consider runoff from the drainage areas which drain into the lagoons.

4.2. Operational Plan

The proposed sewage treatment facility includes, the existing sewage lagoon (referred to as the Upper Lagoon), a second lagoon (referred to as the Lower Lagoon) created at the bottom of the gulch and the wetlands.

The following details the proposed operations of the sewage treatment system for Kimmirut.

October 1– May 15 – Over Winter Storage

Sewage trucks discharge to the Gulch where the sewage begins to freeze and form the ice pack. The Upper Lagoon and Lower Lagoon are empty.

The daily average temperature for October, as published in the Canadian Climate Normals 1971-2000 by Environment Canada (a copy is included in Appendix A) for Iqaluit is -4.9 °C. It is reported that the number of days with a minimum temperature of greater than 0 °C is one, and the number of days with a maximum temperature of less than 0°C is twenty. It therefore is concluded that freeze up has started by October 1st, and sewage discharged to the gulch will freeze and form the ice pack.

May 16 – June 15 - Spring Melt Begins

The truck discharge point is changed from the gulch to the Upper Lagoon. The Upper Lagoon has 5,914m^3 capacity, the equivalent of approximately 65 days of the sewage not considering precipitation and runoff.

The daily average temperature for May as published in the Canadian Climate Normals 1971-2000 by Environment Canada for Iqaluit is -4.4 °C. The report states that the number of days with a minimum temperature of greater than 0 °C is one and a half, and the number of days with a maximum temperature of greater than 0 °C is fourteen. The daily average temperature for June, as published in the Canadian Climate Normals 1971-2000 for Iqaluit is 3.6 °C. The report states that the number of days with a minimum temperature of greater than 0 °C is 17, and the number of days with a maximum temperature of greater than 0 °C is twenty nine. It is therefore concluded that spring melt will begin in mid to late May.

The ice pack and accumulated snow begins to melt and drain towards the Lower Lagoon, where it is retained. Based on a 2 month spring runoff, mid May until mid July, the Lower Lagoon should have capacity to retain half of the estimated flow from the ice pack and spring runoff. It is estimated that it will take approximately 1 month to fill the Lower Lagoon.

There is no discharge to the wetlands.

June 16 – July 15 – Earlier Summer Operations - Discharge Begins

The sewage trucks continue to discharge to the Upper Lagoon which has filled and begins to operate as a detention lagoon with continuous release of sewage over the spillway.

The Lower Lagoon has filled and begins to operate as a detention lagoon with a continuous release of sewage over the spillway. Effluent from the Lower Lagoon is released to the wetlands for further treatment.

The ice pack and snow accumulation finishes melting.

July 15 – August 31 – Summer Operations

The sewage trucks continue to discharge to the Upper Lagoon which operates as a long detention lagoon with a continuous release rate equal to the inflow.

The Lower Lagoon is drained during this period to provide a continuous release of effluent to the wetlands over the optimal period for treatment. The release rate would be controlled by pumping.

September 1 – September 30 – Fall Operations

The sewage trucks continue to discharge to the Upper Lagoon. The operating level of the Upper Lagoon is lowered by pumping to a level equivalent to 15 days storage which allows for storage of the sewage generated in last 2 weeks of September until the subsequent year.

The Lower Lagoon is emptied.

4.3. Lagoon Sizing

The lagoons must be sized to meet the operational requirements set out in the operational plan. Sufficient storage must be available for the sewage generated as well as runoff from the drainage areas draining into both lagoons. The drainage areas of the two lagoons are as shown on Figure 4 and summarized in Table 4.1 – Drainage Areas:

Table 4.1 – Drainage Areas

Lagoon	Drainage Area
Upper Lagoon	2.16 ha
Lower Lagoon	9.51 ha

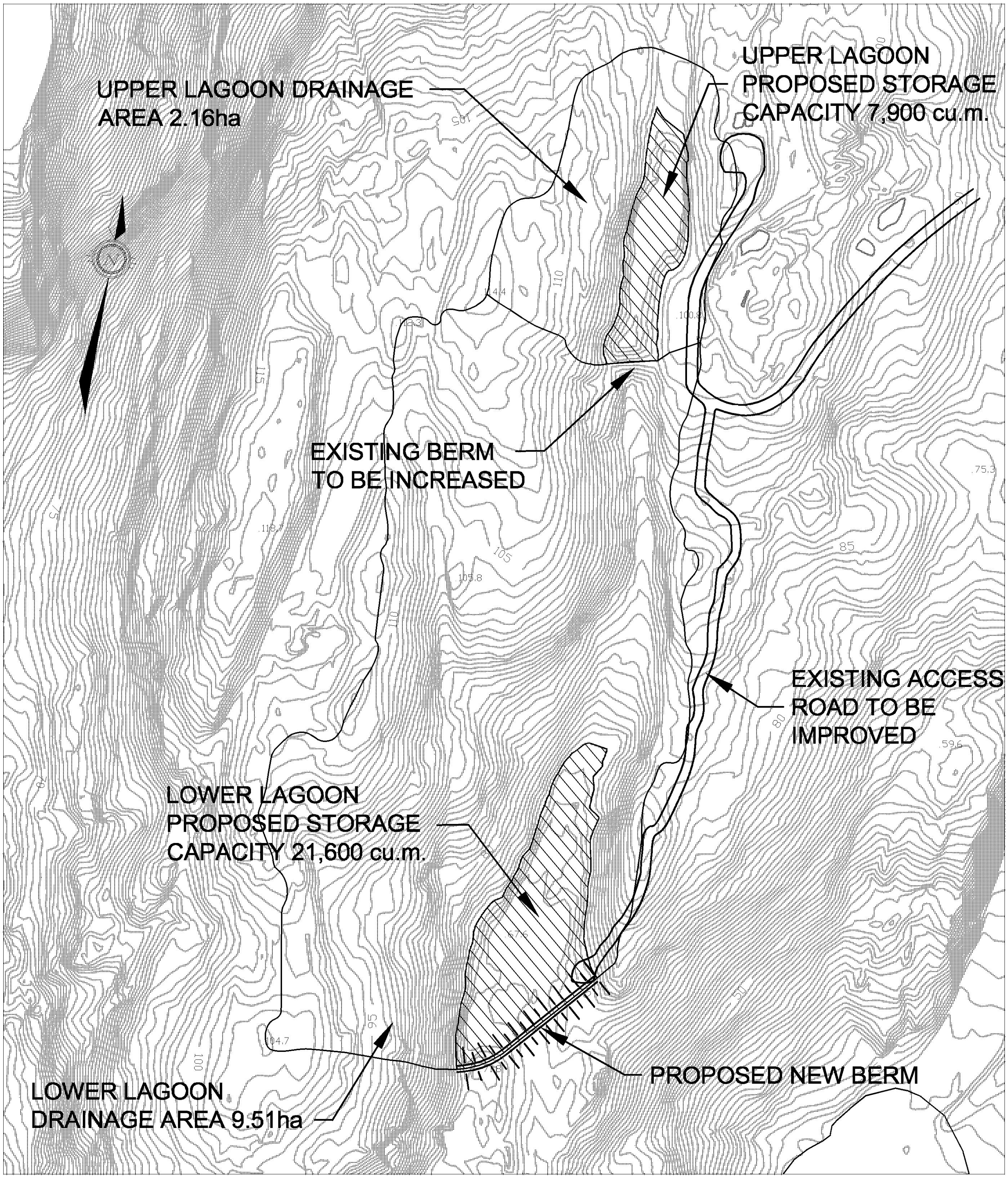
Based on the drainage areas and the precipitation rates from the Canadian Normals 1971-2000 published for Iqaluit the monthly precipitation for the two drainage areas are as shown in Table 4.2 – Monthly Precipitation. As described in Section 4.2 – Operation Plan, the over winter storage based on the published average temperatures for Iqaluit (Canadian Normals 1971-2000), is assumed to be from October 1 to May 15. For the sizing of the lagoons, it is also assumed that the snow melt will occur between May 15 and July 15.

4.3.1. Upper Lagoon

The Upper Lagoon must be sized to meet the operating requirements set out in Section 4.2 – Operational Plan. The Lagoon must be able to store, not only the sewage generated, but also the runoff form precipitation. The following describes the operation and storage requires of the Upper Lagoon.

From October 1 to May 15, the over winter phase of the operational plan, there is no sewage being discharged to the lagoon, and all the precipitation is as snow, therefore there is no runoff to be stored. The lagoon had been drained in September and only the equivalent of the last 2 weeks of sewage (1,959m^3) remains in the lagoon.

From May 16 to June 15 sewage is discharged to the lagoon. In addition, the precipitation from the period and an assumed 50% of the snow within the drainage area melts and drains to the lagoon. As no sewage is being release, this flow has to be stored.



Trow Associates Inc.

154 COLONNADE ROAD SOUTH PHONE (613) 225-9940
OTTAWA, ONTARIO K2E 7J5 FAX (613) 225-7337

scale: NTS	CLIENT: GOVERNMENT OF NUNAVUT	project no.: 18881A
date: 14/01/2008		
drawn by: MEB	TITLE: DRAINAGE AREAS	FIGURE 4

Table 4.2 – Monthly Precipitation

Month	Precipitation Rate	Volume of Precipitation on Upper Lagoon Drainage Area	Volume of Precipitation on Lower Lagoon Drainage Area
January	21 mm	456 m^3	2,007 m^3
February	15 mm	324 m^3	1,427 m^3
March	22 mm	471 m^3	2,074 m^3
April	28 mm	610 m^3	2,683 m^3
May	27 mm	581 m^3	2,559 m^3
June	35 mm	757 m^3	3,329 m^3
July	59 mm	1,284 m^3	5,650 m^3
August	66 mm	1,420 m^3	6,250 m^3
September	55 mm	1,189 m^3	5,232 m^3
October	37 mm	793 m^3	3,491 m^3
November	29 mm	629 m^3	2,768 m^3
December	18 mm	393 m^3	1,731 m^3

From June 16 to July 15 the sewage lagoon acts as a retention lagoon, with the release rate being equal to the inflow. Sewage continues being discharged to the lagoon, and runoff includes the precipitation from the period as well as the remainder of the runoff from snow melt.

From July 16 to August 31 the lagoon continues to operate as a retention lagoon with the release rate being equal to the inflow rate. Inflow to the lagoon includes sewage discharged to the lagoon and precipitation.

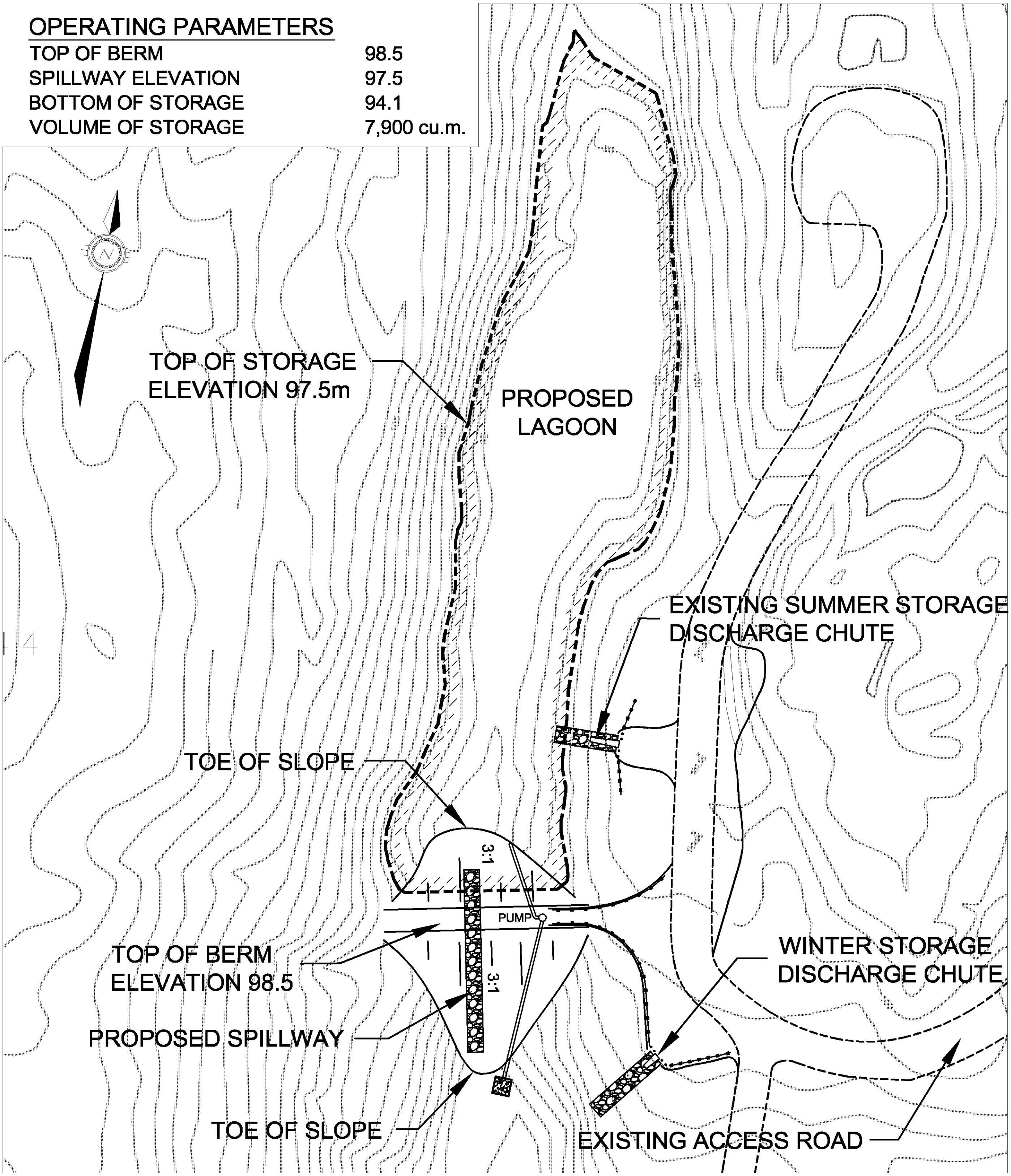
From September 1 to September 30 the lagoon is drained to a level equivalent to half the monthly accumulation of sewage and precipitation.

Table 4.3 – Upper Lagoon Storage Requirements summarize the storage requirements, as set out above, of the lagoon during the year.

The required storage for the Upper Lagoon is 7,431 m3 as shown in Table 4.3 – Upper Lagoon Storage Requirements. The proposed Upper Lagoon is shown in Figure 5 – Upper Lagoon.

OPERATING PARAMETERS

TOP OF BERM	98.5
SPILLWAY ELEVATION	97.5
BOTTOM OF STORAGE	94.1
VOLUME OF STORAGE	7,900 cu.m.



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OTTAWA, ONTARIO K2E 7J5 FAX (613) 225-7337

scale NTS	CLIENT: GOVERNMENT OF NUNAVUT	project no. 18881A
date 14/01/2008	TITLE: UPPER LAGOON	FIGURE 5
drawn by MEB		

Table 4.3 – Upper Lagoon Storage Requirements

From	To	Precipitation on the Watershed (m^3)	Runoff entering the Lagoon (m^3)	Sewage Discharged to the Lagoon (m^3)	Sewage Released (m^3)	Sewage Stored (m^3)
Oct 1	May 15	3,967	-	-	-	1,959
May 16	Jun 15	669	2,653	2,819	-	7,431
Jun 16	Jul 15	1,020	3,003	2,728	5,731	7,431
Jul 16	Aug 31	2,062	2,062	4,274	6,336	7,431
Sep 1	Sep 30	1,189	1,189	2,728	9,389	1,959

4.3.2. Lower Lagoon

The Lower Lagoon must be sized to meet the operating requirements set out in Section 4.2 – Operational Plan. The lagoon must be able to store not only the sewage generated but also the runoff from precipitation. The following describes the operation and storage requires of the Lower Lagoon.

From October 1 to May 15, the over winter phase of the operational plan, there is no sewage being discharged to the lagoon, and all the precipitation is snow therefore there is no runoff to be stored. The lagoon had been emptied in September.

From May 16 to June 15 sewage is discharged to the Upper Lagoon where it is stored and therefore there is no flow to the Lower Lagoon from the trucks discharging. The ice pack formed in the gulch over the winter begins to melt and the runoff must be stored in the Lower Lagoon. In addition, the precipitation from the period and runoff from snow melt within the drainage area drains to the lagoon. It is assumed 50% of the ice pack and 50% of the snow accumulation melts and drains to the lagoon during this period. As no sewage is to be released during this period, all of this flow must be stored. This volume of sewage to be stored sets the storage requirements for the lagoon.

From June 16 to July 15 the remainder of the ice pack and snow melts and drains to the lagoon. In addition, the Upper lagoon has filled and is operating as a retention lagoon and is releasing sewage to the gulch which drains to the Lower Lagoon. The Lower Lagoon operates as a retention lagoon, with the release rate being equal to the inflow.

From July 16 to August 31 the Lower Lagoon is emptied during this period. Inflow to the lagoon includes the effluent released from the Upper Lagoon and precipitation.

From September 1 to September 30 the lagoon is emptied of flow from the Upper Lagoon.

Table 4.4 – Lower Lagoon Storage Requirements summarize the storage requirements as set out above of the lagoon during the year.

Table 4.4 – Lower Lagoon Storage Requirements

From	To	Precipitation on the Watershed (m^3)	Runoff entering the Lagoon (m^3)	Effluent stored in the Ice Pack (m^3)	Effluent released form the Ice Pack (m^3)	Effluent released from the Upper Lagoon (m^3)	Effluent Released (m^3)	Sewage Stored (m^3)
Oct 1	May 15	17,460	-	20,644	-	-	-	-
May 16	Jun 15	2,944	11,674	-	10,322	-	-	21,996
Jun 16	Jul 15	4,490	13,220	-	10,322	5,731	29,273	21,996
Jul 16	Aug 31	9,075	9,075	-	-	6,336	37,407	-
Sep 1	Sep 30	5,232	5,232	-	-	9,389	14,621	-

The required storage for the Lower Lagoon is 21,996 m^3 as shown in Table 4.4 – Lower Lagoon Storage Requirements. The proposed Lower Lagoon is shown in Figure 6 – Lower Lagoon.

4.4. Decanting Methods

One of the significant challenges in the operation of a sewage lagoon in a northern location is the process of decanting or emptying the lagoon. The three methods that are commonly used are:

1. Seepage cell lagoon design

2. Provision of a discharge pipe through the berm

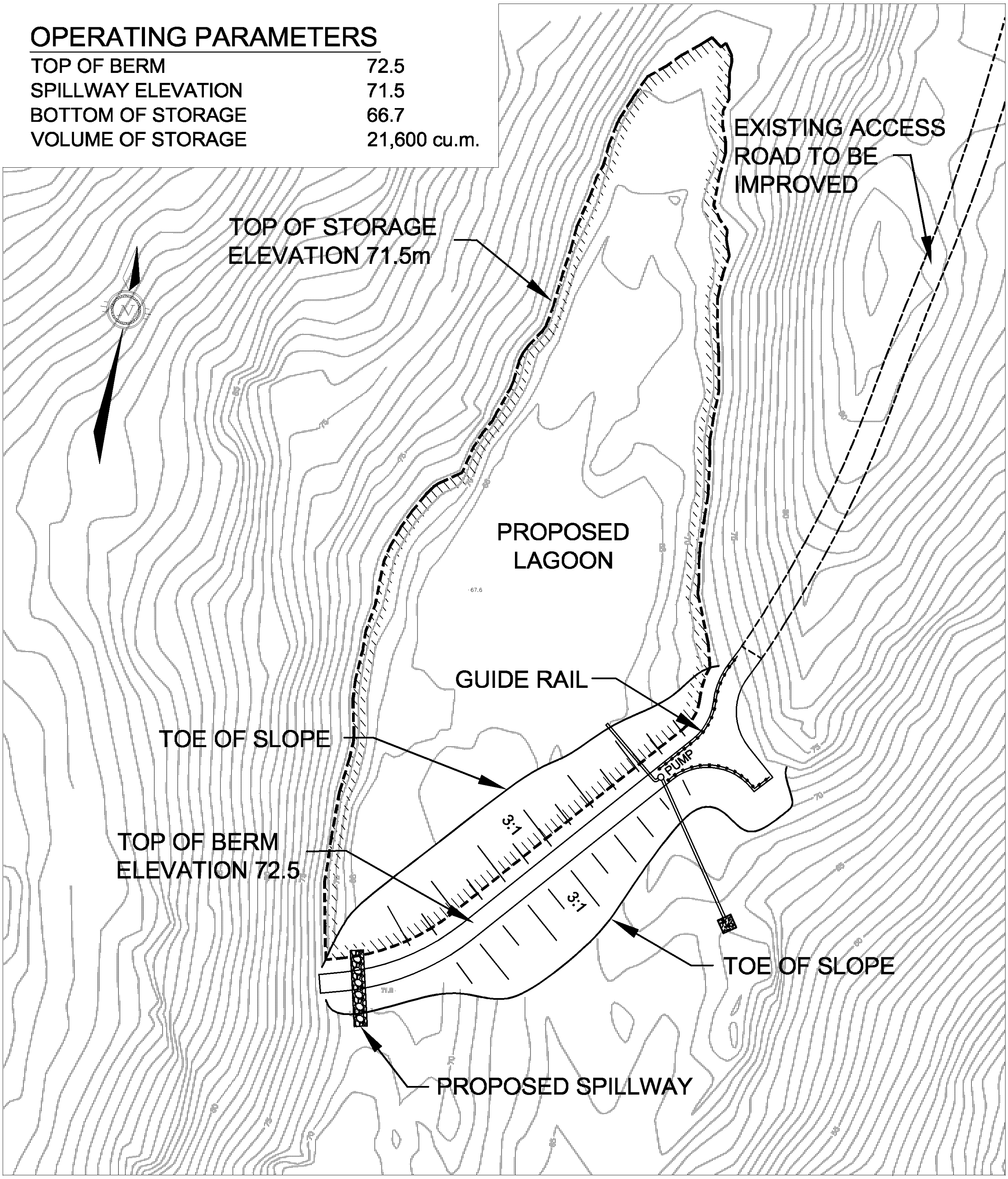
3. Pumping over the berm

4.4.1. Discharge Pipe

For lagoons that are designed to be impermeable a decanting method must be installed. The installation of a discharge pipe and valve through the berm is common in southern locations with

OPERATING PARAMETERS

TOP OF BERM	72.5
SPILLWAY ELEVATION	71.5
BOTTOM OF STORAGE	66.7
VOLUME OF STORAGE	21,600 cu.m.



Trow Associates Inc.

154 COLONNADE ROAD SOUTH PHONE (613) 225-9940
OTTAWA, ONTARIO K2E 7J5 FAX (613) 225-7337

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date 14/01/2008		
drawn by MEB	TITLE: LOWER LAGOON	FIGURE 6

continuous discharge. In storage lagoons in northern locations, the discharge pipe is only used seasonally, and pipe and valve arrangement are installed through a frozen berm. This tends to require the pipe and valve have to be thawed prior to their use. This has caused operational concerns, and in some instances has proven impossible.

4.4.2. Pumping

Pumping the effluent from the lagoon is the most operator demanding alternative, however are also the must dependable. They require the pumps to be installed and removed each year, and during operation must be checked on a regular basis. They also have the added operational cost for fuel. The operation of a pump is a relatively dependable operation, and in the case of failure, a relatively easy system to replace. They also provide a very good method for controlling the time and rate of discharge which is important for lagoons which use a wetlands as a secondary or additional treatment.

4.4.3. Recommended Decanting Method

It is recommended that the pumping be the method used for the decanting of the Kimmirut Lagoons. The Kimmirut system is a wetlands treatment system with the lagoons providing retention and primary treatment. As such its performance is dependent on the time and rate of discharge. Seepage cell construction does not allow for sufficient control over the time and rate of discharge, and therefore are not suitable for this application as the wetlands may not operate as efficiently as required. The installation of piped discharges poses operational challenges, primarily thawing of the pipe at the time of discharge. They are also more prone to freeze and may not be recoverable which would result in a costly repair or abandonment of the system. Although pumping is the most operator dependent, it provides the best control over the release time and release rate, and is the easy to repair or replace as the system is accessible.

4.5. Lease Rates

4.5.1. Upper Lagoon

The Upper Lagoon acts as a storage cell from May 16 until June 15 and therefore there is no effluent released from the lagoon. From June 16 until August 31, the lagoon acts as a detention cell and sewage is released over the spillway at the rates shown in Table 4.5 – Upper Lagoon Release Rates. From September 1 to September 30, the level of the lagoon is reduced through pumping at the daily rate shown in Table 4.5 – Upper Lagoon Release Rates.

4.5.2. Lower Lagoon

The Lower Lagoon acts as a storage cell from May 16 until June 15 and therefore there is no effluent released from the lagoon. From June 16 until August 31, the lagoon acts as a detention cell and sewage is released over the spillway. From September 1 to September 30, the level of the lagoon is reduced through pumping. The daily release rates from the Lower Lagoon are shown in Table 4.6 – Lower Lagoon Release Rates.

Table 4.5 – Upper Lagoon Release Rates

From	To	# of Days	Sewage Released	Release Rate
May 16	Jun 15	31	-	-
Jun 16	Jul 15	30	5,731 m^3	191 m^3/day
Jul 16	Aug 31	47	6,336 m^3	135 m^3/day
Sep 1	Sep 30	30	9,389 m^3	313 m^3/day

Table 4.6 – Lower Lagoon Release Rates

From	To	# of Days	Sewage Released	Release Rate
May 16	Jun 15	31	-	-
Jun 16	Jul 15	30	29,273 m^3	975 m^3/day
Jul 16	Aug 31	47	37,407 m^3	795 m^3/day
Sep 1	Sep 30	30	14,621 m^3	487 m^3/day

4.6. Berm Construction

4.6.1. Existing Berm Rehabilitation – Upper Lagoon

As per the recommendations of the geotechnical report, the existing earth berm will be upgraded to flatten the downstream of the dyke to a 3H:1V slope. The height of the berm will be increased from 97m to 98.5m with a spillway elevation of 97.5 m. This will provide 7,900 m^3 of storage between the spillway elevation of 97.5m and the top of the dead zone of 95m, meeting the storage requirements set out above in Section 4.3.1 of 7,457 m^3. The elevation of the top of the berm will be 98.5 to provide the 1.0 m of freeboard as per the Canadian Dam Safety Guidelines.

The crest width of the top of the berm will be increased from the current 2.5 m width to 4 m.

4.6.2. New Berm Construction – Lower Lagoon

The berm to be constructed to create the Lower Lagoon will be constructed similar to the berm at the Upper Lagoon, with side slopes of 3H:1V and a crest width of 4 m. The berm will incorporate an overflow spillway at an elevation of 71.4m to prevent uncontrolled overtopping of the berm and allow for continuous discharge during spring melt and runoff. The elevation of the top of the berm will be 72.4 m to provide the 1 m freeboard as recommended by the Canadian Dam Safety Guidelines. The lagoon will also incorporate an approximately 1 m deep dead storage to allow for accumulation of sludge with the top of the dead zone being at elevation 68 m. The total volume provided in the Lower lagoon shall be 20,700 m^3 meeting the requirements as set out in Section 4.3.2 of 20,530 m^3.

4.7. Monitoring and Compliance Points

Monitoring the operation of the system will be accomplished through the establishment of seven sampling points, one of which will also be the compliance point. Sampling will provide information regarding the performance of the system and help identify any degradation to the treatment provided. Sampling points will be established at the truck discharge points, the two spillways, and two pump discharges, and the end of the wetlands. The sampling point at the end of the wetlands shall be the systems compliance point. Table 4.7 provides coordinates of the sampling points, which will be confirmed upon construction by hand held GPS units.

A sampling protocol shall be as summarized in Table 4.8.

Table 4.7 – Sampling Points Coordinates

STP#	Description	Latitude	Longitude	Comment
1	Summer Truck Discharge	N62°50’51.00”	W69°54’24.48”	
2	Winter Truck Discharge	N62°50’49.56”	W69°54’24.12”	
3	Upper Lagoon Spillway	N62°50’49.74”	W69°54’26.64”	
4	Upper Lagoon Pump Discharge	N62°50’49.74”	W69°54’24.84”	
5	Lower Lagoon Spillway	N62°50’36.24”	W69°54’32.76”	
6	Lower Lagoon Pump Discharge	N62°50’36.24”	W69°54’30.24”	
7	End of Wetlands	N62°50’5.64”	W69°54’31.50”	Compliance Point

4.8. Sludge Management

Effluent quality will guide when a sludge management program is implemented. Monitoring of the effluent from the lagoon will indicate when the performance of the lagoon starts to degrade. Degradation of the performance of a lagoon is normally caused by sludge accumulation and will be the indicator to desludge the lagoon.

Prior to disposal, the sludge must be tested to ensure the disposal method chosen is safe and environmentally responsible. Sludge removed from the lagoons can be disposed of in a separate cell constructed at the landfill site. The sludge will be covered with granular material and allowed to freeze.

Table 4.8 – Sampling Frequency

STP#	Description	Frequency
1	Summer Truck Discharge	Yearly - Start of Use
2	Winter Truck Discharge	Yearly - Start of Use
3	Upper Lagoon Spillway	Twice Yearly – start of overflow, start of decanting
4	Upper Lagoon Pump Discharge	Twice Yearly – start of overflow, start of decanting
5	Lower Lagoon Spillway	Twice Yearly – start and end decanting
6	Lower Lagoon Pump Discharge	Twice Yearly – start and end decanting
7	End of Wetlands	Monthly from spring to freezeup

5.0 Sewage Treatment

The sewage treatment system purposed for the Hamlet of Kimmirut includes a system of two sewage lagoon cells, an ice pack area and wetlands. As described in Section 4.2 – Operational Plan the operations of the treatment system varies during the year. The worst case scenario for treatment is from approximately mid June to mid July during the highest release rate. During this time the effluent being release is primarily from the melting ice pack. The effluent temperatures will be low and the retention times relatively short.

5.1. Influent Characteristics

The characteristics of sewage generated in a community are heavily dependent on the type of installation and sanitary facilities. The Hamlet of Kimmirut water and sewage systems utilize holding tanks and truck delivery and collection systems. The waste generated from this arrangement is considered to be “Moderately Diluted Wastewater”, as per the Cold Climate Utility Manual. Table 5.1 - Characteristics of Basic Wastewater Categories is an excerpt from the Cold Climate Utilities Manual, summarizing the characteristics of moderately diluted wastewater.

Table 5.1 –Waste Water Characteristics

Parameter	Units	Moderately Diluted
BOD_5	mg/L	460
COD	mg/L	1000
Suspended Solids	mg/L	490
Total Nitrogen	mg/l as N	--
Phosphorus	mg/L as P	--

5.2. Treatment from Over Winter Storage

The “Natural Wetlands Sewage Treatment: Baker Lake, Repulse & Chesterfield Inlet, NT” prepared by Dillon Consulting concluded the following conclusions regarding over winter treatment:

- The mass of faecal coliforms coming from melting ice pack is minimal
- There is only a slight reduction in the level of BOD_5 from a melting ice pack

Therefore for the purpose of analyzing the treatment of the sewage prior for the proposed system, the over winter storage in ice pack area will not be considered to contribute any significant treatment.

5.3. Treatment from the Sewage Lagoons

The proposed sewage lagoons will operate as detention cells with retention times that are relatively short for northern locations. Treatment received from the lagoons will include primary treatment through sedimentation and bio-chemical oxidation.

Sedimentation will remove BOD and suspended solids through settling. The detention lagoon provides a good opportunity for sedimentation due to the large volume and detention time. The *Guidelines for the Design of Water and Sewage Treatment Works*, Ontario Ministry of the Environment, state that typical removal rates of 35% and 65% of BOD and suspended solids respectively can be obtained though primary sedimentation (see Appendix B). The level of treatment based on primary treatment is summarized in Table 5.2 – Effluent Quality from Primary Sedimentation.

Table 5.2 – Effluent Quality from Primary Sedimentation

Parameter	Units	Influent Quality	% Removal	Effluent Quality
BOD_5	mg/L	460	35%	299
Susp. Solids	mg/L	490	65%	172

The remaining BOD and suspended solids is in dissolved or colloidal form, and some other removal mechanism must be applied. The natural processes within the lagoon will result in bio-chemical removal of the dissolved and colloidal fraction.

The first order relation shown below does predict treatment based on temperature, influent strength and retention time.

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

Where:

C_e = Effluent concentration (mg/L)

C_i = influent concentration (mg/L)

K = BOD_5 removal rate constant (day-1)

t = Residence time in lagoon (days)

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

T=Temperature (˚C)

The temperature activity coefficient (Θ) for various sewage treatment processes falls in the range of 1.00 to 1.10, with higher values indicating greater sensitivity to changing temperature. Values in the range of 1.04 to 1.10 are reported as typical for aerated lagoons (Metcalfe and Eddy, Wastewater Engineering Treatment, Disposal and Reuse, Third Edition 1991, McGraw-Hill). The lagoon under consideration is a facultative lagoon. A value of 1.10 has been assumed for this coefficient due to the extreme conditions the lagoon will be operating, i.e. effluent near 0°C during runoff.

The BOD_5 removal rate coefficient for lagoons typically falls in the range of 0.25 to 0.50 (Metcalfe and Eddy, Wastewater Engineering Treatment, Disposal and Reuse, Third Edition 1991, McGraw-Hill). Operating conditions for lagoons in harsh climates vary from those in Southern Canada. Specifically, they experience long periods of low activity due to low temperatures and ice cover. The sewage treated has higher than typical strength. There is limited data regarding the performance of lagoons in harsh climates. For these reasons, it was felt appropriate to use a conservative value for the removal rate coefficient. For this analysis a value of 0.10 has been assumed.

The effluent for the early part of the process will be coming from the ice pack into the Lower Lagoon and there for will have a minimal temperature (just above freezing) at the time of treatment and detention times of as short as 22 days. Based on an effluent temperature of 0°C, retention of 22 days, and the assumptions above are summarized in Table 5.3 – Lagoon Effluent Quality.

The first order equation above used to estimate the level of treatment of BOD_5 from bio-chemical oxidation, but does not estimate the removal of suspended solids. The sedimentation process occurs in short time relative to the retention times of lagoons, therefore it can be concluded that reduction of the suspended solids will continue from further sedimentation, and the bio-chemical oxidation process. For the estimation of the treatment from the lagoons, the removal of suspended solids will only consider the 65% removal from sedimentation as this is deemed to be an acceptable level of removal prior to release to th wetlands.

Table 5.3 – Lagoon Effluent Quality

Parameter	Units	Influent Quality (from table 5.2)	% Removal	Effluent Quality
BOD_5	mg/L	299	28%	216
Susp. Solids	mg/L	172	0%	172

5.4. Treatment from the Wetlands

An assessment of the wetlands capacity to provide treatment to the effluent released from the sewage lagoons proposed for the Hamlet was prepared under a report entitled Kimmirut Wetlands Planning Study prepared by Earth Tech under separate cover.

The Kimmirut Wetlands Planning Study presents an estimate of the wetlands' water quality improvement performance based on the preliminary design and operational plans prepared by Trow in September 2007. The preliminary design and operational plan had the same basic design parameters as used in this design brief. The total quantity of sewage release is constant at approximately 33,000 m^3 over a time of approximately 107 days. Minor changes to the release rates have occurred due to refinement in the design of the lagoons, and finalizing the available volume. Changes in the release rates and effluent quality from the lagoon were relatively minor, and therefore the estimated water quality improvement performance of the wetlands in the Kimmirut Wetlands Planning Study continues to provide a good estimation of the treatment that would be received. For the purpose of this analysis, compliance point is assumed at the inlet to the first small lake to the south as shown on Figure 7. The estimated wetlands water quality improvements from the Kimmirut Wetlands Planning Study are summarized Table 5.4 below.

5.5. Sewage System Treatment Summary

The predicted level of treatment the provided by the proposed sewage treatment system meets or exceeds the requirements of the Hamlets water licence. Table 5.5 summarizes the levels of treatment predicted from the sewage treatment system in comparison to the water licence criteria.

Table 5.4 – Wetlands Water Quality Improvements

Parameter	Units	Effluent from Lower Lagoon		Wetlands Outlet
		Wetlands Study	Design Brief	
TSS	mg/L	245	172	39
BOD	mg/L	230	216	38
TP	mg/L	5	-	4
Org-N	mg/L	20	-	9
NH_4-N	mg/L	40	-	35
NOx-N	mg/L	0	-	11
TN	mg/L	60	-	54
TKN	mg/L	60	-	44
FC	#/100ml	10,000,000	-	157,000

Table 5.5 – Summary of Treatment Levels

Parameter	Units	Criteria	Influent	Effluent from Lower Lagoon	Effluent from Wetland
BOD_5	mg/L	120	460	216	38
TSS	mg/L	180	490	172	39
FC	#/100ml	1×10^6	1×10^7	1×10^7	157,000

Trow Associates Inc.
154 Colonnade Road South, Ottawa, Ontario K2E 7J5
Tel: (613) 225-9940
Fax: (613) 225-7337

DATE JAN 2008		CLIENT GOVERNMENT OF NUNAVUT	JOB No. OTCD00018881A
DESIGN SAD	CHECKED SB		SCALE AS SHOWN
DRAWN RG		TITLE OVERALL SEWAGE TREATMENT SYSTEM	FIG 7

6.0 Granular Material

The Hamlet of Kimmirut does not currently have a long term granular source. The Granular Resource Management – 12 Communities, Baffin Region, Nunavut, prepared by Trow in 2004, referenced a aggregate study which was completed in 2001 by Ferguson, Simik Clark, Engineers and Architects for the Government of Nunavut. The study identified 6 existing deposits and 2 new deposits, and concluded the Hamlet had potential sources to meet their needs for 10 to 20 years.

Through Trow's involvement in the design of the access road to the deposit referred to in the Aggregate study as New Deposit No. 2, Trow is aware that the development of this deposit is in the planning stages and would be required to address any large aggregate demands such as the construction of this project.

The New Deposit No. 2 has a report potential yield of 35,000 to 50,000 m^3 of aggregate which is sufficient to meet the approximately 8,200 m^3 required for this project.

7.0 Cost Estimate

7.1. Capital Cost Estimate

A Class B Capital Cost Estimate has been prepared for the upgrades of the Kimmirut Sewage Treatment Facility. The works included in the cost estimate included the following:

1. Remediation of the existing berm to provide sufficient stabilize the slopes and provide sufficient storage capacity;

2. Construction of a new earth berm to create the second sewage lagoon cell at the outlet of the gulch (the Lower Lagoon);

3. Associated infrastructure required for the operation of the lagoon, including truck discharge locations, lagoon decanting equipment and miscellaneous upgrades.

A detailed breakdown of the cost estimate is included in Appendix C and includes a 10% contingency allowance. The estimated capital cost for the rehabilitation and expansion of the Kimmirut Sewage Treatment Facility is $1,133,000.

7.2. 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 $22,000 as detailed in Appendix C.

7.3. Life Cycle Costing

The Life Cycle Cost of the proposed facility based on the capital and O&M costs presented above, based on a 20 year economic life as per the "Water and Sewage Facilities Capital Program: Standards and Criteria" and a discount rate of 8%, "General Terms of Reference for a Community Water and Sanitation Service Study, Appendix A" MACA 1986, is summarized in Table 7.1, and detailed in Appendix C.

Table 7.1 – Life Cycle Cost Summary

Capital Cost	$1,113,000
Present Value of O&M Costs over 20 Years	$216,000
Life Cycle Cost	$1,329,000

8.0 Conclusions and Recommendations

8.1. Conclusions

The following conclusions were made during the development of the design of the Hamlet of Kimmirut's Sewage Treatment Facility.

1. In 2000-2001, a new sewage lagoon was constructed for the Hamlet of Kimmirut. Detail of the construction of the new lagoon are unavailable, however it is believe the facility was constructed based in principal on the report prepared by Dillon Consulting entitled "*Sewage & Solid Waste Site Selection Kimmirut, NT – Final Report*" dated February 11, 1999.

2. The design of any improvements to the facility must meet a 20 year design horizon as per the Department of Community Government and Services Water and Sewage's Facility Capital Program Standards and Criteria.

3. The projected population for the Hamlet of Kimmirut for the year 2028, based on the Bureau of Statistic population projects is 846 persons.

4. The total volume of sewage generated by the community in the year 2028 is 33,195 m^3, based on the projected population and a projected water consumption rate of 107.5 lpcd from the Sewage's Facility Capital Program Standards and Criteria.

5. The effluent quality would be required to meet the criteria set out in the Hamlet's Water Licence.

6. The volume of the existing lagoon was determined to be 7,300 m^3, with no allowance for freeboard or sludge storage, which is insufficient to meet the Hamlets over winter storage requirements.

7. The wetlands assessment concluded the large wetlands located hydraulically below the existing lagoon could be utilized to provide sewage treatment for the Hamlet, if the sewage was retained until the wetlands was active (mid June).

8. To meet the requirements of retaining the sewage until the wetlands were capable of providing treatment, additional storage would have to be provided through the construction of a second lagoon at the end of the gulch below the existing lagoon.

9. The geotechnical investigation indicated that the existing earth berm required upgrading to address slope stability concerns.

8.2. Recommendations

The following summarizes the recommendations:

1. Over winter storage of the sewage would be provided through the formation of an ice pack in the gulch below the existing lagoon.

2. The retention of the spring runoff until mid June would be accomplished through the construction of a second lagoon at the base of the gulch.

3. The summer operations would continue to use the existing lagoon as a storage and retention lagoon.

4. The existing lagoon would be upgrade to stabilize the berm and top increase its capacity.

5. The two lagoons would provide primary treatment to the sewage prior to being released to the wetlands for subsequent treatment.

6. The Upper Lagoon will be required to provide 7,435 m^3 of storage to meet the operational plan for the sewage system.

7. The Lower Lagoon will be required to provide 21,996 m^3 of storage to meet the operational plan for the sewage system.

8. The Kimmirut Wetlands Planning Study prepared by Earth Tech, concluded that the wetlands would provide sufficient treatment to meet the requirements of the Hamlet's water licence at the compliance point identified to be prior to release into the first body of water.

9. The estimated capital costs for the construction of the Kimmirut Sewage Treatment Facility based on the recommendations put forth is $1,133,000.

10. The estimated annual O&M costs for the facility include $11,000 for general O&M costs (based on 1% of the capital costs) as well as $11,000 for the decanting process.

11. The life cycle cost for the facility is estimated at $1,329,000.

Trow Associates Inc.

REGISTERED PROFESSIONAL ENGINEER
S. L. BURDEN
LICENSEE
12/02/08
N.W.T.

Steven L. Burden, P.Eng. Senior Project Manager Infrastructure Division	Stephen A. Douglas Senior Designer Infrastructure Division

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Appendix A:
Canadian Climate Normals 1971-2000 by Environment Canada

Environment Canada Environnement Canada

[français] [Back]

Canadian Climate Normals 1971-2000

The minimum number of years used to calculate these Normals is indicated by a code for each element. A "+" beside an extreme date indicates that this date is the first occurrence of the extreme value. Values and dates in bold indicate all-time extremes for the location.

> ***NOTE!!*** *Data used in the calculation of these Normals may be subject to further quality assurance checks. This may result in minor changes to some values presented here.*

IQALUIT A
NUNAVUT

Latitude: 63° 45.000' N **Longitude**: 68° 33.000' W **Elevation**: 33.50 m
Climate ID: 2402590 **WMO ID**: 71909 **TC ID**: YFB

Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Daily Average (°C)	-26.6	-28	-23.7	-14.8	-4.4	3.6	7.7	6.8	2.2	-4.9	-12.8	-22.7		A
Standard Deviation	5	3.8	3.7	2.6	2.1	1.7	1	0.9	1.1	2.5	3.6	4.7		A
Daily Maximum (°C)	-22.5	-23.8	-18.8	-9.9	-0.9	6.8	11.6	10.3	4.7	-2	-8.9	-18.5		A
Daily Minimum (°C)	-30.6	-32.2	-28.6	-19.6	-7.8	0.3	3.7	3.3	-0.4	-7.7	-16.7	-26.9		A
Extreme Maximum (°C)	3.9	4.4	3.9	7.2	13.3	21.7	**25.8**	25.5	17.2	7.3	5.6	3.4		
Date (yyyy/dd)	1958/21	1965/22	1955/19	1981/23	1954/30	1955/22+	**2001/28**	1991/08	1964/03+	1981/05	1952/19	2001/29		
Extreme Minimum (°C)	-45	**-45.6**	-44.7	-34.2	-26.1	-10.2	-2.8	-2.5	-12.8	-27.1	-36.2	-43.4		
Date (yyyy/dd)	1953/24+	**1967/10+**	1991/01	1983/10	1949/02	1978/02	1961/03	1996/31	1965/30	1978/30	1978/18+	1993/30		
Precipitation:														
Rainfall (mm)	0.1	0	0	0.2	2.8	24.7	59.2	64.8	41.5	4.5	0.5	0		A
Snowfall (cm)	22.8	16.8	25.3	32.4	25.1	9.8	0.1	0.8	13.7	34.9	32.4	21.7		A
Precipitation (mm)	21.1	15	21.8	28.2	26.9	35	59.4	65.7	55	36.7	29.1	18.2		A
Average Snow Depth (cm)	22	23	25	29	18	2	0	0	0	6	16	20	13	A
Median Snow Depth (cm)	21	23	25	28	16	1	0	0	0	6	15	19	13	A
Snow Depth at Month-end (cm)	23	25	29	27	10	0	0	0	1	10	21	21	14	A
Extreme Daily Rainfall (mm)	2.5	2	0.5	5.1	11.7	28.4	**52.8**	48.2	40.4	23.3	11.9	0.5		
Date (yyyy/dd)	1958/21	1963/03	1958/09	1950/20	1986/14	1961/30	**1968/14**	1995/08	1979/01	1985/24	1955/01	1963/16		
Extreme Daily Snowfall (cm)	30.7	**32.2**	24.6	21.8	29.5	19.2	3.6	6.2	21.3	20.6	27.9	21.8		
Date (yyyy/dd)	1958/18	**1981/12**	1973/08	1973/07	1965/09	1984/09	1970/08	1981/29	1946/26	1961/08	1960/24	1951/03		
Extreme Daily Precipitation (mm)	30.7	27.4	23.9	23.9	27.4	30.2	**52.8**	48.2	40.4	27.2	27.9	21.8		
Date (yyyy/dd)	1958/18	1981/12	1953/29	1973/07	1965/09	1980/06	**1968/14**	1995/08	1979/01	1985/25	1960/24	1951/03		
Extreme Snow Depth (cm)	57	74	69	**86**	86	43	1	3	15	33	52	48		
Date (yyyy/dd)	1977/15+	1956/27	1963/01+	**1958/30**	1958/01+	1987/02	1978/01+	1957/24+	1992/29	1961/29+	1989/27	1958/23		
Days with Maximum Temperature:														
<= 0 °C	30.6	28.2	30.7	27.9	17	0.77	0	0	1.9	19.7	28.1	30.4		A
> 0 °C	0.41	0.07	0.3	2.2	14	29.2	31	31	28.1	11.3	1.9	0.58		A
> 10 °C	0	0	0	0	0.04	5.9	19.6	14.5	1.7	0	0	0		A
> 20 °C	0	0	0	0	0	0.08	0.88	0.23	0	0	0	0		A
> 30 °C	0	0	0	0	0	0	0	0	0	0	0	0		A
> 35 °C	0	0	0	0	0	0	0	0	0	0	0	0		A
Days with Minimum Temperature:														
> 0 °C	0	0	0	0.04	1.6	17	30.5	29.5	13.4	0.92	0.04	0		A
<= 2 °C	31	28.3	31	30	31	23.8	5.9	7.9	25.7	30.9	30	31		A
<= 0 °C	31	28.3	31	30	29.4	13	0.46	1.5	16.6	30.1	30	31		A
< -2 °C	31	28.3	31	29.5	26	4.5	0.04	0.08	6.8	26	29.5	31		A
< -10 °C	30.6	28.1	29.9	25.7	10.4	0.04	0	0	0.04	9	22.5	29.9		A
< -20 °C	27.9	26.3	26.8	16.5	0.42	0	0	0	0	1.2	11.2	24.9		A
< - 30 °C	18.6	18.8	15.7	1.4	0	0	0	0	0	0	1.2	12.2		A
Days with Rainfall:														
>= 0.2 mm	0.04	0.04	0	0.31	1.5	7.4	13.2	14.7	9.9	1.9	0.26	0		A
>= 5 mm	0	0	0	0	0.15	1.5	4	4.2	2.6	0.23	0.04	0		A
>= 10 mm	0	0	0	0	0.08	0.58	1.5	1.6	1.2	0.08	0	0		A

>= 25 mm	0	0	0	0	0	0	0.23	0.23	0.19	0	0	0		A
Days With Snowfall:														
>= 0.2 cm	12	10.7	12.5	12.8	11.6	4.7	0.12	0.58	7.5	15.3	14.5	12.1		A
>= 5 cm	1.2	0.52	1.4	2	1.3	0.58	0	0.04	0.62	2.4	1.9	1.1		A
>= 10 cm	0.33	0.22	0.52	0.62	0.31	0.19	0	0	0.31	0.38	0.48	0.3		A
>= 25 cm	0	0.04	0	0	0	0	0	0	0	0	0	0		A
Days with Precipitation:														
>= 0.2 mm	11.9	10.6	12	12.5	12.2	10.5	13.2	15	15.3	15.4	14.3	11.8		A
>= 5 mm	1	0.48	1	1.7	1.5	2.2	4	4.4	3.3	2.5	1.6	0.81		A
>= 10 mm	0.26	0.19	0.33	0.46	0.42	0.85	1.5	1.6	1.5	0.46	0.33	0.22		A
>= 25 mm	0	0.04	0	0	0	0.04	0.23	0.23	0.23	0.04	0	0		A
Days with Snow Depth:														
>= 1 cm	31	28.3	31	30	28.8	10.5	0.08	0.04	2.7	24	30	31	247.3	A
>= 5 cm	31	28.3	31	29.9	26.3	5.7	0	0	0.31	15.6	28.4	31	227.4	A
>= 10	29.6	27.3	29.9	27.8	20.8	2.1	0	0	0.04	7.8	24	30.3	199.6	A
>= 20	19.2	16.2	20.7	22.6	12	0.69	0	0	0	2.1	8.2	14.3	115.9	A
Wind:														
Speed (km/h)	15	14.8	14.1	15.8	17.3	15.3	12.4	13.9	15	17.6	17.6	15.4	15.4	A
Most Frequent Direction	NW	NW	NW	NW	NW	SE	SE	SE	SE	NW	NW	NW	NW	A
Maximum Hourly Speed	108	100	**129**	116	85	72	80	90	97	104	97	111		
Date (yyyy/dd)	1962/17	2001/23	**1960/29**	1962/05	1961/11	2000/23	1958/15	1961/23	1960/22	1986/12	1957/10	1982/04		
Direction of Maximum Hourly Speed	NE	NE	NW	NW	NW	NE	SE	NW	SE	NW	NE	NW	NW	
Maximum Gust Speed	146	114	**156**	153	103	93	117	109	126	137	126	141		
Date (yyyy/dd)	1963/21	1962/07+	**1960/29**	1962/05	1960/25	1994/16	1958/14	1961/22	1960/22	1986/12	1957/10	1982/04		
Direction of Maximum Gust	NE	NW	NW	NW	NW	W	E	NW	SE	NW	NE	NW	NW	
Days with Winds >= 52 km/hr	3.8	3.2	3.1	2.8	2.3	0.8	0.7	1.1	1.7	2.4	3.7	3.6		A
Days with Winds >= 63 km/hr	1.9	1.2	0.8	0.6	0.4	0.2	0	0.4	0.5	0.8	1.4	1.3		A
Degree Days:														
Above 24 °C	0	0	0	0	0	0	0	0	0	0	0	0		A
Above 18 °C	0	0	0	0	0	0	0	0	0	0	0	0		A
Above 15 °C	0	0	0	0	0	0	0.1	0.1	0	0	0	0		A
Above 10 °C	0	0	0	0	0	1.4	10.4	5.5	0	0	0	0		A
Above 5 °C	0	0	0	0	0	21	88.2	64.1	5.3	0	0	0		A
Above 0 °C	0	0	0	0.5	10.8	112	237.7	210.9	75.8	5.7	0.6	0		A
Below 0 °C	824.1	792.5	735.9	443.5	146.5	4.8	0	0	10.8	156.7	381.8	700		A
Below 5 °C	979.1	933.8	890.8	593.1	290.7	63.9	5.5	8.2	90.3	306	531.2	855		A
Below 10 °C	1134.1	1075.1	1045.8	743.1	445.7	194.2	82.7	104.6	235	461	681.2	1010		A
Below 15 °C	1289.1	1216.4	1200.8	893.1	600.7	[illegible]	[illegible]	254.2	385	616	831.2	1165		A
Below 18 °C	1382.1	1301.2	1293.8	983.1	[illegible]	[illegible]	[illegible]	347.1	475	709	921.2	1258		A
Bright Sunshine:														

Important Notices

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Url of this page : http://climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html

Appendix B:
Guidelines for the Design of Water and Sewage Treatment Works

With each new plant, or major expansion of an existing plant, the designer is, therefore, requested to economically compare the waste treatment and sludge treatment alternatives before finalizing the overall process.

Primary sedimentation treatment offers low cost suspended solids and BOD_5 removal, especially in cases where the raw sewage contains a high proportion of settleable solids, as is often the case with sewage containing significant food processing, or similar wastes.

As shown in Table 6.1, primary sedimentation tanks used for phosphorus precipitation with normal strength municipal wastewaters exhibit BOD_5 and suspended solids removals of 65 and 85 per cent, respectively. Without chemical addition for phosphorus removal, the BOD_5 and suspended solids reductions would be 35 and 65 per cent, respectively. With secondary treatment plants, the use of the secondary clarifiers for phosphorus removal has been the most common approach. This has been at least partially due to the reduced chemical requirements when the secondary units are used for phosphorus removal. In view of the potential for increased BOD_5 and suspended solids removals when the primaries are used for phosphorus removal, there may be circumstances when consideration should be given to their use rather than the secondaries for phosphorus removal. Such circumstances might include the following:

- where economic evaluation shows the process to be more cost effective despite the higher chemical costs;

TABLE 6.1

SEWAGE TREATMENT PROCESSES AND TYPICAL EFFLUENT QUALITY

PROCESS	EFFLUENT PARAMETERS (mg/L)			
	TOTAL BOD_5	SS	TOTAL PHOSPHORUS (as P)	FREE AMMONIA (as N)
PRIMARY				
- Without P Removal	110	70	5.0	20
- With P Removal	90	30	1.0	20
CONVENTIONAL A.S.				
- Without P Removal	15	15	3.5	17
- With P Removal	15	15	1.0	17
- With P Removal And Filtration	10	5	0.3	17
- With Nitrification	15	15	3.5	3.0
CONTACT STABILIZATION				
- Without P Removal	20	20	3.5	17
- With P Removal	20	20	1.0	17
EXTENDED AERATION				
- Without P Removal	15	15	3.5	3.0
- With P Removal	15	15	1.0	3.0
- With P Removal And Filtration	5	5	0.3	3.0
CONTINUOUS DISCHARGE LAGOON				
- Without P Removal	25	30	6.0	
- With P Removal	25	30	1.0	
SEASONAL RETENTION LAGOON				
- Without P Removal	25	30	6.0	
- With P Removal By Batch Chemical Dosage	15	20	1.0/0.5	
- With P Removal By Continuous Chemical Dosage	25	30	1.0	
PRE-AERATION LAGOON (Aerobic - Facultative Type)				
- Without P Removal With 4-5 Days Retention Time	60	100	6.0	

NOTE :

1. The above values are based on typical raw sewage with Total BOD_5 = 170 mg/L, Soluble BOD_5 = 50%, SS = 200 mg/L, P = 7 mg/L, NH_4^+ = 20 mg/L.

Appendix C:
Cost Estimate

Item	Description	Unit	Quantity	Unit Price	Amount
1	Mobilization & Demobilization	L.S.	1	$ 300,000.00	$ 300,000.00
	Upper Lagoon				
2	Supply , deliver and place granular material to stabilize and increase the existing berm, including terracing the existing berm as per geotechnical report.	m^3	1400	$ 60.00	$ 84,000.00
3	Supply deliver and place materials to create an overflow structure	L.S.	1	$ 25,000.00	$ 25,000.00
4	Supply Deliver and Install erosion protection for exist. Truck discharge structures	Ea.	1	$ 10,000.00	$ 10,000.00
5	Supply deliver and install guide rail	m	60	$ 700.00	$ 42,000.00
6	Supply deliver and install bollard	ea	4	$ 1,000.00	$ 4,000.00
7	Supply deliver and install pump , inlet and outlet piping	ea	1	$ 50,000.00	$ 50,000.00
	Gulch				
8	Construct access road and turn around for truck discharge point.	m^3	500	$ 40.00	$ 20,000.00
9	Supply Deliver and Install Truck Discharge Structures, including erosion protection	Ea.	1	$ 30,000.00	$ 30,000.00
	Lower Lagoon				
10	Supply , deliver and place granular material to construct new berm	m^3	6800	$ 50.00	$ 340,000.00
11	Supply deliver and place materials to create an overflow structure	L.S.	1	$ 20,000.00	$ 20,000.00
12	Construct access road and turn around to Loower Lagoon	m^3	500	$ 40.00	$ 20,000.00
13	Supply deliver and install guid rail	m	50	$ 700.00	$ 35,000.00
14	Supply deliver and install pump , inlet and outlet piping	ea	1	$ 50,000.00	$ 50,000.00
				Subtotal	**$ 1,030,000.00**
				10% Contingency	**$ 103,000.00**
				Total	**$ 1,133,000.00**

Operation and Maintenance Costs

Yearly General O&M

1% of Capital Costs

1,133,000 x 1% = $11,000

Decanting Costs

Fuel	20 litres at $1.25	$25
Operator	2 hours per day @ 75	$150
Miscellaneous		$25
Total		**$200**
Pumping 55 days	**55 x $200**	**$11,000**

Annual O&M Costs

General O&M Costs	$11,000
Decanting Cost	$11,000
Total O&M Costs	**$22,000**

Life Cycle Cost of O&M Costs

@ 8% Discount Rate

Year	Year Cost	Present Value
1	$22,000	$20,370
2	$22,000	$18,861
3	$22,000	$17,464
4	$22,000	$16,170
5	$22,000	$14,972
6	$22,000	$13,863
7	$22,000	$12,836
8	$22,000	$11,885
9	$22,000	$11,005
10	$22,000	$10,190
11	$22,000	$9,435
12	$22,000	$8,736
13	$22,000	$8,089
14	$22,000	$7,490
15	$22,000	$6,935
16	$22,000	$6,421
17	$22,000	$5,945
18	$22,000	$5,505
19	$22,000	$5,097
20	$22,000	$4,702
Total		**$215,971**