Sewage & Solid Waste Facility
Kugaaruk, Nunavut

Pre-Design Report

July 22, 2005

Sewage & Solid Waste, Facilities
Kugaaruk, Nunavut

Government of Nunavut

Project No. 03-4305

Gary Strong - Project Manager

Submitted by

Dillon Consulting Limited

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(In reply, please refer to)
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Attention: Navjit Sidhu, Bsc., EIT

Pre-Design Report - Phase I, Kugaaruk Sewage and Solid Waste Facilities Design

Dear Navjit:

Please find attached a copy of the Pre-Design Report for Phase I of the Kugaaruk Sewage & Solid Waste Facility project.

The document contains a detailed summary of the initial site visit along with lab results and sewage forecasts. Design alternative for Phase I are broken down and discussed in a manner that will hopefully satisfy the decision making practice at this time.

Alternative cost estimates are also included based on the success of construction without a lining system as well as a potential option of extending the life of the existing sewage lagoon through blasting.

If you have any questions regarding the information contained within the document, please don't hesitate to contact me.

Yours sincerely,

DILLON CONSULTING LIMITED

Robert Kuta, P.Eng.
Project Engineer

Dillon Consulting Limited

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EXECUTIVE SUMMARY

The attached document contains information that will assist in the decision making process of Phase I of the *Kugaaruk Sewage Lagoon and Solid Waste Facilities* project. This information consists of data and images collected during the July 3rd initial site visit. As the project moves forward, sewage quantity projections must be accounted for; therefore, a twenty year forecast was developed and is included herein.

Alternative methods of dealing with the short term requirements of Phase I are detailed throughout this document, complete with drawing. The costs of performing these modifications, as well as alternative cost options, were estimated and are included at the end of the document.

1 INTRODUCTION

1.1 General

Dillon Consulting Limited (Dillon) has been retained by the Department of Community and Government Services (CGS), Government of Nunavut, to design waste facility alternatives for the Hamlet of Kugaaruk – formerly known as Pelly Bay. This project has been divided into two phases, the first of which concentrates on achieving regulatory compliance with the existing sewage treatment facility, while the second phase will concentrate on modification, planning, and design for the other waste facilities. The second phase will also include planning and design for a new sewage treatment location and facility used by the community. This document concentrates on the first phase of the project which includes the preliminary design plans for an upgraded sewage treatment system put forth by Dillon.

The Hamlet of Kugaaruk is located 68.52° north latitude and 89.9° west longitude in central Nunavut. This places Kugaaruk along the east coast of Pelly Bay, which is roughly nine hundred and sixty kilometers (960 km) west of the capital of Iqaluit.

The annual snowfall in Kugaaruk is approximately 125 cm and the annual rainfall is approximately 11 cm. In January the daily mean temperatures is approximately -33^{0}C while in July the daily mean temperature is approximately 6^{0}C. Freeze up usually occurs during the month of November but may happen as early as September or October while spring thaw usually happen around late May.

The community uses trucked services for both water delivery and sewage collection. The Hamlet is presently using a 2 cell sewage lagoon system that is not meeting environmental regulations. This system cannot be viably upgraded to provide for a long term sewage treatment system; however, modification can be made to sustain sewage treatment for the hamlet until a new location is selected and a new sewage treatment facility is designed and implemented for a longer-term solution (20 years +).

1.2 Background

The sewage and solid waste facilities have been in operation for approximately fifteen (15) years and include a traditional sewage lagoon system, a solid waste land-fill, and a bulk metal/ hazardous waste storage area (*Figure 1.1*). Like most northern communities, the hamlet has experienced steady community growth over the past two decades. The facilities' condition needs to be addressed as the community continues to grow.

The sewage treatment system consists of an upper cell with a current capacity of approximately sixteen thousand cubic meters (16,000 m^3), a lower cell with a current capacity of approximately seven hundred cubic meters (700 m3)[1], and a wetlands area that stretches about one hundred and sixty meters (160 m) from the base of the lower cell to the ocean shoreline. The upper cell is filled via a dumping ramp located directly off the road at the south-east end of the lagoon. Two-thirds of the upper lagoon's perimeter consists of the natural lay of the land while the other one-third is retained by a main berm on the north side of the lagoon and a side berm on the west side of the lagoon.

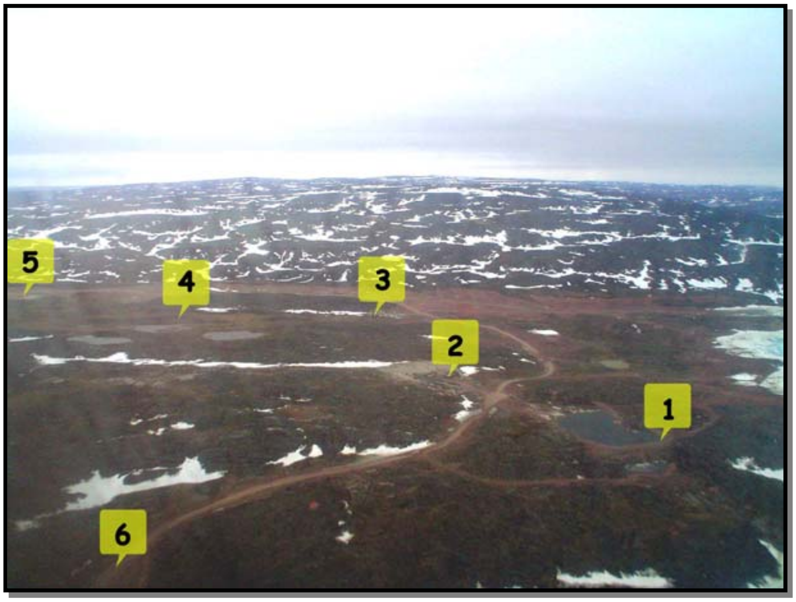


Figure 1.1 Aerial Image of Project Area – 1. Sewage Treatment Lagoon's and Wetlands, 2. Solid Waste Land Fill, 3. Bulk Metal/Hazardous Waste Storage, 4. Proposed Site for New Sewage Treatment Facility and Wetlands, 5. Existing Landfarm, 6. Road heading back towards Community.

The lagoon operated successfully for many years; however, in 2001 the upper cell's main berm permeability and porosity increased to a degree that allows seepage to pass through at levels that are unacceptable by environmental standards. This effluent is seeping into the lower cell that was overloaded and breached this spring. The Hamlet took action in 2004 by adding additional earthen material to the upper cell's main berm. The exfiltration is still flowing at unacceptable environmental levels.

The solid waste landfill is located south-east of the sewage treatment lagoon on the opposite side of the road (*Figure 1.2*). Although current storage level is not close to capacity capabilities of this site, design and development are required to bring the impact this site is having on the surrounding environment under control. For example, wind blown debris is escaping the landfill area, and then traveling north into the community. No cover material is currently being used to top the waste on a regular basis. This results in odor from the site being a community concern. Another concern with the landfill is the runoff

[1] Volume estimates include a half a meter (0.5 m) freeboard.

Figure 1.2 Solid Waste Land Fill – The central image illustrates a panoramic view of the land fill site as it exists today. The upper image shows some out-of-place material, such as metal drums, as well as some runoff towards the road. The lower image illustrates how ineffective the wind fence is for wind blown debris.

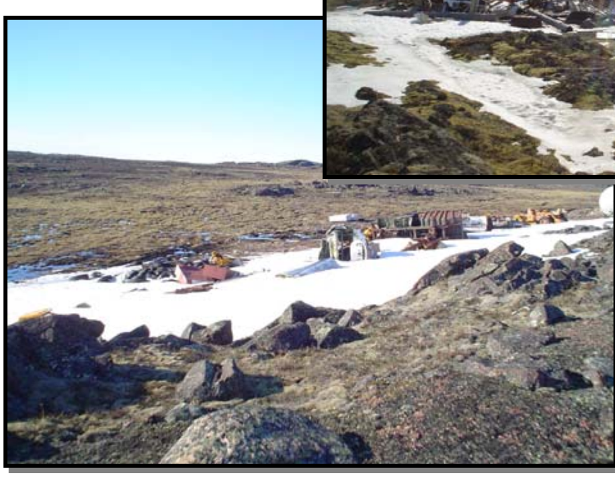


Figure 1.3 Bulk Metal/Hazardous Waste Storage Area – The image above gives a panoramic view of the contents this area. This includes, but is not limited to, fuel drums, old cars, decommissioned heavy machinery, as well as scrap sheet metal. The lower image shows the base of the proposed phase II wetlands as well as some additional bulk metal such as air craft refuse and heavy machinery.

capturing and monitoring. The runoff is currently leaving the site via a drainage ditch on the eastern shoulder of the road, and there is currently no runoff monitoring, or control.

The bulky metal/hazardous waste storage area, is located approximately half a kilometer (500 m) south-east of the sewage lagoon and landfill sites. This area houses a variety of metal waste from old metal fuel drums to decommissioned air-craft refuse (*Figure 1.3*). It is clear that the hamlet does not house the proper facilities for recycling and reuse of this material so a clean-up plan will need to be developed and implemented. Seeing that this site is not causing a significant environmental impact at this time, clean-up planning, design, and implementation will be scheduled for the second phase of the project.

1.3 Scope of Report

The work program for the development of this report follows the terms of reference issued by CGS and Dillon's proposal dated May 2, 2005. Briefly this includes the following:

- Review of initial site investigation,
- Detailed description of existing sewage lagoon system,
- Develop the 3, 5, and 20 year sewage generation values,
- Analytical results of initial site investigation sampling,
- Provide alternative methods for remediation of the existing sewage treatment facility,
- Sample monitoring program.

1.4 Report Layout

The purpose of this report is to document the preliminary design process and is a decision-making document. The sections of the report describe:

- Background information,
- The design requirements, assumptions, and calculations,
- The objectives of the design,
- A description of the design elements, including appropriate sketches and illustrations,
- Cost estimates for the construction.

Drawings are located in Appendix A.

2 SITE INSPECTION

2.1 Initial Site Visit

On July 3 rd, 4th and 5th, a site inspection was completed. At the inspection were Navjit Sidhu, MIT, C&GS Project Officer, Tom Livingston, P. Eng., C&GS Regional Municipal Engineer, Keith Barnes, P. Eng., Geotechnical Engineer, AMEC Earth and Environmental, Robert Kuta, Project Engineer, Dillon Consulting Limited, and Gary Strong, P. Eng, Project Manger, Dillon Consulting Limited. During the site inspection the following information was collected;

- Lengths of the berm crests,
- Measurements of the as constructed berm wall crest widths,
- Measurements of the berm wall side slopes,
- Photographic record of the site at the time of inspection,
- Recovery of granular samples from the berm,
- Sewage effluent and sewage lagoon samples,
- Observations of the berm and lagoon site, specifically of the lagoon berm walls.

The result of these efforts provided the project team an opportunity to collaborate on phase precedence and how the project should proceed. The investigation also provided an opportunity to study potential areas that may be used for future design, material extraction, and construction.

2.2 Additional Site Work

Prior to the start of the project, the client had a survey of the lagoon area completed. This survey provided a good baseline of information for the development of the existing sewage lagoon capacity. Subsequent to the completion of the survey, the Hamlet undertook some repairs to the lagoon. These repair works included raising the elevation of the two earthen berms, and repairing breaches in the berm walls. In July of 2005, Dillon commissioned additional survey work at the site. The survey was completed by Kudlik Construction and the survey results are shown in Appendix B.

3 SEWAGE TREATMENT SITE

3.1 Description and Dimensions

The main lagoon is situated in a natural pond area. The south and east sides of the lagoon are comprised of natural topographic raises. These two sides are rock outcrops (*Figure 3.1*). The southern end of the lagoon floor was exposed during the initial site investigation. The floor slopes upwards from the north to the south. The exposed floor of the lagoon is bed rock, with some boulders.

The north wall of the lagoon is a constructed berm wall. The wall is approximately one hundred and sixty meters (160 m) long, and is crescent shaped. The wall height is estimated to be three and a half meters (3.5 m) on the interior face. The crest of the wall is approximately four and a half to five meters (4.5 m to 5.0 m). Interior and exterior slopes of the berm range from 1.5:1 to 2.0:1 (V:H). The exterior slopes are similar to the interior slopes. The wall appears to have been constructed by end dumping truckloads of granular material, and blading the material with a dozer. This was later confirmed by the Deputy SAO. The berms are not well compacted. The side slope would appear to be close to the natural angle of repose of the material used for the berms.

Figure 3.1 Panoramic View of Main Sewage Lagoon –
This image shows the entire main lagoon of the existing sewage treatment site looking west. The north berm is on the right side of the image while the smaller west berm is located off in the distance near the left side of the image

The west wall is comprised of both rock outcrops, and a constructed berm. The berm is of similar construction to the north wall. The height of the west wall berm is approximately two meters (2.0 m). The capacity of the main lagoon has an approximate retention capacity of sixteen thousand cubic meters (16,000 m^3)[2].

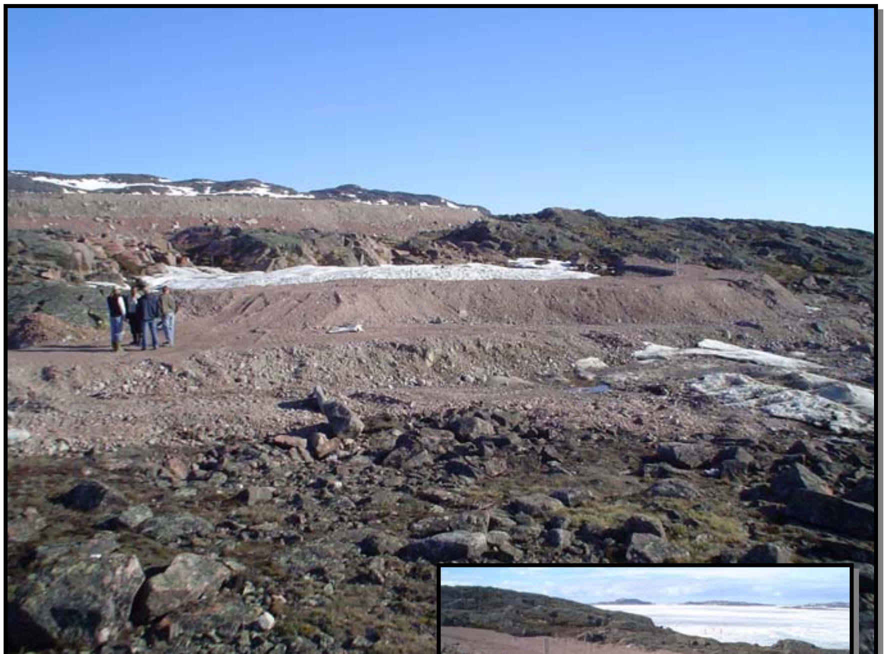
Down gradient of the north wall is a small retention pond. This area was constructed in the last few years in an attempt to increase the treatment of the system, and address regulatory agency concern with seepage

[2] This calculation - generated using the Kudlik AutoCAD drawing 05522880200-DWG-C0001.dwg – results from modeling the volume of the lagoon with the survey data and allowing for a half a meter (0.5 m) freeboard. Refer to Figure C in Appendix A.

leaving the lagoon. This area has an approximate retention capacity of seven hundred cubic meters (700 m^3)[3]. The berms of this retention pond are constructed similar to the berms of the lagoon.

Over the last few years the berm of the lower lagoon experienced hydraulic overloading resulting in washout (*Figure 3.2*). The washout damage sustained by the lower lagoon's berm renders this cell ineffective in the treatment process. As a result, exfiltration and overflow is flowing down over the wetland area, below the lower lagoon, at levels outside of environmental regulation limits.

Figure 3.2 Back Side of Upper and Lower Berm - The upper image illustrates the size and relation of the upper and lower lagoon's berms. The lower image show the damage caused by the breach and washout of the lower lagoon's berm.



To remedy this situation, the project team has developed design options based on a three year projections that will accommodate the Hamlet while designs and plans are developed for longer term projection in Phase II of the project.

Down gradient of the lagoon cells is a wetland area (*Figure 3.3*). The wetland has an average gradient of over 10%. The length of the wetland is approximately one hundred and sixty meters (160 m) made up predominately of land with areas of small water flow courses. There were a few small (less than 5 m^2)

[3] This calculation - generated using the Kudlik AutoCAD drawing 05522880200-DWG-C0001.dwg – results from following the eight-teen and a half meter (18.5 m) contour line around the lagoon's perimeter to acquire an area of seven hundred square meters (700 m^2) followed by the multiplication of an average depth of one meter (1 m).

ponding areas within the wet land area. The wetland discharges to the marine environment along a rocky shore.

Figure 3.3 Wetland Areas – Wetlands flowing from the base of the lower berm to the ocean.

3.2 Operations

In discussion with the deputy SAO it is understood that the lagoon has in the past operated as an exfiltration lagoon. Sewage is trucked to the lagoon 5 days per week. The sewage discharged to the lagoon receives treatment within the lagoon (physical and biological), and filters through the north wall at a rate that seems to prevent overflow of the lagoon. The community does not complete an annual discharge of the lagoon. In the past the exfiltration rate has exceeded the inflow rate.

With the improvements that the community made to the lagoon over the past few years, the berms now have a lower exfiltration rate. In the spring of 2005, the lagoon level was within 600 mm of the berm crests (west berm).

Each year, the lagoon retained some liquid, even at the end of the fall. A portion of the lagoon capacity was unusable because liquid was left in the lagoon. The community has not removed any sludge in the life of the lagoon.

The hamlet does not have a current water license to operate the facility. The Water License expired in 2002. The lack of license exposes the community to regulatory liabilities and potential charges for the regulatory agencies.

4 FUTURE PROJECTIONS

4.1 Sewage Generation Rates

The Hamlet of Kugaaruk has experienced steady community growth over the latter part of the twentieth century. This growth will naturally continue and must be considered during the design process. The following section outlines a population projection calculated using data from Nunavut Bureau of Statistics and Statistics Canada.

The new sewage treatment system, as part of Phase II, will be designed for a 20 year life span (2008-2028 Phase II Projection). In order to do so, the sewage generation rates per capita and the population of Kugaaruk for the year 2028 were determined. Predicted population values until the year 2020 were provided by Nunavut Bureau of Statistics (Appendix C). Population values beyond 2020 were predicted using the same growth rate as previous years (20 persons per year), and using a percentage growth rate (2.6%) as illustrated in Figure 4.1. The population for 2028 was predicted to be 1127 persons.

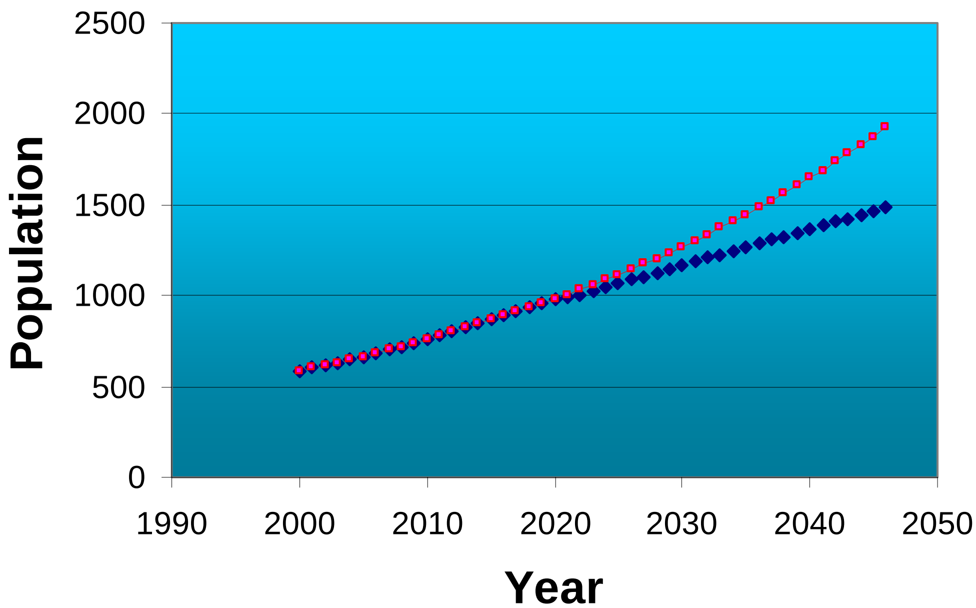


Figure 4.1 Population Growth in Kugaaruk - Data prior 2021 was provided by Nunavut Bureau of Statistics and data proceeding 2021 was predicted. Dark blue data points indicate data calculated using a growth rate of 20 persons per year. Red data points indicate data calculated using a percentage growth rate of 2.6%.

For communities with trucked sewage collection, the amount of sewage generated can be assumed equal to the amount of water consumed. The following formula (Department of Municipal and Community Affairs, Government of the Northwest Territories) is generally used to predict water consumption in Northern communities:

$$\text{Water Usage (l/cd)} = 90 \text{ l/cd} \times (1.0 + 0.00023 \times \text{population}) \quad \textbf{[1]}$$

Based on this information, the lagoon will be designed to treat 46 600 m^3, the annual sewage volume for a population of 1127 persons. Table 4.1 shows the calculated sewage generation for years 2008 – 2028.

Table 4.1 Predicted Sewage Generation 2008-2028

Year	Population	MACA Predicted Sewage Production (L)	MACA Predicted Sewage Production (m3)
2000	582	21677929	21678
2001	601	22471904	22472
2002	616	23102580	23103
2003	631	23736655	23737
2004	648	24459385	24459
2005	664	25143590	25144
2006	682	25917944	25918
2007	701	26740630	26741
2008	719	27525049	27525
2009	737	28314363	28314
2010	756	29152840	29153
2011	779	30175137	30175
2012	802	31205428	31205
2013	823	32153109	32153
2014	844	33107455	33107
2015	867	34160336	34160
2016	889	35174920	35175
2017	911	36196818	36197
2018	934	37272986	37273
2019	957	38357147	38357
2020	979	39401651	39402
2021	987	39779893	39780
2022	1007	40735733	40736
2023	1027	41697587	41698
2024	1047	42665455	42665
2025	1067	43639337	43639
2026	1087	44619232	44619
2027	1107	45605140	45605
2028	1127	46597062	46597

4.2 Sewage Quality

Due to the low water usage of communities using trucked water delivery and trucked sewage collection, sewage tends to be concentrated when compared to typical municipal wastewater. Kugaaruk trucked sewage is assumed to have the following characteristics as per a water chemistry report produced back in 2001 for Department of Indian and Northern Affairs (DIAND):

- Average raw Biochemical Oxygen Demand (BOD_5) concentration of 625 mg/L
- Average raw suspended solids (SS) concentration of 900 mg/L

5 REMEDIATION

5.1 General

To meet the requirements of the regulatory agencies of Nunavut, one of two systems are required for the lagoon. The most prevalent is the use of an annual storage lagoon. This type of lagoon stores sewage for 365 days, and then is discharged over a period of 7 to 10 days in the fall each year. Based on this requirement the lagoon capacity needs to meet the annual sewage generation rate for the community.

Previously collected survey data is used to develop the capacity calculations for the lagoon and is illustrated in Figure C in Appendix A. Using this data, the existing site has a total available storage volume of 16,173 m^3. In section 4.1 of this report, the projected sewage generation rates for the community over the next 20 years was developed and shown in Table 1. Based on these projections the community's sewage generation rates have already exceeded the capacity of the lagoon. It is clear that for the existing lagoon to meet the community's needs over the next 3 years, the site needs to be upgraded to provide additional capacity.

5.2 Potential Upgrades

There are areas that require upgrades to allow the lagoon to service the community over the next few years. The long term sewage system for the community may require the development of a new site, or a new technology. However, the completion of the new facility is a minimum of three years away, and the community needs to be able to treat sewage during this time period.

The areas that require upgrades include;

- Reduction or elimination of the lagoon exfiltration
- Lagoon capacity
- Licensing of the existing facility
- Change the system operation to include an annual controlled discharge operation.
- Completion of annual monitoring and record keeping

5.3 Sources of Exfiltration

Through the inspection of the lagoon, it is believed that there at several areas that are contributing to the exfiltration seepage. These are, in no order of priority;

- Seepage through the berm material due to the material composition and construction techniques. The berms are constructed of a sandy gravel material. There are some fines within the material. The berms appear to have been constructed without sufficient compaction. The combination of a sandy material coupled with insufficient fines, and low compaction effort has resulted in a berm with a higher than desirable permeability.
- Seepage through the berm material due to inconsistency in material selection. The granular source area for the berm construction is a large area of glacial outwash. Moving up or down this source results in a change in the material. Courser grained material is located at the up gradient area of the source, sand and fines are found down gradient. Some areas of the source are gap graded, and consist of primarily small gravel to coble sized material. Observations of the berm construction and the road construction near the lagoon suggest that some truckloads of material were comprised of gap graded material, and were not blended during placement. These areas will provide preferential seepage paths within the berm.
- The berm walls tie into the rock out crops in four locations. There were not special considerations given to making the interface between the rock outcrops and the granular berms a low permeability pathway. There are likely seepage paths in these areas
- The berm walls appear to be founded on a bedrock floor. There is no evidence that the foundation of the berms was designed to provide a low permeability pathway.
- The bedrock and rock outcrops adjacent to the site show signs of cracking, fissures, and faults. There is potential for seepage to occur through the lagoon floor, and rock outcrop areas through the rock fissures and faults.

5.4 Options for Reduction or Elimination of Exfiltration

A strategy needs to be developed to address the likely seepage paths. Option considered in the development of a strategy are discussed in Table 5.1.

Table 5.1 Options for Remediation

Option	Description	Discussion
Installation of a frozen core to the berm.	The use of frozen core dams is common in both Nunavut and the NWT. The system works by installing a frost susceptible material as the inner core of the berm, and then providing sufficient cover material to protect the frozen core from thawing over the	This option is not considered viable for this site. The existing berms have not been constructed using sufficient compaction to enable the center core of the berm to be excavated. It is unlikely that sufficient fine

Option	Description	Discussion
	summer.	grained material can be located for this type of construction. This option is not carried forward for cost assessment
Installation of an impermeable core	The use of an impermeable core dam is common throughout Canada and the north. A clay core is the most preferred material, however fine material with high silt content can be compacted to provide an acceptable core material	This option is not considered viable for this site. The existing berms have not been constructed using sufficient compaction to enable the center core of the berm to be excavated. It is unlikely that sufficient fine grained material can be located for this type of construction. This option is not carried forward for cost assessment
Installation of a low permeability layer on the inside slope	To achieve an impermeable layer on the inner slope of the berm, a fine grained (including silts and/or clays) is placed and well compacted. The impermeable material acts similar to the impermeable core in providing a low permeability layer.	There is potential to use local material for this application. However enhancing the local material with bentonite would likely provide better results. The use of bentonite is discussed below. See Figure A in Appendix A.
Installation of a low permeability liner on the inside slope	The use of synthetic (HDPE and PVC) and natural (bentonite clay) liners has been used in Nunavut (eg Pond Inlet). The liners can be used throughout the lagoon, including the lagoon base, or only on the berm faces, to provide for a low permeability system.	The use of liners is well understood in the arctic. For this application, a bentonite clay liner is the best application. The liner is not available on site. Mobilization of the liner by air will be expensive. Installation of the liner in 2006 is considered for this option. See Figure B in Appendix A.

5.5 Lining Systems

5.5.1 Granular Clay Liners

GCLs are sandwiched composites of high-swelling sodium bentonite clay needle punched between two geotextiles (at least one non-woven). When hydrated with fresh water under confinement, GCLs become a natural low permeability hydraulic barrier resistant to a wide variety of chemicals. GCLs are used in a broad range of environmental applications for containment including stormwater and sewage lagoon applications.

GCLs are not susceptible to cracking from freeze-thaw action or desiccation. Therefore, the hydraulic integrity is assured with a GCL. The tensile strength of the geotextile components of a GCL allows the GCL to tolerate differential settlements with no loss in sealing ability. The installation of a GCL is also less dependent on the weather as it can be installed in freezing conditions, hot conditions, and in light rain. This is a major benefit when tight construction schedules can not afford a weather delay. However, a GCL can not be installed in heavy rain conditions. The rolls must be protected for moisture until they are installed. A GCL requires a cover layer to provide confinement to provide the required force to allow the swelling action of the bentonite to seal the berm.

5.5.2 Bentonite

Bentonite or drillers mud is highly plastic clay prepared from volcanic ash. When wet, bentonite swells and disperses, filling spaces between the soil particles and decreasing soil permeability. It is best added dry and worked into the soil surface before filling the reservoir/lagoon. It can also be added to the lagoon after filling. The second method usually has less chance of success.

The dry method of bentonite application involves removal of all boulders, rock, obstructions and then grading smooth the soil surface. Large holes are filled and covered with a 150 mm layer of compacted material to increase the interior slopes to 1:3 (H:V). Soil surface is graded and bentonite is broadcast at a rate of 5-10 kg/m^2 . Bentonite is mixed into the soil by tilling to a depth of 75-100 mm. The tilled area is then compacted with the compaction roller. The interior slope is then covered with a protective layer of 100 mm minus granular material to a depth of 1.0 meters.

The wet method of application involves determining the total amount of bentonite required to cover the lagoon sides. This calculation is based on an application rate of 10-20 kg/m^2 (2-4 lb/ft^2). Bentonite is then broadcast on the water surface in the lagoon and mixed thoroughly. The mixing can be done using a pump, air compressor or a motor boat to keep the bentonite in suspension for several days by agitating the water. This method is not as effective as the dry method.

5.6 Increased Lagoon Capacity

To meet the community's sewage generation rate over the next three (3) to five (5) years the lagoon capacity will need to be increased. Two methods of expansion are considered. The first is raising the elevation of the crest of the berms, the second is adding a berm in the middle of the lagoon to provide more retention in the upper area of the lagoon. While on site the use of an additional cell was also reviewed, however, due to the topography of the area, this option is not viable.

6 SAMPLING

6.1 Field Results

The sampling program that was carried out during the initial site visit consisted of grab samples at various sampling points to determine if contaminants were present, and if so, how do these values compare with the regulations that are in place today. The sample results (Figure 6.1) also provide an understanding of the type and extent of biological activity that is occurring throughout the filtration process.

The samples were shipped directly to Enviro-Test Laboratories in Edmonton for analysis. The lab report received from Enviro-Test can be found in Appendix D. The samples were tested for;

- Biochemical Oxygen Demand (BOD5)
- Ammonia
- Total Suspended Solids (TSS)
- Fecal Coliforms

The locations of sampling points were chosen in such a way to acquire data that illustrates the decline in contaminants throughout the filtration process. For this purpose a sampling point was used at the outfall of the wetlands on the ocean shore, a mid slope point in the wetlands, and a location at the base of the lower cells berm. Samples were taken at one location in the lower lagoon and three locations of the upper lagoon to indicate the extent of filtration and mixing.

During the site visit an observation was made on the west slope approaching the upper lagoon that indicated potential seepage from the west berm. The flow was escaping the ground of the west slope as a result of artesian pressure.

Samples were collected at two locations along the flow path of the potential wetlands to be used in Phase II of the project. These samples were taken simply for background data.

The last samples were collected within the Solid Waste Land Fill site. The first was a grab sample from the main channel of runoff leaving the site. The second was from a ponding area centrally located within the landfill site.

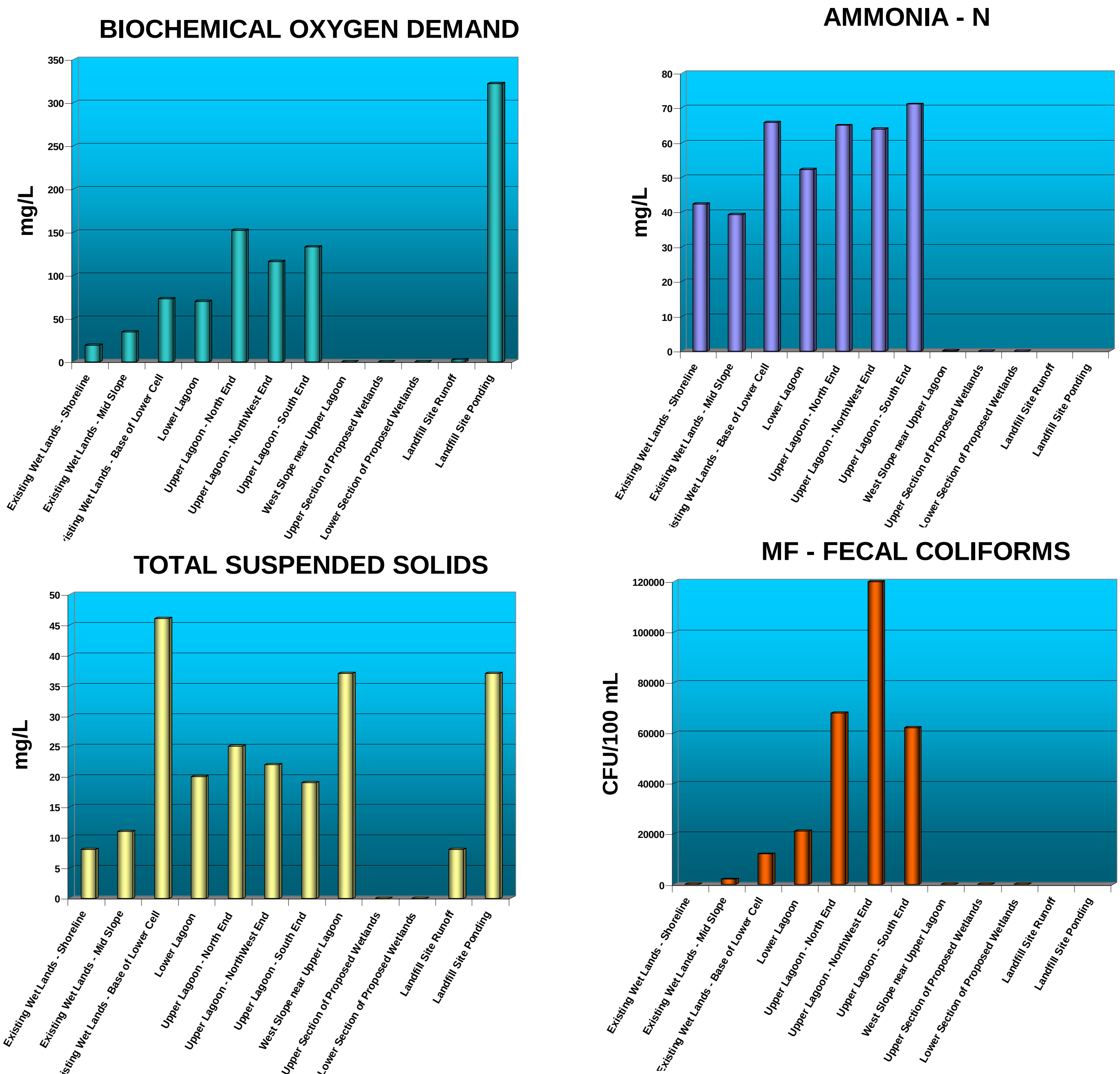


Figure 6.1 Analytical Results from Field Sampling

6.2 Sampling Program

6.2.1 Operations

To ensure that construction accomplishes the desired goal, an ongoing sampling program should be implemented. This program will be developed and implemented during the first phase of the project with longer term ongoing sampling projected for the second phase of the project. As recommended in the terms of reference issued by CGS and Dillon, a local member of the community will be trained on the proper operation and procedure methods used in a sound sampling program. This includes quality and safety training that will ensure the highest quality data.

6.2.2 Analysis

All samples will undergo the same analysis to ensure that seepage is minimized and aeration is occurring throughout the flow path of the wetlands. Once collected the samples will be shipped and undergo the same analysis. This includes the following test;

- Biochemical Oxygen Demand (BOD5)
- Fecal Coliforms
- Total Suspended Solids (TSS)
- Ammonia

6.2.3 Sample Points

Sample collection locations will follow practice and locations used during the initial site visit. It is critical from a quality perspective that sample collection be performed from an area of lower concentration to an area of higher concentration of contaminants; therefore, a sample will be collected in the following locations respectively;

1st. Ocean Outfall – This includes a moderate flowing location near the end of the existing wetlands.
2nd. Mid slope of Wetlands – One of the few ponding areas near the midpoint of the wetlands.
3rd. Base of Lower Berm – Any point below the lower lagoon's berm that will give a good indication of filtration when compared to upstream samples.
4th. Lower Lagoon – Similar to the base of the lower berm sample, this point will give a good indication of filtration when compared with the upper lagoon's results.
5th. Two Locations within Upper Lagoon – These two samples can be collected from the north and south end of the lagoon to ensure mixing is occurring.

6.2.4 Schedule & Cost

The samples will be collected and analyzed on a bi-monthly basis. With holding times for BOD and Coliform samples of forty-eight hours (48 hrs), it is important that scheduling of sampling coincides with First Air Cargo's schedule. This includes flights at 15:25 on Tuesday's, Wednesday's, Friday's, Saturday's, and Sunday's. All samples will be shipped to;

Enviro-Test Laboratories
Edmonton Office
Attn: Sample Receiving
9936-67th Avenue
Edmonton, AB T6E 0P5

Table 6.1 lists costs associated with the program's analysis.

Table 6.1 Lab Analysis Costs

Parameter	Analytical Cost*
BOD_5	$37.50
Fecal coliforms	$22.50
Total suspended solids	$13.50
Ammonia	$15.00
Disposal Fee per Sampling Location	$1.50

*Based on prices from Enviro-Test Laboratories in Edmonton.

For 6 samples, the total cost would be: $540 + GST + Shipping
Shipping Cost for cargo of this nature per shipment from Kugaaruk to Edmonton is approximately $150

For bi-monthly samples on all sample points during water flow season (May – October) and under ice samples on just two lagoon sites completed monthly (November – April) over 3 years, the total cost would be: $30,780 + GST

6.2.5 Equipment

Sample bottles and coolers will be sent to the community by Enviro-Test Laboratories. Proper Health and Safety equipment will include latex gloves for each sample location and rubber boots.

7 SUMMARY & CONCLUSION

The intention of this document, as mentioned, is to document the preliminary design process and to use as a decision-making document. The results contained here-in reveal the precedence of modifying the existing berms of the sewage lagoon system to minimize exfiltration. The modification and design work for the other waste treatment facilities will be addressed in the second phase of the project.

The modified sewage treatment system will be designed for a three (3) year life span (2006-2008). Predicted population values until the year 2020 were provided by Nunavut Bureau of Statistics (Appendix C). The population for 2008 was predicted to be 719 persons. Based on this information, the lagoon will be designed to treat 27 525 m^3, the annual sewage volume for a population of 719 persons.

Kugaaruk trucked sewage is assumed to have the following characteristics:

- Average raw Biochemical Oxygen Demand (BOD_5) concentration of 625 mg/L
- Average raw suspended solids (SS) concentration of 900 mg/L

The lagoon treatment system will be designed to meet the following effluent criteria:

- 45 mg/L BOD_5
- 45 mg/L SS
- 10^4 Fecal Coliform / 100mL

The annual retention lagoon will be constructed with (near) rectilinear dimensions to promote plug flow conditions. Plug flow conditions are important during the time of annual discharge in order to prevent short circuiting, or raw sewage by-passing treatment and directly discharging to the ocean. The lagoon will be constructed to facilitate anaerobic sewage treatment (at full capacity) using the following characteristics:

- 4.5 m liquid operating depth at the deepest point
- 0.5 m of allowance on the lagoon bottom for sludge accumulation

The size of the lagoon was determined to accommodate the above design parameters and the predicted volume of sewage generated in 2008 (27 525 m^3). The parameters of the lagoon are:

- Existing volume of 16 173 m^3
- Additional Volume of 12 000 m^3 when both the north and west berms are raised.[4]

[4] This volume is estimated by following the twenty six meter (26 m) contour line around the lagoon and then multiplying by a one meter (1 m) depth.

- New volume at full capacity of 28 173 m^3.

Drawings A through E shows various designs alternatives and volume calculations to be used in the decision process of Phase I. This includes;

- Design alternatives for berm modifications with and without a liner system,
- Contour details of the main lagoon used for an existing volume calculation of 16 173 m^3,
- Trapezoidal area and volume calculations for required fill material equal to 4,991.2 m3 for the north berm and 1,105.15 m3 for the west berm
- The liner will be keyed into the base to a depth of 1.5 meters. Bentonite will be used to provide a low permeability barrier at the fill to cut section.

The estimated cost of construction for the proposed system in the first phase is shown in the table below. An additional cost estimate is included without a liner and sampling program as well as an alternative long-term option of blasting to increase the volume.

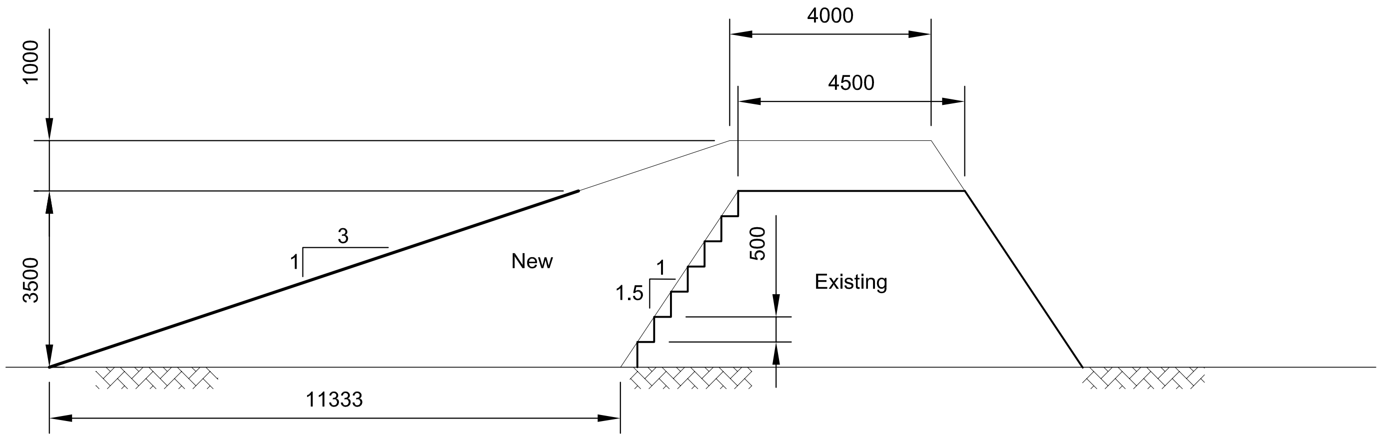
Table 7.1 Cost Estimates

Item	Units	Quantity	Unit Cost	Total Cost
Phase I Estimate				
Materials				
Fill (trucked and placed)	M3	6,100	$40	$244,000
Bentonite	Bag	600	$70	$42,000
Liner	M2	2,700	$20	$54,000
Equipment				
Decanting Pump	Pump	1	$10,000	$10,000
Sampling				
Three year sampling program	N/A	N/A	N/A	$31,000
Subtotal				$400,000
Engineering	10%			$40,000
Contingency	20%			$88,000
GST	7%			$30,800
Total				**$558,800**

Item	Units	Quantity	Unit Cost	Total Cost
Phase I Estimate (Without Liner & Sampling Program)				
Materials				
Fill (trucked and placed)	M3	6,100	$40	$244,000
Bentonite	Bag	600	$70	$42,000
Equipment				
Decanting Pump	Pump	1	$10,000	$10,000
Subtotal				$296,000
Engineering	10%			$29,600
Contingency	20%			$65,120
GST	7%			$22,792
Total				**$413,512**
Phase I Estimate (With Volume Addition Blasting)				
Materials				
Fill (trucked and placed)	M3	6,100	$40	$244,000
Bentonite	Bag	600	$70	$42,000
Liner	M2	2,700	$20	$54,000
Equipment				
Decanting Pump	Pump	1	$10,000	$10,000
Sampling				
Three year sampling program	N/A	N/A	N/A	$31,000
Blasting				
Blast rock from lagoon bottom	M3	20,000	$100	$2,000,000
Subtotal				$2,381,000
Engineering	10%			$238,100
Contingency	20%			$523,820
GST	7%			$183,337
Total				**$3,326,257**

APPENDIX A

Drawings & Calculations

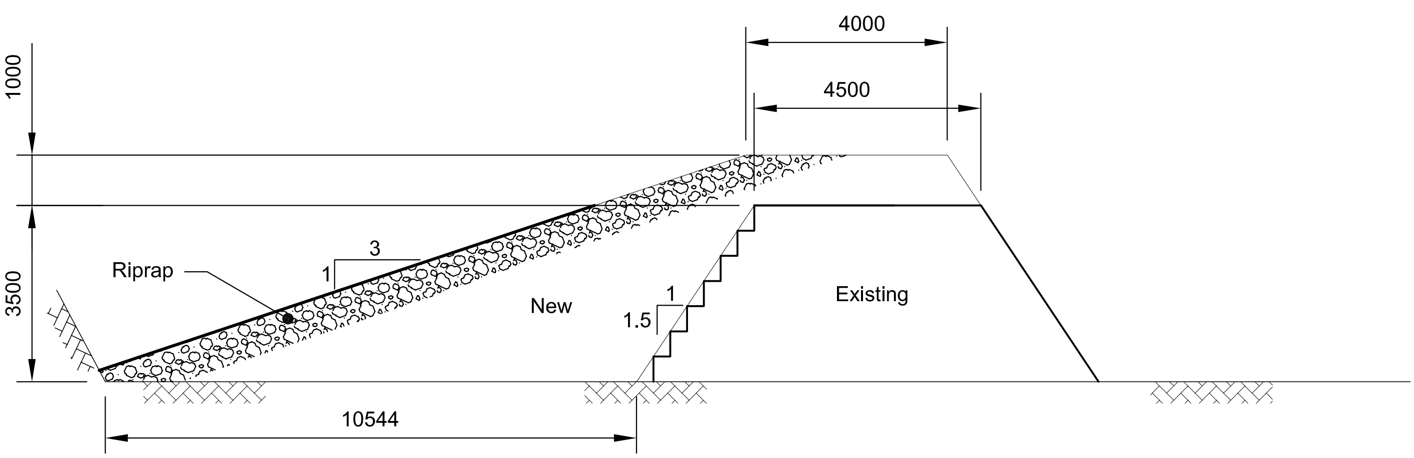


Option A:
Build impermeable inside slope on front of main cell wall
- Step/bench existing berm
- Build inside berm @ 3:1
- 4m top of berm

EDIT DATE: 25.07.2005 PLOT DATE: 41tpw 25.07.2005 ACAD FILE: 41tpw g:\cad\054755\options.dwg

DILLON CONSULTING

PROJECT	Hamlet of Kugaaruk Waste Treatment Facility
TITLE	Main Berm Upgrade Option A
PROJECT NUMBER	05-4755
DATE	July 2005
FIGURE NUMBER	A



Option B:
Build impermeable inside slope on front of main cell wall

- Step/bench existing berm
- Build inside berm @ 3:1
- 4m top of berm
- Line with GCL
- Place protective layer (riprap)

EDIT DATE: 25.07.2005 PLOT DATE: 41tpw 25.07.2005 ACAD FILE: 41tpw g:\cad\054755\options.dwg

DILLON CONSULTING

PROJECT	PROJECT NUMBER
Hamlet of Kugaaruk Waste Treatment Facility	05-4755
TITLE	DATE
Main Berm Upgrade Option B	July 2005
	FIGURE NUMBER
	B

Pond Storage Capacity:
with 0.5m freeboard at elevation 25.5m.
22.0m floor elevation.
16173m^3

EDIT DATE: 25.07.2005 PLOT DATE: 41tpw 25.07.2005 ACAD FILE: 41tpw g:\cad\054755\pond\pond.dwg

DILLON CONSULTING

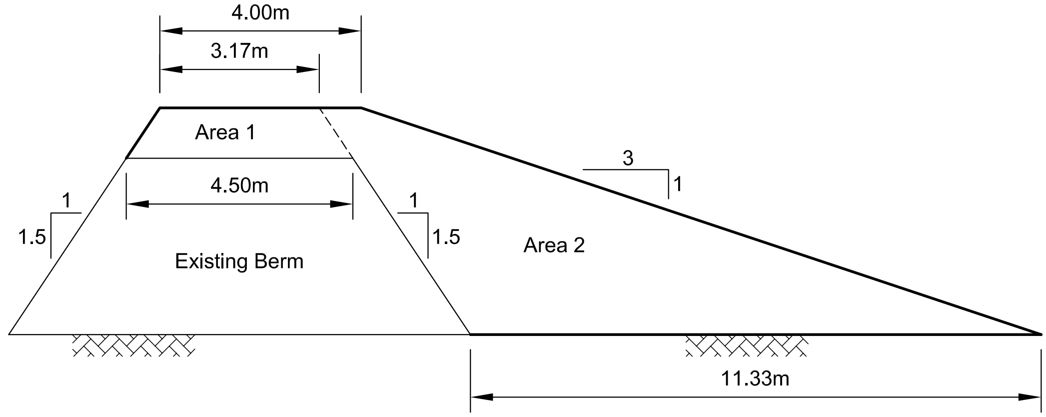
PROJECT

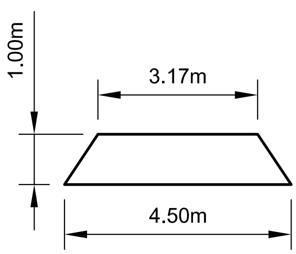
Hamlet of Kugaaruk
Waste Treatment Facility

TITLE

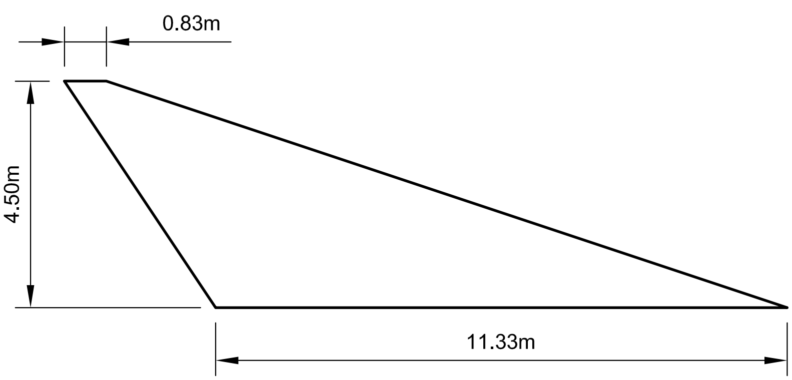
Pond Volume Calculation

PROJECT NUMBER	05-4755
DATE	July 2005
FIGURE NUMBER	C





Area 1



Area 2

Area $= \frac{1}{2}(4.5m + 3.17m) \times 1.0$

$= 3.835m^2$

Area $= \frac{1}{2}(11.33m + 0.83m) \times 4.5$

$= 27.36m^2$

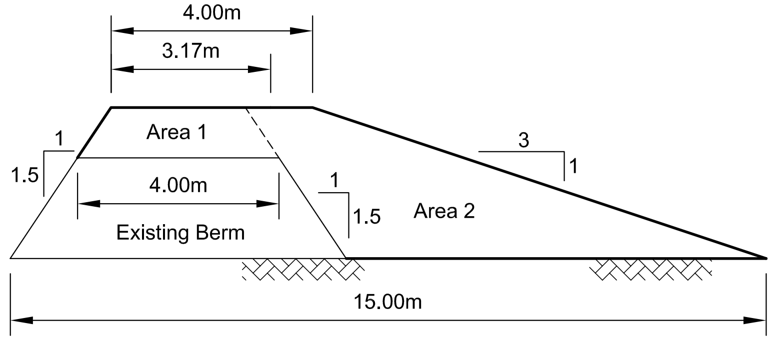
Volume of New Material:
Length of Berm = 160m
Total area of New Sections $= 3.835m^2 + 27.36m^2 = 31.195m^2$
Volume of New Material $= 160m \times 31.195m^2$

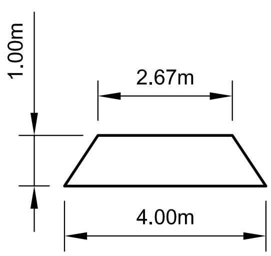
$= \boxed{4{,}991.2m^3}$

EDIT DATE: 25.07.2005 PLOT DATE: 41tpw 25.07.2005 ACAD FILE: 41tpw g:\cad\054755\options.dwg

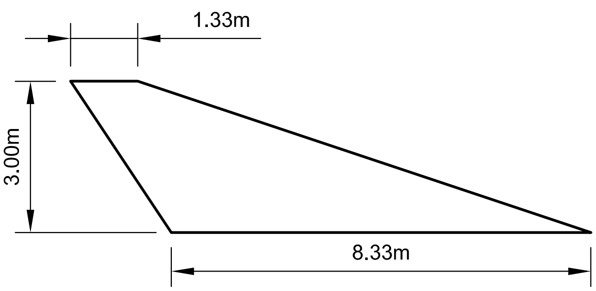
DILLON CONSULTING

PROJECT	PROJECT NUMBER
Hamlet of Kugaaruk Waste Treatment Facility	05-4755
	DATE July 2005
TITLE Material for North Berm	FIGURE NUMBER D





Area 1



Area 2

$$\text{Area} = \tfrac{1}{2}(4.0\text{m} + 2.67\text{m}) \times 1.0$$
$$= 3.335\text{m}^2$$

$$\text{Area} = \tfrac{1}{2}(8.33\text{m} + 1.33\text{m}) \times 3.0$$
$$= 14.49\text{m}^2$$

Volume of New Material:
Length of Berm = 62m
Total area of New Sections = $3.335\text{m}^2 + 14.49\text{m}^2 = 17.825\text{m}^2$
Volume of New Material = $62\text{m} \times 17.825\text{m}^2$

$$= \boxed{1{,}105.15\text{m}^3}$$

EDIT DATE: 25.07.2005 PLOT DATE: 41tpw 25.07.2005 ACAD FILE: 41tpw g:\cad\054755\options.dwg

DILLON CONSULTING

PROJECT
Hamlet of Kugaaruk
Waste Treatment Facility

TITLE
Material for West Berm

PROJECT NUMBER 05-4755
DATE July 2005
FIGURE NUMBER E

APPENDIX B

New Kudlik Survey of Sewage Treatment Area

Kudlik Survey of Kugaaruk Sewage Treatment Area performed on July 21, 2005

POINTS	X	Y	Z	DESCRIPTION
STA 1	4873.435	4284.044	26.218	STATION
1	4863.381	4268.410	24.256	water inside upper lagoon
2	4882.279	4286.104	24.259	water inside upper lagoon
3	4845.144	4238.864	24.219	water inside upper lagoon
4	4913.810	4280.371	24.257	water inside upper lagoon
5	4861.731	4219.083	24.223	water inside upper lagoon
6	4936.046	4260.151	24.403	water inside upper lagoon
7	4885.014	4225.459	24.303	water inside upper lagoon
8	4954.537	4249.029	24.324	water inside upper lagoon
9	4903.644	4210.337	24.269	water inside upper lagoon
10	4901.876	4198.992	24.314	water inside upper lagoon
11	4971.597	4241.369	24.251	water inside upper lagoon
12	4922.900	4174.026	24.246	water inside upper lagoon
13	4954.172	4201.419	24.317	water inside upper lagoon
14	4918.244	4282.455	26.160	DIKE
15	4946.508	4153.100	26.519	DIKE
16	4918.986	4285.374	26.174	DIKE
17	4940.864	4149.250	26.519	DIKE
18	4899.973	4290.130	26.123	DIKE
19	4927.008	4159.109	25.823	DIKE
20	4929.241	4162.508	25.884	DIKE
21	4898.878	4286.643	26.181	DIKE
22	4881.518	4288.262	25.950	DIKE
23	4880.550	4292.154	26.048	DIKE
24	4915.662	4176.279	25.680	DIKE
25	4912.654	4174.314	25.719	DIKE
26	4910.213	4172.904	24.423	DIKE
27	4921.099	4160.845	24.649	DIKE
28	4930.958	4153.555	25.207	DIKE
29	4919.125	4286.537	25.407	DIKE
30	4905.705	4193.781	25.477	DIKE
31	4903.564	4191.771	25.536	DIKE
32	4902.820	4190.135	24.420	DIKE
33	4880.808	4295.667	25.316	DIKE
34	4865.919	4212.406	26.029	DIKE
35	4863.617	4209.829	26.085	DIKE
36	4865.051	4282.603	25.274	DIKE
37	4862.583	4209.085	25.082	DIKE
38	4866.199	4281.125	26.026	DIKE
39	4868.636	4278.487	26.162	DIKE
40	4852.514	4223.486	26.069	DIKE
41	4850.163	4220.459	26.077	DIKE
42	4848.840	4219.334	24.499	DIKE
43	4856.309	4263.804	25.958	DIKE
44	4853.376	4266.242	25.881	DIKE
45	4851.477	4267.940	25.188	DIKE
46	4844.520	4231.407	26.055	DIKE

47	4837.500	4233.907	26.139	DIKE
48	4834.864	4231.459	24.592	DIKE
49	4841.538	4253.724	25.143	DIKE
50	4843.335	4235.656	26.153	DIKE
51	4843.642	4252.366	25.930	DIKE
52	4846.686	4250.635	26.041	DIKE
53	4844.312	4244.278	26.174	DIKE
54	4840.681	4245.820	26.102	DIKE
55	4837.390	4247.691	24.027	DIKE
56	4887.182	4298.224	23.549	DIKE
57	4876.925	4305.118	21.501	DIKE
58	4868.639	4296.589	21.079	DIKE
59	4859.946	4284.423	21.949	DIKE
60	4850.669	4276.086	21.027	DIKE
61	4843.263	4266.085	22.070	DIKE
62	4836.022	4254.717	22.400	DIKE
63	4853.266	4336.327	18.649	DIKE
64	4847.921	4337.676	18.574	DIKE
65	4846.060	4338.471	17.398	DIKE
66	4848.116	4327.870	18.684	DIKE
67	4843.421	4341.710	17.224	DIKE
68	4844.699	4332.503	18.654	DIKE
69	4842.687	4343.433	15.899	DIKE
70	4843.297	4333.884	17.111	DIKE
71	4840.188	4351.556	16.094	DIKE
72	4836.782	4335.367	16.730	DIKE
73	4829.669	4347.670	15.162	DIKE
74	4835.072	4336.779	15.672	DIKE
75	4820.449	4336.443	15.226	DIKE
76	4829.923	4319.189	18.365	DIKE
77	4826.708	4331.677	15.752	DIKE
78	4827.228	4324.059	18.176	DIKE
79	4826.871	4330.353	16.327	DIKE
80	4828.459	4328.079	16.282	DIKE
81	4823.482	4319.118	18.237	DIKE
82	4821.270	4320.902	16.211	DIKE
83	4815.574	4323.277	15.215	DIKE
84	4825.805	4306.288	18.477	DIKE
85	4821.362	4307.529	18.405	DIKE
86	4796.019	4309.493	14.244	DIKE
87	4806.083	4307.925	14.941	DIKE
88	4825.285	4297.024	18.541	DIKE
89	4818.442	4305.892	16.252	DIKE
90	4820.405	4297.888	18.425	DIKE
91	4818.749	4298.762	16.878	DIKE
92	4818.837	4289.159	16.858	DIKE
93	4821.639	4288.739	18.533	DIKE
94	4826.087	4290.597	17.657	water inside lower lagoon
95	4854.391	4334.966	17.547	water inside lower lagoon
96	4838.889	4288.774	17.581	water inside lower lagoon
97	4844.524	4324.691	17.487	water inside lower lagoon

98	4846.114	4297.451	17.600	water inside lower lagoon
99	4831.277	4319.158	17.502	water inside lower lagoon
100	4827.225	4308.854	17.597	water inside lower lagoon
101	4853.289	4310.610	17.602	water inside lower lagoon
102	4860.451	4318.442	17.547	water inside lower lagoon
103	4825.865	4292.194	17.505	water inside lower lagoon
104	4861.594	4330.440	17.560	water inside lower lagoon
105	4839.375	4362.382	16.441	Wet land towards the ocean shore
106	4790.465	4301.217	14.572	Wet land towards the ocean shore
107	4828.145	4351.794	14.744	Wet land towards the ocean shore
108	4793.600	4314.266	13.526	Wet land towards the ocean shore
109	4819.794	4343.303	14.377	Wet land towards the ocean shore
110	4801.025	4320.899	14.291	Wet land towards the ocean shore
111	4817.708	4340.343	16.330	Wet land towards the ocean shore
112	4809.323	4327.878	14.687	Wet land towards the ocean shore
113	4813.387	4333.647	15.317	Wet land towards the ocean shore
114	4802.558	4336.435	12.682	Wet land towards the ocean shore
115	4797.458	4331.759	12.564	Wet land towards the ocean shore
116	4804.131	4337.582	14.541	Wet land towards the ocean shore
117	4795.404	4329.455	13.630	Wet land towards the ocean shore
118	4815.249	4344.560	15.222	Wet land towards the ocean shore
119	4788.990	4322.541	13.036	Wet land towards the ocean shore
120	4813.368	4348.189	13.528	Wet land towards the ocean shore
121	4783.139	4315.310	12.408	Wet land towards the ocean shore
122	4821.037	4356.483	14.223	Wet land towards the ocean shore
123	4778.105	4309.482	11.634	Wet land towards the ocean shore
124	4827.917	4365.447	15.512	Wet land towards the ocean shore
125	4773.508	4303.368	11.573	Wet land towards the ocean shore
126	4820.490	4374.899	13.965	Wet land towards the ocean shore
127	4763.157	4310.499	10.868	Wet land towards the ocean shore
128	4812.754	4368.340	14.532	Wet land towards the ocean shore
129	4769.816	4318.143	9.968	Wet land towards the ocean shore
130	4810.560	4366.959	13.055	Wet land towards the ocean shore
131	4776.746	4324.171	11.267	Wet land towards the ocean shore
132	4802.237	4363.748	11.285	Wet land towards the ocean shore
133	4782.800	4330.920	12.012	Wet land towards the ocean shore
134	4793.187	4354.009	11.289	Wet land towards the ocean shore
135	4784.197	4336.948	10.981	Wet land towards the ocean shore
136	4790.379	4351.798	10.245	Wet land towards the ocean shore
137	4783.950	4340.966	10.323	Wet land towards the ocean shore
138	4784.897	4356.486	9.550	Wet land towards the ocean shore
139	4775.832	4340.859	8.878	Wet land towards the ocean shore
140	4779.191	4349.162	9.097	Wet land towards the ocean shore
141	4768.073	4331.342	8.634	Wet land towards the ocean shore
142	4785.803	4361.676	9.500	Wet land towards the ocean shore
143	4761.341	4324.430	8.604	Wet land towards the ocean shore
144	4790.991	4362.855	11.301	Wet land towards the ocean shore
145	4756.120	4316.381	8.511	Wet land towards the ocean shore
146	4800.046	4372.248	10.987	Wet land towards the ocean shore
147	4750.984	4310.809	8.535	Wet land towards the ocean shore
148	4807.175	4375.743	12.670	Wet land towards the ocean shore

149	4744.887	4305.514	8.705	Wet land towards the ocean shore
150	4800.911	4390.723	12.368	Wet land towards the ocean shore
151	4797.021	4393.267	12.107	Wet land towards the ocean shore
152	4725.464	4305.764	8.207	Wet land towards the ocean shore
153	4787.640	4384.936	10.779	Wet land towards the ocean shore
154	4727.981	4316.589	8.026	Wet land towards the ocean shore
155	4775.150	4375.729	9.660	Wet land towards the ocean shore
156	4734.095	4327.434	7.862	Wet land towards the ocean shore
157	4766.253	4361.923	8.749	Wet land towards the ocean shore
158	4738.461	4337.152	7.156	Wet land towards the ocean shore
159	4747.187	4344.589	8.054	Wet land towards the ocean shore
160	4752.844	4357.479	7.985	Wet land towards the ocean shore
161	4752.339	4368.918	8.029	Wet land towards the ocean shore
162	4730.596	4356.615	6.425	Wet land towards the ocean shore
163	4753.864	4384.007	8.224	Wet land towards the ocean shore
164	4719.925	4345.586	6.320	Wet land towards the ocean shore
165	4764.264	4396.205	9.895	Wet land towards the ocean shore
166	4712.163	4331.207	7.594	Wet land towards the ocean shore
167	4745.543	4388.732	9.556	Wet land towards the ocean shore
168	4703.820	4318.408	8.389	Wet land towards the ocean shore
169	4741.102	4385.382	7.029	Wet land towards the ocean shore
170	4733.848	4395.091	9.675	Wet land towards the ocean shore
171	4690.722	4330.148	8.593	Wet land towards the ocean shore
172	4700.203	4344.869	7.714	Wet land towards the ocean shore
173	4723.837	4405.783	6.687	Wet land towards the ocean shore
174	4704.278	4353.813	5.754	Wet land towards the ocean shore
175	4714.027	4366.587	5.218	Wet land towards the ocean shore
176	4726.494	4389.826	4.267	Wet land towards the ocean shore
177	4719.405	4376.291	4.876	Wet land towards the ocean shore
178	4713.962	4404.114	2.879	Wet land towards the ocean shore
179	4701.531	4385.822	4.101	Wet land towards the ocean shore
180	4704.807	4396.437	3.016	Wet land towards the ocean shore
181	4692.592	4377.180	4.953	Wet land towards the ocean shore
182	4694.457	4401.104	2.685	Wet land towards the ocean shore
183	4682.218	4368.400	5.131	Wet land towards the ocean shore
184	4701.820	4407.209	2.406	Wet land towards the ocean shore
185	4707.523	4409.069	2.572	Wet land towards the ocean shore
186	4690.126	4390.885	4.152	Wet land towards the ocean shore
187	4687.709	4404.096	2.908	Wet land towards the ocean shore
188	4693.652	4415.229	1.749	Wet land towards the ocean shore
189	4695.427	4422.033	1.472	ocean shore shore
190	4687.994	4420.403	1.383	ocean shore
191	4649.519	4426.284	1.583	ocean shore
192	4661.125	4431.052	1.481	ocean shore
193	4662.367	4408.471	5.897	Bedrock (outcrop)
194	4678.779	4393.536	5.769	Bedrock (outcrop)
195	4662.473	4384.474	5.350	Bedrock (outcrop)
196	4671.428	4379.139	6.343	Bedrock (outcrop)
197	4630.489	4377.049	1.575	ocean shore
198	4634.652	4396.032	1.548	ocean shore
199	4648.457	4423.434	1.630	ocean shore

200	4702.185	4423.395	1.588	ocean shore
201	4706.238	4434.030	1.744	ocean shore
202	4721.030	4467.191	1.700	ocean shore
203	4720.299	4440.714	5.950	Bedrock (outcrop)
204	4731.021	4416.649	8.475	Bedrock (outcrop)
205	4743.937	4400.237	10.190	Bedrock (outcrop)

APPENDIX C

Nunavut: Community Population Projections

APPENDIX D

Enviro-Test Field Sample Laboratory Results

EnviroTest LABORATORIES

PRELIMINARY RESULTS

DILLON LIMITED
ATTN: ROB KUTA
PO BOX 1409
YELLOWKNIFE NT X1A 2P1

DATE: 13-JUL-05 11:32 AM

Lab Work Order #: L284184 **Sampled By:** RK **Date Received:** 06-JUL-05

Project P.O. #:

Project Reference: 05_4755_1000

Comments:

DOUG JOHNSON
Director of Operations, Edmonton

RACHEL JONES
Account Manager

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L284184-1 20050705_05_4755_WL1 WETLANDS OCEAN								
Sample Date: 05-JUL-05 10:30								
Matrix: SEWAGE								
Ammonia-N	42.3		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	19		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	90		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	8		3	mg/L		07-JUL-05	SVG	R300750
L284184-2 20050705_05_4755_WL2 WESTLANDS MIDSLOPE								
Sample Date: 05-JUL-05 10:35								
Matrix: SEWAGE								
Ammonia-N	39.3		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	34		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	2000		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	11		3	mg/L		07-JUL-05	SVG	R300750
L284184-3 20050705_05_4755_WL3 WETLANDS LOWER B								
Sample Date: 05-JUL-05 10:40								
Matrix: SEWAGE								
Ammonia-N	65.7		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	73		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	12000		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	46		3	mg/L		07-JUL-05	SVG	R300750
L284184-4 20050705_05_4755LC1 LOWER CELL								
Sample Date: 05-JUL-05 10:45								
Matrix: SEWAGE								
Ammonia-N	52.2		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	70		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	21000		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	20		3	mg/L		07-JUL-05	SVG	R300750
L284184-5 20050705_05_4755_UC1 UPPER CELL NORTH								
Sample Date: 05-JUL-05 10:50								
Matrix: SEWAGE								
Ammonia-N	64.9		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	152		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	68000		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	25		3	mg/L		07-JUL-05	SVG	R300750
L284184-6 20050705_05_4755_UC2 UPPER CELL NORTH WATER								
Sample Date: 05-JUL-05 10:55								
Matrix: SEWAGE								
Ammonia-N	63.9		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	116		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	120000		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	22		3	mg/L		07-JUL-05	SVG	R300750
L284184-7 20050705_05_4755_UC3 UPPER CELL SOUTH								
Sample Date: 05-JUL-05 11:00								
Matrix: SEWAGE								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L284184-7 20050705_05_4755_UC3 UPPER CELL SOUTH								
Sample Date: 05-JUL-05 11:00								
Matrix: SEWAGE								
Ammonia-N	71.0		0.05	mg/L		07-JUL-05	WNG	R300756
Biochemical Oxygen Demand	133		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	62000		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	19		3	mg/L		07-JUL-05	SVG	R300750
L284184-8 20050705_05_4755_WSI1 WEST SLOPE UPPER CELL								
Sample Date: 05-JUL-05 11:05								
Matrix: SEWAGE								
Ammonia-N	0.06		0.05	mg/L		06-JUL-05	WNG	R300309
Biochemical Oxygen Demand	<2		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	<1		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	37		3	mg/L		07-JUL-05	SVG	R300750
L284184-9 20050705_05_4755_PWL1 UPPER PROPOSED WET LAND								
Sample Date: 05-JUL-05 14:10								
Matrix: WATER								
Ammonia-N	<0.05		0.05	mg/L		06-JUL-05	WNG	R300309
Biochemical Oxygen Demand	<2		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	<1		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	<3		3	mg/L		07-JUL-05	SVG	R300750
L284184-10 20050705_05_4755_PWL2 LOWER PROPOSED WET LAND								
Sample Date: 05-JUL-05 14:15								
Matrix: WATER								
Ammonia-N	<0.05		0.05	mg/L		06-JUL-05	WNG	R300309
Biochemical Oxygen Demand	<2		2	mg/L		06-JUL-05	FY	R301814
MF - Fecal Coliforms	<1		1	CFU/100mL		08-JUL-05	PB	R302425
Total Suspended Solids	<3		3	mg/L		07-JUL-05	SVG	R300750
L284184-11 20050705_05_4755_LF1 LANDFILL RUNOFF								
Sample Date: 05-JUL-05 11:10								
Matrix: WATER								
Biochemical Oxygen Demand	2		2	mg/L		06-JUL-05	FY	R301814
Total Suspended Solids	8		3	mg/L		07-JUL-05	SVG	R300750
L284184-12 20050705_05_4755_LF2 LANDFILL PONDING								
Sample Date: 05-JUL-05 11:15								
Matrix: WATER								
Biochemical Oxygen Demand	322		2	mg/L		06-JUL-05	FY	R301814
Total Suspended Solids	37		3	mg/L		07-JUL-05	SVG	R300750
L284184-13 BLANK COOLER 1 CONT. CONTROL								
Sample Date: 05-JUL-05 13:00								
Matrix: WATER								
MF - Fecal Coliforms	<1		1	CFU/100mL		08-JUL-05	PB	R302425

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L284184-14 BLANK COOLER 2 CONT. CONTROL Sample Date: 05-JUL-05 13:00 Matrix: WATER								
MF - Fecal Coliforms	<1		1	CFU/100mL		08-JUL-05	PB	R302425

Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BOD-ED	Water	Biochemical Oxygen Demand (BOD)		APHA 5210 B-5 day Incub.-O2 electrode
FCC-MF-PB	Water	Fecal Coliform Count-MF		APHA 9222D MF
NH4-ED	Water	Ammonia-N		APHA4500NH3F Colorimetry
SOLIDS-TOTSUS-ED	Water	Total Suspended Solids		APHA 2540 D-Gravimetric

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

204285 204286

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
ED	Enviro-Test Laboratories - Edmonton, Alberta, Canada	PB	PBR LABARATORIES

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
< - Less than
D.L. - Detection Limit
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.