Detailed Design Report for the Improvements to the Water Reservoir, Sewage Lagoon, and Solid Waste Disposal Facility The Hamlet of Qikiqtarjuaq, Nunavut

Prepared by

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File No: N-O 09439.0

Table of Contents

Figures

Appendices

1.0 Introduction

The Department of Community and Government Services, Government of Nunavut (GN-CGS) retained Nuna Burnside Engineering and Environmental Ltd. (Nuna Burnside) to undertake the evaluation of and the design of remediation and/or replacement of the water reservoir, sewage lagoon, and solid waste disposal facility for the Hamlet of Qikiqtarjuaq, Nunavut. Nuna Burnside was retained on June 23, 2005 to complete this work as outlined in our proposal dated May 2005. We undertook a three-day site visit both in July and September of 2005 for the purpose of gathering information through site investigations in order to complete the Schematic Design Report and Geotechnical Evaluation. The Final Schematic Design Report for this project was submitted to the GN-CGS on September 7, 2005. Approval to move forward with this project and to complete the detailed design of these facilities was provided by Mr. Brian Duguay, Project Officer with the GN-CGS by email on December 22, 2005 (Appendix A).

The purpose of this Detailed Design Report is to expand upon the selected alternatives outlined in the Final Schematic Design Report (Schematic Design Report). Upon acceptance by the GN-CGS, this Design Report, along with the Operations and Maintenance Plans for each of the facilities and the Canadian Environmental Assessment Act (CEAA) Screening Report included in the appendices, will be submitted for regulatory approvals. This Detailed Design Report and Design Drawings will also serve as the basis for the preparation of documents for the Tender of the construction phase.

1.1 Scope of Work

The scope of work that corresponds to the preparation of the Detailed Design Report includes:

- Take part in reviews of the Schematic Design Report and develop detailed designs of the selected preferred alternative for each facility based on these reviews
- Prepare all necessary documentation necessary to explain the proposed detailed design to all involved individuals; the detailed design to consist of drawings, specifications, and other relevant documents
- Coordinate work with authorities and agencies having jurisdiction
- Prepare and present a Class “B” cost estimate.

1.2 Changes to the Scope

Revising design report and final design to incorporate an adjustment to the design period to 2027.

1.3 Purpose

As stated in the Terms of Reference (TOR), the immediate priorities for the Hamlet are to ensure that ample safe drinking water is available to the community. Furthermore, the community would like to implement improved waste management strategies that will comply with applicable laws, and will comply with foreseeable legislated amendments. This document is intended to provide the Hamlet and the GN-CGS with the design of upgrades and/or addition of new facilities to meet these goals over a 20-year planning period.

1.4 Description of Selected Preferred Alternatives

A schematic design report was prepared for the Hamlet, which outline options to expand, replace the water supply, sewage disposal, and solid water disposal infrastructure that would meet the needs of the community over a 20 year planning period.

The water supply and storage options presented included:

- Maintain status quo – not acceptable, as it does not meet the future needs
- Three (3) options to provide additional storage but maintain the current level of service (trucked water system).

The sewage treatment and disposal options presented included:

- Maintain status quo – not acceptable, as it does not meet the future needs
- Two (2) options to provide additional storage and treatment but maintain the current level of service (trucked sewage system).

The solid waste disposal options presented included:

- Maintain status quo – not acceptable, as it does not meet the future needs
- Two (2) options to expand/replace the solid waste facilities to meet the 20 year projected needs of the community were evaluated.

The Schematic Design Report was presented to the Hamlet and the GN-CGS. Following the presentation and further evaluation of the options, Nuna Burnside received authorization to proceed with the detailed design for:

- **Water – Option #3:** Expand the existing reservoir towards the community, so that the total volume of the reservoir would provide the necessary capacity to meet the 20 year demand presented in the report.

- **Sewage – Option #2:** Construct a second sewage lagoon adjacent to the existing lagoon, to provide the necessary capacity to meet the 20 year sewage volumes presented in the report.

- **Solid Waste – Option #2:** Remediation of the existing facility and continued operation at the same site.

During the Detailed Design, Nuna Burnside was authorized to update the 20 year projections using the projected 2007 population, when the works are anticipated to be completed, as the base year.

This also required revising the design to accommodate the increased water demands and sewage volumes. The reservoir volume was also revised to include 360 m^3 of storage for fire protection. It was also determined that the existing truck fill pumps would need to be replaced with pumps capable of providing a minimum flow to the trucks of 1,000 L/m into transfer water to the community for use in fighting a fire.

1.5 Outline of Detailed Design Report

Section 1 – Provides an introduction to the project, a description of the scope of work involved and briefly summarizes the selected preferred alternatives.

Section 2 – Summarizes the pertinent background information from previous reports, provides a description of the community, discusses historical climate data, presents historical and projected population data, defines common design criteria for the three facilities, and discusses the agency review process.

Section 3 – Summarizes the existing water storage and treatment facility including a synopsis of concerns identified in the Schematic Design Report and describes in detail the design of the selected preferred alternative.

Section 4 – Outlines the existing sewage storage and treatment system with a summary of its condition based on the site assessments. Furthermore, this section presents the anticipated effluent discharge criteria, and the treated effluent parameters prior to discharge from the lagoon. Section 4 also describes the details of an additional sewage lagoon and the concept of including a wetland area that provides both storage and some treatment of the sewage.

Section 5 – Provides a synopsis of the existing solid waste management facilities and identifies current deficiencies. The section also presents the design details of the selected preferred alternative for solid waste management.

Section 6 – Presents the Class 'B' estimates for the capital costs associated with constructing the three facilities. The corresponding estimates of the operation and maintenance costs are also presented.

Section 7 – Provides a summary of the environmental screening process and of the outcome.

It is important to note that throughout the main report there are design drawings that provide a general overview of location and characteristics of the proposed design of the preferred alternatives related to the existing infrastructure. Larger detailed design drawings of each facility including typical details also accompany this report. Furthermore, the appendices to this report provide detailed design calculations, as well as the Operation and Maintenance Plans for the proposed facilities, which include:

- Environmental Emergency Contingency Plan
- Quality Assurance/Quality Control Monitoring Plan.

2.0 Background Information

2.1 Previous Reports

The following is a list of background information that was reviewed as part of the preparation of the Detailed Design Report.

Schematic Design Report – completed by Nuna Burnside Engineering and Environmental Ltd. in September 2005. This study established population projections and the corresponding servicing capacity required for this community. This report presented and evaluated several options that were considered for these facilities.

Geotechnical Report – also completed by Nuna Burnside Engineering and Environmental Ltd. in October 2005. This study was completed in support of the Schematic Design Report. The Geotechnical Report focused on the suitability of the sites considered in the Schematic Design Report for each of the proposed facilities along with the availability of aggregate material, it is appended to this report in Appendix B.

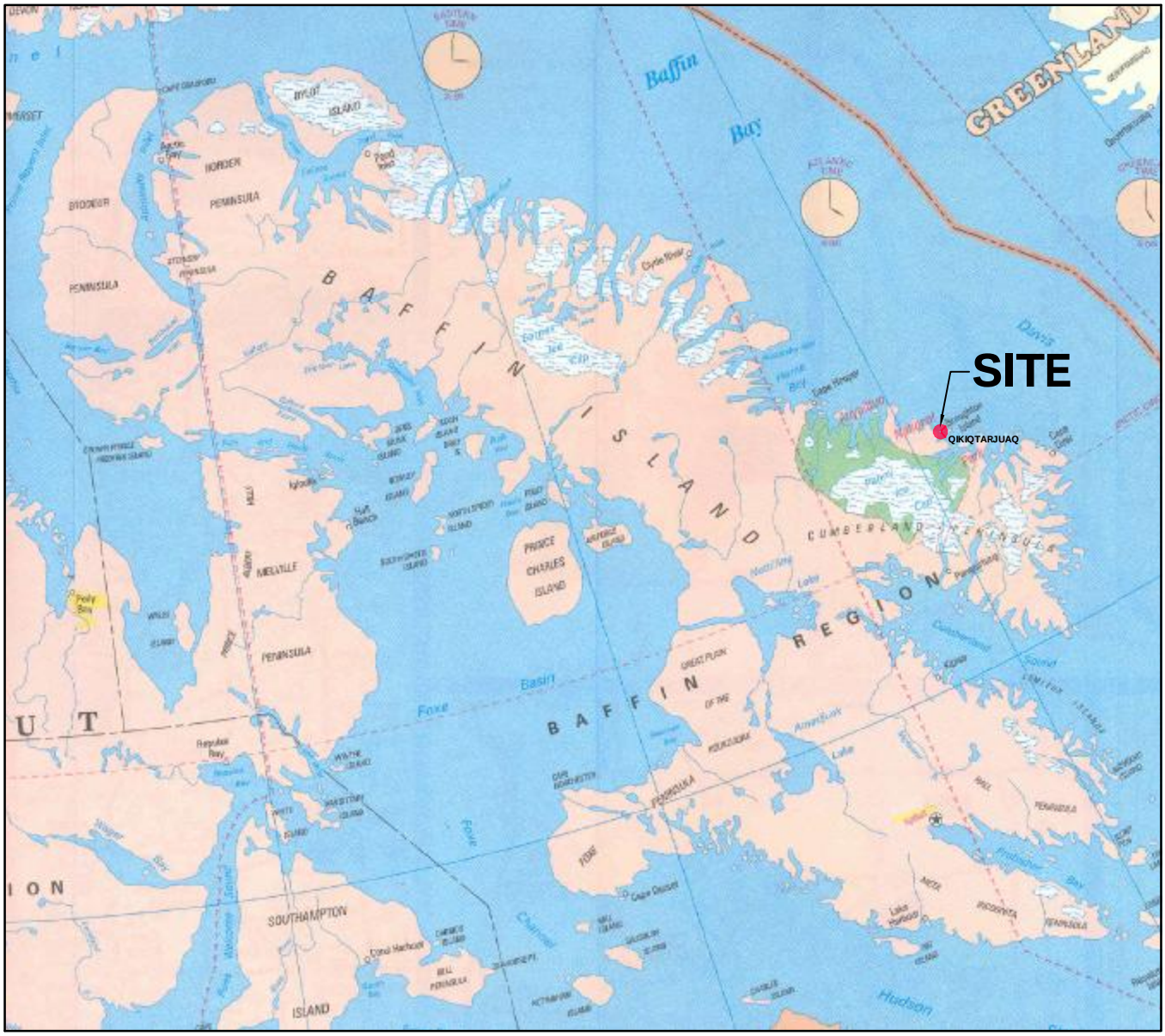
Water License (NWB3QIK0106) – provided by the Nunavut Water Board, stipulates the terms and conditions that the Hamlet must follow in the construction, monitoring, and operation and maintenance of the water supply and solid waste facility sewage infrastructure (Appendix C).

Inspection Reports – prepared by Indian and Northern Affairs Canada (INAC) assessing the current facilities and their compliance with the issued Water License along with any additional health and safety concerns that were observed.

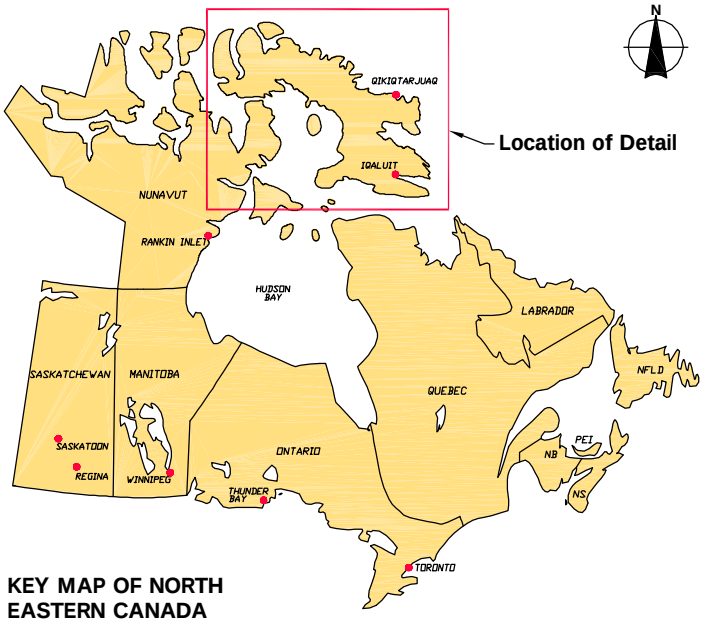
2.2 Community Information

2.2.1 Location

As described in the Schematic Design Report, the Hamlet of Qikiqtarjuaq (meaning “Big Island”), is a community of approximately 599 people (TOR) located in Nunavut, on the eastern coast of Baffin Island and on an island known as Broughton Island. As illustrated in Figure 1, the community is located approximately 470 kilometers northeast of the Capital City of Iqaluit, a distance that is covered by plane in about one hour. The geographic coordinates for Qikiqtarjuaq are 67º33’ north latitude and 64º02’west longitude. As indicated on Figure 2, the community is situated on the northwest portion of Broughton Island.



Map Reference:
Map of Canada
Published by the CAA



KEY MAP OF NORTH EASTERN CANADA

FIGURE 1 - SITE LOCATION MAP

THE HAMLET OF QIKIQTARJUAQ, NUNAVUT

DETAILED DESIGN

January 2006
Project Number: N-O 09439.0

Prepared by: K. Pridham

Verified by: M. Paznar

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FIGURE 2

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

SATELLITE IMAGERY OF ENTIRE COMMUNITY AND EXISTING INFRASTRUCTURE

Satellite Imagery Source:
September 2004 Satellite Image obtained from DigitalGlobe Inc.

N

0 200 400 600 800 1000 1200 1400 1600
Meters

1:20,000
January 2006
Project Number: N-O 09439.0

Projection: UTM Zone 20
Datum: NAD83

Prepared by: C. Sheppard

Verified by: M. Paznar

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2.2.2 Existing Infrastructure and Facilities

The Hamlet provides trucked water and sewage services, along with regular solid waste collection for the residents, businesses and institutions. Historically, water is drawn from the Tulugak River during the summer, and from the lined earthen reservoir for the remainder of the year. Sewage is collected by truck from individual holding tanks at each building and discharged to the unlined sewage lagoon located to the east of the community north of the DEW Line Access Road. Sewage treatment is provided by a facultative lagoon. Effluent from the lagoon is discharged north towards the ocean through a naturally occurring wetland treatment area. Solid waste is disposed of at a facility located adjacent to the sewage lagoon. This solid waste disposal facility includes areas for bulky metals/derelict vehicles, barrels, metal dump borrow, secondary metal, and residential solid waste.

Other infrastructure and facilities located within the Hamlet include:

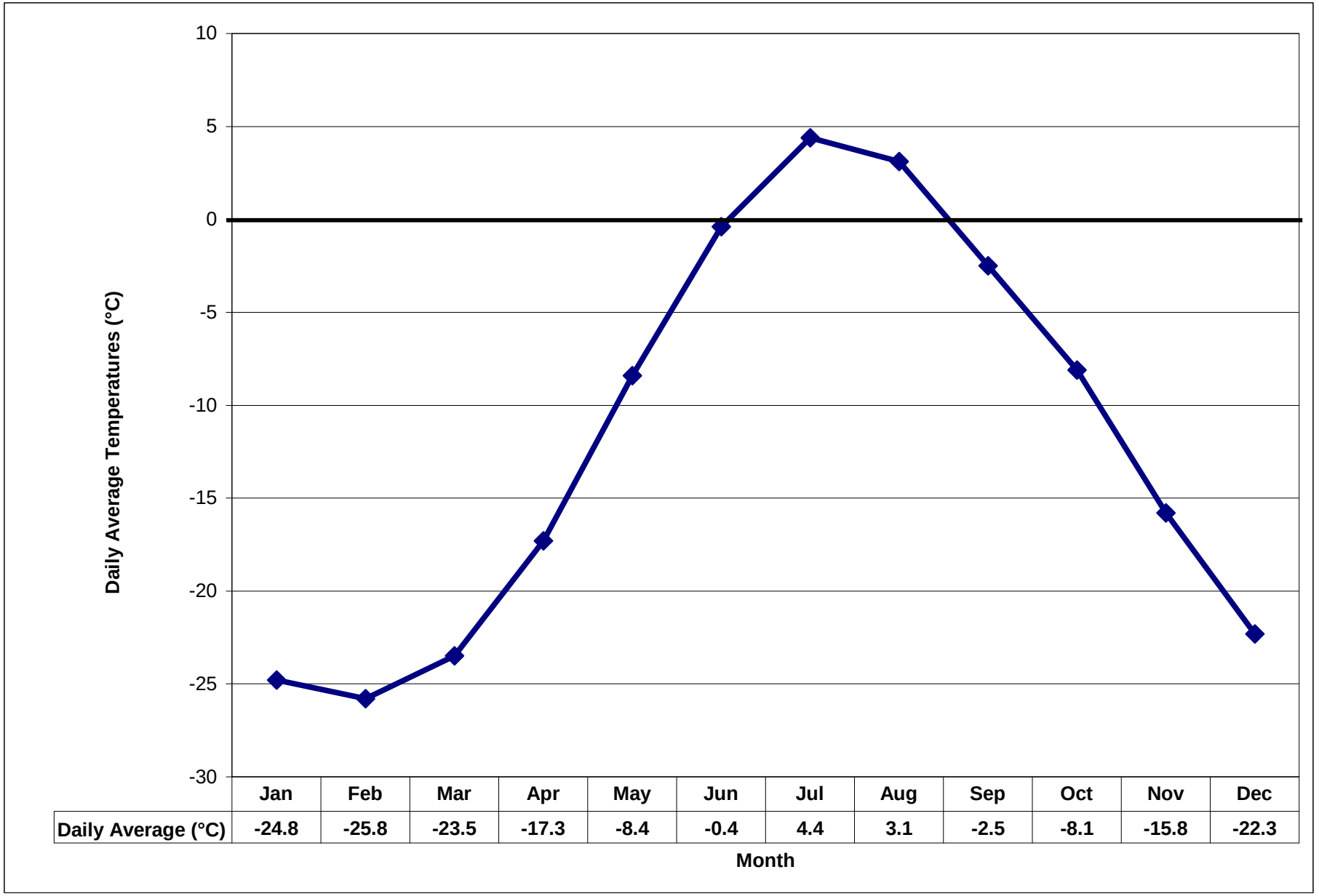
- Diesel power generators
- Barge landing area
- Gravel airstrip.

2.2.3 Climate Data

Qikiqtarjuaq receives an average of 39 mm of rainfall and 223 mm of snowfall per annum. July mean high and low temperatures are 7°C and 1°C, respectively. January's mean high and low temperatures measure -21°C and -28°C, respectively. July and August are the only two months of the year that historically have had average daily temperatures above the freezing mark. Prevailing winds are generally from north-northeast with an annual average velocity of 8.3 km/h. Climate information was obtained from Environment Canada's web site and is available in Appendix D.

The mean temperature during the summer months is an important parameter to be considered in the design process, as it will affect the days that will be available for the decanting of the sewage lagoon and for the filling of the water reservoir. As shown in Figure 3 the mean temperature is above the freezing point only during the months of July and August.

Figure 3: Mean Monthly Temperatures for the Hamlet of Qikiqtarjuaq



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Average (°C)	-24.8	-25.8	-23.5	-17.3	-8.4	-0.4	4.4	3.1	-2.5	-8.1	-15.8	-22.3

2.2.4 Population Data

As stated in the Terms of reference (TOR), the population is expected to reach 668 people by 2010 and 822 people by 2020. This corresponds to an annual population growth rate of 3.3 percent over the next five years and a 1.9 percent growth rate over the subsequent ten years. The GN has requested that the planning cycle for the facilities extend for 20-years based on the facilities berming commissioned in 2007. Based on a growth rate of 2 percent and a 2005 base population of 599 people, Nunavut Bureau of Statistics provides the 20-year (2027) design population to be used for sizing all facilities in this project is 937 people. Table 1 compares the population data provided in the TOR with the calculated values presented in Figure 4. Although there are some slight differences, there is a good correlation of the data that was provided in the TOR.

Table 1: Comparison between Provided and Calculated Population Data

Planning Year	Year	TOR Population	Calculated Population
Schematic Design	2005	566	599 (GN statistics)
3	2010	668	663
13	2020	811	813
18	2025	Not Provided	900
20	2027	Not Provided	937

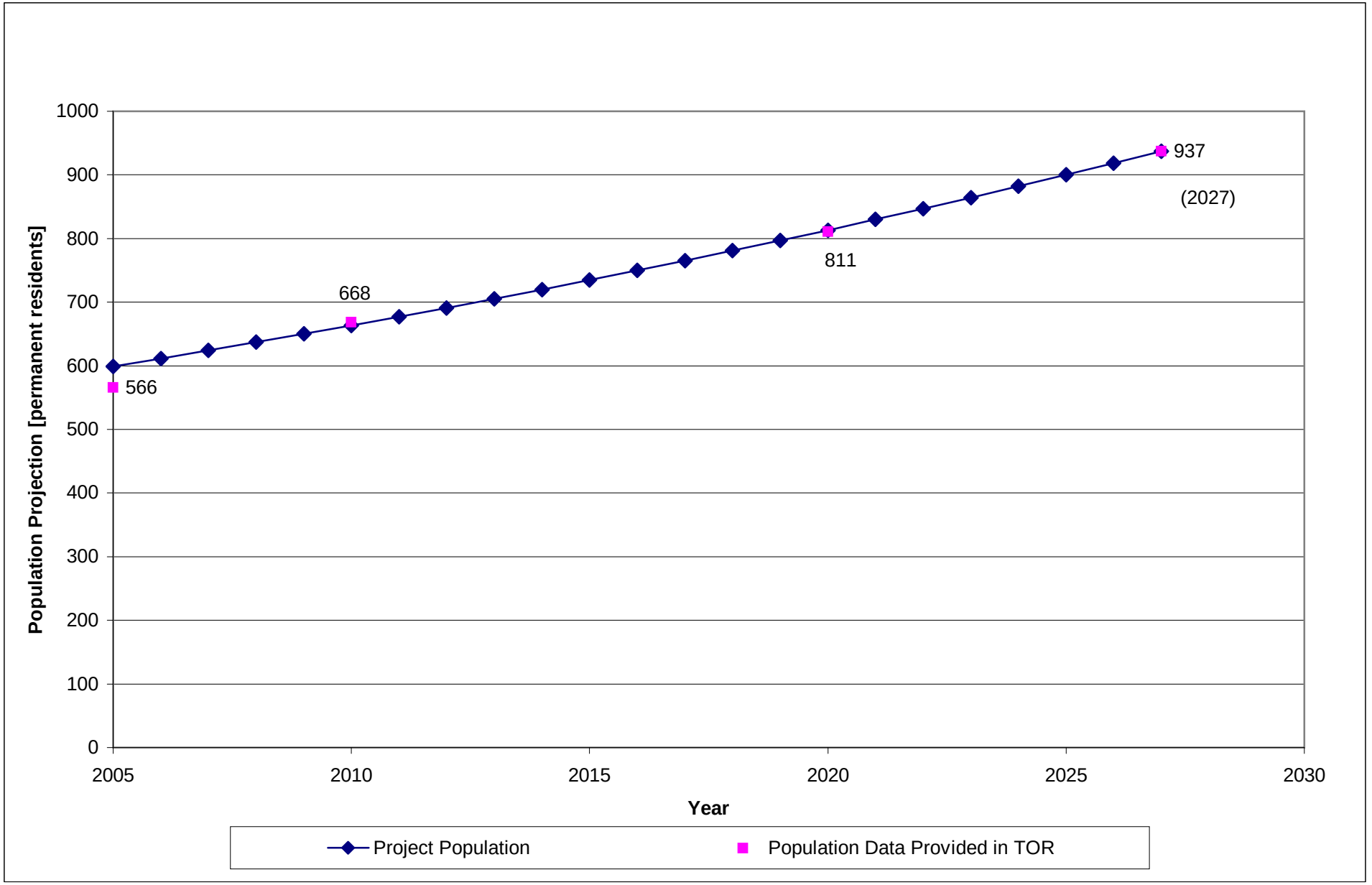
2.3 Design Criteria

All three facilities have common design criteria that must be satisfied when implementing improvements. The common criteria is as follows:

Population Projection – The upgrades to the facilities must meet the projected needs of the community for a 20 year design life following commissioning of the works (projected to be 2007).

Water Use Projections – A determination of historical consumption along with the projection of future water use is essential to properly determine the capacity of the treatment and storage components of the water supply system. The analysis of historical and projected water use also provides the basis for the design of the sewage treatment system, as sewage generation is typically similar to water consumption in communities with trucked services.

Figure 4: Population Projection for the Hamlet of Quikiqtarjuaq, Nunavut



J:/2006/08983-FOE/REports/Detailed Desing/Tables Qikiqatarjuaq Waste Generation FORMULA.xls

Arctic Conditions – The facilities must be designed to operate in and withstand extreme cold temperatures and other harsh climatic conditions such as prolonged daylight during the summer months, which may degrade, installed liners.

Cost Effective – All designs must be cost effective to implement, both in terms of the capital and operation and maintenance costs.

Simplicity – The upgrades must be simple to operate yet effective.

Environmentally Sound – The proposed design solutions should reduce environmental impact and ideally enhance the conditions at the proposed sites and surrounding areas

2.4 Agency Review

The following agencies have been contacted during the design process, and continue to provide comments on the proposed design as part of the approval process for this project:

- Indian and Northern Affairs Canada (INAC)
- Nunavut Water Board (NWB)
- Office of the Fire Marshall, Nunavut
- Department of Community and Government Services – Technical Services Division, Government of Nunavut.

The project also conforms to the requirements of the following regulatory agencies:

- Environment Canada (EC)
- Department of Fisheries and Oceans Canada (DFO).

A Water License is required by the Nunavut Water Board for the construction and operation of water, sewage, and solid waste facilities in the territory of Nunavut. The Hamlet is operating the facilities under the current water license NWB3Q1K0106 which expires on December 31, 2006. An application will be submitted to the Nunavut Water Board upon acceptance of the design brief by the GN.

3.0 Water Supply, Storage and Treatment Reservoir Facility

The Hamlet of Qikiqtarjuaq provides trucked water from the storage reservoir located to the east of the main community (Figure 5) and south of the access road. Hamlet staff operate the water supply system.

The purpose of this section is to describe the details of the existing water supply infrastructure and to review and summarize the concerns noted in the Schematic Design Report. The preferred alternative that was selected by the Hamlet and GN-CGS will be described in greater detail. The design will address all of the noted concerns to ensure that a safe and reliable water supply is available for the community.

3.1 Existing Conditions

The Hamlet of Qikiqtarjuaq obtains its raw water supply from the Tulugak River, which flows in a northwest direction toward Davis Strait. The water is conveyed from the river to the seasonal earthen water storage reservoir using a gravity fill pipe. The Tulugak River flows only during the summer months hence the Hamlet fills the reservoir in order to store water for the remainder of the year. The water is then pumped out of the reservoir and through a truck fill facility into tanker trucks for distribution to all residences and buildings in the community. It is important to note that the water is chlorinated at the truck fill station as it is pumped from the reservoir and into the tanker truck.

The reservoir shown in Figure 5 was expanded in 1978/1979 and lined with a geosynthetic fabric to its current assumed size of approximately 90 m x 90 m x 9 m based on design drawings provided by the Hamlet. Originally, water was supplied directly to the community by a gravity feed line. This arrangement was problematic because the supply line would freeze. To correct the problem, the truck fill station was constructed in 1984. Based on the 2004 water records, the useable storage volume of the existing lagoon is equivalent to approximately 90 percent of the 10 month consumption.

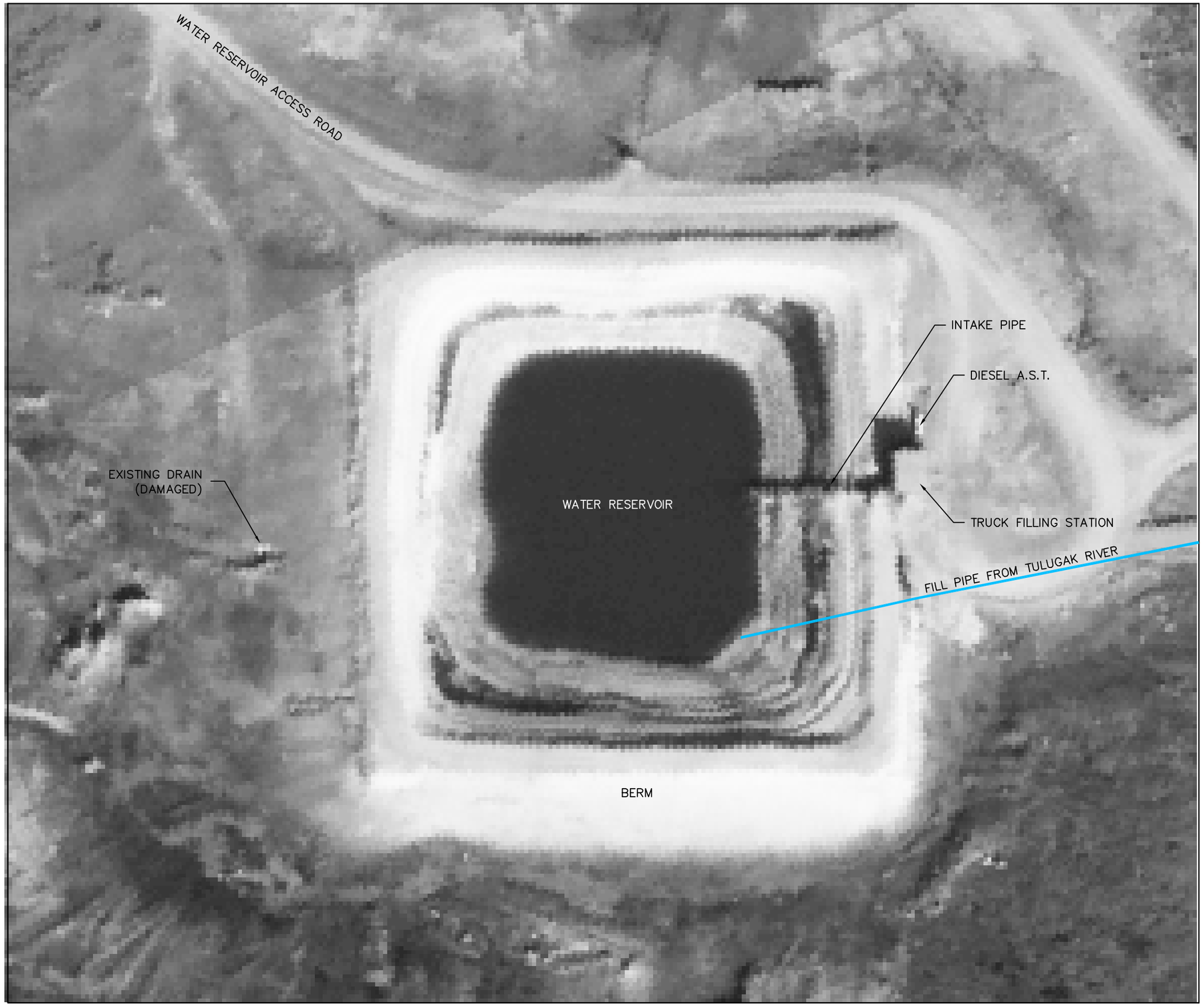


FIGURE 5

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

EXISTING WATER STORAGE AND TREATMENT FACILITY

Satellite Imagery Source:
September 2004 Satellite Image obtained from DigitalGlobe Inc.

N

0 10 20 30 40 50 60
Meters

1:750
January 2006
Project Number: N-O 09439.0

Projection: UTM Zone 20
Datum: NAD83

Prepared by: C. Sheppard

Verified by: M. Paznar

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The reservoir has a gross volume of approximately 37,910 m^3. Assuming that the reservoir is full at the beginning of the winter and allowing for 1.5 metres of ice and 1.5 meters at the bottom for pump submergence, the useable volume of the reservoir is calculated to be approximately 18,000 m^3.

The Schematic Design Report indicated that the on-site assessment carried out by Nuna Burnside determined that there were no significant concerns with the truck fill station or the equipment that is incorporated within its structure. Documented minor concerns include the need to calibrate the water meter and the need to install the stand-by pump to fill the tanker truck.

Our site assessment did not observe evidence of leakage from the water storage reservoir. This is likely due to permafrost re-aggrading into the berms. There were however, numerous areas where the liner had failed and where attempts had been made to repair the liner. The outlet drain for the reservoir did not appear to be working as intended. It was also noted that slumping of the material under the liner was occurring, as well as the sand cover material over the liner had been eroded away and was likely in the bottom of the reservoir.

A water quality sampling program was completed by Nuna Burnside staff during the on-site assessment. This program included sampling the raw water supply from the Tulugak River and the reservoir. The details of the analysis are available in the Schematic Design Report, however, to summarize, the key findings were:

- The water quality from the Tulugak river is excellent with no parameters that exceed the values specified by *Canadian Drinking Water Guidelines*, nor do they exceed the more stringent *Ontario Drinking Water Quality Standards*

- The water quality from the reservoir was below the values of the *Canadian Drinking Water Guidelines*, however, the turbidity parameter of the *Ontario Drinking Water Quality Standards* was exceeded.

Other concerns identified in the Schematic Design Report include:

- The concrete anchors for the intake pipes are deteriorated
- The intake pipes had separated from the truck fill station
- The fence around the reservoir is in need of repair
- The access road is located beside the reservoir and road dust was being blown into the reservoir
- The aboveground fuel storage tank is a single wall tank and without any other secondary containments is showing signs of deterioration (rusting).

Due to the high risk potential, the GN authorized the replacement of the fuel tank with a double walled tank and upgrades to the spill containment, which was completed in 2005.

3.2 Required Capacity

The average water consumption for the community is approximately 1,900 m^3/month for a total of 22,800 m^3/year. Based on a 2005 population of 599, the annual per capita consumption is 38 m^3/person/year or 104 L/person/day. A breakdown of water consumption for residential, commercial, and institutional was not available. Therefore, the per capita consumption includes allowances for commercial and institutional uses. These design parameters were used to calculate the projected capacity of the reservoir and to estimate the capital costs for the expansion described in the Schematic Design Report.

During the Design Development Phase of this project Nuna Burnside has learned that the Government of the Northwest Territories (NWT) Department of Municipal and Community Affairs (MACA) has developed a design standard for water consumption in communities of less than 2000 residents on trucked services. Since the NWT is the territory adjacent to Nunavut, and the NWT Water Board was previously responsible for licensing for these facilities with funding from the NWT Government, the NWT design standard is considered appropriate for Qikiqtarjuaq. Therefore, the projected water consumption can be estimated using the following formula:

Water Use (L/person/day) = 90 L/person/day x (1.0 + 0.00023 x population {allowance for commercial and institutional use})

This formula together with the population projection described in Section 2.0 is used to determine the projected water consumption, which is detailed in Table 2.

Table 2: Projected Water Consumption

Planning Year	Calendar Year	Projected Population	Projected Water Consumption	Projected Total Consumption Volume				10 Month Storage Requirement	Additional Capacity Required
			[Lpcd]	[Litres/day]	[Litres/year]	[m^3/day]	[m^3/year]	[m^3/year]	[m^3]
Schematic	2005	599	102.4	61337	22388071	61	22388	18657	657
Detailed	2006	611	102.6	62718	22891977	63	22892	19077	1077
0	2007	624	102.9	64220	23440330	64	23440	19534	1534
	2008	637	103.2	65729	23991238	66	23991	19993	1993
	2009	650	103.5	67246	24544699	67	24545	20454	2454
	2010	663	103.7	68769	25100714	69	25101	20917	2917
	2011	677	104.0	70417	25702355	70	25702	21419	3419
5	2012	691	104.3	72074	26306958	72	26307	21922	3922
	2013	705	104.6	73738	26914522	74	26915	22429	4429
	2014	720	104.9	75531	27568771	76	27569	22974	4974
	2015	735	105.2	77333	28226420	77	28226	23522	5522
	2016	750	105.5	79144	28887469	79	28887	24073	6073
10	2017	765	105.8	80964	29551917	81	29552	24627	6627
	2018	781	106.2	82916	30264410	83	30264	25220	7220
	2019	797	106.5	84879	30980772	85	30981	25817	7817
	2020	813	106.8	86852	31701001	87	31701	26418	8418
	2021	830	107.2	88960	32470484	89	32470	27059	9059
15	2022	847	107.5	91080	33244334	91	33244	27704	9704
	2023	864	107.9	93212	34022551	93	34023	28352	10352
	2024	882	108.3	95483	34851305	95	34851	29043	11043
	2025	900	108.6	97767	35684955	98	35685	29737	11737
	2026	918	109.0	100064	36523501	100	36524	30436	12436
20	2027	937	109.4	102504	37413945	103	37414	31178	13178

Table 2 indicates that for 2027, the average consumption rate is projected to be 109.4 L/cd and that the Hamlet will require a supply of 37,414 m^3. Assuming that the filling of the reservoir is performed annually during July and August, the total volume required to supply the remaining 10 months of the year would be 31,178 m^3. This differs from the Schematic Design Report as it includes for one additional month of storage capacity. This additional storage is recommended so that the Hamlet has sufficient water available for extreme situations such as when winter conditions are prolonged or should the filling operations be delayed due to an equipment failure (pump failure or a pipe break). The Operation Plan will indicate that the fill operation should begin as soon as the Tulugak River begins to flow each year and until the reservoir is at full capacity. The Hamlet should also "top up" the reservoir near the end of the summer before winter conditions set in.

The reservoir must also provide water storage to fight fires within the community. The NWT Water Board has published a *Good Engineering Practice Guideline* dated April 2004. This document recommends that a minimum of 60,000 L of storage for fire protection be provided in the reservoir of a community that is serviced by a truck haul system, if the source is not available throughout the year.

In addition, the pumping facility should be capable of supplying a minimum of 1,000 L/min from the reservoir to the trucks for delivery of water to the community.

This is a remote site that relies totally on the availability of water from the reservoir for 10 months of the year. Based on this, the reservoir capacity has been increased by 360 m^3 for fire protection. This would be equivalent to six (6) fires, assuming each fire required the minimum volume of 60,000 L (60 m^3).

Therefore, the projected 20-year storage volume required at the reservoir is as follows:

10 Month Annual Consumption	31,178 m^3
Fire Storage	360 m^3
Total Required Volume (rounded)	**31,500 m^3**

Since the existing reservoir already has 18,000 m^3 in useable volume, an additional useable volume of 13,500 m^3 is required.

3.3 Reservoir Design

The water storage reservoir will be designed and constructed following the same approach used for the existing facility. This will involve:

- Expanding the existing reservoir by constructing a new berm for the expanded reservoir
- Removal of existing berm along the northwest fence
- Relining the entire reservoir with a new liner.

Figure 6 illustrates the location and configuration of the reservoir expansion relative to the existing facilities based on detailed design calculations presented in Appendix E.

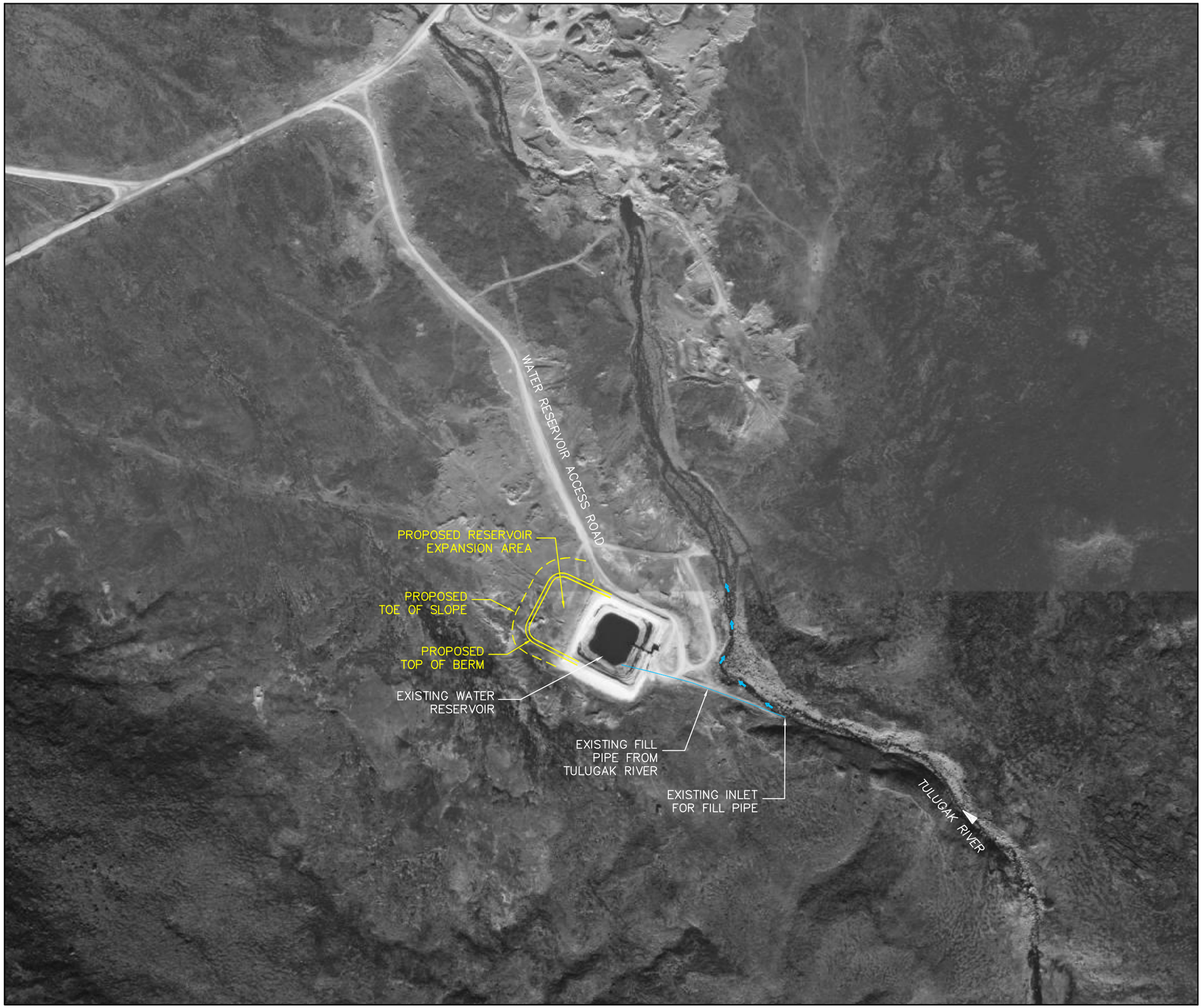

FIGURE 6

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

PROPOSED WATER RESERVOIR DESIGN

Legend

INTERPRETED SURFACE WATER FLOW DIRECTION

Satellite Imagery Source:
September 2004 Satellite Image obtained from DigitalGlobe Inc.

N

0 50 100 150 200 250 300 350 400

Meters

1:5,000
January 2006
Project Number: N-O 09439.0

Projection: UTM Zone 20
Datum: NAD83

Prepared by: C. Sheppard

Verified by: M. Paznar

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The dimensions and important design parameters for the expanded reservoir are as follows:

- Length – 156 m
- Width – 90 m (to match existing)
- Total depth – 9 m (to match existing)
- Required free board allowance – 1.0 m
- Allowance for ice – 1.5 m
- Intake allowance – 1.5 m
- Slope of berms inside of the reservoir – 3:1
- Slope of berms outside of lagoon at 3:1 or to match existing
- Top width of berm – 4.5 m (to match existing).

The implementation of the expansion to the reservoir will occur in two phases. During the first year of construction, the addition to the reservoir will be constructed without affecting the integrity of the existing reservoir. In the subsequent construction season, the common berm will be removed, the old liner removed, a new liner system installed, and the reservoir filled to ensure water is available for the next 10 months.

3.3.1 Liner System

The liner system will consist of two layers of a non-woven geotextile with a nominal thickness of approximately 165 mil with a 300 mm layer of crushed stone sandwiched between the two layers in order to provide reinforcement of the reservoir walls. A 45 mil polypropylene, potable grade geomembrane liner that is able to withstand the cold temperatures and resistant to UV degregation will be installed on top of the non-woven fabric. The purpose of the liner system is to assist in decreasing the risk of any leakage that may occur over the winter so there is an adequate supply available to service the needs of the Hamlet.

3.3.2 Reservoir Piping

The existing double intake piping housing the truck fill pumps is to be replaced. A new double intake pipe system will be installed in a common trench surrounded with crushed stone and a liner.

The intake pipes will be 300 mm diameter HDPE insulated pipe. Submersible pumps will be installed in the intake pipes into the reservoir. The submersible pumps will be mounted on skids with runners and connected to a 100 mm HDPE diameter pipe. The pump skid will be attached to an aircraft grade stainless steel cable for the removal of the pumps. There will be no check valve on the discharge of the submersible pumps to

ensure that the pipes drain after the pump shuts down. This will also protect the line that feeds the truck fill station from freezing.

HDPE pipe material was selected because it eliminates the potential for corrosion. It also allows for some minor adjustments in alignment in the field during construction and to adapt to the grades specified on the design drawings. To protect the carrier pipe from freezing, the pipe will be insulated and open ended in the truck fill station. For all sections where the carrier pipe is to be installed aboveground, the insulated carrier pipe will be wrapped in a 22 gauge, galvanized, spiral wrapped jacket to provide UV protection and to protect the pipe from damage due to surface hazards.

A new 300 mm HDPE gravity fill pipe will be installed at grade from the intake location in the Tulugak River to the reservoir.

The 300 mm diameter pipe will be installed in a swale alongside the access road heading to the intake location at the Tulugak River east of the Water Storage and Treatment Facility.

This pipe will be wrapped in a minimum 22 gauge, galvanized, spiral wrapped jacket to provide UV protection and to protect the pipe from normal mechanical damage. The pipe is to be laid on a continuous downhill grade from the intake to the reservoir. The intake is to be permanently installed in the river bed.

3.3.3 Submersible Truck Fill Pumps

As stated previously, the truck fill pumps are required to provide a minimum flow of 1,000 L/min, to allow for efficient filling of the tanker trucks in the case of providing water for fire protection, based on the information obtained during the site assessment. For the pump in service was a SLP, no further data was available regarding the flow. A replacement pump for the second pump was on site, but had not been installed. This pump was 7.5 hp and was rated for 170 usage @ 100 ft. TDA, this equivalent to 644 L/min.

To satisfy the fire requirements, the truck fill pumps will need to be replaced with units capable of supplying 1,000 L/min.

3.3.4 Miscellaneous Items

Other improvements to the water storage and treatment system for the Hamlet include:

- Replacement of the existing single walled fuel tank with a double walled tank and the installation of a lined secondary containment for spills that many occur during filling operations (completed in 2005)
- Inspection of the two on-site generators and carrying out the necessary repairs as identified by the inspections
- Electrical upgrades as identified by the A.D. Williams Report (Appendix F)
- Upgrades and extension to the perimeter fence to limit access to the water reservoir by both wildlife and people
- Re-grading of the site to ensure positive drainage of all surface water away from the water reservoir and truck fill station
- Construction of the access road so that dust does not blow into the reservoir and to simplify the access for the water truck to and from the truck fill station (i.e. larger turning radius).

3.3.5 Signage at the Water Treatment and Storage Facility

This proposed design also includes the provision of proper site signage. A sign will be posted on the fence at the entry to the water storage and treatment facility indicating the following:

- Name of the Facility (i.e. Hamlet of Qikiqtarjuaq Water Treatment and Storage Facility)
- Trespassing Prohibited
- Health Hazard
- Emergency Contact Information (Hamlet of Qikiqtarjuaq Operations Department, phone number, etc.).

All signs will include English and Inuktitut along with the logos of the Hamlet and of the Government of Nunavut.

4.0 Sewage Storage and Treatment Facility

Currently, the Hamlet of Qikiqtarjuaq operates a single cell sewage lagoon with the effluent discharged to a natural wetland, which eventually discharges into the Davis Strait. This existing sewage lagoon is located approximately 2 km east of the community (Figure 7) and is accessed by the "Landfill Access Road." The lagoon is located adjacent to the solid waste disposal facility. There are no documented complaints of related odours.

Sewage is collected daily by a vacuum truck from holding tanks located at the houses, and at the commercial and institutional buildings. The truck transports the sewage to the lagoon and the operator discharges the sewage onto a spillway, which is used to prevent bank erosion during the discharge operation.

Currently, decanting of the lagoon takes place at the end of the summer, just prior to freeze up. Effluent is discharged directly onto the ground at the base of the lagoon berm. This is considered to be the point of discharge under the Operating License. The only treatment provided for determining compliance with the Water Board guidelines takes place within the lagoon itself.

The Schematic Design Report indicated that considering access, site constraints, the remoteness of the site, availability of suitable soils, simplicity of operation, and anticipated costs, the community should continue to use a lagoon based system for sewage treatment.

FIGURE 7

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

REGIONAL VIEW OF EXISTING WASTEWATER LAGOON & SOLID WASTE DISPOSAL FACILITY (LANDFILL)

Legend

INTERPRETED EXISTING SURFACE WATER FLOW DIRECTION

Satellite Imagery Source:
September 2004 Satellite Image obtained from DigitalGlobe Inc.

N

0 50 100 150 200 250 300 350 400

Meters

1:5,000
January 2006
Project Number: N-O 09439.0

Projection: UTM Zone 20
Datum: NAD83

Prepared by: C. Sheppard

Verified by: M. Paznar

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4.1 Requirements for a Sewage Lagoon in Nunavut

The requirements for the design and operation of lagoons in Nunavut can be found in the following documents:

- G. W. Heinke, D. W. Smith and R. Gerard, 1990. *Guidelines for Disposal of Sewage in Coastal communities of the NWT*
- *Nunavut Water Board Guidelines for the Discharge of Treated Municipal Waste Water in the NWT*, 1992
- *Cold Regions Monograph*, 3rd Ed., 1992
- G.W. Heinke, D. W. Smith and R. Finch, 1998. *Guidelines for the Planning, Design and Operation and Maintenance of Sewage Lagoon Systems in the NWT.*

It should be noted that, although these documents were developed prior to the division of Nunavut from the NWT, they are generally accepted by the regulatory agencies in Nunavut.

4.2 Existing Conditions

The facultative lagoon at Qikiqtarjuaq was originally designed to hold sewage for 365 days, with an annual discharge at the end of summer. The existing unlined earthen lagoon was constructed in 1992 (Figure 8). The design intent was for a 20-year lagoon to be constructed as two independent cells, however, only one cell was built. The current single-cell lagoon is assumed from design drawings provided by the Hamlet to approximately 90 m x 70 m x 4 m, with a volume of 10,558 m^3. This assumes that a 1 m freeboard, which is required by the Nunavut Water Board, will be maintained. The lagoon volume is not sufficient to provide the appropriate storage and treatment of the sewage that is generated by the Hamlet of Qikiqtarjuaq.

The current effluent quality criteria for sewage discharged by the Hamlet of Qikiqtarjuaq are prescribed in the Water License NWB3QIK0106. The effluent criteria are presented in Table 3.

Table 3: Nunavut Water Board Effluent Discharge Quality Criteria

Parameters	NWB License Limits (mg/L)
Biological Oxygen Demand (BOD)	120
Total Suspended Solids (TSS)	180
pH	6-9
Fecal Coliforms (FC)	1×10^4 C.F.U./ dL

4.3 Sewage Quantity and Projected Quality Generation Rates

In trucked service communities, it is normally assumed that the sewage generated is equivalent to water consumption. Accordingly, the daily and annual sewage generation rates for the Hamlet of Qikiqtarjuaq are assumed to be equal to the rates of water consumption rates.

As referenced previously, the Government of the Northwest Territories Department of Municipal and Community Affairs has developed a standard for water consumption in communities of less than 2,000 residents on trucked services. This consumption rate can be estimated with the following formula:

$$\textit{Water Use (L/person/day)} = 90\ \textit{L/person/day} \times (1.0 + 0.00023 \times \textit{population})$$

Where the factor 0.00023 multiplied by the population represents the commercial and industrial water use. The rate of 90 L/person/day is used, as recommended for a community of less than 2,000 people.

Based on the above criteria,. The projected annual volume of sewage generated at the end of 10 years (2017) is 29,552 m^3, while the 20-year (2027) annual volume is 37,414 m^3. Table 4 provides a summary of the sewage generation rate for the Hamlet of Qikiqtarjuaq.

The design objective is to establish an appropriate design for the treatment of the sewage, the amount of sludge that will be produced and the concentrations of the treated discharge. Table 5 summarizes the assumptions made in the calculations.

Table 4: Projected Sewage and Sludge Generation Rates

Planning Year	Calendar Year	Projected Population	Projected Sewage Generation	Projected Volume		Projected Sludge Volume	Cumulative Sludge Volume	BOD	TSS	$T\text{-}PO_4$	TKN	Faecal Coliforms
			[Lpcd]	[Litres/day]	[Litres/year]	[m^3/year]	[m^3]	[mg/L]	[mg/L]	[mg/L]	[mg/L]	[CFU/100 mL]
Schematic	2005	599	102.4	61,337	22,388,071	10.9	10.9	439.5	468.8	22.5	117.2	9.28E+07
Design	2006	611	102.6	62,718	22,891,977	11.2	22.1	438.4	467.6	22.4	116.9	9.25E+07
0	2007	624	102.9	64,220	23,440,330	11.4	33.5	437.2	466.4	22.3	116.6	9.23E+07
	2008	637	103.2	65,729	23,991,238	11.6	45.1	436.1	465.2	22.3	116.3	9.21E+07
	2009	650	103.5	67,246	24,544,699	11.9	57.0	435.0	464.0	22.2	116.0	9.18E+07
	2010	663	103.7	68,769	25,100,714	12.1	69.1	433.8	462.8	22.2	115.7	9.16E+07
	2011	677	104.0	70,417	25,702,355	12.4	81.4	432.6	461.5	22.1	115.4	9.13E+07
5	2012	691	104.3	72,074	26,306,958	12.6	94.0	431.4	460.2	22.1	115.0	9.11E+07
	2013	705	104.6	73,738	26,914,522	12.9	106.9	430.2	458.9	22.0	114.7	9.08E+07
	2014	720	104.9	75,531	27,568,771	13.1	120.0	429.0	457.6	21.9	114.4	9.06E+07
	2015	735	105.2	77,333	28,226,420	13.4	133.4	427.7	456.2	21.9	114.1	9.03E+07
	2016	750	105.5	79,144	28,887,469	13.7	147.1	426.4	454.9	21.8	113.7	9.00E+07
10	2017	765	105.8	80,964	29,551,917	14.0	161.1	425.2	453.5	21.7	113.4	8.98E+07
	2018	781	106.2	82,916	30,264,410	14.3	175.3	423.9	452.1	21.7	113.0	8.95E+07
	2019	797	106.5	84,879	30,980,772	14.5	189.9	422.5	450.7	21.6	112.7	8.92E+07
	2020	813	106.8	86,852	31,701,001	14.8	204.7	421.2	449.3	21.5	112.3	8.89E+07
	2021	830	107.2	88,960	32,470,484	15.1	219.9	419.9	447.8	21.5	112.0	8.86E+07
15	2022	847	107.5	91,080	33,244,334	15.5	235.3	418.5	446.4	21.4	111.6	8.83E+07
	2023	864	107.9	93,212	34,022,551	15.8	251.1	417.1	444.9	21.3	111.2	8.81E+07
	2024	882	108.3	95,483	34,851,305	16.1	267.2	415.7	443.4	21.2	110.8	8.78E+07
	2025	900	108.6	97,767	35,684,955	16.4	283.6	414.3	441.9	21.2	110.5	8.75E+07
	2026	918	109.0	100,064	36,523,501	16.8	300.4	412.8	440.4	21.1	110.1	8.72E+07
20	2027	937	109.4	102,504	37,413,945	17.1	317.5	411.3	438.8	21.0	109.7	8.68E+07

Table 5: Assumptions for the Calculation of Effluent Concentrations of BOD, TSS, T-PO4, TKN and Fecal Coliforms

Parameter	Generation Rate
Sludge	50 grams/person/day
Biological Oxygen Demand (BOD)	45 grams/ person/day
Total Suspended Solids (TSS)	48 grams/ person/day
Total Phosphate (T-PO_4)	2.3 grams/ person/day
Total Kjeldahl Nitrogen (TKN)	12 grams/ person/day
Fecal Coliform (FC)	9.50×10^{10} CFU/100 mL/ person/day

Based on these assumed parameters, the projected annual and cumulative sludge volumes and the design concentrations of Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total phosphate (T-PO_4), Total Kjeldahl Nitrogen (TKN) and fecal coliforms (FC) in the lagoon effluent can be calculated, as shown in Table 3.

4.4 Lagoon Storage Volumes Required

A lagoon with sufficient capacity to retain the estimated annual generated sewage volume for projected 20th year is required.

In addition to sewage, the volume of precipitation, and rates of evaporation, must also be considered in establishing the capacity of the lagoon. It may be assumed that water evaporates from a sewage lagoon at the same rate as from a lake. It is also assumed that sublimation rates, evaporation from a frozen surface, are not a significant factor. The impact of runoff is not considered a factor, as the lagoon berms will be above grade.

The annual evaporation rate for the Hamlet of Qikiqtarjuaq is estimated at approximately 200 mm/year. Climate normal data from the Environment Canada website was obtained, indicating that the average annual precipitation for the Hamlet of Kugluktuk is 262 mm/year (Appendix A). This net addition of approximately 62 mm/year of precipitation over the surface of the lagoon will contribute to the total volume requirement. This volume needs to be accounted for in the lagoon design.

The volume of accumulated sludge must also be considered in determining the total storage. Calculations are presented in Table 3. The projected accumulated sludge volume at year 20 is approximately 318 m^3.

The total lagoon volume required in year 20, with allowances for net precipitation and cumulative sludge accumulation over 20 years is:

Volume of sewage in year 20 (12 months retention)	37,414 m^3
Volume of accumulated sludge by year 20	318 m^3
Annual volume of precipitation	1,205 m^3
Total Volume Required (Rounded)	**38,900 m^3**
Less volume available in existing lagoon	10,558 m^3
Volume to be added	28,342 m^3

The volume calculated above differs from the value indicated in the Schematic Design Report because the actual depth of the existing lagoon was significantly less then assumed during the Schematic Design Phase. The "As-Built" drawings obtained by Nuna Burnside from the Hamlet indicate that the actual depth of the existing reservoir is only 4 m, and not the 8 m assumed in the Schematic Design Report. As a result, a larger addition is required and is proposed as indicated on Figure 9. The proposed lagoon expansion has average dimensions of 110 m x 115 m x 4 m.

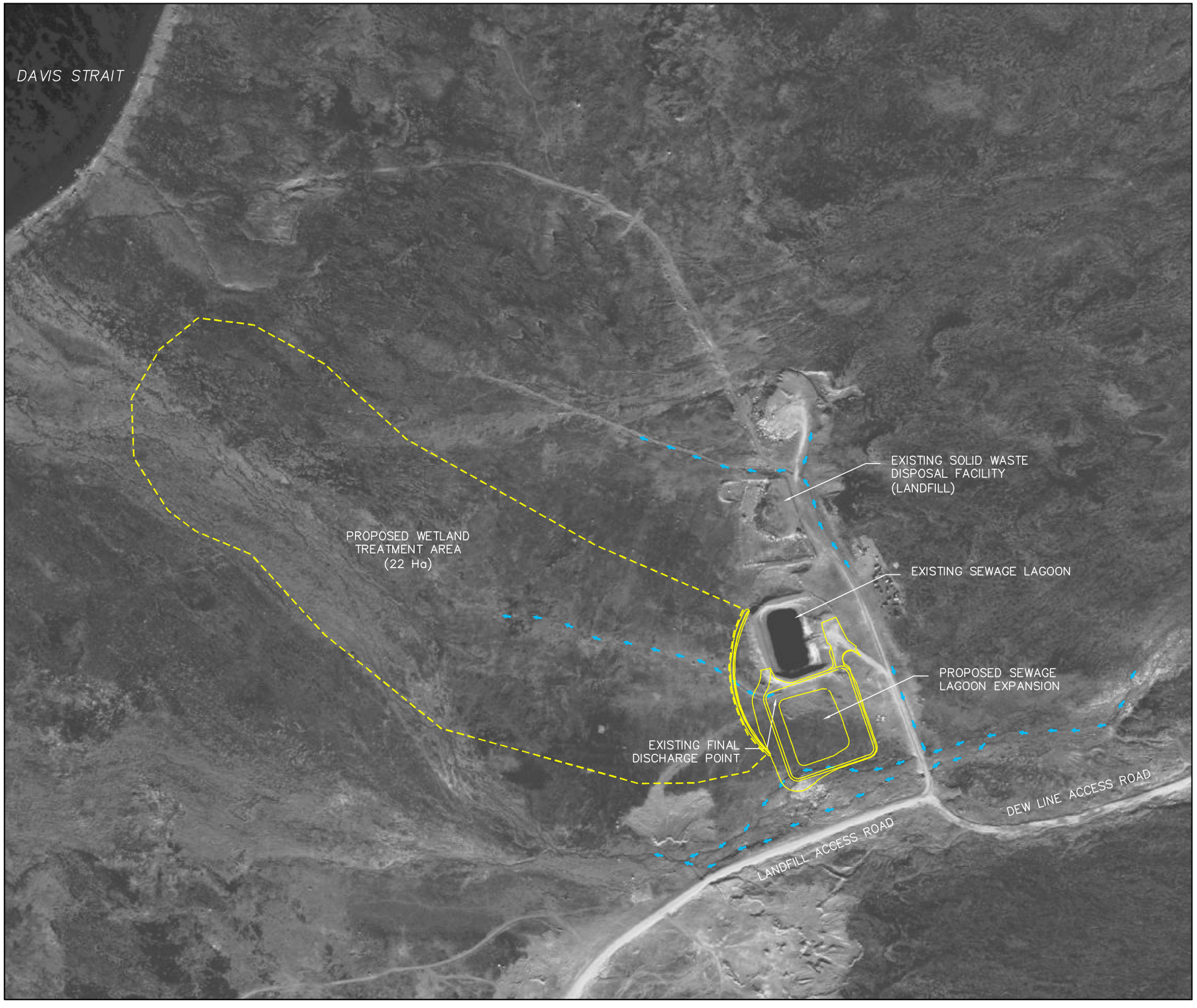

FIGURE 8

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

PROPOSED SEWAGE TREATMENT FACILTY DESIGN

Legend

INTERPRETED EXISTING SURFACE WATER FLOW DIRECTION

Satellite Imagery Source:
September 2004 Satellite Image obtained from DigitalGlobe Inc.

N

0 50 100 150 200 250 300 350 400

Meters

1:5,000
January 2006
Project Number: N-O 09439.0

Projection: UTM Zone 20
Datum: NAD83

Prepared by: C. Sheppard

Verified by: M. Paznar

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4.5 Meeting Effluent Discharge Criteria

The following assessment is provided with regards to meeting the effluent criteria specified in the existing NWB license.

Two scenarios are considered. The first scenario looks at the quality of effluent that is expected when a new lagoon is commissioned. The second scenario considers the effluent quality at the end of the design period.

After the lagoon expansion is commissioned, the sewage generation is anticipated to be approximately 63 percent of the 20 year design flow, and therefore there will be a higher efficiency of treatment.

Table 6 compares a 70 percent reduction in the sewage characteristic parameters, based on published treatment efficiencies for similar systems. these values are compared to the levels specified by the operating license. Based on these assumptions, additional treatment is warranted.

Table 6: Estimated Effluent Quality Assuming a 70 Percent Lagoon Carbon-Removal Efficiency (2005)

Regulatory Parameter	Raw Sewage (2005)	Expected Lagoon Effluent Quality (2005)	Expected Lagoon Effluent Quality Prior to Wetland Treatment with 70 Percent Carbon Removal	NWB License Limits
BOD (mg/L)	439.5	439.5	< 131.9	120
TSS (mg/L)	468.8	468.8	< 140.6	180
T-PO_4 (mg/L)	22.5	22.5	< 6.8	N/A
TKN (mg/L)	117.2	117.2	< 35.2	N/A
FC (CFU/dL)	9.28×10^7	9.28×10^7	$< 2.8 \times 10^7$	1×10^4

As the sewage volume increases, so will the depth of storage along with the volume of sludge accumulation within the lagoons. Treatment efficiencies will be correspondingly reduced. Conservatively, the rates of reduction for carbon based parameters could be as low as 25 percent. Under these conditions, the effluent quality shown in Table 7 is expected.

Table 7: Estimated Effluent Quality Assuming a 25 Percent Lagoon Carbon-Removal Efficiency (2027)

Regulatory Parameter	Predicted Raw Sewage (2027)	Expected Lagoon Effluent Quality (2027)	NWB License Limits
BOD (mg/L)	411.3	< 308.5	120
TSS (mg/L)	438.8	< 329.1	180
T-PO_4 (mg/L)	21.0	< 15.8	N/A
TKN (mg/L)	109.7	< 82.3	N/A
FC (CFU/dL)	8.7×10^7	$< 6.5 \times 10^7$	1×10^4

In order to meet the licensing requirements, additional treatment is warranted. This can be provided by means of a wetland treatment area that can be established between the lagoon system and Davis Strait.

It is anticipated that during the period between 2005 and 2027, the wetland treatment area will evolve into a functioning microbial, and terrestrial plant environment capable of providing additional treatment with some effluent evaporation and disinfection.

It is anticipated that this wetland treatment area will be capable of providing treatment to the concentrations shown in Table 8. The predictive model describing the assimilative capability of this wetland treatment area, developed by the Alberta Department of the Environment is illustrated in Appendix F. The model accounts for a temperature correction to an average temperature of 5ºC.

Table 8: Estimated Wetland Treatment Area Effluent Quality at Final Discharge Point Compared to Nunavut Water Board License Limits and Anticipated Guidelines

Regulatory Parameter	Expected Lagoon Effluent Quality (2027)	NWB License Limits	Anticipated NWB Guidelines	Minimum Wetland Area Required to Meet Anticipated NWB Guidelines (Ha)	Expected Effluent Quality from 22 ha Wetland Treatment Area
BOD (mg/L)	308.5	130	45	7.1	< 45
TSS (mg/L)	329.1	180	45	0.3	< 45
T-PO_4 (mg/L)	15.8	N/A	1	22.0	< 1
TKN (mg/L)	82.3	N/A	10	9.9	< 5
FC (CFU/dL)	6.5×10^7	1×10^4	2×10^2	16.3	$< 2 \times 10^2$

The areas required to provide the level of treatment of the effluent to the anticipated Nunavut Water Board regulatory parameters, based on the Alberta Wetland Predictive Model, are given in Table 8. It should be noted that T-PO_4 reduction to the anticipated Nunavut Water Board Guideline levels requires a significantly greater wetland treatment area in comparison to other parameters of interest. Based on the above, the minimum wetland treatment area is about 22 ha.

4.6 Preferred Design Alternative

The preferred design alternative to upgrade the current sewage treatment system for the Hamlet of Qikiqtarjuaq includes the development of an additional lagoon cell and the addition of a wetland treatment area. The following section describes the design details of this alternative and identifies the differences in the Schematic Design Report. Similar to the Water Supply and Storage Reservoir Facility section, detailed calculations are provided in Appendix E.

4.7 Sewage Storage and Treatment System detailed Design

4.7.1 Sewage Lagoon

The additional lagoon cell will be sited immediately south of the existing lagoon. A common berm will be shared between the two cells thereby providing an optimum configuration and minimizing the land and construction requirements.

In Appendix E, a description of the calculations to determine the capacity required in addition to the existing lagoon are provided. A lagoon with 27,339 m^3 usable capacity is required and this can be achieved with the following configuration:

- Length – 110 m
- Width – 115 m
- Total Depth – 4 m
- Required free board allowance – 1.0 m
- Allowance for solids accumulation at bottom of lagoon – 0.3 m
- Slope of berms inside of lagoon – 3:1
- Slope of berms outside of lagoon – to match the existing ground elevations as indicated on drawings
- Top width of berm – 3.0 m.

This additional lagoon cell will be of similar construction as the existing lagoon. The material excavated will be used to construct the berms. This should reduce the amount of material to be imported. This proposed lagoon cell will remain unlined.

4.7.2 Lagoon Effluent Discharge

The effluent from the lagoons will be decanted each year as per the Operation and Maintenance Plans. The effluent will be decanted by gravity evenly across the tundra to create an engineered wetland area for final treatment.

4.7.3 Wetland Treatment Area and Exfiltration Berm

A wetland treatment area of 22 ha as previously described is an essential component of the proposed treatment system. Since a naturally occurring wetland already exists in the area, the intention is to allow the lagoon effluent to discharge over land in a sheet flow fashion and allow vegetation and other biological systems characteristic to wetland areas develop. This is similar to the approach used by the existing system.

The wetland area will be achieved by the construction of an exfiltration berm made of native rock type material located approximately 10 m west of the berms of the lagoons.

At the toe of the slope of this exfilitration berm will be 200 mm perforated drainage pipe capped on either ends. Note that the perforations will be spaced further apart where the piping connects into the outlet piping and closer together on either end as detailed in the drawings. This is designed to achieve the desired sheet flow pattern and will enhance the treatment effectiveness of the wetland.

4.7.4 Tanker Truck Offloading Area

The truck off loading area will be reconstructed in order to allow the tanker trucks to back-up and discharge to either lagoon cell. A 3,000 mm diameter smoothed wall culvert will be cut into half and laid down on the berm of the new lagoon cell to act as a spillway and prevent erosion of the berm during the offloading of the trucks. A cut off drainage trench will be constructed around the perimeter of both lagoon cells to ensure the diversion of surface water around the site and minimize the potential for surface water from flowing into the lagoon cells.

4.7.5 Site Drainage and Grading

The entire site will be re-graded to ensure that there is positive drainage away from the sewage lagoons. This will ensure that surface water does not enter into the lagoon with the exception of the truck discharge area. The natural drainage patterns will be utilized as much as possible in order to reduce the amount of excavation required in the existing ground. The elevation of the berm located to the east will be increased to a minimum of 0.5 metres above the elevation of the existing ground in order to create a drainage pattern for all surface water run-off coming from the access road. This will be done using excess material excavated from the construction of the lagoon.

4.7.6 Signage

This design also includes the provision of proper site signage. A sign will be posted at the entry to the facility indicating the following:

- Name of the Facility (i.e. Hamlet of Qikiqtarjuaq Sewage Treatment Facility)
- Trespassing Prohibited
- Health Hazard
- Emergency Contact Information (Hamlet of Qikiqtarjuaq Operations Department, phone number, etc.).

Signs will be posted at appropriately spaced intervals along the perimeter of the proposed wetland treatment area. These signs will indicate the following:

- Name and Purpose of the Facility (i.e. Wetland Treatment Area)

- Trespassing Prohibited
- Health Hazard
- Emergency Contact Information (Hamlet of Qikiqtarjuaq Operations Department, phone number, etc.).

Finally, a sign will be placed at the final discharge point of the sewage treatment facility. This will be at the location where sampling will occur in order to monitor the compliance of effluent from the sewage treatment system to the regulations imposed by the NWB water license. It is anticipated that the sign will included the following information:

- Name of Facility
- Surveillance Network Monitoring Program Location Code.

All signs will be in both English and Inuktitut, and will include the logos of the Hamlet and of the Government of Nunavut.

5.0 Solid Waste Disposal Facility

5.1 Overview

5.1.1 Background

Meetings with Hamlet staff indicated they wish to continue their current method of solid waste collection and transportation to the disposal site. This involves Hamlet staff doing house to house collection on a weekly basis with a truck. They also wish to keep the disposal facilities open to community members to use on an as needed basis. Because the community is small and isolated, Hamlet staff had no concerns with controlling waste disposal.

Staff was relatively happy with the current process of waste streaming and disposal, but wanted a long term effective plan for the future. As per the Terms of Reference for the project, waste disposal capacity will be designed to accommodate the Hamlet until end of year 2030.

Existing conditions are displayed on Figure 9.

The facility currently operates under Nunavut Water Board License No. NW133Q1K0106, issued November 28, 2000 (Appendix C). The license was issued for five years to allow the licensee to properly carry out the terms and conditions of the license. The license includes water use and waste disposal (sewage and solid waste). With respect to solid waste the license requires:

- An Annual Report
- An Operations and Maintenance Manual (O & M)
- Abandonment and Restoration (A & R) of the abandoned waste disposal facility (now used as the Bulky Metals Disposal Area)
- Surveillance Network Program (as part of the sewage system and solid waste disposal area monitoring requirements)
- Studies for long term planning.

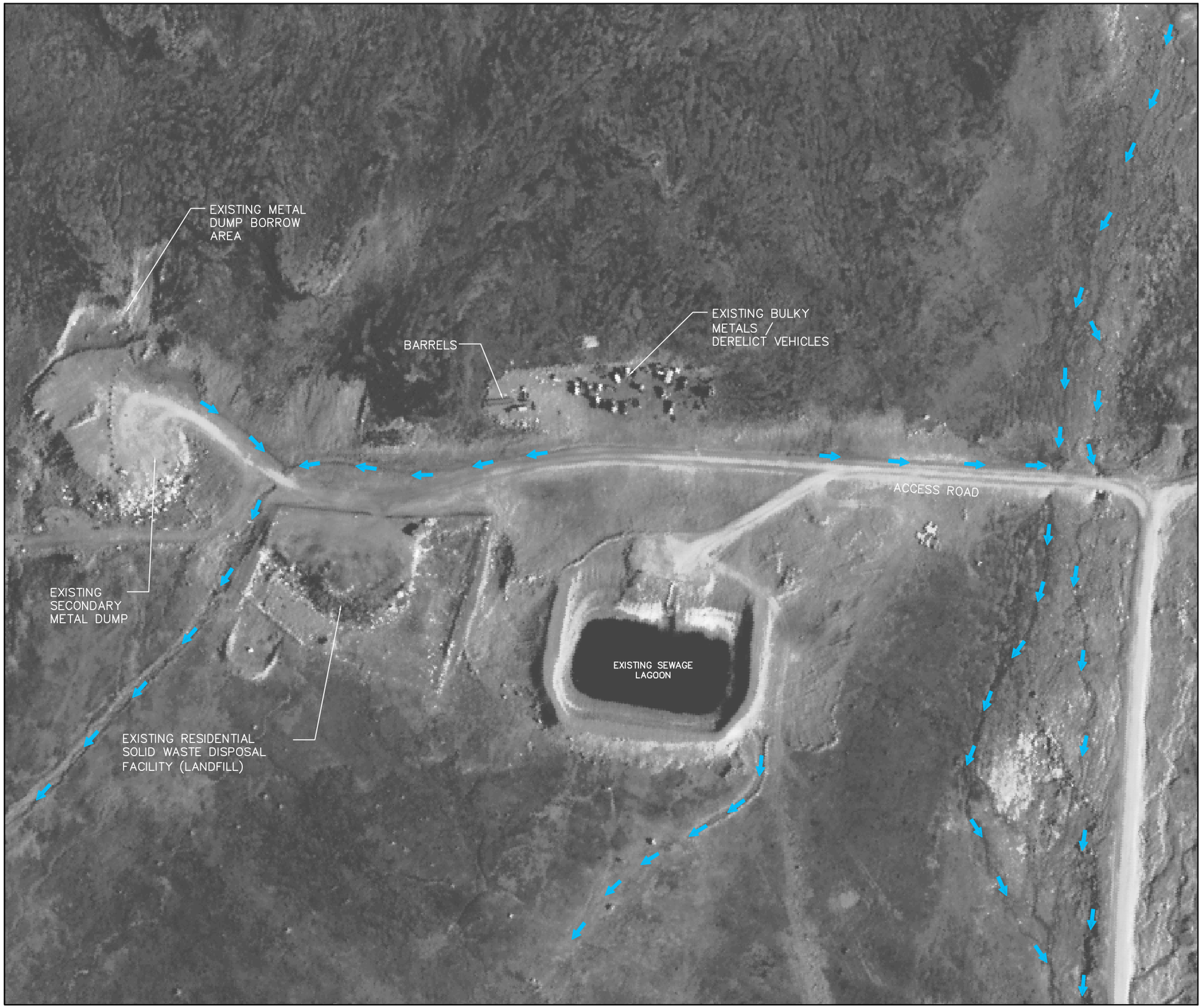

FIGURE 9

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

EXISTING SOLID WASTE DISPOSAL FACILITY (LANDFILL)

Legend

EXISTING SURFACE WATER FLOW DIRECTION

Satellite Imagery Source:
September 2004 Satellite Image obtained from DigitalGlobe Inc.

N

0 20 40 60 80 100 120 140 160
Meters

1:2,000
January 2006
Project Number: N-O 09439.0

Projection: UTM Zone 20
Datum: NAD83

Prepared by: C. Sheppard

Verified by: M. Paznar

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5.1.2 Solid Waste Disposal Regulations

Solid waste disposal in Nunavut is regulated by the Water Board. The following guidelines are applicable:

- Northwest Territories, Municipal and Community Affairs, "Guidelines for the Planning, Design, Operations, and Maintenance of Modified Solid Waste Sites in the Northwest Territories", dated April 2003

- Public Health Act, "Consolidation of General Sanitation Regulations", R.R.N.W.T., 1990.

5.2 Waste Streams

Due to the isolated nature of the Hamlet, the waste stream is divided into the following components:

1. **Hazardous Wastes** – including batteries, waste oil, waste antifreeze, and other materials not suitable for landfilling

2. **Bulky Metals** – equipment machinery and metal materials no long deemed salvageable or recyclable by the Hamlet

3. **Municipal Solid Waste** – the remaining waste materials.

A storage area is provided near the landfill for equipment, machinery and metal materials that are deemed to have potential reuse/recycle value. These are kept out of the waste stream until they are no longer deemed usable, then they are transferred to the bulky metals disposal area.

5.3 Hazardous Wastes

5.3.1 Hazardous Waste Materials

Wastes such as oils, fuels, batteries, antifreeze, and solvents that cannot be rendered safe for landfilling or cannot be reused, must be removed from the community and shipped to a proper disposal facility, usually in the south.

The most cost effective backhaul is by sea, once there is a sufficient stockpile of the materials to warrant a shipment. In a community the size of the Hamlet of Qikiqtarjuaq, this could be once every five years depending on the amount accumulated. Materials must be contained, manifested, and arrangements made with a shipper to back haul the

materials to a licensed waste disposal site. In between backhauls the wastes must be safely stored.

Based on previous studies and discussions with Hamlet staff, the following amounts of waste materials are anticipated to be accumulated between shipping periods:

- 40 – 205 L drums of waste oil, waste fuels, and similar products (10 skids)
- 20 – 205 L drums of waste antifreeze and similar materials (5 skids)
- 50 waste batteries of various sizes (2 skids)
- 6 – 205 L drums of miscellaneous waste unsuitable for landfilling (2 skids).

These materials will be stockpiled at the landfill site in a contained and controlled area, until a sufficient quantity has accumulated to warrant a backhaul shipment.

Some materials such as fuels and oils may be disposed of by using a mobile incinerator. The incinerator can be mobilized to the community and operated for a period of time to consume selected wastes that are suitable for incineration. A cost benefit analysis will be required once a stockpile has been accumulated.

5.3.2 Regulatory Guidelines for Hazardous Waste

Management of hazardous waste must be in accordance with:

- "Environmental Guideline for General Management of Hazardous Waste in Nunavut", Government of Nunavut, January 2002

- "Environmental Guidelines for Waste Batteries", Government of Nunavut, January 2002

- "Environmental Guidelines for Waste Antifreeze". Government of Nunavut, January 2002.

5.3.3 Hazardous Waste Storage Area

Currently there is an approximate 10 m long green shipping container located near the entrance to the municipal solid waste disposal area, which is used to store wastes unsuitable for landfilling. A pile of old batteries sits on the ground next to the container. The rehabilitated area will consist of the following:

- A 15 m x 15 m fenced area with a 1 m high surrounding berm topped with a 1.8 m fence
- A 3 m wide lockable swing gate to provide access

- Base and interior sides will be lined with a 40 mil HDPE arctic liner
- Liner would be held in place by keying it into the berm and armoring the top of the berm with stone
- Floor for the containment area would include 10 cm of sand and gravel over the liner for protection
- Berms would be 1 m high with 3:1 slopes, except for the 3 m wide access ramp, which would have 5:1 slopes to allow easy access for equipment.

The green shipping container would be placed outside the fenced area to receive the weekly volume of hazardous wastes. On a monthly (or other suitable interval as needed) the materials would be bulked into 205 L drums, and stored on pallets in the fenced enclosure to await backhaul.

The floor of the shipping container should include a 0.2 m high lip at the door, and be lined with 40 m HDPE over the floor and 0.2 m up the sides for spill containment. The shipping container will also be equipped with vents to prevent the buildup of odours and vapours.

The container would be equipped with shelves to hold small quantities of hazardous wastes until they can be bulked in drums.

The hazardous waste storage facility will have signs clearly outlining the operations, acceptable materials, and warnings of inherent hazards. A spill kit, emergency kit, and fire extinguisher would be stored in the shipping container for dealing with emergencies.

The proposed upgraded layout of the Hazardous Waste Storage Area is displayed on Drawing 12.

5.4 Recyclable Storage Area

Machinery, equipment, and metal materials that may have reuse/recycle value will be stored in the staging area near the landfill (Figure 2). Materials in this area no longer deemed to have any reuse/recycle value will be disposed of at the bulky metals disposal area.

The reusable storage area requires no modifications other than a sign describing the use of the area and warning of the inherent hazards.

5.5 Bulky Metals Disposal Area

Due to the high cost of removing metals from the community by sea lift backhaul, the disposal strategy has been to dispose of the material by burial in a designated bulky

metals disposal area. By segregating the material from the other waste steams, it provides the possibility for future excavation and backhaul for scrap. In addition, the bulky metals are deemed to have very low potential for an environmental impact, and are considered virtually inert materials. Disposal practices must include scrutiny to ensure oils, fuels, and other items that could cause an environmental impact are removed from the bulky metals waste steam prior to disposal. Based on the historic quantities of metals placed in the bulky metals area and discussions with Hamlet staff, it is anticipated the bulky metals disposal volume with a 4:1 ratio of metals to cover material (20 percent cover by volume) will be approximately 24,000 m^3. This assumes continued use of the recyclable storage area and regular disposal until 2030.

The final estimated footprint for the Bulky Waste Disposal Area is shown on Drawing 13.

The existing ditching in the northeast corner will be improved so that surface erosion of the area is minimized. Areas of existing surface erosion will be repaired with additional cover material.

No operational improvements are recommended regarding the Bulky Metals Disposal Area. The operation method is described in the Operation and Maintenance Report, which is included as Appendix H3.

5.6 Municipal Solid Waste Disposal Area

Currently, when waste arrives at the site, hazardous material is removed. The remaining waste is tipped over a large embankment within the fenced enclosure and periodically lit on fire to reduce volume, breeding sites for flies and potential for scavenging (i.e., bears). The ash and non-burnt material is subsequently pushed over the embankment. Periodically the tipped waste is covered with local soils.

With regards to these practices, we note the following two issues:

- The existing 'working face' is approaching a gradient of 1:1, which is generally not stable and therefore potentially dangerous

- The landfill is currently being developed in an uncontrolled manner without an overall strategy to minimize its footprint and minimize its potential to cause an environmental impact.

The current practice of burning the waste is not considered a good management practice, and is illegal in many parts of Canada. However, we understand that it is accepted in Nunavut. Section 27 of the Public Health Act for Nunavut states *"Every incorporated municipality shall provide adequate waste disposal grounds for the disposal of all*

garbage…and shall cause such waste materials to be burned, buried or covered with a layer of earth ….", and the process has been approved by the Regional Engineer of the Government of Nunavut. Given the site conditions, most notably the climate and the potential for scavengers (i.e., bears) we understand the Hamlet's position that options other than burning are not practicable. Options could be supplied at a later time, if requested.

The preferred alternative involves both initial improvements of the site and overall improvements in the operational procedures to address the issues noted above, and to accommodate the waste in a more efficient and environmentally friendly period during the 24 year design period. Calculations for the expected municipal solid waste quantity required for the Hamlet solid waste landfill site are displayed on Table 5.1.

Quantity calculations are based upon:

- A generation rate of 0.014 m^3/person/day, which is a standard for NWT and Nunavut
- A projected population growth rate of 2 percent
- An estimate of approximately 16 percent of all wastes being non-combustibles, based on typical waste composition rates in NWT
- A 40 percent reduction in combustible waste due to open burning, based on estimates used throughout the NWT
- A volume reduction of 25 percent due to compaction of the waste, based on observations of the waste
- Application of cover material at 4:1 fill to cover ratio (or 20 percent by volume).

5.6.1 Recommended Design Improvements

The recommended design improvements are summarized on Drawing 12, Figures 10 through 16, and described below.

The tipping face will be cut back from the current 1:1 slope, such that it does not exceed a 3:1 slope. This is necessary to reduce the risk of slope failure and facilitate future site development. It is envisioned that this will involve progressively blading the landfill waste from the top of the landfill to the bottom, using appropriate equipment, such as dozers. As necessary and to facilitate a working surface, intermediate cover may be applied.

A 2 m high landfill perimeter berm will be constructed around the entire estimated extent of the waste cells in areas where a berm does not exist (Drawing 12, Detail A). This will demarcate the final extent of the waste and cover and allow for controlled and organized development of the area. The landfill perimeter berm will be constructed using sand, gravel and cobble material from any convenient borrow source, preferably from within

the landfill cell itself. Topsoil materials will be removed and not used in construction. The top of the landfill perimeter berm will be 1 m wide, and the inside slope (landfill side) will be at 2:1, while the outside slope is at a 3:1. In areas where a berm currently exists (i.e., along the southeastern boundary), the inside slopes will be cut back to a 2:1 where practicable.

A water retention area (similar to that which currently exists) will be constructed west of the landfill cell to facilitate temporary storage and testing of any potentially impacted runoff from the facility. The water retention area has been sized to contain a 100 mm storm event or snow runoff. Native materials (sand, cobble and gravel) will be excavated to a depth of 1 m and banked up around the perimeter. A 2 m deep invert (i.e., gap) will be cut into the landfill perimeter berm at the lowest point (See Drawing Detail B), to facilitate water drainage into the effluent retention area.

The 4 m high 50 mm fence posts and associated wire mesh will be removed and disposed of. The existing fence along the western side of the site will be removed and relocated or replaced further to the west along the perimeter landfill berm. Diagonal risers, angled towards the landfill area, will be installed on the top of the fence to provide additional capture of windblown litter (Drawing 12, Detail D). The fence will be constructed along the north and south landfill perimeter berms at a height of 1.8 m, and excavated into the native materials a distance of at least 0.5 m. A 0.5 m deep drainage invert will be constructed at the west side of the berm.

An intermediate berm will be constructed at a distance of 30 m from the top or crest of the tip. This will delineate the interim phase of the landfill development (development until approximately year 6). The cross section of intermediate berm will be constructed in a manner similar to that of the landfill perimeter berm.

The sequence of landfill development is displayed on Figures 9 through 17.

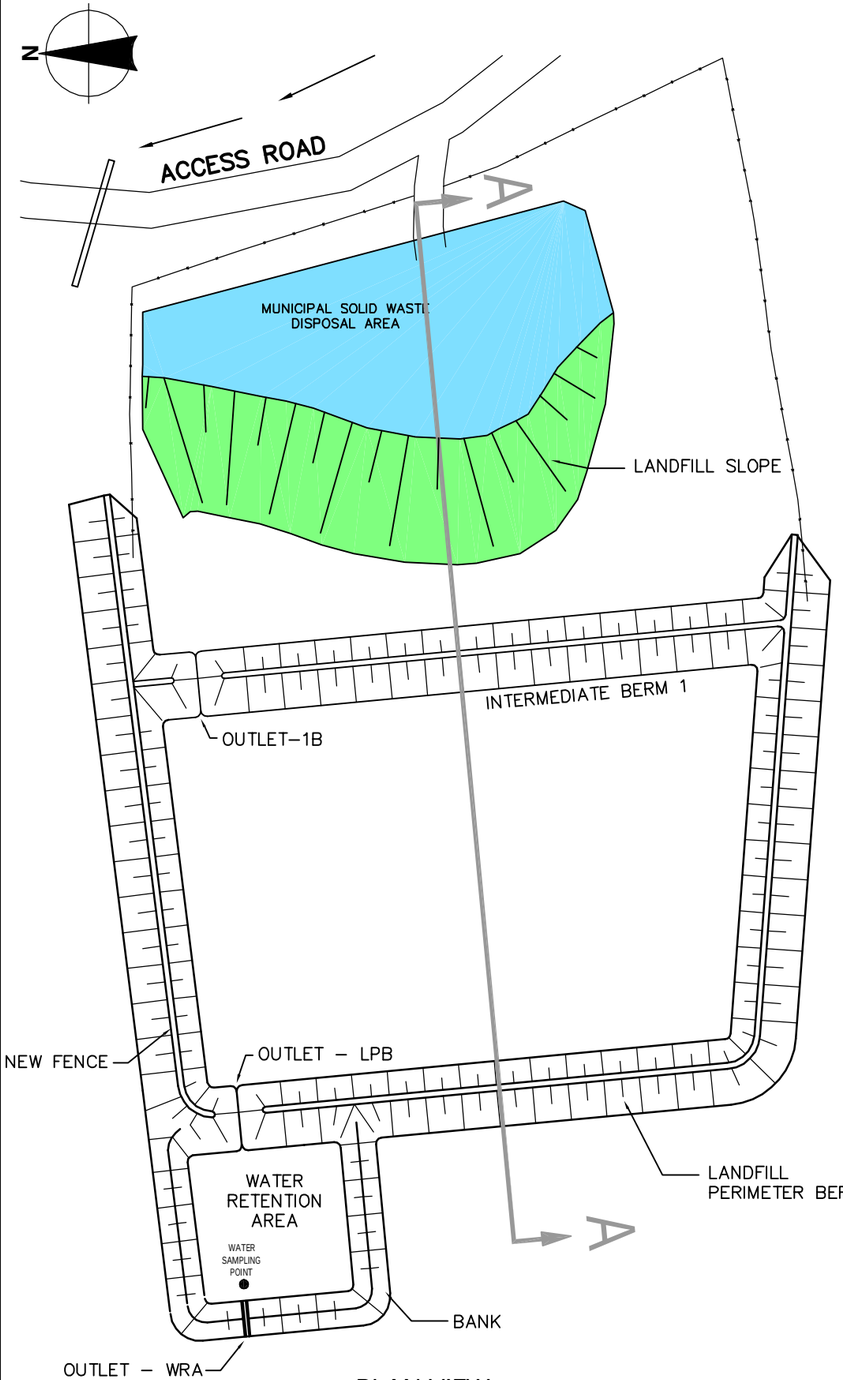
The existing ditch located on the east side of the access road will be extended to a depth of 1.5 m. A 1200 mm diameter culvert will be installed from the eastern ditch to the drainage swale located south of the municipal solid waste disposal area.

Signs shall be posted within the Solid Waste Disposal Area that describe the operations of the site and identify restrictions such as salvaging, waste types and uncontrolled burning.

Table 5.1
Waste Quantity Calculations

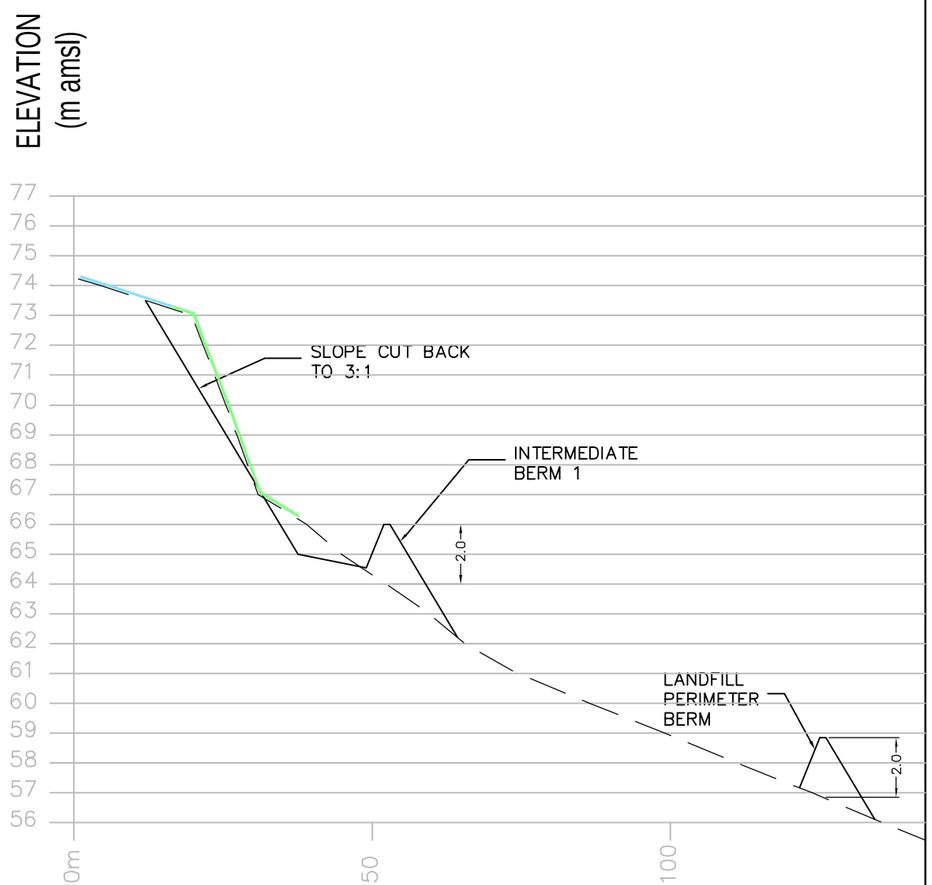
Planning Year	Calendar Year	Projected Population [people]	Annual Volume of Solid Waste [m^3]	Cumulative Volume of Solid Waste [m^3]	Annual Volume of Combustible Solid Waste [m^3]	Annual Volume of Combustible Solid Waste After Burning [m^3]	Annual Volume of Uncombustible Solid Waste [m^3]	Total Annual Volume of Uncombustible and Combusted (Burned) Solid Waste [m^3]	Annual Volume of Compacted Waste [m^3]	Annual Volume of Cover Material [m^3]	Total Annual Volume of Compacted Waste and Cover Material [m^3]	Cumulative Landfill Volume [m3]
0	2006	599	3060.9	3060.9	2571.1	1542.7	489.7	2032.4	1524.3	304.9	1829.2	1,829.19
	2007	611	3122.2	6183.1	2622.7	1573.6	499.6	2073.1	1554.9	311.0	1865.8	3,695.02
	2008	624	3188.6	9371.7	2678.5	1607.1	510.2	2117.3	1587.9	317.6	1905.5	5,600.55
	2009	637	3255.1	12626.8	2734.3	1640.6	520.8	2161.4	1621.0	324.2	1945.2	7,545.78
	2010	650	3321.5	15948.3	2790.1	1674.0	531.4	2205.5	1654.1	330.8	1984.9	9,530.71
5	2011	663	3387.9	19336.2	2845.9	1707.5	542.1	2249.6	1687.2	337.4	2024.6	11,555.34
	2012	677	3459.5	22795.7	2906.0	1743.6	553.5	2297.1	1722.8	344.6	2067.4	13,622.72
	2013	691	3531.0	26326.7	2966.0	1779.6	565.0	2344.6	1758.4	351.7	2110.1	15,732.85
	2014	705	3602.6	29929.3	3026.1	1815.7	576.4	2392.1	1794.1	358.8	2152.9	17,885.73
	2015	720	3679.2	33608.5	3090.5	1854.3	588.7	2443.0	1832.2	366.4	2198.7	20,084.42
10	2016	735	3755.9	37364.3	3154.9	1892.9	600.9	2493.9	1870.4	374.1	2244.5	22,328.92
	2017	750	3832.5	41196.8	3219.3	1931.6	613.2	2544.8	1908.6	381.7	2290.3	24,619.22
	2018	765	3909.2	45106.0	3283.7	1970.2	625.5	2595.7	1946.8	389.4	2336.1	26,955.33
	2019	781	3990.9	49096.9	3352.4	2011.4	638.5	2650.0	1987.5	397.5	2385.0	29,340.30
	2020	797	4072.7	53169.6	3421.0	2052.6	651.6	2704.3	2028.2	405.6	2433.8	31,774.12
15	2021	813	4154.4	57324.0	3489.7	2093.8	664.7	2758.5	2068.9	413.8	2482.7	34,256.81
	2022	830	4241.3	61565.3	3562.7	2137.6	678.6	2816.2	2112.2	422.4	2534.6	36,791.41
	2023	847	4328.2	65893.5	3635.7	2181.4	692.5	2873.9	2155.4	431.1	2586.5	39,377.93
	2024	864	4415.0	70308.5	3708.6	2225.2	706.4	2931.6	2198.7	439.7	2638.4	42,016.35
	2025	882	4507.0	74815.5	3785.9	2271.5	721.1	2992.7	2244.5	448.9	2693.4	44,709.75
20	2026	900	4599.0	79414.5	3863.2	2317.9	735.8	3053.7	2290.3	458.1	2748.4	47,458.11
	2027	918	4691.0	84105.5	3940.4	2364.3	750.6	3114.8	2336.1	467.2	2803.3	50,261.44
	2028	937	4788.1	88893.6	4022.0	2413.2	766.1	3179.3	2384.5	476.9	2861.4	53,122.79
	2029	956	4885.2	93778.7	4103.5	2462.1	781.6	3243.7	2432.8	486.6	2919.4	56,042.16
Design criteria	2030	976	4987.4	98766.1	4189.4	2513.6	798.0	3311.6	2483.7	496.7	2980.4	59,022.61

percentage remaining after burning 0.6



PLAN VIEW

SCALE 1:1000



EAST

CROSS SECTION A-A

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:200

WEST

FIGURE 10

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

LANDFILL DEVELOPMENT 1
INITIAL SITE REDEVELOPMENT

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE

0 10 20 30 40 50 60 70 80
Meters

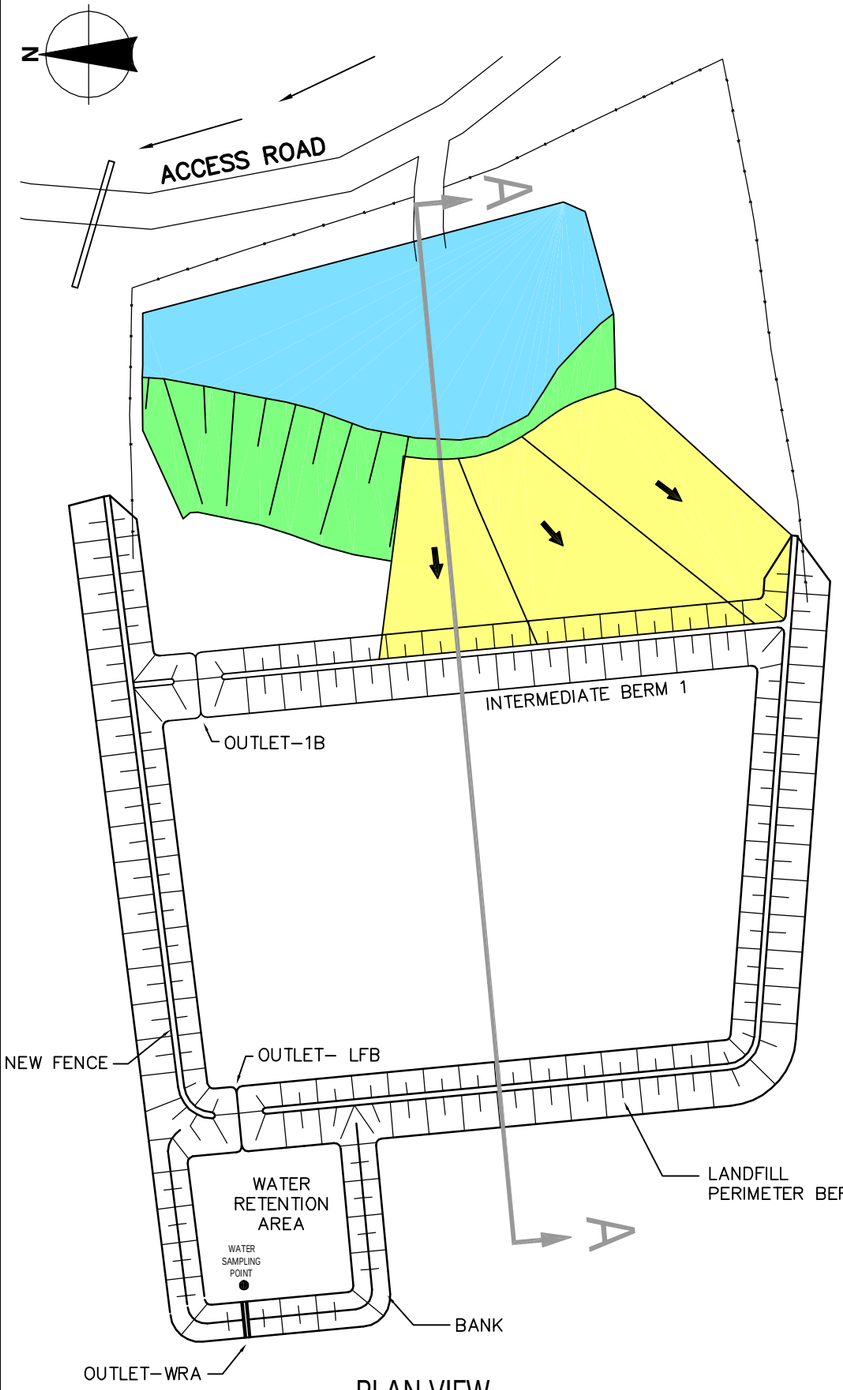
February 2006
Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

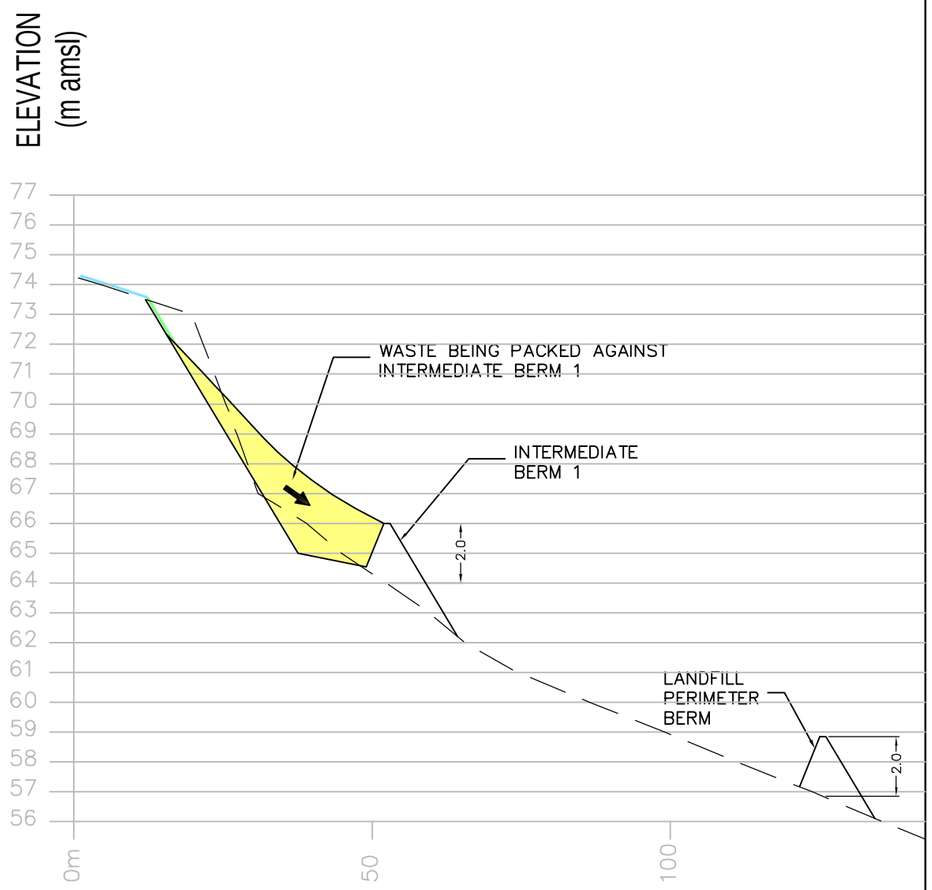
NUNA BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 1.DWG



PLAN VIEW

SCALE 1:1000



EAST

CROSS SECTION A-A

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:200

WEST

FIGURE 11

THE HAMLET OF QIKIQTARJUAQ

DETAILED DESIGN

LANDFILL DEVELOPMENT 2
FILL TO INTERMEDIATE BERM 1

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1

0 10 20 30 40 50 60 70 80

Meters

February 2006

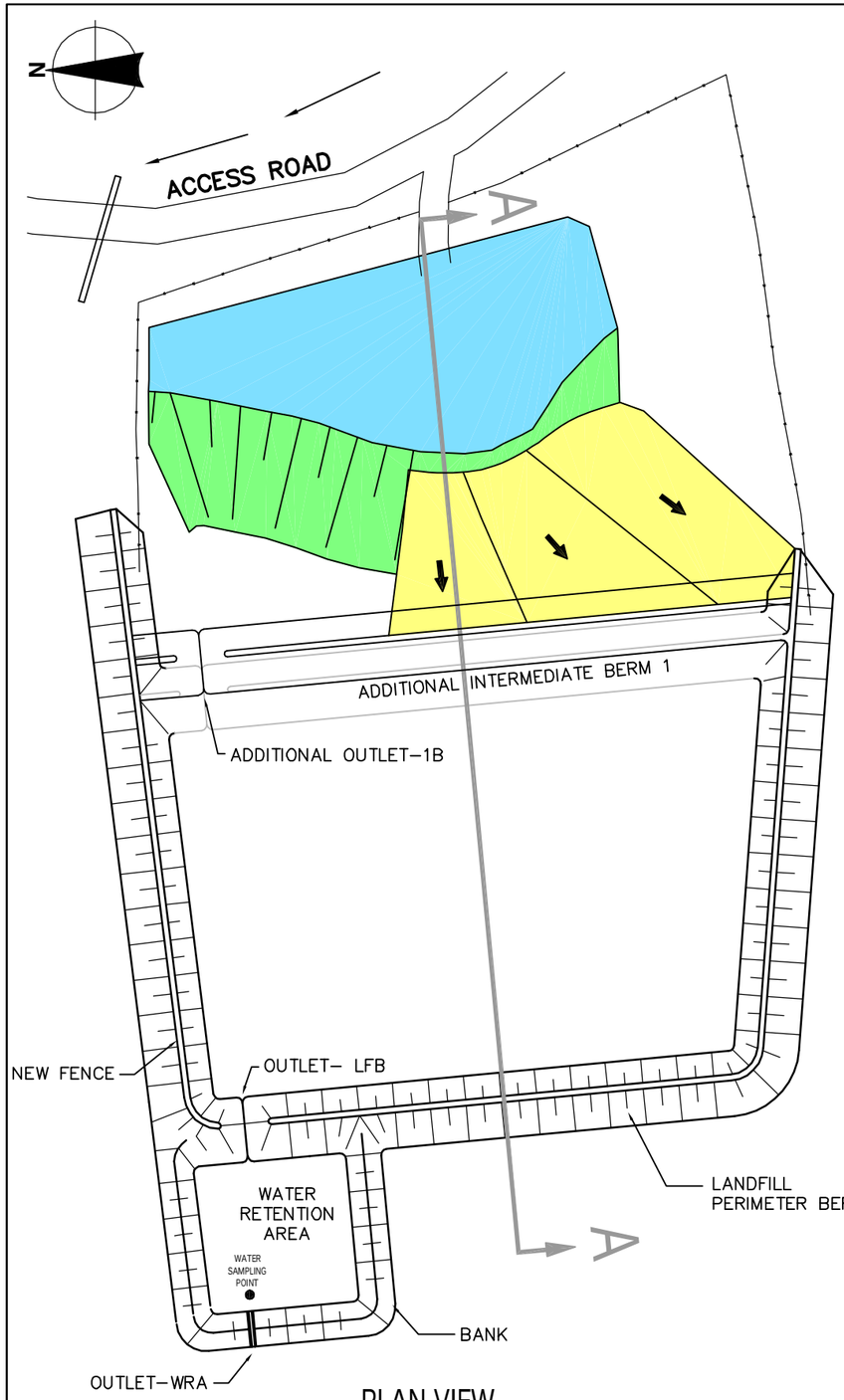
Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

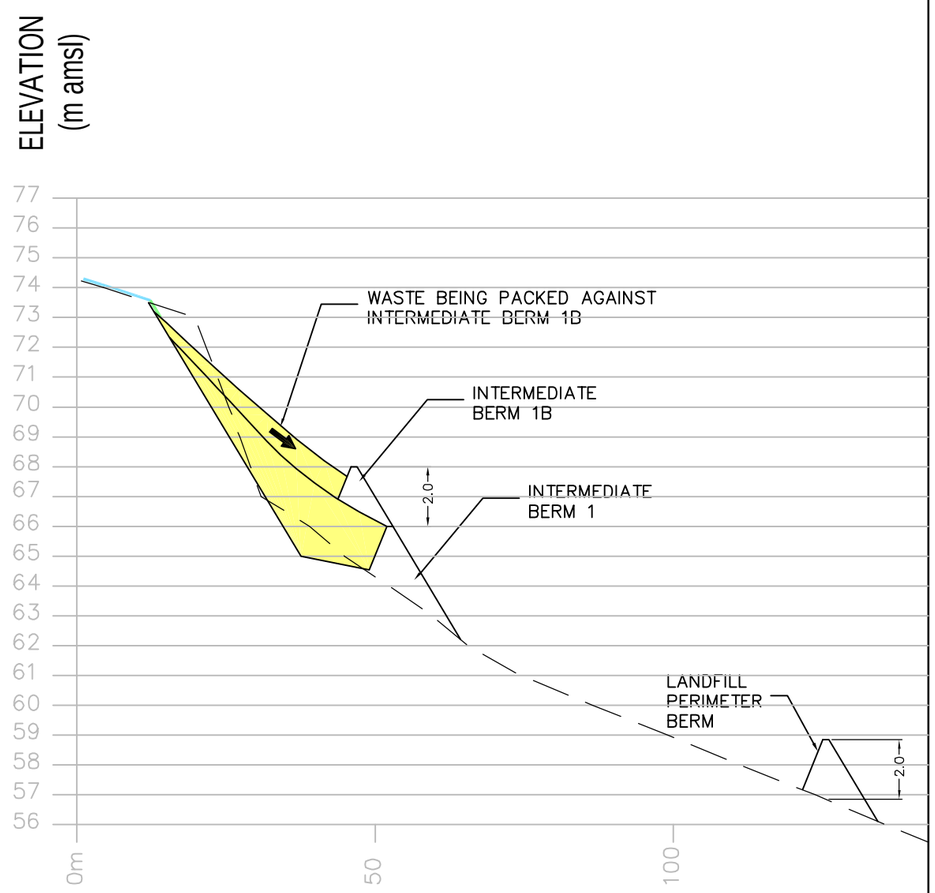
NUNA BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 2.DWG



PLAN VIEW

SCALE 1:1000



EAST

CROSS SECTION A-A

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:200

WEST

NOTE

SITE OPERATORS MAY ELECT TO INSTALL AN ADDITIONAL VERTICAL BERM IF CONSTRUCTION WASTES WITH 3:1 SLOPE IS PROBLEMATIC

FIGURE 12

THE HAMLET OF QIKIQTARJUAQ

DETAILED DESIGN

LANDFILL DEVELOPMENT 2B OPTIONAL CONSTRUCTION OF ADDITIONAL BERM

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1

0 10 20 30 40 50 60 70 80

Meters

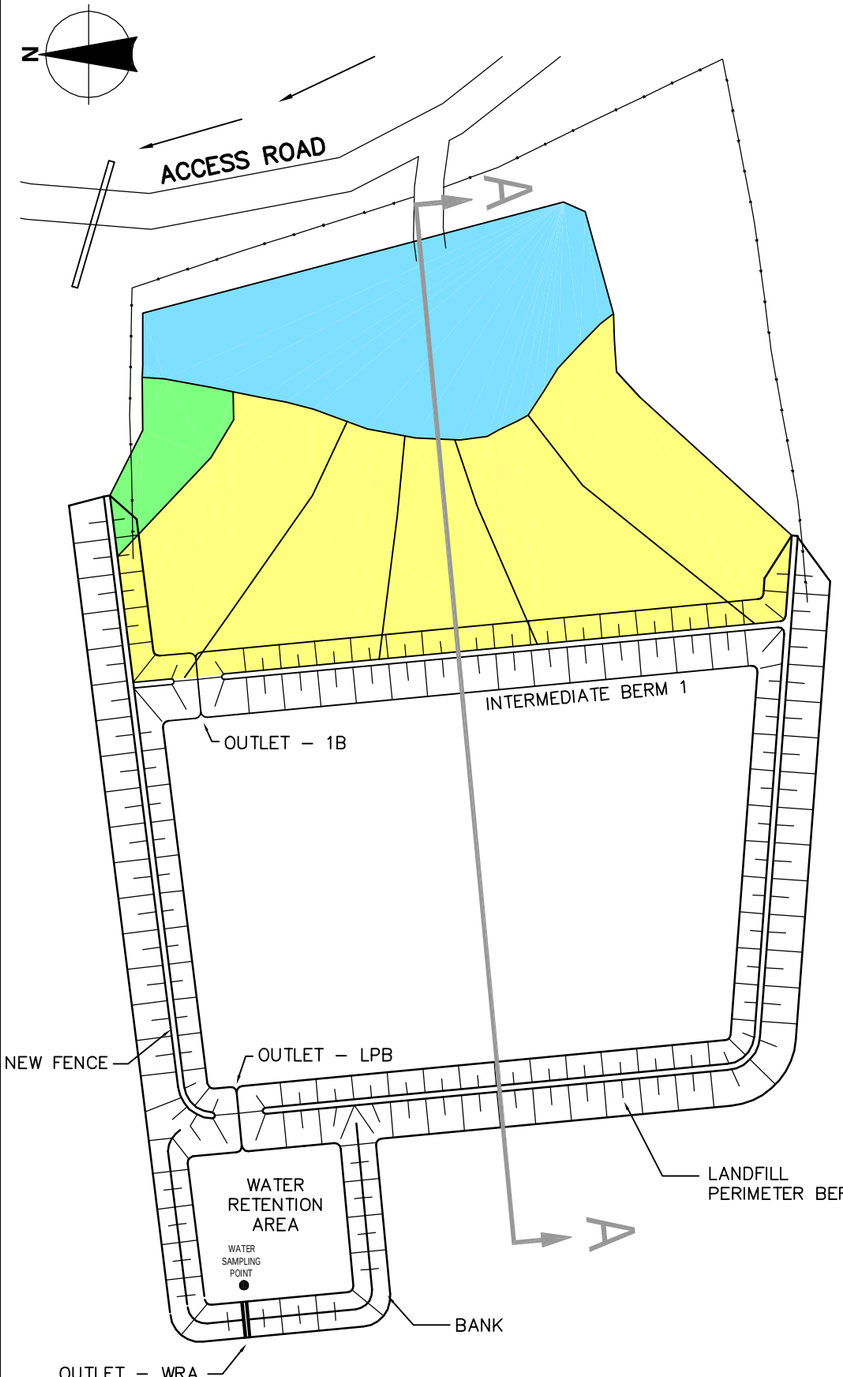
February 2006

Project Number: FOE 08 983

Prepared by: C. Sheppard

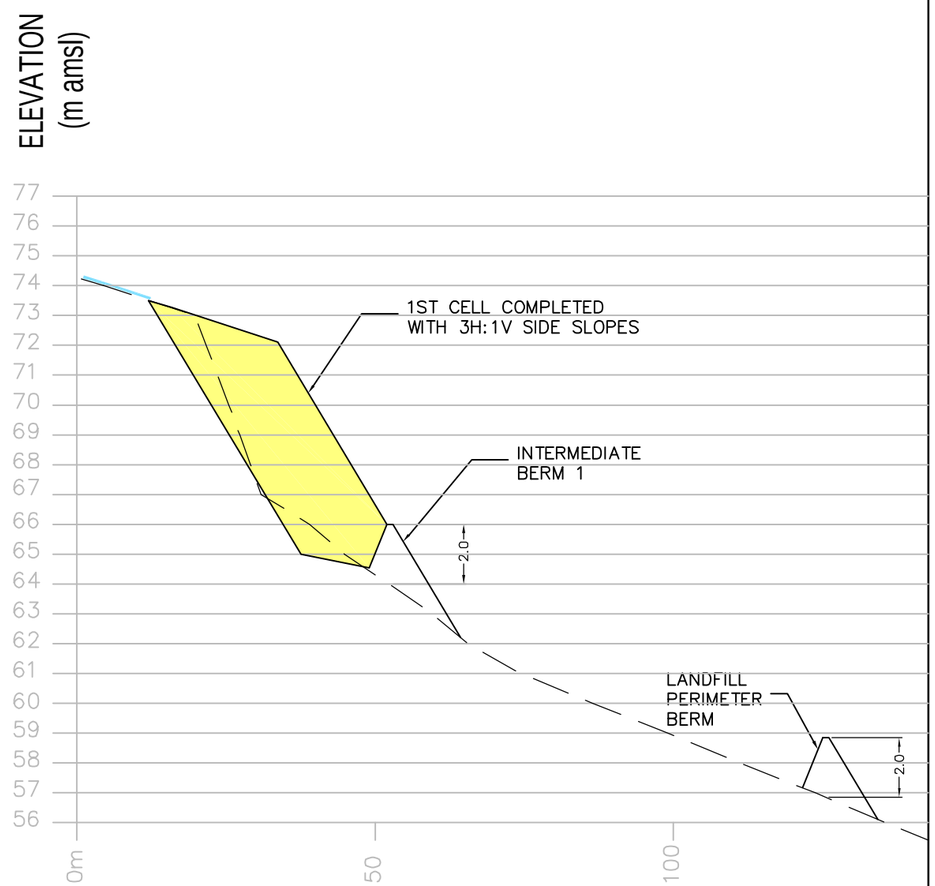
Verified by: K. Hunter

FOE08983 SOLID WASTE DEVELOPMENT 2B.DWG



PLAN VIEW

SCALE 1:1000



EAST

CROSS SECTION A-A

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:200

WEST

FIGURE 13

THE HAMLET OF QIKIQTARJUAQ

DETAILED DESIGN

LANDFILL DEVELOPMENT 3
1ST WASTE CELL COMPLETED

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1

0 10 20 30 40 50 60 70 80

Meters

February 2006

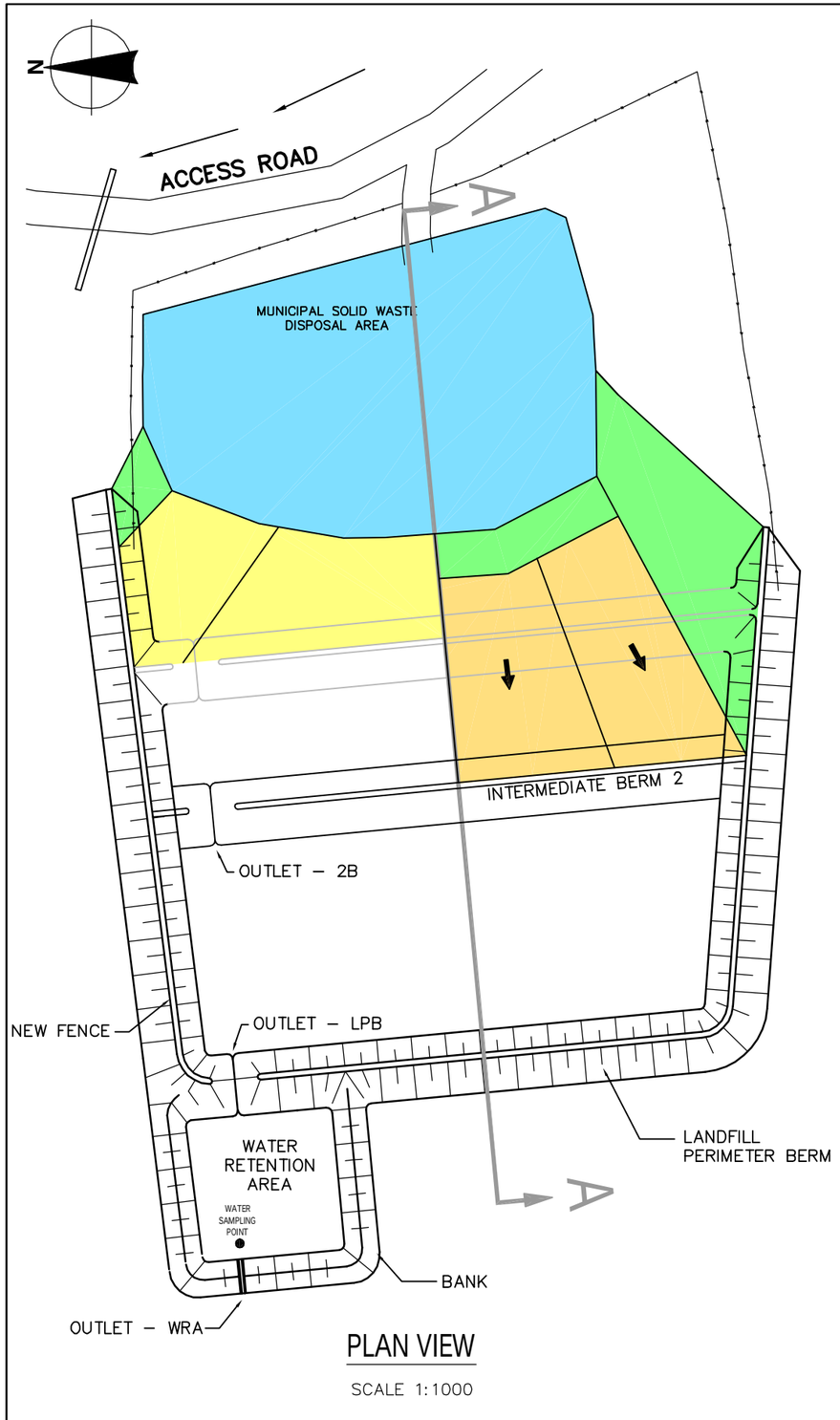
Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

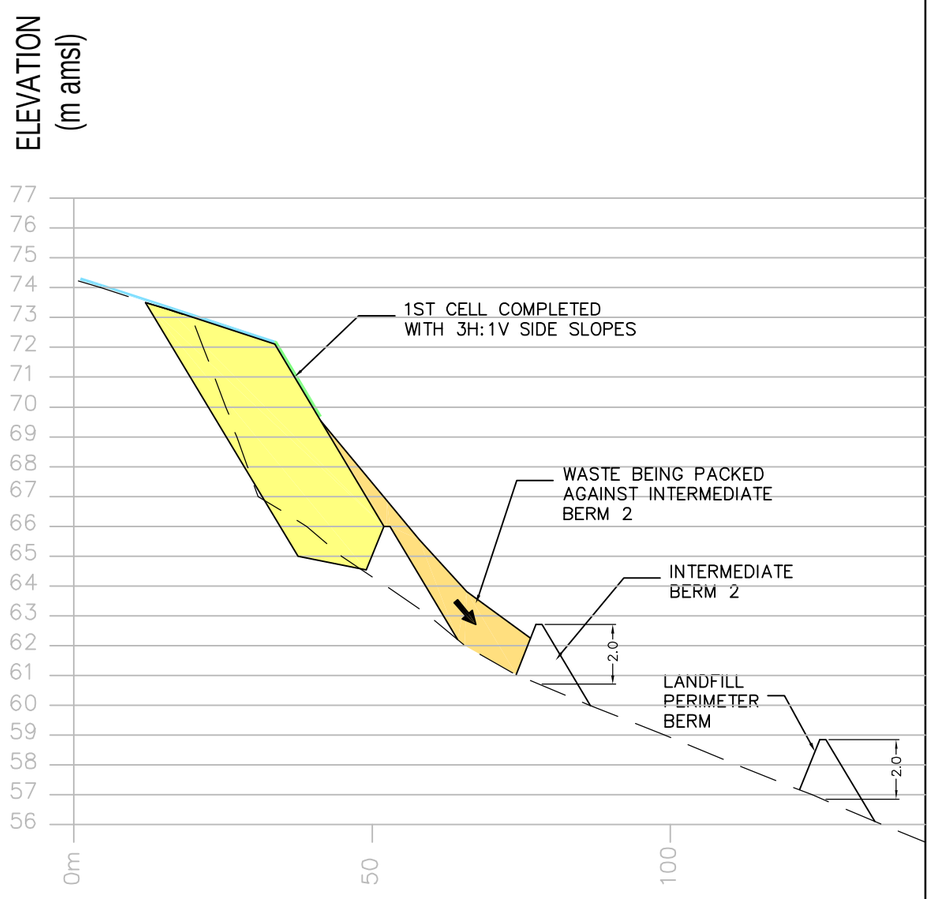
BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 3.DWG



PLAN VIEW

SCALE 1:1000



CROSS SECTION A-A

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:200

FIGURE 14

THE HAMLET OF QIKIQTARJUAQ
DETAILED DESIGN

LANDFILL DEVELOPMENT 4
BEGIN FILLING TO
INTERMEDIATE BERM 2

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1
- WASTE CELLS No. 2

0 10 20 30 40 50 60 70 80
Meters

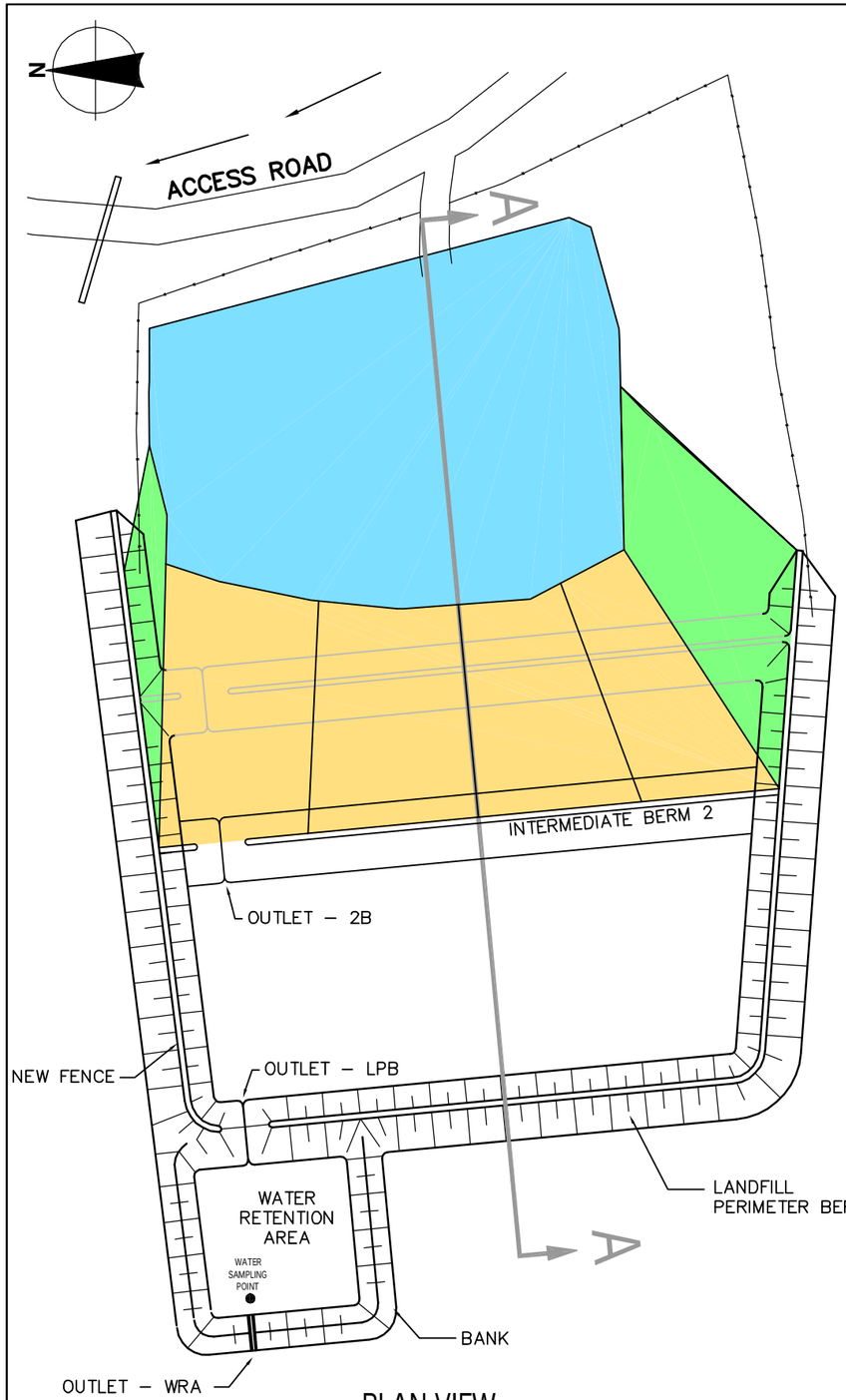
February 2006
Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

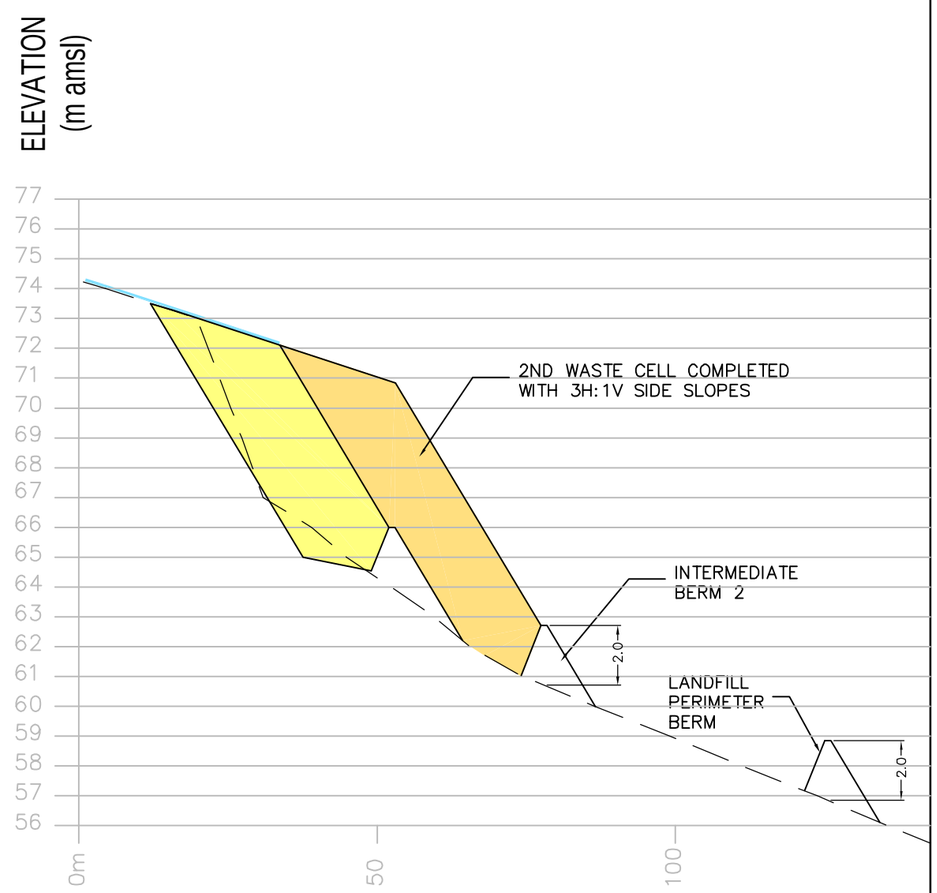
BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 4.DWG



PLAN VIEW

SCALE 1:1000



EAST

CROSS SECTION A-A

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:200

WEST

FIGURE 15

THE HAMLET OF QIKIQTARJUAQ

DETAILED DESIGN

LANDFILL DEVELOPMENT 5
2ND WASTE CELL COMPLETED

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1
- WASTE CELLS No. 2

0 10 20 30 40 50 60 70 80

Meters

February 2006

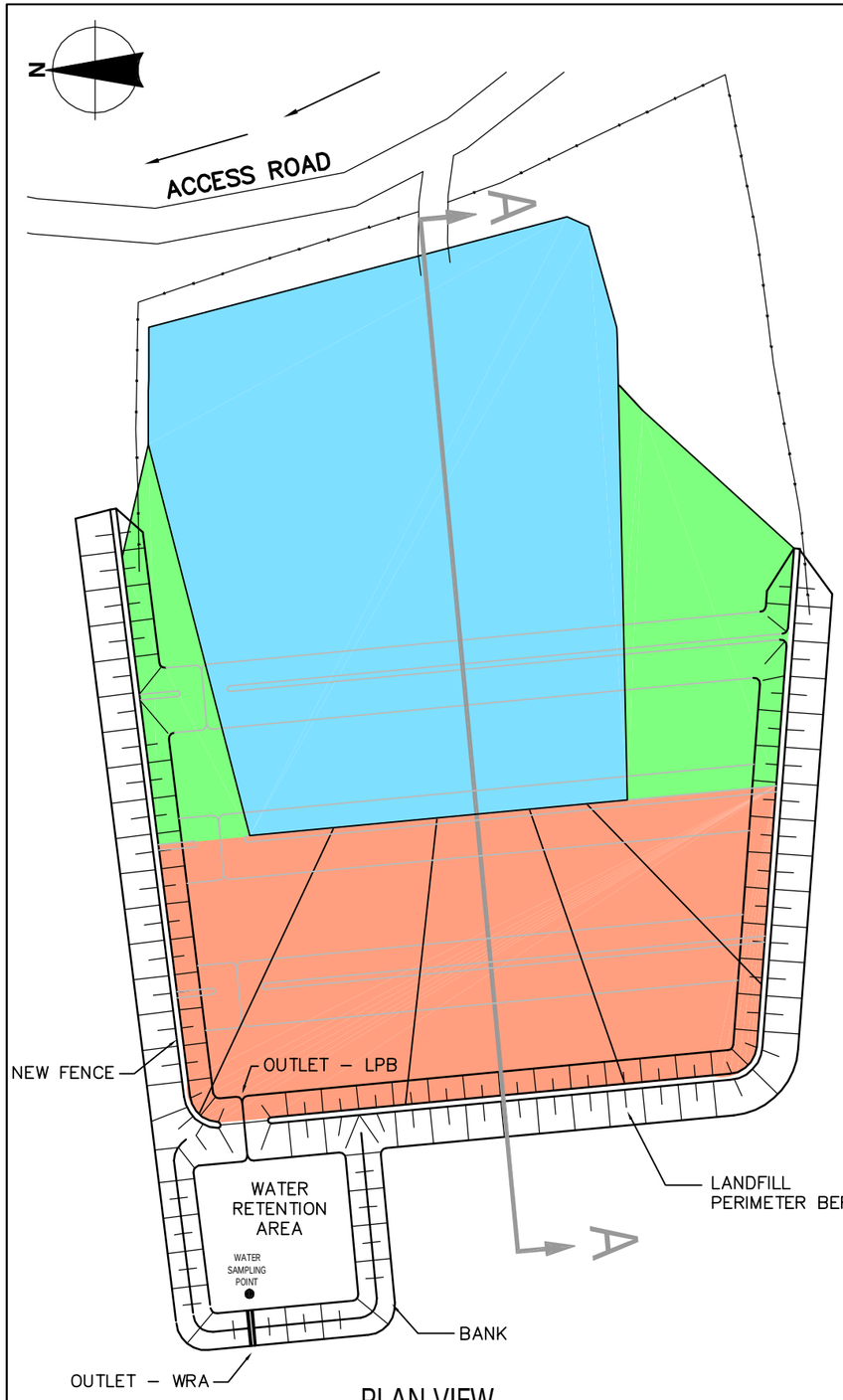
Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

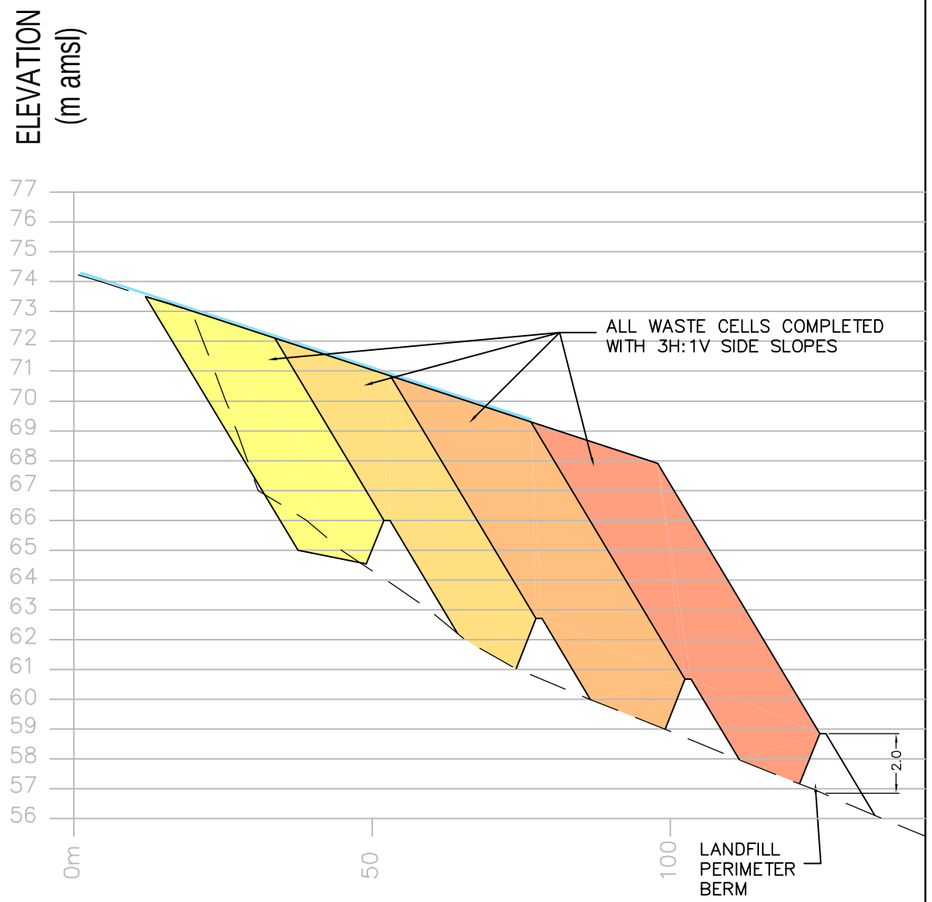
NUNA BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 5.DWG



PLAN VIEW

SCALE 1:1000



CROSS SECTION A-A

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:200

FIGURE 16

THE HAMLET OF QIKIQTARJUAQ

DETAILED DESIGN

LANDFILL DEVELOPMENT 6
ALL WASTE CELLS COMPLETED

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1
- WASTE CELLS No. 2
- WASTE CELLS No. 3
- WASTE CELLS No. 4

0 10 20 30 40 50 60 70 80

Meters

February 2006

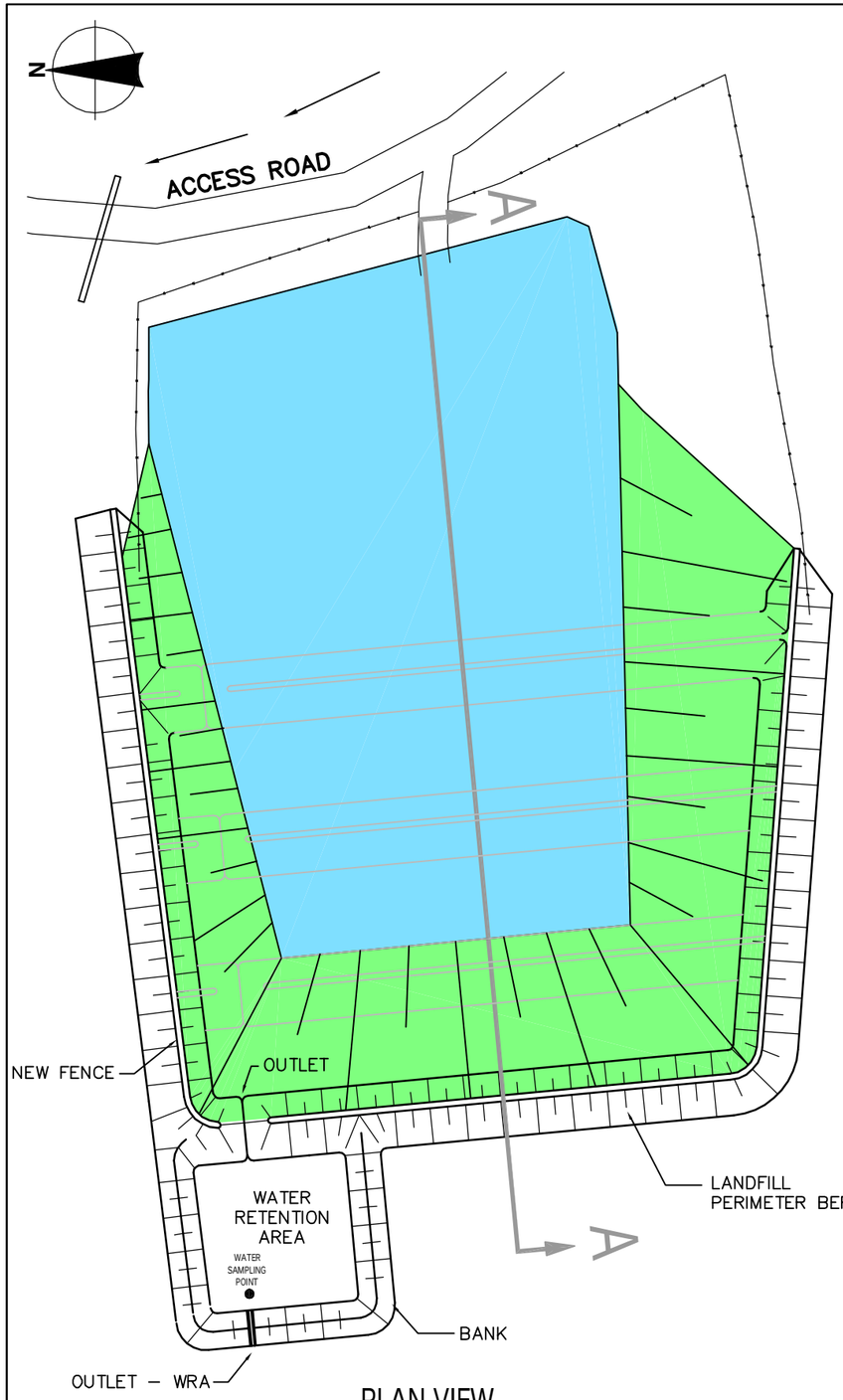
Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

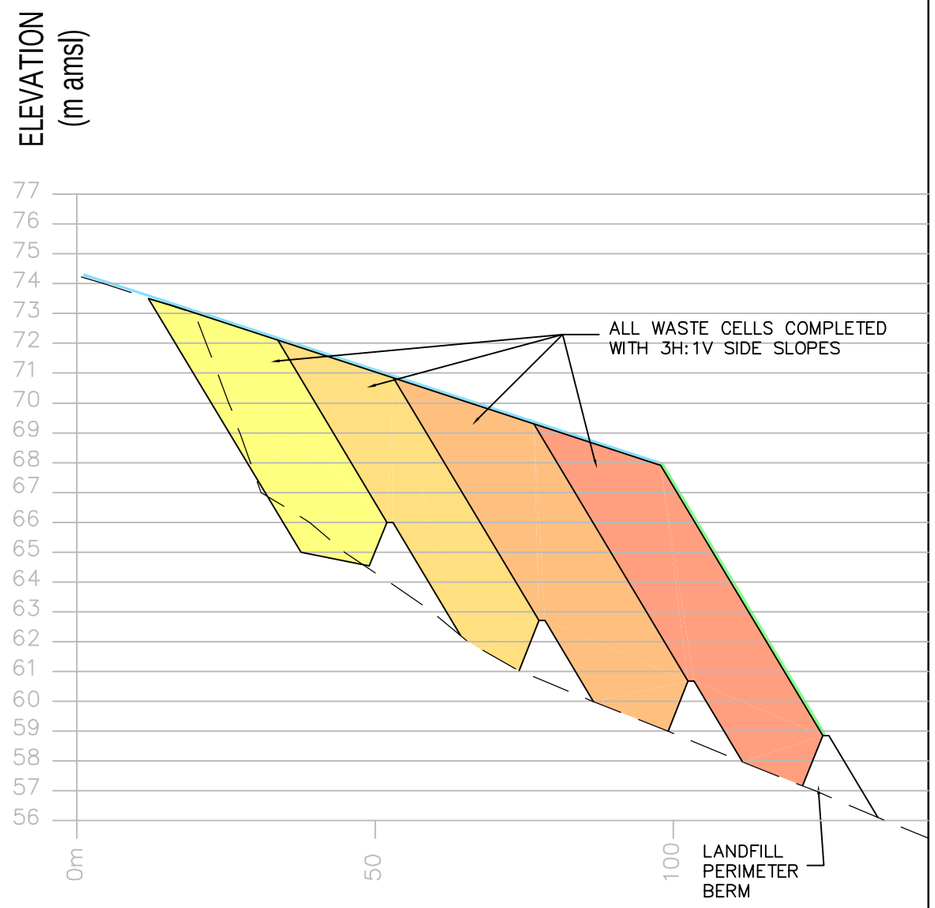
NUNA BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 6.DWG



PLAN VIEW

SCALE 1:1000



CROSS SECTION A-A

HORIZONTAL SCALE 1:1000

VERTICAL SCALE 1:200

FIGURE 17

THE HAMLET OF QIKIQTARJUAQ

DETAILED DESIGN

LANDFILL DEVELOPMENT 7
FINAL SITE CONFIGURATION

Legend

- LANDFILL TIPPING AREA
- LANDFILL SIDE SLOPE
- WASTE CELLS No. 1
- WASTE CELLS No. 2
- WASTE CELLS No. 3
- WASTE CELLS No. 4

0 10 20 30 40 50 60 70 80

Meters

February 2006

Project Number: FOE 08 983

Prepared by: C. Sheppard

Verified by: K. Hunter

NUNA BURNSIDE

FOE08983 SOLID WASTE DEVELOPMENT 7.DWG

5.6.2 Recommended Operational Improvements

Improved operational procedures are detailed in the Operation and Maintenance manual (Appendix H3), which achieve the following objectives:

- Provides higher level of safety than the current practice of dumping on the slope (reduced risk of slope failure and minimization of accident potential (i.e., falling over the edge)
- Organizes and controls development of the landfill to reduce the size and therefore the potential impacts
- Reduces the amount of cover required and the time to cover the material.

Instead of dumping wastes over the edge of the landfill, the wastes are pushing downslope using a dozer or loader for eventual lift development along a berm or working face. Once per year, for duration of approximately 1 to 2 weeks, the staff or sub-contractors will perform an annual shaping of the wastes. The purpose of this shaping is to:

- Fix any irregularities in the surface
- Ensure proper progressive development of the landfill
- Facilitate the placement of intermediate cover.

During this annual shaping, additional berms will be constructed as required to facilitate further development of the site.

General maintenance activities are required to ensure that the site remains in good operating order. This involves repairing damaged features, cleaning the site, and monitoring.

As per the requirements of the Water Board license report is to be prepared and submitted to the Nunavut Water Board once per year.

5.7 Water Board License Requirements

Nunavut Water Board License No. NW133Q1K0106 (Appendix C) technically expired November 28, 2005. The requirements of the license with respect to solid waste disposal are addressed as described in the following sections.

5.7.1 Annual Report

The requirements for annual reporting in 2005 were fulfilled in detail in the report entitled (Schematic Design for Improvement of the Water Reservoir, Wastewater Lagoon

and Solid Waste Disposal Facility in the Hamlet of Qikiqtarjuaq, Nunavut by Nuna Burnside dated September 2005.

Future reporting will be conducted as per the Operations and Maintenance Plan included in this report.

5.7.2 Operations and Maintenance (O&M) Plan

The O&M Plan required by the License is included in Appendix H3.

5.7.3 Abandonment and Restoration

The work required to address the abandonment and restoration at the former waste disposal site now used as a Bulky Metals Disposal Area will consist of application of cover material and construction of ditching to reduce erosion of the cover. The work is described in this report as part of the Bulky Metals Disposal Area improvements.

5.7.4 Surveillance Network Program

The current Water Board license requires in Schedule 1 sampling and analysis of water from ten locations. Of these two (0640-7 and 0640-10) relate specifically to the solid waste disposal facility. One monitoring station will be established down gradient of the landfill at the water retention pond. Another monitoring station will be further down stream coincidental with the sewage lagoon down stream sampling location.

Sampling methodology and analysis parameters are included in the O&M Plan.

6.0 Cost Estimates

A Class "B" cost estimate was determined based on the design of each of the facilities described in this document. Appendix I provides tables with the details of the cost estimates.

The following key assumptions were made to develop these cost estimates:

- Capital costs for each of the facilities include construction, supply, delivery and installation of necessary materials and equipment
- The capital cost estimates do not include other management expense such as operation and maintenance for the facilities, the collection and trucking of wastes to the sewage lagoon or landfill, the distribution of water via tanker truck nor do these include community, training, community liaison, etc.
- Costs are based on the equipment and manpower currently available in the community as per the Hamlet's municipal service rates by-law and discussions with the Hamlet's Senior Administrative Officer (SAO)
- All equipment and material on the site that are in good condition will be salvaged and incorporated or utilized in the construction to the fullest extent possible.

These assumptions together with the detailed design drawings were used to determine the corresponding costs estimates for each facility as presented below. The total estimated cost to undertake the improvements to the water reservoir, sewage lagoon, and solid waste facilities to meet the objectives of this project is $3,350,000.

Class "B" Construction Cost Estimate of Improvements to the Hamlet's Facilities

Facility	Cost Estimate
Schedule A – Miscellaneous	$280,000
Water Storage and Treatment Facility	$2,300,000
Sewage Storage and Treatment System	$570,000
Solid Waste Disposal Facility	$200,000

The above does not include engineering, contingences, or GST.

It should be noted that the overall costs have increased substantially due to the increase in projected volumes for the water reservoir and sewage lagoon.

As indicated in this report, the schematic design costs for the sewage lagoon were based on the existing lagoon having a depth of 8 m. The lagoon depth is actually 4 m (including freeboard). This resulted in an expansion of the new lagoon to provide the additional capacity to meet the revised storage volume requirements.

The schematic design also carried costs for a water reservoir that was 90 x 127 m, which has been revised to 90 x 156 m. This has resulted in a 30 percent increase in the liner costs. The other increase in costs is due to the phasing of the construction. The original thought was to utilize the existing berm material to construct the new berm. Constructing a new berm and then excavating the inside berm results in additional costs to the project.

7.0 Environmental Screening

There are some potential environmental concerns directly associated with the implementation of improvements to the water, sewage, and solid waste facilities in the Hamlet of Qikiqtarjuaq. As such, the GN approved a Change Order to the original scope of the project in order for a Canadian Environmental Assessment Act (CEAA) Environmental Screening Report (ESR) could be completed. An ESR following INAC's 2005/2006 CEAA Screening Report format was undertaken to identify potential concerns and provide appropriate procedures to avoid or mitigate potential adverse efforts on the environment. The Environmental Screening Decision Form for each of the facilities is presented in Appendix J.

The screening decision number for all three facilities (water, sewage, and solid waste) is "01" which means that the project may proceed since al potentially adverse effects are mitigable with known technology, and therefore will be rendered insignificant.

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