Sewage & Solid Waste Site Selection Kimmirut, NT

Final Report

February 11, 1999

Sewage & Solid Waste Site Selection
Kimmirut, NT

Government of the Northwest Territories
Department of Public Works & Services
Iqaluit, NT

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Submitted by

Dillon Consulting Limited

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1.0 INTRODUCTION

1.1 Purpose

The Department of Municipal and Community Affairs (MACA) of the Government of the Northwest Territories (GNWT) retained Dillon in July 1994 to complete a sanitation site planning study for the community of Kimmirut, officially known at that time as Lake Harbour. This study was later designated as Phase I. The need for a new sanitation site was prompted by pressures for new housing areas. The community plan dated 1994 showed the expansion of the community around the existing sanitation site. The relocation of the site was therefore required. The community is bounded by a marine bay, the fresh water lake used for potable water, the airport, and is located on rugged terrain. These boundaries place extreme restrictions on land development and result in high costs to open new areas for housing, airports, and sanitation sites.

During the field work of Phase I, it became apparent that there would be some difficulty in developing a sanitation site that met all the regulatory criteria, the community development plans, and available funding. In total four separate sites and three treatment technologies were identified. This resulted in with a total of six options that were investigated, developed, and presented in a draft report tabled in December of 1994. The analysis of the options indicated that the best balanced choice would negate the community's planned housing subdivision expansion. It was decided that the draft report would be used as a point of discussion with the community, and that the report would not be finalized under the original contract with Dillon.

In July of 1995, MACA retained Dillon to complete further (Phase II) work with respect to the sanitation site. The purpose of work was to examine sites and options that did not heavily impact the community plan. Two sites in addition to those developed in Phase I were identified. These then provided five more options when combined with the technologies.

In the Fall of 1998, Public Works and Services Iqaluit (PWS) retained Dillon to investigate the feasibility of two additional sites for the community's solid waste disposal and sewage treatment site. The location of the additional sites and the access road alignment were provided to Dillon by PWS. Following the development of options, and analysis of these options for the two sites, a comparison to the previous work will be undertaken.

The scope of this study includes:

- an introduction and updating of relevant information from previous reports by Dillon,
- the investigation of the additional sites for their suitability as disposal areas,
- the conceptual development of various technologies at the new sites,
- an evaluation of the new options taking into account capital costs, life cycle costs, compliance issues, and the community plan, to the previous options.

1.2 Community

Kimmirut is an Inuit community located on the south end of Baffin Island. The local economy is based on subsistence hunting, trapping, fishing, carving, and a growing tourism industry. The development of Katanalik Park on the Soper River is expected to increase tourism in the community in the future.

The community has the following services: nursing station, diesel power generation, airport, Co-op and Northern stores, government offices, and annual resupply sealift. Access to Kimmirut is limited to small propeller (Twin Otter) aircraft year round, a snowmobile trail to Iqaluit in winter, and the sealift in the summer.

1.3 Climate

Kimmirut has an arctic climate, although milder than most other communities on Baffin Island. The January and July mean temperatures are -20°C high/-27.2°C low and +12.2°C high/+3.9°C low respectively. The annual precipitation is made up of 20.2 cm of rainfall and 210.1 cm snowfall for a total of 41.2 cm precipitation. The prevailing winds are north and south at 9 to 18 knots (NWT Data Book).

2.0 SYSTEM REQUIREMENTS

2.1 General

The system requirements are to develop a sanitation site that meets the requirements of the community for the 20 year planning horizon. The loadings, volumes, and treatment requirements must be developed to select appropriate technologies and size these technologies for the sewage treatment system and landfill. This section develops the expected sewage and solid waste volumes that will be trucked to the selected site over the planning horizon. For the purposes of this study the General Terms of Reference for Sanitation Planning Studies, MACA is used. A 20 year planning horizon is used as required by MACA's terms of reference.

2.2 Population

The NWT Bureau of Statistics has census records, and has developed population projections for Kimmirut until 2006. The Bureau information is found in **APPENDIX C**. The population growth has been projected to the end of the 20 year planning period. See **Table 2.1**, and the associated charts for the population projections.

A growth rate of 2.31% was used to project the population beyond 2006. The growth rate used for the population projections is the average growth rate of the NWT Bureau of Statistics from 2002 through to 2006. The projected population at the end of the planning horizon (20 years) was calculated to be 738 residents in 2019.

These population projections are used to calculate sewage and solid waste generations over the planning horizon.

2.3 Sewage Generation

In smaller communities where water delivery is provided by trucks, it can be assumed that the sewage generated is equal to the water consumption. Therefore, the daily and annual sewage generation rates for Kimmirut are approximately equal to the water consumption rates.

The MACA general Terms of Reference state that the standard criterion for water consumption in communities of less that 2000 residents, and using trucked water can be estimated with the following equation:

Water Use (l/c/d) = 90 lcd x (1 + 0.00023 x population)

Year	Notes	Population	Sewage Generation			Solid Waste		
			Litres per Capita	Daily (litres)	Annual (m3)	Daily (m3)	Annual (m3)	Cummulative (m3)
1991	Census	365	97.6	35600	13000	4.0	1400	
1995	Projection	418	98.7	41200	15100	4.6	1700	
1996	Cenus	427	98.8	42200	15400	4.7	1700	
1997	Projection	440	99.1	43600	15900	4.8	1800	
1998	Projection	452	99.4	44900	16400	5.0	1800	
1999	YEAR 0	462	99.6	46000	16800	5.1	1900	New Site
2000	Projection	475	99.8	47400	17300	5.3	1900	1900
2001	Projection	486	100.1	48600	17700	5.4	2000	3800
2002	Projection	499	100.3	50100	18300	5.6	2000	5800
2003	Projection	511	100.6	51400	18800	5.7	2100	7800
2004	Projection	525	100.9	53000	19300	5.9	2100	9900
2005	Projection	539	101.2	54500	19900	6.1	2200	12000
2006	Projection	548	101.3	55500	20300	6.2	2300	14200
2007		561	101.6	57000	20800	6.3	2300	16500
2008		574	101.9	58400	21300	6.5	2400	18800
2009	YEAR 10	587	102.1	60000	21900	6.7	2400	21200
2010		601	102.4	61500	22500	6.8	2500	23600
2011		614	102.7	63100	23000	7.0	2600	26100
2012		629	103.0	64800	23600	7.2	2600	28700
2013		643	103.3	66400	24300	7.4	2700	31300
2014		658	103.6	68200	24900	7.6	2800	34000
2015		673	103.9	70000	25500	7.8	2800	36800
2016		689	104.3	71800	26200	8.0	2900	39600
2017		705	104.6	73700	26900	8.2	3000	42500
2018		721	104.9	75700	27600	8.4	3100	45500
2019	YEAR 20	738	105.3	77700	28300	8.6	3100	48600

1. Cenus from NWT bureau of Stats
2. 1995 to 2006, projection by NWT Bof S.
3. 2007 to 219, Projections at 2.31%

Table 2.1 Projected Population,Sewage and Solid Generation
Kimmirut Sewage & Sanitation Site Selection

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

The projected sewage generation at the end of the planning horizon (2019) was found to be 28,300 m^3 per year by the above equation. Table 2.1, and **Chart 2.1** show the annual sewage generations over the planning horizon.

2.4 Solid Waste Generation

MACA's Terms of Reference include a standard for solid waste generation for communities with less than 2,000 persons; the equation for calculating the solid waste generation is:

Solid Waste Generation (m^3/d) = 0.01 m^3/cd (1.0 + 0.00023 x population)

Table 2.1, and **Chart 2.2** show the calculations of solid waste generation using this formula. They also show the cumulative volume which will be generated during the 20-Year planning horizon and which must be contained within a new solid waste site. The cumulative total solid waste is predicted to be 48,600 m^3. This volume is based on the site being operated as a modified landfill which will include:

- Compaction of the waste mass with a dozer.
- Weekly cover with a thin (300 mm) granular layer.

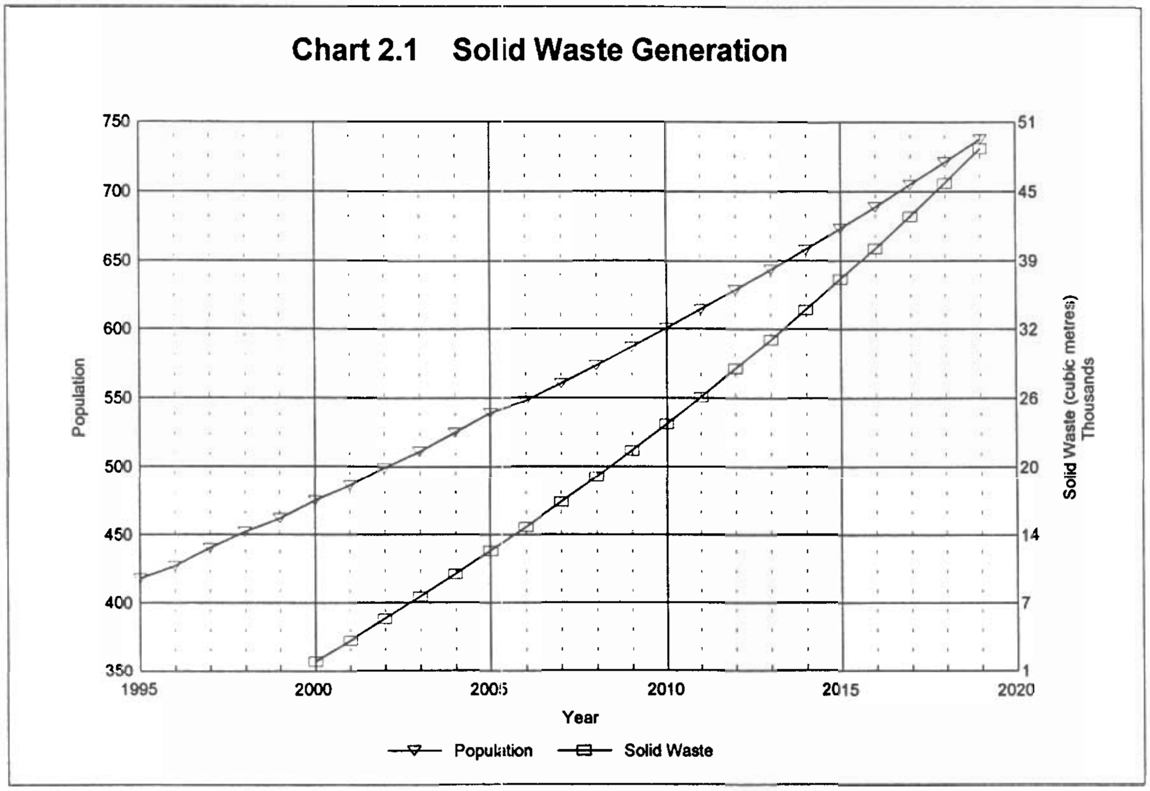


Chart 2.1 Solid Waste Generation
750
700
650
600
550
500
450
400
350
Population
51
45
39
32
26
20
14
7
1
Solid Waste (cubic metres)
Thousands
1995
2000
2005
2010
2015
2020
Year
Population
Solid Waste

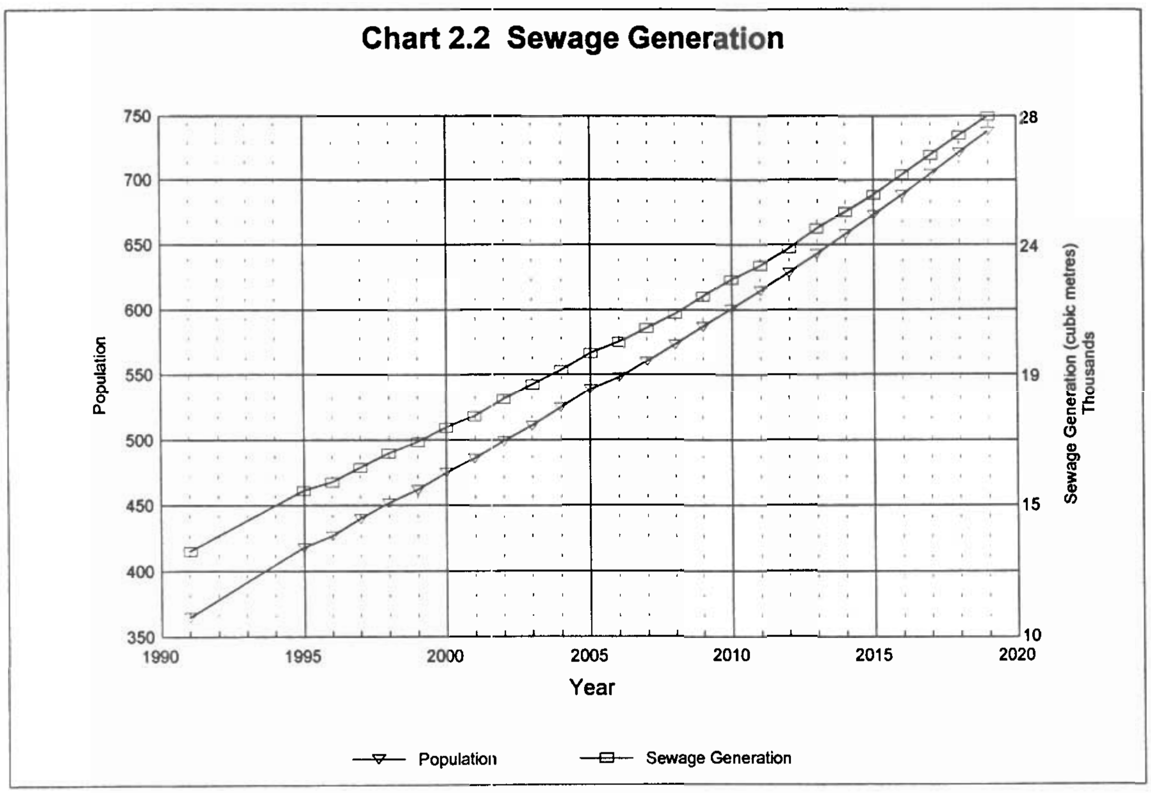


Chart 2.2 Sewage Generation
750
700
650
600
550
500
450
400
350
Population
28
24
19
15
10
Sewage Generation (cubic metres)
Thousands
1990
1995
2000
2005
2010
2015
2020
Year
Population
Sewage Generation

3.0 SANITATION SITE OPTIONS

3.1 Sites

The following sections provide some background on the sites and options developed during the Phase I and Phase II portions of the previous study. The information presented in these sections is provided to bring forward the relative information and to allow for the evaluation of the new sites to the previous sites.

Figure 3.1 illustrates the sites proposed during the Phase I and Phase II portions of the previous study, as well as the two additional sites provided by PWS for this study.

Site 1

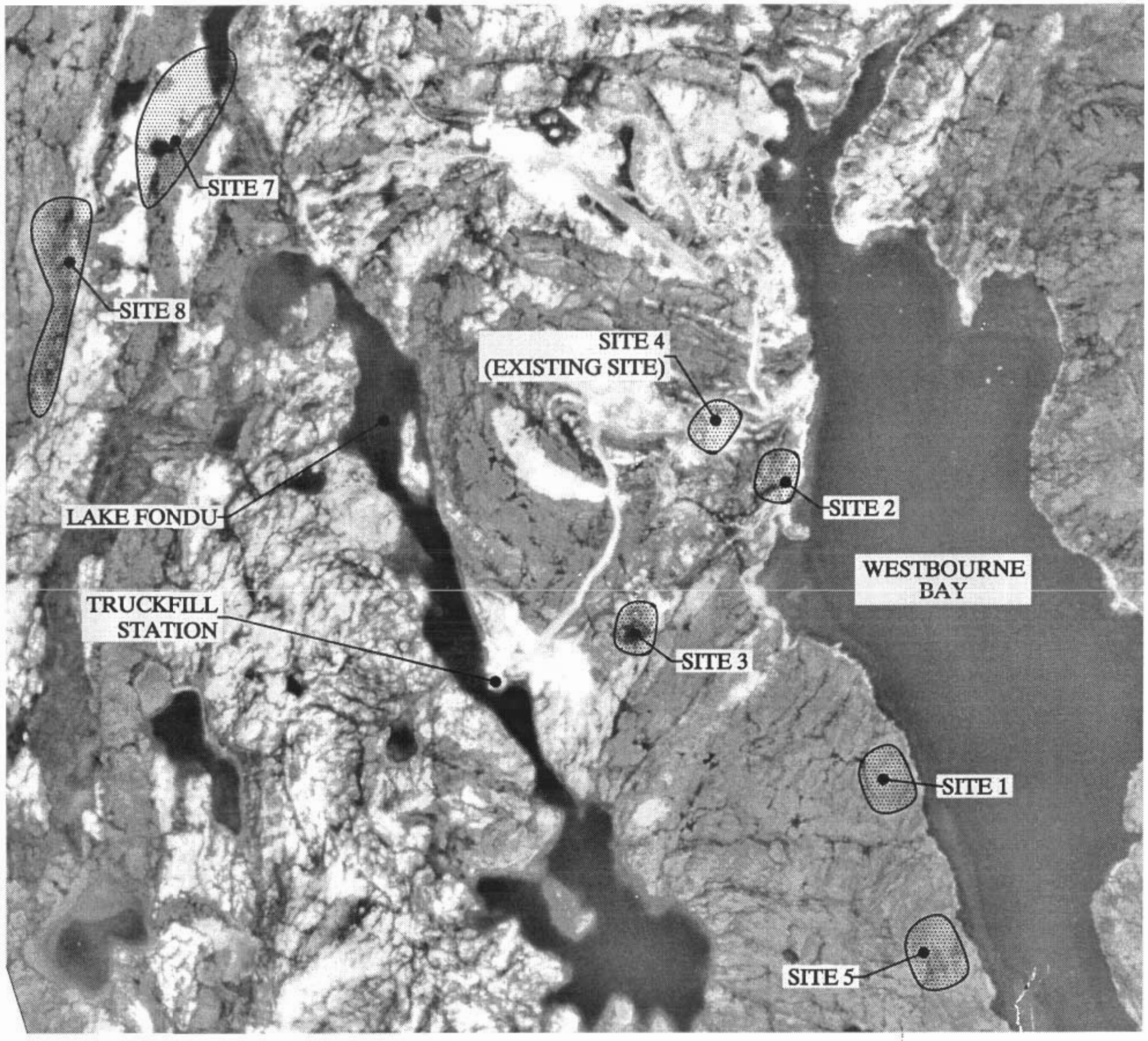
The Terms of Reference for Phase I indicated that site 1 was to be used for the sanitation site. The proposed site from the development plan is located approximately 1 km south of the existing sanitation site on the east slope of a rocky hill which drains to the harbour.

The site is bounded on the north and south by rock bluffs. The area of the site is a draw, with typical tundra vegetation. Access to the site is across several steep draws in the rock terrain. During Phase I site investigation, order of magnitude excavation volumes for a sewage lagoon were developed. Rock cuts and earth fills of up to 10 meters were estimated to be required to develop a lagoon on the proposed site. This would result in quantities of rock blasting and filling in the order of 10,000 cubic meters. The capital costs of such works would be high. Therefore, two other sites with shallower topography and natural drainage basins leading to the harbour were examined for potential development.

Site 2

Site 2 is located at the base of the slope located down-gradient from the existing site. The site is at the northern limit of the proposed new housing development and encompasses a portion of the proposed housing units. The area is characterized by the presence of dense vegetation that is a result of the increase in nutrients from the sewage effluent.

The site is bounded to the east by a rock bluff, and to the northeast by the marine bay. The topography is sloped in a northeast direction with gradients between 5 and 12%. There is a defined drainage path through the site that carries the sewage effluent flow from the current truck discharge location.



APPROXIMATE
SCALE 1:20000

NOTE: SITE 6 IS A NON LOCATION SPECIFIC SITE. SEE DISCUSSION IN TEXT.

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ACAD FILE: 41kag G:\CAD\985730\fig3_1.DWG

DILLON CONSULTING

PROJECT	KIMMIRUT SEWAGE AND SOLID WASTE SITE SELECTION KIMMIRUT, NT	PROJECT NUMBER 98-5730
		DATE FEB 99
TITLE	SITE ALTERNATIVE LOCATION PLAN	FIGURE NUMBER FIG 3.1

Site 3

Site 3 is located in the centre of the proposed new housing development. The site is characterized by a small shallow pond, and a relatively flat topography. The topography of the area slopes from the small pond towards the marine bay. The drainage from this site is directed towards Site 2.

Site 4 (Existing Site)

The existing sanitation site, designated as Site 4, is located at the top of the south road from the town centre. The site is a shallow valley with low rock ridges on three sides. The fourth side to the east drops to a ravine which drains east approximately 400 m to the shore of the harbour. The site is currently operated as an area landfill. This landfill site can be used for many years into the future as waste can be deposited on the existing pad and covered with granular.

The existing sanitation site includes the solid waste disposal area, a trucked sewage discharge area, and a bulky metals area. Sewage is discharged from the truck to the ground where it flows overland along the edge of the solid waste site. The sewage flows down the steep face to the ravine, and out to the marine inlet. No monitoring of this site currently exists. No engineered treatment of the sewage is provided. Surface drainage from the sanitation site follows the path of the sewage discharge.

Site 5

This area contains a small wetlands and pond which drains to the West Bourne Bay and is not within the Lake Fundo watershed. It is relatively flat and can be converted to a lagoon without large amounts of earthwork by damming the existing pond outlet. Access to Site 5 is from the new road to the water supply pumphouse. The access road parallels Lake Fundo, and is approximately 1.8 km in length. The access will be a difficult road to construct, and may require rock blasting and large areas of granular fill.

The site is characterized by a tundra wetlands area bounded on the north and south by rock bluffs. To the west there is a draw through the rock bluffs that provides an access route. To the east the site falls steeply to the marine bay some 20 m below.

Site 6

This is in response to the need for a sanitation site, and a granular resource area. These two activities can be combined. The area used as a blasting quarry, or a blast and crush operation, will result in a site that may be suitable for a lagoon and landfill. This possibility is investigated further in this option. The location of the facility can be selected on the ease of access to an area. The quarry site used in 1995 is located on the water shed to Lake Fundo and, for this reason, is not a candidate area for this alternative.

Site 7

Site 7 is located approximately 2.2 kilometers west of the community. There is an existing road (1.5 kilometer) that accessed the old water truckfill location. A new road branching off this existing road would need to be approximately 700 meters long to complete access to Site 7.

An airphoto review of Site 7 shows that there are two small ponds connected together by a small channel (see Figure 3.1). The northern small pond drains into a larger lake. This lake is approximately 400 meters long and 80 meters wide at its widest section. The lake drains into another larger lake to the north-east, and measures approximately 600 meters long, and 100 meters wide at its widest section. The terrain to the west and east of the lakes are generally enclosed by steep terrain, except for a small area west of the lakes. This area appears to be flatter and contains some smaller ponds that are connected by small channels. Reportedly, at least one of the lakes is five meters deep and contains fish.

A review of a 1:5000, and 1:2000 topographic maps obtained from MACA indicates that this site generally slopes from the south to the north-west; however, the south extreme of this site appears to drain into the watershed of the communities potable water source located south-east of Site 7. The most northern lake appears to drain into Soper Lake by means of a small valley. The edge of Soper Lake is approximately 600 meters from the edge of the second lake.

Site 8

Site 8 is located approximately three (3) kilometers west of the community. Site 8 is approximately 800 meters from Site 7. Therefore, a new road branching off the existing road would need to be approximately 1500 meters long to provide access to Site 8.

An airphoto review of Site 8 shows that there is a small pond in a narrow, deep valley at this site (see Figure 3.1). The pond is only about 100 meters long, and 30 meters wide at its widest point. The valley continues for about 700 meters southward before opening at the top of a hill and draining to a flat wetland area. It appears that this wetland area drains to a number of lakes south of Site 8, and flow may ultimately be received by Pleasant Inlet.

A review of a 1:5000 topographic map obtained from MACA indicates that this site generally slopes from the north to the south. Further review of the topographic map confirms the drainage path described in the airphoto review. Although the topographic map indicates the drainage direction flows away from the water supply water shed, this should be verified by a site inspection and a survey if required.

It was reported by the Mayor of Kimmirut that there is often a lot of spring runoff flowing through this valley, and some of the community's residents like to hunt Ptarmigan here.

3.2 Treatment Technologies

The following describes technologies identified as feasible for northern communities. Standard practice in the NWT for sewage treatment and solid waste disposal has been limited to a few systems which have proven cost effective. Previous studies (Heinke et al.) completed on behalf of MACA and other government agencies have reviewed available technology and listed the most suitable for northern communities, which are:

Sewage Treatment

1) Annual storage lagoon.
2) Wetlands treatment.
3) Mechanical plant (Sequencing Batch Reactor (SBR), Rotating Biological Contractor (RBC), Bio Filter).

Solid Waste Disposal

1) Modified landfill.

A brief description of these disposal/treatment methods follows.

Annual Storage Lagoon

The annual storage lagoon concept has been used extensively through the Northwest Territories. In the early years of sewage disposal, there were two (2) cells within the lagoon concept. A primary cell provides 30 day hydraulic retention, while the second cell provides 335 day hydraulic retention. Due to problems experienced in operating a two-cell lagoon system, a one-cell system with a total of 365 day retention is now used. For this analysis, a single cell lagoon system with 365 day hydraulic retention based on the 20-Year planning horizon will be used.

Typically treatment system is to be an aerobic lagoon, and as such a 2.0 m active depth is selected. The berms to construct the lagoon would be made of granular material. As stated previously, no granular resources currently exist in the community. A blast or blast and crush operation will be required to develop the material for lagoon construction. The material generated from the quarrying work will most likely be a coarse granular that will provide for an exfiltration lagoon. A truck discharge pad and discharge flue would be required at the up-gradient side of the lagoon.

Wetlands Treatment

The use of wetlands as a sewage treatment system has been used extensively in southern Canada. In more recent years the use of tundra wetlands for domestic sewage treatment has been studied in the NWT. Several communities currently use wetlands for sewage treatment (Yellowknife, Hay River, Chesterfield Inlet, Baker Lake, Repulse Bay). Initially studies by Heinke et Al on behalf of MACA established design parameters for the tundra wetlands treatment concept. Further study completed by Dillon in 1994 added data to the development of design parameters for the calculation of expected treatment/removal rates. Three communities were then the subject of a sampling program to determine the effectiveness of wetlands as a sewage treatment system. These communities were Baker Lake, Chesterfield Inlet and Repulse Bay. The work was completed by Dillon (1998) on behalf of the Nunavut Water Board, MACA, DIAND, Environment Canada and the Department of Health. This work further developed the understanding of the wetlands treatment processes, the expected effluent from a wetlands area, and developed a set of desirable site characteristics for a wetlands area.

The work completed by Heinke, et Al indicated that the wetlands area should meet two criteria, one based on organic loadings, the other based on hydraulic loadings. These loading are to be calculated on frost free days experienced by the treatment area. The following are the criteria for these two calculations:

Hydraulic Loading - 100 to 200 m^3/ha.d
Organic Loading - 8 kg/ha.d

The subsequent work on wetlands indicated that these criteria are a good first indication of the potential effectiveness of an area for wetlands treatment, but do not accurately reflect the requirements for a tundra wetlands development. The three systems studied by Dillon (1998) indicated that acceptable results were achieved using areas that varied greatly to the above criteria. The values for hydraulic and organic loading rates varied from 34 to 4000 m^3/ha.d and 1.5 to 350 kg/ha.d respectively. The study of the systems suggested that the following types of areas would be desirable for wetlands development;

- The site needs to be near the existing physical infrastructure of the community, ie roads.
- The discharge area for the trucks ideally should be into a sloping valley area. Slopes in the range of 4:1 to 15:1 are preferred. The discharge area should have sufficient land area to store the winter ice pack (about 8 months of sewage generation). There should be minimal upgradient water shed to the winter ice pack area.
- The discharge area should be sized to maximize the dispersion of the ice pack melt over the greatest treatment area without significantly shortening the melt period of the ice pack.
- The treatment area needs slopes and gradients that will support vegetative growth, but will not allow sewage flow to stagnate. Slopes of 2% to 20% appear to be reasonable and provide adequate treatment.
- The treatment area should be defined by physical features.
- Community consultation, and the use of traditional ecological knowledge (TEK) in the selection of a site is important.
- The treatment area should not form a major part of the community water shed.

Mechanical Plant

Mechanical plants that are applicable for small communities include a rotating biological contractor (RBC), a sequencing batch reactor (SBR), biological filters, and enhanced primary plants that use chemical flocculation and sedimentation/precipitation technologies (Proteus etc.). These types of treatment equipment have been used successfully in northern Canada (Manitoba, Ontario, Saskatchewan, Alberta), and also in the NWT (BHP, Diavik, Hope Bay). The capital and life cycle costs are similar for SBR and RBC's. Further analysis in the selection of the most appropriate mechanical treatment should be completed, in the event that the mechanical plant is selected as the best option. Mechanical plants are enclosed in a heated building. This physical barrier allows the plant to be located within the 450 m health setback criteria. The discharge from the plant is normally piped to a point outside the 450 m setback.

Landfill Technologies

The surficial geology in the Kimmirut area precludes the use of a trench excavation and fill type of operation for a landfill. The new facility will be operated similar to the existing landfill. Waste will be placed over the ground and covered weekly with granular material. If available, a bluff or slope of land would provide for a dumping area and simplify the landfill operation. The operation would include:

- Compaction of the waste with a dozer.
- Covering the waste with a dozer.
- Covering the waste with granular material. This material will come from the blast (or blast and crush) operation described earlier.

3.3 System Alternatives and Nomenclature

As identified in a Section 2.2 six (6) sites were identified in the Phase I and II portions of the work as potential locations for a waste disposal site.

Through the site investigation and site development process, it is apparent that not all sites can support each of the sewage treatment alternatives. For example, there is insufficient available land area to support a wetlands treatment system at Site 1.

The following are the system alternatives that were carried forward for further analysis in Phase I and II portion of the study. A nomenclature has been developed for these alternatives for easy reference.

L1 Construct an annual sewage storage lagoon at Site 1. A landfill is to be developed up-gradient of the lagoon.

L2 As above, only at Site 2.

W2 Construct a wetlands sewage treatment system at Site 2 with a landfill site up- gradient of the sewage discharge location.

W3 As above, only at Site 3.

M1 Construct a mechanical plant at Site 1 with a landfill site at Site 1.

M4 Upgrade the existing landfill site for future use and install a mechanical sewage treatment plant near the existing landfill site.

L5 The development of an annual storage lagoon and area landfill at Site 5. The access road to this site becomes critical in the development of the costs. To be able to develop Class 'C' estimates, additional mapping was developed through existing air photo control surveys MACA had available.

M2 The development of a mechanical plant at Site 2. A landfill site is to be developed away from the proposed housing area. M2 is similar in concept to the work completed previously; however it is developed further to address the concerns raised by the Baffin Regional Health Board.

G6 This is in response to the need for a sanitation site, and a granular resource area. These two activities can be combined. The area used as blasting quarry, on a blast and crush operation, will result in a site that may be suitable for a lagoon and landfill. This possibility is investigated further in this option. The location of the facility can be selected on the ease of access to an area. The quarry site used in 1995 is located on the water shed to Lake Fundo and, for this reason, is not a candidate area for this alternative.

A description of each alternative at its respective site follows.

3.3.1 Annual Storage Lagoon at Site 1 - L1

Due to the terrain, there is a requirement to remove bedrock material to develop a lagoon. The development of a 120 m x 120 m area with an approximate depth of 2.0 m will require rock removal of up to 15 m in depth.

Access to the site will require the development of a road from the existing infrastructure through the rugged terrain.

The area immediately up-gradient of the lagoon site is suitable to develop as a landfill facility. The site can be operated as an area landfill. Granular material will be required for cover, and there is no available granular resource near the site. Again, it will require a blast and/or blast and crush operation to generate granular cover.

3.3.2 Annual Storage Lagoon at Site 2 - L2

Site 2 is located in the drainage area of the existing sanitation site and sewage currently flows through the site. Therefore, using this site for a lagoon is advantageous as it uses the existing disposal area and minimizes the close-out procedures for the existing facility. An annual sewage lagoon can be constructed at this site. Rock blasting similar to Site 1, would also be required at this site.

This site is within the 450 m setback from existing development and the proposed development. Use of this site will require a change to the Community Plan as well as relaxation of the 450 m buffer criteria from the Department of Public Health. The site is separated from existing development by a cliff which provides a deterrent to human and animal activity between the site and the community. Access to the site is possible through the construction of a road along an existing draw.

3.3.3 Wetlands at Site 2 - W2

A direct discharge wetlands can be developed at Site 2. The solid waste facility can be situated immediately up-gradient of the sewage discharge point. A small primary retention pond is required to allow for solids/floatables removal prior to the sewage effluent entering the wetlands area. This pond would be sized for 10 day retention. The effluent will flow over the front dike to the wetlands area. There is no requirement for an overflow structure on the pond. In winter months, the sewage freezes in an ice mass at the top of the wetlands. The winter sewage is released through melt water over a period of time in the spring. The primary pond is not designed or intended to hold the winter's sewage generation.

Berms are required to divert run-off/precipitation away from the wetlands treatment area on the up-gradient side of the landfill site. These will minimize the hydraulic loading on the wetlands that would be created by the precipitation run-off. The site provides the minimum land requirements for hydraulic loading criteria.

3.3.4 Wetlands Treatment at Site 3 - W3

Site 3 is an existing pond situated within the new development. This pond can be dammed and drainage control ditches and berms installed to define an engineered wetlands treatment area. The dammed pond will provide for a primary cell and hydraulic retention of sewage. The effluent will decant over the front dike throughout the summer and flow through the wetlands and discharge into the harbour. The wetlands is expected to provide the secondary and tertiary treatment as the sewage effluent flows among rocks and vegetation. Wetlands treatment has been shown to provide very high quality treatment of sewage in other northern sites (i.e. Hay River, Yellowknife, and Chesterfield Inlet).

Site 3 is outside of the 450 m setback from existing development. Site 3 is located on the harbour watershed and does not drain into Lake Fundo. It is also located within Phase I of the Community Plan. Use of Site 3 will require a new Community Plan. A solid waste facility could be developed adjacent to the primary cell, or retained at the existing location. For the purpose of analysis, a new site adjacent to the primary cell will be assumed. Access is to be provided via a short road to the new access road to the water pumphouse facility.

3.3.5 Mechanical Sewage Plant at Site 1 - M1

A mechanical sewage plant can be installed at Site 1 within the effluent outfall discharging down the valley to the harbour. The installation of a mechanical plant at Site 1 is carried forward for analysis as a comparison to a lagoon at Site 1.

The development of a landfill will be the same as in Option L1.

3.3.6 Upgrading the Existing Facility and Install a Mechanical Plant - M4

The 1980 report by the Department of Public Works and Services indicated that the existing site could provide adequate landfill capacity till the Year 2000. This site has been leveled through the operation of the landfill over the past decades. It provides adequate space for bulky metal disposal, domestic landfilling, and truck access and waste dumping. Granular material is required to provide cover over the waste mass. Continued use of the site as a landfill site will require minimal remedial works. Due to the operation of the site, it is expected that the area can be used for solid waste disposal for the next 20 years using an area fill method.

The existing sewage disposal methods do not meet the requirements of the current guidelines with respect to treatment and site control. An annual lagoon will require the entire landfill area for construction. Further, construction of a lagoon over an old landfill is not recommended. It would be expected that sewage would penetrate the landfill mass and generate high quantities of leachate. Settlements under the lagoon would be expected as the waste mass decomposes and compacts. These settlements will be reflected into the lagoon floor and berm walls, and will result in high maintenance costs for the lagoon. Therefore, a lagoon on this site is not acceptable, and not carried forward for further analysis.

Sewage treatment may be achieved at the existing site through the installation of a mechanical plant. The plant can be constructed adjacent to the landfill truck pad. Treated sewage effluent will be discharged down the ravine slope similar to the current raw discharge.

3.3.7 Annual Storage Lagoon and Landfill at Site 5 - L5

Site 5 is a wetlands and pond approximately 2 km from the southern end of the planned development and approximately 3 km from the community. The site is suitable for creating a natural pond lagoon by damming the eastern outlet to the harbour to create suitable depth of 2 to 2.5 m for and annual storage lagoon. A solid waste landfill can be constructed up-gradient of the lagoon. The site is well outside of the 450 m setback from the development and well outside of the airport clearance of 2 km on the non-approach side. The site will require a gravel access road across rocky and sloped terrain. The cost of trucking sewage and solid waste to this site will be higher than to the other sites.

The site investigation and potential routes to construct an access road to the site were reviewed. The access road shown has grades up to 12%. This is consistent with road grades that currently exist in the community, and meets MACA's criteria for roadways. Areas of this road may be subject to snowdrifting in the draws through the rock valleys. Further work in this area may be warranted in the event that Site 5 is the selected option.

3.3.8 Mechanical Treatment Facility - M2

In this alternative, a "mechanical" type treatment plant will be constructed at Site 2. This plant will be totally enclosed in a weatherproof building.

Three alternative discharge points have been identified as follows:

- **Shoreline Discharge (M-SD2)**

  A pipeline to convey the treated effluent to a point at least 450 m from the proposed development (normal setback requirements) at the shoreline of the harbour. Treated effluent will be discharged through a pipeline to the marine environment.

- **Deep Water Discharge (M-DW2)**

  A pipeline to convey the treated effluent to a deep water discharge location in the harbour. This will require underwater installation of the pipeline and pipe protection to avoid ice and freezing damage. This type of construction has not been completed in the NWT. There are several problems to be addressed in the design and construction of an underwater discharge, i.e., underwater rock blasting, pipe protection, tidal zones, fishery concerns.

- **Land Discharge (M-LD2)**

  Discharge directly from the treatment plant to the land just east of Site 2. Overland, the treated effluent will follow the discharge path to the marine environment.

The level of "mechanical" treatment required to meet the "Guidelines for the Discharge of Treated Municipal Wastewater in the Northwest Territories" (NWT Water Board, 1992) is a function of the point of discharge. Identified treatment requirements for each of the three points of discharge are as follows:

Deep Water Discharge - Alternative (M-DW2)

The mechanical treatment plant will be designed to macerate or remove coarse solids from the sewage influent prior to deep water discharge. The mixing zone established at the point of entry to the marine environment will be used to meet established discharge criteria for BOD_5 and Suspended Solids (SS). This is primary treatment of the sewage. This system has recently been installed in Rankin Inlet and has met the regulatory requirements.

A site specific study may be required for the implementation of this alternative. Bathymetric surveys to locate the outfall pipe will be necessary. Further study on the ice loadings will also be required in the design stage.

Shoreline and Land Discharge - Alternatives (M-SD2, M-LD2)

The mechanical treatment plant will be identical for each of these alternatives and will generally consist of the following unit operations:

- Influent Screening

- Biological Treatment

- Waste Sludge Storage (for subsequent landfill disposal).

Biological treatment will be through the Rotating Biological Contractor (RBC) or Sequencing Batch Reactor (SBR) processes. Both of these treatment processes are proven technologies for the removal of BOD_5 and SS. At the planning level, a distinction between these two alternative biological treatment processes is not necessary as they have similar life cycle costs. This process provides for a secondary level of treatment.

Although the mechanical plant will be designed to meet guideline levels at the point of discharge, if the effluent is land applied then further removal of BOD_5, SS and fecal coliform will likely occur both physically and biologically (depending on the season) as a result of the environment that has been established through historical sewage disposal practices. If the mechanical treatment plant discharges to the shoreline, however, further levels of contaminant removal will not be achieved prior to marine disposal.

Public health concerns resulting from accessibility of the discharge point by the public is of equal magnitude in both alternatives, even though the shoreline discharge point will be located outside of the 450 m setback requirement normally imposed on the development of these facilities. To mitigate this risk, fencing will be required in both cases.

The mechanical treatment plant will be designed to remove BOD_5 and Suspended Solids (SS) to levels below or at established guidelines of 100 mg/l and 120 mg/l respectively for discharge to a marine environment. These levels will be achieved at the point of discharge, namely the shoreline or the land directly east of Site 2.

The landfill operation will be an area landfill to the south of the proposed subdivision. The existing landfill cannot be used as it is within the 450 m setback requirement.

3.3.9 Annual Storage Lagoon and Landfill at Quarry G6

This alternative was suggested to reduce the cost of construction of a lagoon in the rocky land just south of the new development by blasting the cut for the lagoon during the potential blast and crush operations to provide the community with granular material. It is expected that there will be a requirement for a blast, or blast and crush operation every one or two years to stockpile granular material in Lake Harbour. This operation leaves an empty area which could be used to provide the flat area required for a lagoon.

The method of quarrying currently used by the GNWT requires minimum 8 to 10 m depths for the blasting to provide adequate fracture of the rock. The lagoon will require a storage volume of 27,000 m^3 as developed in Section 4.2. The lagoon is to be 2.5 m in depth to provide for aerobic activity and 2.0 is preferred. At 2.0 m depth the lagoon will have a surface area of 13,500 m^2. Therefore, the quarry bottom must be blasted to provide that same area of 13,500 m^2.

Public Works and Services estimates that the community uses 2000 m^3 of granular material per year for road maintenance, road expansion, and housing pads. Some additional granular material is used for specific projects every few years such as the new water supply road. For the development of this alternative, it will be assumed that an average of 3000^3 is used per year. At a depth of 10 m, 3000 m^3 is an area of 300 m^2. It will therefore require 45 years to clear sufficient area to construct an area with sufficient space for a lagoon. The total volume of granular material to be developed to clear a site for the lagoon is 150,000 m^3.

3.4 System Alternative Evaluations

3.4.1 Process of Evaluation

To evaluate the alternatives, a systematic decision making process is used. The intent of using a process as a tool is to aid in the selection of the best alternative when there are several parameters that govern the alternative selection.

All options must meet a set of minimum critical criteria which has been identified as the preselection criteria. Those options that meet the preselection criteria are weighted against a set of needs. Each "needs" criteria is ranked for its importance in the selection process. A ranking of 10 represents a highest priority and a ranking of 0 represents the lowest priority.

Each alternative is then given a rating of 1 to 10 for each criteria. Again, 10 is the highest and 0 is the lowest rating. The product of the criteria priority and the alternative rating give weighted scores. The sum of the weighted scores for each alternative results in the total weighted score for that alternative. The alternative with the highest total weighted score is identified as the best balanced choice. That alternative is then assessed for its risk of failure. If the failure mechanisms identified for this alternative can be mitigated against, or are of low risk, this alternative often becomes the selected alternative.

3.4.2 Analysis of Alternatives

There is only one "must" criteria for this analysis, i.e., the site must meet the approval of the regulatory agencies. All options must treat the sewage, and dispose of the solid waste in accordance with the current guidelines for disposal of municipal waste. All alternatives that do meet this criteria are carried forth to be analyzed against the "want" criteria.

The "want" criteria and the weighting given to these criteria are listed below:

1) The system is to minimize the capital cost of construction. This has a weighting of 10.

2) The system is to minimize the life cycle costs. This has a weighting of 10.

3) The system is to maximize compliance to regulatory requirements. This has a weighting of 5.

4) The system is to have a minimal effect on the Community Plan. This has a weighting of 6.

5) The system is to maximize conformance to the 450 m health setback from existing and future development. This has a weighting of 4.

Capital costs, operating costs and life cycle costs for each alternative are calculated and shown in **APPENDIX A**. The cost estimates are based on:

- Historic construction costs of similar projects completed by the Government of the Northwest Territories.

- Operation and maintenance costs are calculated according to the following percentages of capital cost.

  - Trucking — As calculated in **APPENDIX A**.
  - Access Road — 10%
  - Lagoons — 5%
  - Pipelines — 1%
  - Power Supply — 1%
  - Mechanical Plants — 7.5%

Total life cycle costs are calculated as the sum of the capital cost, plus the present value of the annual operating costs over a 20 year period using an 8% discount rate.

A summary of the individual ranking is carried forward to **Section 6** for comparison with the additional alternatives.

4.0 ISSUES RELATED TO THE NEW OPTIONS

4.1 Site Descriptions

Since the Phase I and Phase II activities, two additional sites have been identified by Public Works and Services (Iqaluit), and provided to Dillon for planning considerations. The two sites are designated as Site 7, and Site 8. **Figure 4.1** illustrates the plan view of these two site areas.

4.2 Siting Constraints

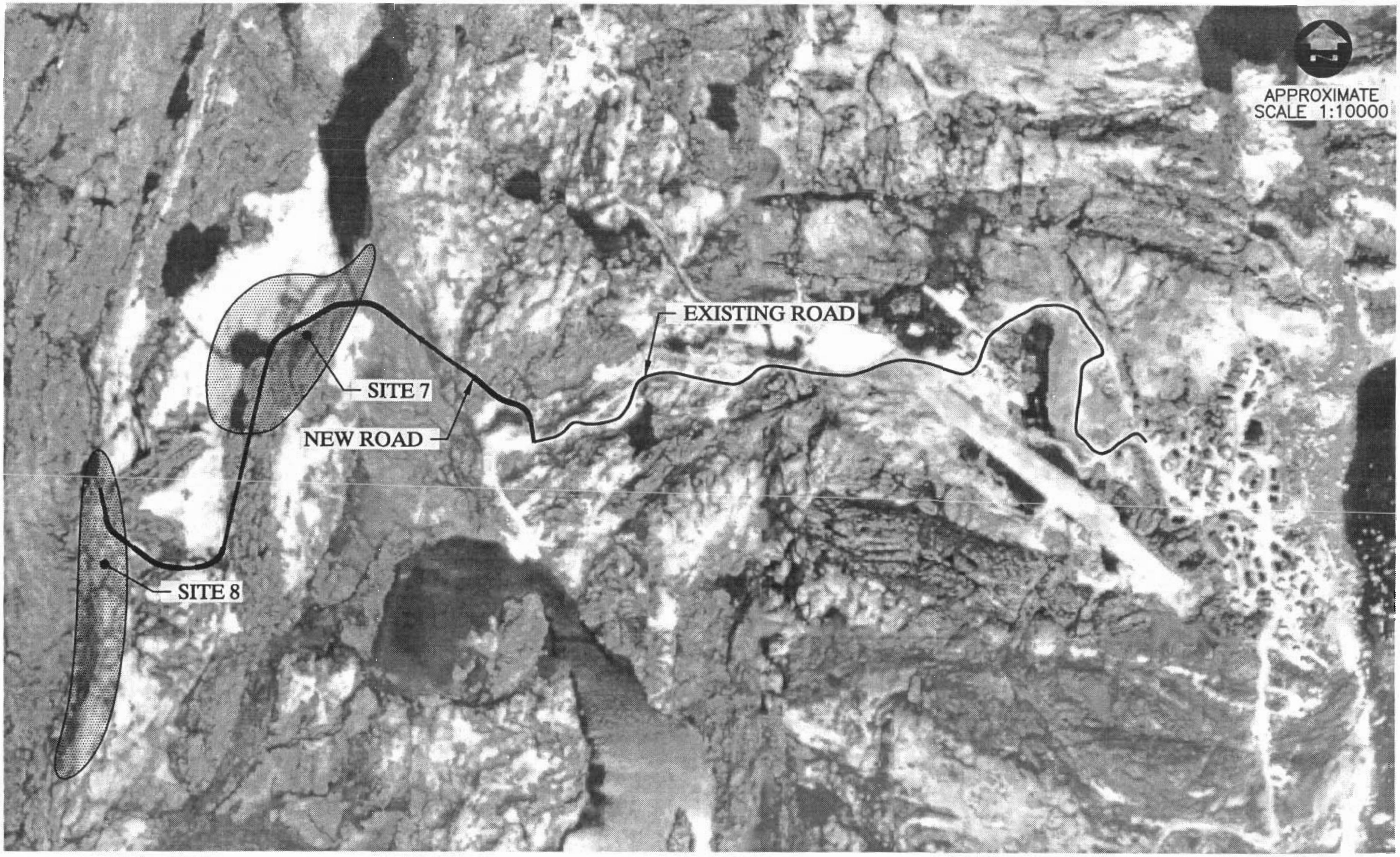
The following sections discuss and compare the sites and their locations to minimum criteria, conditions, and constraints that should be met.

4.2.1 Community Plan

Dillon obtained the most recent community plan information from MACA in Iqaluit. The council approved development plans for the Phase I planning design for the Soper Lake Development in 1998. The Soper Lake Development is located approximately a kilometer north-west of the community. Reportedly, an access road to the new development site has already been constructed. The Southern Valley Development has not yet been approved by council. Reportedly, there are several factors that are preventing the approval of this development. The three major reported factors are: the possibility of relocating the communities' airstrip, the siting of the sanitation site and the location of the proposed new arena. The approved Soper Lake Development, and the existing plans for potential developments in the southern valley do not have any impact on Sites 7, and 8.

4.3 Proposed Access Roads

A proposed access road was provided to Dillon by Mr. David Parker of Public Works and Services (PWS Iqaluit). Mr. Parker walked the alignment and plotted the approximate route on a 1:2000 topographic map. This information was used to develop quantity estimates for constructing the access road to Site 7 and Site 8. Note that the initial 700 meters of new access road is common to both sites. Site 8 requires an additional 800 meters of length, or total length of 1500 meters.



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		DATE FEB 99
	TITLE SITE 7 AND SITE 8 LOCATION PLAN	FIGURE NUMBER FIG 4.1

4.3.1 Granular Resource Review

A granular resource review report was performed during the Phase I portion of this project. Generally Kimmirut is deficient of any good sources of granular, and relies on periodic blasting and crushing operations to provide for the community's requirements. In 1998, a new road was installed part way to the area known as the "Reversing Falls" located at the discharge of Soper Lake. It is reported by PW&S that there is in excess of 45,000 m^3 of granular at this site. The community is responsible for the sale of the resource. The cost of material from this source is $30/truck load, which is approximately 4 m^3 of material.

This value of approximately \$8/m^3, is significantly less than the cost of granular from the blast and crush operation completed in 1995. The cost in 1995 was approximately \$70 to \$95 per m^3.

In addition to the supply pit price of the granular, is the cost to haul and place the material. This will increase the cost of road and berms works to \$25 to \$30/m^3. This is significantly lower than the value used in the previous studies. To reflect this new information, all options are reestimated using the value of \$25/m^3.

4.3.2 Access Road Granular Quantities

Using the given route, contour elevations from the topographic map, and a set of minimum design requirements the approximate granular requirements were calculated and summarized in **Table 4.1 (3.1).**

The following are the minimum design requirements that were used:

1. The road width is 6.0 meters.
2. The side slopes are 3:1.
3. The minimum fill required is 0.5 meters.
4. Two maximum grades were also used for comparison, namely 10%, and 12%.

Table 4.1 (3.1) Granular Quantities for Access Road

	Granular Quantity for Maximum Grades (m^3)	
Grade	**12%**	**10%**
Site 7	9000	9700
Site 8 (with adjusted alignment)	17000	19000

The detailed estimates and general profiles are in **APPENDIX B.**

5.0 NEW OPTION

5.1 Treatment Options

The Annual Storage Lagoon, and Wetlands Treatment will be two technologies carried forward as treatment technologies. The Modified Landfill will be carried forward as a feasible solid waste disposal technology.

The use of a mechanical plant is not carried forth, as there is no benefit to locate the plant at site 7 & 8 over that of the site closer to the community, but there would be high costs to develop the roads and the power lines to the site.

5.2 Planning Option Identification

The given sites (Site 7 and Site 8) will be assessed with both feasible sewage treatment technologies, while the modified landfill will be cost estimated into both sites as there is only the one feasible technology for handling solid waste. The following are the system alternatives that are carried forward for further analysis, for these alternatives are:

L7 Construct an annual sewage storage lagoon at Site 7. A landfill would be developed up-gradient of the lagoon.

L8 As above, but at Site 8.

W7 Construct a wetlands sewage treatment system at Site 7 with a landfill site up- gradient of the sewage discharge location.

W8 As above, but at Site 8.

The following sections describe the development of the alternatives.

5.3 Lagoon, Wetlands, and Landfill Sizing

Calculations for the sizing of the annual storage lagoon, wetlands treatment area, and landfill sizing are included in **APPENDIX D**. A summary of the footprint area calculations for each system is shown in **Table 5.1.**

Table 5.1 Footprint Areas for Respective Systems

SYSTEM	FOOTPRINT AREA
Annual Storage Lagoon	26,000 m^2, or 160 m x 160 m.
Wetlands Treatment Area	40 hectares
Modified Landfill	13,500 m^2, or 120 m x 120 m

5.4 Annual Storage Lagoon at Site 7 - L7

Figure 5.1 illustrates the lagoon concept at this site. A berm south of the smaller lake, and a berm north-west of the larger lake would have been constructed between the existing slopes to contain the sewage.

This option is rejected for the following reasons:

- Using a maximum operating depth of two meters, this lagoon would only be able to store approximately 18,000 m^3, when 28,300 m^3 of storage is required in Year 20.
- The south berm is located in the community's watershed. There is a risk that this berm could leak sewage effluent into the community's watershed eventually reaching the water supply lake.
- Adequate space at Site 7 could not be found to locate the new landfill.

As a result of these L7 will not be carried forward for further analysis.

5.5 Annual Storage Lagoon at Site 8 - L8

Conceivably, a lagoon could be built by constructing berms to the south of the existing pond at Site 8. The existing valley walls and natural topography would have been used for the north, east, and west sides of the lagoon. However, using a maximum operating depth of two meters, this lagoon would only be able to store approximately 5000 m^3, when 28.300 m^3 of storage is required in Year 20. (**Figure 5.2**)

As the capacity of a lagoon at this site is an order of magnitude smaller than the required volume, this option will not be carried forward for further analysis.

5.6 Wetlands Treatment at Site 7 - W7

A sewage wetlands treatment system could be developed at Site 7. The berm configuration would be similar to the lagoon plan but the berms would not be as high, nor would there be a required retention time for the initial cell (primary retention pond). See **Figure 5.3** for a conceptual plan of the wetlands treatment at Site 7.

The primary retention pond would be used to allow solids and floatables to be removed prior to the sewage effluent entering the second holding pond, then the first lake to the north-east. In winter months, the sewage freezes in an ice mass at the top of the wetlands. The winter sewage is released through melt water over a period of time in the spring. The primary pond is not designed or intended to hold the winter's sewage generation. The wetlands is expected to provide the secondary and tertiary treatment as the sewage effluent flows through the receiving lakes, and among rocks and vegetation.

The drawbacks associated with this concept are:

- Adequate space at Site 7 could not be found to locate the new landfill.
- The ultimate receiving water body is Soper Lake, which is part of the Soper River Watershed, and fails the preselection criteria developed by MACA.
- There are not the 40 hectares required on this site for a wetlands.

As a result of these drawbacks, W7 will not be carried forward for further analysis.

5.7 Wetlands Treatment at Site 8 - W8

This is similar to that described for option W7. There is an existing pond at Site 8. This pond can be dammed (primary retention pond), and drainage control ditches and berms constructed to define an engineered wetlands treatment area. The dammed pond would provide for a primary cell and hydraulic retention of sewage. The effluent would decant over the front dike (on the south side) throughout the summer, flow south through the additional retention ponds, and wetlands for additional treatment.

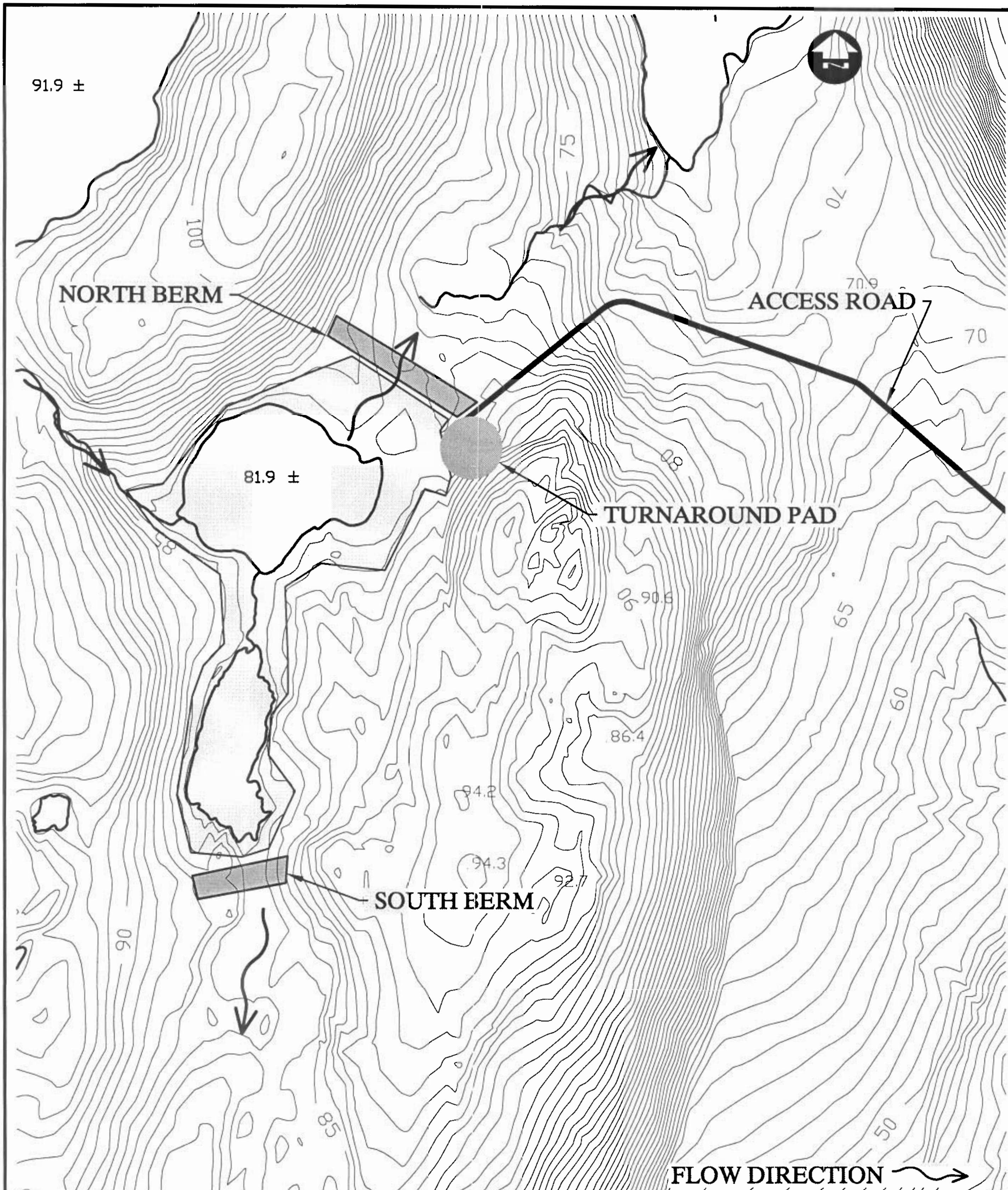
This option would require a slightly longer access road (Approx. 100 meters) and a changed alignment so that the sewage offloading would occur at the up-gradient end of the primary retention pond. The landfill would be situated inside the road slopes. The topography map illustrates that should the landfill leachate seep through the road, it will flow towards the wetlands south of Site 8. See **Figure 5.4** for a conceptual plan of the wetlands treatment area and landfill at Site 8.

Some drawbacks associated with this concept are:

- A slightly longer, and therefore more expensive access road would be required.
- The landfill site is situated on a high topography and will likely be visible for a long distance.

As none of these drawbacks affect the system requirements nor violate any preselection criteria, W8 will be carried forward for further analysis.

Quantity estimates for this option are found in **APPENDIX E**.



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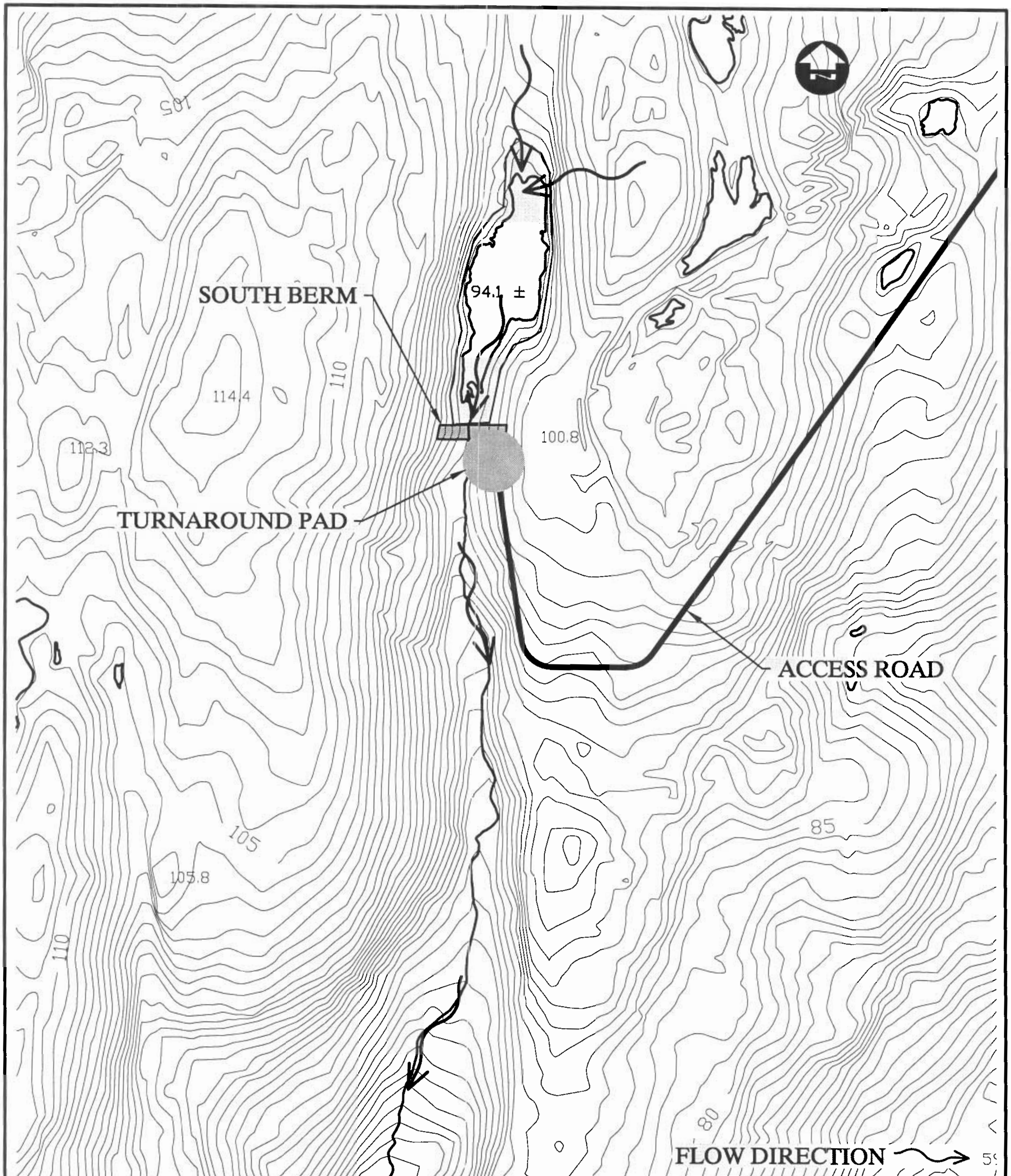
		DATE FEB 99
	TITLE LAGOON AT SITE 7 - L7	FIGURE NUMBER FIG 5.1



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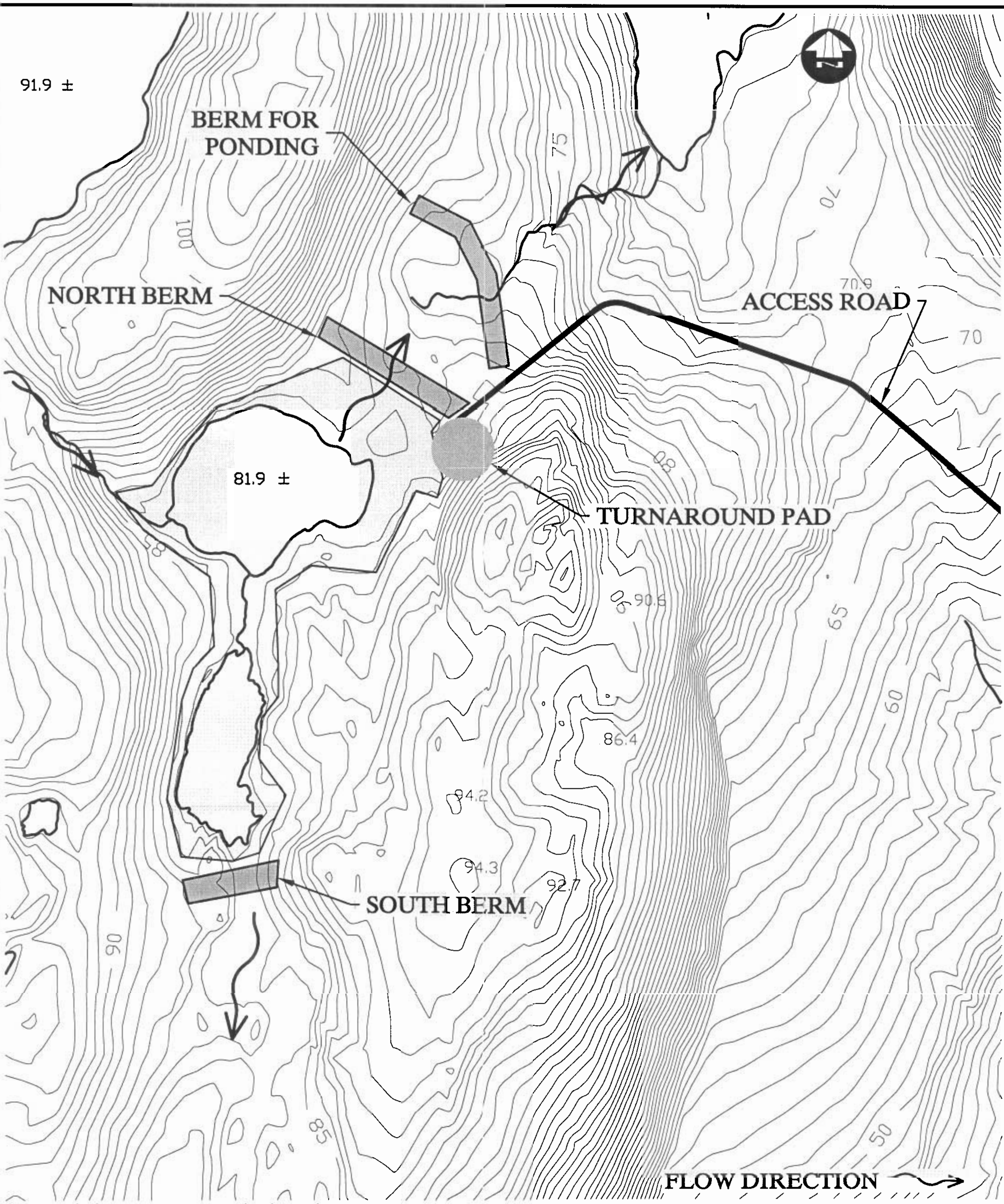
	TITLE LAGOON AT SITE 8 - L8	FIGURE NUMBER FIG 5.2



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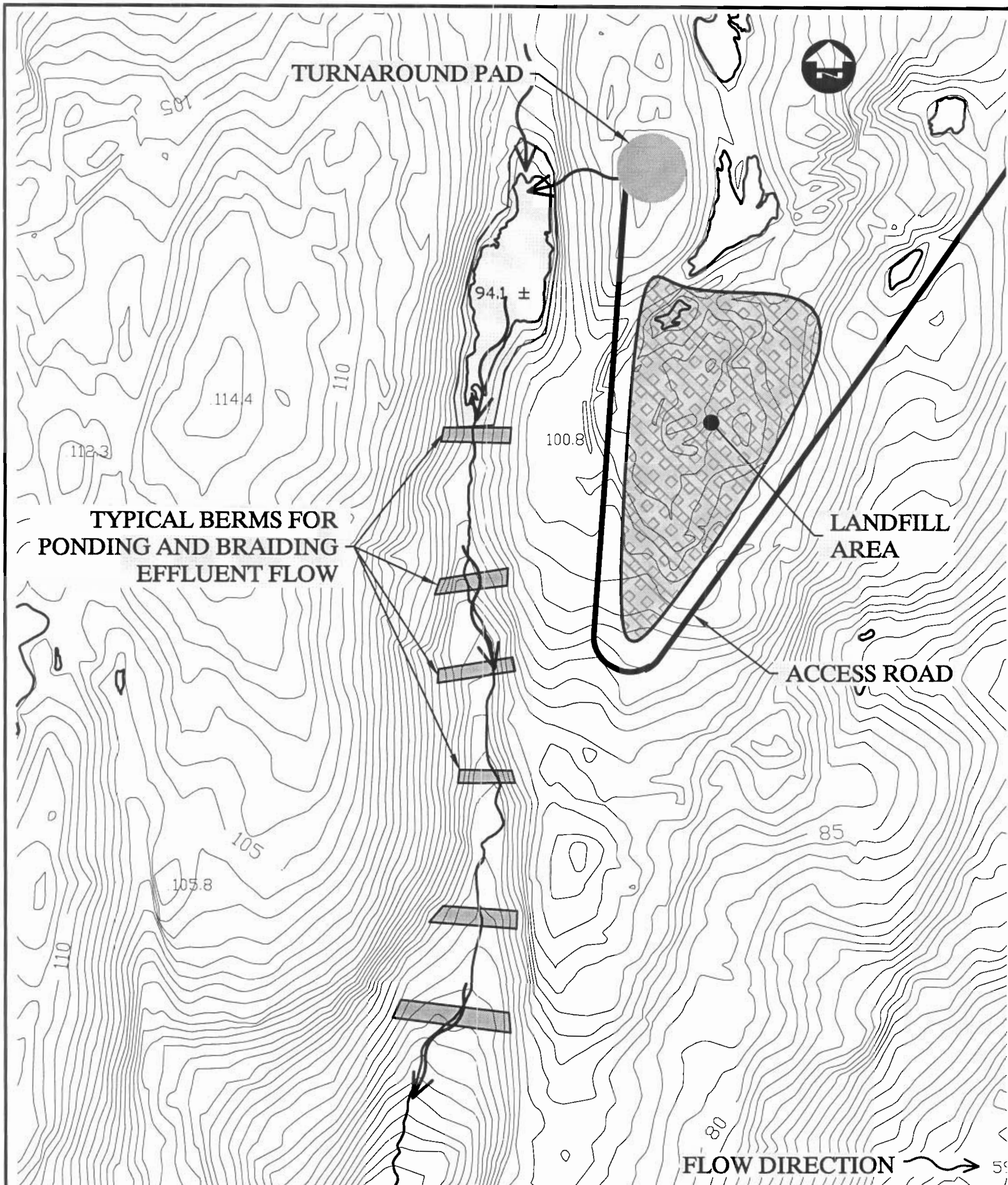
		DATE FEB 99
	TITLE WETLANDS AT SITE 7 – W7	FIGURE NUMBER FIG 5.3



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		DATE FEB 99
	TITLE WETLANDS AT SITE 8 - W8	FIGURE NUMBER FIG 5.4

6.0 EVALUATION

This section follows the format for analysis described in Section 2.5.

6.1 Detailed Analysis of Alternatives

The initial "must" and "want" criteria as listed Section 2.5 has not changed. All the selected options must meet the requirements of the 450 m setback, the community development plan, and effluent discharge criteria. Only option W8 passed all of the preselection criteria, therefore W8 is the only option carried forward for further analysis. See Section 5 for a discussion of all the potential options.

Capital and life cycle costs are calculated for all options, and are shown in **Table 6.1.** The cost estimates are based on:

- Historic construction costs of similar projects completed by the Government of the Northwest Territories where available.
- Operation and maintenance costs are calculated according the following percentages of capital cost:
  - Sewage Lagoons 5%
  - Wetlands Sewage Treatment 5%
  - Access Road 1%
  - Trucking As calculated in **APPENDIX F**

Total life cycle costs are calculated as the sum of the capital cost, plus the present value of the annual operating costs over a 20-Year period using an 8% discount rate. This rate is set in MACA's Standards and Criteria.

6.2 Comparison to Previous Options

All of the options that have passed the preselection criteria since the beginning of the project are brought forward and scored against each other for comparison in **Table 6.2**. The prioritized scores and options are summarized in **Table 6.3.**

Table 6.1 SEWAGE DISPOSAL SYSTEMS ALTERNATIVES
COST ESTIMATES

ITEM	UNITS	PRICE	L1 Qty	L1	L2 Qty	L2	W2 Qty	W2	W3 Qty	W3	M4 Qty	M4	L5 Qty	L5	M2 Qty	M2	G6 Qty	G6	W8 Qty	W8
CAPITAL COSTS																				
Lagoon cut and fill	m3	$95	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	150000	$14,250,000	0	$0
Earthen berms	m3	$25	51000	$1,275,000	37000	$925,000	3000	$75,000	3000	$75,000	0	$0	1000	$25,000	0	$0	5000	$125,000	3000	$75,000
Mechanical Plant	each	$750,000	0	$0	0	$0	0	$0	0	$0	1	$750,000	0	$0	1	$750,000	0	$0	0	$0
Sludge Handling	each	$50,000	0	$0	0	$0	0	$0	0	$0	1	$50,000	0	$0	1	$50,000	0	$0	0	$0
Stick Built Building	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	0	$0	1	$80,000	1	$80,000	0	$0
Outfall Structure	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	0	$0	1	$80,000	1	$80,000	0	$0
Truck Turnaround	m	$25	400	$10,000	400	$10,000	400	$10,000	400	$10,000	400	$10,000	400	$10,000	400	$10,000	400	$10,000	400	$10,000
Discharge Flue	each	$5,000	1	$5,000	1	$5,000	1	$5,000	1	$5,000	0	$0	1	$5,000	0	$0	0	$0	1	$5,000
Portable Pump	each	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	0	$0	1	$10,000	0	$0	0	$0	0	$0
Clearing/Grubbing	h	$2,000	1	$2,000	2	$4,000	1	$2,000	1	$2,000	0	$0	0	$0	0	$0	0	$0	0	$0
Access Road	m3	$25	6000	$150,000	3000	$75,000	3000	$75,000	1000	$25,000	0	$0	24000	$600,000	0	$0	10000	$250,000	17000	$425,000
Power Supply A/G	m	$33	0	$0	0	$0	0	$0	0	$0	100	$3,300	0	$0	48	$1,584	48	$1,584	0	$0
Power Supply U/G	m	$330	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Additional Design	each	$50,000	0	$0	0	$0	1	$50,000	1	$50,000	0	$0	1	$50,000	1	$50,000	1	$50,000	1	$50,000
SUBTOTAL				$1,452,000		$1,029,000		$227,000		$177,000		$973,300		$700,000		$1,021,584		$14,846,584		$565,000
Contigency Allowance @ 20%				$290,400		$205,800		$45,400		$35,400		$194,660		$140,000		$204,317		$2,969,317		$113,000
TOTAL CAPITAL COSTS				$1,742,000		$1,235,000		$272,000		$212,000		$1,168,000		$840,000		$1,226,000		$17,816,000		$678,000
O & M COSTS																				
Lagoons	5.0%			$63,750		$46,250		$3,750		$3,750		$0		$1,250		$0		$718,750		$3,750
Mechanical Plai	10.0%			$0		$0		$0		$0		$80,000		$0		$80,000		$0		$0
Stick Built Build	5.0%			$0		$0		$0		$0		$4,000		$0		$4,000		$4,000		$0
Roads	1.0%			$1,600		$850		$850		$350		$100		$6,100		$100		$2,600		$4,350
Discharge Flue	1.0%			$50		$50		$50		$50		$0		$50		$0		$0		$50
Portable Pump	5.0%			$500		$500		$500		$500		$0		$500		$0		$0		$0
Power Supply	0.01			$0		$0		$500		$500		$33		$500		$516		$516		$500
Monitoring	lump sum			$0		$0		$15,000		$15,000		$5,000		$0		$5,000		$5,000		$15,000
LIFE CYLE TRUCKING COSTS				$6,102,000		$5,864,000		$5,864,000		$4,500,000		$5,864,000		$6,501,000		$5,864,000		$5,864,000		$4,900,000
TOTAL ANNUAL O & M COSTS				$65,900		$47,700		$5,700		$5,200		$84,100		$8,400		$84,600		$725,900		$8,700
PRESENT VALUE OF O & M COSTS **				$647,000		$468,000		$56,000		$51,000		$826,000		$82,000		$831,000		$7,127,000		$85,000
PRESENT VALUE COST OF CAPITAL AND O & M **				$8,491,000		$7,567,000		$6,192,000		$4,763,000		$7,858,000		$7,423,000		$7,921,000		$30,807,000		$5,663,000

SELECTION CRITERIA		Sites	PHASE I						PHASE II			CURRENT
			L1 Lagoon	L2 Lagoon	W2 Wetlands	W3 Wetlands	M1 Mechanical	M4 Mechanical	L5 Lagoon	M-SD-2 Mechanical	G6 Lagoon	W8 Wetlands
			Site 1	Site 2	Site 2	Site 3	Site 1	Existing Site	Site 5	Site 2	Site 6	Site 8
1 *MINIMIZE CAPITAL COST*		Cost $	$1,742,000	$1,235,000	$272,000	$212,000	$1,800,000	$1,168,000	$840,000	$1,226,000	$17,930,000	$672,000
WEIGHT	10	Score	1.2	1.7	7.8	10.0	1.2	1.8	2.5	1.7	0.1	3.2
		Weighted Score	12	17	78	100	12	18	25	17	1	32
2 *MINIMIZE LIFE CYCLE COST*		Cost $	$8,490,000	$7,567,000	$6,192,000	$4,763,000	$8,500,000	$7,860,000	$7,423,000	$7,921,000	$31,286,000	$5,719,000
WEIGHT	10	Score	5.6	6.3	7.7	10.0	5.6	6.1	6.4	6.0	1.5	8.3
		Weighted Score	56	63	77	100	56	61	64	60	15	83
3 *MAXIMIZE REGULATORY*												
WEIGHT	5	Score	7	7	5	7	9	9	10	8	9	10
		Weighted Score	35	35	25	35	45	45	50	40	45	50
4 *MINIMIZE EFFECT ON COMMUNITY PLAN*												
WEIGHT	5	Score	10	4	4	0	10	0	10	4	7	10
		Weighted Score	50	20	20	0	50	0	50	20	35	50
5 *MAXIMIZE CONFORMANCE TO 450 SETBACK*												
WEIGHT	6	Score	10	5	5	10	10	5	10	5	8	10
		Weighted Score	60	30	30	60	60	30	60	30	48	60
		Total Score	**213**	**165**	**230**	**295**	**223**	**154**	**249**	**167**	**144**	**275**
		Ranking	**6**	**8**	**4**	**1**	**5**	**9**	**3**	**7**	**10**	**2**

Table 6.2 Analysis of Sanitation Site Options

Table 6.3 Summary of Scores for Options

Score	Option	Description
295	W3	Wetlands sewage treatment at Site 3, with the existing landfill upgraded to receive solid waste.
275	W8	Wetlands sewage treatment at Site 8, with the landfill developed adjacent to sewage dumping area.
249	L5	A sewage lagoon at Site 5, with a landfill up-gradient of the lagoon.
230	W2	Wetlands sewage treatment at Site 2, with the landfill developed up-gradient of the wetlands.
223	M1	A mechanical sewage plant at Site 1, with a landfill developed at Site 1.
213	L1	A sewage lagoon at Site 1, with a landfill up- gradient of the lagoon.
167	M-SD-2	A mechanical sewage plant at Site 2. The landfill would be developed up-gradient of Site 2.
165	L2	A sewage lagoon at Site 2, with a landfill site up- gradient of the lagoon.
154	M4	A mechanical sewage plant at Site 4, with a landfill developed at Site 4.
144	G6	A lagoon and landfill would be developed in an area provided by a granular blasting operation. The blasting operation would remove as much material for an area large enough to site both the lagoon and landfill.

6.3 Analysis Summary

From the development and analysis of the options, the following can be stated:

- Wetlands treatment options are generally among the highest scoring mainly due to their relatively low capital and lifecycle costs compared to other technologies.
- The use of a mechanical plant with various discharge systems will have a capital cost of $2.2 to $3.2 million, and annual operating costs of approximately $150,000.
- The cost of developing a sanitation site from a quarry operation is prohibitive.

The best balanced choice is W3, a wetlands treatment area facility at Site 3. This option has an estimated capital cost of $272,000, and life cycle cost of $6,192,000. The next best balanced choice is W8, a wetlands treatment area at Site 8. This option has an estimated capital cost of $672,000, and life cycle cost of $5,719,000.

The best balanced choice for a lagoon facility would be option L5, which is located at Site 5. This option's estimated capital cost is $840,000, and the respective lifecycle cost is $7,423,000.

With respect to mechanical treatments, the best balanced option would be M1, at Site 1. This option has an estimated capital cost of $1,800,000, and a life cycle cost of $8,500,000.

6.4 Risk Assessment

As discussed, the best balanced choice from the analysis is a wetlands treatment system at Site 3 (W3), with a landfill operated adjacent to this site. Should this option be selected, the community plan would have to be revised, and the development of housing lots relocated to another area.

The items of risk associated with this development are:

1. The community does not want to, or can not, develop alternative land areas for housing. This may result in the development of Site W3 being stopped part way through development, or that it operates for a short period of time. and because of land pressures is abandoned.

2. The wetlands concept is receiving regulatory approval elsewhere; however there are no approved standard design values for engineering a site. There is a risk that the site may have a lag period of start-up problems that result in non-compliance to the discharge guidelines.

The next best balanced alternative is a wetlands treatment system at Site 8 (W8), with a landfill operated adjacent to this site. This site is far removed from the community and would not impact the community plan at all. W8 carries the following potential risks:

1. Potential road blockage from snowfall or washouts.

2. Item 2. as noted above.

The third choice is L-5, a lagoon at Site 5 with a landfill upgradient of the lagoon. The technologies to construct and operate an access road, lagoon, and area landfill are common throughout the Northwest Territories. The risks with this option are items 1 as noted above, ie. Concern with the access to the site in the winter due to snow.

Any of the mechanical plant options would make the facility the first mechanical plant for the GNWT in a remote, small community. The skills to operate the plant do not currently exist within the community. The risks associated with the implementation of this alternative are:

1. Power failure to the plant. If longer than ± 6 hours, it could result in complete plant failure or damage. Power failures occur a few times each year in the communities. A stand-by on-site

power generator would mitigate the risk of plant failure in the event of a power failure. The risk of both prime and stand-by power failing at the same time is low, with a medium severity in the event of a six (6) hour failure.

2. Freeze-up of discharge pipe. This is a low risk. Numerous pipe systems are installed in the Northwest Territories. Designs have been developed to mitigate the risk of failure. The pipe can be by-passed in the event of failure. This is a low risk and low severity.

3. Operator problems that result in plant failure. This is a medium risk as the operators have no previous experience. Through training, the operators can become proficient at the plant operation. In the early years, the risk and severity may be medium, but with experience of the operators increasing with time, this risk will reduce.

4. Increased construction costs due to the lack of previous experience of contractors. This is a low risk and has a low impact on the project as a whole.

5. Failure to meet regulatory compliance. If the plant is operated correctly, the risk is very low.

7.0 SUMMARY OF REPORT/CONCLUSIONS

To date, there have been three separate projects undertaken for the Kimmirut sanitation planning study. The first portion of the study was performed in 1994, and investigated four separate sites encompassing a total of six options. This part of the study was designated as Phase I. The next portion of the study was conducted in 1995, and was designated as Phase II. Phase II investigated two more sites. Finally, this study has brought forth an additional two sites. Overall, eight sites and ten options have been evaluated.

The results of all the work to date conclude that the development of Site 3 as a wetlands sewage disposal facility and area landfill (W3), is the best balanced choice. The implementation of this option would negate the current Community Plan.

The analysis of Phase I, Phase II, and the additional options developed in this study, can be distilled as follows:

- The best balanced choice for a sanitation site would be a wetlands system at Site #3, with an area landfill adjacent to the wetlands. This alternative has a capital cost of $212,000 and a life cycle cost of $6,400,000. However, it precludes the use of the Southern Valley as a housing subdivision.

- The use of the Southern Valley as a housing subdivision, suggests the use of Site 8 as a sanitation site with a capital cost of $672,000 and a total life cycle cost $5,729,000.

- The use of Site 3 for a sanitation site precludes the expansion of the community in this direction for the next 20 to 40 years. The use of Site 8 for a sanitation site allows the community greater flexibility in growth and development over the next 20 to 40 years. The premium paid to allow for the increase in flexibility is approximately $450,000.

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APPENDIX A

Phase I and II Cost Estimates, Sensitivity Analysis, and Trucking Costs

ITEM	UNITS	PRICE	L1 Qty	L1	L2 Qty	L2	W2 Qty	W2	W3 Qty	W3	M1 Qty	M1	M4 Qt	M4
CAPITAL COSTS														
Lagoon cut and fill	m^3	$95	51000	$4,845,000	37000	$3,515,000	0	$0	0	$0	0	$0	0	$0
Earthen berms	m^3	$95	0	$0	0	$0	3000	$285,000	3000	$285,000	0	$0	0	$0
Mechanical Plant	each	$1,400,000	0	$0	0	$0	0	$0	0	$0	1	$1,400,000	1	$1,400,000
Sludge Handling	each	$50,000	0	$0	0	$0	0	$0	0	$0	1	$50,000	1	$50,000
Stick Built Building	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	1	$80,000
Outfall Structure	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	1	$80,000
Truck Turnaround	m	$200	50	$10,000	50	$10,000	50	$10,000	50	$10,000	25	$5,000	25	$5,000
Discharge Flue	each	$5,000	1	$5,000	1	$5,000	1	$5,000	1	$5,000	0	$0	0	$0
Portable Pump	each	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	0	$0	0	$0
Clearing/Grubbing	h	$2,000	1	$2,000	2	$4,000	1	$2,000	1	$2,000	0	$0	0	$0
Access Road	m	$600	1000	$600,000	500	$300,000	500	$300,000	200	$120,000	1000	$600,000	0	$0
Power Supply A/G	m	$33	0	$0	0	$0	0	$0	0	$0	100	$3,300	100	$3,300
Power Supply U/G	m	$330	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Additional Design	each	$50,000	0	$0	0	$0	1	$50,000	1	$50,000	0	$0	0	$0
SUBTOTAL				$5,472,000		$3,844,000		$662,000		$482,000		$2,218,300		$1,618,300
Contingency Allowance @ 20%				$1,094,400		$768,800		$132,400		$96,400		$443,660		$323,660
TOTAL CAPITAL COSTS				$6,566,000		$4,613,000		$794,000		$578,000		$2,662,000		$1,942,000
O & M COSTS														
Lagoons	5.0%			$242,250		$175,750		$14,250		$14,250		$0		$0
Mechanical Plant	7.5%			$0		$0		$0		$0		$108,750		$108,750
Stick Built Building	5.0%			$0		$0		$0		$0		$4,000		$4,000
Roads	1.0%			$6,100		$3,100		$3,100		$1,300		$6,050		$50
Discharge Flue	1.0%			$50		$50		$50		$50		$0		$0
Portable Pump	5.0%			$500		$500		$500		$500		$0		$0
Power Supply	1.0%			$0		$0		$500		$500		$33		$33
Monitoring	lump sum			$5,000		$5,000		$5,000		$5,000		$5,000		$5,000
Trucking	Life Cycle Cost Per Appendix			$6,102,000		$5,864,000		$5,864,000		$5,579,000		$6,102,000		$5,864,000
TOTAL ANNUAL O & M COSTS				$253,900		$184,400		$23,400		$21,600		$123,800		$117,800
PRESENT VALUE OF O & M COSTS **				$8,595,000		$7,674,000		$6,094,000		$5,791,000		$7,317,000		$7,021,000
PRESENT VALUE COST OF CAPITAL AND O & M **				$15,161,000		$12,287,000		$6,888,000		$6,369,000		$9,979,000		$8,963,000

Notes * The main road extension is not part of this planning study and will not be constructed or funded by MACA

- Costs for this item are only included for comparison

** Present values; costs are calculated at an 8% discount rate over a 20 year planning horizon

Table 6.3 Estimated Construction and O & M Costs

Lake Harbour Sanitation Site Planning Study

Municipal and Community Affairs

M.M. Dillon Ltd

ITEM	UNITS	PRICE	L1 Qty	L1	L2 Qty	L2	W2 Qty	W2	W3 Qty	W3	M1 Qty	M1	M4 Qty	M4
CAPITAL COSTS														
Lagoon cut and fill	m^3	$150	51000	$7,650,000	37000	$5,550,000	0	$0	0	$0	0	$0	0	$
Earthen berms	m^3	$150	0	$0	0	$0	3000	$450,000	3000	$450,000	0	$0	0	$
Mechanical Plant	each	$750,000	0	$0	0	$0	0	$0	0	$0	1	$750,000	1	$750,00
Sludge Handling	each	$50,000	0	$0	0	$0	0	$0	0	$0	1	$50,000	1	$50,00
Stick Built Building	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	1	$80,00
Outfall Structure	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	1	$80,00
Truck Turnaround	m	$200	50	$10,000	50	$10,000	50	$10,000	50	$10,000	25	$5,000	25	$5,00
Discharge Flue	each	$5,000	1	$5,000	1	$5,000	1	$5,000	1	$5,000	0	$0	0	$
Portable Pump	each	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	0	$0	0	$
Clearing/Grubbing	h	$2,000	1	$2,000	2	$4,000	1	$2,000	1	$2,000	0	$0	0	$
Access Road	m	$1,000	1000	$1,000,000	500	$500,000	500	$500,000	200	$200,000	1000	$1,000,000	0	$
Power Supply A/G	m	$33	0	$0	0	$0	0	$0	0	$0	100	$3,300	100	$3,30
Power Supply U/G	m	$330	0	$0	0	$0	0	$0	0	$0	0	$0	0	$
Additional Design	each	$50,000	0	$0	0	$0	1	$50,000	1	$50,000	0	$0	0	$
SUBTOTAL				$8,677,000		$6,079,000		$1,027,000		$727,000		$1,968,300		$968,30
Contingency Allowance @ 20%				$1,735,400		$1,215,800		$205,400		$145,400		$393,660		$193,66
TOTAL CAPITAL COSTS				$10,412,000		$7,295,000		$1,232,000		$872,000		$2,362,000		$1,162,00
O & M COSTS														
Lagoons	1.0%			$76,500		$55,500		$4,500		$4,500		$0		$0
Mechanical Plant	10.0%			$0		$0		$0		$0		$80,000		$80,000
Stick Built Building	5.0%			$0		$0		$0		$0		$4,000		$4,000
Roads	1.0%			$10,100		$5,100		$5,100		$2,100		$10,050		$50
Discharge Flue	1.0%			$50		$50		$50		$50		$0		$0
Portable Pump	5.0%			$500		$500		$500		$500		$0		$0
Power Supply	1.0%			$0		$0		$500		$500		$33		$33
Monitoring	lump sum			$0		$0		$15,000		$15,000		$0		$0
Trucknig	Per Append			$6,102,000		$5,864,000		$5,864,000		$5,579,000		$6,102,000		$5,864,000
TOTAL ANNUAL O & M COSTS				$87,200		$61,200		$10,700		$7,700		$94,100		$84,100
PRESENT VALUE OF O & M COSTS **				$856,000		$601,000		$105,000		$76,000		$924,000		$826,000
PRESENT VALUE COST OF CAPITAL AND O & M **				$17,370,000		$13,760,000		$7,201,000		$6,527,000		$9,388,000		$7,852,000

Notes
* The main road extension is not part of this planning study and will not be constructed or funded by MACA
- Costs for this item are only included for comparison
** Present values costs are calculated at an 8% discount rate over a 20 year planning horizon

Table C - 1 Estimated Construction and O & M Costs Using High Grannular Costs

Lake Harbour Sanitation Site Planning Study

Municipal and Community Affairs.
M.M. Dillon Ltd.

ITEM	UNITS	PRICE	L1 Qty	L1	L2 Qty	L2	W2 Qty	W2	W3 Qty	W3	M1 Qty	M1	M4 Qty	M4
CAPITAL COSTS														
Lagoon cut and fill	m^3	$40	51000	$2,040,000	37000	$1,480,000	0	$0	0	$0	0	$0	0	$0
Earthen berms	m^3	$40	0	$0	0	$0	3000	$120,000	3000	$120,000	0	$0	0	$0
Mechanical Plant	each	$750,000	0	$0	0	$0	0	$0	0	$0	1	$750,000	1	$750,000
Sludge Handling	each	$50,000	0	$0	0	$0	0	$0	0	$0	1	$50,000	1	$50,000
Stick Built Building	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	1	$80,000
Outfall Structure	each	$80,000	0	$0	0	$0	0	$0	0	$0	1	$80,000	1	$80,000
Truck Turnaround	m	$200	50	$10,000	50	$10,000	50	$10,000	50	$10,000	25	$5,000	25	$5,000
Discharge Flue	each	$5,000	1	$5,000	1	$5,000	1	$5,000	1	$5,000	0	$0	0	$0
Portable Pump	each	$10,000	1	$10,000	1	$10,000	1	$10,000	1	$10,000	0	$0	0	$0
Clearing/Grubbing	h	$2,000	1	$2,000	2	$4,000	1	$2,000	1	$2,000	0	$0	0	$0
Access Road	m	$200	1000	$200,000	500	$100,000	500	$100,000	200	$40,000	1000	$200,000	0	$0
Power Supply A/G	m	$33	0	$0	0	$0	0	$0	0	$0	100	$3,300	100	$3,300
Power Supply U/G	m	$330	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Additional Design	each	$50,000	0	$0	0	$0	1	$50,000	1	$50,000	0	$0	0	$0
SUBTOTAL				$2,267,000		$1,609,000		$297,000		$237,000		$1,168,300		$968,300
Contingency Allowance @ 20%				$453,400		$321,800		$59,400		$47,400		$233,660		$193,660
TOTAL CAPITAL COSTS				$2,720,000		$1,931,000		$356,000		$284,000		$1,402,000		$1,162,000
O & M COSTS														
Lagoons	1.0%			$20,400		$14,800		$1,200		$1,200		$0		$0
Mechanical Plant	10.0%			$0		$0		$0		$0		$80,000		$80,000
Stick Built Building	5.0%			$0		$0		$0		$0		$4,000		$4,000
Roads	1.0%			$2,100		$1,100		$1,100		$500		$2,050		$50
Discharge Flue	1.0%			$50		$50		$50		$50		$0		$0
Portable Pump	5.0%			$500		$500		$500		$500		$0		$0
Power Supply	1.0%			$0		$0		$500		$500		$33		$33
Monitoring	lump sum			$0		$0		$15,000		$15,000		$0		$0
Truckng	Per Append			$6,102,000		$5,864,000		$5,864,000		$5,579,000		$6,102,000		$5,864,000
TOTAL ANNUAL O & M COSTS				$23,100		$16,500		$3,400		$2,800		$86,100		$84,100
PRESENT VALUE OF O & M COSTS **				$227,000		$162,000		$33,000		$27,000		$845,000		$826,000
PRESENT VALUE COST OF CAPITAL AND O & M **				$9,049,000		$7,957,000		$6,253,000		$5,890,000		$8,349,000		$7,852,000

Notes * The main road extension is not part of this planning study and will not be constructed or funded by MACA

- Costs for this item are only included for comparison

** Present values costs are calculated at an 8% discount rate over a 20 year planning horizon

Table C - 2 Estimated Construction and O & M Costs
Using Low Grannular Costs
Lake Harbour Sanitation Site Planning Study

Municipal and Community Affairs.
M.M. Dillon Ltd.

SELECTION CRITERIA			L1 Lagoon Site 1 AVE	L2 Lagoon Site 2 AVE	W2 Wetlands Site 2 AVE	W3 Wetlands Site 3 AVE	M1 Mechanical Site 1 AVE	M4 Mechanical Existing Site AVE
1 ***CAPITAL COST***		Cost $	c$6,566	c$4,613	c$794	c$578	c$1,882	c$1,162
WEIGHT	6	Score	0.9	1.3	7.3	10.0	4.2	5.0
		Weighted Score	5	8	44	60	25	30
2 ***LIFE CYCLE COST***		Cost $	c$7,800	c$4,990	c$863	c$629	c$2,767	c$1,988
WEIGHT	6	Score	0.8	1.3	7.3	10.0	3.1	3.2
		Weighted Score	5	8	44	60	19	19
3 ***REGULATORY COMPLIANCE***								
WEIGHT	5	Score	7	7	2	4	9	9
		Weighted Score	35	35	10	20	45	45
4 ***EFFECT ON COMMUNITY PLAN***								
WEIGHT	10	Score	10	4	3	0	8	8
		Weighted Score	100	40	30	0	80	80
5 ***450 m SETBACK FROM EXISTING***								
WEIGHT	7	Score	10	5	5	10	10	5
		Weighted Score	70	35	35	70	70	35
		Total Score	215	125	162	210	239	209

Table C-3 Sensitivity Analysis to Weights
Lake Harbour Sanitation Site Planning Study
Municipal and Community Affairs
M.M. Dillon Ltd.

ITEM	UNITS	PRICE	Qty	L5	Qty	M-SD-2	Qty	M-DW-2	Qty	M-LD-2	Qty	G6
CAPITAL COSTS												
Lagoon cut and fill	m^3	$95	0	$0	0	$0	0	$0	0	$0	150000	$14,250,000
Earthen berms	m^3	$95	1000	$95,000	0	$0	0	$0	0	$0	5000	$475,000
Mechanical Plant	each	$1,500,000	0	$0	1	$1,500,000	1	$1,500,000	1	$1,500,000	0	$0
Outfall Structure	each	$2,000	0	$0	450	$900,000	200	$400,000	20	$40,000	1	$2,000
Truck Turnaround	m	$200	50	$10,000	50	$10,000	50	$10,000	50	$10,000	50	$10,000
Discharge Flue	each	$5,000	1	$5,000	0	$0	0	$0	0	$0	1	$5,000
Portable Pump	each	$10,000	1	$10,000	0	$0	0	$0	0	$0	1	$10,000
Access Road *	m^3	$95	23500	$2,232,500	2900	$275,500	2900	$275,500	2900	$275,500	2000	$190,000
Power Supply A/G	m	$50	0	$0	600	$30,000	600	$30,000	600	$30,000	0	$0
Additional Design	each	$50,000	0	$0	1	$50,000	1	$50,000	1	$50,000	0	$0
SUBTOTAL				$2,352,500		$2,765,500		$2,265,500		$1,905,500		$14,942,000
Contingency Allowance @ 20%				$470,500		$553,100		$453,100		$381,100		$2,988,400
TOTAL CAPITAL COSTS				$2,823,000		$3,319,000		$2,719,000		$2,287,000		$17,930,000
O & M COSTS												
Lagoons		5%		$4,750		$0		$0		$0		$736,250
Mechanical Plant		8%		$0		$112,500		$112,500		$112,500		$0
Roads		1%		$22,425		$2,855		$2,855		$2,855		$2,000
Discharge Flue		1%		$50		$0		$0		$0		$50
Portable Pump		5%		$500		$0		$0		$0		$500
Power Supply		$62,000		$0		$62,000		$62,000		$62,000		$0
Monitoring		lump sum		$5,000		$5,000		$5,000		$5,000		$5,000
Trucking		Per Appen.		$6,501,000		$5,864,000		$5,864,000		$5,864,000		$6,102,000
TOTAL ANNUAL O & M COSTS				$32,700		$182,400		$177,400		$177,400		$738,800
PRESENT VALUE OF O & M COSTS **				$321,000		$1,791,000		$1,742,000		$1,742,000		$7,254,000
TOTAL PRESENT VALUE				$9,645,000		$10,974,000		$10,325,000		$9,893,000		$31,286,000

Notes * The main road extension is not part of this planning *study and will not* be funded by MACA.

- Costs for this item are only included for comparison.

** Present values costs are calculated at an 8% discount rate over a 20 year planning horizon.

Table 13.1 Estimated Construction and O & M Costs
Lake Harbour Sanitation Site Planning Study
Municipal and Community Affairs
M.M. Dillon Ltd.

PHASE II SITE TRUCKING COSTS

ECONOMIC ANALYSIS - TRUCKED SYSTEMS - LAKE HARBOUR (KIMMIRUT)
SITE #1
ASSUMPTIONS:

Population growth	PG	0.0269						
Efficiency of labour	EL	1.5	Distance between buildings (m)	DB	30	Miscellaneous operating cost factor	MISC	0.10
Number of buildings	NB	Pop/4	Speed between buildings (km/h)	SB	10	Discount rate	DR	0.08
Buiding container size (l)	C	2250	Rate of filling at buildings (l/min)	RB	340	Hourly wage of driver ($/h)	WD	13.37
		1800	Turn around time at buildings (min)	TTB	3	Hourly wage of helpers ($/h)	WH	12.73
Container utilization factor	CSF	0.85	Number of trips to each building	NTB	1	Number of helpers	NH	1
Vehicle size (l)	VS	4500	Vehicle capital cost ($)	VCC	110 000	Labour benefit factor	LBF	1.2
Vehicle use factor	VUF	0.95	Vehicle service factor	VSF	0.15	Parking garage base cost ($/sq m)	PGBSF	2,500
Travel distance to source (km)	D	3	Brake housepower (kw)	BHP	55	Vehicle space requirement (sq m)	VSR	75
Speed of vehicle to source (km/h)	S	25	Fuel consumption rate (l/km/h)	FR	0.24	Parking garage economic life (year)	PGEL	20
Rate of filling at source (l/min)	R	450	Fuel cost ($/l)	FUEL	0.71	Parking garage annual O&M factor	PGAOMF	0.06
Turn around time at source (min)	TT	4	Vehicle economic life (year)	VEL	4	Number of persons per building	NOPB	4

YEAR	POP	WATER CONSUMP (lpcd)	NUMBER TRUCKS INV	VEHICLE CAPITAL	VEHICLE O&M	TRUCK LABOUR COST	TRUCK GARAGE CAPITAL	TRUCK GARAGE O&M	TRUCK CAPITAL	TRUCK O&M	RES. O&M	TRUCKFILL O&M	ANNUAL CAPITAL	ANNUAL O&M	TOTAL CAPITAL & O&M	PRESENT VALUE CAPITAL	PRESENT VALUE O&M	PRESENT VALUE TOTAL
1997	422	99	2	66,423	96,673	134,094	38,195	22,500	104,617	253,268	5,000	12,000	1,296,117	270,268	1,566,385	1,200,108	250,248	1,450,356
1998	433	99	3	99,634	115,044	138,033	57,292	33,750	156,926	286,827	5,000	12,060	156,926	303,887	460,813	134,538	260,534	395,072
1999	445	99	3	99,634	116,973	142,096	57,292	33,750	156,926	292,819	5,000	12,120	156,926	309,939	466,865	124,573	246,040	370,613
2000	457	100	3	99,634	118,963	146,288	57,292	33,750	156,926	299,001	5,000	12,181	156,926	316,182	473,107	115,345	232,403	347,748
2001	469	100	3	99,634	121,017	150,612	57,292	33,750	156,926	305,378	5,000	12,242	156,926	322,620	479,546	106,801	219,570	326,371
2002	482	100	3	99,634	123,135	155,074	57,292	33,750	156,926	311,959	5,000	12,303	156,926	329,262	486,187	98,890	207,491	306,380
2003	495	100	3	99,634	125,321	159,678	57,292	33,750	156,926	318,749	5,000	12,365	156,926	336,114	493,039	91,565	196,119	287,684
2004	508	101	3	99,634	127,578	164,429	57,292	33,750	156,926	325,757	5,000	12,426	156,926	343,183	500,109	84,782	185,411	270,193
2005	522	101	3	99,634	129,906	169,334	57,292	33,750	156,926	332,990	5,000	12,488	156,926	350,478	507,404	78,502	175,326	253,828
2006	536	101	3	99,634	132,310	174,396	57,292	33,750	156,926	340,456	5,000	12,551	156,926	358,007	514,933	72,687	165,827	238,514
2007	550	102	3	99,634	134,792	179,622	57,292	33,750	156,926	348,164	5,000	12,614	156,926	365,778	522,704	67,303	156,876	224,179
2008	565	102	3	99,634	137,354	185,018	57,292	33,750	156,926	356,123	5,000	12,677	156,926	373,799	530,725	62,317	148,441	210,758
2009	580	102	3	99,634	140,000	190,590	57,292	33,750	156,926	364,340	5,000	12,740	156,926	382,080	539,006	57,701	140,490	198,191
2010	596	103	3	99,634	142,732	196,345	57,292	33,750	156,926	372,827	5,000	12,804	156,926	390,631	547,556	53,427	132,995	186,422
2011	612	103	4	132,845	162,054	202,288	76,389	45,000	209,234	409,342	5,000	12,868	209,234	427,210	636,444	65,959	134,674	200,634
2012	628	103	4	132,845	164,970	208,427	76,389	45,000	209,234	418,397	5,000	12,932	209,234	436,329	645,563	61,073	127,360	188,434
2013	645	104	4	132,845	167,981	214,770	76,389	45,000	209,234	427,751	5,000	12,997	209,234	445,748	654,982	56,549	120,472	177,021
2014	663	104	4	132,845	171,093	221,323	76,389	45,000	209,234	437,416	5,000	13,062	209,234	455,478	664,712	52,361	113,983	166,343
2015	680	104	4	132,845	174,308	228,095	76,389	45,000	209,234	447,403	5,000	13,127	209,234	465,530	674,764	48,482	107,869	156,351
2016	699	105	4	132,845	177,632	235,093	76,389	45,000	209,234	457,725	5,000	13,193	209,234	475,918	685,152	44,891	102,107	146,998

TOTAL PRESENT VALUE	6,102,091
INITIAL CAPITAL COST	1,191,500

ECONOMIC ANALYSIS - TRUCKED SYSTEMS - LAKE HARBOUR (KIMMIRUT)
SITE #2
ASSUMPTIONS:

Population growth	PG	0 0269						
Efficiency of labour	EL	1 5	Distance between buildings (m)	DB	30	Miscellaneous operating cost factor	MISC	0 10
Number of buildings	NB	Pop/4	Speed between buildings (km/h)	SB	10	Discount rate	DR	0 08
Buiding container size (l)	C	2250	Rate of filling at buildings (l/min)	RB	340	Hourly wage of driver ($/h)	WD	13 37
		1800	Turn around time at buildings (min)	TTB	3	Hourly wage of helpers ($/h)	WH	12 73
Container utilization factor	CSF	0 85	Number of trips to each building	NTB	1	Number of helpers	NH	1
Vehicle size (l)	VS	4500	Vehicle capital cost ($)	VCC	110 000	Labour benefit factor	LBF	1 2
Vehicle use factor	VUF	0 95	Vehicle service factor	VSF	0 15	Parking garage base cost ($/sq m)	PGBSF	2,500
Travel distance to source (km)	D	2.5	Brake housepower (kw)	BHP	55	Vehicle space requirement (sq m)	VSR	75
Speed of vehicle to source (km/h)	S	25	Fuel consumption rate (l/kw/h)	FR	0 24	Parking garage economic life (yaer)	PGEL	20
Rate of filling at source (l/min)	R	450	Fuel cost ($/l)	FUEL	0 71	Parking garage annual O&M factor	PGAOMF	0 06
Turn around time at source (min)	TT	4	Vehicle economic life (year)	VEL	4	Number of persons per building	NOPB	4

YEAR	POP	WATER CONSUMP (lpcd)	NUMBER TRUCKS INV	VEHICLE CAPITAL	VEHICLE O&M	TRUCK LABOUR COST	TRUCK GARAGE CAPITAL	TRUCK GARAGE O&M	TRUCK CAPITAL	TRUCK O&M	RES O&M	TRUCKFILL O&M	ANNUAL CAPITAL	ANNUAL O&M	TOTAL CAPITAL & O&M	PRESENT VALUE CAPITAL	PRESENT VALUE O&M	PRESENT VALUE TOTAL
1997	422	99	2	66 423	93 495	127,401	38,195	22,500	104 617	243 396	5,000	12 000	1,296,117	260,396	1,556,513	1,200,108	241,107	1,441,216
1998	433	99	2	66,423	95,272	131,143	38,195	22,500	104 617	248,915	5,000	12,060	104 617	265 975	370,592	89,692	228,031	317,723
1999	445	99	3	99 634	113,605	135,003	57,292	33,750	156 926	282 359	5 000	12,120	156 926	299 479	456 404	124,573	237,736	362,309
2000	457	100	3	99 634	115,496	138,986	57,292	33,750	156 926	288,232	5,000	12,181	156 926	305 412	462,338	115,345	224,487	339,832
2001	469	100	3	99 634	117,447	143 094	57,292	33,750	156 926	294,291	5,000	12,242	156,926	311,533	468 458	106,801	212,024	318,825
2002	482	100	3	99,634	119,460	147,333	57,292	33 750	156 926	300,543	5,000	12,303	156,926	317,846	474,771	98,890	200,297	299,186
2003	495	100	3	99,634	121,537	151,707	57,292	33 750	156 926	306,994	5 000	12 365	156 926	324,359	481,284	91,565	189,260	280 825
2004	508	101	3	99 634	123,680	156,222	57,292	33,750	156 926	313,652	5 000	12 426	156 926	331,079	488,004	84 782	178,871	263,653
2005	522	101	3	99 634	125,893	160,881	57,292	33,750	156,926	320,524	5 000	12 488	156 926	338 013	494,938	78,502	169 091	247,592
2006	536	101	3	99 634	128,177	165,691	57,292	33 750	156 926	327,618	5 000	12,551	156 926	345 169	502 094	72,687	159,880	232,567
2007	550	102	3	99 634	130,535	170,656	57,292	33,750	156,926	334 941	5 000	12,614	156 926	352 555	509 480	67,303	151,205	218 507
2008	565	102	3	99 634	132,960	175,783	57,292	33,750	156 926	342,502	5 000	12 677	156 926	360 179	517,105	62,317	143,032	205,349
2009	580	102	3	99,634	135,483	181,077	57,292	33,750	156 926	350 310	5 000	12 740	156 926	368 050	524,975	57,701	135,331	193,032
2010	596	103	3	99 634	138,079	186,544	57,292	33,750	156 926	358,373	5 000	12,804	156 926	376,177	533 102	53,427	128,073	181,501
2011	612	103	3	99 634	140,760	192,191	57,292	33,750	156,926	366,701	5 000	12 868	156 926	384,569	541,494	49,469	121,232	170,702
2012	628	103	3	99 634	143,530	198,024	57,292	33,750	156 926	375,303	5 000	12,932	156 926	393,235	550,161	45 805	114,782	160,587
2013	645	104	4	132 845	162,891	204,049	76,389	45,000	209,234	411,840	5,000	12,997	209,234	429,937	639,171	56,549	116,199	172,748
2014	663	104	4	132 845	165,847	210,275	76,389	45,000	209 234	421,123	5,000	13,062	209 234	439 185	648,419	52 361	109,906	162,266
2015	680	104	4	132 845	168,902	216,709	76,389	45,000	209,234	430,611	5,000	13,127	209,234	448 739	657,973	48,482	103,978	152,460
2016	699	105	4	132 845	172,060	223,358	76,389	45,000	209 234	440 418	5,000	13,193	209 234	458 611	667,845	44,891	98,394	143,285

TOTAL PRESENT VALUE	5,884,166
INITIAL CAPITAL COST	1,191,500

ECONOMIC ANALYSIS - TRUCKED SYSTEMS - LAKE HARBOUR (KIMMIRUT)
SITE #3
ASSUMPTIONS:

Population growth	PG	0.0269						
Efficiency of labour	EL	1.5	Distance between buildings (m)	DB	30	Miscellaneous operating cost factor	MISC	0.10
Number of buildings	NB	Pop/4	Speed between buildings (km/h)	SB	10	Discount rate	DR	0.08
Building container size (l)	C	2250	Rate of filling at buildings (l/min)	RB	340	Hourly wage of driver ($/h)	WD	13.37
		1800	Turn around time at buildings (min)	TTB	3	Hourly wage of helpers ($/h)	WH	12.73
Container utilization factor	CSF	0.85	Number of trips to each building	NTB	1	Number of helpers	NH	1
Vehicle size (l)	VS	4500	Vehicle capital cost ($)	VCC	110,000	Labour benefit factor	LBF	1.2
Vehicle use factor	VUF	0.95	Vehicle service factor	VSF	0.15	Parking garage base cost ($/sq.m)	PGBSF	2,500
Travel distance to source (km)	D	2	Brake housepower (kw)	BHP	55	Vehicle space requirement (sq m)	VSR	75
Speed of vehicle to source (km/h)	S	25	Fuel consumption rate (l/km/h)	FR	0.24	Parking garage economic life (year)	PGEL	20
Rate of filling at source (l/min)	R	450	Fuel cost ($/l)	FUEL	0.71	Parking garage annual O&M factor	PGAOMF	0.06
Turn around time at source (min)	TT	4	Vehicle economic life (year)	VEL	4	Number of persons per building	NOPB	4

YEAR	POP	WATER CONSUMP (lpcd)	NUMBER TRUCKS INV	VEHICLE CAPITAL	VEHICLE O&M	TRUCK LABOUR COST	TRUCK GARAGE CAPITAL	TRUCK GARAGE O&M	TRUCK CAPITAL	TRUCK O&M	RES O&M	TRUCKFILL O&M	ANNUAL CAPITAL	ANNUAL O&M	TOTAL CAPITAL & O&M	PRESENT VALUE CAPITAL	PRESENT VALUE O&M	PRESENT VALUE TOTAL
1997	422	99	2	66,423	80,317	120,708	38,195	22,500	104,617	233,524	5,000	12,000	1,296,117	250,524	1,546,642	1,200,108	231,967	1,432,076
1998	433	99	2	66,423	82,001	124,253	38,195	22,500	104,617	238,754	5,000	12,060	104,617	255,814	360,431	89,692	219,319	309,011
1999	445	99	2	66,423	83,737	127,911	38,195	22,500	104,617	244,148	5,000	12,120	104,617	261,268	365,885	83,048	207,403	290,452
2000	457	100	2	66,423	85,529	131,684	38,195	22,500	104,617	249,712	5,000	12,181	104,617	266,893	371,510	76,897	196,175	273,071
2001	469	100	3	99,634	113,877	135,576	57,292	33,750	156,926	283,203	5,000	12,242	156,926	300,445	457,371	106,801	204,478	311,279
2002	482	100	3	99,634	115,784	139,593	57,292	33,750	156,926	289,127	5,000	12,303	156,926	306,430	463,355	98,890	193,103	291,992
2003	495	100	3	99,634	117,752	143,737	57,292	33,750	156,926	295,239	5,000	12,365	156,926	312,604	469,529	91,565	182,401	273,966
2004	508	101	3	99,634	119,783	148,014	57,292	33,750	156,926	301,547	5,000	12,426	156,926	318,974	475,899	84,782	172,332	257,114
2005	522	101	3	99,634	121,879	152,429	57,292	33,750	156,926	308,058	5,000	12,488	156,926	325,547	482,473	78,502	162,855	241,356
2006	536	101	3	99,634	124,043	156,986	57,292	33,750	156,926	314,779	5,000	12,551	156,926	332,330	489,256	72,687	153,933	226,620
2007	550	102	3	99,634	126,277	161,691	57,292	33,750	156,926	321,718	5,000	12,614	156,926	339,332	496,257	67,303	145,533	212,836
2008	565	102	3	99,634	128,584	166,548	57,292	33,750	156,926	328,882	5,000	12,677	156,926	346,558	503,484	62,317	137,623	199,940
2009	580	102	3	99,634	130,965	171,564	57,292	33,750	156,926	336,279	5,000	12,740	156,926	354,019	510,945	57,701	130,172	187,873
2010	596	103	3	99,634	133,425	176,744	57,292	33,750	156,926	343,919	5,000	12,804	156,926	361,722	518,648	53,427	123,152	176,579
2011	612	103	3	99,634	135,965	182,094	57,292	33,750	156,926	351,809	5,000	12,868	156,926	369,677	526,602	49,469	116,538	166,007
2012	628	103	3	99,634	138,590	187,620	57,292	33,750	156,926	359,959	5,000	12,932	156,926	377,892	534,817	45,805	110,303	156,108
2013	645	104	3	99,634	141,301	193,329	57,292	33,750	156,926	368,380	5,000	12,997	156,926	386,377	543,302	42,412	104,426	146,838
2014	663	104	3	99,634	144,102	199,228	57,292	33,750	156,926	377,080	5,000	13,062	156,926	395,142	552,067	39,270	98,884	138,154
2015	680	104	4	132,845	183,496	205,324	76,389	45,000	209,234	413,820	5,000	13,127	209,234	431,947	641,181	48,482	100,087	148,569
2016	699	105	4	132,845	186,487	211,624	76,389	45,000	209,234	423,111	5,000	13,193	209,234	441,304	650,538	44,891	94,681	139,572

TOTAL PRESENT VALUE	5,570,415
INITIAL CAPITAL COST	1,191,500

ECONOMIC ANALYSIS - TRUCKED SYSTEMS - LAKE HARBOUR (KIMMIRUT)
SITE #5
ASSUMPTIONS:

Population growth	PG	0.0260
Efficiency of labour	EL	1.5
Number of buildings	NB	Pop/4
Buiding container size (l)	C	2250
		1800
Container utilization factor	CSF	0.85
Vehicle size (l)	VS	4500
Vehicle use factor	VUF	0.95
Travel distance to source (km)	D	4
Speed of vehicle to source (km/h)	S	25
Rate of filling at source (l/min)	R	450
Turn around time at source (min)	TT	4

Distance between buildings (m)	DB	30
Speed between buildings (km/h)	SB	10
Rate of filling at buildings (l/min)	RB	340
Turn around time at buildings (min)	TTB	3
Number of trips to each building	NTB	1
Vehicle capital cost ($)	VCC	110,000
Vehicle service factor	VSF	0.15
Brake housepower (kw)	BHP	55
Fuel consumption rate (l/km/h)	FR	0.24
Fuel cost ($/l)	FUEL	0.71
Vehicle economic life (year)	VEL	4

Miscellaneous operating cost factor	MISC	0.10
Discount rate	DR	0.08
Hourly wage of driver ($/h)	WD	13.37
Hourly wage of helpers ($/h)	WH	12.73
Number of helpers	NH	1
Labour benefit factor	LBF	1.2
Parking garage base cost ($/sq m)	PGBSF	2,500
Vehicle space requirement (sq m)	VSR	75
Parking garage economic life (year)	PGEL	20
Parking garage annual O&M factor	PGAOMF	0.06
Number of persons per building	NOPB	4

YEAR	POP	WATER CONSUMP (lpcd)	NUMBER TRUCKS INV	VEHICLE CAPITAL	VEHICLE O&M	TRUCK LABOUR COST	TRUCK GARAGE CAPITAL	TRUCK GARAGE O&M	TRUCK CAPITAL	TRUCK O&M	RES. O&M	TRUCKFILL O&M	ANNUAL CAPITAL	ANNUAL O&M	TOTAL CAPITAL & O&M	PRESENT VALUE CAPITAL	PRESENT VALUE O&M	PRESENT VALUE TOTAL
1997	422	99	3	99,634	119,530	147,481	57,292	33,750	156,926	300,761	5,000	12,000	1,348,426	317,761	1,666,186	1,248,542	294,223	1,542,765
1998	433	99	3	99,634	121,587	151,813	57,292	33,750	156,926	307,150	5,000	12,060	156,926	324,210	481,136	134,538	277,958	412,496
1999	445	99	3	99,634	123,709	156,282	57,292	33,750	156,926	313,740	5,000	12,120	156,926	330,861	487,786	124,573	262,648	387,221
2000	457	100	3	99,634	125,898	160,891	57,292	33,750	156,926	320,539	5,000	12,181	156,926	337,720	494,646	115,345	248,234	363,579
2001	469	100	3	99,634	128,156	165,647	57,292	33,750	156,926	327,553	5,000	12,242	156,926	344,795	501,721	106,801	234,662	341,463
2002	482	100	3	99,634	130,486	170,555	57,292	33,750	156,926	334,791	5,000	12,303	156,926	352,094	509,019	98,890	221,879	320,769
2003	495	100	3	99,634	132,891	175,618	57,292	33,750	156,926	342,258	5,000	12,365	156,926	359,623	516,549	91,565	209,837	301,401
2004	508	101	3	99,634	135,372	180,844	57,292	33,750	156,926	349,966	5,000	12,426	156,926	367,393	524,318	84,782	198,491	283,273
2005	522	101	3	99,634	137,933	186,238	57,292	33,750	156,926	357,922	5,000	12,488	156,926	375,410	532,336	78,502	187,798	266,300
2006	536	101	3	99,634	140,577	191,806	57,292	33,750	156,926	366,133	5,000	12,551	156,926	383,684	540,610	72,687	177,720	250,407
2007	550	102	3	99,634	143,307	197,554	57,292	33,750	156,926	374,611	5,000	12,614	156,926	392,224	549,150	67,303	168,218	235,521
2008	565	102	4	132,845	162,625	203,489	76,389	45,000	209,234	411,113	5,000	12,677	209,234	428,790	638,024	83,090	170,278	253,368
2009	580	102	4	132,845	165,535	209,617	76,389	45,000	209,234	420,152	5,000	12,740	209,234	437,892	647,126	76,935	161,012	237,947
2010	596	103	4	132,845	168,540	215,946	76,389	45,000	209,234	429,485	5,000	12,804	209,234	447,289	656,523	71,236	152,285	223,521
2011	612	103	4	132,845	171,644	222,482	76,389	45,000	209,234	439,126	5,000	12,868	209,234	456,994	666,228	65,959	144,064	210,023
2012	628	103	4	132,845	174,850	229,234	76,389	45,000	209,234	449,084	5,000	12,932	209,234	467,016	676,251	61,073	136,318	197,391
2013	645	104	4	132,845	178,162	236,210	76,389	45,000	209,234	459,372	5,000	12,997	209,234	477,369	686,603	56,549	129,018	185,568
2014	663	104	4	132,845	181,584	243,417	76,389	45,000	209,234	470,002	5,000	13,062	209,234	488,064	697,298	52,361	122,137	174,498
2015	680	104	4	132,845	185,121	250,885	76,389	45,000	209,234	480,986	5,000	13,127	209,234	499,113	708,347	48,482	115,651	164,133
2016	699	105	4	132,845	188,776	258,562	76,389	45,000	209,234	492,338	5,000	13,193	209,234	510,531	719,765	44,891	109,534	154,424

TOTAL PRESENT VALUE	6,506,067
INITIAL CAPITAL COST	1,191,500

APPENDIX B

Access Road Quantities and Profiles

KIMMURUT GRANULAR VOLUME CALCULATIONS
FOR ROAD TO SITE 7

12% MAX. GRADED SMOOTH

STN (m)	NOTES	OG.EL (m)	OG.GR (%)	CUT/FILL (m)	DES.EL (m)	DES.GR (%)	DEL.GR (%)	DEL.H (m)	L (m)	A (m^2)	AVG. A (m^2)	V (m^3)	Cum. V (m^3)
0+000.		57.0		0.5	57.5			0.5		3.75			
0+020.		56.5	-2.5%	1.8	58.3	4.0%	2.0%	1.8	20.0	20.52	12.1	242.7	242.7
0+040.		59.0	12.5%	0.5	59.5	6.0%	8.5%	0.5	20.0	3.75	12.1	242.7	485.4
0+060.		57.0	-10.0%	2.0	59.0	-2.5%	1.5%	2.0	20.0	24	13.9	277.5	762.9
0+080.		57.0	0.0%	1.8	58.8	-1.0%	3.5%	1.8	20.0	20.52	22.3	445.2	1208.1
0+100.		57.0	0.0%	2.3	59.3	2.5%	0.5%	2.3	20.0	29.67	25.1	501.9	1710.0
0+120.		59.0	10.0%	0.9	59.9	3.0%	0.0%	0.9	20.0	7.83	18.7	375.0	2085.0
0+140.		60.0	5.0%	0.5	60.5	3.0%	4.5%	0.5	20.0	3.75	5.8	115.8	2200.8
0+160.		59.0	-5.0%	1.2	60.2	-1.5%	0.5%	1.2	20.0	11.52	7.6	152.7	2353.5
0+180.		58.0	-5.0%	2.0	60.0	-1.0%	1.0%	2.0	20.0	24	17.8	355.2	2708.7
0+200.		59.0	5.0%	1.0	60.0	0.0%	7.0%	1.0	20.0	9	16.5	330.0	3038.7
0+220.		60.0	5.0%	1.4	61.4	7.0%	1.0%	1.4	20.0	14.28	11.6	232.8	3271.5
0+240.		60.9	4.5%	2.1	63.0	8.0%	0.5%	2.1	20.0	25.83	20.1	401.1	3672.6
0+260.		63.7	14.0%	1.0	64.7	8.5%	0.5%	1.0	20.0	9	17.4	348.3	4020.9
0+280.		66.0	11.5%	0.5	66.5	9.0%	0.0%	0.5	20.0	3.75	6.4	127.5	4148.4
0+300.		66.8	4.0%	1.5	68.3	9.0%	0.5%	1.5	20.0	15.75	9.8	195.0	4343.4
0+320.		69.0	11.0%	1.0	70.0	8.5%	0.0%	1.0	20.0	9	12.4	247.5	4590.9
0+340.		70.8	9.0%	0.9	71.7	8.5%	2.0%	0.9	20.0	7.83	8.4	168.3	4759.2
0+360.		72.5	8.5%	0.5	73.0	6.5%	4.0%	0.5	20.0	3.75	5.8	115.8	4875.0
0+380.		71.2	-6.5%	2.3	73.5	2.5%	3.0%	2.3	20.0	29.67	16.7	334.2	5209.2
0+400.		72.1	4.5%	2.5	74.6	5.5%	5.0%	2.5	20.0	33.75	31.7	634.2	5843.4
0+420.		72.3	1.0%	4.4	76.7	10.5%	1.5%	4.4	20.0	84.48	59.1	1182.3	7025.7
0+440.		77.1	24.0%	2.0	79.1	12.0%	0.0%	2.0	20.0	24	54.2	1084.8	8110.5
0+460.		80.8	18.5%	0.7	81.5	12.0%	2.5%	0.7	20.0	5.67	14.8	296.7	8407.2
0+480.		82.8	10.0%	0.6	83.4	9.5%	9.0%	0.6	20.0	4.68	5.2	103.5	8510.7
0+500.		82.0	-4.0%	1.5	83.5	0.5%	0.5%	1.5	20.0	15.75	10.2	204.3	8715.0
0+520.		83.0	5.0%	0.5	83.5	0.0%	4.0%	0.5	20.0	3.75	9.8	195.0	8910.0
0+540.	GOES OVER TOP OF LAKE	81.9	-5.5%	2.4	84.3	4.0%	0.5%	2.4	20.0	31.68	17.7	354.3	9264.3
0+560.		83.0	5.5%	2.0	85.0	3.5%	1.5%	2.0	20.0	24	27.8	556.8	9821.1
0+580.		84.9	9.5%	0.5	85.4	2.0%	5.5%	0.5	20.0	3.75	13.9	277.5	10098.6
0+600.		84.0	-4.5%	0.7	84.7	-3.5%	0.0%	0.7	20.0	5.67	4.7	94.2	10192.8
0+620.	OVER TOP OF LAKE	82.0	-10.0%	2.0	84.0	-3.5%	3.5%	2.0	20.0	24	14.8	296.7	10489.5
0+640.	ASSUMED 1m DEEP	81.0	-5.0%	3.0	84.0	0.0%	3.5%	3.0	20.0	45	34.5	690.0	11179.5
0+660.	OVER TOP OF LAKE	82.0	5.0%	2.7	84.7	3.5%	8.5%	2.7	20.0	38.07	41.5	830.7	12010.2
0+680.		85.5	17.5%	1.6	87.1	12.0%	0.0%	1.6	20.0	17.28	27.7	553.5	12563.7
0+700.		88.5	15.0%	1.0	89.5	12.0%	2.0%	1.0	20.0	9	13.1	262.8	12826.5
0+720.		91.0	12.5%	0.5	91.5	10.0%	0.0%	0.5	20.0	3.75	6.4	127.5	12954.0
0+740.		93.0	10.0%	0.5	93.5	10.0%	4.0%	0.5	20.0	3.75	3.8	75.0	13029.0

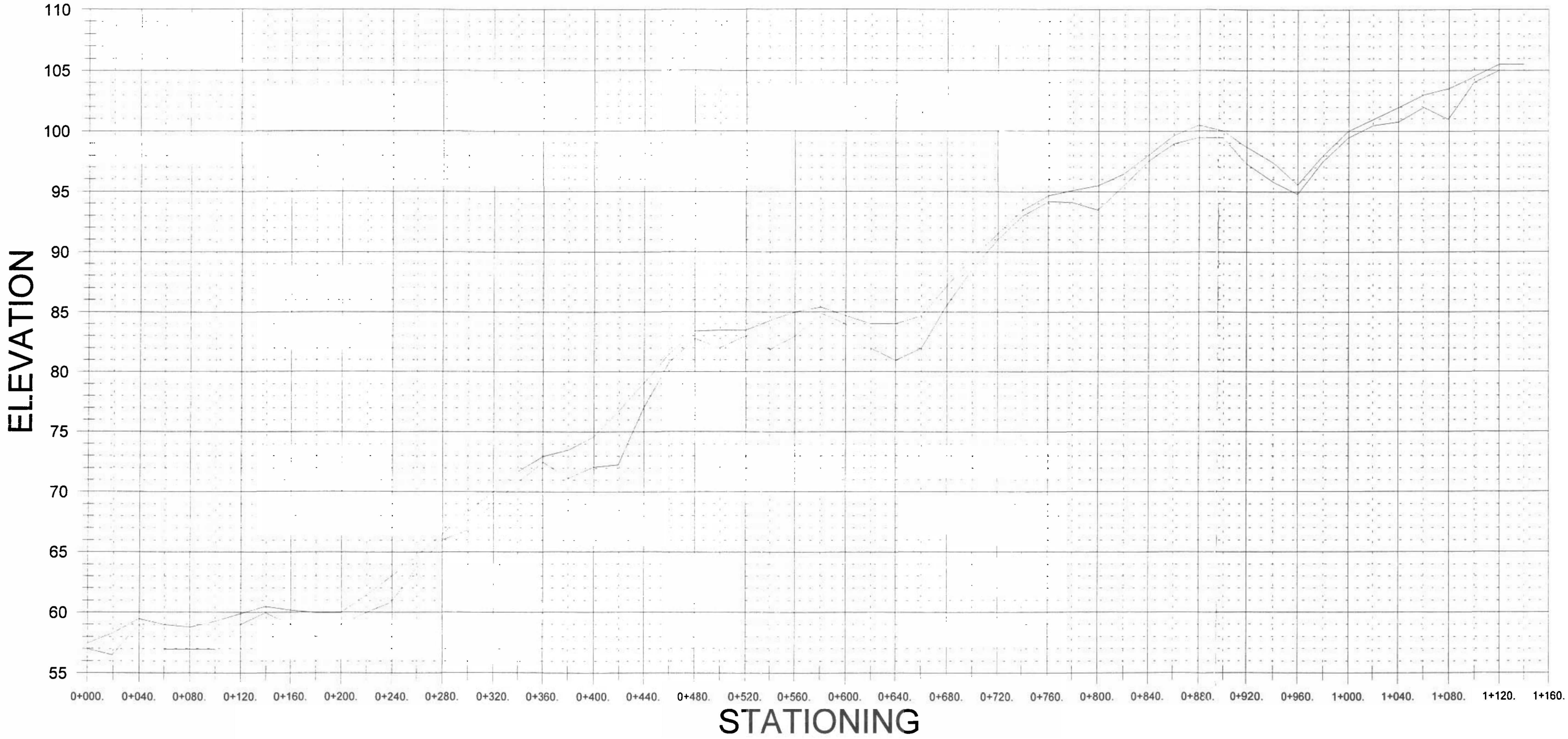
KIMMURUT GRANULAR VOLUME CALCULATIONS
FOR ROAD TO SITE 7

12% MAX. GRADED SMOOTH

STN (m)	NOTES	OG.EL (m)	OG.GR (%)	CUT/FILL (m)	DES.EL (m)	DES.GR (%)	DEL.GR (%)	DEL.H (m)	L (m)	A (m^2)	AVG. A (m^2)	V (m^3)	Cum. V (m^3)
0+760.		94.2	6.0%	0.5	94.7	6.0%	4.0%	0.5	20.0	3.75	3.8	75.0	13104.0
0+780.		94.1	-0.5%	1.0	95.1	2.0%	0.0%	1.0	20.0	9	6.4	127.5	13231.5
0+800.		93.5	-3.0%	2.0	95.5	2.0%	3.0%	2.0	20.0	24	16.5	330.0	13561.5
0+820.		95.5	10.0%	1.0	96.5	5.0%	3.0%	1.0	20.0	9	16.5	330.0	13891.5
0+840.		97.6	10.5%	0.5	98.1	8.0%	0.0%	0.5	20.0	3.75	6.4	127.5	14019.0
0+860.		99.0	7.0%	0.7	99.7	8.0%	4.0%	0.7	20.0	5.67	4.7	94.2	14113.2
0+880.		99.5	2.5%	1.0	100.5	4.0%	6.5%	1.0	20.0	9	7.3	146.7	14259.9
0+900.		99.5	0.0%	0.5	100.0	-2.5%	4.0%	0.5	20.0	3.75	6.4	127.5	14387.4
0+920.		97.3	-11.0%	1.4	98.7	-6.5%	0.0%	1.4	20.0	14.28	9.0	180.3	14567.7
0+940.		95.8	-7.5%	1.6	97.4	-6.5%	2.5%	1.6	20.0	17.28	15.8	315.6	14883.3
0+960.	CHANGE ROUTE	94.8	-5.0%	0.8	95.6	-9.0%	21.0%	0.8	20.0	6.72	12.0	240.0	15123.3
0+980.	1+020.	97.5	13.5%	0.5	98.0	12.0%	2.0%	0.5	20.0	3.75	5.2	104.7	15228.0
1+000.	1+040.	99.5	10.0%	0.5	100.0	10.0%	5.0%	0.5	20.0	3.75	3.8	75.0	15303.0
1+020.	1+060.	100.5	5.0%	0.5	101.0	5.0%	0.0%	0.5	20.0	3.75	3.8	75.0	15378.0
1+040.	1+080.	100.8	1.5%	1.2	102.0	5.0%	0.0%	1.2	20.0	11.52	7.6	152.7	15530.7
1+060.	1+100.	102.0	6.0%	1.0	103.0	5.0%	2.5%	1.0	20.0	9	10.3	205.2	15735.9
1+080.	1+120.	101.0	-5.0%	2.5	103.5	2.5%	2.5%	2.5	20.0	33.75	21.4	427.5	16163.4
1+100.	1+140.	104.0	15.0%	0.5	104.5	5.0%	0.0%	0.5	20.0	3.75	18.8	375.0	16538.4
1+120.	1+160.	105.0	5.0%	0.5	105.5	5.0%	5.0%	0.5	20.0	3.75	3.8	75.0	16613.4
1+140.	1+180.	105.0	0.0%	0.5	105.5	0.0%		0.5	20.0	3.75	3.8	75.0	16688.4

ACCESS ROAD

12% MAX. GRADED SMOOTH



KIMMURUT GRANULAR VOLUME CALCULATIONS
FOR ROAD TO SITE 7

10% MAX. GRADED SMOOTH

STN (m)	NOTES	OG.EL (m)	OG.GR (%)	CUT/FILL (m)	DES.EL (m)	DES.GR (%)	DEL.GR (%)	DEL.H (m)	L (m)	A (m^2)	AVG. A (m^2)	V (m^3)	Cum. V (m^3)
0+000.		57.0		0.5	57.5			0.5		3.75			
0+020.		56.5	-2.5%	1.8	58.3	4.0%	2.0%	1.8	20.0	20.52	12.1	242.7	242.7
0+040.		59.0	12.5%	0.5	59.5	6.0%	8.5%	0.5	20.0	3.75	12.1	242.7	485.4
0+060.		57.0	-10.0%	2.0	59.0	-2.5%	1.5%	2.0	20.0	24	13.9	277.5	762.9
0+080.		57.0	0.0%	1.8	58.8	-1.0%	3.5%	1.8	20.0	20.52	22.3	445.2	1208.1
0+100.		57.0	0.0%	2.3	59.3	2.5%	0.5%	2.3	20.0	29.67	25.1	501.9	1710.0
0+120.		59.0	10.0%	0.9	59.9	3.0%	0.0%	0.9	20.0	7.83	18.7	375.0	2085.0
0+140.		60.0	5.0%	0.5	60.5	3.0%	4.5%	0.5	20.0	3.75	5.8	115.8	2200.8
0+160.		59.0	-5.0%	1.2	60.2	-1.5%	0.5%	1.2	20.0	11.52	7.6	152.7	2353.5
0+180.		58.0	-5.0%	2.0	60.0	-1.0%	1.0%	2.0	20.0	24	17.8	355.2	2708.7
0+200.		59.0	5.0%	1.0	60.0	0.0%	7.0%	1.0	20.0	9	16.5	330.0	3038.7
0+220.		60.0	5.0%	1.4	61.4	7.0%	1.0%	1.4	20.0	14.28	11.6	232.8	3271.5
0+240.		60.9	4.5%	2.1	63.0	8.0%	0.5%	2.1	20.0	25.83	20.1	401.1	3672.6
0+260.		63.7	14.0%	1.0	64.7	8.5%	0.5%	1.0	20.0	9	17.4	348.3	4020.9
0+280.		66.0	11.5%	0.5	66.5	9.0%	0.0%	0.5	20.0	3.75	6.4	127.5	4148.4
0+300.		66.8	4.0%	1.5	68.3	9.0%	0.5%	1.5	20.0	15.75	9.8	195.0	4343.4
0+320.		69.0	11.0%	1.0	70.0	8.5%	0.0%	1.0	20.0	9	12.4	247.5	4590.9
0+340.		70.8	9.0%	0.9	71.7	8.5%	2.0%	0.9	20.0	7.83	8.4	168.3	4759.2
0+360.		72.5	8.5%	0.5	73.0	6.5%	4.0%	0.5	20.0	3.75	5.8	115.8	4875.0
0+380.		71.2	-6.5%	2.3	73.5	2.5%	6.5%	2.3	20.0	29.67	16.7	334.2	5209.2
0+400.		72.1	4.5%	3.2	75.3	9.0%	1.0%	3.2	20.0	49.92	39.8	795.9	6005.1
0+420.		72.3	1.0%	5.0	77.3	10.0%	0.0%	5.0	20.0	105	77.5	1549.2	7554.3
0+440.		77.1	24.0%	2.2	79.3	10.0%	0.0%	2.2	20.0	27.72	66.4	1327.2	8881.5
0+460.		80.8	18.5%	0.5	81.3	10.0%	0.0%	0.5	20.0	3.75	15.7	314.7	9196.2
0+480.		82.8	10.0%	0.5	83.3	10.0%	9.0%	0.5	20.0	3.75	3.8	75.0	9271.2
0+500.		82.0	-4.0%	1.5	83.5	1.0%	1.0%	1.5	20.0	15.75	9.8	195.0	9466.2
0+520.		83.0	5.0%	0.5	83.5	0.0%	4.0%	0.5	20.0	3.75	9.8	195.0	9661.2
0+540.	GOES OVER TOP OF LAKE	81.9	-5.5%	2.4	84.3	4.0%	0.5%	2.4	20.0	31.68	17.7	354.3	10015.5
0+560.		83.0	5.5%	2.0	85.0	3.5%	1.5%	2.0	20.0	24	27.8	556.8	10572.3
0+580.		84.9	9.5%	0.5	85.4	2.0%	5.5%	0.5	20.0	3.75	13.9	277.5	10849.8
0+600.		84.0	-4.5%	0.7	84.7	-3.5%	0.0%	0.7	20.0	5.67	4.7	94.2	10944.0
0+620.	OVER TOP OF LAKE	82.0	-10.0%	2.0	84.0	-3.5%	3.5%	2.0	20.0	24	14.8	296.7	11240.7
0+640.	ASSUMED 1m DEEP	81.0	-5.0%	3.0	84.0	0.0%	7.5%	3.0	20.0	45	34.5	690.0	11930.7
0+660.	OVER TOP OF LAKE	82.0	5.0%	3.5	85.5	7.5%	2.5%	3.5	20.0	57.75	51.4	1027.5	12958.2
0+680.		85.5	17.5%	2.0	87.5	10.0%	0.0%	2.0	20.0	24	40.9	817.5	13775.7
0+700.		88.5	15.0%	1.0	89.5	10.0%	0.0%	1.0	20.0	9	16.5	330.0	14105.7
0+720.		91.0	12.5%	0.5	91.5	10.0%	0.0%	0.5	20.0	3.75	6.4	127.5	14233.2
0+740.		93.0	10.0%	0.5	93.5	10.0%	4.0%	0.5	20.0	3.75	3.8	75.0	14308.2

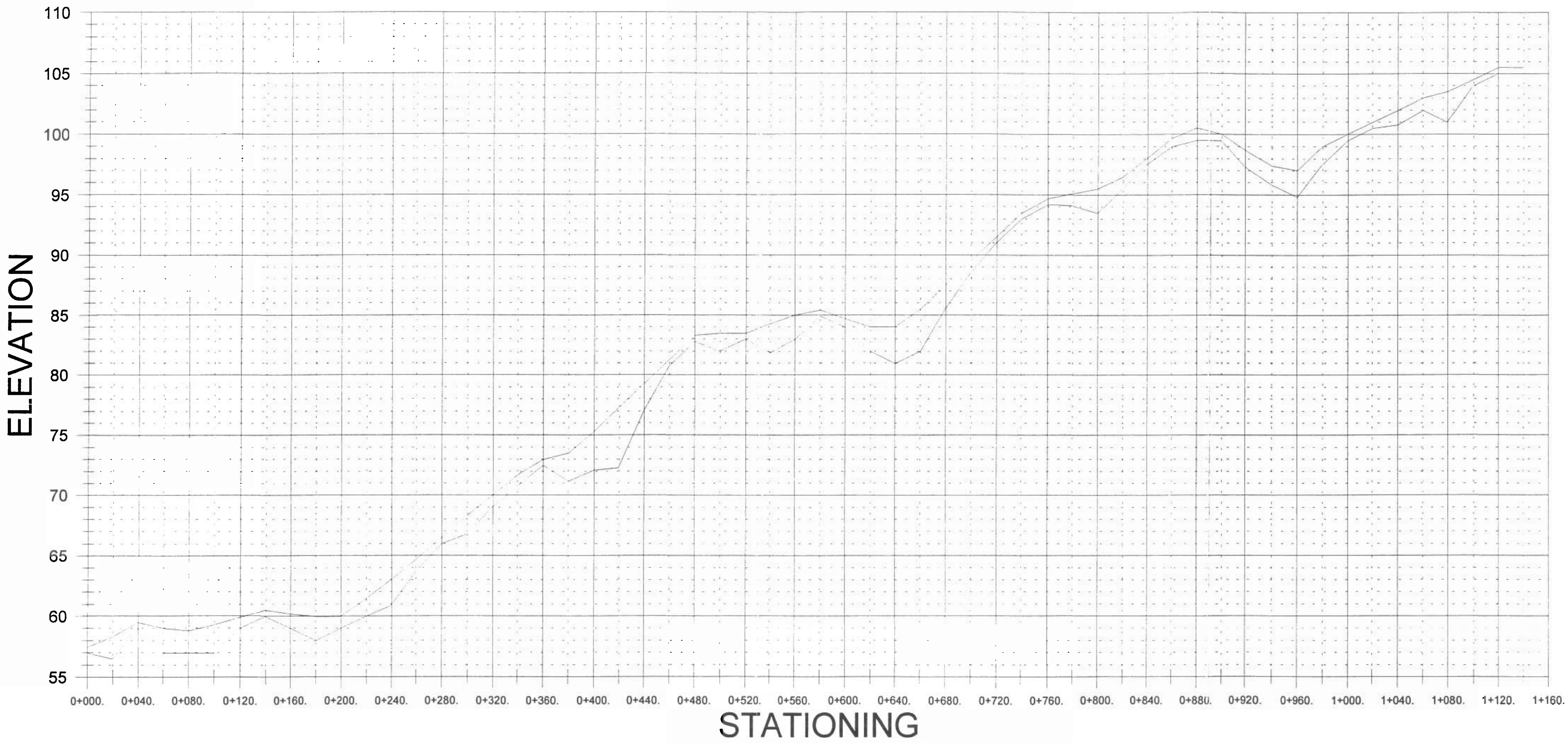
KIMMURUT GRANULAR VOLUME CALCULATIONS
FOR ROAD TO SITE 7

10% MAX. GRADED SMOOTH

STN (m)	NOTES	OG.EL (m)	OG.GR (%)	CUT/FILL (m)	DES.EL (m)	DES.GR (%)	DEL.GR (%)	DEL.H (m)	L (m)	A (m^2)	AVG. A (m^2)	V (m^3)	Cum. V (m^3)
0+760.		94.2	6.0%	0.5	94.7	6.0%	4.0%	0.5	20.0	3.75	3.8	75.0	14383.2
0+780.		94.1	-0.5%	1.0	95.1	2.0%	0.0%	1.0	20.0	9	6.4	127.5	14510.7
0+800.		93.5	-3.0%	2.0	95.5	2.0%	3.0%	2.0	20.0	24	16.5	330.0	14840.7
0+820.		95.5	10.0%	1.0	96.5	5.0%	3.0%	1.0	20.0	9	16.5	330.0	15170.7
0+840.		97.6	10.5%	0.5	98.1	8.0%	0.0%	0.5	20.0	3.75	6.4	127.5	15298.2
0+860.		99.0	7.0%	0.7	99.7	8.0%	4.0%	0.7	20.0	5.67	4.7	94.2	15392.4
0+880.		99.5	2.5%	1.0	100.5	4.0%	6.5%	1.0	20.0	9	7.3	146.7	15539.1
0+900.		99.5	0.0%	0.5	100.0	-2.5%	4.0%	0.5	20.0	3.75	6.4	127.5	15666.6
0+920.		97.3	-11.0%	1.4	98.7	-6.5%	0.0%	1.4	20.0	14.28	9.0	180.3	15846.9
0+940.		95.8	-7.5%	1.6	97.4	-6.5%	4.5%	1.6	20.0	17.28	15.8	315.6	16162.5
0+960.	CHANGE ROUTE	94.8	-5.0%	2.2	97.0	-2.0%	12.0%	2.2	20.0	27.72	22.5	450.0	16612.5
0+980.	1+020.	97.5	13.5%	1.5	99.0	10.0%	5.0%	1.5	20.0	15.75	21.7	434.7	17047.2
1+000.	1+040.	99.5	10.0%	0.5	100.0	5.0%	0.0%	0.5	20.0	3.75	9.8	195.0	17242.2
1+020.	1+060.	100.5	5.0%	0.5	101.0	5.0%	0.0%	0.5	20.0	3.75	3.8	75.0	17317.2
1+040.	1+080.	100.8	1.5%	1.2	102.0	5.0%	0.0%	1.2	20.0	11.52	7.6	152.7	17469.9
1+060.	1+100.	102.0	6.0%	1.0	103.0	5.0%	2.5%	1.0	20.0	9	10.3	205.2	17675.1
1+080.	1+120.	101.0	-5.0%	2.5	103.5	2.5%	2.5%	2.5	20.0	33.75	21.4	427.5	18102.6
1+100.	1+140.	104.0	15.0%	0.5	104.5	5.0%	0.0%	0.5	20.0	3.75	18.8	375.0	18477.6
1+120.	1+160.	105.0	5.0%	0.5	105.5	5.0%	5.0%	0.5	20.0	3.75	3.8	75.0	18552.6
1+140.	1+180.	105.0	0.0%	0.5	105.5	0.0%		0.5	20.0	3.75	3.8	75.0	18627.6

ACCESS ROAD

10% MAX. GRADED SMOOTH



APPENDIX C

NWT Bureau of Statistics Population Projections

Population Estimates & Projections, by Community
Northwest Territories, 1995-2006

		Projection										
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Northwest Territories	65,826	67,312	68,798	70,296	71,802	73,309	74,818	76,323	77,845	79,389	80,942	82,500
Baffin Region	13,195	13,507	13,835	14,150	14,474	14,813	15,149	15,484	15,818	16,152	16,498	16,833
Arctic Bay	625	639	657	671	688	701	717	730	752	764	784	801
Broughton Island	534	549	560	571	584	602	616	630	643	657	668	685
Cape Dorset	1,102	1,125	1,150	1,173	1,197	1,223	1,252	1,280	1,308	1,338	1,366	1,398
Clyde River	656	671	686	701	719	738	754	774	797	817	838	861
Grise Fiord	153	156	161	162	167	170	175	182	189	191	195	196
Hall Beach	623	638	652	665	680	698	718	734	753	773	793	812
Igloolik	1,081	1,112	1,138	1,168	1,199	1,229	1,260	1,295	1,326	1,362	1,402	1,435
Iqaluit	4,156	4,256	4,360	4,460	4,556	4,654	4,752	4,842	4,930	5,022	5,113	5,203
→ Kimmirut	418	427	440	452	462	475	486	499	511	525	539	548
Nanisivik	331	335	341	347	350	355	357	363	368	370	374	380
Pangnirtung	1,317	1,350	1,386	1,422	1,456	1,495	1,531	1,570	1,604	1,642	1,680	1,714
Pond Inlet	1,119	1,146	1,177	1,205	1,237	1,267	1,300	1,333	1,363	1,397	1,432	1,467
Resolute	195	197	205	209	214	221	224	227	228	233	237	238
Sanikiluaq	617	633	653	671	688	707	722	740	756	771	785	802
Keewatin Region	6,845	7,027	7,198	7,382	7,559	7,734	7,908	8,089	8,267	8,451	8,637	8,824
Arviat	1,543	1,581	1,618	1,660	1,700	1,739	1,787	1,832	1,879	1,929	1,975	2,017
Baker Lake	1,378	1,408	1,440	1,469	1,502	1,529	1,557	1,590	1,619	1,648	1,678	1,704
Chesterfield Inlet	381	393	405	416	425	434	441	454	463	473	485	498
Coral Harbour	676	696	713	735	754	776	796	814	831	846	865	887
Rankin Inlet	2,013	2,065	2,118	2,179	2,236	2,288	2,340	2,392	2,445	2,498	2,553	2,613
Repulse Bay	578	597	614	627	643	659	674	690	706	727	746	762
Whale Cove	274	281	286	292	296	305	309	313	321	328	332	339
Kitikmeot Region	5,132	5,266	5,393	5,524	5,660	5,787	5,922	6,052	6,187	6,325	6,457	6,604
Cambridge Bay	1,313	1,349	1,380	1,411	1,442	1,467	1,501	1,533	1,570	1,606	1,640	1,675
Gjoa Haven	916	940	967	998	1,027	1,055	1,083	1,109	1,131	1,154	1,179	1,204
Holman	431	442	450	464	474	487	498	509	521	531	544	553
Kugluktuk	1,239	1,271	1,299	1,327	1,360	1,387	1,419	1,447	1,483	1,517	1,548	1,588
Pelly Bay	473	484	498	509	522	531	541	551	562	574	585	597
Taloyoak	675	692	710	727	746	765	785	802	819	837	855	876

Population Estimates & Projections, by Community
Northwest Territories, 1995-2006

	1995	Projection 1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Inuvik Region	9,476	9,604	9,733	9,866	9,985	10,101	10,210	10,320	10,429	10,547	10,662	10,776
Aklavik	890	904	917	925	940	949	963	978	989	997	1,007	1,016
Deline	613	615	617	620	625	622	627	631	632	631	634	647
Fort Good Hope	646	652	662	667	671	679	684	689	692	700	706	707
Fort McPherson	821	829	841	848	855	865	866	874	881	886	893	897
Inuvik	3,667	3,741	3,806	3,874	3,939	3,998	4,058	4,114	4,169	4,223	4,273	4,317
Norman Wells	673	674	671	676	676	680	677	680	684	689	692	695
Paulatuk	288	291	294	296	300	306	310	318	323	331	341	351
Sachs Harbour	143	144	146	150	152	155	155	158	159	162	162	163
Tsiigehtchic	147	147	151	155	156	162	162	158	158	160	164	165
Tuktoyaktuk	1,049	1,066	1,088	1,112	1,133	1,148	1,168	1,187	1,205	1,232	1,252	1,278
Tulita	407	407	408	410	410	413	419	414	415	413	419	422
Fort Smith Region	31,178	31,908	32,639	33,374	34,124	34,875	35,629	36,378	37,144	37,914	38,689	39,464
Detah	164	166	168	169	169	169	170	172	171	174	172	174
Fort Liard	542	550	559	565	572	580	587	592	592	597	604	609
Fort Providence	700	708	720	725	740	746	754	762	772	775	788	793
Fort Resolution	562	570	579	585	585	590	592	593	602	608	612	615
Fort Simpson	1,266	1,283	1,296	1,305	1,317	1,328	1,340	1,348	1,359	1,375	1,383	1,397
Fort Smith	2,748	2,785	2,819	2,855	2,890	2,927	2,966	3,008	3,043	3,076	3,118	3,161
Hay River	3,488	3,526	3,565	3,603	3,648	3,692	3,734	3,775	3,829	3,876	3,924	3,976
Hay River Reserve	242	246	249	251	256	256	254	256	257	260	263	264
Nahanni Butte	101	104	103	107	108	110	111	110	109	109	110	110
Rae Lakes	276	282	289	292	297	301	306	311	315	321	323	327
Rae-Edzo	1,673	1,696	1,716	1,741	1,762	1,788	1,813	1,836	1,862	1,887	1,912	1,939
Snare Lake	134	130	129	129	131	130	130	132	135	138	141	143
Snowdrift	305	305	307	308	314	316	319	322	326	331	329	335
Wha Ti	428	433	438	445	453	459	466	474	481	487	499	506
Wrigley	190	192	193	196	196	201	205	207	205	207	211	212
Yellowknife	17,596	18,164	18,736	19,320	19,902	20,495	21,083	21,674	22,275	22,876	23,486	24,095

Notes:

a) The 1995 populations estimates are based on the July 1, 1995 territorial population estimates produced by Statistics Canada.

b) The population projections are based on historical growth patterns. Population impacts due to the creation of Nunavut have not been included.

c) Populations for communities with less than 100 persons and for unorganizec areas are not provided although these figures are included in the territorial and regional totals.

APPENDIX D

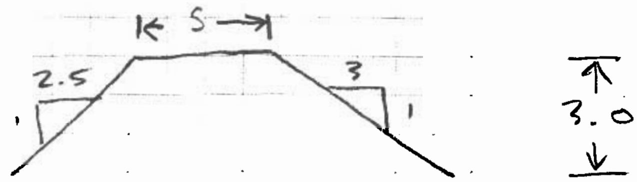
Lagoon, Wetlands, And Landfill Sizing Calculations

1. LAGOON:

YR 20 Sewage Volume = 28 300 m^3

OPERATING DEPTH 2.0 m
SLUDGE ACCUM. DEPTH = 0.25 m
FREE BOARD = 0.75 m

ASSUMED SECTION



$A_1 = V / d = 28\,300\,m^3 / 2\,m$

$A_1 = 14150\ m^2$

$A_T = \left(\sqrt{A_1} + \text{Additional length from Berms}\right)^2$

$A_T = \left[\sqrt{14150} + 2(3(3) + 5 + 3(2.5)\right]^2$

$\doteq 26000\ m^2$ or 160 m × 160 m

2. WETLANDS:

HYDRAULIC LOADING: 18 – 430 m^3 / ha d
ORGANIC LOADING: 0.6 – 5.2 kg / ha d

FROST FREE DAYS 80 d ASSUMED
HYDRAULIC LOADING 28 300 m^3 MACA PROJECTION
ORGANIC LOADING 80 g / person / day STEEL / McGhee 1979

HYDRAULIC LOADING AREA. 28,300 m^3 / 80 / 18 m^3 / ha d
$\doteq$ 20 ha
28,300 / 80 / 430 = 1 ha

By KAG	Date	Project Name	KIMMURUT SITE SELECTION
Checked	Date		AREA ESTIMATES
Page 1	of	Project No.	98 5730

DILLON

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ORGANIC LOADING AREA :

738 PEOPLE × 0.08 kg/d × 365 d / (80 ft/d × 0.6 kg/ha)

= 449 ha

738 × 0.08 × 365 / (80 × 8) = 34 ha

APX 40 ~ 45 ha required.

FROM PAST EXPERIENCE 40 ha IS LIKELY ADEQUATE. (630 × 630 m)

3. LANDFILL SIZING :

FINAL STORAGE DEPTH OF 3.5 m

SEWAGE GENERATION 48 600 m^3

$A = V/d = 48600 / 3.5$ m

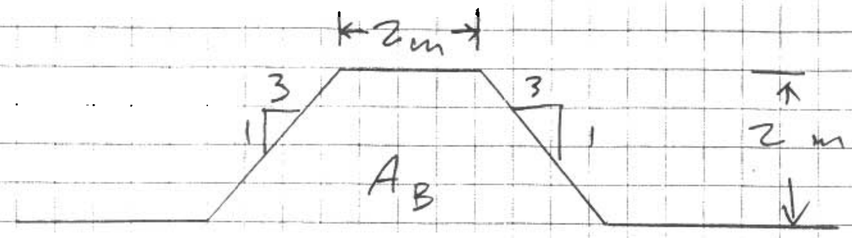
$A = 13900\ m^2$ or 120 m × 120 m

By		Date		Project Name
Checked		Date		
Page	2	of		Project No.

DILLON

APPENDIX E

Quantity Estimates



TYPICAL WETLAND BERM SECTION

$$A_B = (2 \times 2) + \left[\frac{1}{2}(2(3))(2)\right]2 = 16\ m^2$$

FOR APX. VOLUME OF GRANULAR, MULTIPLY BERM LENGTHS BY A_B.

FROM FIG 5.4

$L_B = 40 + 30 + 20 + 30 + 30 + 30$

$= 180\ m$

$V_{GRAN} \doteq 180\ m \times 16\ m^2 = 2880 \Rightarrow \underline{\underline{3000\ m^3}}$

By	KAG	Date	JAN 21/99	Project Name	KIMMIRUT WB WETLAND BERMS
Checked		Date			
Page	1	of	1	Project No.	98-5730

DILLON

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APPENDIX F

Site 7 And Site 8 Trucking Costs

ECONOMIC ANALYSIS - TRUCKED SYSTEMS - KIMMIRUT
SITE 7
ASSUMPTIONS:

Population growth	PG	0.0233						
Efficiency of labour	EL	1.5	Distance between buildings (m)	DB	30	Miscellaneous operating cost factor	MISC	0.10
Number of buildings	NB	Pop/4	Speed between buildings (km/h)	SB	10	Discount rate	DR	0.08
Buiding container size (l)	C	2250	Rate of filling at buildings (l/min)	RB	450	Hourly wage of driver ($/h)	WD	13.37
		1800	Turn around time at buildings (min)	TTB	4.68	Hourly wage of helpers ($/h)	WH	12.73
Container utilization factor	CSF	0.85	Number of trips to each building	NTB	3	Number of helpers	NH	0
Vehicle size (l)	VS	4500	Vehicle capital cost ($)	VCC	130,000	Labour benefit factor	LBF	1.2
Vehicle use factor	VUF	0.95	Vehicle service factor	VSF	0.15	Parking garage base cost ($/sq.m)	PGBSF	2,500
Travel distance to source (km)	D	2.2	Brake housepower (kw)	BHP	55	Vehicle space requirement (sq.m)	VSR	75
Speed of vehicle to source (km/h)	S	35	Fuel consumption rate (l/km/h)	FR	0.24	Parking garage economic life (yaer)	PGEL	20
Rate of filling at source (l/min)	R	450	Fuel cost ($/l)	FUEL	0.71	Parking garage annual O&M factor	PGAOMF	0.06
Turn around time at source (min)	TT	12	Vehicle economic life (year)	VEL	4	Number of persons per building	NOPB	4

YEAR	POP	WATER CONSUMP. (lpcd)	NUMBER TRUCKS INV	VEHICLE CAPITAL	VEHICLE O&M	TRUCK LABOUR COST	TRUCK GARAGE CAPITAL	TRUCK GARAGE O&M	TRUCK CAPITAL	TRUCK O&M	RES. O&M	TRUCKFILL O&M	ANNUAL CAPITAL	ANNUAL O&M	TOTAL CAPITAL & O&M	PRESENT VALUE CAPITAL	PRESENT VALUE O&M	TOTAL
1999	462	100	1	39,250	123,059	111,720	19,097	11,250	58,347	246,029	5,000	12,000	************	263,029	1,512,876	************	243,546	1,400,811
2000	473	100	1	39,250	125,712	114,582	19,097	11,250	58,347	251,544	5,000	12,060	58,347	268,604	326,951	50,023	230,285	280,308
2001	484	100	1	39,250	128,438	117,523	19,097	11,250	58,347	257,212	5,000	12,120	58,347	274,332	332,679	46,318	217,773	264,091
2002	495	100	1	39,250	131,240	120,546	19,097	11,250	58,347	263,035	5,000	12,181	58,347	280,216	338,563	42,887	205,967	248,854
2003	507	101	1	39,250	134,119	123,652	19,097	11,250	58,347	269,021	5,000	12,242	58,347	286,263	344,610	39,710	194,825	234,535
2004	518	101	1	39,250	137,078	126,844	19,097	11,250	58,347	275,173	5,000	12,303	58,347	292,476	350,823	36,768	184,309	221,078
2005	530	101	1	39,250	140,120	130,126	19,097	11,250	58,347	281,496	5,000	12,365	58,347	298,861	357,208	34,045	174,382	208,427
2006	543	101	1	39,250	143,247	133,499	19,097	11,250	58,347	287,996	5,000	12,426	58,347	305,423	363,770	31,523	165,010	196,533
2007	555	102	1	39,250	146,462	136,967	19,097	11,250	58,347	294,679	5,000	12,488	58,347	312,168	370,515	29,188	156,162	185,350
2008	568	102	1	39,250	149,767	140,533	19,097	11,250	58,347	301,550	5,000	12,551	58,347	319,101	377,448	27,026	147,806	174,832
2009	582	102	1	39,250	153,166	144,200	19,097	11,250	58,347	308,616	5,000	12,614	58,347	326,229	384,576	25,024	139,914	164,938
2010	595	102	1	39,250	156,661	147,970	19,097	11,250	58,347	315,881	5,000	12,677	58,347	333,558	391,905	23,170	132,460	155,631
2011	609	103	1	39,250	160,255	151,848	19,097	11,250	58,347	323,353	5,000	12,740	58,347	341,093	399,440	21,454	125,419	146,873
2012	623	103	1	39,250	163,952	155,836	19,097	11,250	58,347	331,038	5,000	12,804	58,347	348,842	407,189	19,865	118,767	138,632
2013	638	103	1	39,250	167,755	159,938	19,097	11,250	58,347	338,943	5,000	12,868	58,347	356,811	415,158	18,393	112,482	130,875
2014	653	104	1	39,250	171,667	164,159	19,097	11,250	58,347	347,076	5,000	12,932	58,347	365,008	423,355	17,031	106,542	123,573
2015	668	104	1	39,250	175,692	168,500	19,097	11,250	58,347	355,442	5,000	12,997	58,347	373,439	431,786	15,769	100,929	116,698
2016	683	104	1	39,250	179,833	172,968	19,097	11,250	58,347	364,050	5,000	13,062	58,347	382,112	440,459	14,601	95,623	110,224
2017	699	105	1	39,250	184,094	177,565	19,097	11,250	58,347	372,909	5,000	13,127	58,347	391,036	449,383	13,520	90,608	104,127
2018	716	105	1	39,250	188,479	182,296	19,097	11,250	58,347	382,025	5,000	13,193	58,347	400,217	458,564	12,518	85,866	98,384
2019	732	105	1	39,250	192,992	187,165	19,097	11,250	58,347	391,407	5,000	13,259	58,347	409,666	468,013	11,591	81,382	92,973
																TOTAL PRESENT VALUE		4,704,777
																INITIAL CAPITAL COST		1,191,500

ECONOMIC ANALYSIS - TRUCKED SYSTEMS - KIMMIRUT
SITE 8
ASSUMPTIONS:

Population growth	PG	0.0233								
Efficiency of labour	EL	1.5	Distance between buildings (m)	DB	30	Miscellaneous operating cost factor	MISC	0.10		
Number of buildings	NB	Pop/4	Speed between buildings (km/h)	SB	10	Discount rate	DR	0.08		
Buiding container size (l)	C	2250	Rate of filling at buildings (l/min)	RB	450	Hourly wage of driver ($/h)	WD	13.37		
		1800	Turn around time at buildings (min)	TTB	4.68	Hourly wage of helpers ($/h)	WH	12.73		
Container utilization factor	CSF	0.85	Number of trips to each building	NTB	3	Number of helpers	NH	0		
Vehicle size (l)	VS	4500	Vehicle capital cost ($)	VCC	130,000	Labour benefit factor	LBF	1.2		
Vehicle use factor	VUF	0.95	Vehicle service factor	VSF	0.15	Parking garage base cost ($/sq.m)	PGBSF	2,500		
Travel distance to source (km)	D	3	Brake housepower (kw)	BHP	55	Vehicle space requirement (sq.m)	VSR	75		
Speed of vehicle to source (km/h)	S	35	Fuel consumption rate (l/km/h)	FR	0.24	Parking garage economic life (yaer)	PGEL	20		
Rate of filling at source (l/min)	R	450	Fuel cost ($/l)	FUEL	0.71	Parking garage annual O&M factor	PGAOMF	0.06		
Turn around time at source (min)	TT	15	Vehicle economic life (year)	VEL	4	Number of persons per building	NOPB	4		

YEAR	POP	WATER CONSUMP. (lpcd)	NUMBER TRUCKS INV	VEHICLE CAPITAL	VEHICLE O&M	TRUCK LABOUR COST	TRUCK GARAGE CAPITAL	TRUCK GARAGE O&M	TRUCK CAPITAL	TRUCK O&M	RES. O&M	TRUCKFILL O&M	ANNUAL CAPITAL	ANNUAL O&M	TOTAL CAPITAL & O&M	PRESENT VALUE CAPITAL	PRESENT VALUE O&M	TOTAL
1999	462	100	1	39,250	131,456	120,779	19,097	11,250	58,347	263,484	5,000	12,000	************	280,484	1,530,331	************	259,708	1,416,973
2000	473	100	1	39,250	134,324	123,873	19,097	11,250	58,347	269,447	5,000	12,060	58,347	286,507	344,854	50,023	245,633	295,656
2001	484	100	1	39,250	137,271	127,052	19,097	11,250	58,347	275,573	5,000	12,120	58,347	292,694	351,041	46,318	232,350	278,667
2002	495	100	1	39,250	140,300	130,320	19,097	11,250	58,347	281,869	5,000	12,181	58,347	299,050	357,397	42,887	219,811	262,698
2003	507	101	1	39,250	143,412	133,677	19,097	11,250	58,347	288,340	5,000	12,242	58,347	305,582	363,929	39,710	207,974	247,684
2004	518	101	1	39,250	146,612	137,129	19,097	11,250	58,347	294,991	5,000	12,303	58,347	312,294	370,641	36,768	196,798	233,566
2005	530	101	1	39,250	149,900	140,677	19,097	11,250	58,347	301,827	5,000	12,365	58,347	319,191	377,538	34,045	186,245	220,290
2006	543	101	1	39,250	153,281	144,323	19,097	11,250	58,347	308,854	5,000	12,426	58,347	326,281	384,628	31,523	176,279	207,802
2007	555	102	1	39,250	156,756	148,073	19,097	11,250	58,347	316,079	5,000	12,488	58,347	333,567	391,914	29,188	166,867	196,055
2008	568	102	1	39,250	160,329	151,928	19,097	11,250	58,347	323,507	5,000	12,551	58,347	341,058	399,405	27,026	157,976	185,002
2009	582	102	1	39,250	164,004	155,891	19,097	11,250	58,347	331,145	5,000	12,614	58,347	348,759	407,106	25,024	149,577	174,601
2010	595	102	1	39,250	167,782	159,968	19,097	11,250	58,347	339,000	5,000	12,677	58,347	356,677	415,023	23,170	141,641	164,812
2011	609	103	1	39,250	171,668	164,160	19,097	11,250	58,347	347,078	5,000	12,740	58,347	364,818	423,165	21,454	134,143	155,597
2012	623	103	1	39,250	175,665	168,471	19,097	11,250	58,347	355,386	5,000	12,804	58,347	373,190	431,537	19,865	127,057	146,921
2013	638	103	1	39,250	179,776	172,906	19,097	11,250	58,347	363,932	5,000	12,868	58,347	381,800	440,147	18,393	120,359	138,753
2014	653	104	1	39,250	184,005	177,469	19,097	11,250	58,347	372,724	5,000	12,932	58,347	390,656	449,003	17,031	114,029	131,060
2015	668	104	1	39,250	188,356	182,163	19,097	11,250	58,347	381,768	5,000	12,997	58,347	399,765	458,112	15,769	108,044	123,813
2016	683	104	1	39,250	192,833	186,992	19,097	11,250	58,347	391,075	5,000	13,062	58,347	409,137	467,484	14,601	102,386	116,987
2017	699	105	1	39,250	197,439	191,962	19,097	11,250	58,347	400,651	5,000	13,127	58,347	418,778	477,125	13,520	97,036	110,556
2018	716	105	1	39,250	202,180	197,076	19,097	11,250	58,347	410,506	5,000	13,193	58,347	428,699	487,046	12,518	91,977	104,495
2019	732	105	1	39,250	207,059	202,340	19,097	11,250	58,347	420,649	5,000	13,259	58,347	438,908	497,255	11,591	87,192	98,783
																TOTAL PRESENT VALUE		4,911,988
																INITIAL CAPITAL COST		1,191,500