Cape Dorset Sewage Treatment System

Preliminary Design Report
June 23, 2005

Cape Dorset Sewage Treatment System
Preliminary Design Report

Community and Government Services
Government of Nunavut

05-4319-1200

Gary Strong - Project Manager

Submitted by
Dillon Consulting Limited

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DILLON CONSULTING

June 16, 2005

Phyllis Beaulieu
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0B 1J0
Tel: (867) 360-6338
Fax: (867) 360-6369

RE: Cape Dorset Water License Amendment

Dear Ms. Beaulieu:

Please find attached the application form for an amendment to the Cape Dorset Water License. We understand that the supplemental questionnaire has already been submitted and it is not included here.

Should you require additional information, we would be pleased to discuss details with you. Please contact the undersigned at (867) 920-4555.

Thank you for your attention on this matter.

Yours sincerely,
DILLON CONSULTING LIMITED

Gary Strong, P.Eng.

Project Manager

Cc Todd Parsons – Project Manager, C&GS Government of Nunavut.
Art Stewart – SAO Hamlet f Cape Dorset

Dillon Consulting
Limited

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1 INTRODUCTION

1.1 General

Dillon Consulting Limited (Dillon) has been retained by the Department of Community and Government Services (C&GS), Government of Nunavut, Dillon Consulting Limited (Dillon) to design a new sewage treatment system for the Hamlet of Cape Dorset. This document outlines the preliminary design plans for a new sewage lagoon treatment system put forth by Dillon.

The Hamlet of Cape Dorset is located on Dorset Island, off the south shore of Baffin Island in Nunavut (**Drawing A**). Dorset Island, jutting southward into Hudson Strait, is part of a chain of islands connected to Baffin Island during low tide. By air, Cape Dorset is approximately 402 kilometers southwest of the city of Iqaluit.

The annual snowfall in Cape Dorset is approximately 118 cm and the annual rainfall is approximately 15 cm. The community experiences mild flooding during spring runoff. In January, temperatures range between a low of about -29^{0}C and a high of about -23^{0}C. In July the temperatures range between a low of 3^{0}C to a high of about 7^{0}C. Freeze up usually occurs during the month of November but may happen as early as September or October. In some years, early freeze up may thaw again before final freeze up. Spring thaw typically occurs during the month of July, but can vary as much as freeze up.

The community uses trucked services for both water delivery and sewage collection. The Hamlet is presently using a 3 cell sewage lagoon system, which will supply treatment for the short-term. Environment Canada has expressed concerns with the existing system. This system cannot be viably upgraded to provide for a long term sewage treatment system. The Hamlet is faced with the task of designing a sewage treatment system that will provide a long-term solution (20 years +) to meet the sewage treatment requirements of the community.

1.2 Background

Dillon was first retained by the Department of Community Government and Transportation (CG&T) in 2001 when the motion was made to produce a new sewage facility plan for the community of Cape Dorset. The motion was put forth due to a structural failure in the existing three-cell lagoon.

Over the course of four years, Dillon has been involved with this project, aiding CG&T and C&GS with planning studies, site selection studies, regulatory requirements and treatment alternatives. Several site options were identified for the new sewage lagoon, all of which were dismissed for various reasons:

Q Lake Lagoon Option– a small lake located to the north east of the community. The Mayor initially identified this site as a potential location for a lagoon. However, in the winter of 2001/2002, the community's water supply pipeline froze, and Q Lake was used as the emergency back-up water supply source. Subsequent to the pipeline freeze up the community stated that Q Lake should not be used as a sewage lagoon facility.

P-Lake Lagoon Option– a small lake located south of the community. The community identified this site as a potential location for a lagoon. The road to P-Lake would have a constant grade of 8 to 10% over a length of approximately 1 km.

Site R Lagoon Option– Site R is a flat area north east of the community. This site is currently used as the granular stockpile for CG&T. The site is also located at the end of the runway. The Airports Division has expressed concerns over this location and the potential for the increased bird strike hazard. The site may not meet regulatory approval because of the increased risk of bird strikes.

Existing Site Mechanical Plant Option - installation of a Mechanical Sewage Treatment Plant would be best at the existing lagoon site. The treated sewage effluent discharge is to the south of the tidal bridge. The proposed discharge location results in the effluent being directed away from the community. The effluent discharge location was an important issue to the community during the consultation period. This option carries with it the issue of higher operational costs and concern with hiring and training qualified operators in the community.

Drawing B shows the community location and the location of the alternative sites.

Based on the results of sewage treatment options and studies completed between 2001 and 2004, the Government of Nunavut has offered two possibilities, the use of "P Lake and wetlands" as a sewage lagoon and the use of a mechanical system for sewage treatment. At present, the Hamlet has identified a sewage lagoon and wetlands system at "P Lake" as their preferred sewage treatment option.

1.3 Scope of Report

The work program for the development of this report follows the terms of reference issued by C&GS and Dillon's proposal dated November 12, 2004. Briefly this includes the following;

- Develop the 5, 10 and 20 year sewage generation values
- Calculate the lagoon size based on the community requirements
- Looking beyond the 20 year horizon, identify the potential for expansion
- Develop the conceptual layout for P-Lake Lagoon which would include;
    - Site access road
    - Site lay-out for lagoon cells
    - Location of the lagoon outfall
    - Complete an assessment of the expected lagoon treatment

Parallel to the development of the lagoon design requirements; Dillon undertook a consultation program with the stakeholders for this project. A tabulated list of the various regulatory agencies consulted and their comments is appended in **Appendix B**.

1.4 Report Layout

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

- The design requirements as laid out in the terms of reference and the background documentation
- The design criteria, assumptions, and calculations
- The objectives of the design
- A description of the design elements, including appropriate sketches and illustrations
- Cost estimates for the construction
- Construction schedule and implementation strategies.

Drawings are located in **Appendix A**.

1.5 Design Criteria

The design criteria for this project will be completed in accordance with the parameters set out by the the project terms of reference and the GNWT, Municipal and Community Affairs "*Capital Standards and Criteria, September 1993*". These are as follows:

Table 1.1 Design Horizons

Facility	Design Horizon (Years)	Design Economic Life (Years)	Design Expected Life (Years)
Building	20	20	40
Pumps	10	20	20
Earth works	20	20	40

Where the:

- Design horizon is the period used to establish capacity requirements for a facility.
- Design economic life is the period used in the economic analysis to establish the present value (or equivalent capital cost) of a facility.
- Design expected life is the practical maximum expected life of a facility assuming no premature failure, destruction or obsolescence.

1.6 Design Standards

The following is a list of the design criteria to be used in the development of the water supply system. These are derived from the GNWT "*General Terms of Reference for Water and Sanitation*" (GTR), the "*National Building Code*" (NBC), "*Capital Standards Criteria, September 1993*," MACA and the "*Good Engineering Practice for Northern Water and Sewer Systems, First Edition, April 2004*". Mechanical and building systems design should comply with the "*Good Building Practice for Northern Facilities*" as related to utility buildings.

Table 1.2: Sewage Generation Rates

Water Consumption Rates		Reference
Domestic	90 Lcd per day	MACA
Commercial	0.00023 x population	MACA
Total Consumption per Capita	90 * (1.0 + 0.00023 * pop.)	MACA
Discount Rates	4%, 8% and 12%	MACA

Table 1.3: Environmental Conditions

Environmental Conditions	
Design Minimum Temperature	-43°C
Degree Days (18°C)	10751
Snow Load SS SR	3.5 kPa 0.2 kPa
Wind Pressures	1.59 kPa

1. Supplement to the National Building Code of Canada 1996 Third Revisions and Errata (Coral Harbour used, data for Cape Dorset not available),
2. Canadian Climate Normals (1961-1990). Yukon and Northwest Territories.

The facility is also to be designed to the current edition of;

- National Fire Prevention Act
- Electrical Code
- Public Health Act (including reference to the GCDWQ)

1.7 Design Parameters

The goals of the project are to treatment sewage with effluent meeting the requirements of the Nunavut Water Board, and the requirements of other regulatory agencies. In meeting this goal, the following items are identified in the TOR as design parameters for the facility:

- The facility must be simple to operate and maintain by local forces with limited locally available equipment, parts and materials.
- Reliability of the facility is extremely important.
- The facility must be efficient and cost-effective.
- All equipment and pipes must be self-draining after each use cycle, where practical. When self-draining of any major component cannot practically be accommodated, some other means of frost protection should be incorporated.
- All major components must be capable of recovering from a frozen condition, in an operable state, if there is any possibility of freezing.

1.8 Cost Analysis

Throughout this document, there are cost analyses of various options. The analyses have been carried out as outlined in the General TOR as described below:

Cost	Description
Capital Cost	Cost of construction for the facility.
Annual operation and Maintenance Costs	The cost of operation may include: manpower, energy requirements, fuel, general maintenance (light bulbs, paint), and equipment replacement.
Life Cycle Costs	The calculation of the total facility cost over a 20-year period includes the capital, operations and maintenance costs. The life cycle value is shown as a present value, which is calculated at a discount rate of 4%, 8% and 12%.

2 SEWAGE QUANTITY

2.1 Sewage Generation Rates

The new sewage treatment system will be designed for a 20 year life span (2006-2026). In order to do so, the sewage generation rates per capita and the population of Cape Dorset for the year 2026 were determined. Predicted population values until the year 2020 were provided by Nunavut Bureau of Statistics (**Appendix C**). Population values beyond 2020 were predicted using both a linear growth rate similar to previous years (31 persons per year), and using a percentage growth rate (1.8%) as illustrated in Error! Reference source not found.. The population for 2026 was predicted to be 2002 persons.

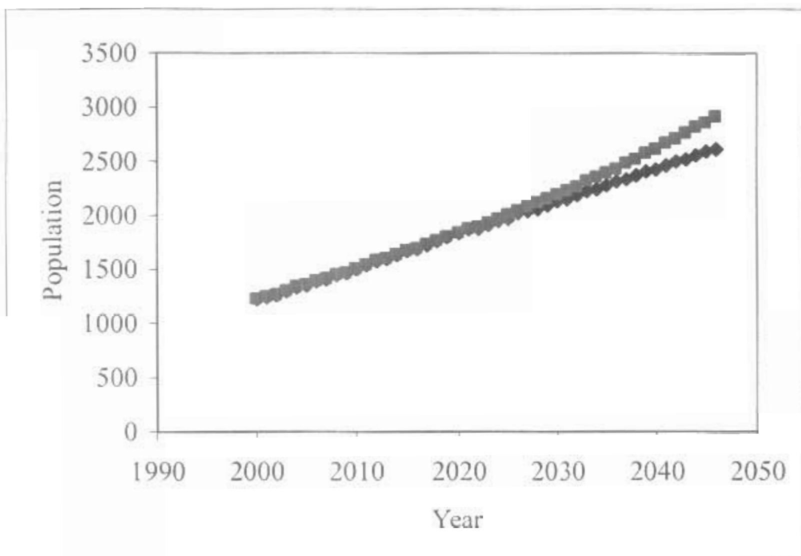


Figure 2.1: Population Growth in Cape Dorset

Data prior to 2021 was provided by Nunavut Bureau of Statistics and data proceeding 2021 was predicted. Blue data points indicate data calculated using a linear growth rate of 31 persons per year. Pink data points indicate data calculated using a percentage growth rate of 1.8%.

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

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

Based on this information, the lagoon will be designed to treat 96 100 m^3, the annual sewage volume for a population of 2002 persons. Error! Reference source not found. shows the calculated sewage generation for years 2006 – 2026.

Table 2.1: Predicted Sewage Generation 2006-2026

Year	Population	MACA Predicted Sewage Production (L)	MACA Predicted Sewage Production (m^3)
2000	1213	50963978	50964
2001	1240	52351337	52351
2002	1268	53801714	53802
2003	1298	55368837	55369
2004	1327	56896649	56897
2005	1354	58330519	58331
2006	1382	59829131	59829
2007	1412	61447933	61448
2008	1441	63025702	63026
2009	1471	64671251	64671
2010	1501	66330399	66330
2011	1536	68283261	68283
2012	1570	70198052	70198
2013	1600	71902080	71902
2014	1632	73734700	73735
2015	1662	75466835	75467
2016	1692	77212569	77213
2017	1726	79207509	79208
2018	1757	81041649	81042
2019	1793	83189842	83190
2020	1829	85357618	85358
2021	1848	86529675	86530
2022	1879	88404583	88405
2023	1910	90293760	90294
2024	1941	92197208	92197
2025	1971	94114925	94115
2026	2002	96046912	96047

The annual sewage generation volume used for design purposes is set at 96,000 m^3.

2.2 Sewage Quality

Due to the low water usage of communities using trucked water delivery and trucked sewage collection, sewage tends to be concentrated when compared to typical municipal wastewater. Cape Dorset trucked sewage is assumed to have the following characteristics:

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

3 LAGOON SITE

The following sections describe the P Lake site area. (**Drawing B**).

3.1 P Lake Fisheries

The Community members have communicated to the Hamlet officials that P Lake is not used as a sport or sustenance fishery. It is, however, believed that the lake supports a forage fish base (i.e. Threespine Stickleback *Gasterosteus aculeatus* or the Ninespine Stickleback *Pungitius pungitius).* The steep terrain between the P Lake outlet and the marine environment precludes the movement of fish between these aquatic environs. At this time we are unaware of any information/data on fish species composition or population estimates for the lake.

3.2 P Lake Area Wildlife

The topography surrounding P Lake is characterized by rock outcrops and steep cliffs. In addition to various mammals and birds common to this part of Baffin Island, the P Lake area is know to support a local population of Common Ravens (*Corvus corax)*. It can be assumed that the Ravens are using this area for nesting as they commonly nest on cliffs and within rock crevices. It is not expected that the development of a sewage treatment lagoon at P Lake would negatively impact the resident raven population or other wildlife of the area.

3.3 P Lake Bathymetry

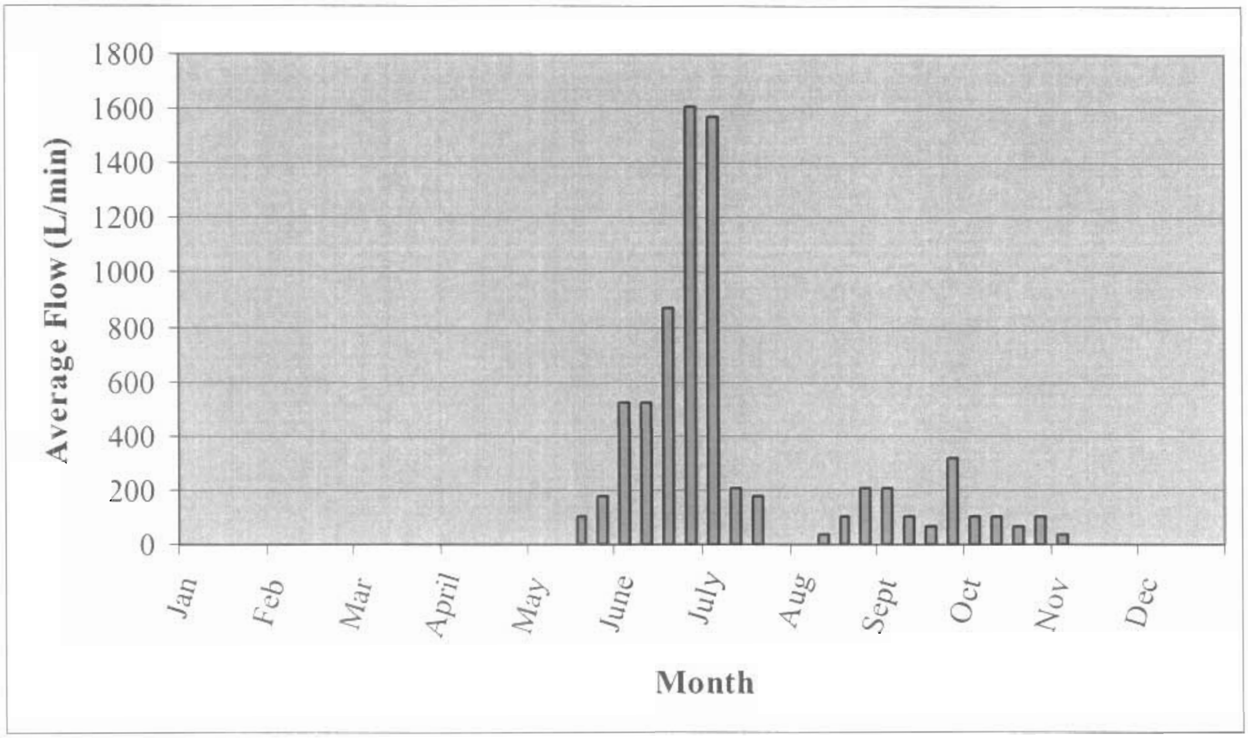
To our knowledge, a detailed bathymetric survey of P Lake has not yet been completed. However, discrete soundings completed in 2003 found the lake to have a maximum depth of approximately 2.5 m. There is no connectivity between P Lake and other fresh water sources on the island. The single outlet from P Lake flows via a single-thread channel for approximately 370 m before entering Tellik Inlet. There is no direct conductivity to the marine environment.

The Lake and has a surface area of roughly 1.3 ha, and a maximum depth of 2.75 m. Leon Neson, Director, Cape Dorset Housing Department provided Dillon with eight (8) measured depths of P Lake (**Appendix D**). These depths were used to approximate a volume of P Lake: 11 667 m^3 (**Drawing C).**

3.4 P Lake Watershed

P Lake is a natural system and is subject to natural water recharge. Using climatic data for Cape Dorset, NU, the water balance and recharge rates for P Lake have been determined and are illustrated in **Figure 3.1.**

Figure 3.1: Water Recharge in P Lake



The method in which this data was determined is detailed in **Appendix E**.

Figure 3.1 illustrates that during the months of June and July, water recharges from the lake at a significant flowrate. In this respect, using P Lake as a primary sewage lagoon is not practical unless the recharge water is directed away from the proposed lagoon. The recharge would significantly reduce the retention of sewage in P Lake and decrease treatment, therefore the use of ditching to divert recharge water is carried forward in the conceptual design development.

3.5 Proposed Lagoon Configuration

As part of the terms of reference the use of P Lake itself to be examined for use as the lagoon. This option has been considered, but is rejected for continued consideration for several reasons;

- Based on 20 year sewage generation values, the estimated 11 667m^2 volume of P Lake is not sufficient to retain and treat a year's volume of sewage;
- Direction from Environment Canada and INAC indicates that exfiltration lagoons (i.e. lagoons that do not retain annual sewage) are not acceptable nor adequate for effective sewage treatment;
- The difficulty associated with constructing berm walls on typically unstable lake bottoms; and
- The difficulties and costs associated with building walls around a lake to increase volume.
- The significant recharge volume as discussed above.

Therefore, to facilitate the best possible sewage treatment for Cape Dorset, a lagoon will be constructed directly east of P Lake to serve as an annual retention lagoon. Upon annual discharge of this primary cell, sewage will flow into P Lake over a period of approximately two (2) weeks. P Lake will serve as a secondary short retention lagoon. P Lake will discharge by gravity to a small wetlands area and over a waterfall before final discharge into Tellik Inlet.

The location of the proposed lagoon treatment system at P Lake meets the following guidelines from the General Sanitation Regulation, Department of Health and Social Services, Government of Nunavut:

- Located more than 450m buffer from the Hamlet
- Located outside of the community watershed
- Enclosed location and prevailing winds at P Lake blow away from town

See **Drawing D** for an illustration of the constraint mapping for P Lake.

4 LAGOON CONSTRUCTION

The P Lake area provides sufficient land to develop an annual retention lagoon, and also use P Lake as a secondary short retention lagoon. The wetlands down gradient of P Lake, which are indigenous to the area, would provide some treatment as well.

As illustrated by aerial photographs and noted topographic maps, the area east of P Lake is situated in a geographic low point, making the area ideal for construction of a bermed lagoon (**Drawing E**).

The level of treatment obtained from each stage of the system is discussed in a subsequent section. (see Section 5)

4.1 Lagoon Configuration

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

- 3.5 m liquid operating depth
- 0.5 m of allowance on the lagoon bottom for sludge accumulation

The size of the lagoon was determined to accommodate the above design parameters and the predicted volume of sewage generated in 2026 (96 100 m^3). The parameters of the lagoon are:

- 185 m x 132 x to the lagoon liquid surface at full capacity in year 2026 (3.1 ha)
- 179 m x 129 m to the inside toe of the berms (2.4 ha)

The above dimensions can be accommodated by the proposed area preceding P Lake (**Drawing E)**.

At the time of reporting the best available data includes digital mapping for the community area and contour mapping for the Lake P area. A site specific survey was completed by CG&T in 2003 of the proposed road alignment. This information was used to develop a site plan, sections and profiles to determine the required earthworks for the lagoon and ancillary components.

The development of the earth work quantities was completed using EaglePoint software and ACAD. Results of the earthwork calculations are shown in **Appendix F**.

4.2 Berm Construction

A site specific geotechnical study will be completed during the design phase of this project. At the time of reporting, there was approximately 1.0 meters of snow at the site. The snow cover precluded the collection of required site data. For the purposes of conceptual design development the following parameters have been developed based on past geotechnical work in the community, and for similar berm construction.

The lagoon will have;

- 1 m freeboard
- 3.5 meter operating depth
- 0.5 meter dead area (sludge retention) at the base of the lagoon.
- Total berm height will be 5 meters.

The berm construction will include;

- 3 m wide at top to facilitate construction
- inside slope to have a 3:1 (H:V) slope
- Outside to be 2.5:1 (H:V) slope
- The berms to have riprap protection over the inside slope in areas subject o ice and wave action.
- Where fine grained material is used in the berm construction, the material will be protected against wind erosion with a layer of 50 mm minus gravel.
- Emergency spillways are to be provided to prevent overtopping of the berm. The spill way to be protected from erosion with riprap or a half culvert pipe.

The types of material to be used in the berm construction are described in section 4.6.

4.3 Truck Pad and Turn-Around

The truck turning access pad will need to be constructed at the top of the lagoon berm to allow for gravity discharge from the truck to the lagoon. The siting of the pad must provide for a cost effective construction, and also provide for a safe operation for the truck drivers in all climatic conditions. The truck pad will have the following elements;

- A minimum turning radius of 15 meters,
- Bollards along the edge of the lagoon to provide for driver safety,
- Stop logs at the discharge location to give the truck driver a physical point to stop the truck,
- Delineators along the edge of the truck pad to indicate the edge of the embankment in winter conditions,
- The side slopes of the truck pad will be protected against erosion with a layer of granular material. The erosion protection will have a minimum gradation of a 50mm minus material. Courser material maybe if economically available.

The truck turn around pad requires a radius of 15 m if a standard sewage truck is to be used. Should the owner feel that the use of larger trucks (B-Trains) are to be used, then a larger turning radius is required. The side slopes of the turn around pad are to be 3:1 (H:V).

4.4 Sewage Discharge Flume

Sewage will be disposed from sewage trucks into the lagoon though a free fall discharge pipe. With respect to trucked sewage, free fall discharges are simple in design and operation, and easy to access and maintain. The discharge will be constructed with the following specifications:

- 8m long 600 mm steel pipe.
- 30% slope
- CSP supported by 2-150 mm 3.0 m long concrete filled Schedule 40 pipes embedded 1.5 m into the embankment.
- 600 mm CSP secured to supports by 12 mm ready rod bent to 600 mm diameter and secured to 150mm x 700mm x 5mm pipe support plate
- Rip rap will be placed on the interior slope of the lagoon berm along the length of the discharge flume, and to the base of the lagoon to prevent erosion.
- Bollards will be in place to prevent the sewage truck from damaging the flume.

Drawing F shows a layout of the truck pad and discharge flume area. Details of the design elements of the truck pad and discharge flume are shown in **Drawing G.**

4.5 Lagoon Discharge Structure

The effluent from the lagoon will be discharged to Lake P through discharge system. Several options are possible. Methods used at other locations in Nunavut include;

- A siphon (used in Qikigtarjuaq)
- A gas or diesel fired pump
- A gravity discharge and valve

The goals and objectives of the project are to provide a system with low operating costs and to simplify the operational elements. For these reasons the use of a pumped system is not recommended.

The use of a siphon works well once the lagoon is operating at design capacity. When it is operating in the early years the siphon system has proven problematic. Often the siphon requires priming with a vacuum pump at each discharge event. For these reasons the use of a siphon system is not recommended

The recommended system is the use of a gravity discharge line with a valve located in a manhole within the berm. This is a common system installed throughout Nunavut, most recently in Pond Inlet. Design components of the system include;

- An intake structure to raise the inlet of the pipe above the sludge deposition level. This is a 90 degree bend located at the inlet of the pipe.
- A steel pipe through the lagoon berm
- An access vault located within the berm. The manhole is located in the berm crest to facilitate access to the top of the manhole.
- A valve installed in the Manhole on the discharge pipe.
- A pipe out fall and discharge channel. The outfall area has riprap protection to prevent erosion and to dissipate the energy of the discharge.

Drawing H illustrates the plan and section of the proposed effluent discharge system.

4.6 Berm and Road Material

4.6.1 Berm

The design intent for the lagoon is an annual retention cell. The berms are to be constructed to provide low permeability to the sewage. There are several options to achieve the desired low permeability lagoon walls, namely;

- Construction of the berm walls using a berm core of fine grained (low permeability) material. The mass of the berm would be constructed of pit run material. The outer faces of the berms would have rip rap on the inside of the walls to protect the berms from wave and ice erosion.
- Construction of the berm walls using a frozen core system. This system is common in the north, however specific geotechnical conditions need to exist to allow for the successful completion of a frozen core berm. Also there is a requirement for very stringent material selection and placement during construction. The mass of the berm would be constructed of pit run material. The outer faces of the berms would have rip rap on the inside of the walls to protect the berms from wave and ice erosion.
- Construction of the berm walls using a synthetic liner. The liner can be continuous throughout the lagoon floor, or it could be keyed into the permafrost/low permeability soil layer, and therefore only used on the berm walls. The mass of the berm would be constructed of pit run material. The outer faces of the berms would have rip rap on the inside of the walls to protect the berms and liner from wave and ice erosion.

Regardless of the construction methods used, there will need to be a large volume of material used to construct the lagoon walls. There are opportunities to use the natural topography to minimize the volume of material required. To complete a detailed assessment of the requirements for the lagoon construction, the following work program is proposed;

- Completion of a detailed site survey of the access road alignment, and the lagoon area. The extent of the survey will include the P-Lake area and a detailed bathymetry of the lake.
- Completion of a site specific geotechnical would include:

- Review of available data
- Overview of the climate and permafrost historical data
- Arial photograph interpretation of the proposed lagoon site
- Completion of a drilling program at the site. The bore hole will be continuously logged with samples retained at regular intervals and returned to the soils laboratory for testing. Testing to include moisture content, grain size, plasticity indices, and pore water content.
- Development of recommendation for the construction of the low permeability lagoon walls
- Development of the design requirements for Lagoon wall stability
- Recommendation for drainage (and sub drain) requirements

4.6.2 Road

The cost estimate for the road alignment and profile are based on the information available at this time. A site inspection and survey of the preliminary route was carried out on April 17 and April 18, 2003 by Jason Andrews and Sameh Elsayed. In order to access the lagoon location a steep rock face must be traversed. Access would be partially provided along an existing road but a new road 950 m in length and with an elevation change of approximately 56 m would need to be constructed. The plan and profile are shown in **Drawing I**. The profile consists of interpreted data from existing contour mapping, survey data and digital mapping.

Additional survey is required to develop the detailed estimates for the quantities during detailed design. At the time of reporting over 1.0 meters of snow still covered the site.

The road will be developed based on the following standards;

- The road width will be 8.0 meters. This will allow two trucks to pass safely.
- The maximum grade will be 8%. Where possible the road grade will be maintained below 6%.
- Guard rails will be provided on curves and areas of steep embankment.
- Curves will be a minimum of 25 meters to provide for road safety is adverse climatic conditions.
- Road side delineators will be install to assist in snow clearing
- Side slope of the road will be governed by the stability of the granular material used for the road construction. Geotechnical recommendation will be used to determine the minimum side slope. For safety reasons, a minimum slope of 2:1 will also govern.

Typical sections of the road are shown in **Drawing J**.

4.6.3 Granular Supply

Cape Dorset does not currently have a granular resource area with sufficient material to supply this project. A blast and crush operation will likely be required as part of the road and lagoon construction. We have had several discussions with the community representatives, and with the local contractor Fred Schell. Based on these conversations it is understood that;

- The Hamlet owns a crusher
- The contractor owns an air track drill rig
- The contractor has previously been given a quarry permit for sufficient resources to complete the proposed works. The permit had a 1 year expiry date, and has since expired.
- There are other contractors (Canadrill) who would be willing to provide services to develop a granular resource for this project.

Based on the above discussions, the development of the granular resources to complete the proposed works is possible and there is little risk to the owner associated with the development of the resource. The costs estimates to develop the resource and supply and place the granular material are based on $\$100/m^3$ for rock excavation and $\$40/m^3$ for fill. Since most of the material will be obtained from a blast and crush operation, there is little cost savings when using on site cut (blast) material for fill material.

We have used a 30% expansion factor for on site cut when applied to fill.

The cost estimates for granular supply are summarized below.

Table 4.1: Cost Estimates

Item	**Quantity (m^3)**	**Unit Cost**	**Total Cost**
Access Road Cut	6,200	$100	$620,000
Access Road Fill (from cut)	8,100	$20	$16,200
Access Road Fill (borrow)	21,700	$40	$868,000
Lagoon Berms Cut	0	$100	0
Lagoon Fill (from cut)	0	$20	0
Lagoon Fill (borrow)	25,200	$40	$1,000,000
Total			**$2,500,000**

All estimated costs have an associated accuracy of ± 20.

4.6.4 Culvert Design

As illustrated in **Drawing J**, the construction of the road from the Hamlet to the proposed lagoon site will require the construction of a culvert. To determine the design parameters for the construction of the culvert, the peak water flow through the culvert was determined.

4.6.4.1 Method of Flood Estimation based on Rainfall Data

The rational method was used to estimate the peak flow for the culvert design. This method generally produces reliable results for small watersheds where the input parameters can be properly quantified. The equation used is:

$$Q = \frac{RIA}{360} \qquad [1]$$

Where,

Q = the design flow in m^3/s

R = a co-efficient that estimates the fraction of rainfall that runs off (the rest is assumed to sink into the ground or get stored in depressions and not appear at the point of concentration (POC) until after the peak flow has passed)

I = the average rainfall intensity (derived from a regional IDF curve for a 10 year return period) during the time of concentration (T_C) (**Appendix G**)

T_c = the time that it takes water to flow from the highest point in the watershed to the point of interest. T_c is also knows as the "response time" of the basin (**Appendix G**)

A = watershed area in hectares (**Determined from Drawing K**).

For the Cape Dorset region, a set of Intensity-Duration Frequency (IDF) curves was available from Environment Canada (**Appendix G**). The data used to create the IDF curves was collected at the Cape Dorset Airport.

Practical difficulties are inherent when estimating design floods based on rainfall data. It is difficult to estimate T_c, the time of concentration, R, the fraction of the rainfall that runs off (rather than sinking into the ground) and I. the "design" rainfall intensity. For this reason, a factor of safety of 10% has been added to the design flow in addition to the following values to account for inaccuracies in the inputs.

Area inaccuracy 5% or 0.05 = 105% of calculated value
R inaccuracy 20% or 0.20 = 120% of estimated value
I inaccuracy 5% or 0.05 = 105% of value taken from IDF curve

With a design peak flow (Q_d) based on an estimated 10 year return peak flow (Q_{10}) established, the Manning's formula (**Equation 2**) was used to size the culvert diameter based on a velocity of water flow in the pipe of approximately 1.5 m/s:

$$Q = \frac{A\left(kr^{\frac{2}{3}}s^{\frac{1}{2}}\right)}{n} \quad [2]$$

Where,

Q = Flow in m^3/s or ft^3/sec
k = units factor (1.0 metric) or (1.486 Imperial)
r = the hydraulic radius of the channel section
s = slope of channel in m/m or ft/ft
n = Mannings coefficient (equal to 0.013 for typical culvert material)

As show in **Appendix F**, the peak flow through the culvert was conservatively calculated to be **1.72 m^3/s** (**60.7 ft^3/sec**). Using a design flow of **1.72 m^3/s** and a slope of 0.18, a typical 1,200 mm (48") circular steel culvert will give a velocity of approximately 1.5 m/s.

4.7 P Lake Dimensions

P Lake will serve as a short retention lagoon. As per **Section 3** and **Drawing B** the volume of the Lake is approximately 11 667 m^3. The P Lake lagoon will offer treatment during a 2 week period in the fall, as the primary lagoon is discharged

Table 4.2 shows the sewage retention time in P Lake for each volume of sewage produced by the community over the 20 year lifespan of the system.

Table 4.2: Sewage Retention Time in P Lake

Year	Annual Sewage Volume (m^3)	Discharge Time (days)	Retention time (days)
2006	59829	14	2.7
2007	61448	14	2.7
2008	63026	14	2.6
2009	64671	14	2.5
2010	66330	14	2.5
2011	68283	14	2.4
2012	70198	14	2.3
2013	71902	14	2.3
2014	73735	14	2.2
2015	75467	14	2.2

2016	77213	14	2.1
2017	79208	14	2.1
2018	81042	14	2.0
2019	83190	14	2.0
2020	85358	14	1.9
2021	86530	14	1.9
2022	88405	14	1.9
2023	90294	14	1.8
2024	92197	14	1.8
2025	94115	14	1.7
2026	96047	14	1.7