P Lake Sewage Lagoon
Water Licence Application
Design Report
Cape Dorset, NU

Draft Report

December 21, 2006

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Water Licence Application
Design Report
Cape Dorset, NU

Government of Nunavut, Community and Government Services

05-4319
Gary Strong, P. Eng. Project Manager

Submitted by

Dillon Consulting Limited

(In reply, please refer to)
Our File: 05-4319-2200

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December 21, 2006

Community and Government Services
Government of Nunavut
Pond Inlet, NU

Attention: Bhabesh Roy, Municipal Planning Engineer

P Lake Sewage Lagoon Water Licence Application Design Report
Cape Dorset, NU

Dear Mr. Roy:

Enclosed please find the report for the ***P Lake Sewage Lagoon Water Licence Application Design Report Cape Dorset, NU.*** This report has been developed to provide the required background on the submission to the Nunavut Water Board in the application for the water licence on the subject.

Yours sincerely,

DILLON CONSULTING LIMITED

Gary Strong, P. Eng

Project Manager

Encl.
cc:

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1 INTRODUCTION

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 design for the P Lake Sewage Lagoon, and the measures taken to comply with the Nunavut Waters and Nunavut Surface Rights Tribunal Act 2002.

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 -29^0C and a high of about -23^0C. In July the temperatures range between a low of 3^0C to a high of about 7^0C. 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.

1.1 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.

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 the area up gradient of P Lake as a sewage lagoon and the use of a mechanical system for sewage treatment. The Hamlet through consultation selected a lagoon adjacent to "P Lake" as their preferred sewage treatment option.

2 WATER LICENCE REQUIREMENTS

The Nunavut Waters and Nunavut Surface Rights Tribunal Act 2002 have several articles that are directly applicable to the facilities at Kimmirut. These are provided below.

Under Article 4 Definitions
"licence" means, unless the context otherwise requires, a type A or type B licence, in accordance with the criteria prescribed by the regulations, issued for the use of waters or the deposit of waste, or both, in Nunavut under section 42

"waste" means any substance that, by itself or in combination with other substances found in water, would have the effect of altering the quality of any water to which the substance is added to an extent that is detrimental to its use by people or by any animal, fish or plant, or any water that would have that effect because of the quantity or concentration of the substances contained in it or because it has been treated or changed, by heat or other means, and includes

(a) any substance or water that, for the purposes of the Canada Water Act, is deemed to be waste;
(b) any substance or class of substances specified by the regulations;

(c) water containing any substance or class of substances in a quantity or concentration that is equal to or greater than that prescribed by the regulations; and
(d) water that has been subjected to a treatment or change described by the regulations.

Article 13

13. (1) Except as otherwise provided by a compensation agreement referred to in this Part, a person, including the designated Inuit organization, who is adversely affected by a licensed use of waters or deposit of waste, or by an unlicensed use of waters or deposit of waste authorized by the regulations, is entitled to be compensated in respect of that adverse effect by the licensee or the person so authorized and to recover the compensation in any court of competent jurisdiction.

Article 38

38. (1) The Board may not issue, amend or renew a licence to use waters or deposit waste if there is an applicable land use plan approved in accordance with Part 5 of Article 11 of the Agreement unless the Nunavut Planning Commission, in accordance with section 11.5.10 of the Agreement,
(a) has determined that the use or deposit, or in the case of an amendment any change to the use or deposit, conforms to the land use plan; or
(b) has approved a variance in respect of the use, deposit or change.

Article 48

48. (1) An application in relation to a licence shall contain the information and be in the form required by the rules or by-laws of the Board, and be accompanied by the fees required by the regulations.
(2) An application, except in relation to a cancellation, shall be accompanied by the information and studies concerning the use of waters or the deposit of waste that are required for the Board to evaluate the qualitative and quantitative effects of the use or the deposit on waters.
(3) On the filing of an application, the Board may provide guidelines to the applicant respecting the information to be provided by the applicant in respect of any matter that the Board considers relevant, including the following:
(a) the description of the use of waters, deposit of waste or appurtenant undertaking, as the case may be;
(b) the qualitative and quantitative effects of the use of waters or the deposit of waste on the drainage basin where the use is to be undertaken or the deposit is to be made, and the anticipated impact of the use or deposit on other users;
(c) the measures the applicant proposes to take to avoid or mitigate any adverse impact of the use of waters or the deposit of waste;
(d) the measures the applicant proposes to take to compensate persons, including the designated Inuit organization, who are adversely affected by the use of waters or the deposit of waste;

(e) the program the applicant proposes to undertake to monitor the impact of the use of waters or the deposit of waste;

(f) the interests in and rights to lands and waters that the applicant has obtained or seeks to obtain; and

(g) the options available for the use of waters or the deposit of waste.

Article 57

57. The Board may not issue a licence unless the applicant satisfies the Board that

(a) any waste produced by the appurtenant undertaking will be treated and disposed of in a manner that is appropriate for the maintenance of the water quality standards and effluent standards that are prescribed by the regulations or, in the absence of such regulations, that the Board considers acceptable; and

(b) the financial responsibility of the applicant, taking into account the applicant's past performance, is adequate for

(i) the completion of the appurtenant undertaking,

(ii) such measures as may be required in mitigation of any adverse impact, and

(iii) the satisfactory maintenance and restoration of the site in the event of any future closing or abandonment of that undertaking.

Article 60

60. (1) The Board may not issue a licence unless

(a) the applicant satisfies the Board that compensation that the Board considers appropriate has been or will be paid by the applicant to any person who would be adversely affected by the proposed use of waters or deposit of waste and who, at the time the application was filed,

(i) used waters for a domestic purpose in the Northwest Territories or in Nunavut,

(ii) held a licence under this Act or the Northwest Territories Waters Act to deposit waste in the Northwest Territories or in Nunavut,

(iii) was an instream user in the Northwest Territories or in Nunavut,

(iv) was, as authorized by regulations made under this Act or the Northwest Territories Waters Act, using waters or depositing waste in the Northwest Territories or in Nunavut without a licence under either Act,

(v) was an owner or an occupier of land in the Northwest Territories or in Nunavut, or

(vi) was a holder of an outfitting concession, a registered trapline or other rights of a similar nature in the Northwest Territories or in Nunavut; or

(b) the applicant has entered into an agreement to compensate any person described in subparagraphs (a) (i) to (vi) who would be adversely affected.

2.1 Summary

This report provides the NWB an application that outlines the following;

(a) the description of the deposit of waste
(b) the qualitative and quantitative effects of the deposit of waste on the drainage basin where the deposit is to be made, and the anticipated impact of the deposit on other users;
(c) the measures the applicant proposes to take to avoid or mitigate any adverse impact of the deposit of waste;
(d) the measures the applicant proposes to take to compensate persons, including the designated Inuit organization, who are adversely affected by the deposit of waste;
(e) the program the applicant proposes to undertake to monitor the impact of the deposit of waste, and
(g) the options available for the deposit of waste.

The Board can not renew or issue a licence if the application indicates that;

(a) any waste produced by the appurtenant undertaking will be treated and disposed of in a manner that is appropriate for the maintenance of the water quality standards and effluent standards that are prescribed by the regulations or, in the absence of such regulations, that the Board considers acceptable; and
(b) the financial responsibility of the applicant, taking into account the applicant's past performance, is adequate for
    (i) the completion of the appurtenant undertaking,
    (ii) such measures as may be required in mitigation of any adverse impact, and
    (iii) the satisfactory maintenance and restoration of the site in the event of any future closing or abandonment of that undertaking

The following sections of this report provide the information required. This information has been previously submitted to the NWB in several documents, and in the technical hearing held in the community. This submission consolidates the information succinctly into one document.

3 ADDITINAL DOCUMENTATION

Appended to this document are the flowing reports and drawings;

- The Geotechnical Report completed by AMEC dated October 13, 2005
- AMEC's letter dated September 12, 2006.
- The Geotechnical Report by AMEC completed on November 1 2006, including the map of the test hole locations
- The detailed design drawings 100, 101, 109, 110, 111 (original drawings are on record with Engineer's Seal and signature). The other drawings in the drawing set (102 to 108) describe works not related to the construction of the waste site. The ancillary works are not regulated under the Nunavut Waters and Nunavut Surface Rights Tribunal Act 2002. The works relate to the access road. In previous correspondence with the NWB and INAC, the road has been determined to be not regulated by the NWB.

The above documents provide additional details.

4 THE DESCRIPTION OF THE DEPOSIT OF WASTE

4.1 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 D)**. 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 **Chart 4.1**. The population for 2026 was predicted to be 2002 persons.

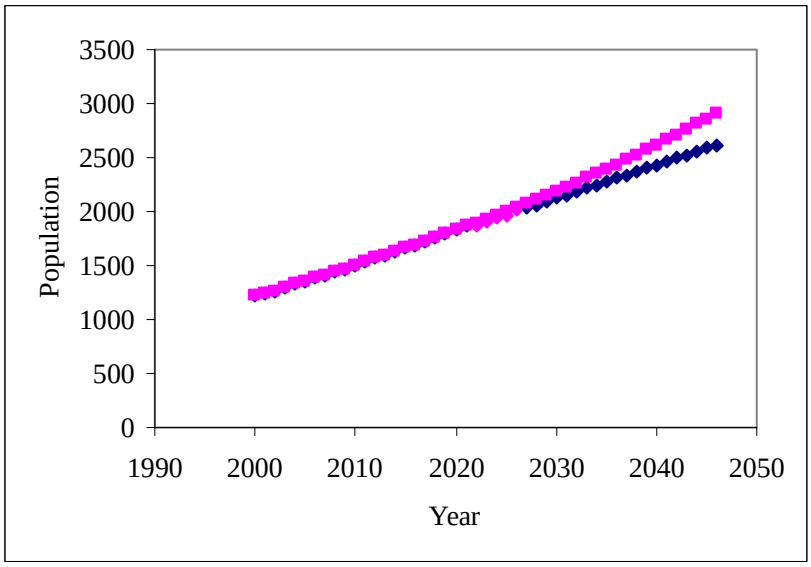


Chart 4.1: Population Growth in Cape Dorset

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 4.1: 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.

4.2 Sewage Quality

Due to the low water usage of communities using trucked water delivery and trucked sewage collection, sewage tends to be concentrated when compared to typical municipal wastewater. 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

5 QUALITATIVE AND QUANTITATIVE EFFECTS OF THE DEPOSIT OF WASTE

The discharge of the lagoon will be directly up gradient of P Lake. Over the design life the sewage effluent will impact P Lake with increased BOD, TSS, and nutrient loading. Aquatic life within P Lake will be adversely affected during lagoon discharge. To understand the impact on the receiving environment, an assessment of P Lake and the P Lake basin was completed. The following sections describe the P Lake site area. (**Drawing B)**.

5.1 P Lake Fisheries

As part of the scope of work for this project Dillon conducted detailed fisheries investigations of P-Lake, the results of which are included as **Section 6.0** of this report.

5.2 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.

5.3 P Lake Bathymetry

A detailed bathymetric survey of P Lake was not 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 Telik Inlet (marine environment). There is no direct conductivity to the marine environment.

P- Lake and has a surface area of roughly 1.3 ha, and a maximum depth of 2.8 m. Leon Neson, Director, Cape Dorset Housing Department provided Dillon with eight (8) measured depths of P Lake. These depths were used to approximate a volume of P Lake: 11 667 m^3 (**Drawing C).**

5.4 P Lake Watershed

P Lake is a natural system and is subject to natural water recharge. Using climatic data for Cape Dorset, NU, and the water balance and recharge rates for P Lake have been determined and are illustrated in **Chart 5.1**

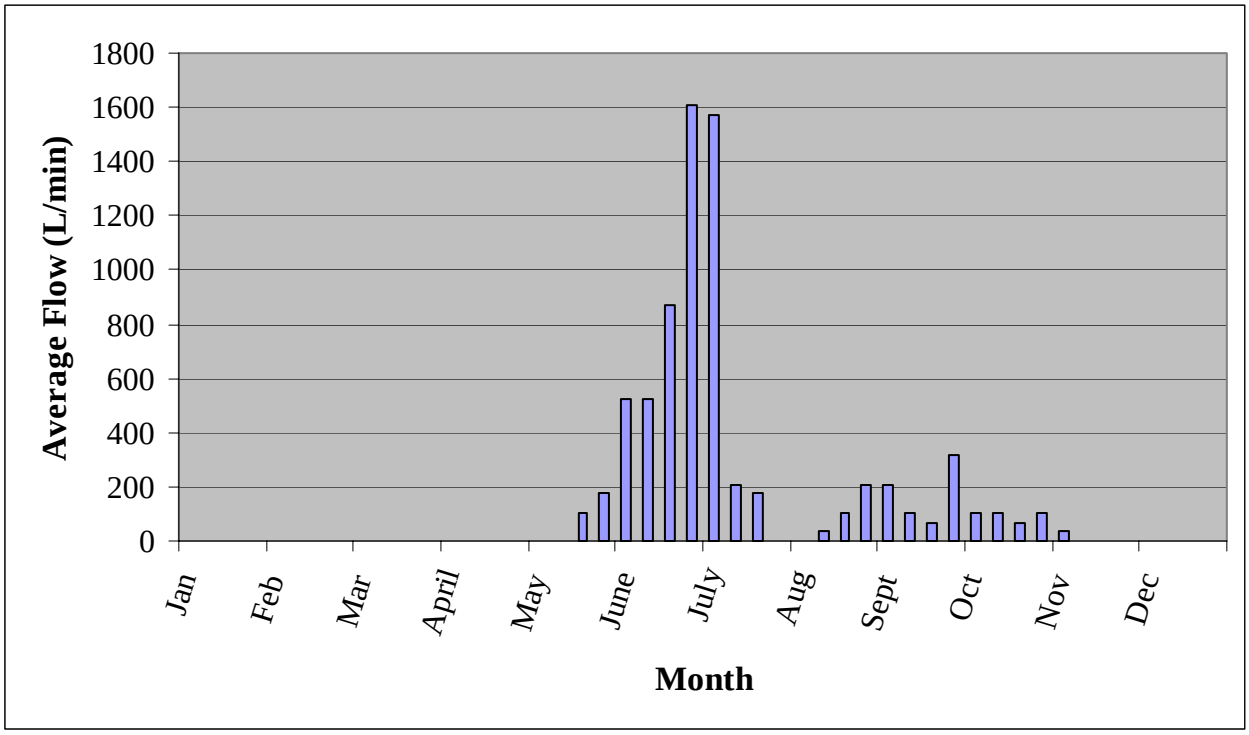


Chart 5.1 Water Recharge in P Lake

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

Chart 5.1 illustrates that during the months of June and July, water recharges from the lake at a significant flow rate. 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.

5.5 Groundwater Movement from the Lagoon

There has been some concern raised with the exfiltration from the lagoon through the base of the lagoon. AMEC (see annexed reports) completed a thermal analysis of the lagoon design and determined that the impact on the permafrost would not create a seepage or exfiltration path from the lagoon, under the constructed berms. Therefore minimal, or no, impact to the environment is expected from exfiltration of the sewage through the lagoon base.

5.5.1 Lagoon Discharge

The lagoon will be constructed in an irregular shape. This particular shape is used to maximize the use of the natural topography to minimize construction costs. The lagoon is designed such that sewage will be entrained in the lagoon for 12 months. During the summer months, the sewage will be treated through natural process (biological and physical). The effluent will discharge from the lagoon through P- Lake and then 500m to the from the shore of Telik inlet. The treatment process is described in the following section of this report.

5.5.2 Effluent Characteristics

The sewage treatment system needs to address two sets of criteria, namely;

- The requirements of the Fisheries Act as governed by the Department of Fisheries and Oceans and Ministry of Environment Canada at the point where the effluent impact fish barring water and or fish habitat. Section 6 of this report describers the work undertaken to identify the regulation point under this criteria. It has been determined that this regulatory point is Telik Inlet. Both departments have indicated that effluent meeting the criteria set out in the Guidelines for the discharge of treated Municipal Wastewater in the Northwest Territories, 1992, are applicable to this location. From this guideline, the criteria for discharge are BOD 100 mg/L and TSS 120 mg/L.
- The requirement of the Nunavut Waters and Nunavut Surface Rights Tribunal Act 2002, which indicates that *any waste produced by the appurtenant undertaking will be treated and disposed of in a manner that is appropriate for the maintenance of the water quality standards and effluent standards that are prescribed by the regulations or, in the absence of such regulations, that the Board considers acceptable.*

Should the Nunavut Water Board also apply the above noted guideline, then the required effluent criteria for a lake with Tr< 5 yr is; BOD 80 mg/L and TSS 100 mg/L, with F. Coli 10E. The following sections describe the expected effluent discharge values fort he design life of the lagoon.

5.6 Annual Lagoon Kinetics

The level of treatment achieved by a lagoon system can be predicted using the following kinetic formula[1]:

$$\frac{C_e}{C_i} = e^{-Kt} \quad \textbf{[2]}$$

Where,
C_e = Concentration of substrate (BOD_5) in lagoon effluent (mg/L)
C_i = Concentration of substrate (BOD_5) in lagoon influent (mg/L)
t = Residence time of sewage in lagoon (days)
K = kinetic rate constant for ($days^{-1}$)

The kinetic rate constant, K, varies according to temperature:

$$K = K_{20}\theta^{T-\theta} \quad \textbf{[3]}$$

Where,
K = BOD_5 kinetic rate constant ($days^{-1}$)
K_{20} = BOD_5 kinetic rate constant ($days^{-1}$) for 20^0C
θ = temperature coefficient
T = temperature of lagoon contents in the critical or coldest winter months in degrees Celsius (^{0}C)

A typical value for θ is 1.06[2]. Although typical values for K_{20} range from 0.25 – 0.50 $days^{-1}$, a significantly lower value for K (0.10 $days^{-1}$) was assumed in this case, to be conservative and to account for the cold climate conditions. Using these assumed values the effluent quality from the constructed primary lagoon was predicted for a variety of conservative temperatures and retention times (Error! Reference source not found.). Although the lagoon will hold sewage for a year's time, the effective treatment time used in Error! Reference source not found. Only accounts for the length of time sewage is completely thawed for treatment during the summer months. Since freeze-up can vary and occur anytime

[1] Environment Canada Report EPS 3 NR 1. (1987) Cold Climate Sewage Lagoons. *Proceedings of the June 1985 Workshop, Winnipeg, Manitoba.* Appendix D-3.
[2] Metcalf and Eddy, Inc. (1991). Wastewater *Engineering: Treatment, Disposal and Reuse, 3rd Edition.* Toronto: McGraw-Hill Inc.

from September – November, a range of 70-90 days of treatment were analyzed. Winter treatment was assumed to be negligible in **Table 5.1**.

Table 5.1: Prediction of Effluent BOD using Lagoon Kinetics (Annual Retention Lagoon)

t (days)	K_{20} ($days^{-1}$)	θ	T (^0C)	K ($days^{-1}$)	C_e/C_i	C_i (mg/L)	C_e (mg/L)
90	0.1	1.06	3	0.037	0.0354	625	22
90	0.1	1.06	4	0.039	0.0289	625	18
90	0.1	1.06	5	0.042	0.0234	625	15
90	0.1	1.06	6	0.044	0.0187	625	12
90	0.1	1.06	7	0.047	0.0147	625	9
80	0.1	1.06	3	0.037	0.0513	625	32
80	0.1	1.06	4	0.039	0.0429	625	27
80	0.1	1.06	5	0.042	0.0355	625	22
80	0.1	1.06	6	0.044	0.0291	625	18
80	0.1	1.06	7	0.047	0.0235	625	15
70	0.1	1.06	3	0.037	0.0743	625	46
70	0.1	1.06	4	0.039	0.0636	625	40
70	0.1	1.06	5	0.042	0.0539	625	34
70	0.1	1.06	6	0.044	0.0452	625	28
70	0.1	1.06	7	0.047	0.0376	625	23

Based on the above data, the BOD_5 of the effluent discharged from the lagoon has an expected range of 9 mg/L (90 day treatment period, 7^0C) to 46 mg/L (70 day treatment period, 3^0C). Therefore using the very conservative value of 70 days of treatment, at a low temperature of 3 degrees for the sewage in the lagoon, the effluent will meet the Guidelines for the discharge of treated Municipal Wastewater in the Northwest Territories, 1992.

The document *Best Available Technology for Sewage Treatment in the North, Indian and Northern Affairs Canada, 2003,* indicates that removal rates of BOD for lagoons with detention times over 180 days is 85 to 95%. This gives a range of expected BOD effluent in the range of 31 to 93 mg/L. These values are below the discharge criteria set out in the reference document.

5.7 Fecal Coliform Reduction

The reduction of fecal coliforms (FC) can also be predicted. The average generation of FC in domestic sewage is $2x10^9$ FC per person per day[3]. Using this value and the predicted sewage volume generation, the average fecal coliform concentration in the P Lake Lagoon system was determined in

[3] Metcalf and Eddy, Inc. (1991). Wastewater *Engineering: Treatment, Disposal and Reuse, 3rd Edition.* Toronto: McGraw-Hill Inc.

Table 5.**2.** The reduction rate is as described in the Guidelines for Planning Design, Operation and Maintenance of Wastewater Lagoon Systems, in the Northwest Territories, Heinke et al.

Table 5.2 Reduction of Fecal Coliform from Lagoon Treatment System

Year	Population	Fecal Coliorm		Sewage Volume	Fecal Coliform	
					Raw Influent	Annual Lagoon Effluent (99.9% Reduction)
		(FC/p/d)	(FC/d)	(L/d)	(FC/L)	(FC/L)
2006	1382	2.0E+09	2.8E+12	1.6E+05	1.7E+07	1.7E+04
2007	1412	2.0E+09	2.8E+12	1.7E+05	1.7E+07	1.7E+04
2008	1441	2.0E+09	2.9E+12	1.7E+05	1.7E+07	1.7E+04
2009	1471	2.0E+09	2.9E+12	1.8E+05	1.7E+07	1.7E+04
2010	1501	2.0E+09	3.0E+12	1.8E+05	1.7E+07	1.7E+04
2011	1536	2.0E+09	3.1E+12	1.9E+05	1.6E+07	1.6E+04
2012	1570	2.0E+09	3.1E+12	1.9E+05	1.6E+07	1.6E+04
2013	1600	2.0E+09	3.2E+12	2.0E+05	1.6E+07	1.6E+04
2014	1632	2.0E+09	3.3E+12	2.0E+05	1.6E+07	1.6E+04
2015	1662	2.0E+09	3.3E+12	2.1E+05	1.6E+07	1.6E+04
2016	1692	2.0E+09	3.4E+12	2.1E+05	1.6E+07	1.6E+04
2017	1726	2.0E+09	3.5E+12	2.2E+05	1.6E+07	1.6E+04
2018	1757	2.0E+09	3.5E+12	2.2E+05	1.6E+07	1.6E+04
2019	1793	2.0E+09	3.6E+12	2.3E+05	1.6E+07	1.6E+04
2020	1829	2.0E+09	3.7E+12	2.3E+05	1.6E+07	1.6E+04
2021	1848	2.0E+09	3.7E+12	2.4E+05	1.6E+07	1.6E+04
2022	1879	2.0E+09	3.8E+12	2.4E+05	1.6E+07	1.6E+04
2023	1910	2.0E+09	3.8E+12	2.5E+05	1.5E+07	1.5E+04
2024	1941	2.0E+09	3.9E+12	2.5E+05	1.5E+07	1.5E+04
2025	1971	2.0E+09	3.9E+12	2.6E+05	1.5E+07	1.5E+04
2026	2002	2.0E+09	4.0E+12	2.6E+05	1.5E+07	1.5E+04

The predicted concentration of FC/100mL of the lagoon effluent is 1.5 E =04 FC/100mL.

5.8 TSS Reduction

The document *Best Available Technology for Sewage Treatment in the North, Indian and Northern Affairs Canada, 2003*, indicates that removal rates of TSS for lagoons with detention times over 180 days is 85 to 95%. This gives a range of expected BOD effluent in the range of 45 to 135 mg/L. These values are below the discharge criteria set out in the reference document.

Guidelines for Planning Design, Operation and Maintenance of Wastewater Lagoon Systems, in the Northwest Territories, Heinke et al indicates that lower values for TSS can be expected for fall discharges. Allowing the lagoon to experience die off of the algae, and other biological organisms, and allowing time int eh fall for these to settle prior to discharge results in a effluent with lower TSS values. The planned operational sequence for the lagoon is to use a fall discharge. Therefore TSS values in the mid to lower range of those predicted using the *Best Available Technology for Sewage Treatment in the North, Indian and Northern Affairs Canada, 2003* is expected.

6 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.

This section of the report describes the methods and results from the following environmental investigations:

- Fishery inventory and habitat descriptions of 'P' Lake;
- Descriptions of general habitat conditions of the outlet stream between P Lake and the marine environment;
- Collection of baseline information from the marine environment (Telik Inlet) where the outlet of P Lake drains; and
- Photo documentation of all activities

In context of a proposed sewage lagoon for Cape Dorset, the purpose of the investigations was to confirm fish presence/absence in P Lake, and to characterize the receiving marine environment.

The lake is fed primarily through surface runoff and there is no connectivity between P Lake and other fresh water sources on the island. Existing information on inlet surface flow, and habitat in a possible inlet channel, was not found.

The single outlet from P Lake flows via a single-thread channel for approximately 370 m (over a steep cliff and then through a mossy area) and over a waterfall before draining into the marine environment (i.e., Telik Inlet). The steep terrain between the P Lake outlet and the marine environment prevents the movement of fish between these aquatic environments and there is no direct connectivity to the marine environment.

Current information on the fish inventory and habitat of P Lake is lacking. Community members have communicated to the Hamlet officials that P Lake is not used as a sport or sustenance fishery. DFO has confirmed that no sportfish are expected to be present in P Lake (Tania Gordanier, DFO, pers. comm.). It is thought, however, that the lake may support forage fish (i.e., threespine stickleback, G*asterosteus aculeatus*, and/or the ninespine stickleback, *Pungitius pungitius*).

6.1 Methods

6.1.1 Fishery Survey of P Lake

A multiple-method sampling protocol was selected to maximize the potential of observing and/or capturing fish that may reside in P Lake. The fishery surveys included: minnow trapping; seine hauls; snorkel surveys; and visual bank observations.

6.1.1.1 Minnow Traps

Minnow traps were set overnight on August 11, 2005. Minnow traps, baited with Power bait Trout Nuggets, were set between 14:00 and 15:15 hrs on August 11 and retrieved between 9:00 and 9:35 hrs on August 12, 2005. Eight traps were set around the shoreline of P Lake, at depths ranging from 0.2-1.0m (see **Figure F** for locations).

6.1.1.2 Seine Hauls

Seine hauls were carried out at various locations along the shoreline of P Lake (see **Figure F** for locations). A total of seven hauls were carried out on August 11, 2005. The seine net used was 10 m long and had a mesh size of 1 cm. The distance the seine hauls were pulled ranged from 10 to 20 m.

6.1.1.3 Snorkel survey

Snorkel surveys were carried out along six transects over a 1.5 hour period on August 11, 2005. Five transects (ranging in length from 50 to 85 m) were oriented east-west across the lake; while a sixth transect was oriented north-south across the lake (see **Figure F** for locations). Although visibility extended beyond 2 m, the snorkel survey focused on observations within a 1.5 m distance on either side of the snorkeller.

6.1.1.4 Visual observations

During all field investigations visual observations were made any time a body of water was sampled or traversed. The field crew was instructed to carefully watch for fish and to record any observations of fish they made.

6.1.2 Habitat and Water Quality Survey of P Lake and Outlet

6.1.2.1 Habitat

Visual observations of underwater and shoreline substrates were recorded both within P Lake and in the outlet stream entering the small bay in Telik Inlet.

6.1.2.2 Water quality

Water quality measurements [dissolved oxygen (DO), pH, conductivity, salinity and water temperature] in P Lake were made with a hand-held pH, conductivity, salinity and temperature monitor (YSI Model 63), and a hand-held dissolved oxygen monitor (YSI Model 55)> Measurements were made once during the sampling period (August 11, 2005).

Water samples collected from the outflow stream from P Lake.

6.1.2.3 Aquatic invertebrates

Visual observations of aquatic invertebrates were made any time a body of water was sampled or traversed. No samples were collected.

6.1.3 Marine Environment

A boat was used to access Telik Inlet where the P Lake outflow stream drains into the marine environment. General habitat conditions of the Inlet were described and efforts to collect sediment sampled were attempted.

6.1.4 Photographic Record

During the site visit numerous photographs were collected so that a photographic record of the site could be developed. The locations of selected photographs are illustrated in **Figure G**.

6.2 Results

6.2.1 Fishery Survey of P Lake

6.2.1.1 Minnow Traps

Table 6.1 provides detailed information regarding the minnow trapping survey completed at P Lake. Despite over 152 hours of trapping effort, no fish were collected in any of the traps that were set.

Table 6.1 Effort and results from minnow trap sets in P Lake

Trap Number	Date Set	Time Set	Date Retrieved	Time Retrieved	Duration of set (hrs)	Number of fish captured
MT 1	Aug 11	14:00	Aug 12	09:00	19.00 hrs	0
MT 2	Aug 11	14:00	Aug 12	09:05	19.08 hrs	0
MT 3	Aug 11	14:00	Aug 12	09:10	19.17 hrs	0
MT 4	Aug 11	14:10	Aug 12	09:15	19.08 hrs	0
MT 5	Aug 11	14:15	Aug 12	09:20	19.08 hrs	0
MT 6	Aug 11	14:30	Aug 12	09:25	19.92 hrs	0
MT 7	Aug 11	15:00	Aug 12	09:30	18.50 hrs	0
MT 8	Aug 11	15:15	Aug 12	09:35	18.58 hrs	0
				Totals	**152.41 hrs**	**0 fish**

6.2.1.2 Seine Hauls

Table 6.2 provides a summary of the fish catch results from seine netting activities in P Lake. No fish were captured, or observed, during any of the seine net hauls.

Table 6.2 Effort and results of seine netting efforts in P Lake on August 11, 2005

Haul #	Date	Length of haul (m)	Number of fish captured
SH 1	Aug 11	15	0
SH 2	Aug 11	15	0
SH 3	Aug 11	20	0
SH 4	Aug 11	10	0
SH 5	Aug 11	10	0
SH 6	Aug 11	10	0
SH 7	Aug 11	20	0
Total			**0 fish**

6.2.1.3 Snorkel survey

Table 6.3 presents the results of the snorkel surveys conducted in P Lake. An estimated area of 1380 m^2, and the complete diversity of habitat types, was examined during the snorkel surveys. This area represented approximately 10.6% of the total area of the lake. It should also be noted that although the snorkel survey concentrated on 1.5 m width on either side of the snorkeller, visibility often extended beyond this width (e.g., 3+ m). No fish were observed during the completion of transects.

Table 6.3 Effort and results of snorkel surveys in P Lake during August 11, 2005.

Transect #	Date	Length of transect (m)	Width of transect (m)	Area sampled by individual transects (m^2)	Number of fish observed
T1	Aug 11	50	3.0	150	0
T2	Aug 11	70	3.0	210	0
T3	Aug 11	75	3.0	225	0
T4	Aug 11	85	3.0	255	0
T5	Aug 11	60	3.0	180	0
T6	Aug 11	120	3.0	360	0
			Total	**1380**	**0**

6.2.1.4 Visual observations

Although efforts were made to observe and record any fish that may have been made during visual bank observations, no fish were observed during the bank surveys. No attempt was made to document the level of effort expended during the bank surveys.

6.2.2 Habitat and Water Quality Survey of P Lake and Outlet

6.2.2.1 Habitat

P Lake

Substrates in P Lake were composed primarily of boulders and fractured rock (**Figure G**). Any cover which could be utilized by fish would have been provided primarily by depth, large boulders and fractured rock. Substrates at maximum depths were primarily composed of sands and fines. The north shoreline substrate was predominately fractured rock, some greater than 1-2 m diameter, (**Photo 1**), while the south shoreline substrate was a mixture of gravel with areas of sand and fines (**Photo 2**). All other shorelines consisted of rock.

No aquatic vegetation was observed in P Lake and only small amounts of algae were observed on the substrate. Caddisfly (trichopterids) and freshwater crustaceans (amphipods) were also observed in P Lake.

Outlet and Inlet of P Lake

The outlet of P Lake is characterized a small channel that drains into a small wetland area. From the wetland area, it drains through a small channel and over a large cliff forming a waterfall (**Photo 3**). Below the waterfall the outlet stream was intermittent as flow was subsurface and at times lacked a defined channel. Intermittent surface flow also continued downstream and is apparent where the channel passes through grassy/mossy area. Mean width and depth of the reaches where a defined channel occurred were approximately 0.1, and 0.05 m, respectively) (**Photo 4**). Below the grassy/mossy area, the stream again goes sub-surface and lacks a defined channel once the outlet reaches boulder cobble shoreline (**Photo 5**). **Figure G** provides a map of the shoreline and distribution of substrates in P Lake and the outlet into Telik Inlet.

The outlet stream does not provide fish access to P Lake from the ocean due to the large cliff and lack of a defined channel at several locations. Limited summer flows and conditions also suggest that the outlet stream would freeze to the bottom in winter.

The inlet stream into P Lake is best described as having a no or limited definition channel, and if fish were present in the lake, it is highly unlikely the inlet area would provide fish habitat. It would also be expected to freeze to the bottom in winter.

The mean depth and wetted widths for both the inlet and outlet streams where defined channels existed were both approximately 0.1 m, and 0.2 m, respectively.

Marine Environment

Substrates in the small bay in Telik Inlet where the P Lake outlet stream eventually drains were dominated by very clean cobble and boulders. Some algae was observed, but in limited quantities. Benthoses were not sampled due to high tide conditions, time limitations, and the coarseness of the substrate.

6.2.2.2 Water quality

Water quality measurements collected from P Lake with the hand-held YSI units are provided in **Table 6.4**. Some of the above readings, however, were unexpected (e.g., pH = 10.1 exceeds the CREM guidelines for aquatic life of 9.0), so the units were re-calibrated after being returned to Dillon's Yellowknife office. The results of the recalibrations suggested that the sensor units had been damaged in transport to Cape Dorset, and therefore, equipment malfunction is suspected and the above results collected during the present field trip should not be considered reliable.

Table 6.4 Water quality measurements collected from P Lake on August 11, 2005

Parameter measured	Measurement and units
Dissolved oxygen	3.0 mg/l
pH	10.1
Conductivity	42 microsiemens
Salinity	0.0 ppt
Temperature	10.2^{o}C

Other water samples were collected, but were not analyzed because unexpected delays in transit were encountered which exceeded the amount of time which would provide reliable analysis for some parameters (e.g., fecal coliforms).

6.3 Conclusions of Fisheries Investigations

Based on the results of the 2005 fisheries investigations, the absence of historical reports documenting fish presence in P Lake, and the presence of impassible barriers that prevent fish movement between P Lake and other fish-bearing waters, it can be concluded that P Lake is barren of fish. The intermittent flow conditions and waterfalls over the cliff indicate that fish passage into P Lake from the marine environment is impossible.

Given that the P Lake system is barren of fish, there is no reason to suggest that converting P Lake into an output lagoon is likely to cause a Harmful Alteration, Disruption or Destruction of fish habitat (HADD). If a HADD is unlikely, a Federal Fisheries Act Authorization for a HADD will not be required.

7 THE IMPACT OF THE DEPOSIT OF WASTE

The waste deposited will adversely impact the water quality of P Lake. The due to the organic, solids and nutrient loading that will result from the sewage effluent, it is likely that P -Lake and the P-Lake basin will under go a number of changes. In other Nunavut locations where sewage effluent his discharged to the land there is an increase in vegetation growth. In particular sedges and grasses become the dominant flora.

Water quality in P-Lake will change as well. The water will carry a higher sediment (TSS) loading, particularly during lagoon discharge. The increase in organic loading, and increase in nutrient will likely result in an increase in algae growth during the open water season.

In other locations (Chesterfield Inlet as an example) the wetlands area down gradient of the sewage treatment cell is a primary staging area for water fowl and snow geese. This appears to occur for a number of reasons, two of which are; the prevalence of the sedges and grass attract the migratory birds

that use the vegetation as forage; and there are areas of ponded water that open earlier in the spring and remain open longer in the fall that adjacent ponds. It is expected that there may be an increase in water fowl in the P-Lake basin as the impacts from the sewage discharge impact and change the P -Lake Basin.

8 COMPENSATE PERSONS, INCLUDING THE DESIGNATED INUIT ORGANIZATION, WHO ARE ADVERSELY AFFECTED BY THE DEPOSIT OF WASTE

During the community meetings and public presentations there were no identified Inuit persons or organizations impacted by the proposed works. The communities, through several council resolutions, support the proposed sewage treatment facility.

9 MONITOR THE IMPACT OF THE DEPOSIT OF WASTE

A key component to the operations and maintenance of the proposed sewage treatment system is a sampling program. Dillon has developed the following sampling program to:

- Monitor treatment and verify compliance to regulations; and
- Model and understand the treatment process to aid with future expansions of the system.

The proposed sampling program will address the water quality on a temporal basis, the cumulative impacts to the plants and soil, and allow for trending of the data to see if we reach a stasis point after several years of treatment. The sampling program should be undertaken by the community as part of the annual operations.

9.1 Sampling Protocol

It is estimated that 8 sample locations will be required to document conditions along the effluent path:

- Control;
- Lagoon inflow;
- Lagoon effluent;
- P-Lake effluent;
- Wetlands effluent; and
- 3 taken along wetlands (between P-Lake discharge and outlet).

Water samples would be taken weekly, during periods of open water. With these sample locations, each stage of the treatment process would be noted, with emphasis on the wetlands area. This sampling

protocol would need to be conducted over several years, to obtain data for trend analysis. It could be scaled down after the first year, to remove sample locations that are not considered essential (i.e. lagoon inflow, along wetlands flow path).

As recommended in Dillon's "Sewage Treatment Using Tundra Wetlands" report (1997), a site specific ecological study of the wetland system should be undertaken, to identify and characterize the plant species in the wetland system. If this is conducted before discharging sewage to the wetland and for a few subsequent years, it could be used to monitor changes in the plant species with time. A minimum of two plots is recommended, located along the wetlands channel, and one control plot. Data would be collected twice during the growing season, late June (early stages of growth) and early-August (peak growth). This should be conducted by trained biologists, made up of the same team each season, to ensure consistency. No sample analysis is required, as data collection and logging is done in the field, by trained personnel. Costs would include the time and disbursements to send biologist(s) to site to conduct survey, twice/year.

Cumulative impacts to the soil have not been addressed in the above program. Sediment sampling could occur, if desired, at various locations along the wetlands. Deposition rate could be measured, or sediment samples could be analyzed themselves, for various parameters. These options could be explored further, if desired.

Table 9.1: Analytical Parameters and Costs for Water Sampling

Parameter	Analytical Cost*
BOD_5	$21.60
Fecal coliforms	$11.20
Total suspended solids	$8.80
Ammonia nitrogen	$12.80
Total phosphorus	$14.40
Total (per sample)	$68.80

*Based on prices from Accutest Laboratories in Ottawa

For 8 samples, the total cost would be: $550.40 + GST

For weekly samples, over 10 weeks, the total cost would be: $5504.00 + GST

9.2 Sample Shipment

If samples are taken early Tuesday or Thursday mornings, they can be shipped on the 11 am First Air flight to Iqaluit. There is a 6 pm freighter from Iqaluit to Ottawa on Tues/Thurs. Coolers can be delivered/picked-up first thing Wednesday or Friday morning to/by Accutest.

According to Accutest, FC samples need to be analyzed within 48 hours, and BOD_5 samples need to be analyzed within 7 days of sampling. For both parameters, 24 hours is preferred between sampling and analysis, but not required.

Shipping costs are approximately $140 (general) and $180 (priority). Regular shipping should be sufficient to make the Iqaluit connection, but it could be sent priority just in case.

9.3 Sampling Equipment

Sample bottles and coolers will be sent to the community by Accutest. Latex gloves will be required for each sample. If a boat was available, samples could be taken from the middle of the wetlands.

Cost of latex gloves for the summer: $80.00

10 OPTIONS AVAILABLE FOR THE DEPOSIT OF WASTE

The site selection process completed over a number of years included the investigation into a number of sites and applicable technologies. Previously registered with the NWB are the selection process and the consultation undertaken by the GN to involve the community in the selection process. It is understood that the selection of the proposed site is consistent with the process and selection requirements of the NWB.

11 ASSESSMENT OF THE REQUIREMENTS OF THE NUNAVUT WATER BOARD

The description of the deposit of waste

This information is available and described in Section 5 of this report.

The qualitative and quantitative effects of the deposit of waste on the drainage basin.

This has been under taken. The effluent from the lagoon is described for quantity and quality. We have undertaken to describe the expected treatment rates of the sewage lagoon. Environmental impacts are described for the P- Lake basin.

The measures the applicant proposes to take to avoid or mitigate any adverse impact of the deposit of waste

The application of best practices to the development to the lagoon treatment system is the means that the GN and the designers undertook to mitigate against adverse impacts. The use of an annual storage lagoon is described as one of the best practices by the INAC document.

The design elements have used standard engineering practices and reviewed by the geotechnical engineer.

> The measures the applicant proposes to take to compensate persons, including the designated Inuit organization, who are adversely affected by the deposit of waste.

The background work completed by the GN undertook several community consultations. The community is supportive of the proposed systems and the location of the proposed system and discharge location. There has been no impacted Inuit or Inuit organization identified during the consultation, and as such no compensation requirements have been identified.

> The program the applicant proposes to undertake to monitor the impact of the deposit of waste.

A monitoring program is required. In Section 7 we outline the propose monitoring program for the system.

> The options available for the deposit of waste.

The background documents include the reporting on the selection process. We understand that this process has been accepted by the NWB.

> Effluent standards that are prescribed by the regulations or, in the absence of such regulations, that the Board considers acceptable; and

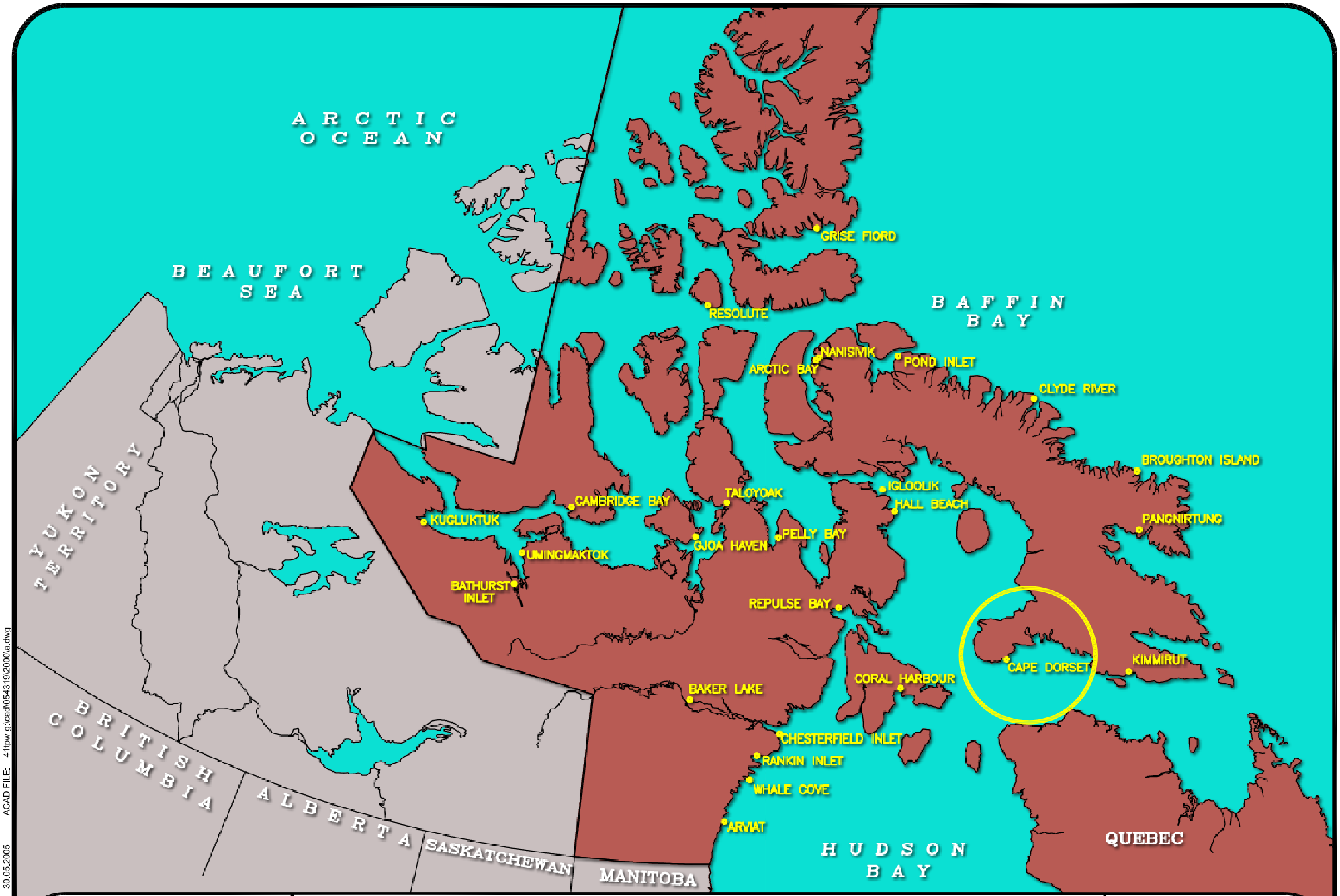
The proposed system will meet the current regulations at the point of discharge from the lagoon, and at the marine receiving environment.

> Financial responsibility of the applicant

Hamlet of Cape Dorset will look after.

APPENDIX A

FIGURES



EDIT DATE: 30.05.2005 ACAD FILE: 41tpw g:\cad\05431912000la.dwg

DILLON CONSULTING

PROJECT	Cape Dorset Sewage Treatment System
TITLE	Cape Doset Location Plan
PROJECT NUMBER	05-4319-2000
DATE	May 05
FIGURE NUMBER	A

EDIT DATE: 30.05.2005 ACAD FILE: 41tpw g:\cad\054319\2000\b.dwg

DILLON CONSULTING

PROJECT
Cape Dorset
Sewage Treatment System

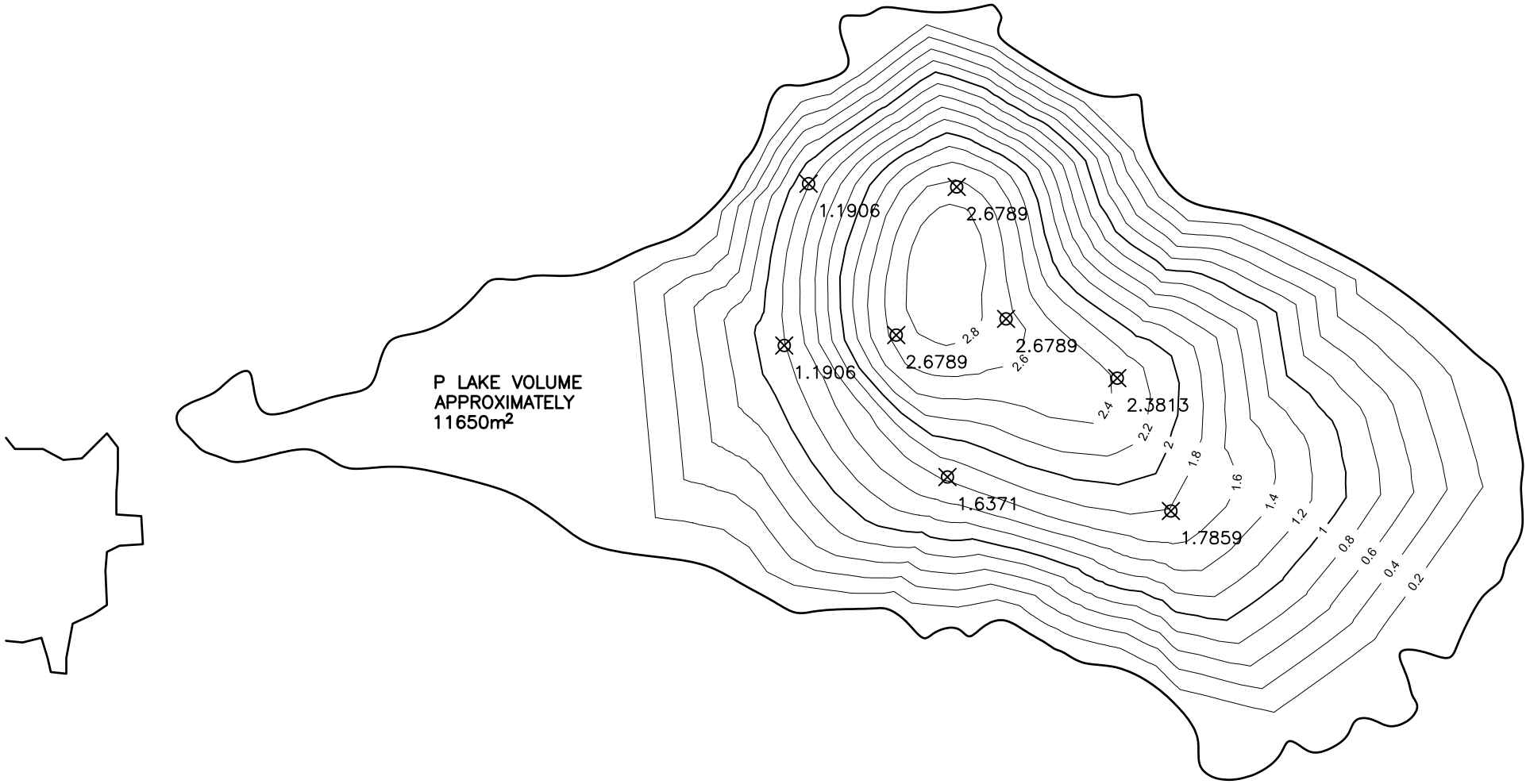
TITLE
Community Layout and Alternative Sites

PROJECT NUMBER
05-4319-2000

DATE
May 05

FIGURE NUMBER
B

SCALE 1:1000



NOTE: ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE.

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DILLON CONSULTING

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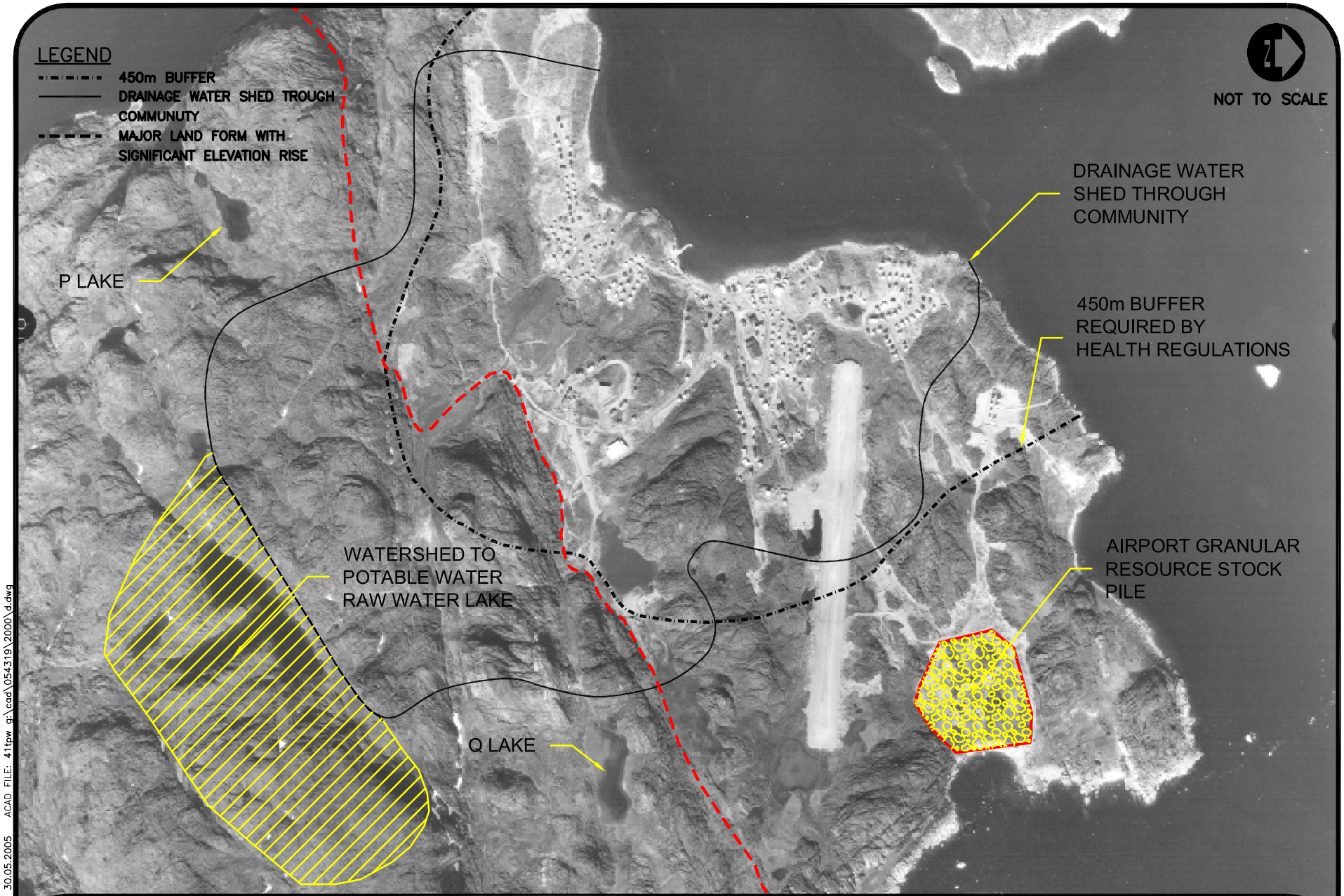
TITLE	Bathymetry of Lake – P
PROJECT NUMBER	05–4319–2000
DATE	June 05
FIGURE NUMBER	C



EDIT DATE: 30.05.2005 ACAD FILE: 41tpw g:\cad\054319\2000\d.dwg

DILLON CONSULTING

PROJECT
Cape Dorset
Sewage Treatment System

TITLE
Constraint Map – Community Water Shed and 450m Setback

PROJECT NUMBER
05-4319-2000

DATE
June 05

FIGURE NUMBER
D

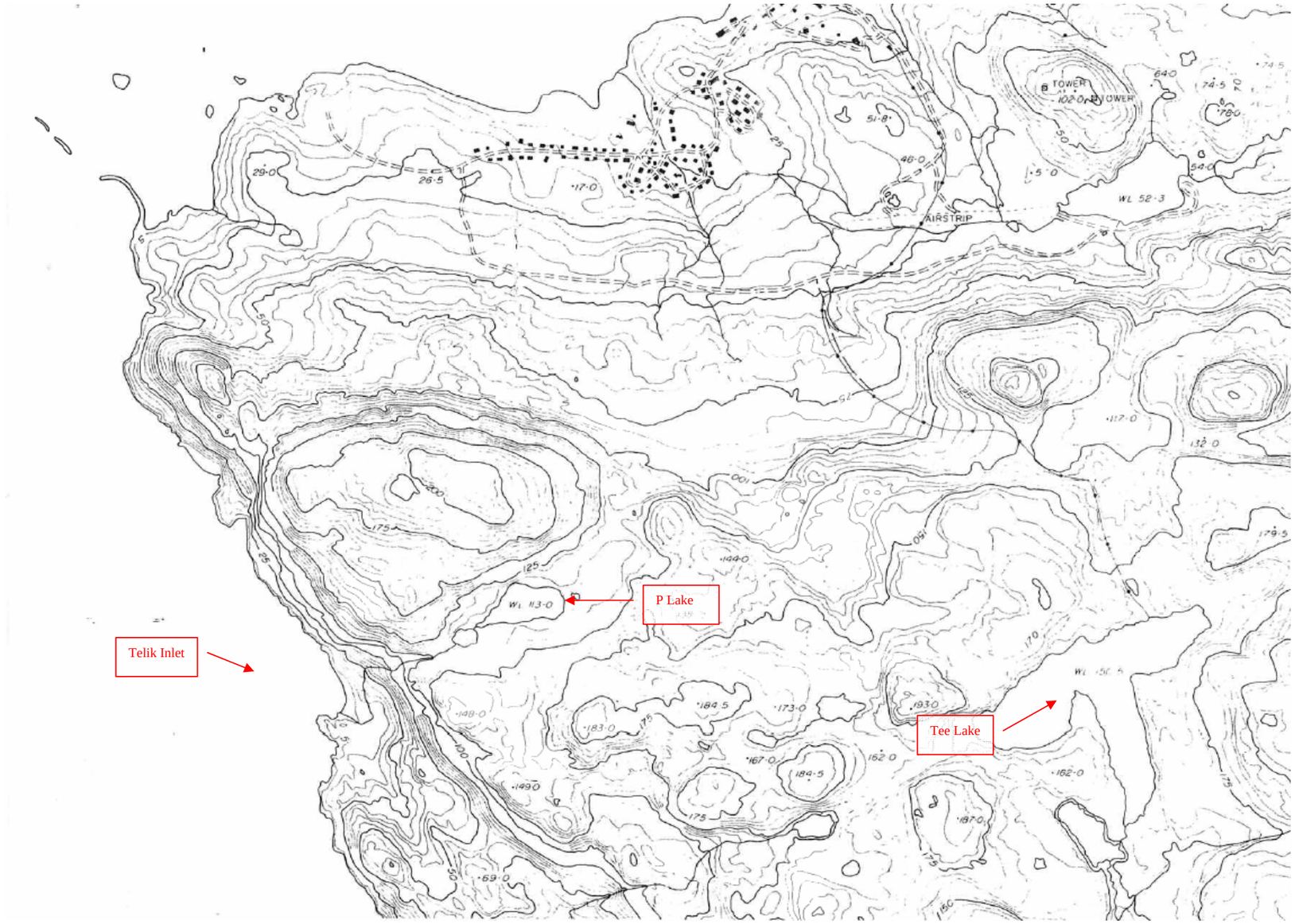


Figure E Topographic Map

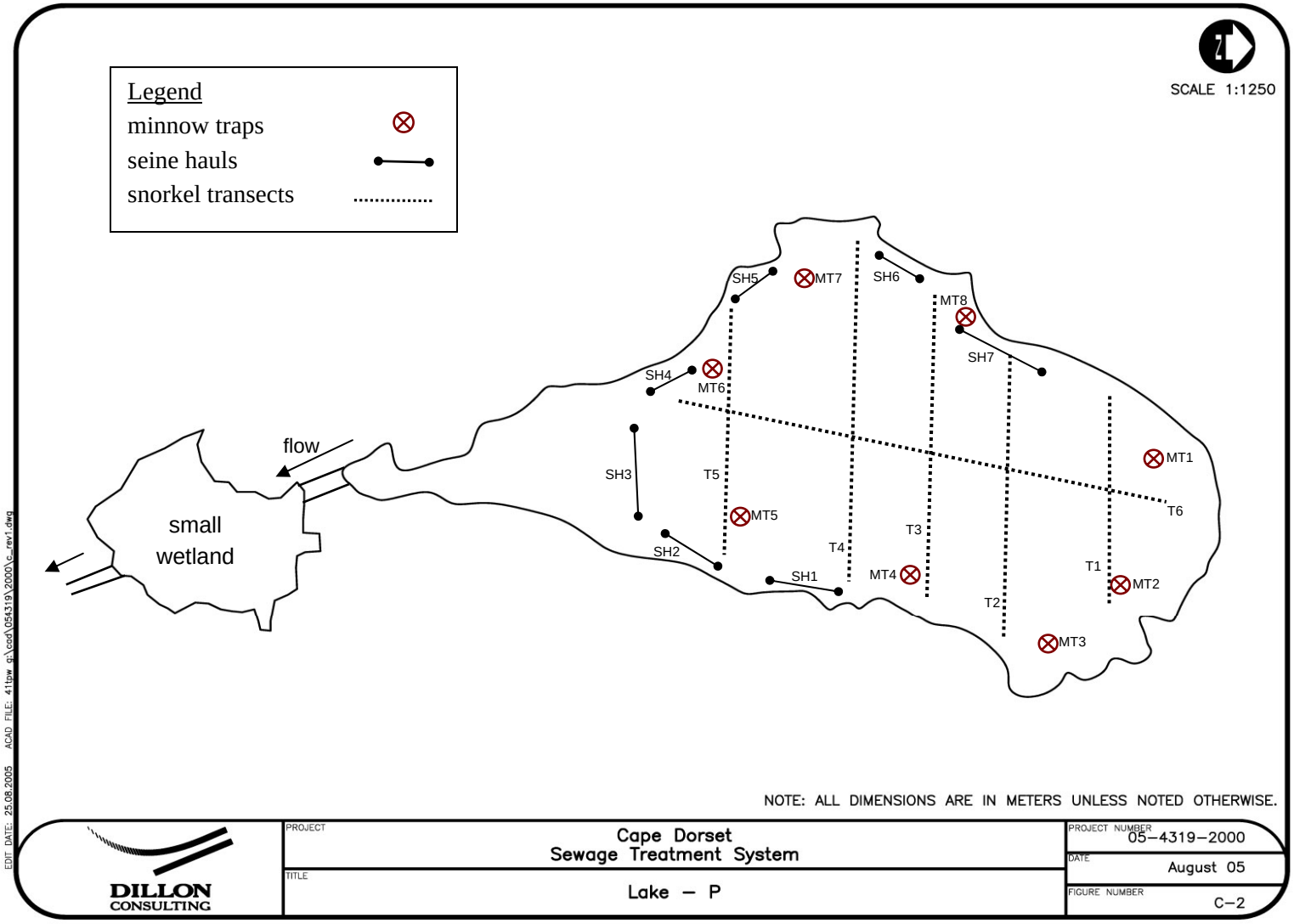


Figure F. Map showing locations of minnow trap sets, seine hauls and snorkel survey transects in P Lake.

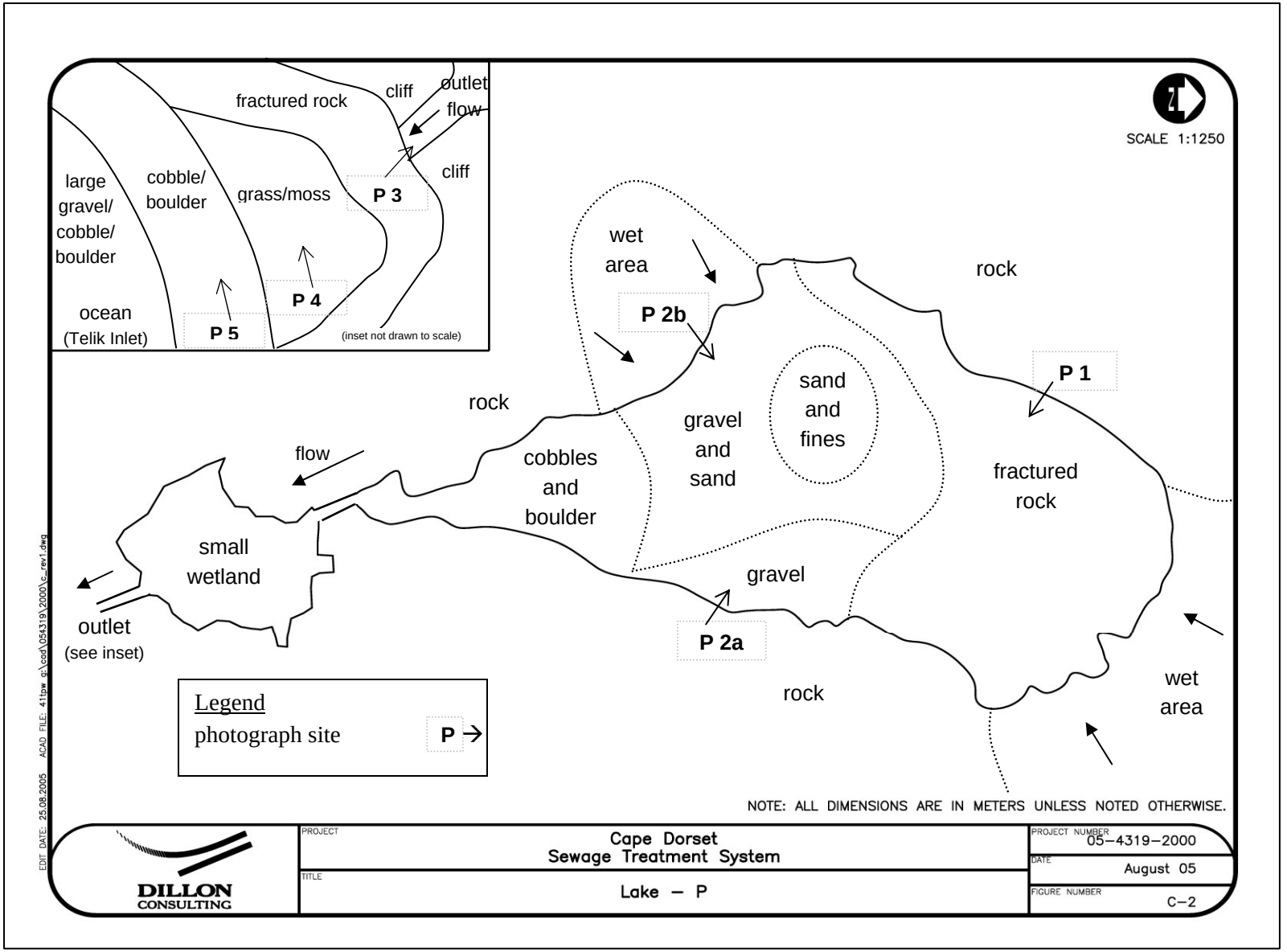


Figure G. Map showing shoreline and underwater substrate conditions in P Lake and the outlet into Telik Inlet (inset).

EDIT DATE: 30.05.2005 ACAD FILE: 41pw gt\cad\0543192000\e.dwg

DILLON CONSULTING

PROJECT	Cape Dorset Sewage Treatment System
TITLE	Proposed Lagoon and Road
PROJECT NUMBER	05-4319-2000
DATE	June 05
FIGURE NUMBER	H

APPENDIX B

PHOTOS

Photo 1. Substrate of north shoreline.

Photo 2a and 2b. Substrate of south shoreline.

Photo 3. Path of outlet stream over large cliff. Photo taken from base of cliff.

Photo 4. Path of outlet stream through mossy area at base of large cliff. Photo taken from bay.

Photo 5. Cobble/boulder substrate at shoreline of Telik Inlet.

APPENDIX C

P LAKE WATER SHED CALCULATIONS

Tributary Area & Runoff Calculations

Condition: 10 Year Return Period
Location: "P" Lake Catchment area (Cape Dorset)

Date: 14-Apr-05
P.O.C. P Lake

Area No.	Cover or Dev. State	Approx. Grade (%)	Area (m^2)	Area (ha)	R*	A X R	Comments:
1	Undeveloped	34	118507	11.85	0.85	10.0731	Steep, solid rock
2	Undeveloped	4	108010	10.80	0.50	5.4005	Flat. Silt-soil. Storage
3	Undeveloped	30	67303	6.73	0.80	5.3842	Steep. Channeled rock
4	Undeveloped	10	58242	5.82	0.70	4.0770	Moderate, small storage
		∑Areas=	352063	35.21	Total ∑AXR=	24.9348	

* R values were estimated using Table 2-26 "Watershed Characteristics for Determining Runoff Coefficinent..." (U.S. Soil Conservation Service)

Tc=Ts + Tr where,

Ts=Saturation Time (Inlet Time)
Tr=Running or system flow time

NOTE: For frozen or highly impervious surfaces, the value for Ts is near zero (0).

Method of Tr determination: Overland Flow Nomograph
Drop from Remote Point to Outlet: **25** m (From Topographic Map) Average Slope (%) = 5.2
Length of Overland Travel: **480** m (AutoCAD drawing - Figure 6)
Time Correction Factor: **1** (For Bare Earth)

Tr = **13** minutes (Overland Flow Nomograph)

Preliminary check: Velocity (average) = L/t **0.615 m/s**

CALCULATED FLOW (Qc):

Qc = (A · R · I) / 360 = (Total AR · I) / 360

Return Period: **10 years**
Drainage Area: **35.2** (AutoCAD drawing - Figure 6)
Total AR: **24.9** (See above)
Running Time (Tr): **7** (Overland Flow Nomograph - attached)
Saturation time (Ts): **3** (near 0 for frozen/impervious surfaces)
Concentration Time (Tc): **10** (minutes)
Intensity: **18** (mm/hr) - IDF curves for Cape Dorset

$$Q_{10} = \frac{24.9 \times 18}{360}$$

Q_{10} = **1.2467 m^3/s**

DESIGN FLOW:

$Q_d = Q_{10} \cdot (1+A\%)(1+R\%)(1+I\%)(FOS)$

Where: FOS 0.10
A%= 0.05
R%= 0.20
I%= 0.05

Q_d= 1.81 m^3/s

Cape Dorset A, NU WATER BUDGET MEANS FOR THE PERIOD 1980-1993

P' LAKE CATCHMENT AREA CALCULATIONS

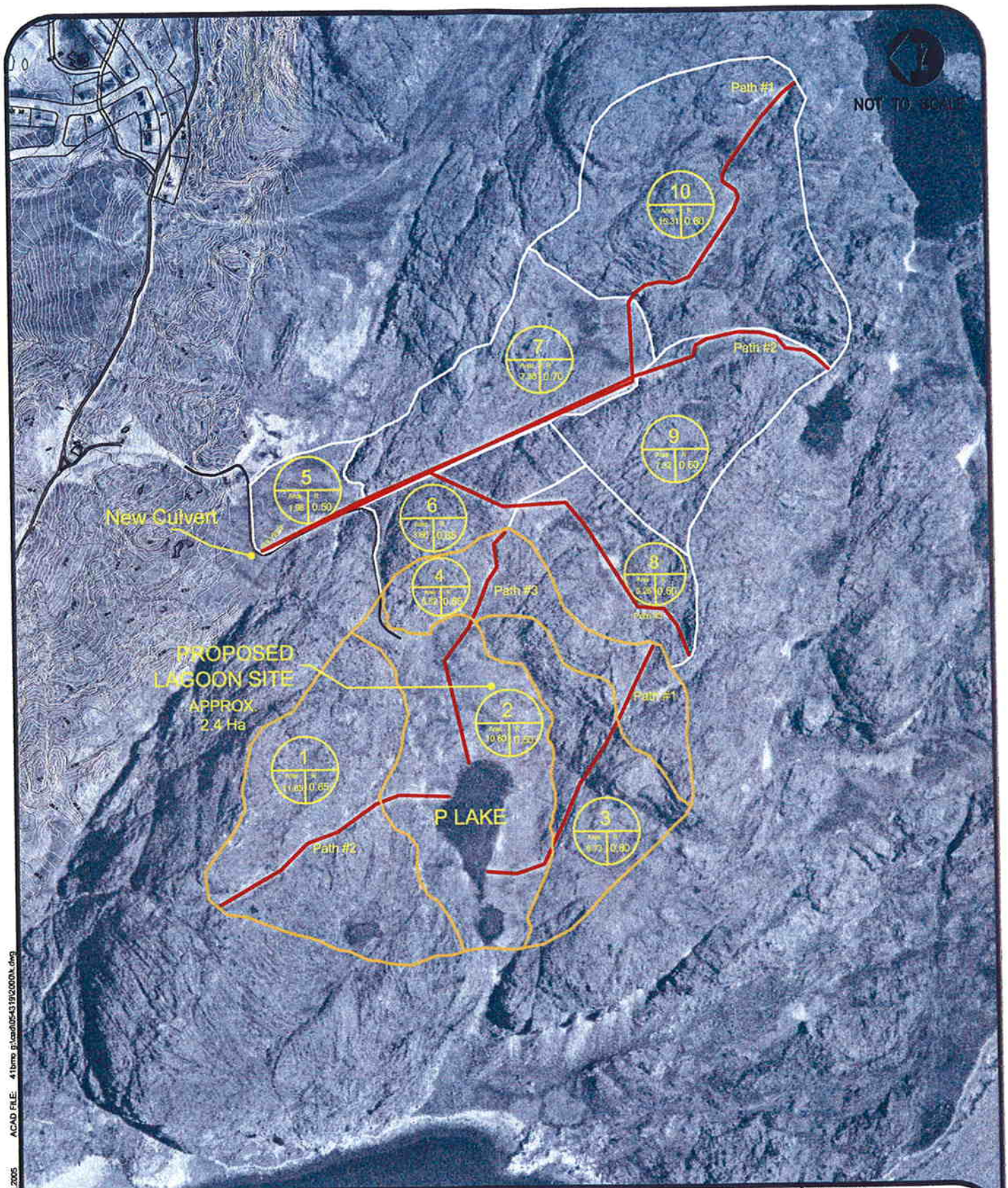
LAT.... 64.23 WATER HOLDING CAPACITY... 5 MM HEAT INDEX... 3.42
LONG... 76.53 LOWER ZONE..... 3 MM A..... .553

MONTH	TEMP °C	PCPN	RAIN	MELT	PE	AE	DEF	SURP	SNOW	SOIL	ACC P	AREA (m3)	AREA (ha)	AVRG Q (m^3/week)	AVRG Q (m^3/day)	AVRG Q (m^3/hr)	AVRG Q (m^3/sec)	AVRG Q (L/min)
01-Jan	-24	4	0	0	0	0	0	0	94	5	113	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-Jan	-24.9	5	0	0	0	0	0	0	99	5	117	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-Jan	-24.3	6	0	0	0	0	0	0	105	5	123	352063	35.21	0.00	0.00	0.00	0.0000	0.00
04-Jan	-25.4	3	0	0	0	0	0	0	109	5	127	352063	35.21	0.00	0.00	0.00	0.0000	0.00
01-Feb	-27.3	4	0	0	0	0	0	0	112	5	131	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-Feb	-26	2	0	0	0	0	0	0	114	5	133	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-Feb	-25.5	6	0	0	0	0	0	0	120	5	139	352063	35.21	0.00	0.00	0.00	0.0000	0.00
04-Feb	-24.5	5	0	0	0	0	0	0	125	5	144	352063	35.21	0.00	0.00	0.00	0.0000	0.00
01-Mar	-25.4	3	0	0	0	0	0	0	128	5	146	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-Mar	-23.6	6	0	0	0	0	0	0	134	5	153	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-Mar	-22.9	4	0	0	0	0	0	0	138	5	157	352063	35.21	0.00	0.00	0.00	0.0000	0.00
04-Mar	-20.4	5	0	0	0	0	0	0	143	5	161	352063	35.21	0.00	0.00	0.00	0.0000	0.00
01-Apr	-18.5	5	0	0	0	0	0	0	148	5	166	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-Apr	-18.4	5	0	0	0	0	0	0	153	5	171	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-Apr	-16.7	7	0	0	0	0	0	0	160	5	177	352063	35.21	0.00	0.00	0.00	0.0000	0.00
04-Apr	-13.9	8	0	0	0	0	0	0	168	5	184	352063	35.21	0.00	0.00	0.00	0.0000	0.00
05-Apr	-10.6	6	0	0	0	0	0	0	173	5	189	352063	35.21	0.00	0.00	0.00	0.0000	0.00
01-May	-8.9	8	0	0	0	0	0	0	182	5	197	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-May	-7.7	6	0	0	0	0	0	0	188	5	204	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-May	-5.6	4	0	4	1	1	0	3	188	5	209	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
04-May	-3.7	8	1	6	2	2	0	5	189	5	217	352063	35.21	1760.31	251.47	10.48	0.0029	174.63
01-Jun	-1.3	8	2	18	4	4	0	15	177	5	224	352063	35.21	5280.94	754.42	31.43	0.0087	523.90
02-Jun	-0.1	7	5	14	5	5	0	15	164	5	231	352063	35.21	5280.94	754.42	31.43	0.0087	523.90
03-Jun	1.6	5	5	32	13	12	0	25	133	4	236	352063	35.21	8801.57	1257.37	52.39	0.0146	873.17
04-Jun	3.3	5	4	59	21	18	-4	46	75	4	242	352063	35.21	16194.89	2313.56	96.40	0.0268	1606.64
01-Jul	5.7	3	3	59	29	18	-11	45	16	3	245	352063	35.21	15842.82	2263.26	94.30	0.0262	1571.71
02-Jul	6.3	6	6	10	31	12	-19	6	6	1	251	352063	35.21	2112.38	301.77	12.57	0.0035	209.56
03-Jul	8.4	5	5	6	35	7	-28	5	0	0	257	352063	35.21	1760.31	251.47	10.48	0.0029	174.63
04-Jul	7.6	8	8	0	32	8	-25	0	0	0	265	352063	35.21	0.00	0.00	0.00	0.0000	0.00
05-Jul	7.8	11	11	0	32	11	-20	0	0	0	275	352063	35.21	0.00	0.00	0.00	0.0000	0.00
01-Aug	6.3	8	8	0	27	8	-19	0	0	0	283	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-Aug	6.3	14	14	0	26	13	-13	1	0	1	297	352063	35.21	352.06	50.29	2.10	0.0006	34.93
03-Aug	6	16	16	0	24	13	-11	3	0	1	314	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
04-Aug	5.3	17	17	0	21	11	-10	6	0	2	331	352063	35.21	2112.38	301.77	12.57	0.0035	209.56
01-Sep	3.7	15	15	0	16	9	-7	6	0	2	347	352063	35.21	2112.38	301.77	12.57	0.0035	209.56
02-Sep	3.3	11	11	0	14	8	-7	3	0	2	358	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
03-Sep	1.9	6	6	1	10	4	-5	2	0	2	365	352063	35.21	704.13	100.59	4.19	0.0012	69.85
04-Sep	0.7	17	16	0	6	5	-1	9	1	4	382	352063	35.21	3168.56	452.65	18.86	0.0052	314.34
05-Sep	-1.4	7	5	0	2	2	0	3	3	4	390	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
01-Oct	-2.3	9	4	1	1	1	0	3	8	5	10	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
02-Oct	-2.9	8	2	2	0	0	0	3	12	5	18	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
03-Oct	-4.6	10	1	1	0	0	0	2	19	5	28	352063	35.21	704.13	100.59	4.19	0.0012	69.85
04-Oct	-5.8	10	2	2	0	0	0	3	26	5	39	352063	35.21	1056.19	150.88	6.29	0.0017	104.78
01-Nov	-8.4	7	0	0	0	0	0	1	33	5	46	352063	35.21	352.06	50.29	2.10	0.0006	34.93
02-Nov	-9.5	12	0	0	0	0	0	0	45	5	58	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-Nov	-13.7	10	0	0	0	0	0	0	54	5	68	352063	35.21	0.00	0.00	0.00	0.0000	0.00
04-Nov	-13.7	13	0	0	0	0	0	0	67	5	80	352063	35.21	0.00	0.00	0.00	0.0000	0.00
01-Dec	-14.8	7	0	0	0	0	0	0	74	5	87	352063	35.21	0.00	0.00	0.00	0.0000	0.00
02-Dec	-18.3	5	0	0	0	0	0	0	79	5	92	352063	35.21	0.00	0.00	0.00	0.0000	0.00
03-Dec	-20.2	6	0	0	0	0	0	0	86	5	99	352063	35.21	0.00	0.00	0.00	0.0000	0.00
04-Dec	-22.4	7	0	0	0	0	0	0	93	5	106	352063	35.21	0.00	0.00	0.00	0.0000	0.00
05-Dec	-24.2	6	0	0	0	0	0	0	99	5	112	352063	35.21	0.00	0.00	0.00	0.0000	0.00

Cape Dorset

STANDARD DEVIATIONS FOR THE PERIOD 1980 - 1993

MONTH	TEMP °C	PCPN	RAIN	MELT	PE	AE	DEF	SURP	SNOW	SOIL	ACC P
01-Jan	4.3	2	0	0	0	0	0	0	38	1	26
02-Jan	3.8	3	0	0	0	0	0	0	37	1	27
03-Jan	4.3	4	0	0	0	0	0	0	38	1	28
04-Jan	5.9	3	0	0	0	0	0	0	38	1	28
01-Feb	3.5	3	0	0	0	0	0	0	40	1	29
02-Feb	5.5	1	0	0	0	0	0	0	40	1	29
03-Feb	4.3	3	0	0	0	0	0	0	40	1	30
04-Feb	4.7	4	0	0	0	0	0	0	40	1	30
01-Mar	6	3	0	0	0	0	0	0	40	1	31
02-Mar	5.2	6	0	0	0	0	0	0	43	1	33
03-Mar	4.3	3	0	0	0	0	0	0	44	1	34
04-Mar	5.5	4	0	0	0	0	0	0	43	1	34
01-Apr	4.6	4	0	0	0	0	0	0	44	1	35
02-Apr	2.4	4	0	0	0	0	0	0	44	1	36
03-Apr	3.7	6	0	0	0	0	0	0	45	1	37
04-Apr	3.9	7	0	0	0	0	0	0	45	1	40
05-Apr	3.8	5	0	0	0	0	0	0	44	1	40
01-May	2.2	7	0	0	0	0	0	0	50	1	46
02-May	2.9	6	0	1	0	0	0	0	53	1	49
03-May	3.4	3	1	11	3	3	0	9	58	1	51
04-May	2.8	8	2	11	3	3	0	9	60	1	48
01-Jun	2.1	6	3	28	7	7	0	23	82	0	51
02-Jun	1.1	7	7	17	5	5	0	15	87	0	48
03-Jun	2.2	8	8	23	9	8	1	17	94	2	52
04-Jun	1.6	6	5	39	7	8	8	31	86	2	51
01-Jul	1.9	4	4	67	6	13	14	55	50	3	51
02-Jul	1.4	9	9	26	4	10	11	23	24	2	51
03-Jul	2.9	5	5	24	7	8	13	19	0	1	51
04-Jul	2.4	8	8	0	6	6	11	1	0	1	50
05-Jul	2	9	9	0	5	8	11	0	0	0	53
01-Aug	1.5	7	7	0	4	7	9	0	0	0	52
02-Aug	2	10	10	0	4	8	11	2	0	2	55
03-Aug	1.8	14	14	0	4	8	11	7	0	2	53
04-Aug	1.9	19	19	0	4	8	10	14	0	2	61
01-Sep	1.7	15	15	0	4	6	9	10	0	2	63
02-Sep	1.4	11	11	0	4	6	8	6	0	2	65
03-Sep	1.8	7	7	2	5	3	6	4	0	2	63
04-Sep	1.5	12	10	0	4	4	2	8	4	2	66
05-Sep	1.9	6	6	1	3	3	1	5	4	2	64
01-Oct	1.6	7	5	2	2	2	0	4	7	1	7
02-Oct	1.5	5	2	2	1	1	0	4	11	1	7
03-Oct	2.1	7	3	4	1	1	0	4	11	1	10
04-Oct	3.1	6	4	5	1	1	0	9	16	1	11
01-Nov	4	4	1	1	0	0	0	1	18	1	12
02-Nov	3.1	6	0	0	0	0	0	0	17	1	11
03-Nov	3.8	8	0	0	0	0	0	0	23	1	17
04-Nov	3.2	7	0	0	0	0	0	0	27	1	21
01-Dec	4.5	4	0	0	0	0	0	0	27	1	22
02-Dec	5.1	3	0	0	0	0	0	0	26	1	21
03-Dec	5.4	4	0	0	0	0	0	0	27	1	22
04-Dec	4.4	5	0	0	0	0	0	0	28	1	24
05-Dec	4.4	6	0	0	0	0	0	0	28	1	26



DILLON CONSULTING

PROJECT	Cape Dorset Sewage Treatment System
TITLE	Lake - P and Lagoon Site Catchment Areas
PROJECT NUMBER	05-4319-2000
DATE	May 05
FIGURE NUMBER	K

EDIT DATE: 30.05.2005 ACAD FILE: 41bmp p:\ae\05431920001k.dwg

APPENDIX D

COMMUNITY POPULATION PROJECTIONS

Nunavut: Community Population Projections

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Nunavut	27,688	28,410	29,154	29,885	30,601	31,317	32,036	32,774	33,530	34,311	35,114
Arctic Bay	730	747	763	782	801	819	837	855	876	894	916
Arviat	1,690	1,736	1,784	1,833	1,883	1,929	1,982	2,033	2,088	2,142	2,198
Baker Lake	1,470	1,501	1,534	1,563	1,594	1,624	1,655	1,683	1,712	1,745	1,777
Bathurst Inlet	X	X	X	X	X	X	X	X	X	X	X
Bay Chimo	X	X	X	X	X	X	X	X	X	X	X
Cambridge Bay	1,418	1,449	1,484	1,517	1,550	1,581	1,609	1,642	1,679	1,715	1,752
Cape Dorset	1,213	1,240	1,268	1,298	1,327	1,354	1,382	1,412	1,441	1,471	1,501
Chesterfield Inlet	372	382	391	401	409	420	431	443	452	465	476
Clyde River	771	789	812	830	848	867	890	913	937	959	982
Coral Harbour	845	865	888	911	933	955	978	1,003	1,024	1,049	1,078
Gjoa Haven	984	1,005	1,023	1,045	1,063	1,084	1,102	1,117	1,136	1,154	1,173
Grise Ford	145	146	147	146	146	147	149	151	151	153	155
Hall Beach	635	656	677	696	714	734	754	771	790	810	829
Igloolik	1,379	1,417	1,456	1,495	1,529	1,562	1,594	1,627	1,660	1,701	1,736
Iqaluit	4,762	4,930	5,108	5,278	5,438	5,606	5,768	5,936	6,108	6,289	6,477
Kimmirut	450	461	474	485	496	506	519	530	546	560	573
Kugaaruk	582	601	616	631	648	664	682	701	719	737	756
Kugluktuk	1,389	1,422	1,456	1,490	1,522	1,556	1,585	1,618	1,653	1,686	1,720
Nanisivik	230	225	224	226	225	223	222	220	221	221	220
Pangnirtung	1,506	1,539	1,575	1,613	1,651	1,687	1,722	1,756	1,792	1,831	1,870
Pond Inlet	1,314	1,361	1,405	1,443	1,489	1,532	1,574	1,624	1,668	1,714	1,761
Qikiqtarjuaq	522	537	551	566	582	599	614	629	641	654	668
Rankin Inlet	2,277	2,327	2,376	2,432	2,483	2,527	2,576	2,629	2,683	2,734	2,791
Repulse Bay	615	630	648	664	682	702	720	738	757	777	797
Resolute Bay	243	246	247	249	251	253	252	255	257	260	263
Sanikiluaq	702	722	740	758	776	796	816	834	853	873	896
Taloyoak	804	825	847	866	886	904	925	947	968	992	1,016
Whale Cove	312	321	328	336	344	351	358	367	378	388	397

Notes: Population projections produced by Statistics Canada and the Nunavut Bureau of Statistics include people in the population who are residents of Nunavut and do NOT have a home elsewhere in Canada from which they are temporarily absent. Therefore, temporary residents such as construction crews, residents in mining camps, etc. are not included in the population projections.

Data are suppressed for (a) communities with a population of 50 or less and (b) 'unorganized areas' -- but they are included in the Nunavut total.

Released by the Nunavut Bureau of Statistics *March 2000*

Nunavut: Community Population Projections

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Nunavut	35,114	35,937	36,773	37,619	38,471	39,335	40,217	41,106	42,001	42,904	43,824
Arctic Bay	916	939	960	980	1,003	1,019	1,033	1,049	1,065	1,078	1,094
Arviat	2,198	2,256	2,320	2,381	2,449	2,517	2,584	2,658	2,721	2,791	2,855
Baker Lake	1,777	1,808	1,843	1,882	1,918	1,957	1,996	2,036	2,072	2,108	2,148
Bathurst Inlet	X	X	X	X	X	X	X	X	X	X	X
Bay Chimo	X	X	X	X	X	X	X	X	X	X	X
Cambridge Bay	1,752	1,790	1,828	1,865	1,900	1,939	1,979	2,018	2,057	2,095	2,137
Cape Dorset	1,501	1,536	1,570	1,600	1,632	1,662	1,692	1,726	1,757	1,793	1,829
Chesterfield Inlet	476	486	498	509	519	528	539	549	563	572	583
Clyde River	982	1,007	1,028	1,050	1,072	1,095	1,121	1,144	1,167	1,190	1,214
Coral Harbour	1,078	1,101	1,128	1,158	1,187	1,219	1,250	1,281	1,312	1,345	1,376
Gjoa Haven	1,173	1,194	1,217	1,242	1,266	1,290	1,317	1,345	1,375	1,405	1,435
Grise Ford	155	157	160	160	163	165	166	168	169	172	173
Hall Beach	829	850	870	890	912	934	957	982	1,008	1,029	1,052
Igloolik	1,736	1,773	1,807	1,842	1,883	1,922	1,960	2,001	2,043	2,086	2,131
Iqaluit	6,477	6,669	6,866	7,064	7,276	7,456	7,637	7,814	7,997	8,178	8,391
Kimmirut	573	589	601	612	624	636	649	662	675	688	706
Kugaaruk	756	779	802	823	844	867	889	911	934	957	979
Kugluktuk	1,720	1,760	1,793	1,827	1,859	1,893	1,928	1,965	2,000	2,041	2,076
Nanisivik	220	218	215	215	209	205	202	200	196	195	191
Pangnirtung	1,870	1,905	1,955	1,995	2,032	2,074	2,117	2,160	2,202	2,243	2,280
Pond Inlet	1,761	1,808	1,851	1,904	1,951	1,999	2,047	2,093	2,137	2,184	2,233
Qikiqtarjuaq	668	683	697	711	724	737	752	765	780	795	811
Rankin Inlet	2,791	2,848	2,907	2,970	3,030	3,120	3,213	3,314	3,429	3,537	3,633
Repulse Bay	797	818	838	858	881	903	928	949	970	990	1,012
Resolute Bay	263	266	269	270	272	275	279	281	283	287	288
Sanikiluaq	896	918	939	963	987	1,008	1,029	1,050	1,069	1,090	1,108
Taloyoak	1,016	1,039	1,065	1,094	1,119	1,147	1,179	1,209	1,236	1,265	1,294
Whale Cove	397	405	412	422	432	442	450	458	469	481	491

Notes: Population projections produced by Statistics Canada and the Nunavut Bureau of Statistics include people in the population who are residents of Nunavut and do NOT have a home elsewhere in Canada from which they are temporarily absent. Therefore, temporary residents such as construction crews, residents in mining camps, etc. are not included in the population projections.

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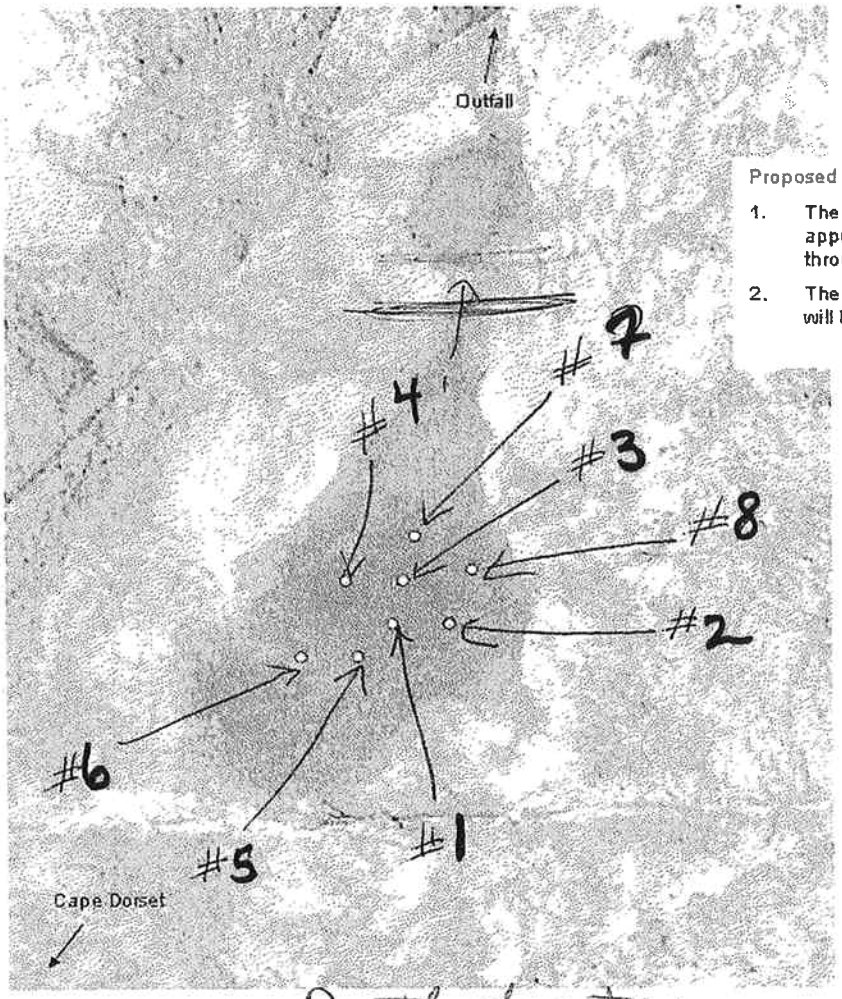
Released by the Nunavut Bureau of Statistics *March 2000*

APPENDIX E

P LAKE BATHYMETRY AND VOLUME



Proposed Drill Points:

1. The yellow spots indicate the approximate locations for drilling through the ice
2. The depth of the ice and water will be required.

P Lake

	Depth of Ice	Depth of water	Total Depth from Top to Bottom
1	4'	5'	9'
2	4'	5'	9'
3	4'	5'	9'
4	4'	1.5'	5.5'
5	4'	4'	8'
6	4'	2'	6'
7	4'	Ø	4'
8	4'	Ø	4'