P Lake Area Sewage Lagoon System

Final Design Report
January 2006

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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January 30, 2006

Department of C&GS, Capital Programs
Government of Nunavut
PO Box 100 Stn. 700
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Attention: Todd Parsons
Cape Dorset Sewage Treatment System

Dear Mr. Parsons:

Please find enclosed a copy of the Final Design Report for the Cape Dorset P- Lake Lagoon. This report includes all your comments received on the earlier submissions. In accordance with our proposal, this is the final report submission for this task.

The intent of the report is to describe all the elements of the proposed system, and develop the Class "C" Cost Estimates for the construction phase.

This report includes the information obtained from the geotechnical assessment, the fisheries assessment, and the site survey and has been updated to include your changes.

Upon your approval, we will submit the report to the Nunavut Water Board.

Yours sincerely,

DILLON CONSULTING LIMITED

Gary Strong, P. Eng.
Project Manager
Encl.
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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 C**.

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 and photos are located in **Appendix A and B**, respectively.

1.5 Design Criteria

The design criteria for this project will be completed in accordance with the parameters set out by 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 treat 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 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 2.1**. The population for 2026 was predicted to be 2002 persons.

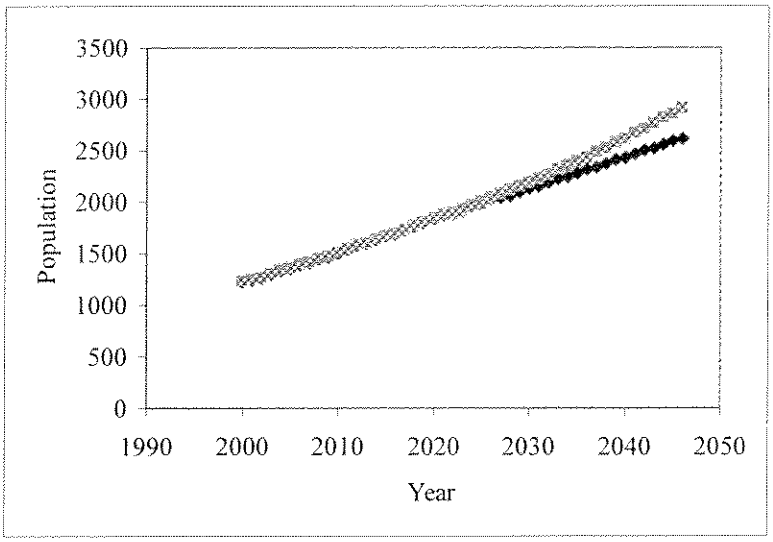

Chart 2.1: Population Growth in Cape Dorset

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. Table 2.1 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

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 4.0 of this report.

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 and the P Lake area would negatively impact the resident raven population or other wildlife of the area.

3.3 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. 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 E**). 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.**

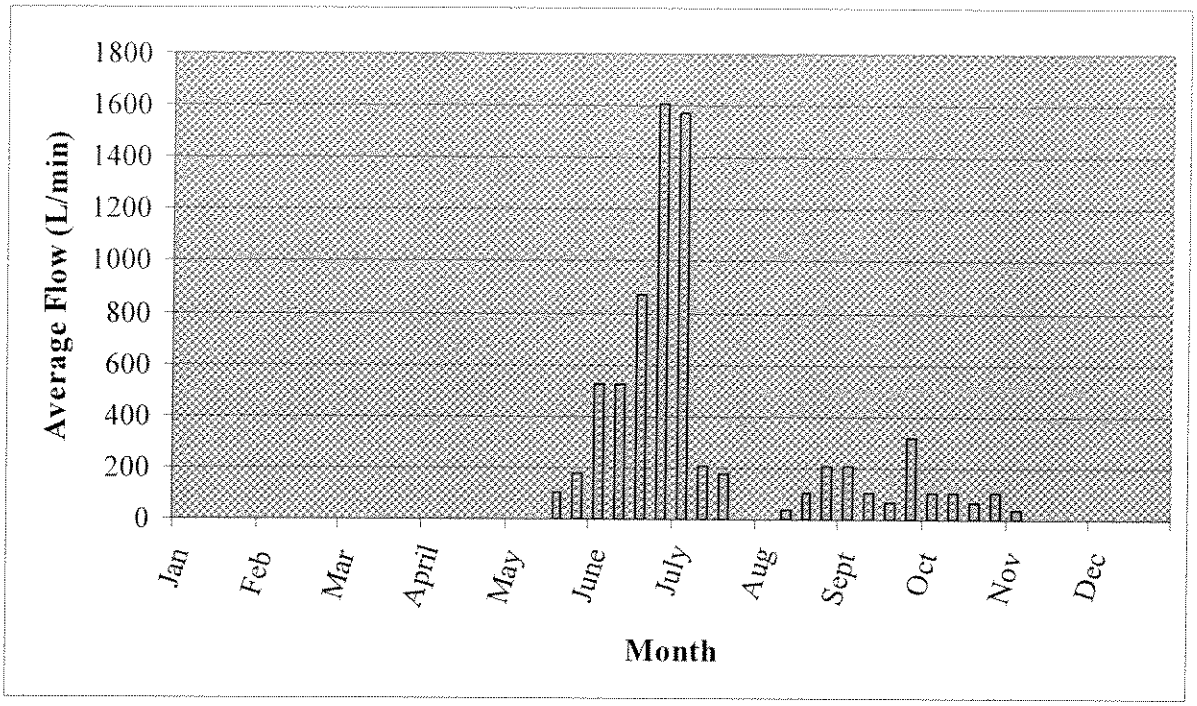

Chart 3.1 Water Recharge in P Lake

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

Chart 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 for this project, the use of P Lake itself is 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 11 667 m^3 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 in the area 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 two (2) weeks. P Lake will discharge by gravity to a small wetlands area and over a waterfall before final discharge into Telik Inlet.

The location of the lagoon treatment system at P Lake and the area east of 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 **Figure D** for an illustration of the constraint mapping for P Lake.

3.6 Groundwater Movement from P Lake

There has been some concern raised with the proposal to use P Lake and the P Lake area as the location for Cape Dorset's new sewage lagoon. The main concern is the notion that sewage may flow from P Lake lagoon to Tee Lake, the Hamlet's source of drinking water. There are several reasons why the risk of sewage contamination to the drinking water source is extremely low. These are discussed below.

3.6.1 Ground Water Movement in Permafrost

There is considerable literature on the issue of groundwater movement within the permafrost region. Much of this literature relates to the movement of contaminations within permafrost, and or the ability of the permafrost to form an impermeable barrier to the movement of the contaminant. The use of frozen core dams at northern mine sites is a common means to contain tailings. Most recently, the Government of Canada (INAC) has approved the use of passive freezing to contain 260,000 tons of arsenic trioxide dust at the Giant Mine Site in Yellowknife.

There is little documentation related to ground water movement and the permafrost in Cape Dorset. However the experiences and research available in other locations where permafrost is present can be applied at the Cape Dorset site. Most of the work associated with ground water movement in permafrost regions in Canada is completed through one of the following means;

- Primary research related to the development of an exploration or development project (mining and oil and gas sites);
- Research completed in conjunction with a University (U of Alberta and Calgary are prominent institutes involved in this area, as is the Ottawa University); or
- The Geological Surveys of Canada.

This body of research indicates that the groundwater movement in the permafrost areas can best be characterized as seasonal flow in the active layer. The active layer in Cape Dorset is expected to be to a depth of 2 to 2.5 meters. Flow within the permafrost (below the active layer) has been identified in some of the documentation. However, the flow measurements suggest that contaminants migrate at a geological pace. In these cases, flow of the contaminants follows the topography of the surface. In summary, the documentation reviewed indicates that ground water flow will be restricted to the upper 2.0 meters of the ground (within the active layer).

3.6.2 P Lake and Tee Lake Elevations

P Lake and Tee Lake are located approximately 1 km apart. As per **Drawing E**, the surface of Tee Lake is located at 150.5 metres above sea level (masl), which is significantly higher in elevation than the surface of P Lake (113.0 masl). This variance in elevation suggests that the possibility of sewage running from P Lake to Tee Lake is highly unlikely; sewage would, in essence, have to run uphill in order to reach Tee Lake. In addition, the land mass lying in between P Lake and Tee Lake is significantly higher in elevation than P Lake (183.0 masl, 184.5 masl, 184.5 masl, 193.0 masl) creating a physically impossible path for sewage to flow to Tee Lake from P Lake.

The second flow path extends north east from the P Lake. This flow path will be blocked by the construction of lagoon berms that will contain the volume of sewage discharged into P Lake.

3.6.3 P Lake Discharge

As per the pre-design report submitted by Dillon Consulting Limited (July 2005), the P Lake lagoon will be constructed in a rectilinear shape. This particular shape is used to promote plug-flow dynamics during the summer months when the sewage is not frozen. Hence, the lagoon is designed such that sewage will flow as a slug from the truck discharge point to the lagoon discharge point, towards Telik Inlet, and away from Tee Lake.

P Lake is situated approximately 500m from the shore of Tee Lake inlet. There is a steep drop off following the sewage discharge point (**Figure E**), which will promote the plug flow of sewage towards the inlet and away from Tee Lake.

Groundwater migration from the P Lake to T Lake is not supported by the available literature. Documentation reviewed as part of this review indicates that flow of contaminants will follow the topography of the land. With the construction of the berms to contain the sewage, the preferential pathway for the sewage contaminants will be directed to Telik Inlet. **Figure E** shows the topography of the area, and the relative elevations of the two lakes.

4 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, *Gasterosteus aculeatus,* and/or the ninespine stickleback, *Pungitius pungitius*).

4.1 Methods

4.1.1 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.

4.1.1.1 Minnow Traps

Minnow traps were set overnight on August 11, 2005. Minnow traps, baited with Powerbait 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).

4.1.1.2 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.

4.1.1.3 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.

4.1.1.4 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.

4.1.2 Habitat and Water Quality Survey of P Lake and Outlet

4.1.2.1 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.

4.1.2.2 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.

4.1.2.3 Aquatic invertebrates

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

4.1.3 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.

4.1.4 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**.

4.2 Results

4.2.1 Fishery Survey of P Lake

4.2.1.1 Minnow Traps

Table 4.1 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 4.1 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**

4.2.1.2 Seine Hauls

Table 4.2 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.