5 TREATMENT QUALITY

The lagoon treatment system will be designed to meet the following effluent criteria at the discharge point to Tellik Inlet:

- 45 mg/L BOD_5
- 45 mg/L SS
- 10^4 Fecal Coliform / 100mL

Dillon has taken several measures to predict treatment quality and ensure that the lagoon treatment systems effluent discharged to Tellik Inlet will meet the above criteria.

5.1 Annual Lagoon Kinetics

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

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

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:

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

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

[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.

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 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 (^oC)	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 primary lagoon will range from 9 mg/L (90 day treatment period, 7^0C) to 46 mg/L (70 day treatment period, 3^0C). The short detention lagoon (P Lake), wetlands area and outfall to Tellik Inlet will reduce this value even further to meet the effluent discharge criteria.

5.2 P Lake Lagoon Kinetics

The same kinetics used in **Section 5.1** can determine the amount of treatment that the P Lake lagoon will offer during the 14 day annual discharge of the primary lagoon. Error! Reference source not found. illustrates the effluent BOD_5 values determined for P Lake. These values were determined using equations **[2]** and **[3]** and the following parameters:

- The range of retention times determined in **Table 4.2**
- The range of BOD_5 influent values (BOD_5 effluent values from primary lagoon) determined in **Table 5.1**
- $\theta = 1.06$
- $K = 0.1\ days^{-1}$

Table 5.2: Prediction of Effluent BOD using Lagoon Kinetics (P Lake Lagoon)

t (days)	K_{20} (days^{-1})	θ	T (°C)	K (days^{-1})	C_e/C_i	C_i (mg/L)	C_e (mg/L)
3.5	0.1	1.06	5	0.042	0.8641	50	43
3.5	0.1	1.06	5	0.042	0.8641	40	35
3.5	0.1	1.06	5	0.042	0.8641	30	26
3.5	0.1	1.06	5	0.042	0.8641	20	17
3.5	0.1	1.06	5	0.042	0.8641	10	9
2.5	0.1	1.06	5	0.042	0.9009	50	45
2.5	0.1	1.06	5	0.042	0.9009	40	36
2.5	0.1	1.06	5	0.042	0.9009	30	27
2.5	0.1	1.06	5	0.042	0.9009	20	18
2.5	0.1	1.06	5	0.042	0.9009	10	9
1.5	0.1	1.06	5	0.042	0.9393	50	47
1.5	0.1	1.06	5	0.042	0.9393	40	38
1.5	0.1	1.06	5	0.042	0.9393	30	28
1.5	0.1	1.06	5	0.042	0.9393	20	19
1.5	0.1	1.06	5	0.042	0.9393	10	9

Although equation **[2]** is useful for a first look at the potential performance of the annual retention lagoon and P Lake lagoon, the equation has not been tested for it's effectiveness in modeling Northern lagoon systems. Heinke *et al*[3] studied the effectiveness of lagoon sewage treatment in the North, and tabulated predicted lagoon treatment for Northern lagoon systems (**Table 5.3**).

[3] Heinke, G.W., Smith, D. W., Finch, G.R. (1991) Guidelines for the planning and design of wastewater lagoon systems in cold climates. *Canadian Journal of Civil Engineering,* 18(4) 556-567.

Table 5.3: Expected Performance of Lagoon Treatment of Municipal Type Wastewaters for Lagoon Systems

Parameter	Short Detention (% Reduction)	Long Detention (% Reduction)
Summer		
BOD_5	40	80
Suspended Solids	50	80
Fecal Coliform	60	99.9
Winter		
BOD_5	40	50
Suspended Solids	60	50
Fecal Coliform	70	80

Based on this data, the primary annual detention lagoon will reduce the influent 625 mg/L BOD_5 to 86 mg/L from both winter and summer treatment. Following this treatment, the secondary short detention lagoon (P Lake) will reduce the influent 86 mg/L to 51 mg/L. The wetland treatment and outfall for Tellik Inlet will offer additional treatment to meet the effluent discharge criteria.

5.3 Fecal Coliform Reduction

The reduction of fecal coliforms (FC) can also be predicted using **Table 5.3**. The average generation of FC in domestic sewage is $2x10^9$ FC per person per day[4]. Using this value and the predicted sewage volume generation from **Table 2.1**, the average fecal coliform concentration in the P Lake Lagoon system was determined in **Table 5.4.**

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

Table 5.4: Reduction of Fecal Coliform from Lagoon Treatment System

Year	Population	Fecal Coliorm		Sewage Volume	Fecal Coliform			
					Raw Influent	Annual Lagoon Effluent (99.9% Reduction)	P Lake Lagoon Effluent (40% Reduction)	P Lake Lagoon Effluent
		(FC/p/d)	(FC/d)	(L/d)	(FC/L)	(FC/L)	(FC/L)	(FC/100mL)
2006	1382	2.0E+09	2.8E+12	1.6E+05	1.7E+07	1.7E+04	3.4E+03	3.4E+02
2007	1412	2.0E+09	2.8E+12	1.7E+05	1.7E+07	1.7E+04	3.4E+03	3.4E+02
2008	1441	2.0E+09	2.9E+12	1.7E+05	1.7E+07	1.7E+04	3.3E+03	3.3E+02
2009	1471	2.0E+09	2.9E+12	1.8E+05	1.7E+07	1.7E+04	3.3E+03	3.3E+02
2010	1501	2.0E+09	3.0E+12	1.8E+05	1.7E+07	1.7E+04	3.3E+03	3.3E+02
2011	1536	2.0E+09	3.1E+12	1.9E+05	1.6E+07	1.6E+04	3.3E+03	3.3E+02
2012	1570	2.0E+09	3.1E+12	1.9E+05	1.6E+07	1.6E+04	3.3E+03	3.3E+02
2013	1600	2.0E+09	3.2E+12	2.0E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2014	1632	2.0E+09	3.3E+12	2.0E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2015	1662	2.0E+09	3.3E+12	2.1E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2016	1692	2.0E+09	3.4E+12	2.1E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2017	1726	2.0E+09	3.5E+12	2.2E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2018	1757	2.0E+09	3.5E+12	2.2E+05	1.6E+07	1.6E+04	3.2E+03	3.2E+02
2019	1793	2.0E+09	3.6E+12	2.3E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2020	1829	2.0E+09	3.7E+12	2.3E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2021	1848	2.0E+09	3.7E+12	2.4E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2022	1879	2.0E+09	3.8E+12	2.4E+05	1.6E+07	1.6E+04	3.1E+03	3.1E+02
2023	1910	2.0E+09	3.8E+12	2.5E+05	1.5E+07	1.5E+04	3.1E+03	3.1E+02
2024	1941	2.0E+09	3.9E+12	2.5E+05	1.5E+07	1.5E+04	3.1E+03	3.1E+02
2025	1971	2.0E+09	3.9E+12	2.6E+05	1.5E+07	1.5E+04	3.1E+03	3.1E+02
2026	2002	2.0E+09	4.0E+12	2.6E+05	1.5E+07	1.5E+04	3.0E+03	3.0E+02

The predicted concentration of FC/100mL of P Lake Lagoon effluent is far beneath the design criteria of 10^4 FC/100mL.

5.4 Wetland Sewage Treatment - Nutrient Removal

Lagoon treatment systems often have difficultly reducing nutrients (nitrogen and phosphorus) to regulated levels. The effluent from the P Lake lagoon will be discharged to a wetlands area. Northern lagoon systems that run into wetlands areas can generally meet nutrient levels. Wetlands remove nutrients by a variety of natural processes: plant uptake, filtration, sorption, flocculation, sedimentation and biological degradation.

5.5 Suggested Design Criteria

Design criteria have been developed to ensure that conditions in a lagoon treatment system are sufficient for proper sewage treatment. These design criteria take the following details into consideration:

- Sunlight for disinfection of microorganisms
- Wind for sewage aeration
- Odour control
- Sufficient Treatment of BOD_5

For sewage lagoons, the province of Manitoba[5] recommends not exceeding an organic loading of 56 kg/ha/d. Based on equation **[1]** and a BOD_5 of 625 mg/L, the maximum organic loading (in year 20) will be 53 kg/ha/d (**Appendix H**).

5.6 Functional Lagoon Systems in the North

To support the proposed lagoon treatment system design, Dillon will draw design parameters from existing sewage treatment lagoon that are functional and achieving the proposed effluent criteria for Cape Dorset, NU.

5.6.1 Nunavut

Dillon consulted with Mr. Constantine Bodykevich, Water Resources Officer, Indian and Northern Affairs Canada, Nunavut District Office. Based on his annual inspections of existing lagoons systems in Nunavut, Mr. Bodykevich offered the following advice for constructing a functional sewage lagoon system in Cape Dorset:

- Construct an annual retention lagoon as opposed to a seepage lagoon
- Construct lagoon berms with fine grade material that won't allow for the seepage of small particulate matter, i.e. shale, not course gravel
- Construct berms will a 3 m width at the top and a side slope with less than 50% grade

Dillon's preliminary design meets and/or exceeds these recommendations.

[5] Province of Manitoba. (1985) Design Objectives for Standard Sewage Lagoons.

5.6.2 Fort Liard

Dillon has been involved with various stages of the design of the sewage lagoon system in Fort Liard, NWT. Although the system in Fort Liard consists of 3 cells in sequence, the first 2 cells have a retention time of approximately 1 year and are comparable to a single cell with annual retention, proposed for Cape Dorset. A sample taken from the second cell on July 16, 2002 showed the following concentrations:

- BOD_5: 16 mg/L
- FC: 8 CFU/100 mL
- TSS: 41 mg/L

Although the climate in Fort Liard is warmer than in Cape Dorset, this sample was taken mid-way through the treatment season, after approximately 2.5 months of treatment. This is approximately the length of the treatment season in Cape Dorset. The results indicate that an annual retention lagoon is capable of treating sewage to the required guidelines.

5.7 Additional Sewage Treatment

Looking beyond the 20 year design horizon, there are opportunities to expand the lagoon system on the site, or to enhance the treatment system to provide additional future capacity. The proposed lagoon treatment system may be upgraded to enhance treatment and prolong the life of the system using a number of technological means. A long tem monitoring program is recommended to determine what maybe undertaken in the future to extend the 20 year design life of the facility. These are discussed below.

5.7.1 Aeration

Should additional treatment be required by the lagoon treatment system, the annual retention lagoon can be retro-fitted with aerators during the summer months. Aeration enhances the level of treatment in several ways:

- Completely mixes the system
- Increases temperature
- Addition of dissolved oxygen

All of the above factors lead to an increased rate of BOD_5 degradation. Depending on the detention time of the lagoon, the effluent from an aerated lagoon contains about one-third to one-half the value of BOD_5 from that of a non-aerated system.

Aeration is best practiced in an on/off operation. Approximately one-month prior to annual discharged the sewage can be aerated to advance treatment of the system. Two weeks prior to annual discharge, the aerators can be turned off, allowing settling of solids and removal of microorganisms.

5.7.2 Solar Aerators

The client has expressed interest in using a solar aerator in the sewage lagoon, to increase the rate of treatment. However, the effectiveness of this is uncertain. Cooler water temperatures hold more dissolved oxygen, and decrease the metabolic rate of microorganisms. Thus, the rate of BOD_5 degradation may be temperature-limiting, rather than oxygen-limiting.

The rate of BOD degradation in a lagoon system assumes that there is sufficient oxygen in the system. Adding aerators would not substantially increase the treatment rate above what is given by this equation. In the feasibility report, values of k were estimated to be between 0.037 – 0.047 d^{-1}. Using an influent concentration of 625 mg/L and an effluent concentration of 45 mg/L (as required by the Water Board), the treatment time would range between 56 and 71 days. To increase this rate, the water temperature would need to be increased.

5.7.2.1 Feasibility of Aerators in Cape Dorset

SolarBee® aerators have 3-80 watt solar panels, each producing 68 watts of usable output, for a total of 102 usable watts. Low speed, surface aerators typically have an oxygen transfer rate of 0.7 – 1.5 kgO_2/KWh.

The oxygen demand of 7 months of sewage (November – May), with an influent BOD_5 concentration of 625 mg/L, would range between 32719 kg in 2006 to 52525 kg is 2026. This is the total oxygen demand, assuming a ratio of BOD_u : BOD_5 of 1.5, where BOD_u is the ultimate oxygen demand. Over a 60 day period, the daily oxygen demand would be 875 kg O_2/d.

According to H2O Logics Inc., a SolarBee® distributor, the oxygen transfer rate for one of their machines is 300 lbs O_2/acre/day (or 336 kg O_2/ha/d). Also according to H2O Logic, the natural reaeration rate of lakes is 50 lbs O_2/acre/day (or 56 kg O_2/ha/d). With a lagoon size of 2.4 ha (185 m x 132 m), the natural surface reaeration is 134 kg O_2/d, considerably less than the 875 kg O_2/d predicted above.

5.7.3 Treatment Beyond 20 years

The proposed 2-celled lagoon treatment system is designed for a 20 year use; however, to maximize the utilization of the system, the treatment area may be expanded to accommodate sewage beyond 2026. **Table 5.5** lists the predicted yearly volume of sewage for years 20-40 of the systems use.

Table 5.5: Predicted Sewage Generation Beyond Year 2026

Year	Population	MACA Predicted Sewage Production (L)	MACA Predicted Sewage Production (m^3)
2027	2072	100520230	100520
2028	2110	102924133	102924
2029	2148	105392901	105393
2030	2186	107928488	107928
2031	2226	110532909	110533
2032	2266	113208245	113208
2033	2306	115956647	115957
2034	2348	118780333	118780
2035	2390	121681597	121682
2036	2433	124662807	124663
2037	2477	127726409	127726
2038	2522	130874930	130875
2039	2567	134110979	134111
2040	2613	137437253	137437
2041	2660	140856538	140857
2042	2708	144371710	144372
2043	2757	147985745	147986
2044	2806	151701714	151702
2045	2857	155522791	155523
2046	2908	159452257	159452

In order to treat sewage up to year 2046 (year 40 of system operation) the P Lake lagoon must be built up to accommodate 63 900 m^3 of sewage (160 000m^3 generated in 2046 – 96 100 m^3 capacity of primary lagoon). This may be accomplished by building up berms surrounding P Lake similar to those described in **Section 4.1**.

After this expansion, the system would operate in a slightly different manner. The primary lagoon would no longer act as an annual retention lagoon since it would no longer accommodate a year's volume of sewage. Once full, the primary lagoon would be discharged to the newly expanded P Lake lagoon. The P Lake lagoon would then act as an additional long retention plug flow lagoon. After making its way to the plug flow lagoon, effluent would flow by gravity to the wetlands area before final discharge to Tellik Inlet.

6 SAMPLING PROGRAM

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.

6.1 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 6.1: 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

6.2 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.

6.3 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

7 CONSTRUCTION STRATEGY

The GN's intent is to complete this project over the fiscal years 2005/06 and 2006/07. The work is to proceed with the supply of as much of the materials on the 2005 sea lift. Some earth works may proceed in 2005. The majority of the works will be completed in 2006. The tender of the major works will occur in 2005. The entire project is to be commissioned in September/October 2006.

A schedule outlining this construction strategy is shown in **Table 7.1**.

Table 7.1: Project Schedule

Task	Milestone Date
Acceptance of the Pre-Design Document	June 7th, 2005
Site Survey, geotechnical investigation & Community Consultation	June 10 to 15, 2005
Fisheries study Field Work	July 10 to 20 2005
50% submission Detailed Design	June 24, 2005
Comments	July 4, 2005
Application for Water License	**July 6th, 2005**
Completion of Fisheries Study	July 31, 2005
100% Submission of Detailed Design	July 22, 2005
Comments Received From DFO & EC	August 6th, 2005
Comments Received From Water Board	August 6th, 2005
Comments Received From Client	August 6th 2005
Authorization From Water Board received	August 15, 2005
Tender Period	August 15th to September 2, 2005
Construction 2005	
Contract Award	September 9, 2005
Quarrying and Road Construction	September 12 to October 31, 2005
Quarrying	November 2005
Construction 2006	
Quarrying and material mobilization	April to June 2006
Road Construction	July 2006
Lagoon works	July to September 2006
Sea lift of materials	September 2006
Commissioning	October 2006

8 APPROVALS

8.1 Regulatory Agencies

To complete this project there are several approval agencies that need to be made aware of the intended works. Not all of the agencies provide authorization, however, they all can be involved through the required licensing and authorization processes required of the project owner. **Table 8.1** outlines the agencies that need to be involved in the approval process.

Table 8.1: Approval Agencies

Agency	Regulations
Indian and Northern Affairs Canada (INAC)	Inland Waters Act Marine Waters Act Monitoring of Water Licenses
Department of Health	Health Act General Sanitation Act
Department of Fisheries and Oceans (DFO)	Fisheries Act (Section 35) related to fish habitat
Environment Canada (EC)	Fisheries Act (Section 36) related to the discharge of deleterious substances
Nunavut Water Board	Nunavut Land Claims agreement

Each of the above agencies has been contacted to discuss their requirements for the proposed works. While the project proposal must meet the requirements of all the agencies of particular note are the Nunavut Water Board, the Department of Fisheries and Oceans, and Environment Canada. The project can not proceed without specific authorization from each of these three bodies.

The Water Board issues a Water License to the community for the withdrawal of water (over 50,000 L) and the subsequent deposit of the waste water. There is a formalized licensing process and application form to be completed and submitted to the Water Board for review and approval. This can only proceed once the detailed design is at the point to show sufficient information for the Board's review.

8.2 DFO Approvals

Authorization from the Department of Fisheries and Oceans and Environment Canada is in the form of a letter of authorization will be needed for the destruction of fish and fish habitat. The application for the letter of authorization will require the submission of the project plans and details to DFO for require, comment and approval.

In March, 2005 Dillon Consulting Limited (Dillon), on behalf of the Government of Nunavut (GN) submitted a position paper to the Department of Fisheries and Oceans (DFO) concerning the sewage treatment facility options for the hamlet of Cape Dorset, NU. During the preliminary review of the project under the habitat protection provisions of the *Fisheries Act*, DFO provided comment. The following document has been prepared by Dillon to address each of the comments set out by DFO.

8.2.1 "P" Lake vs. Mechanical Treatment Facility

The hamlet of Cape Dorset, along with the Government of Nunavut (GN) has been struggling to find an acceptable solution to their need for a sewage treatment facility since 2000. Numerous options have been looked at, and subsequently rejected for various reasons. It is the opinion of both the hamlet of Cape Dorset and the GN that the best solution would be to convert "P" Lake into a sewage lagoon and wetland. The rationale behind not using a mechanical sewage facility is as follows:

- The capital cost for a mechanical system is covered entirely by senior governments (GN and in this instance Fed under SIF) whereas communities are 100% responsible for operations and maintenance costs. The operations and maintenance (O&M) cost of a mechanical plant are significant and will place tremendous pressure on a community. Cape Dorset is already in a deficit position. Coupled with already high power costs, the O&M costs would place a significant burden on the community

- Where a lagoon and wetlands system can achieve suitable treatment acceptable to all parties, they are preferred over mechanical treatment plants.

- The ability to find, retain and train skilled operators is a challenge. Our experience thus far in Pangnirtung is an example.

- Mechanical systems require back-up systems, which often lead to complications in small systems where there is not built-in redundancy or peak period loading capacity.

- Trucked sewage systems subject mechanical plants to point loads requiring "balancing" in the system, particularly overnight, on weekends and Mondays.

- Down time on mechanical systems could be extensive should repairs be required (even for simple parts) as local labour and materials are not available.

8.2.2 Alternate Options to P Lake

In March 2001, Community Government and Transportation (CG&T) retained Dillon to conduct a planning study that would identify a long term solution to Cape Dorset's sewage treatment requirements. Several options for technologies and alternative solutions were reviewed. Aside from "P" Lake and the Mechanical Plant options, two other options were reviewed (figure 1):

Q Lake Lagoon Option

Q Lake is a small lake located to the north east of the community. The Mayor of Cape Dorset initially identified this site as a potential lagoon site. 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.

Site R Lagoon Option

Site R is a flat area north east of the community. This site is currently used as a granular stockpile for CG&T, and is located at the end of the runway. Because of its close proximity to the airstrip, and increased bird strike hazard, this site was dismissed.

8.2.3 Access to "P" Lake, and Impacts to Fish or Fish Habitat

A new road has been planned to access "P" Lake. Based on the information we have, there is no indication that the road will have any impact on fish or fish habitat. The current road design does not include any stream crossings, nor does the route encroach on any permanent water bodies. All construction work will likely be carried out in isolation of flow or in the dry. The culvert being installed is intended to handle natural runoff that intersects the road at the point indicated on figure 2.

Additional sediment resulting from the construction works will not enter any fish habitat. During construction, sediment controls will be in place to ensure sediment-laden water is not released to areas downstream of the work site. All disturbed areas will be isolated from fisheries habitat, and there will be no permanent disruption of native plants or grasses

8.2.4 Effects of Effluent on the Marine Environment

Fisheries and habitat data for the receiving marine environment of Telik Inlet have not yet been collected. However, it is the intent of Dillon and the GN to conduct baseline studies of all areas to be impacted by the conversion of "P" Lake and wetland to a sewage lagoon system. A work plan specific to this marine environment will be developed and included in the fisheries and habitat assessment of the "P" Lake area.

Dillon designed a wetlands treatment system in Chesterfield Inlet in the mid-1990's. The area selected for the wetlands was an intermittent drainage basin. Several ponds are now scattered throughout the drainage area, and drainage flows are divided in the upper portion of the basin and re-converge downstream in the central portion of the basin. Vegetation in the upper region is dominated by sedges and grasses. The downstream portion, just prior to discharge to the ocean, is similar to a boulder tundra environment.

Dillon has conducted studies with the wetlands treatment system in Repulse Bay. Similar to the system in Chesterfield Inlet, the area was once an intermittent drainage channel. Now, surface and sewage drainage permanently flow through the series of on-line ponds connected by partially defined and braided drainage channels. Vegetation is dominated by sedges and mosses in the floodplain. This vegetation ends abruptly at shield rock ridges, where mosses and lichen provide intermittent cover of the mostly barren rock.

Dillon conducted an intensive monitoring study of three wetlands systems (Baker Lake, Repulse Bay and Chesterfield Inlet) in 1996. All three system discharged sewage directly into the wetlands treatment system, with no form of pretreatment. Percent removal was calculated for various parameters, over the length of the entire wetlands, on a mass basis. This method removed any effects due to dilution. During the spring, when frozen sewage discharged during the winter was thawing, percent removal of contaminants ranged from 8 to 100%. Low removal efficiencies were noted for total phosphorus and ammonia nitrogen. Fecal coliforms had high removal efficiencies. Removal efficiencies for total suspended solids and 5-day biological oxygen demand (BOD_5) were in the middle of the range. During the summer months, percent removals ranged from 80 to 100%, for the parameters mentioned previously (calculated on a mass basis).

These studies show that wetlands are effective at treating municipal sewage. The water quality of the discharge water should not dramatically affect the water quality in the Inlet. Additional nutrients in the wetlands channel will stimulate the growth of sedges and grasses. Monitoring studies will be undertaken to ensure this is the case.

8.2.5 No Net Loss Plan

The Department of Fisheries and Oceans' long-term policy objective is the achievement of an overall net gain of the productive capacity of fish habitats. The **no net loss** principle is fundamental to the habitat conservation goal. Under this principle, the Department strives to balance unavoidable habitat losses with habitat replacement.

In the event that DFO approves the use of "P" Lake as a sewage lagoon facility, the GN will develop a work plan to compensate for lost fisheries habitat. Restoration and development of fish habitat near the hamlet of Cape Dorset will be undertaken in response to the no net loss objective.

This work plan will include the following:

- Fisheries inventory and habitat mapping of "P" Lake
- Fisheries inventory and habitat mapping of adjacent marine environment (Telik Inlet)
- Bathymetric mapping of "P" Lake
- Site visit to proposed compensation sites
- Photo documentation of all activities

The GN will follow the *procedures to apply the no net loss principle*, outlined in Chapter 5 of Canadian Waters. Using this as a guideline, the *hierarchy of preferences* will be referenced during site selection.

8.2.6 Habitat Compensation

Compensation for Loss, is defined as: *The replacement of natural habitat, increase in the productivity of existing habitat, or maintenance of fish production by artificial means in circumstances dictated by the social and economic conditions, where mitigation techniques and other measures are not adequate to maintain habitats for Canada's fisheries resources.*

In an effort to establish possible habitat compensation sites within the vicinity of "P" Lake, Dillon has contacted the Hunter's and Trapper's Association (HTA) of Cape Dorset. Through communication with this organization, three possible sites have been identified:

1. The HTA has submitted a proposal to the Nunavut Wildlife Management Board (NWMB) to request funding for the stream enhancement of two Arctic char streams. The NWMB has approved their application, subject to conditions, one being that the HTA seek other sources of funding (**Appendix I**). It may be possible to work jointly on this project, offering technical assistance and additional funding.

2. Tessikakjuak Lake is a popular Arctic char fishery. It is located approximately 30 km east of Cape Dorset, and provides seasonal habitat for sea-run Arctic char. It may be possible to increase the productivity of this lake through various methods of habitat enhancement (e.g. habitat structures, enhance inlet/outlet etc.)

8.3 Water License Application Requirements

As part of the regulatory review process completed by Dillon, the technical advisor for the Nunavut Water Board was contacted to discuss the requirements for the Water License application. With the license application, or shortly after the application, the Water Board will likely require the submission of the following documents;

- Operations and Maintenance Plan for the Proposed System
- Abandonment and restoration plan for the Existing 3 Cell Sewage Lagoon System
- Abandonment and Restoration Plan for the new P Lake lagoon
- An Emergency or Contingency Plan to address the potential for sewage discharge in the event that the new system (P Lake Lagoon) is not accessible. An example would be in blizzard conditions when the access road maybe blocked with snow.

The GN has identified the use of the existing Cell 1 of the 3 cell system as a potential resolution to the contingency plan at times that the proposed access road is inaccessible. This will be carried forward through the design.

9 SUMMARY AND CONCLUSIONS

The new sewage treatment system will be designed for a 20 year life span (2006-2026). Predicted population values until the year 2020 were provided by Nunavut Bureau of Statistics (**Appendix B**). The population for 2026 was predicted to be 2002 persons. 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.

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

The lagoon treatment system will be designed to meet the following effluent criteria:

- 45 mg/L BOD_5
- 45 mg/L SS
- 10^4 Fecal Coliform / 100mL

Dillon has taken several measures to predict treatment quality and ensure that the lagoon treatment systems effluent discharged to Tellik Inlet will meet the above criteria. Each method indicates that the use of an annual storage lagoon will meet the discharge criteria.

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

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

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

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

The above dimensions can be accommodated by the proposed area preceding P Lake.

Drawings D through I shows the proposed detail to be carried forward to the detailed design phase. This includes;

- Approximately 950 meters of new road construction. The road will have a maximum grade of 6%. Guard rails will be installed on all down gradient edges. The road width will be 8.0 meters.
- A truck turn around pad.
- A gravity truck discharge flume
- A gravity discharge pipe complete with an access vault and valve to control the lagoon discharge
- Ditching and culverts to direct runoff away from the lagoon.
- The lagoon walls will be constructed partially from fill, and partially from cut into the rock. The rock removed will be use for fill sections. The inside of the lagoon walls will be riprap protected in the fill sections.
- The berm will be constructed with a granular clay liner for fill sections. The liner will be keyed into the base to a depth of 1.5 meters. Bentonite will be used to provide a low permeability barrier at the fill to cut section.

The estimated cost of construction for the proposed system is shown in .

Table 9.1 Cost Estimates

Item	Units	Quantity	Unit Cost	Total Cost
Access Road & Truck Pad				
Cut (rock blasting)	M3	620	$100	$620,000
Fill (on site borrow)	M3	8,100	$20	$162,000
Fill (off site Borrow)	M3	21,700	$40	$868,000
Culvert (1,200 mm)	LM	30	$1,000	$30,000
Guard Rail	LM	400	$200	$80,000
Road Delineators	each	180	$20	$3,600
Lagoon Construction				
Cut (rock blasting)	M3	0	$100	$0
Fill (on site borrow)		0	20	$0
Fill (off site Borrow)		25,200	40	$1,000,000
Rip Rap	M2	4,000	$30	$120,000
Discharge Flume	Each	1	$10,000	$10,000
Effluent Discharge Structure	Each	1	$80,000	$80,000
Bollard	Each	30	$500	$15,000
Ditching	LM	350	$10	$3,500
Liner	M2	4,000	$40	$160,000
Fisheries Compensation Work	Lump Sum	1	$100,000	$100,000
Subtotal				3,250,000
Engineering	10%			325,000
Contingency	20%			650,000
GST	7%			295,000
Total				**$4,520,000**