APPENDIX C

Gjoa Haven Waste Management Assessment – Planning Report (Dillon Consulting Limited, 2008)

Gjoa Haven Waste Management Assessment

Planning Report - Draft

March 11, 2008

Gjoa Haven Waste Management Assessment

Community & Government Services
Government of Nunavut

Gary Strong - Project Manager

Submitted by
Dillon Consulting Limited

(In reply, please refer to)
Our File: 07-8253-1000

March 11, 2008

Community & Government Services
Bag 200, Enokhok Center
Cambridge Bay, NU, X0B 0C0
Phone: (867) 983-4146
Fax: (867) 983-4123

Attention: Mr. Thomas G. Livingston, P.Eng
Municipal Engineer

SUBJECT: Gjoa Haven Waste Management Assessment

Dear Mr. Livingston:

Enclosed please find the draft report for the above mentioned project entitled *Gjoa Haven Waste Management Assessment, Draft Report*. Please review and submit your comments to us so we may produce a final copy of this report.

We trust that this report meets the department's needs and look forward to working with you in the future.

Yours truly,

Dillon Consulting Limited

Gary Strong, P.Eng.

Project Manager

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1 INTRODUCTION

1.1 General

Recently the sewage lagoon in Gjoa Haven has experienced a number of problems relating to the stability of the berm wall surrounding the lagoon. The first report of berm instability was in July 2004 when it was noted that raw sewage was being discharged from the lagoon each time a sewage truck disposed of its cargo. In September 2005, the berm walls were reinforced and built back up in order to stop the flow of raw sewage from the lagoon. However, an inspection in September 2006 revealed that a section of the berm wall had collapsed and a continuous stream of raw sewage was being discharged into the surrounding wetland area. No further attempts to repair the berm have been made. The purpose of this report is:

- To analyze the water quality sampling data that was collected and compare it to the standards set out in the Hamlet of Gjoa Haven Water Licence and the *Canadian Water Quality Guidelines for the Protection of Aquatic Life*;
- Based on the above analysis, determine the potential usage of the wetland as part of the wastewater treatment system;
- To make recommendations on all water treatment issues/constraints/risks and provide remedial detail for all issues/constraints and risks.

1.2 Community Setting

The Hamlet of Gjoa Haven is located at 61^0 05' N latitude and 94^0 00' W longitude on the southern tip of King William Island, Kitikmeot Region, Nunavut. Topography consists mostly of sands and gravels with a continuous permafrost zone. Low lying vegetation such as mosses and lichens are predominant with hardy grasses found in some areas. Year round access to the Hamlet is limited to air travel, however, during the summer months freight may be brought in by sealift.

1.3 Scope of Work

As per the terms of reference for this project, this report includes the following:

- Results of the site investigation including the sewage lagoon and adjacent wetland;
- Analysis of water sample results taken from the wetland;
- Evaluation of the wetland as a possible addition to the current wastewater treatment system.

2 BACKGROUND INFORMATION

2.1 Existing System

Currently sewage is collected from the community by a sewage truck and is then discharged into a single-cell sewage lagoon. The lagoon is located 1.5km from the community and has an approximate volume of 22,700m^3. Due to the collapse in the berm wall, sewage now flows from the lagoon along a 1.2km path through a natural wetland. Discharge from the wetland percolates into the sandy soil matrix before it reaches the ocean edge eliminating a direct discharge route from the wetland into the ocean.

2.2 Community Water Use Projections

Annual sewage production is estimated based on annual water consumption. Therefore the following section predicts the amount of water used by the residents of Gjoa Haven. According to the Nunavut Bureau of Statistics, the latest recorded population of Gjoa Haven was 960 people in 2001. The historical population of Gjoa Haven is tabulated below:

Table 2.1 Historical Population Data for Gjoa Haven, NU

Year	Population
1981	523
1986	650
1991	783
1996	879
2001	960

The population of Gjoa Haven has been continually increasing over the last 25 years. According to projections released by the Nunavut Bureau of Statistics, the population of Gjoa Haven will continue to increase.

Table 2.2 Projected Population Data for Gjoa Haven, NU

Year	Population
2007	1117
2008	1136
2009	1154
2010	1173
2011	1194
2012	1217
2013	1242
2014	1266
2015	1290
2016	1317
2017	1345
2018	1375
2019	1405
2020	1435

In order to provide for a 20 year planning horizon, the projected population values were extrapolated further to the year 2028. Table 2.3 below shows the expected population from 2008 to 2028.

Table 2.3 Expected Population Growth from 2008 to 2028

Year	Population	Year	Population	Year	Population
2008	1136	2015	1290	2022	1497
2009	1154	2016	1317	2023	1529
2010	1173	2017	1345	2024	1562
2011	1194	2018	1375	2025	1595
2012	1217	2019	1405	2026	1629
2013	1242	2020	1435	2027	1664
2014	1266	2021	1466	2028	1700

Based on the above table, the design population for the planning year 2028 is 1700.

Design guidelines for communities with populations less than 2,000 people, and trucked water are as follows:

Design per capita residential water use (RWU) = 100 Lcd
Total per capita community use = RWU x [1.0 + (0.00023 x population)]

Based on the projected population of Gjoa Haven in the year 2028 (1700 people), **236.4 cubic meters per day, 86,286 cubic meters per annum** are required by the community, as illustrated in Table 2.4.

Table 2.4 Projected Water Usage

Year	Population	Daily Water Usage Projection (m^3/d)	Annual Water Usage Projection (m^3/y)
2008	1136	143.3	52305
2013	1242	159.7	58291
2018	1375	181	66065
2023	1529	206.7	75446
2028	1700	236.4	86286

The average day is based on the trucked delivery system operating 5 days of the week. Therefore the average day is calculated as;

Average Day = (annual usage/365) * 7 days per week usage/5 days per week delivery)

Average Day = 86,286/365 *7/5 = 330.96 m^3 per day

Peak day is 1.5 times average for truck fill operations. Peak day is therefore 496.4 m^3.

The above calculation is consistent with that described in the MACA Standards and Criteria.

3 WETLAND SAMPLING RESULTS

3.1 Methodology

On August 23, 2007, two Dillon personnel took water samples at 5 different locations along the length of the wetland starting at the point furthest from the lagoon. Samples were sent to Taiga Environmental Laboratory for analysis. Please refer to Appendix A for sample locations.

3.2 Sample Results

3.2.1 Effluent Quality Standards and Compliance

According to Water Licence NWB3GJO0409 issued to the Hamlet of Gjoa Haven, effluent discharged from the sewage lagoon must meet the following standards:

Table 3.1 Effluent Quality Standards as Required by the Gjoa Haven Water Licence

Parameter	Maximum Average Concentration
Fecal Coliforms	1 x 10^4 CFU/dl
BOD_5	80 mg/L
Total Suspended Solids	100 mg/L
Oil and Grease	No visible sheen
pH	Between 6 and 9

Based on the obtained sample results, water exiting the wetland has been treated to well below the acceptable effluent quality standards. Figure 3-1 is a graphical representation of effluent concentrations for fecal coliforms, BOD_5 and total suspended solids (TSS) at each sample location. As well this graph illustrates where compliance for each of the above parameters has been achieved based on wetland location. As for the oil and grease and pH parameters, no visible oil or grease sheen was observed and pH values ranged from 8.11 to 8.37. Therefore both of these parameters were also well within the acceptable limits.

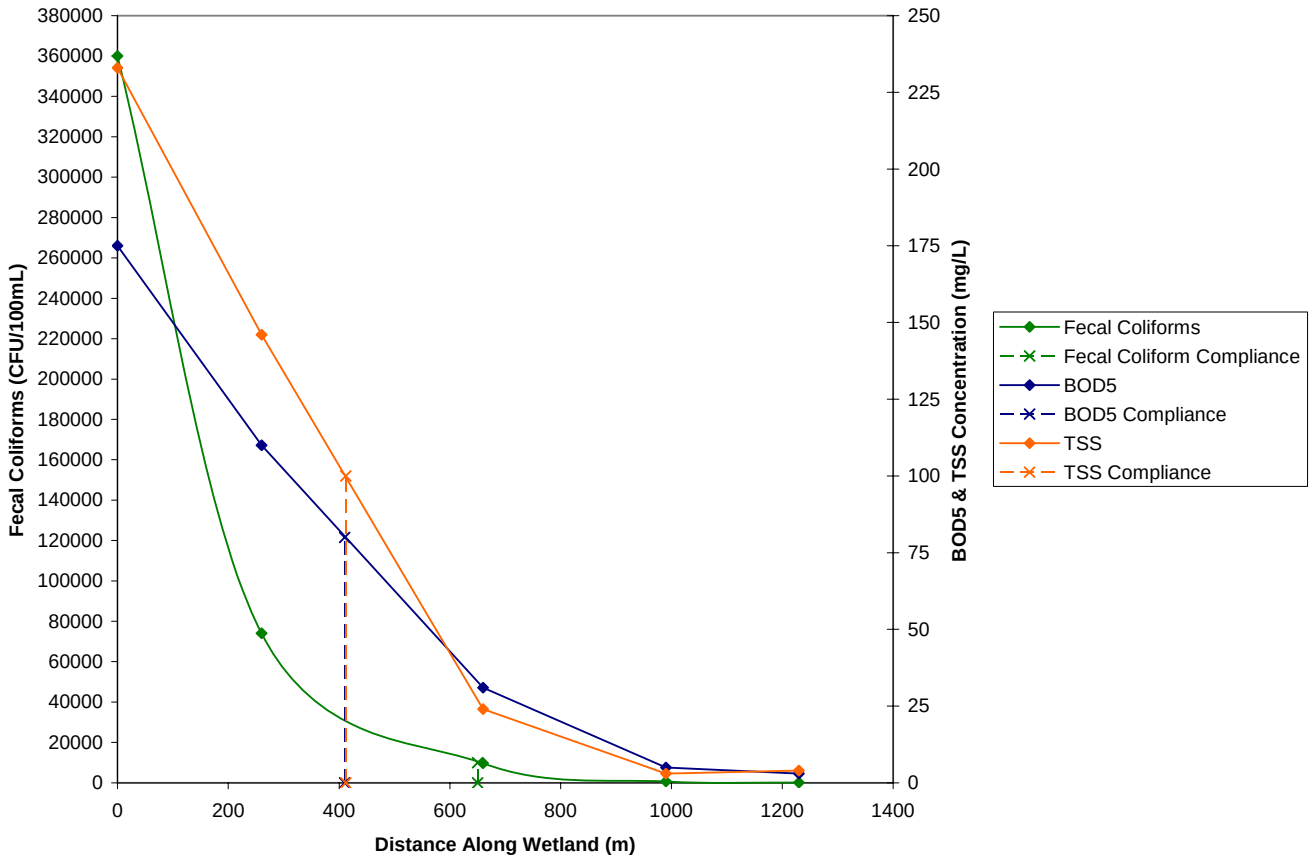

Figure 3-1 Sample Results Showing Compliance Points

As is shown in the above figure, compliance for BOD_5 and TSS occurs at approximately 400m down the wetland where as compliance for fecal coliforms occurs at 650m. Therefore, based on the above sample results, the wetland is able to effectively treat sewage lagoon effluent within 650m. Since the wetland is 1230m long, there is more than enough space for adequate treatment to occur. However, decisions regarding the use of the wetland for sewage effluent treatment should not be based solely on the above data. This data was collected in August and therefore represents only one condition experienced in the wetland. A wetland monitoring system should be put in place to observe conditions in the wetland during the entire year. This is especially important in the spring as spring runoff will increase the amount of water flowing through the wetland.

The monitoring system should be performed on a weekly basis during spring runoff and on a monthly basis for the rest of the summer and fall. No treatment will occur during the winter in the wetland as it is very shallow will completely freeze. The following table is a list of parameters to be tested during each sampling event.

Table 3.2 List of Parameters to be Tested During Sampling Events

Parameter
Fecal Coliforms
$CBOD_5$, and BOD_5
Total Suspended Solids
pH
Total Kjeldahl Nitrogen (TKN)
Ammonia - N
Total Phosphorous

Another point of concern is leachate from the nearby landfill draining into the wetland. Further sampling for metals should also be incorporated into the wetland monitoring program to determine the level of impact on the wetland.

3.2.2 Ammonia

Currently there are no recommended guidelines for ammonia concentration in effluent being discharged to marine environments. Therefore the amount of ammonia removal in the wetland is not crucial to meeting effluent quality guidelines. It is interesting to note however that ammonia concentrations were reduced from 9.48 mg/L to 0.514 mg/L which results in a 95% removal efficiency. This is very encouraging however many factors play a role in ammonia removal including temperature and pH. Below 6^oC ammonia removal decreases significantly. As a result there will be little to no ammonia removal during the fall and winter months.

3.2.3 Phosphorous

As with ammonia, there are no environmental quality guidelines for phosphorous in marine environments. Again, based on the sample results, the wetland has a high removal efficiency for total phosphorous decreasing the concentration from 13 mg/L to 0.23 mg/L. This is interesting because ortho-phosphate is the only type of phosphorous that can be utilized by aquatic biota. Accordingly, ortho-phosphate accounted for less than half of the total phosphorous. The rest of the phosphorous may have been removed through precipitation and interactions with the soil matrix of the wetland. If this is the case, the soil will eventually become saturated with phosphorous. When this happens, phosphorous will begin to leach out of the soil and back into the wetland system.

3.2.4 Area Requirement Calculations

The most important characteristic that determines effluent treatment capability is the square area of the wetland. To determine the area required for effective removal of fecal coliforms, BOD_5 and TSS, the methodology outlined in *Guidelines for the Approval and Design of Natural and Constructed Treatment Wetlands for Water Quality Improvement* (Alberta Environment, 2000) was used. Employing current water use estimations and the Alberta model, an area of 8800m^2 is needed. However, the total area from the discharge point of the lagoon to the point where compliance is reached for BOD and TSS in the existing wetland is approximately 15,600m^2. The actual area is nearly twice as much as the area predicted by the model. We then extrapolated the required area based on the 20 year design (year 2028) using the Alberta model and found the total area required is 22,100m^2. If we then assume that the actual required area will be double the calculated area then 44,200m^2 will be needed. Unfortunately the total surface area of the current wetland is 19,500m^2. The latter part of the wetland is mostly channel flow with very little width at the time of monitoring. It may be that the width varies depending on the time of year. Additional monitoring of the wetland area is recommended as part of the chemical and biological sample collection.

Low retention time of effluent in the wetland is the most likely cause of poor removal efficiency. Currently effluent flows through the wetland in the form of a stream which decreases the amount of surface area contact between the water and wetland vegetation. To increase surface area contact, the wetland could be modified into a series of cells containing vegetation and a sandy soil matrix. Directing effluent through these cells will cause the water to spread over the cell thus increasing surface area contact. Constructing such cells would also increase the total surface area of the wetland.

4 LAGOON INSPECTION AND ANALYSIS

As part of the inspection the lagoon walls were reviewed. As stated in the introduction there is a failed section of lagoon berm wall. The walls are constructed of a sandy pit run material. The lagoon is constructed in a circle. There has been a number of reported leaks, seepages and breaches throughout the life of the lagoon. These are reported in the INAC inspection reports, and anecdotally from the Hamlet staff.

The material and construction methods used for the lagoon walls are inconsistent with the material and construction required to provide an impermeable berm. The sandy pit run material appeared to have been end dumped, and there was very little compaction. Further the lagoon walls appear to be about a 2:1 slope. The sandy material is subject to erosion, both from run off and wind. The material found locally in Gjoa Haven has a history of wind erosion, and this is apparent at the lagoon.

To repair the lagoon using the locally available material a low permeable liner will be required. The existing walls will need to be excavated to a sound base. It was not within the scope of this assignment to complete a drilling program and therefore our observations are based on a surficial inspection. It can be assumed that the majority of the berm material will need to be removed, replaced and recompacted as part of the upgrade work should a new lagoon be the final option selected for sewer treatment.

5 CONCLUSIONS & RECOMMENDATIONS

As the above results illustrate, the wetland is capable of treating effluent from the sewage lagoon to well below the required effluent water quality standards. However, it must be noted that these samples were taken during late August, thus representing wetland conditions in early fall. Changes in weather and temperature have a great effect on the ability of the wetland to treat effluent. A year-round monitoring program should be implemented to determine the treatment ability of the wetland during each season. Regular sampling of landfill leachate discharging into the wetland should also be included as part of the effluent monitoring program.

Size of the wetland must also be taken into consideration. If the wetland is included as part of the wastewater treatment system, it will need to be modified and properly managed in order to accommodate for the predicted population increases. A larger area and a system of constructed wetland cells to increase surface area contact between the water and wetland vegetation will be required. This is not a difficult task, but will require planning and design work prior to construction.

The current lagoon is serving only as a short retention lagoon. During the open water season, the lagoon is providing primary treatment. During the winter months, there is likely some storage of the sewage in the wetlands. The remainder of the sewage is likely stored in the upper reaches of the wetland. The lagoon structure is not suitable for an impermeable lagoon. A full reconstruction, complete with a liner system is required should an annual retention lagoon be selected as the long term solution.

The current site is a candidate site for a shorter retention lagoon and wetland sewage treatment system. These systems are used throughout Nunavut. In recent years it has been challenging to regulate these systems through the water licence process. However there is renewed interest in these systems from the regulators, and the Gjoa Haven system would be a solid candidate for construction as a wetland system. The next steps in the process to achieve regulation as a wetland are;

- Discussion with the regulators to fine tune the required monitoring and analysis to gain regulatory approval.
- Establishing a monitoring system as described in the above sections.
- Completing the monitoring on a continual basis.
- Through discussion with the regulators make physical changes to the wetland to improve treatment.
- Complete pilot testing of alternative wetland enhancements and monitor the results.
- Rehabilitate the lagoon to perform the function of a primary lagoon.

6 REFERENCES

1. Alberta Environment. “Guidelines for the Approval and Design of Natural and Constructed Treatment Wetlands for Water Quality Improvement;” March 2000.

2. Canadian Council of Ministers of the Environment. “Canadian Water Quality Guidelines for the Protection of Aquatic Life”; September 2007 – Update 7.0.

3. Nuna Burnside. “Sewage Lagoon and Wetland Treatment System Assessment”; December 2005.

APPENDIX A

Figures

EDIT DATE: 10.03.2008 PLOT DATE: spencer, jennifer 10.03.2008 FILE: 41tpw r:\projects\draft\078253 gjoa wetlands\report\draft planning report\gjoa haven.dwg

DILLON CONSULTING

PROJECT
Gjoa Haven Wetlands
Gjoa Haven, Nunavut

TITLE
Sample Point Locations

Image Taken From: Nuna Burnside. "Sewage Lagoon and Wetland Treatment System Assessment, Gjoa Haven, NU", December 2005.

PROJECT NUMBER
07-8253

DATE
Jan 2008

FIGURE NUMBER
Figure 1

APPENDIX B

Area Calculations

Surface Flow (SF) Treatment Wetland - Preliminary Feasibility Calculation Sheet

Location: **Gjoa Haven Sewage Lagoon**

Design Flow (m^3/d) Q = 200

Used average day calculation for 2008

143.3 x (7/5) = 200

		TSS	BOD_5	FC
Influent Concentration	C_i =	900	625	10000000
Target Effluent Concentration	C_e =	100	80	1000
Wetland Background Limit (mg/L)	C^* =	64.5	36.625	100
for TSS, $C^* = 7.8 + 0.063Ci$				
for BOD, $C^* = 3.5 + 0.053Ci$				
Areal rate constant @ 20^oC (m/yr)	k =	1000	34	77
Required Wetland Area (ha)	A =	0.023057	0.559842	0.883176
(m^2)	A =	230.5703	5598.416	8831.759

$A = [0.0365 \times Q/k] \times \ln[(C_i - C^*)/(Ce - C^*)]$

maximum calculated area from above boxes (A_{max}) = 8831.759 **m^2**

Surface Flow (SF) Treatment Wetland - Preliminary Feasibility Calculation Sheet

Location: **Gjoa Haven Sewage Lagoon**

Design Flow (m^3/d) Q = 500

Used peak day calculation for 2028
(236.4 x (7/5)) x 1.5 = 496.4

		TSS	BOD_5	FC
Influent Concentration	C_i =	900	625	10000000
Target Effluent Concentration	C_e =	100	80	1000
Wetland Background Limit (mg/L)	C^* =	64.5	36.625	100
for TSS, $C^* = 7.8 + 0.063Ci$ for BOD, $C^* = 3.5 + 0.053Ci$				
Areal rate constant @ 20°C (m/yr)	k =	1000	34	77
Required Wetland Area (ha)	A =	0.057643	1.399604	2.20794
(m^2)	A =	576.4258	13996.04	22079.4

$A = [0.0365 \times Q/k] \times \ln[(C_i - C^*)/(Ce - C^*)]$

maximum calculated area from above boxes (A_{max}) = 22079.4 **m^2**

APPENDIX C

Sample Results

Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788 Fax: (867)-669-2718

Taiga Batch No.: 270588

- FINAL REPORT -

Prepared For: Dillon Consulting Ltd.

Address: Suite 303 - 4920 47 St.
Box 1409
Yellowknife, NT
X1A 2L8

Attn: Jennifer Spencer **Facsimile:** (867) 873-3328

Final report has been reviewed and approved by:

Helene Harper
A/Laboratory Manager

NOTES:

- Test methods and data are validated by the laboratory's Quality Assurance Program. Taiga Environmental Laboratory is accredited by the Canadian Association of Environmental Analytical Laboratories (CAEAL) as a testing laboratory for specific tests registered with CAEAL.
- Routine methods are based on recognized procedures from sources such as
  - Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF;
  - Environment Canada
  - USEPA
- Samples shall be kept for thirty (30) days after the final report is issued. All microbiological samples shall be disposed of immediately upon completion of analysis to minimize biohazardous risks to laboratory personnel. Please contact the laboratory if you have any special requirements.
- Final results are based on the specific tests at the time of analysis and do not represent the conditions during sampling.

ReportDate: Tuesday, September 11, 2007
Print Date: Tuesday, September 11, 2007

Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788 Fax: (867)-669-2718

Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: **08-07-GH1** **Taiga Sample ID:** **001**

Client Project: 07-Gjoa
Sample Type: Sewage
Received Date: 23-Aug-07
Sampling Date: 23-Aug-07
Sampling Time: 9:30
Location: Gjoa Haven
Report Status: **FINAL**

Test Parameter	Result	Detection Limit	Units	Analysis Date	Analytical Method *	Qualifer
Inorganics - Physicals						
Alkalinity, Total (as CaCO3)	177	0.1	mg/L	24-Aug-07	SM2320:B	
Conductivity, Specific (@ 25°C)	533	0.4	µS/cm	24-Aug-07	SM2510:B	
pH	8.19		pH units	24-Aug-07	SM4500-H:B	
Solids, Total Suspended	4	3	mg/L	05-Sep-07	SM2540:D	
Inorganics - Nutrients						
Ammonia as Nitrogen	0.514	0.005	mg/L	29-Aug-07	SM4500-NH3:	
Biochemical Oxygen Demand	3	2	mg/L	24-Aug-07	SM5210:B	81
Chemical Oxygen Demand	48.7	5.0	mg/L	24-Aug-07	SM5220:D	
Nitrate+Nitrite as Nitrogen	0.96	0.01	mg/L	27-Aug-07	SM4110:B	
Nitrogen, Dissolved	1.68	0.04	mg/L	29-Aug-07	SM4500-N:D	
Nitrogen, Total	1.68	0.04	mg/L	29-Aug-07	SM4500-N:D	
Ortho-Phosphate as Phosphorus	0.039	0.002	mg/L	31-Aug-07	SM4500-P:D	
Phosphorous, Dissolved	0.07	0.01	mg/L	04-Sep-07	SM4500-P:D	
Phosphorous, Total	0.23	0.01	mg/L	10-Sep-07	SM4500-P:D	

ReportDate: Tuesday, September 11, 2007
Print Date: Tuesday, September 11, 2007

Taiga Environmental Laboratory
4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788 Fax: (867)-669-2718

Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH1 **Taiga Sample ID: 001**

Major Ions						
Calcium	35.6	0.1	mg/L	28-Aug-07	SM4110:B	
Chloride	49.5	0.7	mg/L	28-Aug-07	SM4110:B	
Fluoride	< 0.1	0.1	mg/L	28-Aug-07	SM4110:B	
Magnesium	24.4	0.1	mg/L	28-Aug-07	SM4110:B	
Nitrate as Nitrogen	0.87	0.01	mg/L	28-Aug-07	SM4110:B	
Nitrite as Nitrogen	0.09	0.01	mg/L	28-Aug-07	SM4110:B	
Potassium	4.0	0.1	mg/L	28-Aug-07	SM4110:B	
Sodium	43.3	0.1	mg/L	28-Aug-07	SM4110:B	
Sulphate	13	1	mg/L	28-Aug-07	SM4110:B	
Microbiology						
Coliforms, Fecal	80	4	CFU/100mL	23-Aug-07	SM9222:D	
Coliforms, Total	>24196.0	10.0	MPN/100mL	23-Aug-07	SM9223:B	74
Escherichia coli	61.7	1.0	MPN/100mL	23-Aug-07	SM9223:B	
Fecal streptococcus	19.5	1.0	MPN/100mL	23-Aug-07	IDEXX	

ReportDate: Tuesday, September 11, 2007
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Tel: (867)-669-2788 Fax: (867)-669-2718

Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH2 **Taiga Sample ID: 002**

Client Project: 07-Gjoa
Sample Type: Sewage
Received Date: 23-Aug-07
Sampling Date: 23-Aug-07
Sampling Time: 9:30
Location: Gjoa Haven
Report Status: **FINAL**

Test Parameter	Result	Detection Limit	Units	Analysis Date	Analytical Method *	Qualifer
Inorganics - Physicals						
Alkalinity, Total (as CaCO3)	181	0.1	mg/L	24-Aug-07	SM2320:B	
Conductivity, Specific (@ 25°C)	536	0.4	µS/cm	24-Aug-07	SM2510:B	
pH	8.27		pH units	24-Aug-07	SM4500-H:B	
Solids, Total Suspended	< 3	3	mg/L	05-Sep-07	SM2540:D	
Inorganics - Nutrients						
Ammonia as Nitrogen	0.987	0.005	mg/L	29-Aug-07	SM4500-NH3:	
Biochemical Oxygen Demand	5	2	mg/L	24-Aug-07	SM5210:B	81
Chemical Oxygen Demand	43.9	5.0	mg/L	24-Aug-07	SM5220:D	
Nitrate+Nitrite as Nitrogen	0.70	0.01	mg/L	27-Aug-07	SM4110:B	
Nitrogen, Dissolved	1.79	0.04	mg/L	29-Aug-07	SM4500-N:D	
Nitrogen, Total	1.93	0.04	mg/L	29-Aug-07	SM4500-N:D	
Ortho-Phosphate as Phosphorus	0.028	0.002	mg/L	31-Aug-07	SM4500-P:D	
Phosphorous, Dissolved	0.06	0.01	mg/L	04-Sep-07	SM4500-P:D	
Phosphorous, Total	0.26	0.01	mg/L	10-Sep-07	SM4500-P:D	
Major Ions						

ReportDate: Tuesday, September 11, 2007
Print Date: Tuesday, September 11, 2007

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4601-52nd Ave., Box 1500, Yellowknife, NT. X1A 2R3
Tel: (867)-669-2788 Fax: (867)-669-2718

Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH2 **Taiga Sample ID: 002**

Calcium	35.3	0.1	mg/L	28-Aug-07	SM4110:B	
Chloride	49.5	0.7	mg/L	28-Aug-07	SM4110:B	
Fluoride	< 0.1	0.1	mg/L	28-Aug-07	SM4110:B	
Magnesium	24.0	0.1	mg/L	28-Aug-07	SM4110:B	
Nitrate as Nitrogen	0.63	0.01	mg/L	28-Aug-07	SM4110:B	
Nitrite as Nitrogen	0.07	0.01	mg/L	28-Aug-07	SM4110:B	
Potassium	4.5	0.1	mg/L	28-Aug-07	SM4110:B	
Sodium	43.8	0.1	mg/L	28-Aug-07	SM4110:B	
Sulphate	11	1	mg/L	28-Aug-07	SM4110:B	
Microbiology						
Coliforms, Fecal	760	10	CFU/100mL	23-Aug-07	SM9222:D	
Coliforms, Total	>24196.0	1.0	MPN/100mL	23-Aug-07	SM9223:B	74
Escherichia coli	461	1.0	MPN/100mL	23-Aug-07	SM9223:B	
Fecal streptococcus	81.6	1.0	MPN/100mL	23-Aug-07	IDEXX	

ReportDate: Tuesday, September 11, 2007
Print Date: Tuesday, September 11, 2007

Taiga Environmental Laboratory
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Tel: (867)-669-2788 Fax: (867)-669-2718

Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH3 **Taiga Sample ID: 003**

Client Project: 07-Gjoa
Sample Type: Sewage
Received Date: 23-Aug-07
Sampling Date: 23-Aug-07
Sampling Time: 9:30
Location: Gjoa Haven
Report Status: **FINAL**

Test Parameter	Result	Detection Limit	Units	Analysis Date	Analytical Method *	Qualifer
Inorganics - Physicals						
Alkalinity, Total (as CaCO3)	258	0.1	mg/L	24-Aug-07	SM2320:B	
Conductivity, Specific (@ 25°C)	811	0.4	µS/cm	24-Aug-07	SM2510:B	
pH	8.11		pH units	24-Aug-07	SM4500-H:B	
Solids, Total Suspended	24	3	mg/L	05-Sep-07	SM2540:D	
Inorganics - Nutrients						
Ammonia as Nitrogen	6.53	0.005	mg/L	29-Aug-07	SM4500-NH3:	
Biochemical Oxygen Demand	31	2	mg/L	24-Aug-07	SM5210:B	
Chemical Oxygen Demand	167	5.0	mg/L	24-Aug-07	SM5220:D	
Nitrate+Nitrite as Nitrogen	0.69	0.01	mg/L	27-Aug-07	SM4110:B	
Nitrogen, Dissolved	1.24	0.04	mg/L	29-Aug-07	SM4500-N:D	
Nitrogen, Total	1.09	0.04	mg/L	29-Aug-07	SM4500-N:D	
Ortho-Phosphate as Phosphorus	0.157	0.002	mg/L	31-Aug-07	SM4500-P:D	
Phosphorous, Dissolved	0.21	0.01	mg/L	04-Sep-07	SM4500-P:D	
Phosphorous, Total	1.35	0.01	mg/L	10-Sep-07	SM4500-P:D	
Major Ions						

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH3 **Taiga Sample ID: 003**

Calcium	40.6	0.1	mg/L	28-Aug-07	SM4110:B	
Chloride	88.5	0.7	mg/L	28-Aug-07	SM4110:B	
Fluoride	0.1	0.1	mg/L	28-Aug-07	SM4110:B	
Magnesium	29.7	0.1	mg/L	28-Aug-07	SM4110:B	
Nitrate as Nitrogen	0.65	0.01	mg/L	28-Aug-07	SM4110:B	
Nitrite as Nitrogen	0.04	0.01	mg/L	28-Aug-07	SM4110:B	
Potassium	11.3	0.1	mg/L	28-Aug-07	SM4110:B	
Sodium	76.6	0.1	mg/L	28-Aug-07	SM4110:B	
Sulphate	14	1	mg/L	28-Aug-07	SM4110:B	
Microbiology						
Coliforms, Fecal	9700	100	CFU/100mL	23-Aug-07	SM9222:D	
Coliforms, Total	120000	100	MPN/100mL	23-Aug-07	SM9223:B	
Escherichia coli	7760	100	MPN/100mL	23-Aug-07	SM9223:B	
Fecal streptococcus	>2419.6	1.0	MPN/100mL	23-Aug-07	IDEXX	74

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH4 **Taiga Sample ID: 004**

Client Project: 07-Gjoa
Sample Type: Sewage
Received Date: 23-Aug-07
Sampling Date: 23-Aug-07
Sampling Time: 9:30
Location: Gjoa Haven
Report Status: **FINAL**

Test Parameter	Result	Detection Limit	Units	Analysis Date	Analytical Method *	Qualifer
Inorganics - Physicals						
Alkalinity, Total (as CaCO3)	349	0.1	mg/L	30-Aug-07	SM2320:B	
Conductivity, Specific (@ 25°C)	1270	0.4	µS/cm	24-Aug-07	SM2510:B	
pH	8.20		pH units	24-Aug-07	SM4500-H:B	
Solids, Total Suspended	146	3	mg/L	05-Sep-07	SM2540:D	
Inorganics - Nutrients						
Ammonia as Nitrogen	21.2	0.005	mg/L	29-Aug-07	SM4500-NH3:	
Biochemical Oxygen Demand	110	2	mg/L	24-Aug-07	SM5210:B	
Chemical Oxygen Demand	654	5.0	mg/L	24-Aug-07	SM5220:D	
Nitrate+Nitrite as Nitrogen	0.11	0.01	mg/L	27-Aug-07	SM4110:B	
Nitrogen, Dissolved	0.36	0.04	mg/L	29-Aug-07	SM4500-N:D	
Nitrogen, Total	< 0.04	0.04	mg/L	29-Aug-07	SM4500-N:D	
Ortho-Phosphate as Phosphorus	3.05	0.002	mg/L	31-Aug-07	SM4500-P:D	
Phosphorous, Dissolved	3.87	0.01	mg/L	04-Sep-07	SM4500-P:D	
Phosphorous, Total	7.38	0.01	mg/L	10-Sep-07	SM4500-P:D	
Major Ions						

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH4 **Taiga Sample ID: 004**

Calcium	38.5	0.1	mg/L	28-Aug-07	SM4110:B	
Chloride	167	0.7	mg/L	28-Aug-07	SM4110:B	
Fluoride	0.1	0.1	mg/L	28-Aug-07	SM4110:B	
Magnesium	31.7	0.1	mg/L	28-Aug-07	SM4110:B	
Nitrate as Nitrogen	0.09	0.01	mg/L	28-Aug-07	SM4110:B	
Nitrite as Nitrogen	0.02	0.01	mg/L	28-Aug-07	SM4110:B	
Potassium	29.6	0.1	mg/L	28-Aug-07	SM4110:B	
Sodium	144	0.1	mg/L	28-Aug-07	SM4110:B	
Sulphate	25	1	mg/L	28-Aug-07	SM4110:B	
Microbiology						
Coliforms, Fecal	74000	1000	CFU/100mL	23-Aug-07	SM9222:D	
Coliforms, Total	1120000	1000	MPN/100mL	23-Aug-07	SM9223:B	
Escherichia coli	105000	100	MPN/100mL	23-Aug-07	SM9223:B	
Fecal streptococcus	>2419.6	1.0	MPN/100mL	23-Aug-07	IDEXX	74

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH4D **Taiga Sample ID:** 005

Client Project: 07-Gjoa
Sample Type: Sewage
Received Date: 23-Aug-07
Sampling Date: 23-Aug-07
Sampling Time: 9:30
Location: Gjoa Haven
Report Status: **FINAL**

Test Parameter	Result	Detection Limit	Units	Analysis Date	Analytical Method *	Qualifer
Inorganics - Physicals						
Alkalinity, Total (as CaCO3)	348	0.1	mg/L	30-Aug-07	SM2320:B	
Conductivity, Specific (@ 25°C)	1270	0.4	µS/cm	24-Aug-07	SM2510:B	
pH	8.24		pH units	24-Aug-07	SM4500-H:B	
Solids, Total Suspended	100	3	mg/L	05-Sep-07	SM2540:D	
Inorganics - Nutrients						
Biochemical Oxygen Demand	107	2	mg/L	24-Aug-07	SM5210:B	
Chemical Oxygen Demand	646	5.0	mg/L	24-Aug-07	SM5220:D	
Nitrate+Nitrite as Nitrogen	0.02	0.01	mg/L	27-Aug-07	SM4110:B	
Nitrogen, Dissolved	0.32	0.04	mg/L	29-Aug-07	SM4500-N:D	
Nitrogen, Total	< 0.04	0.04	mg/L	29-Aug-07	SM4500-N:D	
Ortho-Phosphate as Phosphorus	3.30	0.002	mg/L	31-Aug-07	SM4500-P:D	
Phosphorous, Dissolved	3.40	0.01	mg/L	04-Sep-07	SM4500-P:D	
Phosphorous, Total	8.05	0.01	mg/L	10-Sep-07	SM4500-P:D	
Major Ions						
Calcium	35.1	0.1	mg/L	28-Aug-07	SM4110:B	

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- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH4D **Taiga Sample ID: 005**

Chloride	167	0.7	mg/L	28-Aug-07	SM4110:B	
Fluoride	< 0.1	0.1	mg/L	28-Aug-07	SM4110:B	
Magnesium	30.1	0.1	mg/L	28-Aug-07	SM4110:B	
Nitrate as Nitrogen	< 0.01	0.01	mg/L	28-Aug-07	SM4110:B	
Nitrite as Nitrogen	0.01	0.01	mg/L	28-Aug-07	SM4110:B	
Potassium	29.2	0.1	mg/L	28-Aug-07	SM4110:B	
Sodium	143	0.1	mg/L	28-Aug-07	SM4110:B	
Sulphate	25	1	mg/L	28-Aug-07	SM4110:B	
Microbiology						
Coliforms, Fecal	55000	1000	CFU/100mL	23-Aug-07	SM9222:D	
Coliforms, Total	1200000	1000	MPN/100mL	23-Aug-07	SM9223:B	
Escherichia coli	81600	100	MPN/100mL	23-Aug-07	SM9223:B	
Fecal streptococcus	>2419.6	1.0	MPN/100mL	23-Aug-07	IDEXX	74

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH5 **Taiga Sample ID: 006**

Client Project: 07-Gjoa
Sample Type: Sewage
Received Date: 23-Aug-07
Sampling Date: 23-Aug-07
Sampling Time: 9:30
Location: Gjoa Haven
Report Status: **FINAL**

Test Parameter	Result	Detection Limit	Units	Analysis Date	Analytical Method *	Qualifer
Inorganics - Physicals						
Alkalinity, Total (as CaCO3)	297	0.1	mg/L	24-Aug-07	SM2320:B	
Conductivity, Specific (@ 25°C)	1340	0.4	µS/cm	24-Aug-07	SM2510:B	
pH	8.37		pH units	24-Aug-07	SM4500-H:B	
Solids, Total Suspended	233	3	mg/L	05-Sep-07	SM2540:D	
Inorganics - Nutrients						
Ammonia as Nitrogen	9.48	0.005	mg/L	29-Aug-07	SM4500-NH3:	
Biochemical Oxygen Demand	175	2	mg/L	24-Aug-07	SM5210:B	
Chemical Oxygen Demand	1340	5.0	mg/L	24-Aug-07	SM5220:D	
Nitrate+Nitrite as Nitrogen	0.01	0.01	mg/L	27-Aug-07	SM4110:B	
Nitrogen, Dissolved	< 0.04	0.04	mg/L	29-Aug-07	SM4500-N:D	
Nitrogen, Total	< 0.04	0.04	mg/L	29-Aug-07	SM4500-N:D	
Ortho-Phosphate as Phosphorus	5.66	0.002	mg/L	31-Aug-07	SM4500-P:D	
Phosphorous, Dissolved	6.65	0.01	mg/L	04-Sep-07	SM4500-P:D	
Phosphorous, Total	13.0	0.01	mg/L	10-Sep-07	SM4500-P:D	
Major Ions						

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: 08-07-GH5 **Taiga Sample ID: 006**

Calcium	35.8	0.1	mg/L	28-Aug-07	SM4110:B	
Chloride	204	0.7	mg/L	28-Aug-07	SM4110:B	
Fluoride	0.1	0.1	mg/L	28-Aug-07	SM4110:B	
Magnesium	29.8	0.1	mg/L	28-Aug-07	SM4110:B	
Nitrate as Nitrogen	0.01	0.01	mg/L	28-Aug-07	SM4110:B	
Nitrite as Nitrogen	< 0.01	0.01	mg/L	28-Aug-07	SM4110:B	
Potassium	40.2	0.1	mg/L	28-Aug-07	SM4110:B	
Sodium	178	0.1	mg/L	28-Aug-07	SM4110:B	
Sulphate	44	1	mg/L	28-Aug-07	SM4110:B	
Microbiology						
Coliforms, Fecal	360000	10000	CFU/100mL	23-Aug-07	SM9222:D	
Coliforms, Total	9800000	10000	MPN/100mL	23-Aug-07	SM9223:B	
Escherichia coli	345000	1000	MPN/100mL	23-Aug-07	SM9223:B	
Fecal streptococcus	>2419.6	1.0	MPN/100mL	23-Aug-07	IDEXX	74

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Taiga Batch No.: 270588

- CERTIFICATE OF ANALYSIS -

Client Sample ID: **08-07-GH5** **Taiga Sample ID:** **006**

- DATA QUALIFERS -

Data Qualifier Descriptions:

74 *Unable to repeat analysis at higher dilution. Holding time exceeded.*

81 *Results are inconclusive due to insufficient depletion of sample, minimum 2 mg/L required over 5 days.*

*** Taiga analytical methods are based on the following standard analytical methods**

SM - Standard Methods for the Examination of Water and Wastewater

EPA - United States Environmental Protection Agency

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