Operations and Maintenance Manual
for the
Wastewater Treatment Facility
Hamlet of Clyde River

Prepared for:

Department of Community Government and Services
Government of Nunavut

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Chapter 1 – Manual Document Control

Manual Document Control

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Chapter 2 – Index

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Chapter 3 – Background and Design Data

Introduction

Clyde River is a small, arctic community located on the west shore of Patricia Bay within Clyde Inlet. The average annual rainfall in Clyde River is 4.6 cm and the average annual snowfall is 203 cm (RWDI, 2008). Temperatures in the summer range between 0 and 8^{o}C and in winter between -22.5^{o}C and -30^{o}C. It is generally quite windy with an average wind speed of 14.4 km/h (Dillon, 2003). Permafrost is present in the soil, it recedes to approximately 1 m below the surface in the summer time.

The location of the existing sewage lagoon is approximately 1.2 km west of the Hamlet, 800 m north of Patricia Bay. It is adjacent to a scrap metal dump which is located to the north and the community landfill to the east. There is a small watercourse to the west of the lagoon which runs south to Patricia Bay. The existing sewage lagoon does not have sufficient holding capacity for the present population size of Clyde River of 800 people. The berms of the lagoon are failing and raw sewage is leaking out of the toes of the berms in several places. The existing lagoon was constructed in 1976. It is an unlined earth lagoon with a reported capacity of approximately 11,600 m^3 and was designed to hold sewage for 365 days with manual discharge.

The existing sewage lagoon does not meet the storage requirements of the Hamlet, and effluent samples taken in August 2006 did not meet the regulatory requirements of the Hamlet's water licence. The intention of this project is to upgrade the sewage treatment facility to meet the needs of the Hamlet for 20 years, and the requirements of their water licence.

The purpose of this Operations and Maintenance Manual (O&M Manual) is to assist the Hamlet of Clyde River (Hamlet) staff with the proper operation and maintenance of the wastewater treatment facility. This manual will outline the description on how the facility is to be operated and maintained and outline the required testing and maintenance operations.

The project will not have long term negative effects on the environment or wildlife. Most effects are related to construction activities and are short term and all effects can be mitigated by applying suitable mitigation measures.

General

The proposed sewage treatment facility must meet the long term needs of the Hamlet, as well as the regulatory requirements of the Hamlet's water licence. The Water and Sewage's Facility Capital Program Standards and Criteria indicate the design horizon for sewage lagoons is to be between 15 - 20. As per the direction of the Community and Government Service, Government of Nunavut, the design horizon for this project shall be the year 2028.

Sewage Treatment

The wastewater treatment system for the Hamlet of Clyde River includes two sewage lagoon cells and a natural wetland.

The wastewater treatment system utilizes the sewage lagoons as the main method of treatment, with the wetlands providing additional treatment prior to the release to the environment.

As monitoring the performance of natural wetlands is difficult, the Hamlet of Clyde River's water license has set the compliance point for the wastewater treatment system at the discharge of the lagoon. This point represents the last point of measurement and control for the system. The water license further recognizes the treatment potential of the natural wetland and has set the compliance criteria recognizing the treatment the effluent will receive through the wetland.

Population Projections

The population projections for this project will be based on "Nunavut: Community Population Projections" as published by the Nunavut Bureau of Statistics. The Nunavut Bureau of Statistics population projections provide projected populations of the Nunavut communities to the year 2020. As a planning horizon for this project is past the current population projections available from the Nunavut Bureau of Statistics, the population projection from 2020 to 202 are estimated using the average annual growth rate for the Hamlet between the year 2000 and 2020 of 2.3%. The table below summarizes the population projections to the year 2028.

Table 2.1 - Population Projections

Planning Year	Year	Population	Planning Year	Year	Population
	2000	771	7	2015	1095
	2001	789	8	2016	1121
	2002	812	9	2017	1144
	2003	830	10	2018	1167
	2004	848	11	2019	1190
	2005	867	12	2020	1214
	2006	890	13	2021	1242
	2007	913	14	2022	1270
0	2008	937	15	2023	1300
1	2009	959	16	2024	1330
2	2010	982	17	2025	1360
3	2011	1007	18	2026	1391
4	2012	1028	19	2027	1423
5	2013	1050	20	2028	1456
6	2014	1072			

The design population for the end of the design horizon, 2028, is projected to be 1456 persons.

Sewage Generation

Sewage generation rates are generally assumed to be equal to the water consumption rates for a community, with the water consumption rate being the total of the residential and non-residential water consumption. The Water and Sewage Facility Capital Program Standards and Criteria provide the following design values and formulae for estimating the water consumption and therefore the sewage generation rates for communities.

The residential water usage (RWU) for a community is based on the method of water delivery and sewage collection in the community. The per capita water usage rates for the different methods of water delivery and sewage collection are summarized in the Table 3.2.

Table 3.2 - Residential Water Usage

Service Method	Residential Water Usage (RWU)
Trucked water and sewage	90 lpcd
Piped water and sewage	225 lpcd
Piped water supply and truck sewage pump out	110 lpcd
Trucked water delivery and individual septic fields	100 lpcd

The Hamlet of Clyde River has a trucked water and sewage system, therefore the RWU for the community from table 3.2 is equal to 90 lpcd.

Non-residential water usage by a community tends to increase with increases in the population. To determine the Total Community Water Usage (TCWU, the Residential Water Usage is adjusted based on population to provide a Total Water Usage Per Capital. The daily water consumption by the community is equal to the population multiplied by the Total Water Usage Per Capital. The Total Water Usage Per Capital, including residential and non residential activities are estimated based on the equations in Table 3.3 – Total Community Water Usage.

Table 3.3 - Total Community Water Usage

Community Population	Total Water Use Per Capita
0 – 2000	RWU x (1.0 + 0.00023 x Population)
2000 – 10,000	RWU x [-1.0 + {0.323 x Ln(Population)}]
Over 10,000	RWU x 2.0

The daily water consumption, and therefore the sewage generated by the community, is equal to the population multiplied by the Total Water Usage Per Capital. Based on the design population of 1456 for the year 2028, and a total water usage per capita rate of 120 lpcd, the daily sewage generation rate is equal to 175,000 lpd. This is equal to a yearly sewage generation rate of 63,900 $m^{3.}$

Influent Characteristics

The characteristics of sewage generated in a community are heavily dependent on the type of installation and sanitary facilities. The Hamlet of Clyde River water and sewage system's utilize holding tanks and truck delivery and collection systems. The waste generated from this arrangement is considered to be "Moderately Diluted Wastewater", as per the Cold Climate Utility Manual. Table 3.4 - Characteristics of Basic Wastewater Categories is an excerpt from the Cold Climate Utilities Manual, summarizing the characteristics of moderately diluted wastewater.

Table 3.4 –Waste Water Characteristics

Parameter	Units	Moderately Diluted
BOD_5	mg/L	460
COD	mg/L	1000
Suspended Solids	mg/L	490
Total Nitrogen	mg/l as N	--
Phosphorus	mg/L as P	--

‘Canadian Society for Civil Engineering, 1986, *Cold Climate Utilities Manual*

Regulatory Requirements

The proposed sewage treatment facility will be required to meet the effluent quality standards as set out in the Hamlet’s water licence. The effluent quality standards set out in the water licence are summarized in the Table 3.5 - Effluent Quality Standards.

Table 3.5 – Effluent Quality Standards at Monitoring Points CLY-4 and CLY-5

Parameters	Maximum Average Concentration
BOD_5	120mg/L
Total suspended solids (TSS)	180mg/L
Faecal coliforms	1 x 10^6 CFU/dl
Oil and grease	No visible sheen
pH	6 and 9

Seasonal Climatic Conditions

Table 3.6 summarizes the Seasonal Climatic Conditions for Clyde River. The data presented is extracted from the climatic normal’s from the National Climate Data and Information Archive posted by Environment Canada.

Table 3.6 – Monthly Precipitation

Month	Precipitation Rate	Average Daily Maximum Temperature	Average Daily Minimum Temperature
January	8 mm	-24.2 °C	-31.9°C
February	4 mm	-25.6 °C	-33.4°C
March	7 mm	-22.7 °C	-31.5°C
April	10 mm	-14.1°C	-23.9°C
May	17 mm	-4.3°C	-12.7°C
June	23 mm	3.6°C	-2.3°C
July	35 mm	8.2°C	0.6°C
August	41 mm	7.1°C	-0.6°C
September	43 mm	2.4°C	-2.4°C
October	31 mm	-4.5°C	-10.6°C
November	16 mm	-13.8 °C	-21.0°C
December	7 mm	-21.0 °C	-28.5°C

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Chapter 4 – Schematic and Functional Data

Operational Plan

The sewage lagoon system for Clyde River is a duel-cell storage lagoon providing the capacity to store the sewage generated by the Hamlet over one-year.

The following details the proposed operations of the sewage treatment system for Clyde River.

August 15 – September 15 - Discharge Operations

Mid-August the wetlands have melted and are now considered active. The lagoon is drained during this period to provide a continuous release of effluent to the wetlands over the optimal period for treatment. The release rate would be controlled by pumping.

Discharge will be done with a six inch portable priming assisted centrifugal pump driven by a liquid cooled diesel engine. The pump will be stored until the decanting period has begun where it will be transported and connected to the decanting infrastructure. The pump will be in operation for an average eight hour day for approximately four weeks, the entire decanting period.

The lagoon will be decanted to the south through the natural wetlands, and ultimately effluent will be released to Patricia Bay.

The sewage trucks continue to discharge to the lagoons which operate as a long detention lagoon with a continuous release rate greater then the inflow during this period.

September 15 – August 15 – Detention Lagoon Storage

Sewage trucks discharge to the lagoons over an eleven month period, beginning with the decanted lagoon. During this period the lagoon acts as a long term detention lagoon.

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Chapter 5 – Component Details

Berm Construction

New Berm Construction

The proposed new berm design is to have a 3H:1V slope. The berm crest width will be 4 m, except where the top of the berm is utilized for access, either for the decanting process or discharging of the sewer trucks, where it will be 5 m wide to better accommodate vehicles. As per the recommendations of the geotechnical report and geothermal analysis, the berms will be constructed with a liner on the upstream slope to provide an impermeable boundary, with an ice dam providing secondary containment and ensuring the liner is keyed into an impermeable surface, i.e. the permafrost. Improvements to the existing cell will follow the same specifications as the proposed new berms, slopes will be improved to 3H:1V and will be keyed into the steep side slopes of the existing cell.

Existing Berm Rehabilitation

The rehabilitation of the existing berms will include re-establishing the preferred 3H:1V slope. The granulars will be keyed into the existing berm and liners applied to the inside perimeter, and both sides of the berm when shared with the second cell.

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Chapter 6 – Operating Procedures

Normal Operating Procedures

.1 Berm Maintenance and Inspections

Berm monitoring will be vital during the first operational year to ensure proper freeze-back of the permafrost into the base soils and berm core. Temperatures will be recorded every three months by a data logger using installed thermistors along the crest of the berm to model the progressive frost, and to ensure that anticipated levels of freeze-back are achieved. The thermistors are installed with sensors going down to a final depth of 10.0m. The permafrost is expected to be re-established after the first year reducing the monitoring requirement to monthly periods throughout the summer season only. The monitoring will trace the lower limit of the active permafrost revealing an early warning if the permafrost does not recover. See Thermistor detail in Appendices.

In addition, a series of standpipes will also be installed to monitor for seepage. The standpipes should be monitored yearly, early to mid fall, for the presence of seepage. See Seepage Detail in Appendices.

.2 Sludge Management

It is anticipated that the sewage lagoon will not require desludging during its 20 year design life, as the available storage for sludge is greater then the quantity estimated to be generated.

Effluent quality will guide when a sludge management program is implemented. Monitoring of the effluent from the lagoon will indicate when the performance of the lagoon starts to degrade. Degradation of the performance of a lagoon is normally caused by sludge accumulation and will be the indicator to desludge the lagoon.

Prior to disposal, the sludge must be tested to ensure the disposal method chosen is safe and environmentally responsible. The sludge must meet the CCME guidelines as follows, or the requirements of the Solid Waste Disposal Facility

Sludge removed from the lagoons can be disposed of in a separate cell constructed at the landfill site. The sludge will be covered with granular material and allowed to freeze.

Inorganics

Parameter	CCME – Industrial ug/g	Parameter	CCME – Industrial ug/g
Antimony	40	Lead	600
Arsenic	12	Mercury	50
Barium	2000	Molybdenum	40
Beryllium	8	Nickel	50
Cadmium	22	Selenium	3.9
Chromium	87	Silver	40
Chromium VI	1.4	Thallium	1
Cobalt	300	Vanadium	130
Copper	91	Zinc	360

VOCs

Parameter	CCME – Industrial ug/g	Parameter	CCME – Industrial ug/g
Acetone	Nv	Trans-1,3-Dichloropropylene	50
Benzene	5	Ethylbenzene	20
Bromodichloromethane	Nv	Ethylene Dibromide	
Bromoform	Nv	Methyl Ethyl Ketone	
Bromomethane	Nv	Methylene Chloride	
Carbon Tetrachloride	50	Methyl Isobutyl Ketone	
Chlorobenzene	10	Methyl-t-Butyl Ether	
Chloroform	50	Styrene	50
Dibromochloromethane	Nv	1,1,1,2-Tetrachloroethane	nv
1,2-Dichlorobenzene	10	1,1,2,2-Tetrachloroethane	50
1,3-Dichlorobenzene	10	Toluene	1
1,4-Dichlorobenzene	10	Tetrachloroethylene	1
1,1-Dichloroethane	50	1,1,1-	50

		Trichloroethane	
Cis-1,2-Dichloroethylene	50	1,1,2-Trichloroethane	50
Trans-1,2-Dichloroethylene	50	Trichloroethylene	31
1,2-Dichloropropane	50	Vinyl Chloride	nv
Cis-1,3-Dichloropropylene	50	Total Xylenes	20

BTEX, CCME PETROLEUM HYDROCARBONS

Parameter	**CCME – Industrial ug/g**	**Parameter**	**CCME – Industrial ug/g**
F1 (C6-C10)	310	F4 (C34-C50)	3300
F1 (C6-C10) - BTEX	Nv	F1 (C6-C10)	310
F2 (C10-C16)	760	F1 (C6-C10) - BTEX	nv
F3 (C16-C34)	170		

Note: nv = no value
1. Criteria refers to Ministry of Environment "Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act" March 9, 2004
2. This table represents a summary of the data presented in the Laboratory Certificate of Analysis for convenience purposes only
3. This summary is to be use in conjunction with, not as a replacement of the Laboratory Certificate of Analysis which contains all QA/QC information
4. Criteria in brackets apply to medium and fine textured soils
5. Guideline flagging accuracy only guaranteed when result units correspond with guideline units on spreadsheet.

QA/ QC Program

.1 Monitoring

Monitoring the operation of the system will be accomplished through the establishment of two sampling points. Sampling will provide information regarding the performance of the system and help identify any degradation to the treatment provided. Table 6.1 provides coordinates of the sampling points (which will be confirmed upon construction by hand held GPS units).

Table 6.1 – Monitoring Points

Monitoring Program Station Number	Description	Latitude	Longitude
CLY-3a	Raw Wastewater Discharge (existing cell)	70° 28’ 11.92”	68° 37’ 49.12”
CLY-3b	Raw Wastewater Discharge (new cell)	70° 28’ 10.80”	68° 37’ 59.76”
CLY-4	Lagoon Pump Discharge (existing cell)	70° 28’ 06.90”	68° 37’ 45.51”
CLY-5	Lagoon Pump Discharge (new cell) (same as CLY-4)	70° 28’ 06.90”	68° 37’ 45.51”
CLY-6a	Sampling Well at end of Wetlands	70° 27’ 47.92”	68° 37’ 24.75”
CLY-6b	Surface water near sampling well at end of Wetlands	70° 27’ 47.92”	68° 37’ 24.75”
CLY-7	Water five (5) metres from effluent enters Patricia Bay		
CLY-8	Sewage Sludge		

.2 Sampling Frequency

The following outlines the Sampling Testing and Compliance requirements of the Wastewater Disposal Facility.

Table 6.2 – Sampling Frequency

Monitoring Program Station Number	Description	Frequency
CLY-3a	Raw Wastewater Discharge (existing cell)	Water Quality: Monthly and Annually
CLY-3b	Raw Wastewater Discharge (new cell)	Water Quality: Monthly and Annually
CLY-4	Lagoon Pump Discharge (existing cell)	Water Quality: Three Times Annually – Start, middle and end of decanting
CLY-5	Lagoon Pump Discharge (new cell) (same as CLY-4)	Water Quality: Three Times Annually – Start, middle and end of decanting
CLY-6a	Sampling Well at end of Wetlands	Water Quality: Three Times Annually – Start, middle and end of decanting
CLY-6b	Surface water at the end of the Wetland Area	Water Quality: Three Times Annually – Start, middle and end of decanting
CLY-7	Water five (5) metres from effluent enters Patricia Bay	Water Quality: Three Times Annually – Start, middle and end of decanting
CLY-8	Sewage Sludge	To be determined

.3 Sampling Parameters

Samples should be analyzed for the following parameters:

Biochemical Oxygen Demand – BOD_5	Faecal Coliforms
Total Suspended Solids	pH
Conductivity	Nitrate-Nitrite
Oil and Grease (visual)	Total Phenols
Magnesium	Calcium
Sodium	Potassium
Chloride	Sulphate

Total Hardness	Total Alkalinity
Ammonia Nitrogen	Total Zinc
Total Cadmium	Total Iron
Total Cobalt	Total Manganese
Total Chromium	Total Nickel
Total Copper	Total Lead
Total Aluminum	Total Arsenic
Total Mercury	Total Organic Carbon (TOC)q

.4 Compliance Point

The water license has set the lagoon discharge as the compliance point for the new wastewater facility as it is the last point of measurement and control.

The effluent released from the Lagoon must meet the criteria list in Table 6.3. This criteria recognizes the treatment ability of the wetlands.

Table 6.3 – Effluent Criteria at the Compliance Point

Parameter	Maximum Average Concentration
BOD_5	120 mg/L
Total Suspended Solids (TSS)	180 mg/L
Faecal Coliforms	1×10^6 CFU/100mL
Oil and Grease	No visible sheen
pH	Between 6 and 9

.5 Laboratory Requirements

All analyses shall be performed by a laboratory certified by the Canadian Association for Laboratory Accreditation (CALA), or as otherwise approved by an Analyst.

.6 Sampling Procedures

The sampling procedures should be as per "Quality Assurance (QA) and Quality Control (QC) Guidelines for use by Class "B" Licenses in Collecting Representatives water samples in the field" as summarized in the appendix.