ARCTIC BAY TRUCKFILL
ARCTIC BAY, NT

OPERATIONS AND MAINTENANCE MANUAL

VOLUME 1 OF 2

Prepared for:
Government of Northwest Territories
Department of Public Works and Services
Bag 1000
Iqaluit, NT
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Department of Public Works and Services Project No. 4-001-658
Dillon Project No. 96-3817

June 1998

1.0 INTRODUCTION

1.1 Project Title

ARCTIC BAY TRUCKFILL

ARCTIC BAY, NT

JUNE 1998

Set No. 2 **of 4**

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1.2 Revision Data

Date	Description	Pages

1.3 Changes after Commissioning

Date	Change

1.4 Project Representatives

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3.0 DESIGN DATA

3.1 General

This section contains the predesign report entitled "Truckfill Stations - Arctic Bay & Clyde River, NWT Predesign Report" as originally published. The page numbering, figure numbers, table numbers, headers, footers, and appendices are independent of this manual's organization.

Truckfill Stations - Arctic Bay & Clyde River, NWT
Predesign Report

November 19, 1996

Truckfill Stations
Arctic Bay & Clyde River, NWT

Government of the Northwest Territories
Department of Public Works & Services

96-3817-01-01

Submitted by

Dillon Consulting Limited

December 18, 1996

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Attention: David Parker, P. Eng
Project Officer

Arctic Bay and Clyde River
Truck Fill Stations, NWT

Dear Mr. Parker;

Enclosed, please find three copies of the final version of the predesign report for the above project. As requested we have forwarded a copy of this report to the NWT and Nunavut Water Boards for their review and comment. This report has been revised to the comments we received from you recently.

The design of the truck fill stations is proceeding based on the information contained in the document. We anticipate the design will be completed early in the new year. We trust that you find this final report to your satisfaction.

Yours sincerely

Dillon Consulting Limited

Gary Strong, P.Eng.

Project Manager

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 010
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96-3817/158/draft.let

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APPENDICES

1.0 INTRODUCTION

General

The Government of the Northwest Territories (GNWT) identified the installation of truckfill stations in the communities of Arctic Bay and Clyde River as priorities in the 1997/98 fiscal period. The implementation of these initiatives was combined by the Department of Public Works and Services (PW&S) into one project. The facilities will have many similar components in the design and construction, and it was determined by PW&S that there will be economies in scale in the completion of these projects as one design assignment. In October of 1996, Dillon Consulting Limited was retained to complete the engineering services related to this assignment.

Background

Planning studies for the water supply systems in Arctic Bay and Clyde River were completed by Dillon in 1995. These planning studies identified the conceptual water supply system for each community. The water supply systems, as set out in the planning studies, and stated in the project terms of reference, are as follows:

"The new facility shall accommodate the following design characteristics:

It is assumed that power to the site will be provided by on site power generation, however the consultant is to investigate the construction of a power line to the site and provide a cost analysis for both alternatives.

Pumphouse / Truckfill Building

- *Truckfill pumps (1 duty, 1 standby).*
- *In-line chlorination through the truckfill line.*
- *Insulated and heat traced overhead truckfill arm, with water totalizer meter.*
- *Building heating and light.*
- *System controls / monitoring.*
- *Spares for the critical components subject to breakdown.*

- *One year supply of consumable (ie. chlorine)*
- *Adequate storage space for chlorine chemicals, space should be secure.*
- *On site power source for the station to be diesel motor / generator sets (1 duty) and are to be low RPM units.*
- *Heat trace (1 duty, 1 standby) c/w heat trace monitoring capability.*
- *Bench / cupboard for storage.*
- *Eyewash station.*
- *Exterior Fuel Tank.*
- *Interior day tank c/w (1 duty, 1 standby) fuel transfer pumps.*
- *Metal skid foundation for portability.*
- *Truckfill intake to be, single intake with screen and intake protection.*
- *Insulated and heat traced intake pipe at minimum length."*

Report Approach

This design concept brief will develop the planning concepts for the water supply system to a design level of detail. Where alternative approaches are possible, these will be discussed, and cost estimates developed. Recommendations for each of the component systems will be made. The report will deal with each of the community water supply systems individually. Where components can be maintained through both facilities to reduce costs, this will be identified.

2.0 SYSTEM DESIGN STANDARDS

2.1 Design Criteria

The design criteria for this project will be completed in accordance with the parameters set out by the GNWT, "Water and Sewage Facilities Capital Programs" and as modified by the terms of reference. These are as follows:

Facility	Design Horizon	Design Economic Life	Design Expected Life
Building	20	20	40
Pumps	10	20	20
Pipelines	20	20	30

Where the:

a) Design horizon is the period used to establish capacity requirements for a facility.

b) Design economic life is the period used in the economic analysis to establish the present value (or equivalent capital cost) of a facility.

c) Design expected life is the practical maximum expected life of a facility assuming no premature failure, destruction or obsolescence.

2.2 Design Standards

The following is a list of the design standards to be used in the development of the water supply system. These are derived from the GNWT "General Terms of Reference for Water and Sanitation" (GTR), and the "National Building Code" (NBC), and "Capital Standards Criteria, September 1993," MACA.

Water Consumption Rates		Reference
Domestic	90 litres per capita per day	MACA
Commercial	0.00023 x population	MACA
Total Consumption per Capita	90 x (1.0 + 0.00023 x pop.)	MACA
Fire Demand	910 litres per minute for 60 minute duration	MACA & Fire Marshal
Discount Rates	4%, 8% and 12%	MACA

Environmental Conditions		Arctic Bay	Clyde River
Design Minimum Temp.		-43°C	-41°C
Degree Days (18°C)		11693	11006
Snow Load	SS SR	1.9 kPa 0.1 kPa	3.2 kPa 0.2 kPa
Wind Pressures		0.5 kPa	0.8 kPa

2.3 Design Parameters

The project terms of reference identified the following as design parameters for the facilities.

- *"Facilities must be simple to operate and maintain by local forces with limited equipment, and parts and materials which are available locally.*
- *Reliability of the facility is extremely important.*
- *The facility must be efficient and cost effective.*
- *The truckfill supply shall have a minimum pumping capacity of 1000 L/min.*
- *All equipment and pipes must be self draining after each use cycle, where practical. When self draining of any major component cannot practically be accommodated, some other means of frost protection should be incorporated.*
- *All major components must be capable of recovering from a frozen condition, in an operable state, if there is any possibility of freezing.*
- *Provisions of spares for all equipment is required, particularly components that have bulbs, fuses, relays, timers, etc.*
- *The first year supply of consumable, such as calcium hypochlorite, must be a requirement of the construction contract.*
- *Provision for standby power generation at the truckfill station is in accordance with GNWT's Municipal and Community Affairs Guidelines.*
- *The electrical drawings are to be provided to an industrial electrical standard and all drawings must have adequate detail to ensure that they are easily understood by*

local and northern contractors.

- *If the truckfill station is constructed at some location other than the site, the building is to be mounted on skids should relocation be required.*
- *Fuel storage at the truckfill station must provide for spill containment.*
- *Water supplied from the truckfill station must be metered.*
- *A copy of the design must be submitted to the NWT Water Board, for review.*
- *Provision for an alarm system which indicates loss of power and low building temperature, is required."*

2.4 Cost Analysis

Throughout this document, there are cost analysis of various options. The analysis have been carried out as outlined in the GTR as described below:

Capital Cost

Cost of construction for the facility

Annual Operation and Maintenance Costs

The cost of operation, which may include manpower, energy requirements, fuel, general maintenance (light bulbs, paint), and equipment replacement.

Life Cycle Costs

The calculation of the total facility cost over a 20-Year period. This includes the capital, operations and maintenance costs. The life cycle value is shown as a present value which is calculated at a discount rate of 4%, 8% and 12%.

3.0 WATER QUANTITY REQUIREMENTS

The water supply system for the communities is to meet the 20-Year demand. The program implementation schedule and fiscal budgets set out by the GNWT indicate that the construction of the facility will be completed in 1997 and therefore, Year 0 of the facility is 1997. In the planning study completed by Dillon, Year 0 was set at 1998. The water consumption data from the planning study has been brought forth into this document, and updated to reflect the change in the design horizon.

The following illustrates the historical population and water consumption data for the communities.

ARCTIC BAY

Year	Population	Water Consumption (lcd)
1976	387	N/A
1978	414	34
1986	480	50
1994	592	73.9

CLYDE RIVER

Year	Population	Growth Rate of Population	Water Consumption (lcd)
1974	350	4.6%	N/A
1979	439	4.5%	20.6
1981	443	1.2%	N/A
1986	471	3.7%	N/A
1989	500	2.0%	49.2
1991	565	2.4%	49.9
1993	592	1.5%	48.0
1994	601	1.5%	N/A

The Bureau of Statistics for the Northwest Territories provides population projections for all communities in the NWT with a population in excess of 100 people. **Figure 3.1** shows the population growth and annual water consumption for the community of Arctic Bay and **Figure 3.2** for Clyde River. Based on the values presented in this table, the 20-Year design population and consumption for Arctic Bay are 973 people and 39,100 m^3 respectively, and for Clyde River are 1,076 people and 44,100 m^3.

Design Year	Year	Population	Consumption		
			Litres per Capita	Daily (litres)	Annual (cubic metres)
0	1997	628	103.0	64,700	23,600
1	1998	637	103.2	65,700	24,000
2	1999	651	103.5	67,400	24,600
3	2000	666	103.8	69,100	25,200
4	2001	682	104.1	71,000	25,900
5	2002	698	104.4	72,900	26,600
6	2003	714	104.8	74,800	27,300
7	2004	730	105.1	76,700	28,000
8	2005	747	105.5	78,800	28,800
9	2006	763	105.8	80,700	29,500
10	2007	780	106.1	82,800	30,200
11	2008	797	106.5	84,900	31,000
12	2009	815	106.9	87,100	31,800
13	2010	833	107.2	89,300	32,600
14	2011	852	107.6	91,700	33,500
15	2012	871	108.0	94,100	34,300
16	2013	890	108.4	96,500	35,200
17	2014	910	108.8	99,000	36,100
18	2015	931	109.3	101,800	37,200
19	2016	952	109.7	104,400	38,100
20	2017	973	110.1	107,100	39,100

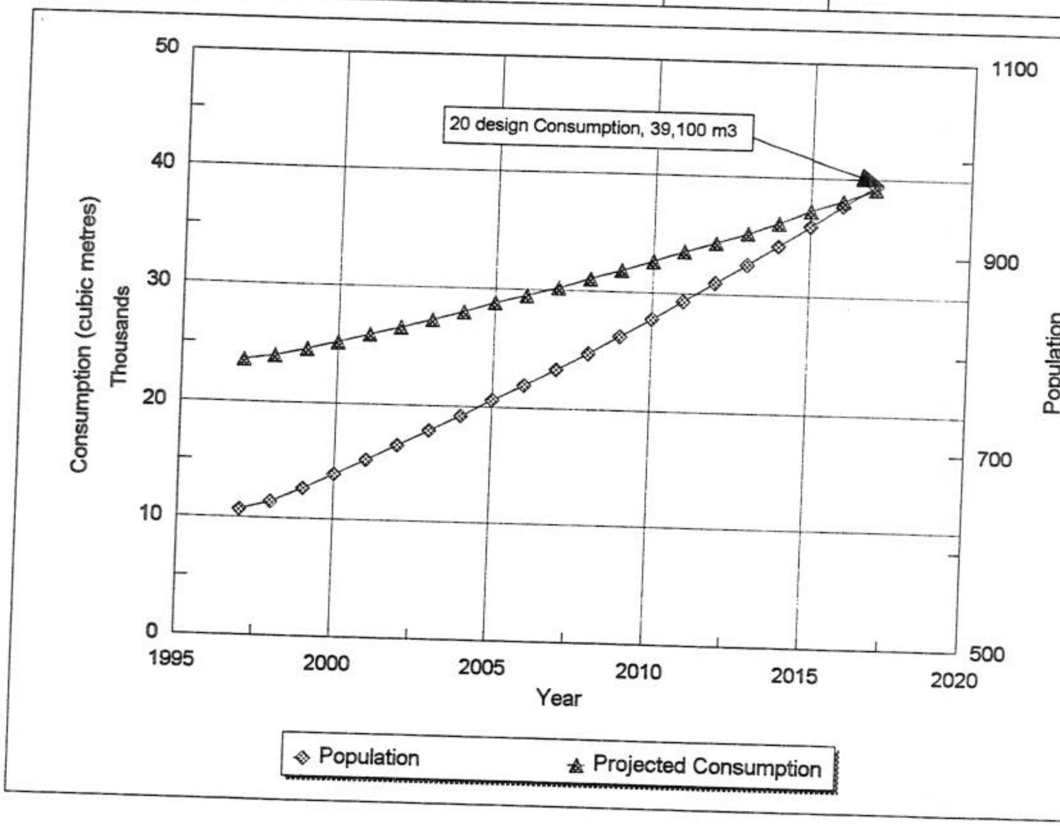

Figure 3.1 Population Projections, Arctic Bay

Predesign Report, Arctic Bay & Clyde River Truck Fill Station, NWT

Public Works and Services

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Design Year	Year	Population	Consumption		
			Litres per Capita	Daily (litres)	Annual (cubic metres)
0	1997	655	103.6	67,900	24,800
1	1998	672	103.9	69,800	25,500
2	1999	688	104.2	71,700	26,200
3	2000	706	104.6	73,800	26,900
4	2001	723	105.0	75,900	27,700
5	2002	742	105.4	78,200	28,500
6	2003	760	105.7	80,300	29,300
7	2004	779	106.1	82,700	30,200
8	2005	799	106.5	85,100	31,100
9	2006	819	107.0	87,600	32,000
10	2007	840	107.4	90,200	32,900
11	2008	861	107.8	92,800	33,900
12	2009	882	108.3	95,500	34,900
13	2010	905	108.7	98,400	35,900
14	2011	927	109.2	101,200	36,900
15	2012	951	109.7	104,300	38,100
16	2013	975	110.2	107,400	39,200
17	2014	999	110.7	110,600	40,400
18	2015	1,024	111.2	113,900	41,600
19	2016	1,050	111.7	117,300	42,800
20	2017	1,076	112.3	120,800	44,100

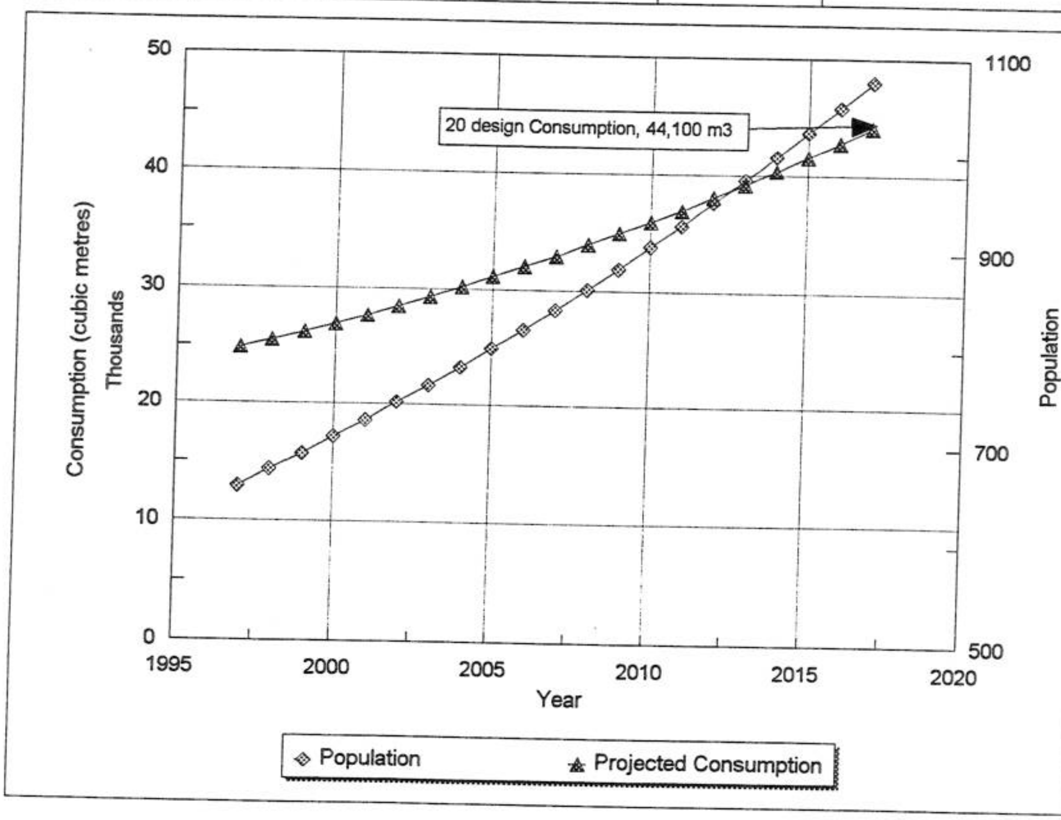

Figure 3.2 Population Projections, Clyde River

Predesign Report, Arctic Bay & Clyde River Truck Fill Station, NWT

Public Works and Services

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3.1 Water Quality and Water Treatment

3.1.1 Arctic Bay

The long term water supply for Arctic Bay has been identified as Marcil Lake. The community has indicated that they accept this water source, and that they find the water aesthetically acceptable.

Water quality testing has been completed on this water source by various parties, including Dillon during the previous planning assignment. **Figure 3.3** summarizes the water sample data completed on Marcil Lake in previous studies.

Parameters tested were selected to provide indicators of the water quality of the raw water source. The test results indicate that there is not a particular area of concern with the water source. The water quality meets the requirements of the Guidelines for Canadian Drinking Water Quality (1996) (GCDWQ) for all parameters except turbidity. The guidelines require an average level of turbidity below the level of 1.0 NTU (Nephelometric Turbidity Units). However, the guidelines allow the average level of turbidity to be less than 5.0 NTU if it can be shown that disinfection is not affected by the higher level of turbidity.

The water data indicates that turbidity ranged from 1 to 15 NTU with an average of 6.2 over the test samples. The historic use of the water source by the community with no reported problems of water related disease attributed to the raw water source, suggests that the presence of the slightly elevated levels of turbidity do not affect the disinfection of the water. The number of data sets available is limited, and the data doesn't provide a clear understanding of the temporal water charateristics.

In discussions with MACA it was decided that the truckfill station is to be designed to allow for the addition of filtration to remove the turbidity in the future. This addition will be made if the operation of the facility and the results of the sampling program indicate that the turbidity levels are problematic.

Monitoring of the raw water source should be done as part of the operation of the facility. The parameters to be tested for should include the major ions and turbidity. Monthly testing should be completed of the raw water supply to develop a more extensive data base to allow for future treatment assessment. Parameters to be tested for are to include; balance, bicarbonate, chloride, carbonate, conductance, fluoride, hardness, calcium, iron, potassium, magnesium, manganese, sodium, sulphate, nitrate, nitrite, pH, total alkalinity, TDS, and turbidity.

3.1.2 Clyde River

Historic water sampling has been completed on the selected water source from 1983 to date. **Figure 3.4** illustrates the sample collection and analysis completed. The 1994 samples were collected from various depths. The results of the samples indicated that the water is of good quality with no major areas of concern.

Turbidity levels are slightly elevated, the average is 3.0 NTU, which is within the guidelines.

Two samples indicate that the pH is below the aesthetic guidelines. The community has not raised concerns with the taste of the water, however, should continued sampling indicate that the water is consistently below the guideline, remedial treatment is to be considered. Treatment would consist of the addition of Soda Ash ($NaCO_3$) to the water. This can be completed automatically or manually. Due to fluctuations in the pH, monthly testing of the water for pH, and pH control manually is recommended. A supply of Soda Ash, and a hach pH Kit will be included in the design. The design of the facility will not address this issue.

There has been concerns expressed by MACA and/or the community with respect to late spring water quality. In other communities, water quality deteriorates over the winter due to a decrease in the level of dissolved oxygen. Sampling to date indicates that this will not be a concern at Clyde River. However, if in future a concern is raised, the small lake can be aerated using a compressor and a hose to convey air to the intake screen. This system is in place elsewhere in the NWT (Rankin Inlet). No provision in the design of the facility is required to address this future installation.

3.1.3 Disinfection

The GCDWQ require that the disinfection process for raw water also have a residual disinfection component. This is achieved through the use of chlorination. A typical residual chlorination level is 1 part per million (ppm). Many communities in the NWT find the taste of chlorine unpleasing, and residual levels are often set at 0.5 ppm. Several chemicals are available for disinfection of domestic water supplies. These include:

- Gaseous Chlorine
- Sodium hypochlorite (liquid)
- Calcium hypochlorite (solid)

Date Sampled :		Aug 26/83	Mar 13/84	Oct 24/84	Sept 10/85	Sept 11/85	Dec 1/87	Aug 18/92	July 26/94						GCDWQ GUIDELINES		
Sample Depth (m):		0	0	0	0	0	0	0	2.0	4.0	6.0	8.0	10.0	12.0	Maximum Acceptable Concentrations	Interim Maximum Acceptable Concentrations	Aesthetic Objectives (Max. Conc.)
PARAMETER	NOTES																
Ammonia									0.0250	0.0090	0.0030	0.0030	0.0110	0.0005			
Arsenic		0.0010	0.0010			<0.5		<0.005	0.0003	<0.003	0.0003	<0.0003	0.0003	0.0003	0.05	0.025	
Cadmium		<0.05	0.0013					<0.0002							0.005		
Calcium		<0.10	0.50	0.20	1.20	<1.0	1.70	<1.0	0.67	0.62	0.62	0.59	0.62	0.62			
Chloride		2.00	4.50	3.80	3.20	3.30	4.10	3.90	2.42	2.34	2.30	2.29	2.31	2.28			250
Chromium		0.0080	0.0045					0.0030							0.05		
Color (TCU)	2	<5.0	<5.0	10.0	15.0	10.0	10.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0			15
Conductivity (μmho/cm)		18.0	36.0	29.0	28.9	9.0	46.1	22.5	23.2	22.5	22.3	22.2	22.6	22.3			
Copper								0.003									1.0
Iron		0.0555	0.0400	0.2300	0.2300		0.0200	0.0055									0.3
Lead			0.0057					<0.001							0.01		
Magnesium		0.53	0.80	0.60	0.20	0.54	0.80	0.60	0.50	0.50	0.50	0.50	0.50	0.60			
Manganese				0.006	0.005		<0.01										0.05
Mercury		0.00010	0.00006						0.00022	0.00002			0.00030		0.001		
Nickel			0.001					0.001									
Ortho Phosphate	3								<0.002	0.002	0.002	0.002	0.002	0.002			
pH (unitless)		6.50	6.60	6.90	7.43	4.10	6.90	6.76	6.48	6.53	6.59	6.58	6.58	6.60			6.5 - 8.5
Potassium		0.35	0.70	0.70	0.60	0.60	0.60	0.50	0.58	0.41	0.41	0.41	0.42	0.42			
Silica									0.061	0.135							
Sodium		1.80	3.60	2.70	3.60	2.35	2.70	2.50	2.13	1.90	1.92	1.89	1.91	1.90			200
Sulphate		<1.0	1.5	2.0	2.0	2.0	<1.0	<2.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0			500
Suspended Solids		<5	<5					<3	<3	<3	<3	<3	<3	<3			
Total Alkalinity	4	3.1	5.8	8.2	8.4	Note 1.	7.5	4.0	3.1	3.1	3.1	3.0	3.1	3.0			
Total Dissolved Solids								19.0	17.0	<10.0	13.0	10.0	10.0	11.0			500
Total Hardness	4	2.36	4.50	3.00	3.80	4.20	7.40	5.00	3.70	3.60	3.60	3.50	3.60	4.00	500.00		100
Total Kjeldahl N	5								<0.008	<0.008							
Total Nitrates	6			0.050	0.050		<0.05	<0.04	<0.008	<0.008	0.011	0.011	0.038	0.012	45.0		
Total Nitrites	6			0.005	0.003		<0.05				0.011	0.011	0.038	0.012	3.2		
Total Phosphorus	3							<0.005	<0.002	0.008	0.007	0.005	0.010	0.008			
Turbidity (NTU)	7	1.5	0.6	5.0	6.5	6.0	1.0	15.0	2.2	2.2	2.0	2.1	2.1	2.3	1		5
Zinc		0.0440	0.0052					0.0010									5

Notes

All Results are expressed in mg/L, unless indicated in brackets ( ).
Blank cells indicate that the sample was not tested for that parameter.
Shaded cells indicate that the sample exceeds the GCDWQ guidelines for the indicated parameter.

1. Sample was too acidic for alkalinity titration.
2. TCU - True Color Units
3. Ortho Phosphate, and Total Phosphorus are stated in terms of mg/L of P (phosphorus)
4. Total Hardness, and Total Alkalinity are stated in terms of mg/L of CaCO3 (calcium carbonate)
5. Total Kjeldal N is stated in terms of mg/L of N (Nitrogen)
6. Equivalent to 10.0 mg/L nitrate as nitrogen, where nitrate and nitrite are determined separately. Levels of nitrite should not exceed 3.2 mg/L
7. NTU - Neophelometric Turbidity Units

Figure 3.4 Clyde River Water Samples
Arctic Bay & Clyde River Truck Fill Stations, NWT

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Gaseous chlorine requires storage in a separate room that is monitored for chlorine gas emissions. Safety equipment and training is necessary to comply with the Occupational Health and Safety Regulations when chlorine gas is used. The transparent of gaseous chlorine is regulated by the Transportation of Dangerous Goods (TDG) and it cannot be transported by passenger airplane. For these reasons, the use of gaseous chlorine is not recommended for small facilities such as the Arctic Bay or Clyde River Truckfill Stations.

Sodium hypochlorite is shipped and stored as a liquid. The liquid is subject to freezing, and is to be stored in a heated room (above -10°C). Sodium hypochlorite used in water treatment is similar to house hold bleach. It is available at 12% available chlorine, whereas bleach is 6% available chlorine. Sodium hypochlorite looses its concentration with time. After 90 days the level of available chlorine drops slowly and may reach a level similar to bleach after 6 months. If the 12% available sodium hypochlorite is diluted to 2% available, the shelf life is significantly extended. The operation of the disinfection system using sodium hypochlorite is relatively simple. The liquid is used directly without mixing. An injection pump is used to inject the liquid into the water as it flows through the truckfill arm.

Calcium hypochlorite is shipped and stored as a powder. There is no concern with freeze protection, and heated storage is not required. Calcium hypochlorite has 65% available chlorine by weight. The powder is mixed with water to make a solution that can be used in the disinfection process. Typically the solution is mixed at a concentration similar to that of sodium hypochlorite (2% available chlorine is typical). The disinfection system for calcium hypochlorite requires a mixing tank, a solution tank, and an injection pump.

Both calcium and sodium hypochlorite are commonly used for disinfection in small facilities. The use of calcium hypochlorite is more common in the NWT. The issues to be addressed in the selection of a disinfectant are; the cost of the optional system; the relative ease of use; and the risk of failure.

Cost of System

Sodium hypochlorite, as a liquid, requires a greater volume of disinfectant to be shipped to site than calcium hypochlorite. Based on 12% available chlorine for sodium hypochlorite and 65% available for calcium hypochlorite the required shipping weight of disinfectant and volume to be shipped to site are as follows:

Disinfectant	Year 0 (1997)	Year 20 (2018)
Calcium Hypochlorite	37 Kg	60 Kg
Sodium Hypochlorite	200 L (200 Kg)	325 L (325 Kg)

The supply and transportation costs associated with each chemicals.

Disinfectant	Supply (Year 0)	Transportation (Year 0)	Life Cycle
Calcium Hypochlorite	$270	$20	$2,850
Sodium Hypochlorite	$160	$77	$2,350

The above is based on using the sealift for all transportation.

Operation

The mechanical and control systems for either disinfectant is similar. The difference is that calcium hypochlorite requires a mixing and solution tank. Typically these are 30 to 60 litre tanks each. They require a floor area of 1.5 m^2 for the tanks. The mixing tank is elevated to allow it to gravity feed into the solution tank. The sodium hypochlorite does not require any additional tanks as it is transported in its own 22 litre container. The tanks and additional space required for the calcium hypochlorite system increases the capital cost of the facility.

The mixing process requires approximately 1 hour of operation time every 2 weeks for the calcium system. Less than 10 minutes per month will be required for the sodium system.

Risk of Failure

As the two systems are mechanically and electrically the same, the risk of failure for these systems are also similar. These is an additional risk associated with the sodium hypochlorite when there is a power failure. The liquid could freeze during an extended power loss. With the calcium system, the mixed disinfectant will also freeze, however, the remaining powdered calcium hypochlorite will not be damaged.

Summary

The use of sodium hypochlorite is operatively more simplistic and user friendly. The difference in supply ad transportation costs for these chemicals is negligible. The sodium hypochlorite has a risk of freezing in the event of a power outage. Should this occur, standard household bleach from the local Northern Store can be used as a substitute until additional sodium hypochlorite is flown in. To assess the risk, it is assumed that each year 50% of the sodium hypochlorite is flown to site.

Item	Sodium Hypochlorite	Calcium Hypochlorite
Supply Cost (Year 1)	$ 77.00	$ 170.00
Transportation Cost (Year 1)	$ 421.00 * 400	$ 7.00
Operations Time (Year 1)	$ 40.00	$ 520.00
Total Annual Cost (Year 1)	$ 1,015.00	$ 1,140.00
Capital Cost	$ 800.00	$ 920.00
Life Cycle Cost	$ 12,000.00	$ 16,000.00

The above analysis indicates that sodium hypochlorite is the more economical system for disinfection. The detailed cost calculation is Appended.

* The transportation cost for sodium hypochlorite in this annalysis is based on 50% of the required volume being transported by air to the community.

The Department of Municipal and Community Affairs selected the use of the calcium hypochlorite for disinfection in these facilities.