DESIGN BRIEF

Sewage Lagoon/Solid Waste Site Improvements

ARCTIC BAY, N.W.T.

Prepared for:

Department of Public Works and Services
Baffin Region
Government of the N.W.T.
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1.0 INTRODUCTION

The community of Arctic Bay, Northwest Territories, currently operates sanitary landfill and sewage lagoon facilities on a site approximately 2.5 km from the Hamlet, located adjacent a runoff stream bed between the plateau and the water shoreline (Arctic Bay).

The existing sewage lagoon was of a permeable dyke design, portions of the berm have become plugged, which has caused the sewage to breach the berm and overflow in the past. Currently, sewage leaks through the bottom of the south berm at an uncontrolled rate.

The solid waste site is somewhat undefined as solid waste is scattered all along the access road as well as at the present fill face. Currently, there are no defined areas for bulky metals, waste oils, animal carcass, or hazardous wastes. The existing old vehicle dump is separated from the areas and is located along the road, approximately midway between the disposal site and the community.

Public Works and Services has a need to upgrade and expand these facilities to meet current design standards and to meet the requirements of the community for a ten year design horizon ending in the year 2009, based on a facility start up in 1999.

This Design Brief is intended to set out the design parameters and assumptions, present the information gathered during the preliminary engineering phase and to develop conceptual designs for the facilities.

2.0 DESIGN CRITERIA

2.1 Statement of Objectives

To provide sewage and solid waste facilities to ensure the community of Arctic Bay a safe, reliable means of disposing sewage and solid waste. The facility shall be simple in operation and maintenance and have (wherever feasible) minimal impact on the environment.

2.2 Goals

Public Safety	no hazardous structures or facilities to which public has casual access.
Operator Safety	no undo hazards to operations and maintenance personnel within the facilities.
Maintenance	routine maintenance must be within the ability of local operators without need for specialized skills or tools.
Operation	operation must be simple and intuitive.
Cost Effectiveness	facilities must be cost effective with respect to capital, operation and maintenance costs.
Aesthetics	view of the facility must blend into the existing setting.

2.3 Constraints

- severe Arctic climate;
- short construction season;
- remote location;
- limited availability of local tradesmen;
- limited material and equipment availability;
- high transportation costs;
- relative steep terrain along shores of Arctic Bay; and
- short treatment season (summer) with limited favourable temperatures and sunlight.

2.4 Criteria

Common Criteria

- design must provide for cleanup and rehabilitation of the existing facilities; and
- facilities must be accessible year round.

Lagoon Criteria

- components of sewage lagoon must be able to operate in, or recover from a condition where there is any possibility of freezing;
- temporary honeybag disposal area is required;
- provide for truck dumping facility at the lagoon;
- lagoon must have adequate storage volume for a minimum of 365 days retention, based on 10 year design loads;

- provide a means of draining lagoon(s) in the fall with complete discharge to a body of water;
- provide a plan of operation for periodic de-sludging of the lagoon;
- design to allow for construction of future adjacent cell;
- provide site security, if necessary, fencing;
- provide effective signage.

Solid Waste Facilities

- provide separate areas for:
  - general solid waste
  - bulky metals
  -waste oils (fenced?)
  - animal carcass disposal
  - hazardous waste (paints, solvents, and other toxic materials) (fenced?);
- provide for relocation of old vehicle dump to new solid waste site, allowing for a scavenging area;
- provide for disposal/recycling of tires, considering use for landfill containment, etc.;
- provide an area and a means for burning garbage to reduce volume of waste for the landfill.

3.0 INITIAL DESIGN ASSUMPTIONS AND DATA

Winds: Prevailing winds are NW at 21 km per hour

Climate:	February Ambient	High/Low/Mean	-27.5/-35.4/-31.4 ° C.
	July Ambient	High/Low/Mean	9.9/2.0/6.0 ° C.
	Summer Season	July to September	
	Winter Season	September to July	

Precipitation:	Average Annual Snowfall (Precipitation)	77.7 mm
	Average Annual Rain	54.4 mm
	Total	135.1 mm

Population Projection:

The average annual growth rate of the community has been 2.75% according to the Terms of Reference. The current (1996) population of 622 projected to the years 1999 and 2009 at 2.75% annual growth gives projected populations of 675 and 884 in the start year (1999) and in the horizon year (2009), respectively.

Statistics Canada projects a population growth from 639 (1996) to 801 (2006). Extending the Statistics Canada projection calculations to a population of 857 in the year 2009.

For the purpose of this report, we have averaged the two projections and will use a population of 871 for the year 2009.

The population in the year 1999 (start year for using the new landfill facility) averaged to 681.

Existing Effluent Quality:

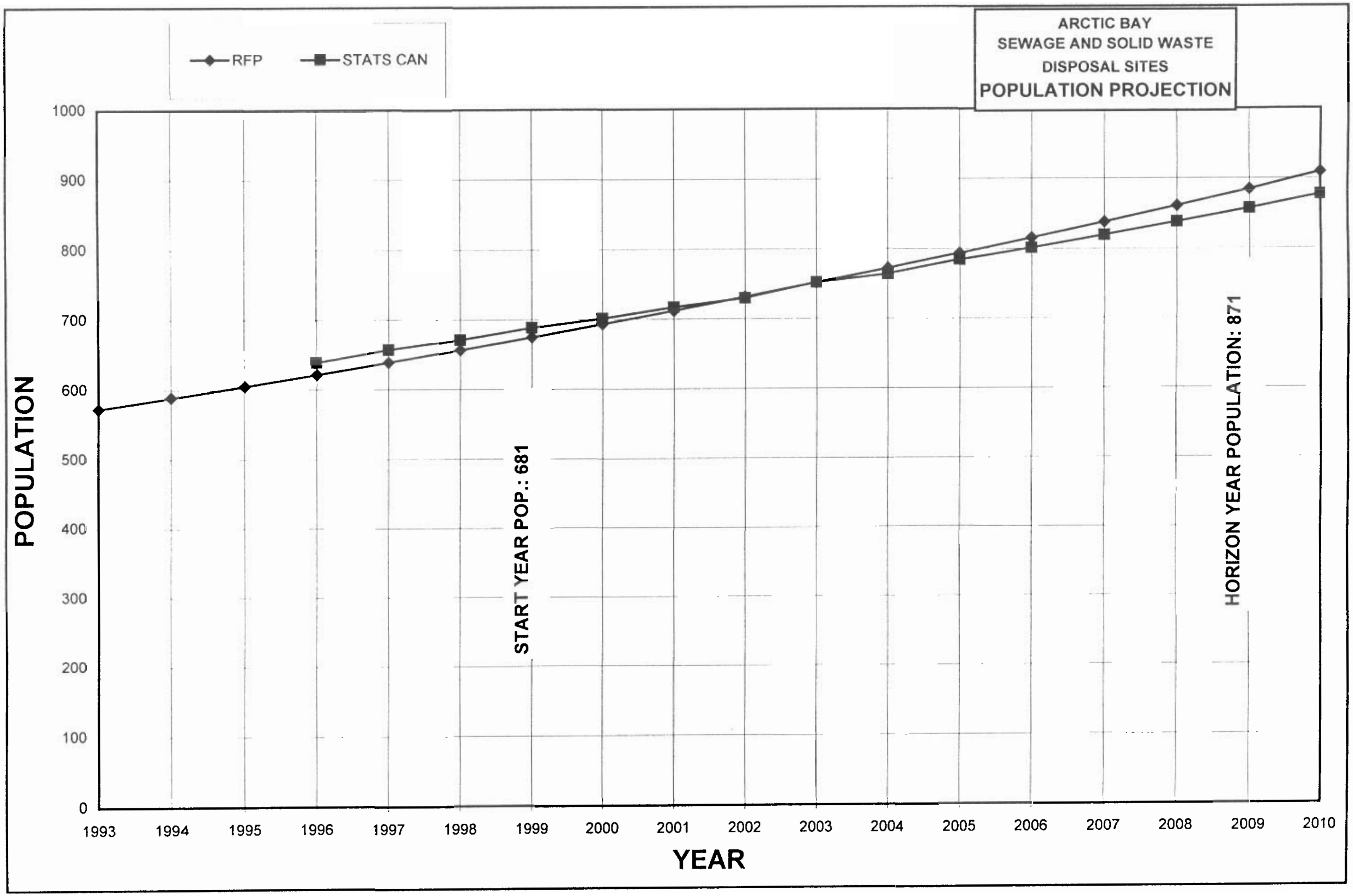
Currently, during the summer months, the sewage that enters the existing lagoon receives minor settling (unless the berm is breached) and effluent that passes through the berm drains directly down the hill, through the culverts at the Nanasivik Road and into the Bay.

A very noticeable plume at the shore shows the relatively raw, untreated nature of the effluent. While no samples have been taken yet, we recommend that samples of effluent be taken for analysis during the summer months of 1997 to allow for comparison of the effects of the new lagoon system on the quality of effluent.

3.1 Sewage Generation

Sewage generation is assumed to be equal to water usage. For the purpose of calculating the size requirements of the sewage lagoon and solid waste sites, the horizon year (2009) population 871 was used.

The formulas found in the document entitled "Guidelines for the Planning, Design, Operation and Maintenance of Wastewater Lagoon Systems in the Northern Territories" was used for calculating the sewage generation rates. These calculations are presented below. Sewage generation is assumed to equal water consumption.


ARCTIC BAY
SEWAGE AND SOLID WASTE
DISPOSAL SITES
POPULATION PROJECTION
RFP
STATS CAN
POPULATION
1000
900
800
700
600
500
400
300
200
100
0
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
YEAR
START YEAR POP.: 681
HORIZON YEAR POPULATION: 871

From the existing usage of 80 l/p.d., the current (1997) annual sewage generation is as follows:

$$675 \text{ p} \times 365 \text{ d/yr} \times 80 \text{ l/p.d} = 19{,}710 \text{ m}^3\text{/yr}$$

The average current usage measured by local personnel is 80 l/p.d. The future usage is therefore calculated as follows:

Current Sewage Generation	=	Water usage (measured) =	80 l/p.d
Water Use Adjustment	=	Residential rate x [(1.0) + (0.00023)(Pop.)]	
	=	80 x [1.0 + 0.00023 (871)]	
	=	96.0 l/p.d	

Using the calculated value for sewage generation, in the design horizon year of 95.9 l/p.d, the required capacity of the sewage lagoon is:

$$\frac{1\,m^3}{1000\,l} 871\,p \times \frac{365\,days}{Yr} \times 96.0\,l/p.d = 30{,}520\,m^3$$

3.2 Solid Waste Generation

According to local personnel, the community currently generates approximately 20 m^3 per week $\left(\frac{.0047\,m^3}{p/day}\right)$ of solid waste, much of it being cardboard and other paper products.

Given the growth rate from the present population of 605 to a population of 871 in 2009, (see graph on the following page) we find the following:

Future generation = present waste generation x $\frac{\textit{future population}}{\textit{present population}\ (1995)}$

$$= \frac{20\ m^3}{wk} \times \frac{871}{605}$$

$$= \frac{28.8\ m^3}{wk}\ or\ \frac{1497\ m^3}{year}$$

Assuming 25% of this volume to be paper and a compacted volume of the remainder to be 33% of original (from GNWT Design Guidelines) we find the following compacted volume at design year 2009 (with burning) to be:

$$= 1497\ m^3 \times 0.75 \times 0.33 = 371\ m^3\ /\ year$$

Total production of solid waste (uncompacted volume) in the design period of 1999 to 2009 is then calculated as follows:

$$\frac{365\,V\,P_1}{\ln(1+G)}\left[(1+G)^{PH} - (1+G)\right] + \frac{0.084\,V\,P_1^2}{2\ln(1+G)}\left[(1+G)^{2PH} - (1+G)^2\right] \text{ (GNWT Guidelines)}$$

Where V = Average residential solid waste (m^3/person/day).
Pn = Population in 10th year.
G = Average community population growth rate (1% = .01)
PH = Planning horizon (years).

$$= \frac{365(.0047)\,674}{\ln(1+.0275)}\left[(1+.0275)^{10} - (1+.075)\right] + \frac{.084(.0047)(674)^2}{2\ln(1+.0275)}\left[(1.0275)^{2(10)} - (1.0275)^2\right]$$

$$= 14{,}306\ m^3$$

With burning and compaction, this volume will be:

$$= \quad 14{,}306\, m^3 \times 0.75 \times 0.33 = 3{,}576\, m^3$$

This volume of 3,576 m^3 seems somewhat small for a 10 year period. The measured solid waste generation rate of 20 m^3/week received from local personnel is approximately 1/3 of the rate suggested in the NWT Guidelines. While it is quite possible that the rate is that low, we will request that measurements and truck counts be taken again this spring so that these volumes can be confirmed.

4.0 ALTERNATIVES

Cost Estimates

Cost figures used in this report were derived from several sources. The cost of supply, load and install for granular pitrun (24/m^3) and crushed road gravel (\$45/m^3) were supplied by the Department of Public Works and Services in Iqaluit. Excavation costs were projected from the \$24/m^3 supply and install cost, assuming the \$12/m^3 would pay for the excavating of the trench along the centre line of the lagoon berms and for excavating the core material at the bottom of the hill. The material excavated for the berm centre line would not require hauling as the spill pile could be left aside the trench. The costs for the truck dump chutes are taken from previous projects, prorated to cover freight on the materials.

4.1 Berm Design and Construction

The lagoons are proposed to be constructed utilizing a "frozen core" berm system. The berms will be constructed in two parts. First, a "core" berm will be built using frost susceptible silts. A source for the material has been identified at the test pit area shown on Figures 1 and 2. This "core" will then be covered with a layer of granular material which will protect the frozen core from the sun and rain, effectively acting as a protective insulation blanket.

At the start of construction, a 5 to 10 m wide area will be excavated along the centre line of the berm to the permafrost and/or hard shale below (approximately 0.6 m). The core berm will then be built on top of the permafrost or shale. Removal of the over burden is necessary to allow the core material to be frozen with the underlying material, effectively creating a bond so that the frost can move up into the core.

Construction of the core will take up the entire first season, as it is best to leave the granular protective layer off for one winter to allow the core to get a good start freezing.

It will be important during this first season to complete, if possible, the core to the design grade so that when construction started the following summer, the insulation and granular protective layer can be started without delay. Delay at this time may allow the upper region of the core to thaw, which would be undesirable.

While constructing the protective layer, overburden material from within the lagoon berms will be used for part of the protective layer. Additional material from another source will be needed to complete the protective layer. This additional material will come from a combination of the overburden from the core material excavation at18 the bottom of the hill, the cliff above the site, and current stockpile along the Nanasivik Road.

Site drainage will be provided by a ditch constructed alongside the upper berm of the lagoon and down the sides of the lagoon. Ditching will be constructed so as to divert runoff around the lagoon and into the existing stream bed or, in the case of the east side of the lagoon, away from the area directly below the lagoon.

4.2 Sewage Lagoon Alternatives

During our initial visit to Arctic Bay, we considered all of the areas between the shores of the Bay and the foot of the cliffs that lead up to the plateau above the community. The majority of this area is of narrow width, while the area of the existing site is the area of the least slope between the cliffs and the shore. There is one other area of similar slope to the north of the bulk fuel storage area.