Guidelines For Disposal Of Wastewater In Coastal Communities Of The Northwest Territories

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of the Northwest Territories

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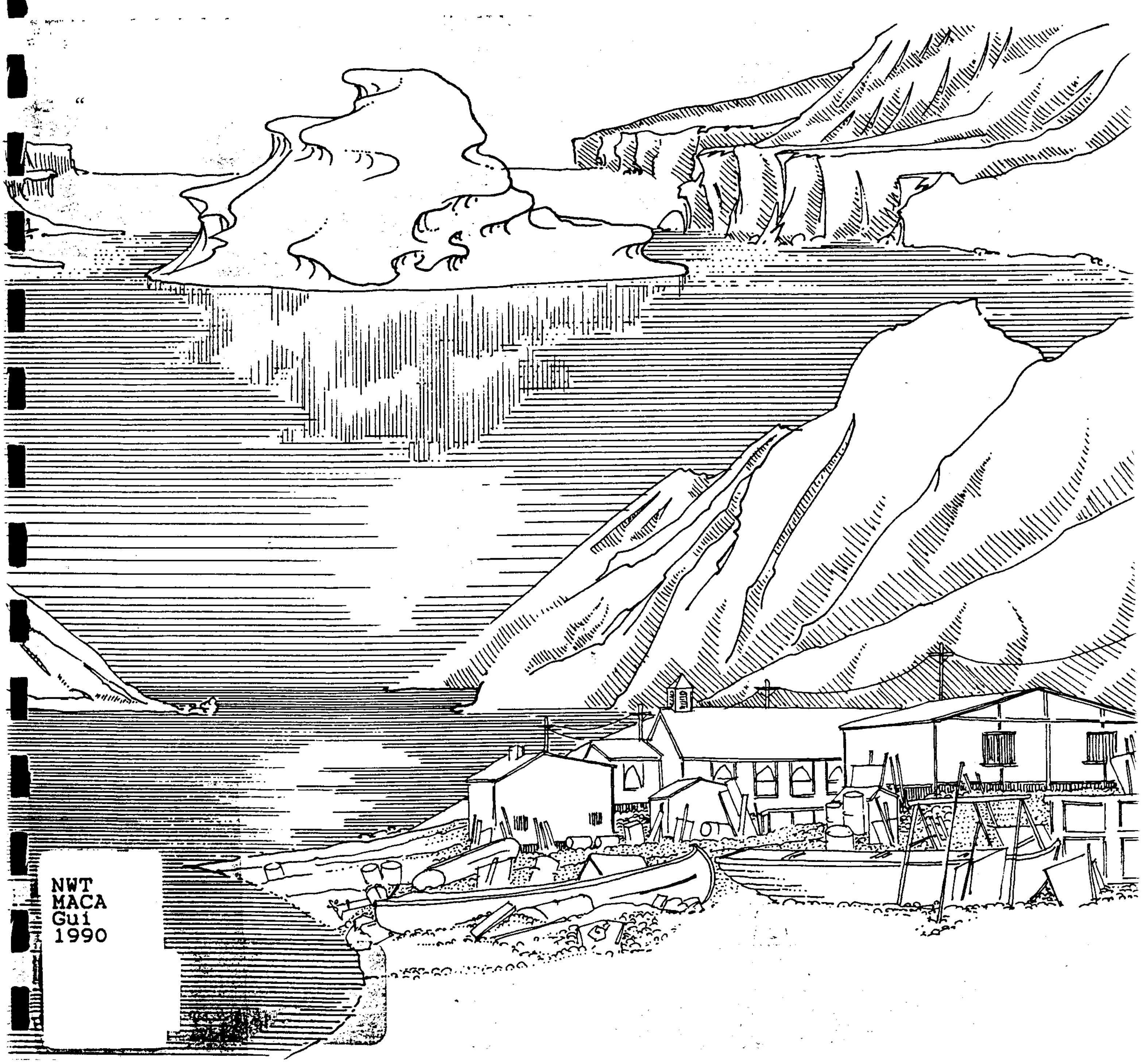

GUIDELINES FOR DISPOSAL OF WASTEWATER IN COASTAL COMMUNITIES OF THE NORTHWEST TERRITORIES

FOR

THE DEPARTMENT OF MUNICIPAL AND COMMUNITY AFFAIRS
GOVERNMENT OF THE NORTHWEST TERRITORIES

BY

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MARCH 1990

FOREWORD

This document was developed to establish guidelines for disposal of municipal-type wastewater in coastal communities of the Northwest Territories. Because wastewater lagoons are frequently the disposal system of choice, reference should also be made to the *Guidelines for the Planning, Desire, Operation and Maintenance of Wastewater Lagoon Systems in the Northwest Tern"tories. Volumes I (1990) and II (1991)*, available from the Government of the N.W.T., Department of Municipal and Community Affairs.

ACKNOWLEDGEMENTS

Financial support for this project was provided through a contract with G.W. Heinke and the Department of Municipal and Community Affairs, Government of the N.W.T. The advice and support of several officials of the Government of the N.W.T. are gratefully acknowledged, in particular Messrs. Vern Christensen, Moheb Michael, Ken Johnson and Al Shevkenek. Additional helpful comments were also received from Jim Cameron, Consultant, and J.A. McKinnon, NWT Health.

DISCLAIMER

The authors of this document recognize that there is substantial lack of information and research on the disposal of wastewater in coastal communities of cold climate regions. The guidelines recommended in this document represent the best judgement of the authors based on the available information. The user of this document should exercise good engineering judgement in its application.

It is expected that these guidelines will need to be updated when significant further experience has been gained.

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1. OBJECTIVES

1.1 Background for Study

Public health and environmental protection, community location and size, and limited funds for capital and operation, influence the selection of a municipal wastewater management system. The Department of Municipal and Community Affairs (MACA) has the responsibility, delegated to it by GNWT, to select between several possible capital construction options for meeting the water and wastewater servicing needs of communities. Technical, economic and social factors must be evaluated to provide information to allow the rational selection of the communities and the type of utilities to be funded. Protection of public health and environment involves comparing the impact and benefits of all service options. To this end, the disposal of wastewater requires careful, objective evaluation. For communities located along the coast, of which there are31 in the N.W.T., the discharge of untreated, primary level treated, or secondary level treated wastewater to the ocean are options which may meet various objectives.

Figure 1.1 identifies the communities in each of the five administrative regions of the N.W.T. which are located on the ocean. Table 1.1 summarizes the number of communities and the population for each region, and separately those which are on the ocean.

Table 1.1 Number and Population of N.W.T. Communities and Those Located on the Ocean.*

Region	TOTAL No. of Communities	TOTAL Population (1986)	ON OCEAN No. of Communities	ON OCEAN Population (1986)
Baffin	14	9,675	14	9,675
Keewatin	7	4,973	6	3,964
Kitikrneot	8	3,705	8	3,705
Inuvik	12	8,405	3	1,280
Fort Smith	25	24,515	0	0
Total	66	51,273	31	18,624
Percent of Total	100	100	**47**	**36**

**Source: Community Profiles (1982, 1983), Updated to 1986.*

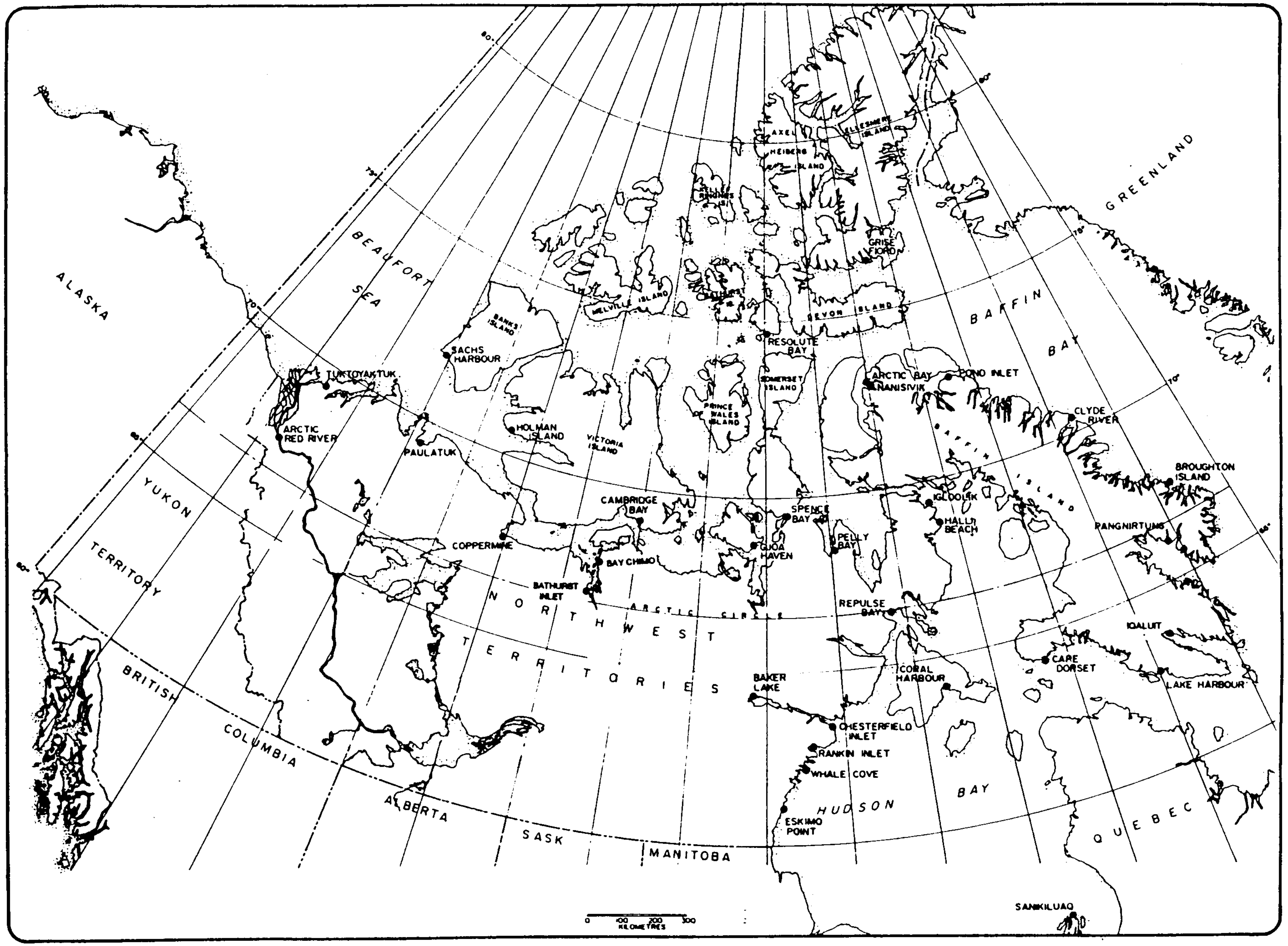


Figure 1.1 **Map** of Northwest Territories Showing **Coastal Communities.**

Table 1.1 shows that nearly half of N. W.T. communities are located on the ocean, and have a total population of more than one-third of the total N.W.T. population. Therefore waste disposal for ocean communities represents a very substantial part of the overall waste disposal requirements.

Realizing that the current best available technical wastewater treatment and disposal option might not be required in some communities, or might be of limited benefit in others, and would certainly exceed the available funds if installed in all, it is essential that the option be identified for each community which is acceptable environmentally, technically and financially.

1.2 Ocean Disposal Options

The disposal of wastewater to the ocean can be accomplished by using one of the following options:

1. direct shore discharge;
2. indirect discharge;
3. seepage shore discharge;
4. surface outfall;
5. submerged outfall; or
6. batch disposal.

The possible use of each of these ocean disposal options is presented in Section 3. The current guidelines of the N.W.T. Water Board outlining the level of treatment required before ocean disposal are reviewed in Section 2.

13 Objectives of Study

This report provides a guide for the selection of the appropriate treatment/disposal options for N.W.T. communities located at or near the ocean. Specifically:

1. Reviews the current practice of wastewater collection, treatment and disposal in coastal communities.

2. Identifies the possible treatment and disposal options and their appropriateness for application in coastal communities.

3. Develops the site information requirements necessary for the selection of the appropriate treatment/disposal option for coastal communities.

4. Prepares a protocol for the selection of the most appropriate treatment/disposal option which will aid consultants applying it to each coastal community.

1.4 Organization of Report

The report is organized as follows:

Section 1 summarizes the reasons for carrying out the study, provides an overview of the options available for ocean disposal and states the specific objectives for the study.

Section 2 reviews the current practice of wastewater collection and disposal in the 3 I N. W.T. coastal communities based on information in the files of N.W.T. government departments and through discussions with officials. No site visits were carried out. The current Guidelines for Municipal Type WasteWater Discharges in the Northwest Territories are reviewed with respect to ocean disposal.

Section 3 describes the available ocean disposal options and their advantages and disadvantages.

Section 4 describes the available treatment options.

Section 5 develops the site information requirements necessary for the selection of appropriate treatment/disposal options.

Section 6 presents a protocol to aid Consultants in the selection of the appropriate treatment/disposal option for a community.

Section 7 presents a summary and recommendations. A preliminary estimate of the financial implications of adopting the recommendations is included.

Section 8 list the references used in the study.

Appendix A presents regional summary tables on wastewater collection systems, wastewater treatment and disposal systems on the31 coastal communities and makes preliminary judgments on the acceptability of existing waste disposal systems.

In the course of carrying out the study the existing conditions with respect to waste disposal in each community were updated from the records of MACA and the Department of Public Works, where available. No site visits were carried out. The 31 community profiles are assembled in a separate report. It should be of value when MACA prepares an update to the 1982/83 community profile project.

2. REVIEW OF CURRENT PRACTICE

This section presents information on the existing wastewater collection, wastewater treatment and disposal systems in the 31 coastal communities of the N.W.T. The latest comprehensive data on these topics is contained in the Community Profiles (1982,83). These *were* updated in 1988 through review of available information in government files. This was successful for population (1986) on all communities. However, for all aspects of the waste system, updates were possible for only very few communities. This is not a serious problem for the main objective of the study -- to provide guidelines for future waste treatment and disposal options. It is realized that in many communities, the gradual elimination of honeybags by installation of pump-out/holding tanks will have proceeded beyond the information summarized here. This process is expected to continue until all homes in these communities are on either a trucked or piped collection system.

Important information for the design of wastewater treatment and disposal include the quantity and quality of the wastewater and the criteria for discharge. This section, therefore, also presents the current and future quantity and quality of wastewater information for coastal communities, based on material contained in Smith (1986). The current guidelines for waste disposal to the ocean (N.W.T. Water Board (1981)) are reviewed.

2.1 Wastewater Collection

The quality and quantity of water supplied and the method of wastewater collection are important influences on the type of wastewater disposal facility to be designed for a community. The type of collection system varies among communities, and for many communities more than one type of collection system is in use. The three types of wastewater collection systems in use are as follows:

1. truck collection of honeybags;
2. truck collection from holding tanks/pumpout; and
3. piped collection.

Trucked collection of wastes in honeybags is the most primitive method. The honeybag is removed from the home and trucked to a disposal site. The disposal of these honeybags should

occur at a landfill site, separate from solid waste disposal. They must not be disposed of to the ocean. For public health protection and convenience, the policy of the G. N.W.T. is to replace the existing honeybag systems with either a pumpout or a piped system. Homes now on the honeybag system are gradually being refitted. The existing situation is that many communities still have a considerable number of homes on the honeybag system (see Table 2.1). By the year 2000, it is planned that all homes will be on a pumpout or piped system. The significance of this is that by the end of that period, all wastewater produced in these communities can potentially be disposed of to the ocean. Therefore, the design of a wastewater treatment and disposal facility will have to allow for the future wastewater production from that community. By 1989 the percentage of people still served by honey bags has been reduced to about 10?ZO.

In the pumpout collection system, the wastewater is held in a holding tank at the house. It is then pumped into a truck and hauled to the treatment/disposal site. The piped collection of wastewater is similar in many respects to wastewater collection in the south. Differences include the increased protection needed from freezing.

At the present time, there are only four communities with a piped collection system. These are Iqaluit, Rankin Inlet, Nanisivik, and Resolute Bay. The remaining communities in the study use trucked collection, either with holding tanks/pumpout or plastic bags. The continued use of the trucked system in these communities is expected with the gradual phasing out of the use of plastic bags by 2000. No new piped collection systems are expected to be constructed except for extensions in the four communities which now have a piped system. This is pointed out in the reports prepared by UMA (1987) and Reid Crowther (1987), which showed that piped systems are not economical for the various N.W.T. communities they studied. These studies looked also at several coastal communities. The results are expected to be similar for all the communities in this study now on the pumpout system.

The conclusion that pumpout systems will continue and increase in use, effects the design of the wastewater treatment and disposal facilities. The variables that may be affected by the type of collection system include the size, location and type of facility. The operation of a treatment facility will be altered if in the future the piped collection becomes more economical or if demand for a piped systems increases. If the possibility of a piped system exists in the future, the design of the treatment facility must consider this point.

Table 2.1 Summary of Coastal Community Wastewater Collection Methods (Present and Estimated Future).

	Existing			Projected[4] (2009)		
Collection System	**Population**	**Percent**	**Volume[2] m^3/d**	**Population**	**Percent**	**Volume[2] $m^3/$**
Trucked collection:						
Plastic bags	5,614	35.3[5]	11	0		
Pumpout-holding tanks	7,105	44.7	639	24,940	80	2,244
Piped	2,866	18.1	645	6,317	20	1,422
Individual disposal	96	0.6	1	0	0	0
Unknown	209	1.3	2	0	0	0
TOTALS	15,890	100	1,343	31,257	100	3,666

1 *Based on 1982 and 1983 data (Ref. G.N.W.T. Community profiles)*
2 *Based on Smith, 1986. Piped 225 L/(p.d), Pumpout 90 L/(p.d), Plastic Bag 2 L/(p.d)*
3 *The assumption is made that the honeybag system will be replaced by the pumpout-holding tank system, rather than by a piped system.*
4 *The resumption is made that only Iqaluit, Rankin Inlet, Nanisivik and Resolute Bay will provide piped collection for future population; all others will have trucked collection from pumpout-holding tanks.*
5. *Based on information by J. Cameron reduced to about 10% by 1989.*

2.2 Wastewater Treatment and Disposal

Table 2.2 summarizes the current situation with respect to wastewater treatment methods being used in coastal communities.

Many communities do not have formally designed wastewater treatment/disposal facilities. The disposal of wastewater from many communities is accomplished by discharging the wastewater to the land or a pond, usually near the landfill site. The wastewater is allowed to pond, drain overland and then is directly or indirectly discharged to the ocean. Appendix A, Table A.2 provides

provides the summary of known information on waste treatment and disposal in all 31 coastal communities as of 1983. This information requires updating. Preliminary judgments on acceptability of the existing waste treatment/disposal systems are made.

The community of Nanisivik has a rotating biological contactor (R. B.C.) to treat wastewater. The R.B.C. secondary biological treatment process had not been working for several years but in 1987 was reported to be operating properly. This was short-lived. As of 1989 it was not operating and requires major repairs. Communities with storage lagoons of sufficient size for winter storage are Tuktoyaktuk, Eskimo Point and Whale Cove. Pond Inlet has a short detention lagoon with disposal through an overland ditch. These are the only four costal communities whose wastewater treatment/disposal system is judged acceptable. Their combined 1986 population is 3,124 or 17% of the total population of 18,624 (1986) in the 31 coastal communities, or 6% of the N. W.T. population of 51,273 (1986).

23 **Current Guidelines for Ocean Disposal**

Requirements of Guidelines (1981)

The "Guidelines for Municipal Type Wastewater Discharges in the Northwest Territories (1981)" issued by the N.W.T. Water Board make the following statements with regard to disposal of wastewater to the ocean. The reader is referred to the entire Guidelines for complete understanding

p.14, Item 6:

> *Wastewater with the specified characteristics (see Table 2.1 of the Guidelines) must be discharged by outfalls which are designed according to the specifications given in Appendix A. In general, discharge of untreated wastewater to the open sea is permitted, if as a minimum, floatable materials are removed and the discharge is comminuted or macerated The requirements for discharges to bays and fjords may be relaxed, depending on the findings of site specific studies.*

p.22, Section 223 ***Effluent Discharges*** *to the Sea*

> *A site specific study maybe required for effluent discharges to the sea when the following may be affected shellfish waters; waters used for fish propagation; waters used intensively by marine mammals; waters used for recreation; and confined waters.*

Table 2.2 Summary of Coastal Community Present Wastewater Treatment/Disposal Methods (Present and Estimated Future)

Method	No. of Communities	Treatment Provided	Acceptability
Bagged waste to dump	29	None	No
Liquid waste to dump/land	6	Minimal	No
Liquid waste to pond	19	Minimal	No
Liquid waste to lagoon			
. Short detention	2	Primary	
- Pond Inlet		Primary	Yes
- Iqaluit		Primary	No
. Storage	3		
- Tuktoyaktuk		Primary +	Yes
- Whale Cove		Primary +	Yes
- Eskimo Point		Primary +	Yes
. Long detention	-	Secondary	
Liquid waste to plant:			
. Nanisivik[1]	1	Secondary	No
Ocean Discharge Method			
Direct shore	5		
Indirect shore	21		
Submerged outfall	1 (Rankin Inlet)		
Surface outfall	1 (Resolute Bay)		
Ocean/ice dumping	-		
Land disposal only	3 (Grise Fjord, Bathurst Inlet, Umingmatuk)		

[1] As of 1989 plant is not operating, needs major repair.

Such a study will also be required where the objectives are to be met by a long outfall (Appendix A), or for a proposal to discharge sludge down the outfall. In cases where the boundary between marine and estuary conditions is in question, the outfall length is to be determined site-specifically by appropriate current and dilution studies.

p.28, Section 3.7 *Outfall Objectives*

. . . Minimum outfall lengths, depths and depths-distance combination for marine discharges that may be permitted for disposal of untreated wastewater, are given in Appendix A.

... Both marine and non-marine outfalls should be located and designed to make optimal use of the mixing and dilution characteristics *of the receiving water. Protection from ice-scour shall be a consideration in &signing outfalls.*

The cases in which a site-specific study of the outfall length and depth may be required are outlined in Section 2.2. The approval of shore-line discharges would be subject to site specific &termination.

Conformance with Present Guidelines (1981)

The large majority of N.W.T. coastal communities (26) use shore-type discharge techniques (see Table 2.2). It is not clear whether any of these had a site specific study carried out nor whether any of them would meet the present guidelines.

Two communities use constructed outfalls. Resolute Bay has a surface outfall, and Rankin Inlet has a submerged outfall. Both are discharging untreated wastewater to the ocean. Maceration was attempted at Rankin Inlet, but was abandoned because of operating problems.

The Guidelines (1981) call for removal of floatable materials and comminution/maceration of the untreated wastewater, as a minimum. Scott and Heinke (1980) have reviewed the experience with maceration in several N.W.T. communities. The experience has been totally unsatisfactory where it has been tried (Rankin Inlet, Norman Wells and Iqaluit).

Experience at Rankin Inlet in discharging untreated waste through a submerged outfall appears to be unsatisfactory. No information is available on the success/acceptability of waste disposal at Resolute Bay.

Table 2.3 Effluent Quality for Municipal Wastewater Discharges

Wastewater Flow Ratios (2) (Sewage Strength)	Parameters	RECEIVING ENVIRONMENT							
		Streams, Rivers and Estuaries (3)				Lakes (3)		Marine (6)	
		Dilution (4)				Residence Time or Dilution (5)			
		>10:1 <100:1	>100:1 <1000:1	>1000:1 <10000:1	>10000:1	T_r > 5 yr, or $\frac{Qt}{Qw} \leq 1000$	$T_r \leq 5$ yr, or $\frac{Qt}{Qw} > 1000$	Open	Bays ● d Fjords
50.5 (high)	BOO, mg/L	30	90	360	360	30	90	600	360
	SS, rig/L	35	110	250	250	35	110	725	250
	pH	6-9	6-9	6-9	6-9	6-9	6-9		
	Oil and Grease	none visible	none visible	none visible	none visible	none visible	none visible	none visible	none visible
	P, ● g/L (7)	9 (8)	- (8)	- (8)	- (8)	1.0	2.0		2.0
	Coliforms	< 10^3 (9	< 10^4 (9)	< 10^5 (9)	< 10^6 (9)	< 10^3 (9)	< 10^4 (9)	(lo)	(lo)
> 0.5 <2.0 (normal)	BOO, rig/L	30	45	180	180	30	45	300	180
	SS, ● gll-	35	55	125	125	35	55	360	125
	pH	6-9	6-9	6-9	6-9	6-9	6-9		
	Oil and Grease	none visible	none visible	none visible	none visible	none visible	none visible	none visible	none visible
	P, ● g/L (7)	5 (8)	- (8)	- (8)	- (8)	1.0	2.0		2.0
	Coliforms	< 10^3 (9)	< 10^4 (9)	< 10^5 (9)	< 10^6 (9)	< 10^3 (9)	< 10^4 (9)	(lo)	(lo)
≥ 2.0 (1OM)	BOD, ● g/L	25	25	90	90	25	25	150	90
	SS, ● g/L	30	30	60	60	30	30	180	60
	pH	6-9	6-9	6-9	6-9	6-9	6-9		
	Oil and Grease	none visible	none visible	none visible	none visible	none visible	none visible	none visible	none visible
	P, mg/L (7)	2 (8)	- (8)	- (8)	- (8)	1.0	2.0		2.0
	Coliforms	< 10^3 (9)	< 10^4 (9)	< 10^5 (9)	< 10^6 (9)	< 10^3 (9)	< 10^3 (9)	(10)	(lo)

•Bracketed numbers refer to the notes which follow

[1] Source: Northwest Territories Water Board (1981)

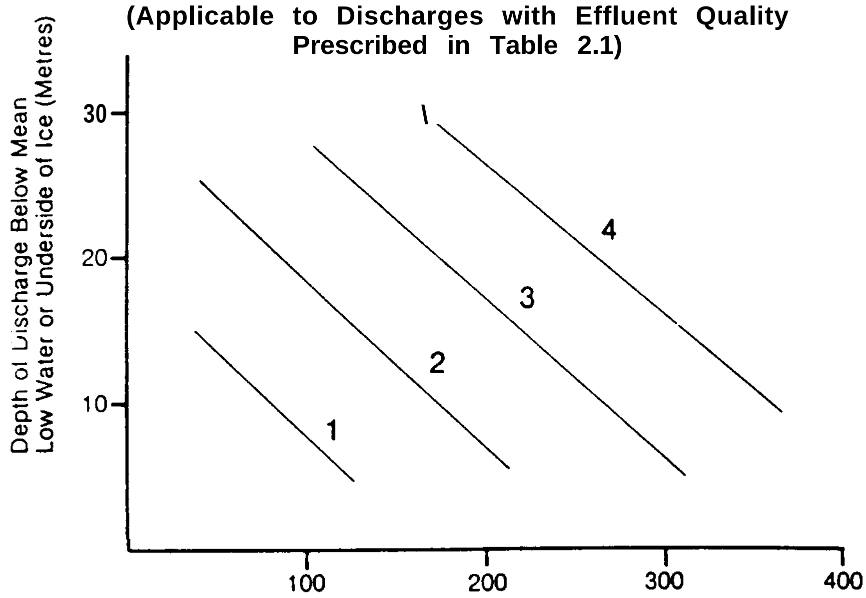
Source: Table 2.1, p.12 — From "Guidelines for Municipal Type Wastewater Discharges in the Northwest Territories (1981)"

Table 2.1, p.13 — Note 1: The values in Table 2.1 (above) are to be met for average daily wastewater flows greater than 30 m^3/day. If the wastewater flow is less than 30 m^3/day, values for BOD, SS, p may be multiplied by a factor of 1.5.

Note 10: Only in the case of a fishery or recreational use of water would bactinological standards be of concern.

APPENDIX A OF GUIDELINES (1981)

**Depth-Distance Combinations for Outfalls into Marine Waters •
(Applicable to Discharges with Effluent Quality Prescribed in Table 2.1)**



Minimum Horizontal Distance to Closest Point of Discharge from Mean Low Water Mark (Metres)

1 *Q = 50 m^3/d or less*
2 *Q = 500 m^3/d (25 m^3/d in shellfish waters)*
3 *Q = 2,500 m^3/d (125 m^3/d in shellfish waters)*
4 *Q = 5,000 m^3/d (250 m^3/d in shellfish waters)*

Where Q = design average dry weather flow.

NOTES:

1. For discharges in excess of 5,000 m^3/d (250 m^3/d in shellfish waters) see Section 2.2.3.
2. Interpolated lines maybe used for intermediate flows.
3. Minimum outfall length in shellfish waters is normally 120 m.

2.4 Implications for Future Wastewater Management

From the above information, it is clear that past practice has encouraged the use of simple, low cost systems. Only four communities appear to meet current guidelines. N.W.T. policy dictates that more water be delivered to the homes as the plumbing facilities are improved. Therefore more water will need to be removed as wastewater. As this policy is implimented, wastewater treatment and disposal facilities are to be improved to protect public health and the receiving environment. These two factors in-turn influence the selection of:

- the treatment process,
- the method of discharge, and
- the point of discharge.

Since these three factors are interrelated, the procedure for their evaluation must be done jointly.

3. *OCEAN* DISPOSAL OPTIONS

The only means of ocean disposal of wastewater allowed under the current guidelines (1981) is through a submerged outfall to deep water. However, in other areas of the world ocean disposal has been accomplished in a sound manner in a number of different ways. Given the appropriate circumstances, any one of the options outlined below may be suitable in the Canadian Arctic and should be considered:

1. Direct shore discharge;
2. Indirect shore discharge;
3. Seepage shore discharge;
4. Surface outfall;
5. Submerged outfall; and
6. Batch disposal.

This section describes these options. The description outlines the advantages and disadvantages of each, indicating where they are being used, where they may suitably be used provided that the necessary treatment of wastewater prior to disposal to the ocean is carried out.

3.1 Direct Shore Discharge

Direct shore discharge is used in seven coastal communities (see Appendix A, Table A.2). The wastewater is discharged from a short-detention pond near the ocean shore, or with direct truck discharges of wastewater on or near the shore. For the usual bay or estuary situation, the dilution will vary from none to a little. If the discharge is near a community, there is therefore a potential for exposure of the public and wildlife to wastewater effluent, the consequences of which could be serious even if the wastewater is treated. However, if the disposal site was well removed from the community, either by distance or topography, or if wastewater was disposed of on a very steep shore on an open coast, direct shore discharge may be acceptable. During winter, storage of wastewater will be required unless year-round open ocean flow is present.

3.2 Indirect Shore Discharge

The discharge of wastewater through overland drainage to the ocean shore is the most commonly used method in coastal communities. It is used in 21 communities (see Appendix A,

Table A.2). The wastewater may be discharged from a short- or long-detention lagoon or directly from a truck to the ground and then flows overland to the ocean. At one extreme, the wastewater may be discharged into a large pond or lake from where it flows overland to the ocean. In this case, the effluent will have received primary treatment and, depending on its exposure during the summer, a considerable dose of secondary treatment as well. At the other *extreme,* wastewater may be dumped directly onto the ground at some distance from the shore, from where it flows overland to the ocean. In this case, there is some slight 'treatment' before entering the ocean, in that at least some of the settleable solids are removed before the sewage enters the water and, in summer, there is some direct exposure to sunlight, but there would be a considerable public health concern if the discharge was close to a community or a frequented area.

33 **Seepage Shore Discharge**

The construction of a lagoon near the shore allows the option of direct bank seepage to the ocean. This has the advantage over direct shore discharge in that many of the solids and microorganisms in the wastewater will be removed when it flows through the bank, much as is the case with a trickle falter. It is therefore akin to indirect shore discharge but without the option of directly monitoring the effluent. If the system is to be designed to achieve a particular standard of effluent, a difficulty will be encountered in ensuring that the desired permeability is achieved and maintained over the life of the installation, determining the degree of treatment attained over the seepage path, and allowing for the effect of ground freezing on this path in the winter. Nevertheless, it would seem to have some promise under certain conditions (e.g. Eskimo Point).

3.4 **Surface Outfall**

This is the disposal of sewage to deep water using a surface outfall. AES (1980) indicate that it is a common technique in Greenland. However, despite its Arctic location, western Greenland is characterized by deep near-shore water that is ice-free for most, if not all, of the year because of the warm current that washes along the Greenland coast. Few such situations exist in the N.W.T. Current guidelines (1981) require the removal of solids, and particularly flotable material by screening/comminution/maceration. While steep shores, deep water and an open coast may exist near some N.W.T. communities, the shore water is generally ice covered for 9-10 months of the year. Hence such disposal would not be satisfactory through the winter and provision of storage of wastewater for the winter would be required. A means to convey the wastewater from the storage lagoon to the ocean would be required in late spring. A floating surface outfall, smaller but similar in nature to those used in dredging, that conveys the pumped or siphoned sewage from storage out to deep water could be used. This would be deployed and anchored *in* position for an appropriate period at some suitable time each year. Another alternative to winter storage is laying an insulated outfall on the ice in winter to discharge through a hole in the ice. At other times, the outfall structure would be stored on shore. It is envisaged that at a suitable site, one with a moderately steep shore, with deep water close to shore to limit the required outfall length, and a reasonably open coast (Pond Inlet or Grise Fiord, for example), this disposal option may provide an economic alternative, being cheaper than a submerged outfall. Other advantages for a surface outfall would include: being of lower density than the cold sea water, the discharged wastewater will spread into a thin layer at the surface and remain there, thus exposing it to treatment by sunlight and aeration (as against simply dilution; this would of course not occur when the wastewater is discharged under the ice); the sea bed and the associated flora and fauna will not be exposed to a continuous and fixed-location flow of effluent; and the offshore disposal site could be varied somewhat to suit changing circumstances. A disadvantage of this option would likely be the formation of an unesthetic 'slick' and the ease with which the effluent plume could be blown back onshore. However, in this regard, it will likely not differ much from that of a submerged outfall in other than very deep water. With reasonable care taken in the selection of the location and timing of the releases, these problems should be avoidable.

The only surface type outfall close to shore is installed at Resolute Bay (see Appendix A, Table A.2).

3.5 **Submerged Outfall**

Submerged outfalls are a familiar mode of wastewater disposal in temperate climates, and they are the only mode of ocean disposal currently allowed under the Guidelines (1981). Despite this, at present there is only one submerged outfall in the N. W. T., which is at Rankin Inlet. This is likely because the guidelines have been adopted relatively recently and the combination of the requirements of the guidelines and the unfavorable circumstances to be found in many communities, such as Tuktoyaktuk and Paulatuk, would require long and expensive outfalls. As the wastewater will have a density less than that of sea water, due to its being both fresh and perhaps warmer, it will rise more rapidly and may reach the surface. In summer, this will form a surface slick, as with a surface outfall, and in winter may result in portion of the wastewater plume being incorporated into the ice cover.

The Rankin Inlet outfall was built before the Guidelines were established and does not appear to meet them. The untreated wastewater is discharged through an outfall that terminates in a cove at a location only about 200 m offshore and in water only about 2 m deep at low tide. Perhaps not surprisingly, therefore, its performance has apparently not been satisfactory, a feature it has in *common* with many other submerged outfalls elsewhere in the world which are coming under increasing criticism because of low design standards and their resultant propensity to foul beaches.

3.6 Batch Disposal

The disposal methods discussed so far involve more-or-less continuous discharge of wastewater to the sea, at least during the summer. Another possibility is a marine extension of the 'batch' (trucked) transport and discharge of wastewater already used for land disposal in small communities. During open water, a boat or barge could be used to carry wastewater offshore before dumping. Such 'batch' disposal to open water is not uncommon in milder climates and was investigated by Dillon (1983) for the disposal of 'uncontaminated' industrial wastes in the Beaufort Sea. This mode of disposal shares some of the same advantages and disadvantages of the surface outfall discussed above. However, an additional advantage is that the dispersion and dilution can be increased by discharging from the boat or barge while it is moving, and the discharge location can be varied over a wide range.

The possibility also exists that in winter, after a firm ice cover has developed, the wastewater could be trucked out onto the ice to a hole at some appropriate location offshore where the wastewater could be discharged under the ice. At freeze-up and break-up, the wastewater would have to be stored temporarily. This storage would provide the necessary primary treatment. A disadvantage would be the risk of loss of life and equipment associated with over-ice operations and the operation and maintenance costs to keep an ice road open.

3.7 Summary on Ocean Disposal Options

Ocean disposal of wastewater in the Arctic can be environmentally and technically viable. Whether is is economically so will depend on many factors, not least of which is the value placed on a clean environment. Furthermore, there are ocean disposal techniques that may be as environmentally and technically viable as a submerged outfall, which is presently the sole option permitted under the current regulations, and which are likely to be more economical.

4. TREATMENT OPTIONS

The levels of treatment required for ocean disposal of wastewater according to the existing Guidelines (198 1) are reviewed in Section 2.3. Combining these with knowledge of available technology applicable to small communities in cold climates provides the following levels.

Level z. *Minima[treatment (removal of floatable materials and screening and/or comminution).*
Level 2 *Primary treatment.*
Level 3. *Secondary treatment.*

The achievement of these levels of treatment can be accomplished in an efficient and practical way for small northern communities by the following treatment processes.

4.1 For Level 1: Minimal Treatment

The experience with maceration in several N.W.T. communities has been reviewed in Section 2.3. Based on these experiences, maceration in small northern communities is not recommended. The recommended solutions include:

- a heated disposal station designed for discharge from trucks and/or sewers, as applicable.
- small concrete tank equipped with bar screens and manual removal of floatable material and screening, to be disposed of at solid waste disposal site.
- comminution, as an alternative to fine screening, if proved workable
- discharge outlet to ocean.

Figure 4.1 provides a schematic sketch of a disposal station.

42 For Level 2: Primary Treatment

Short-Detention Lagoons (SDL) are the most economical means of achieving primary treatment in small northern communities. Heinke, Smith and Finch (1988) provide performance and design guidelines. Because all coastal communities experience cold weather for at least eight months per year, and because the majority of waste discharged to the lagoon is by truck, the waste will freeze soon after discharge. Very little effluent, if any, occurs during the winter months. Therefore, there is a need to provide storage for all wastewater accumulated during the winter in a storage lagoon. During the summer months treated effluent can be disposed of through direct or indirect shore discharge, provided local conditions allow this (see Section 6).

For illustrative purposes, the size of storage lagoon required for typical communities of 200 and 1,000 people are shown in Table 4.1.

Table 4.1 Storage Lagoon for Coastal Communities

Population	Waste Production Lpcd	Waste Volume for 8 Months m^3	Liquid Depth of Lagoon m	Area Required m^2	Dimensions m
200	90	4,380	4	1,102	2 cells 30 x 18
1,000	90	21,900	4	5,510	2 cells 77 x 36

Where only primary treatment is being proposed, consideration should be given to site location and system design to provide for future secondary treatment, should present standards be upgraded, without necessitating the relocation or construction of a completely new system.

43 For Level 3: Secondary Treatment

Long-Detention Lagoons (LDL) are normally the most economical means of achieving secondary treatment in small northern communities. Heinke, Smith and Finch (1988) provide performance and design guidelines. In some communities, particularly those which have an industrial base and therefore trained manpower available, a package type treatment plant may be an acceptable alternative, as is the case now at Nanisivik. The length of storage period required may be as long as 365 days, making the size of the long-detention lagoon 50% larger than a storage lagoon for a given size community. The long-detention lagoon would be emptied just before freeze-up, would be filled by truck and/or sewer discharge during the winter months, with little or no discharge occurring. During the summer months, secondary treatment would occur, with some discharge taking place over the mid summer period leading to emptying of the lagoon in early fall.

The need for secondary treatment for a particular community needs to be established on the basis of a site investigation. Concerns include public health, environmental protection, effect on fish and marine life, and aesthetics.

5. SITE INFORMATION REQUIREMENTS

The development of an information base which will lead to understanding of the environmental conditions in and around a community is required for the assessment of wastewater treatment and disposal options. The information base required includes the community conditions, site conditions, oceanographic information, construction site conditions and economic considerations.

5.1 Community Condition

Present and future community population and commercial and industrial development which may contribute to wastewater flows must be examined. In addition, information of wastewater volume and wastewater collection infrastructure are required.

5.1.1 Population Data

The Bureau of Statistics, Department of Information, GNWT routinely evaluate actual and projected population for each community. This information is necessary to estimate present and future quantities and strength of wastewater to be disposed of.

5.1.2 Wastewater Volume

The volume of wastewater produced will depend on the quantity, quality and method of delivery of water to the users; on the types and number of water use devices in each building; and on the system of collection and transport to the treatment and disposal point.

Trucked water delivery at a design rate of 90 litres per person per day (L/(p·d)) is the minimum water use rate to be used for design. This level of service is the minimum to be expected within the design life of any wastewater management facility.

Where water supply and wastewater collection by pipeline *exists* or is expected, higher volumes of wastewater production are expected. A conservative estimate assuming no inflow and infiltration, is that the wastewater flow will equal the water use. . The guideline information presented in Table 5.1 maybe used to estimate design flows. Actual flow rates, if available, should be used for design.

Where underground pipe systems are used, **inflow and infiltration must be** accounted for in the flow estimates. Where welded polyethylene pipe is used, only the service connections and manholes permit infiltration. Inflow may originate from improper connections to the sewers or from surface runoff to a manhole. Other pipe materials should be considered accordingly.

Table 5.1 Relationships for Estimating Water Use and Related Wastewater Production

Source	Estimated Wastewater Production* L/(p"d)
Residential	
- Non-pressure water system with bucket toilet	10
· Trucked water delivery and sewage pumpout collection	90
· Piped water supply and trucked sewage pumpout collection	110
· Piped water supply and sewage collection	225

Water Use Adjustment Relationships for Community Size

Total Community Population	Per Capita Water Use (Residential & Non-Residential)
o to 2,000	Residential Rate x [(1.0) + (0.00023)(Population)]
3,000 to 10,000	Residential Rate x [(-1.0) + (0.323)(In(Population))]
Over 10,000	Residential Rate x [2.0]

** Water consumption and wastewater flo ws should be determined where possible.*

5.13 Wastewater Collection

There are three principal methods of wastewater collection practiced in the Northwest Territories:

- vehicle plastic bag collection;
- vehicle pumpout collection; and
- piped collections.

Since most communities use a combination of these methods, the percentage of the population seined by each type of system, presently and in the future, must be estimated. Future projections for design should assume all plastic bag collection has been replaced with pumpout collection systems, unless provided for differently for a specific community.

5.2 Site Condit ions

The geomorphology, climate, geotechnical factors and space availability influence decisions on wastewater management.

5.2.1 Geomorphology

The topography, drainage and landforms of the community greatly influence the layout of the collection, treatment and disposal system. The system should, if possible, be located to permit gravity drainage, if a piped collection is used, now or in the future.

An ocean disposal location should be selected to ensure maximum sunlight reaching the surface. Melting of the discharge area as early in the spring as possible is desirable to reduce overflow problems. Therefore, the south side of landforms and unshaded areas are preferred.

52.2 Climatic Factors

The wind information is required to aid in assessment of currents, particularly in a bay environment, and of the range of movement of any plume issuing from the outfall. Temperature data will provide support information on ice conditions and, possibly, be needed to estimate the water and effluent temperatures, both of which have a strong influence on plume behaviour. Precipitation is likely only of concern if the disposal option involves interaction with streamflow.

Wind direction and velocity, precipitation (rain and snow), snow drifting and temperature are important to the selection of the wastewater disposal facility location. Lagoons and the discharge from lagoon may be odorous, particularly in the spring after break-up. Therefore, these facilities should be sited downwind of the community with regard to prevailing spring winds and in accordance with minimum separation distances from nearest developments (see Section 5.2.5).

Snow drifting can be a problem if it causes increased periods of ice cover. This maybe a factor downwind of a lagoon.

Air and receiving water temperature should be considered in examining site conditions. Air temperatures are important with regard to the freeze/thaw related problems while water temperatures are important with regard to ice formation and freezing temperatures of fresh verses saline water.

5.2.3 Geotechnical Factor

There are several basic factors related to the geotechnical characteristics of disposal sites which must be examined. Among them are:

- the soil classification at different depths;
- the presence or absence of permafrost;
- the potential of frost heave and ice lens formation; and
- the permeability.

These factors need to be considered in evaluating the suitability of a particular site to each of the outfall options. Of particular concern is frost heave potential and permeability of the soil. For final design, a cold regions geotechnical specialist should be consulted.

5.2.4 Suitable SDace Availability

Land area required for a short-detention lagoon and a surface discharge will be easy to identify and meet in most communities. Land area requirements for a long-detention lagoon and disposal site in some locations maybe more difficult, particularly within a reasonable distance from the community, so that costs for an access road do not become prohibitive.

5.2.5 Separation Distances

Factual information on separation distance requirements from water supply wells and other public facilities is more difficult to set in cold regions. The possible presence of permafrost and the seasonal occurrence of increasing frost penetration make accurate prediction of groundwater movement difficult. It is recommended that where there is concern about groundwater contamination or movement that a geotechnical specialist familiar with cold regions be consulted.

The recommended minimum separation distances between lagoons and outfalls, and adjacent land uses are presented in Table 5.2.

Table 52 Recommended Minimum Separation Distances

Land Uses of Concern	Distance to Water Surface
Residential Dwelling	300 m
Institutional Use (school, hospital, community centre, church)	300 m
Commercial Building	100 m
Industrial Building	50 m
Main Roadway (boundary of right-of-way)	100 m
Rural Roadway (boundary of right-of-way)	30 m
Private Property Line	50 m

Source: Heinke, Smith and Finch (1988)

5.2.6 Area Planning and Zoning

The selection of a lagoon site requires consideration of community growth plans. Current development plans and future direction of growth must be considered. In addition, topography and the requirement for wastewater lift stations (for communities with piped systems) and the prevailing wind direction (particularly in the spring and early summer) must be evaluated.

53 Oceanographic Information

No matter what marine disposal system is chosen, an environmental assessment will likely be required. This involves three major components; definition of the physical, chemical and biological environment over the design life of the project; calculation of the advection, dilution, dispersion and die-off that will occur in the different circumstances; and assessment of the impact of the resultant pollution levels on public health and the environment. It should be noted that in the Arctic the main concern is likely to be the possibility of pollution of the coastline, with its public health implications rather than the impact of the wastewater discharge into the ocean per se.

It is likely that the cost of an environmental impact assessment for an ocean wastewater disposal system for an Arctic community can be a significant item in the overall *cost* of the *system.*

A rather detailed description of the type of data that may need to be collected for a reasonable environmental assessment is provided by AES (1980). In the Arctic adequate definition of the physical environment will likely be the 'bottle-neck' constraint on the analysis component of the assessment. The mathematical analysis to predict dilution, advection, diffusion, dispersion and die-off at a level compatible with the field data likely to be available is relatively straightforward.

Requirements for a reconnaissance study of the viability of marine wastewater disposal for Arctic communities would include compilation of the foUowing information:

- general oceanographic setting;
- offshore bathymetry;
- available information on ice conditions and duration;
- offshore currents; and
- tides.

For the purpose of a reconnaissance study, this information may be obtained from existing publications and maps, with some additional airphoto interpretation likely required. A site visit would be necessary in some cases and desirable in all.

With this information, it is possible to assess in a preliminary manner whether ocean disposal of wastewater is a plausible option from the point of view of economics, operations, public health and environmental impact. More detailed, but staged, studies can then be carried out for those sites for which ocean disposal seems reasonable. Once the decision about ocean disposal has been made, and likely sites selected, more detailed information will have to be obtained, such as:

- detailed near-shore setting of likely sites;
- bathymetry;
- geomorphology;
- surficial geology, including shore and bottom materials;
- ice conditions;
- tides;
- near-shore currents; and
- wave conditions.

Of the above, only bathymetry, tides and, possibly, ice conditions, are likely to be available. Others may require special investigations to obtain site data. Wave conditions may be required to assess the near-shore mixing they provide, along-shore currents they may set up, the loads they may exert on a surface or submerged outfall, and possibly the maximum run-up that can be expected on-shore for the design of near-shore installations. These can usually be satisfactorily hindcast from available wind information. The usual major problem is that there is little information on currents, yet some information on these is essential if any reasonable attempt is to be made to assess the behaviour of the plume from a shore or offshore discharge. The distribution of currents in time and space can be very complex, particularly in a situation such as an estuary. The obvious fiist approach is to combine some elementary assessment of the currents from what is known of the bathymetry, tides, winds, offshore currents and, if in an estuary, streamflow, with information obtained from local residents. It is emphasized that both the analysis and interview components are essential - neither should be expected to stand on its own, no matter how reliable either seems to be. If it appears from this that the ocean disposal option chosen could have a significant public health or environmental impact and that currents have an influence on this, a limited, but very targetted, field study should be carried out to confirm or calibrate the assessment of the current field. If the assessment of the current field is not confirmed in its essential details, a much more extensive field data collection exercise will be required. The potential expense of this may well eliminate the outfall option from consideration.

5.4 Construction Site Conditions

In the majority of communities, a winter storage lagoon and outfall will be the option selected. Such a system will consist of an access road, a storage lagoon (either a modified lake lagoon or a constructed facility) with the necessary inlet and outlet appurtenances, and a surface outfall channel.

Considerable experience exists with respect to construction of roadways and berms in various cold regions conditions. A cold regions geotechnical specialist should be consulted on a case-by-case basis.

The selection of an outfall option must take into consideration the problems of design in an environment of ice movement. Different tidal action, wind and currents will influence how sea ice and the outfall interact. In many cases, shallow bottom slopes make it uneconomical to build submerged pipeline outfalls.

Permafrost, active layer and seasonal frost conditions may make buried outfalls unacceptable from the point-of-view of potential freeze-up. Areas of rock outcrops may also limit the outfall options which can be used.

55 Economic Considerations

Out falls

Because there is only one submerged outfall that has been constructed in the N. W.T., there is little information on likely costs. Moreover, the circumstances are so varied, both with regard to natural environment and construction constraints, that it is hard to generalize. A 1973 estimate for an outfall proposed for the Polar Continental Shelf base at Tuktoyaktuk (Stanley Associates, 1973) was estimated to cost about $200/m in 1988. The 220 m of submerged outfall in Rankin Inlet was installed for a contract price of $135/m in the late 70’s, a price equivalent to at least $250/m in 1988. In both these cases, it is presumed the outfall would have been simply laid on the bottom, with a minimum of burial, if any. However, a small diameter outfall considered for Spence Bay, a much more isolated community, with more difficult construction conditions, was estimated to cost $2,300/m in 1987 (chinniah, 1987). Reynolds (1981) also gives values of about *L500/m* (or about $2,000/m in 1987) for small diameter outfalls in the U.K. and Europe; while having much easier site access, this latter location does not enjoy the free construction platform provided in the Arctic by the ice cover each year.

It, therefore, seems that at present a submerged outfall can cost anywhere between $250 and $2,500 per metre, depending on its length, diameter and material, the water depth, the accessibility and presence of suitable construction equipment at the location, the geology, and the required burial to avoid destruction by ice and wave action. Even for very short submerged outfalls there is a significant fixed cost for mobilization of special equipment and manpower. Hence a 1 km outfall could cost between $250,000 and $2,500,000 for just the construction costs. This does not include the substantial design costs likely to be incurred because of the environmental impact assessment required before the outfall length and location could be chosen (Guidelines, 1981). In more settled areas, this can be expensive, ranging from, say, $10,000 for a desk study based on existing background information when it is available, to well over $100,000 for just the physical environment study component for a difficult site with little background information (Oakley, 198 1). These figures apply to a temperate climate and a relatively accessible site. In the Arctic, with its more difficult conditions and limited accessibility, together with the general dearth of required background information, it can be expected to be much more expensive,

It is, therefore, apparent that a submerged outfall will represent a major cost for what is just one component of a wastewater treatment system for many locations in the N.W.T.

Lagoons

Many components of community development and public health must be included in the overall economic analysis of the *costs* and benefits of alternative waste management options. This discussion is limited to the capital costs of a lagoon system consisting of a roadway to the lagoon of one kilometre, an engineered lagoon treatment facility (various options), an outlet facility (a manhole with stop logs), and an outfall structure (various options).

To deal with the variety of combination available Table 5.3 was assembled. Obviously a short detention lagoon with a surface discharge is the least expensive treatment/disposal option provided. It may not be acceptable based on community development and public health concerns.

Each community and set of local conditions must be evaluated carefully to select the "best" treatment/disposal option.

Table 5.3 Cost of Various Wastewater Treatment/Disposal Options

Component	Option	cost $	Criteria
Engineered Lagoon Facility	1 short detention (SD) cell (180 d)	86,000	Berm height 5 m Top width 3 m 3 to 1 slope
	2 short detention cells (240 d)	121,000	Design population 500 Design flow 90 L/(p.d)
	1 SD, 1 long detention cell (300 d)	231,000	
Outlet Works	Manhole w/stoplogs	75,000	Insulated Hinged top
Piping (berms)		30,000	With valves
Outfall	Direct shore discharge	10,000	Minimum site work
	Indirect shore discharge	10,000	Minimum site work
	Seepage shore discharge	30,000	Selected granular fill
	Surface outfall	50,000	Supports variable
	Submerged outfall	100,000+	Function of length required

SUPPORTING CALCULATIONS

Short Detention Cell (1SD)

(180 d)(90 L/(p.d))(500 p) = 8.1 x 10^6 L

= **8100** m^3

Assume 1 m freeboard

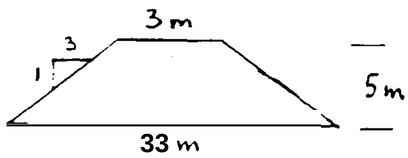
Depth = 4 m

$\frac{8100\ m^3}{4m} = 2025\ m^2$

Assume square cell

45 m x 45 m Length of berms = 4 x 45 = 180 m

$\frac{18\ m^3}{lin.m}$ of beam



180 m x 18 m^3 x $20/$m^3$) = $65,000

Liner @ $10/$m^2$ ‘ S W
,

2 Short Detention Cells (2 SD)

(240 d)(90 L/(p.d))(500 p) = 10,800 m^3

Volume = 10,800 m^3

Depth = 4 m

$\frac{10{,}800\ m^3}{4m} = 2700 m^2$

Assume 2 square cells

1 common wall

$1350\ m^2 = 36.7\ m \times 36.7\ m$

Length of berm = (2)(36.7)(2) + 3(36.7)

= 146.8 + 110.1

= 256.9 = 260 m

$\left(\frac{18\ m^3}{lin.m}\right)(260\ lin.m) = 4680\ m^3$

($20)(4680 m^3) = 94,000

Liner @ $ 10/m^2 = <u>$27,000</u>
$121,000

<u>1 Short Detention. 1 Long Detention</u>

(300 d)(90 L/(p.d))(500 p) = 10,800 m^3

Short Detention Lagoon:

Assume SD = 10 d

LD = 290 d

(10 d)(90 L/(p.d))(500 p) = 450 m^3

$\frac{450\ m^3}{4m} = 112.5\ m^2$

or = 11 x 11 m

(290 d)(90 L/(p.d))(500 p) = 13,050 m^3

$$\frac{13{,}050\ m^3}{4m} = 3262.5m^2$$

= 57.12 x 57.12 = 58x58 m

Length of berm = (4)(58 m) + 3(11)

=232 +33= 265m

$$\left(\frac{18\ m^3}{lin.m}\right)(265\ m)(\$20) = \$95{,}400$$

$95,400

Liner @ $ 10/m^2 = 135,000

$230,400

6. PROTOCOL FOR SELECTION OF DISPOSAL OPTIONS

The selection of an ocean disposal option requires an orderly evaluation of the public health, environmental, community, geographic, and cost factors. All of these factors have been discussed in other parts of this report. In this section, those factors are drawn together into a decision driven protocol, which may be used to ensure all major options for an outfall are considered. Figure 6.1 presents the protocol in a diagram form for easy reference.

Decision A

Before any decisions can be made about wastewater discharge, information must be gathered on the community and the geographic and environmental characteristics of the area. The community information must include data on present and future water use, wastewater production and transport systems for both. Long term projections for growth of population, commercial and industrial activities must be obtained. The geographical growth of the community is also important to the decision process in terms of distance and type of outfall. Residents' travel patterns both on land and water must also be noted as they will affect outfall type and location.

The geography and bathimetry of the community will greatly affect Decision A as to whether a direct discharge or treated discharge can be used. The topography of present and future development areas may influence not only the growth of the community but also the way the collection system works and the suitability of disposal sites.

The near shore bathimetry is very important to this decision. In locations where a steep shoreline and good ocean water movement exists, a 'Greenland type of discharge' may work. This would involve locating the outfall facility well above the high water marks, to insure it is not damaged by ice, and discharging the collected wastewater after minimal treatment by screening and comminution directly into the ocean. The selection of such a site would require assurance that travel routes, and fishing and hunting areas are not adversely impacted. It is expected that only a few communities in the Baffin region may be suitable for this type of outfall.

Where the shoreline topography is relatively flat and where the off-shore bathimetry is relatively flat, the above type of outfall is not suitable. As a result, the decision must be for the treated discharge type of outfall.

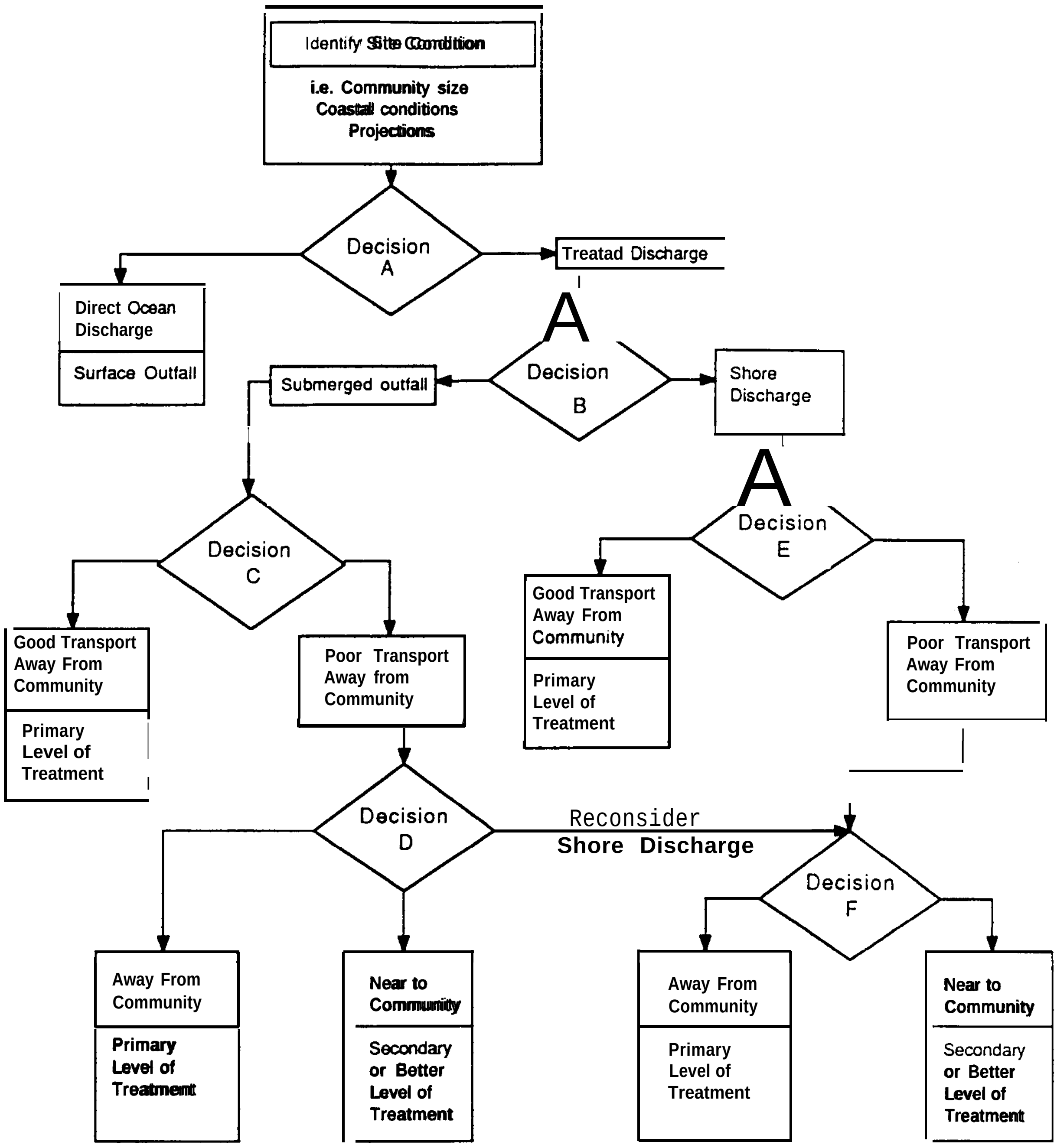


Figure 6.1

Diagram Presentation of the Protocol for Selection of Disposal Options

Decision B

The bathimetry and community growth travel patterns and cost will influence the decision between the use of a submerged outfall and a shore discharge. The bathimetry is important in terms of how close to shore an acceptable discharge depth can be found. The type of bottom material will influence excavation for burial of the outfall for protection from ice, boats and anchors.

Cost estimates based on length and burial requirements as discussed in subsection 5.5, may dictate the selection of the shore discharge option.

Decision C

The nature of the off-shore current and winds will influence the transport of the discharged wastewater. The currents along with water travel routes and environmental concerns combine together to influence the treatment required.

The collection of information on the water movement at various times of the year may be difficult. Existing bathimetry maps and marine charts may provide some or most of the information needed. The time of year that discharge will occur must be considered. For example, a truck collection system discharge to a holding lagoon will only discharge in the spring, summer and fall when the wastewater is melted. Therefore, winter off-shore currents are not critical.

If winds and currents will carry the discharged wastewater away from the shore near the community, then a treatment option which involved settling only may be suitable, a shore detention lagoon or with a truck collection system, a storage lagoon to hold the frozen material. In the latter case, an outfall pipe may be subjected to freezing at the lagoon and at the point where the pipe goes below the water surface.

Decision D

If poor transport away from the community is expected, then the decision is whether to move the discharge location further away from the community and use the primary treatment approach as above, or to use a long detention facility to ensure a secondary or better level of treatment, or to divert to a shore discharge option.

The criteria for selecting one of the three options becomes very site specific and difficult to pre-judge. In general, it appears that the selection of a shore discharge would be most economical.

Decision E

The selection of a shore discharge means that a treated wastewater is to be disposed of at the shoreline. If good transport conditions exist where wastes are carried away from the community and away from shore and water travel routes, then primary level of treatment in the form of a short detention lagoon may be used.

If the transport conditions away from the community are poor, then relocation or a high level of treatment is called for.

Decision F

Where poor wastewater discharge transport conditions exist, the only decision available is whether to treat the wastewater to a level which would give a good quality effluent or to move the facility to a location where the impact would be minimum. The treatment option involves the use of a pair of short detention lagoons in series with a storage lagoon to be discharged in the fall. This should provide an effluent that is better than a mechanical secondary treatment device with respect to microorganism reduction.

The move option, which would also be expensive, would require the identification of a location within 1.0 to 1.5 km.

7. SUMMARY AND RECOMMENDATIONS

The Present Situation

- The 31 coastal communities account for about 36% of the N.W.T. population. Their 1986 population of 18,624 is predicted to increase to 31,257 by the year 2,009. The provision of adequate waste treatment and disposal for ocean communities is therefore a significant part of the total task of providing adequate wastewater treatment and disposal.

- Only four of the31 coastal communities now have adequate waste treatment and disposal, accounting for 17% of the population in coastal communities or 6% of total NWT population. These four communities have lagoons,

- The large majority of communities dispose of waste either in plastic bags to dumps or through discharge of liquid waste mostly by trucks to natural depressions or small ponds. Some treatment may be occurring before discharge to shore. Two communities provide direct outfall to the ocean of untreated sewage through a surface outfall (Resolute Bay) and a submerged outfall (Rankin Inlet). It appears that probably all of the existing facilities will require substantial upgrading or complete new facilities.

- The existing Greenland ocean disposal method of discharge of untreated or minimally treated waste through a surface outfall into year-round ice free, fast flowing ocean currents will only find application in a very few locations in the N. W.T., because of the different coastal conditions encountered. Submerged outfalls for N.W.T. coastal communities, currently the only recommended method of ocean disposal, will likely be very expensive to build and maintain. They are therefore judged not a generally suitable option. Batch disposal by means of barges in open water season and by trucks over ice may not be acceptable from a safety and environmental point of view. This leaves shore discharge as the only widely applicable option. To be acceptable, treatment and storage will have to be provided.

- Storage lagoons providing at least primary treatment level is judged the most feasible method prior to shore discharge. This works successfully now in four coastal communities. Winter storage must be provided in the lagoon. The location of the lagoon and shore discharge must be carefully chosen to minimize public health risks and aesthetics on the shoreline. In some communities, local conditions may dictate the need of secondary treatment levels. In this case, a long-detention lagoon, or in special circumstances a treatment package plant, will provide the answer.

The **Future Requirements (2,009)**

- Volumes of wastewater to be disposed of **will increase** from the present volumes because **of:**

  - increases in population in coastal communities
  - increases in water supply, and thus wastewater volumes towards design levels of 90 L/p-d
  - elimination of the plastic bag method of waste disposal by replacing it mostly by a pump-out/holding tank truck disposal system

  Wastewater volumes to be disposed of will more than double current values.

- Continued acceptance of the current methods of ocean disposal will be unlikely from a public health, social, environmental and thus regulatory standpoint.

- The technology to provide adequate waste treatment and disposal to the ocean exists now. What is required is a financial plan and the political will to implement the solution over a sufficiently long period.

An **Estimate of Financial Requirements**

In the year 2,009, the population of the 31 coastal communities is estimated to be 31,257 or about an average of 1,000 people per community. For most communities, an adequately sized storage lagoon providing at least primary treatment and shore disposal will need to be provided. Based *on* Table 4.1 and costs provided in Section 5.5, the required facilities are estimated to cost the following:

- volume of 22,050 m^3
- liquid depth 4 m
- area required 5,510 m^2
- 2 cells @ 77 m x 36 m
- Lengths of berms, approx. 400
  (3 m wide, 3:1 slope, 5 m deep)
- Est. cost (1989) per meter of berm $1,350
- Cost of Berm Construction $540,000
- Cost of Site Preparation, Clearing $50,000
- Cost of Truck Disposal and Outlet Works $60,000

  Est. Total for Lagoon $650,000

- Access Road Construction
  Assume 1 km @ $300 per lin. m. $300,000

  Total Cost/Community $950,000
  =====

For all 26 communities needing facilities:

Total Cost = 26 X 950,000 = $24,700,000.

If this program is carried out over a 20-year period, it would require the provision of $1.25 Million (1989) per year. The cost per person would be $24.7 Million/31,257 ≃ $790.

Recommendations

The following actions are recommended before guidelines based on this study can be adopted:

1. To review the draft report by all appropriate agencies leading to changes before the final guidelines are adopted.

2. To discuss the proposed guidelines with the Northwest Territories Water Board, leading to changes in the draft guidelines.

3. To prepare a financial plan for the implementation of waste treatment and disposal for

3. To prepare a financial plan for the implementation of waste treatment and disposal for coastal communities over a 20-year period.

4. To set priorities for timing of implementation for each community, taking into account the schedule for upgrading of collection facilities in the communities.

5. To setup a monitoring program on a number of completed facilities to establish the success of the program for public health, environmental and social acceptability. The relevant NWT and federal department should be consulted to review the criteria to be used for monitoring before the program is implemented.

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APPENDIX A

Summary of Wastewater Collection, Treatment and Disposal in Coastal Communities of the N.W.T.

APPENDIX A

SUMMARY OF WASTEWATER COLLECTION, TREATMENT AND DISPOSAL IN COASTAL COMMUNITIES OF THE N.W.T.

Table of Contents

Table A.1 Wastewater Collection Systems in N.W.T. Coastal Communities

BAFFIN REGION COMMUNITY	POPULATION			WASTE WATER COLLECTION SYSTEM (1981)					
				HONEY BAGS		PUMP OUT/ HOLDING TANKS		PIPED	
	1981	1986	2009	No. of People	l/d	No. of People	l/d	No. of People	l/d
Arctic Bay	375	477	899	224	7	151	27		
Broughton Island	378	439	821	211	34	67	336[a]		
Cape Dorset	784	872	1490	581	u	203	4186[b]		
Clyde River	443	471	800	120	u	323	u		
Grise Fiord	106	114	187	106	u				
Hall Beach	350	451	807	180	38	170	1329[c]		
Igloolik	746	857	1579	387	8	359	234		
Iqaluit	2333	2947	4438	250	u	605	167	1478	u
Lake Harbour	252	326	581	84	u	168	63d		
Nanisivik	261	315	444					261	273
									31822[e]
Pangnirtung	839	1004	1786	369	u	470	3670[f]		
Pond Inlet	705	796	1360	258	7	447	916[g]		
Resolute Bay	168	184	280			42	1875[h]	126	660[h]
Sanikiluag	383	422	704	182	u	201	421		
SUBTOTAL BAFFIN REGION 14	8123	9675	16176	2952	N.A.	3306	N.A.	1865	N.A.

Source: Community Profiles (1982, 1983)

u = unknown
a) = includes school
b) = includes business, offices, nursing station, school
c) = includes school, D.E.W. Line Station, nursing station
d) = includes school
e) = mill (Nanisivik Mines Ltd.)
f) = includes school, hotel, nursing station, store
g) = includes school
h) = incomplete

Table A.1 Wastewater Collection Systems in N.W.T. Coastal Communities (Continued)

REGION COMMUNITY	POPULATION			WASTE WATER COLLECTION SYSTEM (1981)					
				HONEY BAGS		PUMP OUT/ TRUCKED		PIPED	
	1981	1986	2009	No. of People	l/d	No. of People	l/d	No. of People	l/d
Keewatin									
Chesterfield Inlet	249	294	509	98	u	151	u		
Coral Harbour	429	477	828	174	u	255	u		
Eskimo Point	1022	1189	2154	239	u	783 '	>83[i]		
Rankin Inlet	1109	1374	2160	28	u	80	u	1001	u
Repulse Bay	352	420	749	211	8.4	141	u		
Whale Cove	188	210	346	129	u	59	u		
SUBTOTAL KEEWATIN REGION 6	3349	3964	6746	879		1469		1001	
Inuvik									
Paulatuk	174'	193	316	174	u				
Sachs Harbour	161	158	227			161[a]	1504		
Tuktoyaktuk	772	929	1529	>235[i]	u	>321[i]	8125[b]		
				>326[e]		>446[e]			
SUBTOTAL INUVIK REGION 3	1107	1280	2072	500[e]		607[e]			

u = unknown
a) = includes school, nursing and RCMP stations
b) = total pump out for whole hamlet
i) = incomplete data
e) = estimated

Table A.1 Wastewater Collection Systems In N.W.T. Coastal Communities (Continued)

REGION COMMUNITY	POPULATION			WASTE WATER COLLECTION SYSTEM (1981)							
				HONEY BAGS		PUMP OUT/ TRUCKED		PIPED		INDIVID. DISPOSAL	SERVICE UNKNOWN
	1981	1986	2009	No. of People	l/d	No. of People	l/d	No. of People	l/d	No. of People	No. of People
Kitikmeot											
Bathurst Inlet	31	16	26	individual sewage disposal						96	
Umingmaktok	65	61	93								
Cambridge Bay	815	1002	1664	138	u	597	u				80
Coppermine	809	888	1507	301	71	435	1799[a]				73
Gjoa Haven	523	650	1121	219	u	304	u				
Holman Island	367	303	564	216	u	108	681[b]				43
Pelly Bay	270	297	475	194	u	63	324				13
Spence Bay	431[c]	488	813	215[c]		216[c]					
SUBTOTAL KITIKMEOT REGION 8	3311	3705	6263	1283		1723				96	209
Fort Smith											
None											
TOTAL FOR N.W.T. 31	15890	18624	31257	5614		6913		2866			

u = unknown
a) = includes nursing station, hotel, store, airport, school
b) = includes nursing station, hotel
c) = about half of the houses are on the H.B. system, others are pump out

Table **A.2** Wastewater Treatment and Disposal in N. W.T. Coastal C[redacted]ties

REGION COMMUNITY	TYPE	POPULATION 1981	1986	2009	WASTEWATER TREATMENT	COMMENTS	BAGGED TO DUMP	LIQUID TO DUMP	LIQUID TO POND	DISTANCE TO OCEAN	DISCHARGE TO OCEAN DIRECT	INDIRECT	ACCEPTABILITY
					TREATMENT/DISPOSAL (1981)								
Baffin Region													
Arctic Bay	Hamlet	375	477	899	None		x		x	100m		x	NO
Broughton Is Land	Hamlet	378	439	821	None		x	x		150m		x	NO
Cape Dorset	Hamlet	784	872	1490	None		x					x	NO
Clyde River	Hamlet	443	471	800	None		x	x		Close		x	NO
Grise Fiord	Settlement	106	114	187	None		x			Close			NO
Hall Beach	Hamlet	350	451	807	None		x		X	Close	x		NO
Igloolik	Settlement	252	857	1579	None		x	x		1 km		x	NO
Iqaluit	Town	2333	2947	4438	Lagoon and Macerator*		x		X	Close	x		NO
Lake Harbour	Settlement	252	326	581	None		x		x			x	NO
Nanisivik	Settlement	261	315	444	R.B.C.**					Close	x		NO
Pangnirtung	Hamlet	839	1004	1786	None		x		X			x	NO
Pond Inlet	Ham[et	705	796	1360	Short-det. lagoon		x		X			x	YEs
Resolute Bay	Settlement	168	184	280	None						x		NO
Sanikiluaq	Hamlet	383	422	704	None		x	x				x	NO
SUBTOTAL BAFFIN REGION		8123	9675	16176			12	4	7		4	9	

• A small storage lagoon was built in about 1983, and reconstruction of the failed dam occurred in 1987. A macerator built in about 1980 has never worked and is now abandoned.

** R.B.C. - Rotating biological contactor. Not operating since 1989, requires major repair.

Table A.2 Wastewater Treatment and Disposal in N.W.T. Coastal Communi"ties (Continued)

REGION COMMUNITY	TYPE	POPULATION 1981	1986	2009	WASTEWATER TREATMENT	COMMENTS	TREATMENT / DISPOSAL (1981) BAGGED TO DUMP	LIQUID TO DUMP	LIQUID TO POND	DISTANCE TO OCEAN	DISCHARGE TO OCEAN DIRECT	INDIRECT	ACCEPTABILITY	
Keewatin Region														
Chesterfield Inlet	Hamlet	249	294	509	None		x		x			x	no	
Coral Harbour	Hamlet	429	477	828	None		x		x			x	NO	
Eskimo Point	Hamlet	1022	1189	2154	Storage Lagoon				x			X	YES	
Rankin Inlet	Hamlet	1109	1374	2160	Macerator		x							
Repulse Bay	Hamlet	352	420	749	None		x		x			x	NO	
Whale Cove	Hamlet	188	210	346	Storage Lagoon				X		X		YES	X
SUBTOTAL KEEWATIN REGION		3349	3964	6746			6	-	5		2	4		
Kitikmeot Region														
Bathurst Inlet	Unorganized	31	16	26	None		x						NO	
Umingmaktuk	settlement	65	61	93			x						NO	
Cambridge Bay	Settlement	815	1002	1664	None		x		x	700 m		x	NO	
Coppermine	Hamlet	809	888	1507	None		x		x	700 m		x	NO	
Gjoa Haven	Hamlet	523	650	1121	None		x		x			x	NO	
Holman Island	Settlement	367	303	564	Trench		x		x			x	NO	
Pelly Bay	Hamlet	270	297	475	None		x		x			x	NO	
Spence Bay	Hamlet	431	488	813	None		x	x				x	NO	
SUBTOTAL KITIKMEOT REGION		3311	3705	6263			8	1	5			6		

Table A.2 Wastewater Treatment and Disposal in N.W.T. Coastal C[redacted]ities (Continued)

					TREATNENT/DISPOSAL (1981)						DISCHARGE TO OCEAN		
REGION COMMUNITY	TYPE	POPULATION 1981	1986	2009	WASTEWATER TREATMENT	COMMENTS	BAGGED TO DUMP	LIQUID TO DUMP	LIQUID TO POND	DISTANCE TO OCEAN	DIRECT	INDIRECT	ACCEPTABILITY
Inuvik Region													
Paulatuk	Settlement	174	193	316	None		x		x	300 m			NO
Sachs Harbour	Settlement	161	158	227	None		x	x		250 m			NO
Tuktoyaktuk	Hamlet	772	929	1529	Storage Lagoon		x		x	100 m	x		YES
SUETOTAL INUV1KREG1ON		1107	1280	2072			3	1	2		1	2	
SUBTOTAL FOR SMITH REGION	None	0											
TOTAL FOR" N.W.T. OCEAN COMMUNITIES	3 1	15890	18624	31257			29	6	19		7	21	YES 5 NO 26

Source: Community Profiles (1982, 1983)
Updatedon a number of *communities*

NOTES

To Accompany

TABLE A.2 WASTEWATER TREATMENT AND DISPOSAL IN N.W.T. COASTAL COMMUNITIES

COMMUNITY	TREATMENT/DISPOSAL DETAILS
Arctic Bay	Short detention settling pond. Indirect overland discharge.
Broughton Island	Wastewater disposed in pit at dumpsite. Indirect overland discharge.
Cape Dorset	Wastewater disposed on brow of incline, then runs down to a small pond. Indirect overland discharge.
Clyde River	Wastewater disposed on side of small valley near ocean. Indirect overland discharge.
Grise Fjord	Bagged wastewater.
Hall Beach	No treatment, discharged near ocean and covered. Direct discharge as released near ocean.
Igloolik	Short detention settling pond at dump. Indirect overland discharge.
Iqaluit	Short detention settling lagoon. Direct discharge.
Lake Harbour	Short detention lagoon. indirect discharge, wastewater flows through two lakes to the ocean.
Nanisivik	Rotating biological contact. Direct discharge.
Pangnirtung	Short detention settling pond. Indirect overland discharge.
Pond Inlet	Short detention settling lagoon. Indirect overland discharge.

... Continued

TABLE A.2 (Continued)

COMMUNITY	TREATMENT/DISPOSAL DETAILS
Resolute Bay	No treatment. Direct discharge, surface outfall at high tide mark.
Sanikluaq	Wastewater disposed on ground at the dump. Indirect overland discharge.
Bathurst Inlet	Bagged wastewater.
Bay Chimo (Umingmaktuk)	Bagged Wastewater.
Cambridge Bay	Short detention lake lagoon. Indirect discharge as wastewater flows through a couple of lakes to ocean.
Coppermine	Short detention settling pond. Indirect overland discharge.
Gjoa Haven	Short detention settling pond. Indirect overland discharge.
Holman Island	Short detention settling pond. Indirect overland discharge.
Pelly Bay	Short detention settling pond. Indirect overland discharge.
Spence Bay	Wastewater disposed on ground at the dump. Indirect discharge as wastewater flows through lakes to ocean.
Paulatuk	Wastewater disposed in lake 400 m from community. Indirect overland discharge.
Sachs Harbour	Discharged to a drainage ditch with some retention time. Indirect discharge through the ditch to ocean.
Tuktoyaktuk	Storage lagoon, built by increasing size of a natural lake. Direct discharge to ocean through channel.
Chesterfield Inlet	Short detention settling pond. Indirect overland discharge.
Coral Harbour	Short detention settling pond. Indirect overland discharge.
Eskimo Point	Storage lagoon. Direct shore discharge.
Rankin Inlet	No treatment. Submerged outfall.
Repulse Bay	Short detention settling pond. indirect overland discharge.
Whale Cove	Storage Lagoon (Built 1988)