1.0 INTRODUCTION

1.1 General

The Hamlet of Resolute Bay is serviced by a water supply system that uses a utilidor system to deliver water to houses and commercial users, and collect the sewage from these users. The water supply and sewage disposal systems are comprised of several components, namely:

- The raw water source known as Char Lake
- The Char Lake pumphouse
- The water supply line from the Char Lake pumphouse to the Water Treatment Plant (WTP)
- The utilidor system that is comprised of the water distribution system and the sewage collection system
- The Sewage Treatment Plant
- The sewage outfall.

The above components are shown in **Figure 1.1** and will be described in more detail in the body of the report. Previous studies (UMA 1996) assessed each of the system components for condition, expected remaining life and required remedial action to be undertaken to extend the current facility life to 20 years. The results of this study indicated that in general the facility components are well maintained, and will meet the Hamlet's requirements for the next 20 years. The exception is the utilidor system that has experienced a number of failures over the past 5 to 7 years. The increase in failures is of significant concern to the utilidor maintainers and the Hamlet Council.

The GNWT, Department of Municipal and Community Affairs (MACA) owns the assets of the water and sewer systems. The Department of Public Works & Services (DPW&S) completes the operation and maintenance on the systems. The GNWT has identified the transfer of the community assets to the communities as a priority. In this vein, the GNWT intends to transfer the water and sewer system to the Hamlet of Resolute Bay. Prior to the transfer of the facilities, the systems are to be upgraded to meet the requirements of the Hamlet for the 20 year design life. The intent of this report is to review the system in this light, and develop an upgrading plan for the sewage and water systems assuming that the piped distribution system will be maintained in the community.

Figure 1.1 Water Supply and Sewage Disposal System

1.2 Scope of work

The scope of work for this report is outlined in the project terms of reference, and the proposal for engineering services. A summary of the scope of work is described below:

- Complete a review of the existing documentation.
- Complete a site investigation to update the UMA, 1996 report with respect to the utilidor system.
- Debrief the system operator on his concerns, and review the system operator's records of the system.
- Complete an assessment of the hydraulic and thermal capacity of the system, and determine the system's ability to meet the 20 year design requirements.
- Complete an Impact Study to develop an understanding of the effect that the sewage discharge is having on the receiving body.
- Develop a list of required upgrades to be completed to have the system meet the Hamlet's system needs for the next 20 years.
- Develop an upgrading plan for the system, complete with cost estimates.

2.0 EXISTING DATA REVIEW

2.1 Community Data

Resolute Bay is located on the south coast of Cornwallis Island and is about 1,660 km north east of Yellowknife and 1,550 Km north west of Iqaluit. The community is located at latitude N74-43-01 and longitude W94-58-10 (NAV CANADA). The average daily minimum and maximum temperatures for July and January are 1.3°C & 6.8°C and -35.8°C & -28.5°C respectively. An average of 50.4 mm of rainfall and 97.3 cm of snowfall for a total of 139.6 mm of precipitation is received each year (Environment Canada).

The community was founded in the early 1970's when it was decided to relocate the existing community from the beach area near the existing south camp to the present location. The development of the community and the initial infrastructure was based on a projected population of some 1,500 people. The expected growth was not realized and the current population is slightly less than 200 persons.

2.2 Population Projection

To be able to develop the system requirements it is necessary to determine the design flow rates for the piped system. The flow rates are based on the population of the community and the expected per capita consumption. The historic populations and per capita water use rates are based on the records found at the Hamlet’s office, MACA’s records and in previous reports (UMA, 1993, 1996). The population projections are based on the data supplied by the Bureau of Statistics. These are as follows:

Table 2.2.1
Population Projects from the Bureau of Statistics

Year	Population
1991	171
1992	174
1993	178
1994	181
1995	184
1996	197
2001	224

2006	238

The consumption is based on the formula developed by MACA (MACA, 1986) and on the historic consumption of the community. The formulae for predicting water consumption of communities with piped water distribution and populations less than 2,000 people is:

$$\text{Daily Consumption} = 225*(1 + 0.00023 * (\text{Population})) * \text{Population}$$

Based on this formula and the population projections shown in Table 2.2.1, the projected annual consumption for the Hamlet of Resolute Bay for the next 20 years can be predicted. The system uses bleed water from the watermains to provide freeze protection to the sewermains. The bleed water is not metered. The total water pumped into the system is metered, and the individual consumers are metered. The resultant of the water supplied to the system and the metered volume of the consumers is the total of the system losses. The total system losses include the bleed water, losses due to watermain breaks, and water losses within the system. Prior to 1996, this value was fairly constant at approximately 38,000 m^3 per year. As a result of increased problems with the system the amount of bleed water has increased in 1996 to 52,000 m^3 and again in 1997 to 56,000 m^3. At the time of reporting, the Hamlet was projecting an annual total consumption for 1998/99 of 55,000 m^3 of which 45,000 m^3 would be the bleeders and other system losses. For the purposes of water consumption projections the value of 45,000 m^3 of bleed water and other system losses is used. The projected annual consumption is shown in **Table 2.2.2.**

2.3 System Description

The following is a description of the complete water and sewage system from the up gradient intake to the down gradient sewer outfall. **Figure 2.1** illustrates this system in a schematic diagram.

Char Lake

- A ductile iron gravity intake line extends from Char Lake to wet wells in the Char Lake Pump House.
- Char Lake Pump House tempers the water using a hot water injection into the wet wells. Diesel fired boilers are used to heat the injection water. The tempered water is pumped through the 150 mm heat traced and insulated HDPE Water Supply Main to the Water Storage Reservoir at the Water Treatment Plant (WTP).
- Two jockey pumps and two demand pumps are operated in the Char Lake Pump House. Typically one jockey pump operates 24 hours a day, with one demand pump coming on for less than one hour per day. The second jockey pump and second demand pump are on-line standby pumps and are brought on-line automatically if the first pump fails.
- The Char Lake Pump House pumps are controlled from a level controller located in the Water

Storage Reservoir. The controller has a high level alarm, jockey pump off, jockey pump on, demand pump off, demand pump on, and low level alarm control levels.

- A standby diesel engine generator is situated in the Char Lake Pump House in case of loss of power to the Pump House.

Table 2.2.2 Population and Consumption Projections

Figure 2.1 Existing System Schematic

Water Treatment Plant

- The Water Storage Reservoir is a steel 530 m^3 vertical steel tank constructed above grade. The tank is insulated and is freeze protected by the use of hot water injection.
- The Water Treatment Plant uses diesel fired boilers to provide tempering water for the Water Storage Reservoir hot water injection.
- The distribution water to the community is chlorinated using calcium hypochloride through injection pumps.
- The WTP uses pumps to provide distribution flow. The pressure is maintained at approximately 170 kPa (25 psi) at the WTP (October 1998 reading), and approximately 600 kPa (85 to 90 psi) at the low end of distribution system. The difference between the discharge pressure and the low end main pressure is the result of the static head difference in the mains due to elevation changes. The supply pump runs continuously at a constant rate of 1,700 rpm. The flow to the distribution mains is not regulated. Whatever water is not used within the distribution system is returned to the reservoir through the 150 mm return line.

Utilidor

- The distribution system is a looped HDPE insulated pipeline. The pipes are mostly 200 mm in diameter with two sections of 150 mm supply line and a 150 mm return line.
- Water is supplied to users (approximately 60 buildings) through a 20 mm copper heat traced (Stage 1A only) and insulated services. A return service is also installed from each building to the water main. Flow is moved continuously through the supply and return services by a small recirculation pump (1/4 h.p.) located in each building.
- The return water is directed back to the Water Storage Reservoir.
- The building sewage is collected using 100 mm insulated HDPE sewers to the sewer mains.
- The water and sewer services are in a common insulated jacket. The latent heat from the recirculation of the water services is used to freeze-protect the sewer service.
- Bleed water from the water mains is also used to provide freeze protection to the sewer mains during power failures when the water service recirculation pump is not operating
- The sewer mains are gravity run 150 mm insulated HDPE. These are installed in the same trench as the watermain.
- The sewermains and watermains are accessed through common concrete cast in place Access Vaults (AVs). The AVs contain all valves, hydrants, pipe connections and sewer clean outs.
- The sewer main is freeze-protected by the use of bleed water from the watermain to the sewermain. The bleeders are unmetered and located in the AVs.

Sewage Discharge

- The sewer mains join at the low end of the community and flow by gravity to a comminutor building.
- The sewage is macerated in this facility and discharged by gravity through an outfall pipe to the shore line of the marine environment.

There have been several changes to the system since the original design. Some of these changes have been incorporated into the O&M manuals. The changes recorded during the site investigation completed on October 20 to 22, 1998 are from the discussions with the DPW Maintainer, Mr. Neil MacDonald, the Hamlet Administration, Mr. Dan Leman & Mr. Ralph, and from the existing documentation are as follows:

- A heat trace has been installed in the Water Supply Line from the Char Lake Pump House to the WTP in 1993. Five access vaults have been installed along this line as well. (Record Drawings)
- Two jockey pumps have been installed in the Char Lake Pump House.
- The utilidor heat trace system was abandoned in 1984 due to corrosion problems.(UMA, 1996)
- All electrical devices and service were removed from the Access Vaults in 1998. This includes the sump pumps, heat trace, and AV heaters. (N. Macdonald)
- The line to Block 1 is abandoned due to a freeze-up prior to 1986. The Health Centre water service currently uses the abandoned water main as a carrier pipe. The other buildings in this area are connected to the water and sewer mains between AV2 & 3. (N. MacDonald) The sewer service to the Health Centre is still in operation (D. Leman).
- The Hydrant in AV 20 was removed prior to 1986.
- AV 15 was never installed during the original construction. (N. MacDonald)
- A new hydrant was installed in 1998 in AV 13, (N. MacDonald)
- The valves in AV3 were replaced in 1998. These are the valves that were indicated to leak in the UMA 1996 report, but were incorrectly identified as AV2 valves in the UMA report (N. MacDonald).
- A new valve was installed in AV30 in 1998. This allows the section of main between AV21 and AV30 to be shut off. (N. MacDonald)
- The ventilation systems for the WTP and Char lake Pump House have been disabled and are blocked up in the winter. Combustion air for the facility burners is supplied through building envelope infiltration. It is reported by the DPW Maintainer that the buildings are very leaky and have poor insulation.

With respect to the utilidor system, there are no known changes made from the original construction other than the changes noted above. The complete system description and components is found in three sets of O&M Manuals. Copies of these manuals are stored in the community, DPW&S Iqaluit, and DPW&S Yellowknife.

2.4 System Deficiencies

The previous assessment of the facility as a whole was completed by UMA and documented in a report dated 1996. The report identified a number of concerns with the system, some of which have been addressed through the maintenance of the system while others are still outstanding. **Table 2.4.1** lists the deficiencies noted in the UMA report, and the changes that have occurred with respect to these deficiencies since the writing of the UMA report.

Table 2.4.1
Reported System Deficiency Update

Deficiency Noted in 1996		Current Status
1.	Building ventilation may not meet code requirements.	The building envelopes are poor, and there is significant leakage of air into the building. The ventilation system has been disconnected to prevent the buildings from freezing. These systems can be re-instated if the building envelope is improved.
2.	Wet well in Char Lake pump house requires confined entry safety equipment to access.	No action taken.
3.	Inadequate safety equipment. (First Aid kit and fire extinguisher)	Fire extinguishers installed. First aid kits ordered but not yet received in Hamlet
4.	The heat trace for the water supply line must be manually turned on when there is a no flow alarm on this line.	No action required. The no flow alarm is a major alarm, and the operator must go to the Char Lake Pump House to respond to the alarm. The no flow alarm only occurs if the Water Supply Line is frozen, which is very infrequent. The DPW&S Maintainer does not see any reason to make changes to the control system on this issue.
5.	Heat trace controllers, AV heaters, and sump pumps in AV's are non-functioning due to corrosion.	These components stopped working in 1985. All derelict components were removed in 1998, and will not be replaced.
6.	Concern with a potential sewer crossover into the watermain through the AV bleeders.	No action taken.
7.	Valves in AV 2 are leaking.	These were reported incorrectly, and are actually in AV 3. These valves were replaced in 1998.
8.	Suspected bad pipe joints in the mains due to construction techniques.	This was suggested in the UMA 1996 report based on anecdotal information from the Hamlet/DPW&S Maintainer. However, a review of the known breaks to date (see Section 3.1) indicates that there is no reason to suspect that there is bad joint construction. The concern over the number of breaks in recent years, however, persists.
9.	Improve the circulation in the mains.	No action taken.
10.	The lighting level in the Char Lake Pump House is insufficient.	No action taken.
11.	Surveillance Network Program signs required.	Signs installed.
12.	Statement by the Department of Health that the system does not comply with the Health Act because "the discharge of sewage is directly into the ocean without any prior treatment".	No action taken.
13.	Compliance with the Federal *Fisheries Act* is unconfirmed and subsequent DFO position paper is outstanding.	No action taken.

3.0 UTILIDOR SYSTEM CONDITION ASSESSMENT

3.1 Detailed Description

The utilidor system was constructed in two phases known as Stage 1A and Stage 1B in 1977 and 1978 respectively. Figure 1.1 shows the layout of the utilidor system, the phases of the construction, the pipe sizes and the main flow directions. The following is a list of the material components used for the construction of the utilidor.

Table 3.1.1
Utilidor Materials

Component	Material	Approx Quantity
Watermain	200 mm insulated PE series 125	Stage 1A - 1333 m Stage 1B - 633 m Total 1966 m
Watermain	150 mm insulated PE series 125	Stage 1 A - 323 m Stage 1B - 204 m Total 527 m
Sewermain	150 mm insulated PE series 45	Stage 1A - 1541 m Stage 1B - 762 m Total 2303 m
Building Water Services	2 @ 20 mm copper type K tubing c/w insulation	60 buildings
Building Water Appurtenances	18 mm Neptune meter 20 mm Pressure reducing valve - singer model 140 Armstrong Circulator 20 mm ½ H.P. pump	1 per building
Building Sewer Services	100 mm insulated PE pipe	1 per building
Water main Connections	200 mm x 2@20mm I.P. tap Ductile Iron Service Sleeve	1 per connection
Sewer main Connections	100 mm sewer service saddle	1 per building
Access Vaults	Concrete Cast in Place, c/w 50 mm insulation	Stage 1A - 22 Stage 1B - 9 Total 31
	200 mm Valves - Lug type	1 per direction of piping in AV
	Sewer clean out & cover	1 per direction of piping in AV
	Hydrant c/w valve - MaCavity	Stage 1A - 5 Stage 1B - 5 Total 10
	Frost cover	1 per AV
	Frame and cover	1 per AV

3.2 Utilidor Repair History

3.2.1 Repair History

The DPW&S Maintainer provided a description of the repairs that have been made to the utilidor system over the years. In total 12 repair clamps have been installed on the main system. Ten of the repair clamps have been installed on the water mains and two on the sewer mains. The Maintainer, Mr. Neil MacDonald, has been in Resolute Bay since 1986. The exact years of the repairs are not recorded; however, he provided an indication of which repairs occurred prior to his arrival in the community. Further, he indicated that there were no repairs completed on the mains in the first five years of his service in the community. The following is a list of the locations of the repair clamps as noted by the DPW&S Maintainer. The approximate location of the breaks is shown in **Figure 3.2.1**.

Table 3.2.1
Record of Main Repairs

From	To	Distance	Comments
AV21	AV30	6 m from AV21	Watermain, repair clamp, prior to 1986, split in pipe
		18 m from AV21	Watermain, repair clamp, prior to 1986, split in pipe
		6 m from AV21	Sewermain, repair clamp, since 1991, collapsed pipe
		18 m from AV21	Sewermain, repair clamp, since 1991, collapsed pipe
AV30	AV29	12 m from AV30	Watermain, 600 mm long repair clamp over a 500 mm long split in pipe, since 1991
AV3	AV2	Mid point	Watermain, prior to 1986
AV4	AV5	At AV 4	Watermain pipe flange broke in AV. Replaced with new 2.5 meter section of pipe and repair clamp installed 2.5 m from AV, since 1991
AV10	AV11	At AV10	Watermain pipe flange broke in AV. Replaced with new 2.5 meter section of pipe and repair clamp installed 2.5 m from AV, since 1991
AV9	AV10	9 m from AV 9	Watermain, approx. 400 mm split, since 1991
		18 m from AV 9	Watermain, approx. 400 mm split, since 1991
AV5	AV6		Watermain, small crack 50 mm to 75 mm long, since 1991
AV27	AV28	At 90 bend	Watermain, small split, since 1991

Figure 3.2.1 Water Supply and Sewage Break Locations

3.2.2 Break Assessment

All split pipes have split along the top of the pipe, or just off the centre line of the top of the pipe. Except for the two repairs that were made to the pipe flange in the AVs all other repairs were made in the pipe away from the pipe joints. To develop remedial repairs for the utilidor system it is useful to determine the most likely cause of the pipe failures. Through the identification of the probable cause, the likely areas of future failures and the likely rate of failures can be developed. There are several possible failure mechanisms; namely,

- Poor construction methods or materials
- "Freeze Back"
- Excessive operating pressures
- Water hammer
- Ground movement

Poor Construction or Materials

The UMA 1996 report suggests that the pipe failures may be due to poor construction of the butt fused joints in the pipe. This was based on the report from the Hamlet that the breaks had occurred at the joints, and appeared to be joint failure. However, during discussions with the DPW&S Maintainer (N. MacDonald), it was determined that except for the failures in the AVs, none of the failures have been at a joint. The failures have all been longitudinal splits of the pipe, and this is not consistent with the premise that the pipes are failing at the joints. Therefore it is unlikely that the cause of the pipe failures is related to poor butt fusing of the pipe during construction.

Freeze Back

Over a number of years, Agra Earth and Environmental (under the name HBT Agra Limited) completed studies on the pipe failures in Iqaluit, NT. These failures were characterized by the mains becoming out of round or oval shaped. The mechanism proposed by Agra is increased soils pressures on the top of the pipes due to the freezing of the ground around the utilidor system. This is termed a "Freeze Back" failure. The failures in the Agra HBT study were all in the sewer mains. There were no noted failures related to the freeze back failure method in the watermains of the study area. The failures in the sewer mains had serval common characteristics; these include:

- Ground water was encountered at all sites,
- Failures between 2 and 10 years after installation,
- Series 45 HDPE piping,
- Presence of silt in soils,
- Shallow pipes, with the pipe located in the active layer of the soils.

The failures of the pipes in Resolute Bay do not appear to be consistent with the failure mechanisms described in the Agra reports. The Resolute Bay failures are occurring some 20 years after installation; the failures are in the watermains series 125, not the sewer mains series 45; and the Resolute Bay mains are not in the active layer. Therefore the freeze back mechanism is not considered the likely cause of the watermain failures.

Excessive Operating Pressures

Watermains can be damaged from excessive operating pressures. The main pressures are not metered, and as such there are not any records of the main pressures prior to or after a main break. There is a pressure relief valve (PRV) located at the WTP. This PRV is set to 200 kPa (30 psi). This valve was checked by the DPW&S Maintainer in September 1998, and noted to be operating properly. Over-pressuring of the mains from the WTP is therefore considered unlikely.

Water Hammer

Water hammer is a cause for pipe system failure. This is produced by the sudden closure of a valve on the pipe system, and the shock wave produced from this action. Normally, the pipe system will fail at a bend, valve, or tee within the system where the shock wave from the water hammer is cause to change direction or velocity. As the recorded breaks do not occur at these locations, it is unlikely that this is the mechanism for failure.

Ground Movement

Differential settlement of the ground that supports the piping system can cause stresses on the pipe system, particularly where the piping system enters/exits a building or structure. Based on the report of the two breaks at the AV structures, it is highly probable that this is the mechanism of failure for these two breaks.

Settlement of the piping within the pipe trench is also a common occurrence. The settlement can be created by frost heaving, thaw settlement, erosion of the pipe bedding material, and consolidation of the sub-soils. In addition to the repairs on the watermains, there are sections of the sewer main that have poor flow characteristics. This is possibly due to settlement of the sewer pipe, poor pipe grade or blockages. Table 3.2.2 is a listing of these areas.

Table 3.2.2
Sewermain Flow Problem Locations

From	To	Distance	Comments
AV 14	AV 13	Mid point	Sewermain, small dip in road over main.
AV 25	AV 23	At road Crossing	Sewermain, dip in road.
AV 12	AV 11	Along section	Sewermain is sagged and needs regrading.
AV 19	AV 21	Along section	Sewermain, slow flow requires a lot of bleeding.

These problem areas are most likely due to the differential ground movement around the piping. It could also be due to ovalling of the pipe caused by the Freeze Back failure mechanism, but as this has not been noted by the maintainers to date, the freeze back mechanism is considered an unlikely cause.

The utilidor was constructed over phases known as Stage 1A and Stage 1B. The limits of each year's construction is shown on Figure 3.2.1. Stage 1A was completed in 1977, and Stage 1B was completed in 1978. All the repair clamps have been placed on piping installed under the Stage 1A phase of the work. Sewermain settlement would appear to be more predominant in the Stage 1B area, but it does appear in both stages.

The fact that the Stage 1A area is the only location for the watermain breaks is significant. It strongly suggests that there is a difference in the two systems' design, construction, operation or the foundation soils that would cause the failures in one area but not the other. To assess the cause of this phenomena the Record Drawings, O & M Manuals, construction records and photographs were reviewed. The results of the review are:

- The record drawings indicate that the design of the system was completed by the same firm, UMA. The design layout and details are very simular for all components of the utilidor installation. From this it can be concluded that there is little or no difference in the design of the system.
- The two stages are operated as one system, therefore system operation is an unlikely cause.
- The construction was completed under the same specifications, and the same rigour of testing. There are no noted differences in the manner in which the two stages were constructed, therefore construction methods is an unlikely cause.
- A review of airphotos from 1959 indicates that there appears to be a difference in the natural ground conditions between Stage 1A and Stage 1B. Stage 1A has areas were it appears ground water is seeping out, and creating wet areas. When this airphoto is overlayed with the developed community (**Figure 3.2.2**) there is a correlation between the "wet" seepage areas and the problems areas of the utilidor.

Water in the foundation soils of the pipes can be a cause for long term pipe problems. The available water allows for frost leave, ice lensing, and freeze - thaw ground movements. These in turn create localized stresses on the pipes on an annual basis. Continued movement over time will create fatigue, increased stresses and ultimately pipe failures.

There is also anecdotal evidence to support that there is ground water flow. The AVs are reported to have continued infiltration from the spring thaw to November each year. The infiltration continues after the spring run off is finished and is noted to be below the active layer. Further, there are reports of water seeping into excavations in the piping area up to 2 to 3 metres below the ground surfaces.

Though the cause of the pipe failures can not be determined with certainty, it is most likely that the failures were due to ground water flow, and the stresses placed on the pipes due to the freeze action of the ground water which creates ground movements.

3.2.3 Commentary

The number of breaks in the system in any given year is not unusual for the age of the system. In assessing water and sewer piping systems, a break frequency of less than 1 break/kilometre/year is considered to be good performance. Municipalities use the break frequency per kilometre per year to develop capital plans for system upgrades. In large systems, a break frequency of 3 or 4 is often the value required prior to the link being replaced.

The total number of breaks per link is also used as a means to develop repair requirements. A break frequency of 4 or 5 breaks per link is often used as a value to indicate the link needs replacement.

In Resolute Bay there are 2 links that meet the above values for replacement. These are from AV21 to 30 m past AV30 and AV8 to AV10. These repairs would cover 8 of the 12 recorded breaks. These sections should take priority over other pipe replacement sections.

During discussions with the Hamlet and DPW&S Maintenance, it was noted that the concern with the main breaks is not mainly related to the number of breaks, but is related to the risk of system failure in the event of a break. The system is not designed to allow for sections of the utilidor to be shut down and have the remainder of the system operate. Should a failure occur, there is a risk that the loss of the system could create a long term no flow condition in the system. This could result in system freeze up and loss of water supply, fire protection, and sewage disposal to the Community as a whole.

Given this risk, it may be prudent to complete upgrades at a break frequency sooner in Resolute Bay than is typically used for piped systems elsewhere. The cost for upgrading sections of the system is developed in Section 6 of this report.

Figure 3.2.2.

3.3 Regulatory Compliance of the Utilidor System

3.3.1 The Public Health Act

The NWT Public Health Act (PHA) regulates the supply of potable water to consumers, and the methods for the collection of waste in the NWT. The applicable sections of the PHA are the"Consolidation of Public Water Supply Regulations, P-23" (PHA P - 23) and the "Consolidation of Public Sewerage Systems Regulations" (PHA P - 22). No other sections of the Public Health Act would relate directly to the water supply and sewage collection system. With respect to the utilidor system the requirements are set out in the in Part III of the PHA-P23.

The utilidor meets the requires of Part III of PHA-P23 except for the requirements of section 20.9 which states:

> "Where water and sewer pipes are contained in a utilidor, there shall be adequate provision for drainage in order to prevent contamination of the water supply during repairs to the system."

The AV's contain both water and sewer pipes. The sewer clean out covers have been removed to allow infiltration water to drain out of the AVs. This is an annual problem, as each spring run off water enters the AV and must be removed. This occurs from about June to October (N. MacDonald) and then the remaining water is pumped out of the AVs. The clean out cover remains open year round. This creates concern that in the event of a water main break a negative pressure in the watermain can be created within an upstream AV from a syphoning effect of the down stream main. If the watermain is not completely sealed, or during the repair of the water main, there is the possibility of cross contamination from the open sewer clean out. This is greatly reduced if the clean out is closed and sealed prior to the start of any maintenance on the water main system.

The PHA P - 22 has two requirements that are of issue for the utilidor system. The first is the same as described above. The second is the requirement for treatment for the sewage. The PHA P - 22 states in Part IV article 9:

> "Sewage treatment systems shall be designed to provide for adequate protection of the receiving water considering the possible uses of the receiving water"

This issue does not particularly relate to the operation of the utilidor system, but is raised as the UMA, 1996 report indicates that the Public Health Department required that sewage treatment is needed to meet the requirements of the Department. Based on the above section of the act, which is the only section of the PHA that addresses sewage treatment, there appears to be no specific requirement for treatment other than to protect the receiving body of water. This issue is addressed in a subsequent section of the report.

3.3.2 Occupational Health and Safety

Occupation Health and Safety Act (OH&S) regulates the entry into confined spaces. The AVS are clearly considered to be a confirmed entry location and require the appropriate safety requirements. These requirements include:

- A metre to detect and monitor gases in the AV during the entry into this space. Gases of concern are methane from the sewage, and for low oxygen levels. The maintainers are not supplied with these meters.
- Safety harness and extraction equipment. These devises are required to remove a person from the AV in the event of injury or if the person becomes unconscious. This equipment is required to be on hand and used for entry into the AVS

3.4 Summary of Assessment

The assessment of the utilidor system identified a number of areas that require upgrading for the system to meet the 20 year design life. In addition to the upgrades of the utilidor system, there are several issues outstanding from the UMA report. A summary of these is as follows:

Component	Deficiency
Char Lake Pump House	Building envelope is poor.
	Wet well does not have confined entry provisions.
	Light levels are insufficient.
	Requires first aid kit.
WTP Pump House	Building envelope is poor.
	Requires first aid kit.
Access Vaults	Requires confined entry provisions.
	Concern with open sewer clean outs needs to be addressed.
	Concern with cross over of sewer through bleeders to watermain.
Watermains	Increasing break frequency is a concern of the Hamlet.
	System needs to be assessed for circulation and future capacity.
Sewermains	Areas of poor flow are a concern of the operators and require frequent maintenance and increased bleed water.

The issue of the sewage discharge is further discussed in Section 5. The watermain system requires modelling to determine the capacity of the system, and the requirements for the future expansion. This is completed in Section 4.

The remaining deficiencies are carried forward to Section 6 to develop alternatives to the upgrading requirements. The most significant of these are the concerns with the watermain failures and sewer main flow problems. The remaining concerns can be addressed at relatively low cost through the supply of the appropriate equipment.

4.0 MODELLING

4.1 Water Distribution Network

4.1.1 Introduction

This section summarizes the development of the water distribution analysis model for the existing system and the 5 year proposed residential development in Resolute Bay, NT. Results of the analysis and recommendations are included.

4.1.2 Existing Conditions

There is approximately 2,500 m of pipe in the water distribution system. All water mains are 200 mm HDPE pipe with the exception of three 150 mm sections. A constant pressure of 150 kPa (20 psi) is provided at the water treatment plant to the distribution system. There are 20 mm bleeds into the sanitary sewer in AV17, AV19, AV22, and AV25. The outflow through these bleeds is approximately 5.25 l/s each.

The water is constantly being recirculated within the system with the aid of a 150 mm return line to the water treatment plant.

4.1.3 Future Conditions

An area to the southwest of the current community is proposed for 37 new residential lots. This will require approximately 1,090 m of 200 mm additional water main. A commercial area to the northwest is proposed but not expected to be developed within the next 5 years and therefore not included in the scope of this project. The connections to the existing system will be made at AV17 and AV11.

4.1.4 Hydraulic Model (EPANET)

EPANET is a computer program that performs extended simulation of hydraulic and water quality behaviour within pressurized pipe networks. A network can consist of pipes, nodes, pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, and the height of water in each tank during a multi-time period simulation. EPANET Version 1.1e was developed by the Water Supply and Water Resources Division, National Risk Management Research Laboratory of the U.S. Environmental Protection Agency in Cincinnati, Ohio.

4.1.4.1 Model Setup and Assumptions

Since the network is relatively small, each pipe is modelled individually. Existing details such as slopes, diameters, elevations and the configuration were obtained from the as-built drawings obtained from PW&S. Elevations and slopes for the proposed development were interpreted from contour mapping. A schematic diagram is shown for existing conditions in **Figure 4.1** and for future conditions in **Figure 4.2**.

The Hazen-Williams head loss equation is used. (h=fn(C,d,L,q))

The Hazen-Williams coefficient (C) for HDPE pipe is assumed to be 110.

The return line to the water treatment plant is modelled with a check valve to ensure one direction of flow. The node at the end of the return line is modelled as a reservoir with a constant elevation equal to the inflow elevation at the plant. The water reservoir is modelled with a constant head of 17.3 m to simulate the a constant pressure of 150 kPa (20 psi) leaving the plant.

Demands in Resolute Bay are based on an estimated number of units of 63 in the existing model and 113 for the future conditions, and 5 people per unit.

Unit consumption rates are as follows:

Average Day	225 Lpcd
Maximum Day	450 Lpcd
Peak Hour	900 Lpcd

Total water use in a community can be estimated as a function of residential water use(RWU) (MACA, 1986).

Total water use=RWU*(1+(.00023*population)) for a community of less than 1000 people.

Total water use is used in the model, residential and commercial flows are not distinguished.

The allocation of demands is based on the as-built drawings and approximated for the future development. For both existing and future conditions the following scenarios are modelled. Average day demand, maximum day demand, peak hour demands and average day demands plus fire flow at the worst location. The results of these runs is in appendix A.

Figure 4.1 EPANET Resolute Bay October 1998 Existing Conditions Schematic

Figure 4.2 EPANET Resolute Bay October 1998 Future Conditions Schematic

The fire flow rate based on MACA criteria is 3600 l/min for 2 hours during average day demands. Fire flows were simulated at the edges of the network and at the highest elevations to determine the worst case scenario and verify fire flows can be met. For existing conditions a fire at AV4 has the lowest pressures associated with it but the minimum pressure of 150 kPa can be easily maintained. For future conditions a fire at AV201 has the lowest pressures associated with it, but again the minimum of 150 kPa is maintained throughout the system.

The model was also run with pipe diameters of 150 mm instead of 200 mm to determine if the pipe size can be reduced, as the Community has not grown to the anticipated size. The model indicates that the 150 mm size is not sufficient to maintain the fire flow requirements.

4.2 Sanitary Sewer System

4.2.1 Introduction

This section summarizes the utilization of the existing sanitary sewer system, and estimates the peak hour flows for the 5 year proposed residential development in Resolute Bay, NT. Results of the analysis and recommendations are included.

4.2.2 Existing Conditions

There is approximately 2,500 m of sanitary sewer pipe. Most sewers are 150 mm HDPE pipe with five 200 mm sections at the downstream end of the system. There are 20 mm bleeds into the sanitary sewer in AV17, AV19, AV22, and AV25. The inflow through these bleeds is approximately 5.25 l/s each.

4.2.3 Future Conditions

An area to the southwest of the current community is proposed for 37 new residential lots. This will require approximately 768.5 m of 200 mm additional sewer pipe. A commercial area to the northwest is proposed but not expected to be developed within the next 5 years and therefore not included in the scope of this project. The connection to the existing system will be made at AV32. In addition to the existing 20 mm bleeds into the sanitary sewer, they were also added to AV201 and AV203 to prevent freezing.

4.2.4 Capacity Utilization Analysis

The full flow capacity of a circular pipe can be calculated using Manning's equation (Q=1/n*(A*R^2/3*S^1/2).

Model Setup and Assumptions

Each pipe with its details is identified in the spreadsheet shown for existing conditions in Table 4.1 and for the proposed development in Table 4.2. Existing details such as slopes, diameters, and the configuration were obtained from the as built drawings obtained from PW&S. Slopes for the proposed development were interpreted from contour mapping.

A schematic diagram is shown for existing conditions in **Figure 4.11** and for future conditions in **Figure 4.12**. The Manning's n coefficient for HDPE pipe is assumed to be 0.013.

Demands in Resolute Bay are based on an estimated number of units of 63 in the existing model and 113 for the future conditions, and 5 people per unit.

Unit consumption rates are as follows:

Average Day	225 Lpcd
Maximum Day	450 Lpcd
Peak Hour	900 Lpcd

Total water use in a community can be estimated as a function of residential water use(RWU) (MACA, 1986).

Total water use=RWU*(1+(.00023*population)) for a community of less than 1000 people.

It is assumed that waste water is equal to water use.

<u>Results</u>

Nearly all pipe in the system have adequate capacity to carry the peak hour flows. The exception is between AV11 and AV32 in the existing system due to a small slope, and between AV 11 and AV35 in the future system. The problem is solved by replacing the sewer pipes at these locations with 250 mm diameter pipe.

Figure 4.11 EPANET Resolute Bay October 1998 Existing Conditions Schematic

Figure 4.12 EPANET Resolute Bay October 1998 Future Conditions Schematic

5.0 IMPACT STUDY

5.1 Introduction

This section presents an overview of the Environmental Impact Study (EIS) of the Hamlet's current sewage discharge practices to Resolute Bay. This study was initiated as a follow-up to a previous water and sewer facilities study by UMA Engineering Ltd. (1996). That study identified potential concerns relating to the Hamlet's sewage discharge with respect to health issues and components of the Federal Fisheries Act relating to the discharge of a deleterious substance.

The UMA Report reviewed the correspondence from the Baffin Region Medical Health Officer, and indicated that the sewage disposal system does not comply with the Public Health Act because, "*the discharge of sewage is directly into the ocean without any prior treatment*". However, the sewage does receive some treatment in the form of dilution from the bleed water.

There is uncertainty whether or not the sewage discharge complies with the Federal Fisheries Act as it relates to the introduction of a deleterious substance to a waterbody. It is not known if the current discharge would be considered deleterious, however, the UMA report states that the preparation of a DFO position brief on Resolute Bay is being considered. Currently, the status of the development of this position paper is unknown.

This EIS is based on existing environmental information for Resolute Bay, discussions with local residents, and Dillon's experience with similar studies (e.g. Repulse Bay Sewage Discharge -Preliminary Impact Assessment 1998). A major component of the EIS is a review of potential impacts of sewage discharge to the marine environment based on existing information. The EIS characterizes the existing environment of Resolute Bay including physical habitat characteristics, water quality, and marine flora and fauna. As part of this task data gaps or deficiencies have been identified to provide direction for a more detailed environmental assessment.

5.2 Potential Impacts of Discharging Sewage Waste to the Marine Environment

When wastewater is discharged to marine waters there are possible implications for the surrounding marine environment. The following discussion is intended to provide background regarding the potential environmental impacts of sewage to the marine environment.

The Department of Indian Affairs and Northern Development (DIAND, 1987), indicates that the principal components of sewage and the potential effects of these components to the receiving water body can be summarized in the following manner:

- *Organic Matter*: organic compound degradation may reduce the dissolved oxygen (DO) concentration of a receiving water body

- *Settleable Solids*: the benthic community structure may be altered if settling solids modify the particle size distribution of the sediments; localized anaerobic conditions may be a consequence of organic sediment decay

- *Inorganic Nutrients*: increased nitrogen and phosphorus levels could lead to increased primary production and hence decreased dissolved oxygen levels from microbial degradation of plant biomass at the sediments

- *Pathogenic Organisms*: the receiving water body may receive disease-causing bacteria and viruses

- *Residual Chlorine*: any chlorine remaining in the effluent that was used to reduce pathogenic micro-organism levels may be toxic to fish (not an issue in Resolute Bay)

- *Suspended Solids*: increased turbidity may alter fish migration patterns and reduce the amount of light available for photosynthesis

- *Floatables*: slowly degradable materials (i.e. fats, oils, plastic, rubber) may be aesthetically offensive if floating on the receiving water surface

Several of the impacts mentioned above are expanded upon in the following discussion as they relate to sewage discharge from coastal communities into the marine environment.

Of particular concern relating to impacts to the receiving environments is a potential decreased DO concentration due to the breakdown of organic matter, as well as the oxidation of hydrogen sulfide, ammonia, methane and iron compounds (DIAND, 1987). Anoxic conditions have been known to cause fish mortality in marine waters. Problems can arise where there is inadequate dilution or dispersion of an arctic communities sewage discharge which may result in anoxic conditions in the marine environment even when discharge is at relatively low volumes of sewage. DO reductions can also be exacerbated due to the long periods of ice-cover that effectively prevent atmospheric re-aeration. DIAND (1987) concluded that negligible decreases in dissolved oxygen levels could be expected in Arctic waters due to the small size of any one outfall, if dilutions greater than 100 to 200:1 are achieved.

The DO content immediately above the sediment and in its interstitial spaces may also decrease significantly due to organic compound decomposition. If the water at the level of the sediment were to become anoxic, this would have implications for the benthic and fish communities inhabiting this zone. In fact, Birtwell *et al*. (1983) suggested that the sediment chemical environment was a factor in the observed decrease in fish numbers near the sewage outfall of the Fraser River estuary. The accumulation of particulate organic matter may also have an effect on benthic invertebrates in the area and alter the relationships between benthic and pelagic trophic levels. Otte and Levings (1975) reported alterations in the benthic community associated with a sewage outfall discharging to the mud flats of the Fraser River estuary increased. The authors observed an increase in the number of individuals, biomass, and species with increasing distance from the discharge. The extent of impacts to the benthos community is dependent on many factors such as: the degree of deposition; the presence or absence of toxic materials; the decomposition rate of the organic matter; and any change to the characteristics of the sediment (i.e. particle size) (DIAND, 1987).

In addition to organic loading and decreased dissolved oxygen levels being potential consequences of sewage discharge, nutrient levels may increase in the marine environment, resulting in the stimulation of primary production. Welch (1980) has suggested that enhanced primary production as a result of increased nutrient levels may lead to increases in zooplankton production and biomass. However, during the open-water season, Arctic marine waters are likely nitrogen-limited, in addition to being light-limited when the sea is covered with ice (DIAND, 1987). Thus, it is unlikely that nitrogen loading from the relatively small sewage outfalls in the north will result in stimulating primary production to any noticeable degree. Furthermore, because zooplankton and phytoplankton are moved continuously through well-circulated areas, any local changes in species composition would likely not significantly alter the structure of the community (DIAND, 1987).

The potential impact of micro-organisms may also be a concern when sewage is discharged into Arctic marine waters. Faecal coliforms, such as *E. coli*, may contaminate local invertebrate species and hence pose a risk to human health if any of these organisms are harvested for consumption by the residents. Shellfish are of particular concern because they are filter feeders and tend to concentrate bacteria in their tissues. This makes shellfish harvesting for human consumption a potential risk. Coliform bacteria have a much higher survival in the Arctic, due to the cold temperatures and because there is less ultra violet light to provide natural disinfection in the winter months (DIAND, 1987).

It is suggested by DIAND, 1987 that sewage discharge to the marine environment from small northern communities may have an insignificant environmental impact at a regional level. There could be minimal impact at the local level if sewage is discharged to a not well-mixed waters where the effluent is not diluted. Any effects to the receiving water from raw or partially treated sewage may be limited to localized benthic impacts (DIAND, 1987). In addition, sewage generation rates for Resolute Bay, both in the present and predicted for future years, are relatively small.

5.3 Existing Environment

Information regarding the existing environment of Resolute Bay is extremely limited, and is generally restricted to marine studies completed in the early 1970's (see summary by Buchanan and Ragnit 1978). Several of the studies provide descriptions and information regarding the general marine biological characteristics of the Resolute Bay and Wellington Channel. Study components include physical measurements, phytoplankton, zooplankton, benthos, and fish.

The following sections provide brief summaries for each of these components or areas:

5.3.1 Physical Environment

The physical data summarized in this section is related to tides and winds. Tidal influences experienced by Resolute Bay are considerably less than those observed in other areas in the eastern Arctic. Resolute Bay has a mean tidal variation of 1.3 m and a maximum tidal variation of 2.1 m (UMA 1996).

Wind speed and direction information is particularly noteworthy as they have a direct effect on physical oceanography of an area and can play an important role in the behaviour and distribution of any pollutant. Mean wind speeds for Resolute Bay are reported to be between 10.4 and 12.6 mph with a predominant wind direction from the northwest (Bitello 1973 *cited in* Buchanan and Ragnit 1978).

5.3.2 Water Quality

Water quality monitoring has been completed periodically for the sewage discharge to Resolute Bay The water quality data includes a small sub-set of parameters from the final sewage discharge into Resolute Bay as well as from a station located 5-10 meters down current of the final discharge. Additional water quality information is available for comparative purposes for run-off from the solid waste disposal facility and for Char Lake waters.

Water quality data related to the sewage discharge are parameters pH, conductivity, total suspended solids, dissolved solids, biochemical oxygen demand (BOD), turbidity, total nitrogen, ammonia-N, nitrate, total phosphorus, and coliform bacteria. The effluent has not been characterized with respect to other parameters of potential concern such as metals or organics. Metal levels have been evaluated however, for the run-off from the solid waste disposal facility and for Char Lake.

The results of water quality monitoring completed between 1992 and 1997 for the Resolute Bay sewage discharge are presented in Table 5.1. Relevant guidelines and criteria have been included for comparison where possible. The solid waste site is not the subject of this assessment and is not discussed further in this report.

Generally, water quality is quite variable between sampling periods, although in all cases within relevant guidelines or criteria. The high variation is not surprising given that sampling likely took place over a wide range of physical conditions and as such may reflect tidal differences, wind- and wave-induced differences, etc.

Table 5.1

Water Quality Parameters at the sewage discharge to Resolute Bay and at a station located 5-10meters downcurrent of the discharge (data supplied by DIAND).

Parameter	Guideline/ Criteria	Sewage Discharge at End of Pipe (Stn 1571-3)					Resolute Bay[1] (Stn 1571-4)	Water Licence Criteria
		July 17, 1992	June 28, 1993	Aug. 17, 1994	July 26, 1996	July 8, 1997	July 17, 1992	
CONVENTIONAL PARAMETERS								
pH	7.0-8.7[2]	7.2	7.24		7.82	8.00; 8.03	7.39	6 to 9
Conductivity (uS/cm)	-	450	304			201	420	
Total Suspended Solids (mg/L)	1203	27	19	<3	10	15; 15	26	80
Dissolved Solids (mg/L)	-			260				
BOD (mg/L)	1003				76	15; 18		120
Turbidity (NTU)	-		15	2.9				
NUTRIENTS								
Nitrates/ Nitrites (mg/L)	-	<0.01	1.26	2.21			<0.01	
Ammonia-N (mg/L)	124			1.41	0.721	0.561; 0.597		
Nitrate (mg/L)	-			2.2				
Total Phosphorus (mg/L)	-	1.3	1.115	0.219			0.691	
BACTERIA								
Total Coliform (CFU/dL)	-				300,000	2,600,000		
Faecal Coliform (CFU/dL)	-				110,000	210,000		

Notes:

1- Resolute Bay 10m down current from discharge pipe.

2- CCME Interim Marine and Estuarine Water Quality Variable (December 1996)

3- Effluent discharge to a marine bay or fjord (Guidelines or the Discharge of Treated Municipal Wastewater in the Northwest Territories, 1992)

4- BCMoELP (Nordin 1990) *cited in* BCMoELP (1995) - water quality criteria for saltwater life. Ammonia to (T = 0ºC; Salinity 30g/kg; pH = 7.6)

The range of pH, 7.0 to 8.7, is recommended by the Canadian Water Quality Interim Guidelines for marine and estuarine environments (CCME 1996). The guideline also states that within this range, pH should not vary by more than 0.2 pH units from the natural pH expected at that time. This is intended to protect marine organisms which have narrow pH tolerances. During the July 1992 sampling, the pH 5-10 meters down current of the effluent discharge point is almost 0.2 pH units higher that the pH at the point of discharge (Table 5.2) indicating that the sewage effluent may be resulting in a slight decrease in pH in the immediate vicinity of the discharge.

TSS levels were some what variable between sampling periods which is not surprising given that sewage strength will vary over the day. Diurial testing of the sewage discharge would be required to determine daily/weekly peaks for this parameter.

The Faecal and Total Coliform tests varied considerably (10 fold) over the tests. Like TSS this is an indication of varied sewer strengths. The fact that the FC levels are high when the BODs is low can not be explained. Logically, these levels should follow somewhat similar trends.

5.3.3 Phytoplankton

The following information regarding phytoplankton communities is summarized from Bain *et. al.* (1977 *cited in* Buchanan and Ragnit 1978).

Common "spring" phytoplankton species reported in the area include *Nitzschia grunowii,* followed to a less extent by *Nitzschia seriata*, and *Thalassiosira nordenstioeldii.* Common "Summer" phytoplankton species include *Chaetoceros socialis*. No differences in phytoplankton populations observed between sites sampled under ice and those sampled in open water, most likely due to the presence of strong southward moving currents in Wellington Channel. Similarity, phytoplankton communities demonstrated no consistent depth preference, again most likely due to physical influences such as tidal action and light intensity.

Phytoplankton communities reported along the Resolute Passage ice-edge sampled in early July exhibited low standing stock and differed considerably in composition from populations in the Wellington Channel.

Particularly noteworthy is a study by Welch and Kalff (1975 *cited in* Buchanan and Ragnit 1978) which presents measurements of marine photosynthesis and respiration in Resolute Bay. The authors reported chlorophyll concentrations in the water ranging from 0.001 - 0.1 mg/m^3 during the winter to 15 mg/m^3 in August. This information could potentially provide an interesting comparison to current conditions within Resolute Bay.

Potential impacts to phytoplankton populations due to the sewage discharge to the bay are expected to be minimal and restricted to the area in the immediate vicinity of the discharge point. Increased loadings of nutrients may result in a localized increase in phytoplankton productivity, however the magnitude of this increase would be determined by overall nutrient loadings, characteristics of the mixing zone, and physical aspects such as tidal and weather (ie. wind, waves, etc.) effects.

5.3.4 Zooplankton

Thirty-five zooplankton species were identified by Bain *et al.* (1977). The community was numerically dominated by copepods such as *Pseudocalanus* spp., but in terms of biomass the community was dominated by the copepods *Calanus glacialis* and *Calanus hyperboreus*. Barnacle nauplii were also extremely abundant in some samples. Unlike phytoplankton, pelagic and under-ice fauna are generally less abundant (Green and Steele 1975 *cited in* Buchanan and Ragnit 1978).

As with phytoplankton, potential impacts to zooplankton populations inhabiting Resolute Bay would most likely be minimal and restricted to the area in the immediate vicinity of the discharge point. Increased phytoplankton productivity due to nutrient loadings could potentially result in an associated increase in zooplankton productivity, but any increases would be expected to be small.

5.3.5 Benthic Invertebrates

Dominant benthic invertebrates reported (Green and Steele 1975 *cited in* Buchanan and Ragnit 1978) in Resolute Bay include:

- clams (*Mya truncata*)
- brittle star (*Ophiura sarsi*)
- starfish (*Lepasterias groenlandicus*)
- mud shrimp (*Sclerocrangon boreas*)
- isopods (*Munnopsis typica*)
- whelk (*Buccinum belcheri*)

Motile invertebrates such as amphipods are often concentrated at the tidal surface and as such provide an important food source to shorebirds and seabirds and fish, particularly Arctic char (Ellis and Wilce 1961).

Benthic invertebrates, including shellfish, within the sewage discharge area could potentially be impacted by contaminant loadings. Unlike phytoplankton and zooplankton which are directly influenced by tides and water currents, benthos form a relatively sedentary population which continually exposed (to varying degrees) to diluted sewage and associated contaminants, and as such, the health of the organisms reflect the quality of the environment they inhabit. Shellfish, such as clams can also bioaccumulate various contaminants such as metals. Shellfish also filter out coliform bacteria from the water column, resulting in a potential health risk to humans if the shellfish are harvested.

5.3.6 Fisheries and Marine Mammals

Available information regarding fish and marine mammal communities is extremely limited for Resolute Bay.

Fish species reported in the area include arctic cod (*Boreogadus saida*), and ninespine stickleback (*Pungitius pungitius*). All fish were found to be actively feeding on amphipods Several species of marine mammals are reported in the Resolute Bay area including Narwhal (*Monodon monoceros*), bowhead (*Balena mysticetus*), and white whales (*Delphinapterus leucas*)

Given the relatively low levels of discharge of sewage to Resolute Bay, fish and marine mammals communities are not likely to be directly impacted. Nutrient enrichment of the bay may in fact result in a localized increase in primary and secondary production (phytoplankton, zooplankton, benthos) which could potentially provide a greater food source for fish.

5.4 Public and Regulatory Agency Consultation

In an effort to further determine the status of a "Position Paper or Brief"(UMA 1996) regarding current sewage treatment and disposal for the Hamlet of Resolute Bay and authored by Fisheries and Oceans Canada and/or Environment Canada, several attempts have been made to contact appropriate staff from both federal agencies. However, no new information has been provided to establish what requirements may or may not be needed to further explore regulatory issues. This being the case, it is still unclear whether or not there are issues and concerns relating to sewage disposal that justify those requirements of the *Act*.

On November 4, 1998 an information session and consultation meeting was held at the Hamlet of Resolute Bay. This session was to provide Hamlet administrators and residents information regarding this study. An introduction to this study was provided to identify the scope of work being completed. The main focus of the meeting was to discuss the current and historical operational practices of sewage outfall and the perceived and potential environmental effects of the discharged wastes to the marine environment.

Consultation with the community consisted of an evening meeting at the Hamlet's community center. The meeting received publication through radio, television and newsprint media one week and again, one day prior to the event to ensure that community members were given adequate notice and the opportunity to attend.

Approximately 20 members of the community, including three Hamlet councilors and the Hamlet's Senior

Administrative Officer (SAO), attended the session. Dillons' staff presented a study overview and described the intended scope of work through the use of overhead slides. One member of the community assisted in the presentation of materials to the community group by providing language translation services for both the presentation of information and follow-up inquiries from local residents. A copy of Dillon's presentation is provided in Appendix 1.

Provided below is a summary of those comments, questions and discussions brought forward by community members at the meeting;

- During certain times of the open water season and when specific wind patterns exist the smell of sewage is very apparent within the Hamlet;

- What were the concerns raised under the NWT Health Act, with respect to the sewage issue?

- What is a cut off population for which the existing type of utilidor facility structure is not appropriate?

- How far out into the bay does effluent travel beyond the immediate discharge point?

- During the open water season the beach or shoreline area, in the vicinity of the sewage outfall, is used as an access point for boating;

- The current discharge location is not considered appropriate, as it is limiting the community development, small boat access, and there are olfactory problems during the summer period;

- Successful hunters will bring their animals (primarily seals) to the beach area where they are partially butchered;

- Some hunting does occur in Resolute Bay. Baffin Health Board was to have conducted a study to determine any impact from the sewage outfall. Therefore the people of Resolute Bay submitted some food samples (seals, whales that were captured from all over, including the Bay) to DFO, but no results are available so far. Some seal liver and fat studies were also to have been conducted;

- Due to DFO's long-time presence in Resolute, they should be able to provide some information and documents to Dillon with respect to sewage issues;

- Resolute Bay is not a heavily fished area, due to the lack of fish. Shellfish and clams are not typically collected from the Bay area, but it was suggested that they be studied as these food items are considered as a delicacy by the local people;

- Schools of cod are noted to inhabit the bay area in the vicinity of the outfall, especially when forced close to the shore as a result of feeding whales in the area;

- The bay area is not specifically used by the community for fishing and the cod that are forced into the near shore area are not typically fished;

- Raw sewage is visible along the shoreline area in close proximity to the outfall location;

- No particular care is taken with respect to the substances being flushed. It is unknown (to the people of Resolute) whether DPW has any problems with their cleaning facility;

- There were several questions raised with respect to the acceptability of the current system (only grinding, no treatment) and constant flow towards the Bay. The community suggested that they would like an upgrade to a cleaning process to be done (e.g., filters at the very least) or any other appropriate improvement;

- Although significant concerns regarding the discharge of sewage at this location were not voiced, the potential impacts of the discharged sewage to the marine environment were identified as not being well known to the community;

- Should there be the potential for impact to the marine environment at this location it was noted that further study should be conducted to confirm it's significance and to identify/incorporate potential changes to the current sewage treatment system that would minimize those impacts and any community concern;

- One alternative identified was the relocation of the piped outfall location from its' existing location to a location south along the shoreline away from shoreline areas of use;

- Deep water discharge (e.g., 10-20 m off shore) would also be an acceptable alternative, from the prospective of the boat access, quick freezing which typically happens in the winter (which would be avoided if the discharge would be somewhere further from the shore), and to establish a deeper water discharge location and the enhancement of potential mixing;

- Discussion included the identification of requirements of the federal *Fisheries Act* and how it might apply to the current sewage treatment system and discharge at Resolute Bay;

- Compliance requirements of the Nunuvat Water Board and the associated water licence were also discussed resulting in the identification of current and historical licence compliance with the required discharge requirements.

In summary, no significant issues were raised by the community with regard to the discharge of sewage to the marine environment. However, they acknowledged that they were not totally familiar with what maybe the potential impacts. Certain activities that involve the processing of hunted seals and other mammals are conducted within the Bay and near shore areas the sewage smells and wastes are obvious to the residents at certain times. Certain food items, such as clams, are opportunistically harvested from the outfall area. Based on these issues it was noted that further consideration of these potential impacts should be reviewed.

5.5 Conclusions and Recommendations

The limited water quality data collected from the sewage discharge to Resolute Bay, and a sampling location 5-10 metres down current from the discharge location, tends to indicate that there is localized impacts to the marine receiving environment. The extent or magnitude of these impacts cannot be determined in detail based on the extremely limited data collected to date for water quality and for the biota inhabiting the marine receiving environment.

The Hamlet of Resolute Bay currently meets the discharge requirements of their water licence issued by the Nunavut Water Board. It is also apparent from the results that the strengths of the sewage could be increased two or three times and still meet compliance. This may occur in the bleeding rate is decreased over time.

Regardless of the bleeder rate, the total mass loadings of the contaminant to the receiving environment will remain consistent. The long term environmental and human impacts are more related to the mass loading, rather than the concentration of the discharge. There are impacts related to "shocks" to the marine system created by sudden increases in the contaminants of concern. This would be related to at shore organisms, only. As such, a reduction in the bleeding rate by 1 or 2 fold is not expected to impact the effects of the sewage and the receiving environment. To determine the long term impact of the sewage mass loadings, there is the requirement to collect and assess data at the marine environment. A summary is shown in **Table 5.2**.

Table 5.2
Summary of Information Required for Detailed Impact Assessment

Information/Data Required	Rationale
Physical	
- tidal information, wind speeds, wind directions, wave climate, etc.	- this information will help determine the magnitude and extent of any plume, etc. - also help address any dilution issues - much of this information should be readily available from Environment Canada
Chemical (i.e. water and sediment quality)	
- more detailed characterization of effluent and receiving environment water quality.	- current annual sampling results do not provide the necessary detail to assess diurnal variation in effluent characteristics - the current program also does not assist in the determination of the spatial extent of any effluent plume - this information would be used to determine average effluent concentrations
- include a control location in any sampling program perhaps in an adjacent bay	- control site data will provide a good comparison to sewage discharge results
- evaluation of dissolved oxygen levels within Resolute Bay	- given concerns with respect to oxygen depletion in the bay it would be worthwhile to determine oxygen levels in the bay particularly under the ice-cover.
- characterize sediment quality with the receiving environment	- determine distribution of any contaminants within the marine sediments - sampling program would be designed to delineate impacts from the sewage discharge and those potentially from the solid waste disposal site.
Biological	
Shellfish, such as clams (*Mya truncata)* should be sampled to assess potential shellfish contamination	- elevated coliform levels observed in the vicinity of the discharge could potentially result in shellfish contamination - clams are also excellent biomonitors for other contaminants such as metals.
Benthic-invertebrate communities	- benthic invertebrates provide excellent indicators of overall environmental quality - benthos information can be related back to water and sediment quality data to assess impacts

6.0 REMEDIAL SYSTEM NEEDS

6.1 Upgrade Requirements

The water and sewage system in Resolute Bay has previously been assessed by UMA, and the findings of that assessment are in the 1996 report. Several of the recommendations from the UMA report have been completed, while others are outstanding. For the purpose of providing an overall picture of the current upgrading requirements, the outstanding issues from the UMA report are brought forward. The following sections describe the system upgrade requirements, the alternatives to the upgrades and the recommendations for the upgrades.

Char Lake Pump House

Building Envelope is Poor

The vapour seal on the building and insulation value of the building need to be upgraded to improve the overall building envelope performance. There are two approaches to this upgrade;

- Add insulation, air barrier and cladding to the outside of the building. This will require an structural assessment of the building frame to determine if the rigid frame of the building meets the structural requirements for the additional load.

- Add insulation to the inside of the building using spray foam.

Typically the external construction is the less expensive approach. As this would require an assessment of the structure, which is beyond the current scope of work. The use of the internal spray foam will be used for costing purposes. The cost to complete this work typically runs at $150/m^2$ of building wall and roof space. The Char Lake Pump house is approximately 9.7 m x 7.9 m (32' x 26'). The estimated cost to complete the insulation work is $35,000 to $40,000.

Wet Well

A safety harness and retrieval device is required in the wet well. Safety harnesses cost approximately $200 per harness. A safety lifting device is approximately $5,000.

Lighting Levels

The lighting in the pump house is insufficient for a work space. The wet well also needs a light. Currently a trouble light is used in this space to allow the operator access to the wet well. The lighting levels can be increased for an estimated $5,000.

First Aid Kit

A first aid kit needs to be installed in the pump house. These kits typically cost $100 to $200.

WTP Pump House

Building Envelope is Poor

The vapour seal on the building and insulation value of the building need to be upgraded to improve the overall building envelope performance. There are two approaches to this upgrade;

- Add insulation, air barrier and cladding to the outside of the building. This will require an structural assessment of the building frame to determine if the rigid frame of the building meets the structural requirements for the additional load.

- Add insulation to the inside of the building using spray foam.

Typically the external construction is the less expensive approach. This would require an assessment of the structure, which is beyond the current scope of work. The use of the internal spray foam will be used for costing purposes. The cost to complete this work typically runs at $150/m^2 of building wall and roof space. The WTP Pump House is approximately 25 m x 15 m (80' x 50'). The estimated cost to complete the insulation work is $105,000 to $120,000.

First Aid Kit

A first aid kit needs to be installed in the pump house. These kits typically cost $100 to $200.

Access Vaults

Confined Entry

The access vaults are considered a confined entry location and may contain hazardous gas. A safety harness and retrieval device is required, as well as a gas monitor. The operators require training in the proper use of this equipment. Safety harnesses cost approximately $200 per harness. A safety lifting device is approximately $5,000. The gas monitoring equipment is approximately $2,000. The training can be received from Workmens' Compensation Board, usually at no cost to the owner.

Open Sewer Clean Outs

The sewer clean outs are opened to allow the infiltration water to exit the AV. The use of sump pumps in the AV has been attempted, but failed due to corrosion of the electronic components.

A) One method of sealing the existing AV is through modifications to the AV structure and piping. The piping has been installed with the pipe insulation passing through the concrete wall of the AV. Developing a water tight seal between the concrete and the pipe insulation jacket is not possible at this penetration. The pipe insulation through the wall would need to be removed and a “puddle flange” fused to the pipe. The puddle flange would then be cast into the concrete wall of the AV. Additional insulation would be install on the outside of the AV at the new pipe penetration to provide freeze protection to the pipe.

B) Additional water sealing can be placed on the outer surface of the AV to prevent water penetrating the AV through cracks in the concrete and pipe penetrations. Although the AV structures inspected are all in good condition, there are always small fissures and cracks in concrete that will allow penetration of water. A water tight seal can be added to the outside of the AV using a mastic sealant. This sealant would encompass the AV and seal to the insulation jacket of the piping. Any cracks or fissures in the pipe insulation will be a point of future infiltration. The floor of the AV can not be sealed through this approach.

C) The original design used a sump pump to remove any infiltration water from the AV and pump it into a 25 mm nipple attached to the sewer pipe. The electrical supply, sump pump, AV heaters, and all controllers located in the AV corroded and became unusable. The design drawings and specifications indicate that the electrical components were to be water tight. A similar system could be reinstalled using updated equipment that may provide better long term service than the original system. The new system would require:

- Electrical service to each AV
- A panel board and metre in each AV
- A sump pump and controller in each AV

D) The installation of a new water tight AV. These are produced from either HDPE or steel and are now the more typical standard than the concrete AV for utilidors. All piping would need to be disconnected and re-instated in the new AV with water tight penetrations. Table 6.1.1 shows an assessment of the above options.

Table 6.1.1
Assessment of AV Sealing Options

Option	A - Seal Penetrations	B - Seal AV from Outside	C - Install Sump Pump	D - Install New AV
Long Term Reliability	Poor - there will still be some infiltration, and the operators will, likely leave the sewer clean outs open to remove the water in the AV	Poor - there will still be some infiltration, and the operators will, likely leave the sewer clean outs open to remove the water in the AV	Good - The sump pump will require replacement every 5 years. The system should operate for 20 years.	Excellent - New AV construction can provide long term water tight seals.
Ease Of Construction	Difficult - Will require the existing AV to be excavated to the foundation. The system will need to be shut down a number of time to complete the work. Work can only be completed in the summer.	Difficult - Will require the existing AV to be excavated to the foundation. Work can only be completed in the summer.	Easy - All work can be completed within the AV. No disruption of services. Work can be completed through out the year, though would be easier in the summer months.	Difficult - Will require the existing AV to be excavated to the foundation. Work can only be completed in the summer.
Risk of Failure	High - There will still be some infiltration. The amount will be dependant on the rigour of care taken during the remedial work.	High - There will still be some infiltration. The amount will be dependant on the rigour of care taken during the remedial work.	Medium - the original system failed after ten years of operation. There is a risk that the new system could experience the same corrosion problems.	Low - There has been good success with the newer AV construction in other communities (Iqaluit, Rankin Inlet)
Estimated Construction Cost	$20,000 per AV	$12, 000 per AV	$8,000 per AV	$50,000 per AV

Cross over through Bleeders

There is a requirement to install check valves on all the bleeders. This is a fairly simple operation, and could be completed during routine maintenance on the system. The cost for the check valves is $200 per valve. The installation would be approximately 1 to 2 hours per AV bleeder.

Water Mains

Future Capacity

The system was designed for a population of 1,500 people and a consumption of 225 lcd. The total daily average consumption for the original design was approximately 340,000 l/day. The projected 20 year demand based on the current growth rate and bleeder rate is approximately 200,000 l/day. Section 4 developed and completed a model for the distribution system to verify that there is sufficient capacity for the peak demand and the fire flow requirements. The model indicates that the fire flow demand is met by operating a valve in AV3 during the fire flow conditions. This should be verified as part of the standard operating procedures for the facility Maintainer.

One section of sewer main AV11 to AV32 is required to be increased to 250 mm to meet the design flows.

The flow requirements for the proposed new subdivision can be met through the expansion of the existing system. The new areas can be serviced with a 150 mm pipe line for the Water mains and the sewer mains.

The model was also run using 150 mm piping throughout the system. This run indicates that the 150 mm size will not meet the 20 year demand of the community. Therefore all replacement piping should maintain the 200 mm pipe size for the water main.

It should be noted that a significant amount of the system capacity is consumed through the use of the bleeders. These bleeders are not metered for flows. It would be useful to have actual measurements of the bleeder flows, bleed water temperature, as well as sewer pipe temperatures throughout the system. These measurements can be used to assess the required bleeder rates with the indent to reduce the overall bleed water consumption. As the community expands, this will become necessary to allow for the expansion of the system beyond the 20 year horizon to the 40 year planning horizon. The metres can be mechanical type metres, identical to house water metres. They should be read on a weekly bases and recorded by the Hamlet, and/or the system Maintainer. The cost to install the metres would be approximately $2,000 per unit.

The measurement of the sewer temperatures should be completed for each leg of the sewer system. This will allow for the balancing of the bleed water. The sewer flow temperature should be measured weekly and recorded by the Hamlet and/or DPW&S Maintainer. The temperature metres can be installed for approximately $1,000 per unit.

Once a year of data is collected, the information can be used to determine the required flows on a seasonal bases for the bleeder system. This will need to be fine tuned through the continued recording of the bleeder flow metres and the sewer temperature readings.

Increase in Break Frequency

The upgrading alternatives described in this section assume that the piped system will be maintained. Other alternatives to the piped system were investigated in the 1996 UMA report and are not repeated herein. Based on the number of breaks in the system in the past five years, there is a need to complete an upgrade of the piping system. Six scenarios were reviewed for this upgrade these are shown in Table 6.1.2.

Table 6.1.2

Cost Estimates for Pipeline Replacements

Scenario		Description	Estimated Cost
1	Total Water and Sewer Replacement	Remove all existing pipelines, AV, and ancillary equipment and replace with new system. Pipes replaced at same depth as current system.	$6,200,000
2	Partial replacement of Water and Sewer Lines	Replace the water and sewer lines in the Stage 1a area in the sections that there have been previous breaks. Replacement will include the AV in these sections. Pipes replaced at same depth as current system.	$1,380,000
3	Replacement of Water mains in areas of previous breaks.	Replace the water mains only in the areas of previous breaks. The water mains will be installed in new AV and installed with a minium of cover (1.0 m).	$1,100,000
4	Replace the sewer mains where there is poor flow.	Replace the sewer mains in the sections of the lines where poor flow has been noted in the past.	$310,000
5	AV 20 to AV 22 Replacement.	Replace the section of the utilidor that has been abandoned.	$275,000
6	Break Repairs.	Remove the existing repair clamps and install sections of butt fused pipes complete with insulation and heat shrink jacket.	$150,000

The cost estimates shown above include a 20% contingency and a 15% engineering factor. The detailed section by section estimate is shown in Appendix B. The cost of scenario 5 is included in the cost of scenario 1.

Table 6.1.3 shows a summary of the possible upgrades for the system.

Table 6.1.3
Summary of Remedial Work

Component	Deficiency	Remedial Action	Estimated Costs
Char Lake Pump House	Building envelope is poor.	Install insulation, vapour barrier, and cladding.	$ 40,000
	Wet well does not have confined entry provisions.	Provide safety harness and retrieval device.	6,000
	Light levels are insufficient.	Install new lighting bank.	5,000
	Requires First Aid kit.	Install First Aid kit.	200
WTP Pump House	Building envelope is poor.	Install insulation, vapour barrier, and cladding.	120,000
	Requires First Aid kit.	Install First Aid kit.	200
Access Vaults	Requires confined entry provisions.	Provide safety harness and retrieval device. Provide safety gas monitoring meter and operator training.	7,000
	Concern with open sewer clean outs needs to be addressed.	Install sump pumps.	80,000
	Concern with cross over of sewer through bleeders to watermain.	Install check valves.	20,000
Water Mains	System needs to be assessed for circulation and future capacity.	Assessment requires sewer AV11 to AV32 to be replaced Install monitoring devices.	195,000 20,000
	Increasing break frequency is a concern of the Hamlet.	Replace mains with poor performance.	1,100,000
Sewer Mains	Areas of poor flow are a concern of the operators and require frequent maintenance and increased bleed water.	Replace existing sewers in poor flow sections.	310,000
Water & Sewer Mains	Abandoned lines in Block 1.	Replace mains.	275,000
Sewage Discharge	Expressed public concern over discharge location.	Assess impact on clams and other traditional harvest foods.	40,000

- 31 total AV in system. 14 AV's replaced as part of sewer and water line up grades, 6 AV's have only water or sewer (not both).

6.2 Prioritization

The previous section developed some $2,300,000 in upgrades that could be completed to the water and sewer system. Not all of these upgrades carry the same importance nor are all necessary in the near future unless conditions change. Some require immediate attention, others may not be completed for several years, while others can be omitted without adversely effecting the system. To prioritize the upgrading requirement, a set of criteria is required. The set has been developed for this system.

Priority	Description	Comments
1	Risk to Human Health Concerns	The maintenance for good health is a fundamental importance for the delivery of water and sewer services. These should be completed as soon as possible in the program.
2	Minimize risk of failure to the system	Work that can be under taken to reduce the potential future risk of the system is of high priority. These should be completed early in the program.
3	Reduce future emergency repair costs.	This is the basis for sound economic management of a system. A dollar spent on maintenance can save several dollars spend on emergency or more costly repairs. Should be scheduled in 1 to 5 year of program.
4	Reduce operating costs	The infusion of capital funds can make a system more efficient, and therefore reduce the future O&M costs. To be implemented at the discretion of the owner.

It is also recognized that the GNWT has a limit to the available capital to be spent on this system in any given year. For the purposes of this assessment it is assumed that budget of $1,000,000 is available. Based on the above prioritization criteria Table 6.2.1 illustrate the capital plan to upgrade the existing sewer and water system.

Table 6.2.1
Capital Plan

	Component	Remedial Action	Priority	Estimated Cost
1	Sewage Discharge	Complete Assessment on traditional foods	1	$40,000
2	Char Lake Pump house	Provide Safety Harness and Retrieval Devices *	1	$6,000
3		Provide First Aid Kits *	1	$200
4	WTP Pump House	Provide First Aid Kits *	1	$200
5	Access Vaults	Provide Safety Harness and Retrieval Devices *	1	$6,000
6		Install Check Valves and Flowmeters on Bleeders	1	$20,000
7		Sewer Cross over in AV due to open Sewer clean outs	1	$80,000
8	Water mains	Replace Sections with history of increased breaks AV 21 to 30 m Past AV 30, and AV 8 to AV 10	2	$320,000
9		Replace Sections that are likely to experience Problems in next few years based on break history.	3	$530,000
		Total Year 1		**$1,000,000**

* These items are being addressed by operations.

The division between the mains replaced in this year of the program and the potential for future work is some what arbitrary in some areas (ie. Item 9). There would be benefit in completing a camera inspection of the sewer mains. The inspection can be used to identify the more critical sections to be replaced. The inspection cost would be in the order of $15,000. Detailed cost estimates for each years work can be developed once the specific links to be replaced are determined from the camera inspection.

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APPENDIX A

Pipe Network Model Results

APPENDIX B

Cost Estimate Data

APPENDIX C

Impact Study -
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Final Report
February 17, 1999

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Resolute Bay, NT

Hamlet of Resolute Bay,
Northwest Territories

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Submitted by

Dillon Consulting Limited

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