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. Dillon was retained 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. Three reports were produced, namely;

Volume 1 - Utilidor Upgrade
Volume 2 - Water System Building Assessment

Volume 3 - Sewage treatment and Future System Expansion

Figure 1.1 Water Supply and Sewage Disposal System

1.2 Scope of work

The scope of work for this volume relates to the utilidor system. A summary of the scope of work is described below:

- Complete a review of the existing documentation.

- Complete a site investigation to update the previous work.

- Debrief the system operator on his concerns, and review the system operator's records of the system.

- Develop a list of required upgrades to be completed to have the system meet the Hamlet's system needs for the next 20 years and complete cost estimates for these upgrades.

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. Alexander, 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 utilidor 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.	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.
2.	Concern with a potential sewer crossover into the watermain through the AV bleeders.	No action taken.
3.	Valves in AV 2 are leaking.	These were reported incorrectly, and are actually in AV 3. These valves were replaced in 1998.
4.	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) 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.
5.	Improve the circulation in the mains.	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

Component	Material	Approx Quantity
	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

From	To	Distance	Comments
		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
AV20	AV22		Frozen due to no flow condition and is reported to be a result of the pit orifice system.

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 AV is pumped dry, the clean out is closed and sealed and the area disinfected prior to the start of any maintenance on the water main system.

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
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 for future capacity. **
Sewermains	Areas of poor flow are a concern of the operators and require frequent maintenance and increased bleed water.

* IT's understood that DPW&S had addressed this issue at the time of the final report. This issue will not be carried forth.

** Volume 3 address this issue.

4.0 REMEDIAL SYSTEM NEEDS

4.1 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 utilidor system upgrade requirements, the alternatives to the upgrades and the recommendations for the upgrades.

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 4.1.1 shows an assessment of the above options.

E) Adhearance to an O&M process that will minimize risk of contamination of the water supply. This would include dewatering the AV, sealing the sewers prior to repair, and disinfecting the work area with a bleach solution.

Table 4.1.1
Assessment of AV Sealing Options

Option	A - Seal Penetrations	B - Seal AV from Outside	C - Install Sump Pump	D - Install New AV	E - O&M Procedures
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.	Good - there remains a 5 light opportunity for contamination in extreme circumstances.
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.	No construction required. Requires supply to pump and portable generator.
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)	Low - There has been no replacement problems to date.
Estimated Construction Cost	$20,000 per AV	$12, 000 per AV	$8,000 per AV	$50,000 per AV	$5,000 Total
Life Cycle Cost	$20,000 per AV	$12,000 per AV	$20,000 per AV	50,000 per AV	

Options A and B are eliminated due to the poor long term reliability of the repairs. Option C has high O&M costs related to pump replacement every 2 years, plus power demands. Option D has high capital cost. Option E has provided good service for 20 some years, has the lowest capital and life cycle costs, and is recommended for a continued use.

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

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 4.1.2.

Table 4.1.2
Cost Estimates for Pipeline Replacements

Scenario		Description	Estimated Cost
1	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. This includes AV 4 to AV 5, AV 5 to AV 6, Av6 to AV 7, AV7 to AV8, AV8 to AV9, AV9 to AV10, AV10 to AV11, AV21 TO AV30, AV 30 to AV29, AV29 to AV6.	$1,380,000

Scenario		Description	Estimated Cost
2	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). This includes AV21 to AV30, AV2 to AV3, AV4 toAV5, AV9 to AV10, AV10 to AV11, AV5 to AV6, AV30 to AV29.	$1,100,000
3	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. This includes, AV14 to AV13, AV25 to AV23, AV12 to AV11, AV19 to AV21.	$310,000
4	AV 20 to AV 22 Replacement.	Replace the section of the utilidor that has been abandoned. Use recirculation pump.	$275,000
5	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.

Table 4.1.3 shows a summary of the possible upgrades for the system.

Table 4.1.3
Summary of Remedial Work

Component	Deficiency	Remedial Action	Estimated Costs
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.	Provide pump and portable generator	5,000
	Concern with cross over of sewer through bleeders to watermain.	Install check valves.	20,000
Water Mains	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
TOTAL	**Remedial Work**		**1,717,000**

- 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).

4.2 Prioritization

The previous section developed some $1,717,000 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 4.2.1 illustrate the capital plan to upgrade the existing sewer and water system.

Table 4.2.1
Capital Plan - Year 1

	Component	Remedial Action	Priority	Estimated Cost
1	Access Vaults	Install Check Valves and Flowmeters on Bleeders	1	$20,000
2		Sewer Cross over in AV due to open Sewer clean outs	1	$5,000
3	Water mains	Replace Sections with history of increased breaks AV 21 to AV30, AV30 to AV29, AV 8 to AV9 and AV9 to AV10.	2	$700,000
4		Replace AV20 to AV22.	3	$275,000
		Total		**$1,000,000**

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APPENDIX A

Cost Estimate Data

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