Town of Inuvik
Unit Cost of Water, 2006

Prepared for:

Town of Inuvik
Box 1160, 2 Firth St.
Inuvik, NT X0E 0T0

Prepared by:

Earth Tech (Canada) Inc.
17203 103 Ave.
Edmonton, AB T5S 1J4
Phone: 780 488 6800
Fax: 780 488 2121

February 2008

Project No. 49195

Over 100 years of Engineering in Canada

EarthTech

A tyco International Ltd. Company

17203-103 Avenue
Edmonton, Alberta
T5S 1J4 Canada

P 780.488.6800
F 780.488.2121
earthtech.com

February 21, 2008

Refer to File: 49756-all-04b

L:\PROJECTS\wat\49195\0Utility\06UtilO&M\06$$O&M\2006ff\03Report2006\2Letter_finl.doc

Town of Inuvik
P.O. Box 1160
Inuvik, N.W.T. X0E 0T0

Attention: Mr. Rick Campbell, Director of Public Services

Dear Sir:

Re: Unit Cost of Water, 2006

We are pleased to provide five final copies of our report entitled Town of Inuvik, Unit Cost of Water, 2006.

As you know, Inuvik has been using the five copies of this report provided for review and comment 17 June 2007 for various purposes including setting of water rates, and it appears that no comments have been generated. Accordingly, no changes have been made since the draft was issued.

As noted in the letter covering the draft submission, it needs to be decided whether or not to include "non-cash" items such as lease cost equivalents in operating cost totals, and in the unit cost of water. As well, the question remains as to how Inuvik will fund ongoing infrastructure renewal needs.

Again, we acknowledge with thanks the contributions of various members of Inuvik's staff to this report. Essentially all of the operating cost data used was compiled and sorted by members of Inuvik's accounting and public services staff. It has been a pleasure working with all of you on this report.

Very truly yours,

EARTH TECH (CANADA) INC.
Per:

Richard E. K. Feilden, P.Eng.

REKF:vad
Encl.

cc:

June 17, 2007 Refer to File: 49195-all-04b

L:\PROJECTS\wat\49195\0Utility\06UtilO&M\06$$O&M\2006ff\03Report2006\2Letter.doc

Town of Inuvik
P.O. Box 1160
Inuvik, N.W.T.
X0E 0T0

Attention: Mr. Ken Crocker, A/S.A.O.

Dear Sir:

Re: Unit Cost of Water, 2006

We are pleased to provide five draft copies of our report entitled Town of Inuvik, Unit Cost of Water, 2006, for review.

A policy decision is needed as to whether to include the "non-cash" item of lease cost equivalents for office, shop and yard facilities in the total cost of water and sewer utility operations, and in the unit cost of water.

As well, discussion is needed as to how Inuvik may be able to deal with the ongoing capital costs of renewal of the utilidor system, and the potentially looming capital cost of a new and upgraded water supply and treatment system.

Various members of the Town's staff have contributed substantially to this report. It has been a pleasure to work with everyone involved in its development.

We look forward with pleasure and interest to further discussion.

Very truly yours,

EARTH TECH (CANADA) INC.
Per:

Richard E. K. Feilden, P.Eng.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 OBJECTIVE

In 1999 the Town of Inuvik reached an understanding with the Government of the Northwest Territories (GNWT) whereby GNWT would transfer to Inuvik all of the Town's water and sewage infrastructure. Since June 2000 Inuvik has acted as the systems' owner and operator.[1]

The design of Arctic utilities systems is driven by such factors as extended cold winters and thaw-sensitive permafrost ground. Compared to southern systems, Inuvik's are costly to build and complex to operate. Also, for various reasons, including aboveground exposure, they are likely to have shorter service lives.

The current aggregate replacement value of Inuvik's water and sewage infrastructure is well in excess of $100 million. Daily operation and maintenance of those systems, and their long-term stewardship, are significant responsibilities.

The objective of this study is to summarize the operating, maintenance and ownership costs of Inuvik's water and sewage infrastructure, using data available from the Town's cost accounting system and estimates where data do not exist. Inuvik needs to know its systems' costs in reasonable detail for various purposes, including rate setting, capital planning and system management.

1.2 HISTORY AND CONTEXT

Piped utilities systems in an arctic, thaw-sensitive permafrost setting such as Inuvik's are uniquely expensive to operate, maintain and renew. Fearing those costs, Inuvik declined ownership of the water and sewage infrastructure serving the townsite when it incorporated, in 1970. Transfer of that responsibility remained a subject of ongoing negotiation between GNWT and Inuvik for many years.

Pursuant to that discussion, Inuvik's water and sewage infrastructure and costs were the subject of a fairly detailed investigation in the mid-1980's, recorded in a two-volume report referred to as the "Handover Assessment" (HOA) studies.[2] HOA Volume I dealt with physical condition and capacity. Volume II dealt with water and sewage system costs and economics.

The original HOA studies were in time overtaken by incremental changes in the systems themselves and by economic inflation. In 1997 the "Economics" study was updated.[3]

Matters have again moved on. In 1998-99 Inuvik's high temperature water (HTW) heat distribution system was phased out, requiring extensive changes to utilidor insulation and active freeze protection systems. In the years since 1997 there have been a number of

---

[1] Transfer has not been completed, pending GNWT's consolidation of utilidor lands.

[2] Inuvik Utilities Handover Assessment. Reid Crowther and Partners Ltd (RCPL). Vol. I, Condition and Capacity, 1986. Vol. II, Economics, 1987 and (with minor updates) 1988.

[3] Inuvik Utilities Handover Assessment. Reid Crowther and Partners Ltd (RCPL). Vol. II, Economics, Second Edition, 1998.

renewal and expansion projects. Market prices are now quite different from what they were then. Further, GNWT has greatly changed its approach to sharing capital costs of water and sewage infrastructure between itself and tax-based municipalities, resulting in a much higher level of responsibility for such cost being borne by municipalities.

In 1987 it was GNWT's policy to fund 100 percent of the capital cost of "trunk" water and sewage infrastructure.[4] The findings of the 1987-88 HOA study were that Inuvik's annual operations and maintenance cost for water and sewage utilities would be $1.04 M, and that Inuvik's average annual capital replacement cost (to cover just non-trunk facilities) would be $1.58 M; for a total annual cost of $2.62 M (all $1987).

A decade later it had become GNWT's policy to fund 80 percent of the capital cost of "trunk" water and sewage infrastructure. The findings of the 1997-98 HOA study update were that the annual O&M cost would be $1.34 M (as compared to $1.04M in 1988), and that the Town's average annual capital replacement cost (to cover non-trunk facilities and 20% of trunk ones) would be $0.81 M (as compared to $1.58M in 1988), for a total annual cost of $2.15 M (all $1998). Regarding the apparent reduction in capital costs, the 1998 report noted that the new estimates were based on assumed useful service lives that were, in Inuvik's environment, "ambitious and optimistic".

Under current (2007) policy, the GNWT grants tax-based municipalities such as Inuvik an annual amount, referred to as "block funding", which is a formula-based share of such monies as are available to GNWT to distribute to municipalities. Municipalities are responsible for all costs of owning, operating and maintaining water and sewage infrastructure that is over and above the contribution made by GNWT.

The systems under discussion are extensive, representing perhaps $120 to $130 million accumulated investment at current replacement cost. Inuvik has a summer water supply and treatment system drawing from Lake B and Hidden Lake, a winter one using East Channel, and a 2300 m^3 (500,000 Ig) reservoir on Hidden Lake Hill. There are about 15 km of water distribution and sewage collection utilidors, and an additional 3.2 km of trunk water and sewer mains, plus the 5 km long Lake B pipeline. Utilidor system appurtenances include a number of valve houses ("vaults" or "junctions"); a number of water circulation and heating stations, a water temperature monitoring system, and a large number of road crossings ranging in complexity from small diameter culvert ducts to complete concrete bridges. Sewage is treated in a 3-cell lagoon before being discharged to East Channel, below the townsite.

1.3 SCOPE

As convenient shorthand, the Inuvik's water and sewage infrastructure is referred to in this report as the "Utility". The Utility encompasses the water supply, treatment and storage facilities Hidden Lake and at East Channel; the Lake B pumphouse and pipeline; the trunk water utilidors from Hidden Lake to the townsite and the trunk sewage lines from the townsite to the lagoon; the entire utilidor system within the townsite; ancillary systems such as circulation and heating stations and the water temperature monitoring system, and the structures and foundations of utilidors and vaults; trunk sewage mains

[4] "Trunk" facilities are ones serving the entire town, or large districts, such as water supply and treatment works, water storage reservoirs, water and sewage transmission mains, district water pumping, re-heating and circulation stations, district sewage lift stations, and sewage treatment and discharge facilities.

running to the lagoon; the sewage lagoon system; and Utility lands and easements. The Utility also encompasses operations, maintenance administrative and management staff, shop building and headquarters space within the Town Hall, vehicles, tools and equipment. Excluded are the residual heat recovery and supply systems in NWTPC's powerhouses and yard. Also excluded concrete are bridge and steel arch road crossing structures, as those generally are considered to be part of the roads system.

Utility costs arise from various sources, including:

1. Direct Operations Costs, which include:
   - Purchase of chemicals used in water and sewage treatment.
   - Purchase of electricity used by pumps and many other types of equipment, and in buildings.
   - Purchase of fuel to warm (“temper”) water for utilidor freeze protection, and to heat utility system buildings. Fuel includes residual heat as well as gas and oil.
   - Communications costs, such as telephone line rental.

For calculation of direct operations costs, utility system buildings include water treatment plants, pump stations and large utilidor vaults. The utilidor shop, and “head office” space in the Town Hall building are considered separately.

Salaries, wages and benefit costs of personnel engaged in operations work are also considered separately; and likewise such costs as use of vehicles for operations work.

2. Direct Maintenance Costs, which include:
   - Purchase of spare parts, supplies and small tools consumed in the course of maintaining facilities.
   - Contracts for repair projects too large to be undertaken by staff, or requiring highly specialized equipment or skills.
   - Snowclearing, to maintain access to facilities.

Staff, vehicle and similar costs attributable to maintenance activities are considered separately. So are contracts for capital replacement of ongoing facilities.

3. Staff Costs, which include:
   - Salaries, wages and benefits paid to full time and part time (summer) staff assigned full time to Utility operations and maintenance.
   - Pro-rated portion of salaries, wages and benefits paid to Town office staff having Utility-related managerial and administrative duties.

4. Office and Shop Costs, which include:
   - Building and yard lease equivalent cost.
   - Office and shop operations and maintenance costs: spares, hardware and other supplies, small tools, and many other things.
   - Insurance, of various types.

- Vehicle ownership and operating costs.
- Office costs, including
- Water licence costs; engineering costs.
- Miscellaneous office costs.

5. Capital Replacement Costs, which include the capital costs of replacing of aging or obsolete facilities.

1.4 ACKNOWLEDGEMENT

The analysis of Utility operations and maintenance costs presented in Chapters 3 through 6 are based on data from Inuvik's cost accounting systems. Costs have been ferreted out and compiled by various members of Inuvik's staff, including Ken Crocker, Director of Finance, Rick Campbell, Director of Public Works, Bryce O'Connor, assistant to the Director of Public Works, Greg Stromgren, in charge of Utility system operations and maintenance, and others. Earth Tech acknowledges and thanks all members of Inuvik's staff who have worked with us on this report, and notes that the report could not have been done without those contributions.

1.5 REPORT OUTLINE

Like its forerunners, the 2007 edition of Volume II begins with a brief overview of current facilities. Analyses of Utility costs are then presented, in order listed above.

2.0 UTILITY OVERVIEW

2.1 INTRODUCTION

The current extent and layout of the Utility is shown in Figure 1.

Its main components include:

- Water Supply Facilities:
  - East Channel portable intake
  - East Channel water treatment plant (ECWTP)
  - Lake B intake pumphouse and pipeline
  - Hidden Lake raw water pumphouse
  - Hidden Lake water treatment plant (HLWTP).
- Treated Water Pumping, Transmission and Storage Facilities:
  - Distribution pumps, East Channel
  - Transfer pump, Hidden Lake WTP
  - Hidden Lake reservoir
  - Trunk water utilidors from Hidden Lake.
- The "Utilidor System":
  - Water distribution pipe network
  - Water circulation stations
  - Water re-tempering and circulation stations
  - Water pressure booster stations
  - Truck fill station
  - Sewage collection piping
  - Utilidor structure, pipe support systems, vaults and valve houses.
- Utilidor Appurtenances and Subsystems:
  - Water temperature monitoring system
  - Road crossing bridges and arch structures.[1]
- Sewage Treatment Facilities;
  - Multi-cell lagoon and outlet.

---

[1] In times past, for purposes of calculating funding eligibility, GNWT classified all types of bridges over utilidors as belonging to the roads system, not the water and sewer Utility. In this report, the same classification has been continued.

Brief introductory descriptions of facilities are included below. The chapter ends with overview data on Inuvik's water consumption and sewage generation rates.

2.2 WATER SUPPLY FACILITIES

2.2.1 Seasonal Water Sources

In winter Inuvik draws water from East Channel. Through the ice-covered period, the river water is clear, requiring only filtration, disinfection and “tempering” (warming, to prevent freezing in the distribution system).

Through the ice-free period, Mackenzie River waters are too turbid (silty) to be treated by filtration alone. Accordingly, in summer Inuvik draws water from Hidden Lake. Hidden Lake is not, however, a water source: it has only a very small watershed and virtually all of the water taken out must be replaced. At intervals through the summer Hidden is refilled from Lake B ("Three Mile Lake"), by means of a 5 km pipeline. Inuvik’s summertime water source is Lake B, with Hidden Lake acting as a raw water reservoir.

The East Channel, Lake B and Hidden Lake water supply facilities are described briefly below. Locations of facilities are shown in Figure 1.

2.2.2 East Channel Portable Intake

The East Channel portable intake consists of a small insulated building on skids, a power supply from the shore, and a 22 kW (30 hp) submersible pump. Portable insulated piping connects the pump discharge to a permanent raw water pipeline, which runs from the riverbank to the filtration plant. The intake house is heated electrically.

The intake is set up on river ice, below the East Channel filtration plant, in October or November (occasionally December): as soon as ice conditions permit. It is removed again early in May. During its season of operation, the intake pump cycles automatically to maintain the water level in the Hidden Lake reservoir between set operating limits.

2.2.3 East Channel Water Treatment Plant

The East Channel WTP is located immediately southeast of NWTPC's plant and yard; just above Duck Lake. It provides water tempering, turbidity reduction, disinfection (by gas chlorine) and fluoridation. Plant contents include the water tempering system, four sand-anthracite filters, a chlorine contact tank; chemical feed systems; distribution pumps, an office-laboratory, and ancillary equipment. The plant building is 12 m by 18.3 m, and 7.9 m high.

Raw water is sent to the plant from the East Channel Intake through a 155 m raw water pipeline. Filter backwash containing extracted river silt is discharged from the plant through a 50 m pipeline running to Duck Lake. The plant operates with the East Channel intake: from some time in October or November until early May.

The East Channel water plant was built in 1980. Its water tempering system was replaced in 1999, with a new one arranged to use residual heat from power generation recovered and delivered by NWTPC.

Originally the plant was laid out for future addition of a clarifier stage capable of treating East Channel's summertime water. Considering the plant's design and age relative to current technology and evolving standards, replacement probably will be more cost-effective than addition when the need for change arrives.

2.2.4 Lake B Intake and Pipeline

The Lake B intake structure is a pipe and catwalk supported on piles. It is vulnerable to damage during break-up by windblown ice, and needs to be rebuilt at intervals averaging every ten years or so. Designs that could resist or avoid ice forces have been considered, but rejected due to high capital cost.

The Lake B pumphouse is a small metal structure on piles, containing a 56 kW (75 hp) split case horizontal centrifugal pump. Power is brought to the pumphouse on a 5 km long pole line, which parallels the Lake B pipeline.

The Lake B pipeline is 150 mm and 200 mm welded steel, unlined, and externally bare except for prime paint. It has 90 degree offset pieces at intervals to take up expansion and contraction, and offsets are chained to piles to prevent movement of the entire pipeline. Low points have drain plugs. The pipeline runs nearly 5 km from Lake B, and discharges into Hidden Lake.

Originally the pipeline was laid directly on the ground. In time it became entirely overgrown and embedded in ground cover. During the 1990's work was done on raising it and placing it on railroad tie sleepers. Roughly three km was completed.

The Lake B pipeline cannot be run in cold weather, as it is essential not to freeze it. Often minor winter damage needs to be repaired in spring before the line can be started. Once operational for the summer season it is run for periods of two to four weeks at a time from mid June until the end of September.

2.2.5 Hidden Lake Pumphouse

The Hidden Lake pumphouse has a timber crib foundation resting on soft lakebed deposits, topped by a concrete floor structure that supports a structural steel framed metal building. It has two 11.3 kW (15 hp) duty pumps, electric motor driven. The pumphouse operates from early May until about the end of October, as many hours a day as necessary to maintain water level in the Hidden Lake reservoir within its set operating limits.

2.2.6 Hidden Lake Water Treatment Plant

The Hidden Lake WTP contains chlorination and fluoridation equipment, a 410 m^3 (90,000 ig) chlorine contact tank (sometimes useful as a small secondary reservoir), treated water transfer pump, and ancillary systems.

The Hidden Lake WTP operates with the Hidden Lake pumphouse, from early May until around the end of October.

2.2.7 Outlook Regarding Seasonal Water Supply Arrangements

Changing the water source away from East Channel in the summer avoids the high capital and operating costs of treating turbid summertime river water. Changing the water source away from Lake B in winter avoids the alternative high cost of insulating and heating the Lake B supply pipe for wintertime operation.

The Hidden Lake pumphouse and treatment plant were designed and built in the late 1950's, and the Lake B pipeline was added in 1970. All of these facilities are now between 35 and 50 years old. Gradual deterioration, gradually increasing maintenance needs, and capacity limits are all factors to remain aware of, but none of these appear, so far, to set a visible end date on useful service life. At this time the factor that seems most likely to spur change is rise in standards for water treatment and rise in consumer expectations.

When need for major renewal arises, economics will favour a change to East Channel as the sole, year-round source, and abandonment and removal of the Hidden Lake -- Lake B system.

Use of East Channel as the year-round source will require installation of an all-season intake and construction new water treatment plant capable of dealing with East Channel's summertime levels of turbidity. Clarification of summertime water will involve use of additional standard water treatment chemicals, such as alum and sodium carbonate.

2.3 TREATED WATER PUMPING, STORAGE AND TRANSMISSION

2.3.1 Primary Functions: Treated Water Reserves, System Pressure

Inuvik's water supply-treatment systems operate at constant rate, as is usual. The town's water demand, however, continually varies, following established daily and weekly patterns. Treated water stored in the Hidden Lake reservoir provides the necessary buffering between the steady supply and the fluctuating demand.

The reservoir also provides a reserve of water for fire emergencies, and in fact this is where most of its storage is allocated. The volume used for normal daily operations is only about 10 percent of the reservoir's total.

Pressure in a municipal water distribution system can be maintained by continuous pumping or by gravity discharge from an elevated reservoir. The relatively high elevation of the Hidden Lake reservoir provides gravity pressure throughout Inuvik's system, with supplemental booster pumping needed only in the upper hillside areas from Ptarmigan Subdivision west. This is a considerable advantage whenever power outages occur: there is no pressure interruption, with attendant risk of back-siphoning through cross-connections, while backup generators mobilize.

The Hidden Lake reservoir is interconnected with the water distribution system and water supply systems by a single, large-diameter transmission main that runs in HTW-style utilidor down Hidden Lake Hill.

The locations of the Hidden Lake Reservoir and the water transmission main are shown in Figure 1.

2.3.2 Water Supply and Storage System Control

Water level in the Hidden Lake reservoir is monitored in the reservoir's nearby valve house. Signals from the valve house start and stop the duty water supply and treatment system – East Channel in winter and Hidden Lake in summer – as necessary to keep the water level between set operating limits. When either water plant is running, the water being produced is pumped into the water distribution system at the water plant's pre-set rate, and whatever amount of the supplied volume is in excess of concurrent town demand refills the reservoir. The plant will run until signaled off by the valve house, when the reservoir level again reaches the normal-full mark.

2.3.3 Hidden Lake Transfer Pump

Treated water is moved from the Hidden Lake WTP's chlorine contact tank to the town's water distribution system and the Hidden Lake reservoir by the water plant's single transfer pump. Being located at about the same elevation as the bottom of the reservoir the pump operates against low pressure, and is 5.6 kW (7.5 hp).

2.3.4 East Channel Distribution Pumps

Treated water is moved from the East Channel WTP's chlorine contact tank to the town's water distribution system and the Hidden Lake reservoir by the water plant's three "high lift" distribution pumps. Being located near river level, far below the reservoir, these operate against the highest pressures in the distribution system and are 37.3 kW (50 hp).

2.3.5 Treated Water Storage

The Hidden Lake reservoir is a 2.3 ML (0.5 mig) insulated lined steel tank located in the same yard as the Hidden Lake WTP.

The reservoir's Valve House, adjacent, contains reservoir monitors and controls, and oil-fired boilers. The boilers were installed in 1998 in preparation for loss of HTW heat service. They provide building heat to all of the water supply and storage facilities located at Hidden Lake, and maintain a temperature safe against freezing in the reservoir.

The Valve House originally was laid out for future addition of a second, similar reservoir. However, much of the space intended for that purpose has been taken up by the 1998 changes. The detailed planning for addition of the next reservoir, when the time draws near, will need to determine whether the building will need to be enlarged.

2.3.6 Treated Water Transmission Mains

Treated water is delivered from the Hidden Lake reservoir into the townsite water distribution network through 300 mm (12 inch) diameter trunk water mains. The original main runs from the Valve House down Hidden Lake Hill to J106, in HTW-style (steel framed, aluminum paneled) utilidor. Another main branches off from the original one, and runs to the Ptarmigan Booster Station.

2.4 UTILIDOR SYSTEM

2.4.1 Overview

Nearly all of Inuvik's piped water and sewage system is above ground. In the first decades of townsite development, aboveground utility pipes were carried in insulated, heated metal or wooden boxes called “utilidors”. “Utilidor” now refers to aboveground water and sewer systems generally, including the jacketed, insulated steel pipe on steel pile (“JIPSP”) one used in Inuvik since 1989.

The total length of Inuvik’s utilidor system is 18.3 km.[2] The total includes short runs of public water mains through the crawl spaces of the two large schools, SAMS and SHSS; a few underground water mains, most of which are short connections between adjacent blocks; and trunk water and sewage lines between Hidden Lake and the developed townsite and from the developed area to the lagoon. It does not include the 5 km long Lake B pipeline. Nor does it include privately-owned utilidors (examples being the Finto Hotel utilidor, the utilidors that run to and between row house units in Block 45, and utilidors in at least one mobile home park), or any utilidettes.[3]

Individual runs of utilidor can be classified according to age, design, current condition, method of freeze protection and various other parameters.

2.4.2 Water Distribution Network

The total length of Inuvik’s water distribution network is 15.9 km. This includes 1.1 km of trunk mains, most of which are 300 mm (12 in) in diameter, and 14.8 km of distribution mains, most of which are 200 mm (8 inch); the normal minimum size for reasons of fire protection. In the distribution system there are a few older utilidors having 150 mm (6 in) water mains.

The water network has multiple interconnected loops. This is an arrangement forced by townsite layout, and in any case one that provides best fire flows and good flexibility in isolating any system problems that occur. It is, however, problematic for assurance of freeze protection, as discussed in the next section.

2.4.3 Water Network Freeze Protection

Inuvik’s aboveground utility system needs to survive the extremes of the Town’s winter, with a good margin of safety. Further, if something fails, time is needed for discovery and response.

To protect against freezing, “passive” systems (weather shields and insulation, mainly) reduce the rate of heat loss as much as possible, while “active” systems (such as water tempering boilers, circulation pumps, heat tracing, etc) add and distribute heat to compensate for the unavoidable losses.

---

[2] Utilidor statistics in this report are for April 2007.

[3] A utilidette is a small utilidor, normally privately owned, that that brings services from the main (public) utilidor to a building.

Utilidors present significant surface area to the outdoors. In terms of equivalent external building wall area, the total exposed surface area of Inuvik's 18.3 km long public utilidor system (trunk sewers included) is thought to be in the neighborhood of $33{,}000m^2$. For perspective this is about 30 times the wall area presented by a building 25 m by 45 m by 8 m high: a building of about the size of Inuvik's town office and fire hall.

In cold, windy weather the rate of heat loss from such a large surface area is substantial, even with good insulation. Regardless, the temperature cannot be allowed to drop to near freezing anywhere in the system at any time. Ice crystals will stop circulation flow in a water main almost at the moment they start to form. With flow stopped, the frozen zone is likely to spread quickly in both directions. Thus, once initiated, a freeze-up in a main utilidor can be very difficult to contain, and can soon cause widespread damage that is both very difficult to deal with in winter and extremely costly to repair.

Inuvik's active defense against freezing in utilidors is tempering of water, and distribution of the tempering heat added by a combination of forced circulation and bleeding.

When the East Channel WTP is in operation, from early winter until early May, the raw water it receives (from East Channel, at a temperature just above freezing) is warmed to 10°C (or more) using residual heat from power generation. The WTP also houses the water distribution system's primary circulation station, whose pumps send treated, tempered ("finished") water eastward, toward the Camsell area, on a large loop that passes near the Family Centre, the Library, and back to the WTP. Out in the distribution network, secondary circulation stations maintain flows around sub-loops that are arranged around the primary circulation loop. The layout of sub-loops is such that flow is maintained in all branches of water distribution network, with the exception of dead ends. Flow is maintained in the water system's few dead ends by bleeding.

Water that returns to the East Channel WTP along the main circulation loop is re-tempered, also using recovered residual heat, and sent on its way again. In addition, there are several boiler-equipped secondary water re-tempering stations at strategic locations within the utilidor network, that automatically come on if the temperature of the circulating water falls below certain level. During the period of operation of the East Channel WTP's primary tempering system the secondary stations are rarely, if ever, called on to fire.

In the fall, cold weather arrives some weeks before the East Channel intake and WTP can be put into service. During that time the circulation stations (including the one at the WT)) are all in action, and a limited degree of tempering is provided by the secondary stations. The same occurs for a brief time in May, following seasonal shut-down of the East Channel water supply system and changeover to Hidden Lake.

Naturally, tempering of water using residual heat is costs far less, in terms of both capital and fuel cost, than tempering using an independent boiler system burning its own fuel.

2.4.4 Truck Fill Station

Trucked water is required for domestic use by industrial and commercial establishments outside the serviced area, and by a very small number of older houses within the developed townsite which are not connected to the utilidor. The truck fill station is located on Navy Road, at the intersection with the Marine Bypass.

2.4.5 Sewage Collection Network

The total length of Inuvik's sewage collection network is 16.4 km. This includes 2.2 km of trunk mains, which range in size up to 350 and 400 mm, and 14.2 km of collection mains, most of which are 200 mm (8 inch); the normal minimum size for reasons of self-cleaning and of steam cleaning or rodding when needed. In the collection system there are a few older utilidors having 150 mm (6 in) sewer mains.

Inuvik's sewage system operates by gravity. At this time there are no publicly owned or operated sewage lift stations or forcemains.

2.4.6 Sewage Network Freeze Protection

Sewage systems are somewhat less vulnerable to freezing than water networks, because household sewage includes a significant amount of domestic hot water; resulting in typical temperatures of 10°C to 15°C. Sewage normally can afford to lose a considerable amount of heat, and therefore can flow a long distance in an insulated system, before cooling to the point of freezing. However, upper ends of sewers, where flows are small and intermittent, can be problematic and, typically, need the added protection of a bleed system.

2.4.7 Utilidor Designs and Structure

Inuvik's original utilidors are of the steel framed, aluminum paneled "HTW" design, built between 1957 and the very early 1970's. HTW-style utilidors still make up just over one third of the total length of the utilidor system, with an aggregate length of 6.6 km.

Several other designs were used in the 1970's, to avoid the very high capital cost of HTW-style utilidor. Corrugated metal shell ("CMS) utilidors and some wood box utilidors built in the mid-1970's are still in use, but the wood box ones are due (perhaps overdue) for replacement and the CMS ones not far from the end of useful service life. In fact, wood box utilidors still in service are a fraction of Inuvik's original inventory; most have been replaced already. Current aggregate lengths of CMS and wood box styles are 0.9 km each.

Single mains (water or sewer) built before the late 1980's are jacketed insulated pipe on wood piles ("JIPWP"). The aggregate length of JIPWP style utilidors is 2.4 km, much of that total being in the sewage trunk lines that run to the lagoon.

All of the utilidors built before the late 1980's are on timber piles. Timber piles are vulnerable to groundline rot, and need to be diligently preserved to prevent foundation failures from placing a premature limit on the service lives of existing utilidors. Utilidors are very expensive to build, and it generally is very worthwhile to extract as much useful service life as possible from existing installations.

From 1989 onward utilidors built in Inuvik have been jacketed insulated pipes on steel piles ("JIPSP"). By avoiding timber piles and other wood components, the JIPSP style aims at greater durability and a longer service life. Inuvik currently has 6.5 km of JIPSP-style utilidor.

HTW, CMS, wood box, JIPWP and JIPSP styles of utilidor account for 17.4 km of Inuvik's total utilidor system length of 18.3 km. The small remainder is made up of buried pipes and pipes carried in the crawl spaces of the two large schools.

2.5 UTILIDOR ANCILLARY SYSTEMS

2.5.1 Water Temperature Monitoring

Temperature in water mains is monitored at 68 selected locations, widely distributed throughout the pipe network. Each thermal probe is wired to one of seven readout substations, which are located in utilidor vaults. Readout stations are read locally during rounds, and can be read from the East Channel WTP. The temperature record from each probe is transferred from each readout station to the central computer in the WTP daily.

2.5.2 Road Crossings

Aboveground water and sewage systems conflict with roads (and other land uses). Inuvik currently has 72 utilidor-road intersections: 65 crossings of Town roads, one crossing of a GNWT highway (the Marine Bypass), two crossings of access driveways to public buildings (Aurora Residence and SAMS), and four crossings of private residence driveways.

Inuvik's original utilidors are HTW-style that until the 1998-99 carried high temperature water (HTW) heat distribution mains. Direct burial of 170°C HTW piping through roadbeds was not a feasible design option, as the underlying permafrost would have been melted. Accordingly, all of the intersections with HTW-style utilidors are roadway bridges, with the exception of the one at Duck Lake Street where the road passes under the utilidor.

Currently there are a total of 17 bridges across HTW utilidors: 10 concrete bridges and 7 multiplate arches.[4,5] The concrete bridge crossings are significant structures, and to a slightly lesser extent the multiplate arch crossings are as well. However, structural maintenance needs have in general been small, and the structures are not, by and large, showing signs of significant deterioration or distress.

With two levels of pipes to be accommodated, HTW-style utilidor box is over a meter tall, and with clearances above and below, plus the thickness of the bridge and roadway, bridge-type crossings result in road humps of 2 m or more, interfering with sight lines. Wood box utilidors are somewhat lower in profile and CMS, JIPWP and JIPSP designs significantly lower; and their crossings usually can be direct-buried through the roadbed with far less effect on road profile and traffic safety.

Currently there are a total of 54 direct buried road crossings. A small number of these are in underground sections of pipe and pass under the roadbed, but most are in aboveground utilidor and pass through the roadbed, usually in carrier culverts.

---

[4] The Marine Bypass crossing is actually a multiplate culvert. All of the in-town ones are arch structures.

[5] Originally there were 11 concrete bridges, but one on Tununuk was replaced in 2001 by roadway fill and direct buried water main after it began to lean due to downslope creep. There were at one time 9 arch bridges, but two have been eliminated by replacement of HTW utilidor with JIPSP utilidor and direct-buried crossings.

2.6 SEWAGE TREATMENT FACILITIES

Inuvik's sewage is treated in the multi-cell lagoon system, before being discharged into East Channel. Active wastewater treatment cells include two primary sedimentation cells, and a large pond which operates as a facultative lagoon in summer. Two additional cells just east of the primary lagoons are used for sludge storage.

The system is operated on a continuous discharge basis. The system's total capacity is five to six month's sewage flow.

2.7 WATER DEMANDS AND EFFECT ON COSTS

2.7.1 Measurement of Water Use and Sewage Generation

Water delivered to the distribution system is metered. Total sewage generation is considered to be equal to total metered water consumption. This is a reasonable approach in the case of Inuvik's above ground utilities system. It is almost entirely free of uncontrolled leaks and inflows, and the quantities of water "lost" to lawn watering, vehicle washing, truck haul to places outside the serviced area, and so on, are on the whole relatively minor. Over the operating year the great majority of the water distributed by the Utility is returned to it as sewage.

2.7.2 Current Town Water Consumption

Current (2006) water supply data are summarized in Table 2.1.

TABLE 2.1

INUVIK WATER SUPPLY AND CONSUMPTION, 2006

Parameter	ML	mig
Total consumption:	502	110
Supplied from East Channel	361	79
Supplied from Lake B	141	31
Supplied from Hidden Lake	0	0
Minimum month's demand (summer)	35	8
Maximum month's demand (winter)	51	11

Relevant to the calculation of certain variable water supply costs, a significant amount of the water consumed by Inuvik under the Town's dual water supply arrangements actually passes through supply and treatment facilities twice, due to winter re-filling of Hidden Lake after fall drawdown. For example, 86 ML of the 502 ML consumed by Inuvik in 2006 was originally pumped from East Channel, treated, and then discharged into Hidden Lake; then later, during the spring drawdown of Hidden Lake, was again extracted, treated a second time, sent back into the distribution system, and finally consumed.

Although total Town consumption was only 502 ML, the East Channel WPT treated 361 ML and the Hidden Lake one 227 ML (141 ML + 86 ML).

86 ML of the water consumed by Inuvik in 2006supplied from East Channel was used to re-fill Hidden Lake after fall drawdown. Accordingly, the water referred to was In effect, the total amount of water pumped from supply, treated, and pumped into the distribution system was 588 ML (502 ML consumed, of which 86 ML was "supplied" twice).

2.7.3 Estimated Per Capita Water Consumption

GNWT Bureau of Statistics lists Inuvik's 2004 population as 3586, and its forecast 2009 population as 4051; indicating an average expected growth rate of 2.47 percent per year. Interpolating, these data suggest a 2006 population of 3765. Per capita water use data for 2006 are summarized in Table 2.2, based on an assumed population of 3765.

TABLE 2.2

INUVIK PER CAPITA WATER CONSUMPTION, 2006

Parameter	Lcd	Igcd
Average, year	365	80
Average, minimum summer month	312	69
Average, maximum winter month	435	96

Per capita water use appears to be about 40 percent higher in winter than in summer. The seasonal change is due partly to summer shut-down of schools and out-of-town vacations; but a significant component is shut-down of some of the municipal bleeders needed to maintain freeze protection in winter.[6]

2.7.4 Future Trends

Inuvik installed water meters in all customers' premises and moved to consumption-based billing in the early 1990's. Per capita water use went through a significant downward adjustment at that time, and stabilized at the new, lower seasonal levels. Further change in the typical per-capita water use patterns is not expected.

Inuvik's population has not changed much in recent times. According to GNWT's Bureau of Statistics it was 3,462 in 1996; subsequently it fell slightly and then gradually rose to 3,535 in 2004; most recently has fallen again slightly, to 3,354 in 2006.

If or when the Mackenzie Gas Project proceeds, Inuvik's settled population probably will rise by a few hundred people; but no very dramatic change is expected. Bureau of

[6] Not all bleeders are turned off in summer. Some are kept running to prevent stagnation in long dead ends.

Statistics' projections place Inuvik's future population at (rounded slightly) 4,400 in 2014 and 5,100 in 2024.

Bureau of Statistics' projections suggest that the average annual rate of population growth in Inuvik is expected to be about 2.1 percent between 2004 and 2014, and about 1.5 percent thereafter. Calculations using Bureau of Statistics' growth rates indicate a 2006 population of 3765, and future populations of 4533 in 2016 and 5242 in 2026. The respective cumulative growth rates from 2006 are just over 20 percent by 2016 and just under 40 percent by 2026.

Since little change is foreseen in per capita water use patterns, Inuvik's water consumption is expected to follow population changes quite closely. The growth rates just described suggest that Inuvik's water demand will be in the order of 604 ML in 2016 and 700 ML in 2026.

2.7.5 Fixed and Variable Costs

A few of the costs of operating Inuvik's water and sewage systems vary up or down directly with the Town's water demand, but most do not. The majority of costs are "fixed", varying only with the size and scale of the operation overall, rather than with the amount of water being produced in a particular year.

Examples of variable costs include the cost of water treatment chemicals, and the cost of electricity used by water supply pumps. Water tempering costs may be variable to a degree.

Examples of "fixed" costs include the capital costs of facilities, including replacement costs, however financed; the cost of maintenance staff and their vehicles, tools, spares, consumables, workshop and so on; and the cost of management and administration including billing and finance. These are just examples; there are others.

Even though day-do-day operations costs are not much affected by variation in water consumption, it is nevertheless most important to foster conservation of water as much as possible. Unchecked growth in water demand eventually leads to needs to enlarge primary water supply and sewage treatment facilities, usually at great capital cost, and usually resulting in increases in operating costs.

2.8 SUMMARY

Inuvik's water and sewage systems are extensive. Relative to the municipal utility systems found south of the 60th parallel, and in the NWT communities around Great Slave Lake, they are also of quick complex design and construction; and require a high level of skill, diligence and effort to operate and maintain.

Direct and indirect operations, maintenance and ownership costs are discussed in the next five chapters.

3.0 DIRECT OPERATIONS COSTS

3.1 INTRODUCTION

Direct operations costs arise from consumption of water and sewage treatment chemicals, electricity and heat; and from staff time used in daily operations (as distinct from staff time spent on preventative maintenance, administration or management).

Indirect operations costs arise from daily operation of the utility's vehicles in the course of performing system operating work. A portion of management, general administration and various other Utility headquarters expenses could also be attributed to system operations, since all of these provide necessary support to operations.

Section 3 examines the direct operations costs of water treatment chemicals, electricity and heat. Maintenance costs are dealt with in Section 4. All staff costs, whether spent on direct operations or other utility activities, are dealt with in Section 5.

3.2 CHEMICAL COSTS FOR WATER AND SEWAGE TREATMENT

3.2.1 Water Treatment Processes

The East Channel Water Treatment Plant runs from near the beginning of winter until early May. The Hidden Lake Water Treatment Plant runs the rest of the year, from early May until the East Channel plant is re-started. At both plants water is disinfected using gas chlorine supplied in cylinders, and fluoride is supplemented to 1.0 mg/L using hydrofluosilicic acid.

If in future Inuvik moves to East Channel as its sole, year-round water source, clarification of summertime water will involve use of additional standard water treatment chemicals, such as alum and sodium carbonate.

3.2.2 Water Treatment: Chlorine

Chlorine is by far the most common waterworks disinfectant. A great advantages is that it remains as a residual in water in storage and in the distribution mains, after leaving the treatment plant, which many other disinfectants do not. Inuvik uses it, and buys it as liquid in cylinders of gross weight 109 kg, tare 41 kg, product 68 kg.

Inuvik maintains a free chlorine residual of 0.4 to 0.5 mg/L in finished water leaving the treatment plant. Typical chlorine application rates to achieve this residual are about 3.5 mg/L at East Channel and 5.0 to 6.5 mg/L (highest in early summer) at Hidden Lake. In 2006, total production of treated water was 588 ML[1] and total chlorine use just over 2.44 tonnes.

Inuvik calculates that chlorine costs $3.57/kg delivered to the water plant (i.e. shipping included). The total cost in 2006 was $8,710.[2 3]

---

[1] Inuvik's 2006 water use was 502 ML. The difference, 86 ML, is in wintertime re-filling of Hidden Lake with treated water from the East Channel plant.

[2] Data in this report are rounded.

3.2.3 Water Treatment: Fluorine

Fluorine is an important minor element in bone and tooth enamel structure. It is one of many element naturally dissolved in water, but its concentration in any particular water source depends on various factors; for instance, source basin geology. Population studies have shown that optimum intake of fluoride ion occurs at a drinking water concentration of about 1 mg/L. Many communities, including Inuvik, add a small amount of fluoride to domestic water, to maintain that concentration. Inuvik buys fluorine as hydrofluosilicic acid supplied in 30 ig polyethylene barrels.

In 2006, total water production was 588 ML and hydrofluosilicic acid use 1.83 tonnes.

Inuvik calculates that hydrofluosilicic acid costs $3.63/kg delivered to the water plant. The total cost in 2006 was $6,640.

3.2.4 Sewage Treatment

The primary cells of the sewage lagoon system are dosed with "Acti-zyme"[4] throughout the open water season, to promote a healthy microbe population and reduce sludge deposition. The dose rate is 22.7 kg (one 50 lb bucket) per cell per week for the first three weeks, and then half that amount per week for the remainder of the season.

Inuvik finds that Acti-zyme costs $24.28/kg delivered. Its cost in 2006 was $5,510.

3.2.5 Summary, Water and Sewage Treatment Chemical Costs

Estimates of consumption of water treatment chemicals, and the cost of those materials, are summarized in Table 3.1.

TABLE 3.1

**WATER AND SEWAGE TREATMENT
ESTIMATED CHEMICAL CONSUMPTION AND COST**

Chemical	**Consumption** kg/yr	**Cost** $/yr
Chlorine	2,440	$ 8,710
H_2SiF_6	1,830	6,640
Acti-zyme	230	$ 5,500
Total Annual Cost		**$ 20,900**

Quantities of water treatment chemicals used are directly related to Town water demand. Quantities of lagoon enzyme used are not.

[3] The deposit is paid on cylinders is not a recurring annual operating cost. It is more like a capital cost (though non-depreciating).

[4] Acti-zyme Productions Ltd., Vancouver, B.C.

3.3 ELECTRICITY

3.3.1 Scope

Inuvik's water and sewer system has about two dozen electrical accounts. Six accounts, however, together account for about 80 percent of total annual consumption of electricity. These six include the summer and winter water supply facilities (67 percent of the total) and the two booster pumping stations that increase pressures in higher areas (13 percent). The remaining 18 accounts are for water re-heating and circulation stations, water circulation stations without re-heat, the truck fill station, and the utilidor shop.

In the water supply facilities and booster stations that account for so much of the total consumption, electricity is used to run a variety of equipment and systems. However, the great majority of the total use is in supply or booster pumping against the full normal pressure in the distribution system; in effect, lifting water from the elevation of the particular pump to water level in the Hidden Lake reservoir.

A portion of the electricity used in the Town office is also attributable to water and sewer utility operations: all headquarters costs are dealt with separately.

All Utility installations that use electricity have a standard electrical service connection and meter. NTPC reads meters and issues bills for all water and sewage utility services.

3.3.2 Cost of Electrical Service

NTPC's[5] "General Service" rate structure for Inuvik applies to power services to the water and sewage utility. Billing is monthly, and the bill has two components:

- Electricity is billed at $0.3221/kWh, plus rate rider of $0.0610, plus interim refundable rate rider (from 1 February 2007) of $0.0514; total $0.4345/kWh.
- "Demand" meters record the peak instantaneous load through the meter since the meter was last read and reset. A demand charge of $8.00/kw applies to the highest peak recorded in the preceding 12 months.
- The minimum monthly charge for any service is $40.00.

Annual use of electricity by water and sewage utility infrastructure is discussed below, based on power bills and consumption data for the period 1 February 2006 to 31 January 2007 (or nearest similar reading cycle for the particular meter). Use by all facilities, and annual cost, are tabulated in Table 3.2.

3.3.3 East Channel ("River") Pumphouse

The East Channel Pumphouse and East Channel WTP operate from early winter until early May. In the most recent five years the East Channel system has supplied Inuvik with an average of 335 ML of treated water per year. The amounts in both 2005 and 2006 were just over 360 ML. Metered supply to the town does not include amounts of water used in the WTP for backwashing filters; accordingly, the amount pumped to the WTP by the East Channel Pumphouse is somewhat greater than the recorded supply. The difference is thought to be around 5 to 10 percent.

---

[5] Northwest Territories Power Corporation.

The East Channel Intake Pumphouse has one 22 kW (30 hp) submersible pump, and an electric heater. The pump is controlled automatically by signals generated in the Hidden Lake Valve House, and runs as needed to keep level in the Hidden Lake reservoir within normal limits. Operating staff throttle the rate of flow from the Intake Pumphouse so that the Town's daily demand plus any concurrent refill of Hidden Lake will be produced during a daily WTP run times of reasonable duration.

During the winter of 2004-05 the metered supply to the town was 380.6 ML. NTPC's records for the winter indicate that the River Pumphouse used 58,904 kWh of electricity during that period. Total use of electricity, including electricity used to heat the pumphouse, is equivalent to 0.155 kWh/m^3 of finished water.

The same data from the winter of 2005-06 are 335.1 ML of water and 32,058 kWh of electricity: 0.096 kWh/m^3. Again, for the first part of the winter of 2006-07 (startup to January 27) the same data are 191.8 ML and 29,303 kWh: 0.153 kWh/m^3. It is not known why the data suggest a year-to-year variability in the energy use rate of some 60 percent. There are differences in backwashing needs from year to year, due to differences in raw water quality, but variability due this factor would be expected to be much less.

An attempt could be made to separate the “fixed” heating electricity use from the “variable” (with water use) pumping use by estimating pumping energy consumption based on an estimate of total head losses through the hydraulic system: laborious, and probably inaccurate. More simply, the electricity use attributed to heating is 2 kW per hour for (typically) about 190 days of operation, or 9120 kWh/yr. This allocation leads to estimates of the variable rate of electricity use of 0.130, 0.069, and 0.128 kWh/m^3 for the same three time periods, respectively.

The electricity use rates selected for current purposes are 9120 kWh/yr for heating and 0.130 kWh/m^3 for pumping. These rates indicate that at Inuvik's current water demand level of just around 500 ML/yr, with 72 percent (360 ML) being supplied from East Channel, the River Pumphouse will use 55,920 kWh/yr. With a demand charge for 17.3 kW added in the equivalent annual power cost at current rates is $25,960.[6]

3.3.4 East Channel Water Treatment Plant

As noted above the East Channel Water Treatment Plant operates from early winter until early May, and in each the most recent two years has supplied Inuvik with just over 360 ML of treated water. In 2006, of 360.6 ML supplied, 274.6 ML went directly to Town consumption, and 86.0 ML went to refilling Hidden Lake after fall drawdown.

The East Channel WTP contains 37.3 kW (50 hp) "high lift" pumps that deliver treated water into the water distribution network at full system operating pressure, and a wide range of other electricity-using equipment including a number of smaller pumps.

During the 12 month period from 25 January 2006 to 28 January 2007 the East Channel WTP supplied 384.7 ML of water and used 208,740 kWh of electricity. Meter readings throughout the year suggest that at least 50,000 kWh of the total electrical consumption is not sensitive to the rate of water production so must go toward water circulation, plant

---

[6] GST excluded.

heating and lighting, and other “fixed” uses. Taking the “variable” portion of the period’s electrical use to be 158,740 kWh suggests a “variable” use rate of around 0.413 kWh/m^3 of finished water produced. The rates indicated here are adopted for current purposes.

Electricity use rates of 50,000 kWh/yr for fixed uses and 0.413 kWh/m^3 for high-lift pumping indicate that at Inuvik’s current water demand level of just around 500 ML/yr, with 72 percent of that amount (360 ML) being supplied from East Channel, the East Channel WTP will use 198,700 kWh/yr. With a demand charge for 37.3 kW added in[7] the equivalent annual power cost at current rates is $89,900.

3.3.5 Lake B Intake

The Lake B intake is operated for periods of weeks at a time, from mid June until late September, as necessary to restore and maintain operating level in Hidden Lake within normal limits. In 2006 the Lake B pipeline supplied 141 ML of water, as compared to the average of the most recent five years of 205 ML. If it is assumed, as above, that about 72 percent of Inuvik’s current annual water demand of 500 ML will be supplied from east Channel, then the amount expected to come from Lake B is about 140 ML.

The single intake pump is driven by a 56 kW (75 hp) motor.

Unfortunately, it seems that the Lake B meter has not been read since some time in 2004. The records obtained are not sufficient for analysis of electricity consumption rate per unit of water pumped. Analyses done in the mid-1990’s suggest a use rate of between 0.25 and 0.39 kWh/m^3 pumped, including any fixed uses (which in any case would be small). A figure of 0.35 kWh/m^3 is adopted for current purposes. It would be desirable to re-check the rate, as it may be sensitive to any changes that may be occurring in lake level, or in pump elevation relative to lake level.

The most recent readings (summer 2004) indicate a demand rate of just under 45 kW.

Based on the limited data available, it appears that at Inuvik’s current water demand level the Lake B Pumphouse can be expected to use 49,000 kWh/yr. With a demand charge for 45 kW added in, the annual power cost is expected to be $25,610.

3.3.6 Hidden Lake Pumphouse, Water Treatment Plant, and Valve House

Facilities at Hidden Lake include an intake pumphouse, a water treatment plant, and a reservoir and its valve house. The intake pumphouse has two 11.3 kW pumps (duty and standby); the water treatment plant has a 5.6 kW transfer pump, and the valve house has a pair of boilers for water tempering. There is in addition a range other equipment and components that use electricity, in smaller amounts. All of the Hidden Lake facilities are on a single electrical meter.

The Hidden Lake water supply system, which includes the intake pumphouse and water treatment plant, operates from early May until some time in the early part of winter: the season when the East Channel system is at rest.

---

[7] With two pumps running together the demand charge would double. Available records of demand charges suggest that, at current plant flow rates, only one pump is needed at a time.

As noted earlier, in 2006 the system supplied 227 ML of water, of which 141 ML originated in Lake B and 86 ML in East Channel.

Power consumption by the Hidden Lake facilities in the 12 month period from 25 January 2006 to 25 January 2007 totaled 60,920 kWh. During the "rest" months of December through April, when the Hidden Lake water supply system is not being run and the boilers are providing building heat only, not water tempering, use averaged about 2,750 kWh/mo. During the active months of May through November it averaged about 6,750 kWh/mo. These averages amount to a rounded annual consumption of 61,000 kWh. The billed demand cost suggests a demand load of about 16 kW.

In the late-1990's it was estimated that the Hidden Lake Valve House would use 13,900 kWh/yr. Allocating a total of 22,400 kWh/yr to all fixed uses in the Hidden Lake facilities leaves 38,600 kWh/yr for variable uses, at the current water demand level. This implies a use rate for pumping of 0.170 kWh/m^3.

Electricity costs at Hidden Lake for the twelve month period ending 25 January 2007 totaled $27,431. At the current water consumption level, current power costs, and the allocations noted above (including a demand load of 16 kW), the annual power cost is expected to be $28,040.

3.3.7 Booster Pumping, Re-Heating and Circulation Stations

As noted earlier, continuous movement of water throughout the system according to a planned pattern is maintained by circulation stations installed at key points within the water distribution network.

Certain stations also have boilers to re-heat circulating water, if water temperature falls below a certain level.

Two stations, the large Booster Station in Ptarmigan Subdivision and Junction 115 (J115), also provide booster pumping to elevate water pressures in the subdivisions above the level, roughly, of Inuit Road.

All stations require building heat, to maintain temperature a little above freezing. Where boilers are installed to provide re-heating of water they also provide space heating. Stations without boilers have small electric space heaters.

As would be expected, consumption of electricity use is quite different between individual stations, depending on the functions performed, equipment sizes, and so on. Booster pumping uses much more electricity than operation of boilers or circulating pumps. Smaller circulating pumps serving small districts in fact tend to use very little energy, because the head losses involved in maintaining circulation are quite small.

The Town's water demand rate has virtually no effect on consumption of electricity for water circulation, and so little effect on consumption for re-heating and booster pumping, that the rates of electricity use at these stations can for current purposes be considered to be fixed.

Electricity consumption in circulation, re-heat and booster pumping stations is listed in Table 3.2.

3.3.8 Water Temperature Monitoring Stations

Water temperature monitoring panels require electrical service but take very little power. They are all installed, in water circulation stations where electrical service already exists.

3.3.9 Sewage Pumping

As indicated earlier there are no publicly owned or operated sewage pumping stations.

3.3.10 Electric Heat Tracing

Heat tracing is an expensive form of freeze protection for main utilidor, but cables were installed in several “problem” locations before the 1998-99 conversion of older utilidors from HTW-system heating to circulation of tempered water. All remaining cables have now been disconnected.

3.3.11 Summary of Electricity Use and Cost

Current (2006) electricity use and cost in Inuvik’s water and sewage system are summarized in Table 3.2 (page 8).

3.4 HEAT

3.4.1 Scope

The Utility uses heat for freeze protection of utilidors, and for space heating of stations and plants containing exposed piping.

Freeze protection of the water distribution network is provided by tempering water and continuous forced circulation of tempered water throughout the system. Bleeders are installed where needed to maintain flow of tempered water to dead-end branches and into upper ends of sewers. While bleeders are needed to protect lightly-used upper ends of sewers, most of the freeze protection of the sewage collection network comes from inflow of domestic sewage that naturally contains a fair amount of heat originating in domestic hot water tanks.

Water is tempered, primarily, in the East Channel Water Treatment Plant. As noted earlier, the heat source is recovered residual heat from power generation.

There are six points within the water distribution system where water can be re-tempered, if temperature falls below a certain level, using gas or oil fueled boilers. These are the Hidden Lake Valve House, Ptarmigan Booster Station, J107, J68, J115 and J116. During the winter, when the East Channel WTP is running, the finished water being fed into the system is warm enough that the secondary stations do not fire, except as needed for space heating. The secondary stations do fire provide useful service, however, in the colder periods of the shoulder seasons when the ECWTP is not in service, and Hidden Lake’s water is cool enough to need tempering.

The Utility’s space heating needs are modest. In the East Channel WTP, the Hidden Lake Valve house and the Ptarmigan Booster Station indoor temperatures are set at basic comfort levels for operators. In other stations having exposed piping, such as circulation stations in utilidor vaults, they are set a few degrees above freezing.

TABLE 3.2

WATER AND SEWGE FACILITIES
ESTIMATED ANNUAL POWER CONSUMPTION AND COST

Station	Consumption Fixed kWh/yr	Consumption Variable kWh/yr	Demand kW	Cost $/yr
Trunk Facilities				
East Channel Intake PH	9,120	46,800	17.3	25,960
East Channel WTP	50,000	148,700	37.3	89,910
Lake B Intake	0	49,000	45.0	25,610
Hidden Lake WTP, Etc	22,400	38,600	16.0	28,040
Circulation, Re-Heating, Booster Pumping				
Ptarm. Booster	29,210	0	4.0	13,080
J115	38,940	0	4.8	17,380
Circulation, Re-Heating				
J107	16,840		4.0	7,700
J68	10,780		4.0	5,070
J116	12,870		2.5	5,830
Circulation – Medium Sized				
J106	4,590		3.0	2,470
J48	7,390		3.5	3,690
J17	8,400		3.8	4,130
J96	4,510		3.2	2,440
J74	2,520		2.9	1,580
J46-2	7,620		2.8	3,790
J70-1	6,870		3.0	3,430
Circulation - Small				
J20	1,480			1,120
J33	2,480			1,560
J117	1,810			1,270
Miscellaneous				
Truck Fill	3,550			2,020
Totals	241,400	283,100		**$ 246,100**

Town water demand has effectively no influence on space heating needs. It may or may not have influence on heat demand for water tempering, depending on how the freeze protection system is controlled.

In principle, the amount of tempering heat being distributed by circulating tempered water needs to be just sufficient, at any (and every) point in the system, to just match and compensate for the heat being lost to outdoors at that point. Accordingly, the utilidor system's actual heat demand at any time is a function of ambient weather conditions, not a function of current water demand.

In practice, the concept of matching heat supply to requirements set by ambient weather presents a number of practical difficulties. Among others, one is the nearly-day-long response time needed to adjust water temperatures throughout the system; and a second is the forecasting and controls complications involved.

It would be worthwhile to practice weather-scheduling of water tempering if by doing so a substantial saving in fuel cost could be achieved. As matters stand, though, the low-grade heat now being used to temper water would, in milder winter weather, otherwise be exhausted to the outdoors through radiators. Under current circumstances it is most practical to set the finished water temperature at a fixed level that safe for all weather and provides a time cushion for operators to respond if something fails.

No change in the prevailing arrangements for water tempering are foreseen. Inuvik's water demand is not expected to change on a per capita basis. The population may increase, however. If that happens, demand for water and electricity will both increase; probably in essentially the same proportions. Increased production of water will increase the need for heat for tempering; but it is expected that there will be a matching increase in the production of recoverable residual heat to satisfy that need.

Heat use and costs are summarized in this Section.

3.4.2 Cost of Heat

Fuel prices fluctuate and have risen significantly in recent years. In Inuvik the price for heating oil rose in 2006, from about $0.93/L early in the year to nearly $1.08/L in December. The price of natural gas in Inuvik is tied to the price for heating oil.

Heating oil has a thermal content of about 0.0330 MMB/L (0.0097 MWh/L, 0.0348 GJ/L). Accordingly, a price of $1.08/L is equivalent to about $31/GJ. In December 2006 the Utility paid $19.35/GJ for natural gas.

Residual heat could be valued using market prices for heating fuels. However, in case of NTCP and Inuvik, all of NTPC's costs in generating power for Inuvik, direct, indirect and capital, are charged to Inuvik's electricity customers. The heat has already been paid for. By agreement, Inuvik pays NTPC $40,000/yrr for residual heat service to the East Channel WTP; and this presumably is credited to the cost of electricity in the Inuvik rate zone.[8]

---

[8] The residual heat recovery and delivery system was designed and installed by NTPC in 1999. NTPC calculated Inuvik's pro-rata share of the system's capital cost to be $425,000; and was repaid that amount by the Town. The annual payment of $40,000 therefore is not related to capital cost.

3.4.3 Residual Heat for Water Tempering

Much of the heat that can be recovered from an engine used to drive a power generator is "low grade": of a temperature somewhat below the ideal range for use in building space heating, but still well above the level needed for water tempering. Further, the daily and weekly demand schedules for power and for water follow somewhat similar patterns, another advantage.

In Inuvik's setting, water tempering is a very well matched use for low grade heat recovered from power generation. To provide an equivalent level of freeze protection independently, the water and sewer utility would need to burn substantial amounts of fuel in a large and costly boiler system.

In 2006 the East Channel WTP provided 360 ML of water. Typically, the temperature of water passing through the plant was raised from between 0 and 1 °C to between 10 and 13 °C, for a total heat use in the general range of 15,000 to 18,000 GJ. The equivalent cost of natural gas at the December 2006 price of $19.35/GJ, allowing an average boiler efficiency of 85%, would be around $340,000 to $410,000.

3.4.4 Oil and Gas Space Heating and Water Re-Tempering

Nine stations use oil or gas for space heating and/or water re-tempering, as follows.

The East Channel WTP has a gas-fired boiler for back-up space heating. Primary space heating is by residual heat.

The Hidden Lake Valve House has two oil-fired boilers for re-tempering of water (in the reservoir) and for space heating of all of the Hidden Lake buildings.

The Ptarmigan Booster Station and J107 have oil-fired boilers for re-tempering of water and for space heating. J68, J115 and J116 have gas-fired boilers for the same uses. The Navy Road truck fill station and the Utilidor Shop have gas service for space heating.

Uses of fuel, and costs based on rates in effect at December 2006, are summarized in Table 3.3

TABLE 3.3

WATER AND SEWAGE FACILITIES
ANNUAL FUEL CONSUMPTION AND COST

Station	Fuel	Use L/yr	Use GJ/yr	Cost $/yr
East Channel WTP	Gas		305	5,900
Hidden Lake Valve House	Oil	37,540	1310	40,500
Ptarmigan Booster	Oil	6,810	240	7,400
J107	Oil	4,100	145	4,500
J68	Gas		380	7,400
J115	Gas		55	1,100
J116	Gas		150	2,900
Truck Fill	Gas		102	2,000
Totals			**2,690**	**$ 71,700**

3.4.5 Summary, Heat Costs

Earlier estimates of annual heat consumption and costs are summarized in Table 3.4.

TABLE 3.4

WATER AND SEWAGE UTILITY
ANNUAL HEAT CONSUMPTION AND COST

Use	Consumption GJ/yr	Cost $/yr
East Channel WTP, primary tempering	up to 18,000	40,000
Re-tempering, building heat	2,690	71,700
Totals	up to 20,700	**$ 111,700**

As noted earlier, the equivalent value of residual heat used, if supplied as natural gas, is thought to be in the neighborhood of $340,000 to $410,000.

3.5 COMMUNICATIONS COST

The water and sewer utility uses telephone lines and cable network services to connect a few installations, for alarm and water temperature monitoring purposes. Communications costs total about $4,100/yr.

3.6 SUMMARY OF DIRECT OPERATIONS COSTS

Direct operations costs are summarized in Table 3.5.

TABLE 3.5

**WATER AND SEWAGE UTILITY
ESTIMATED DIRECT OPERATIONS COSTS**

Item		**Consumption**	**Cost** $/yr
Water and sewage treatment chemicals			$ 20,900
Electricity	kWh/yr	535,600	246,100
Heating	GJ/yr	up to 21,200	111,700
Communications			4,100
Total			**$ 383,000**

Previous discussions have shown that most of the Utility system's direct operations cost is more or less fixed: most costs are not at all sensitive to Inuvik's water demand, or only slightly sensitive. Items that do vary directly by water demand are water treatment chemicals, and water supply pumping costs. It is estimated that the anticipated increase in Town water demand of about 20 percent from 2006 to 2016 will increase direct operating costs by only about $30,000 (at 2006 price levels) or about 7.5 percent. Similarly, the anticipated water demand increase from 2006 to 2026 of about 40 percent is expected to increase direct operating costs from current levels by about $50,000 or about 12.5 percent.[9]

[9] It is believed that by 2026 (and probably by 2016) Inuvik will have changed its water supply arrangements to use East Channel as its year-round source. The change will bring a substantial rise in water treatment costs from current levels (but the total economic impact will be less than what would be the case if the current, dual-source system was completely overhauled, as will become necessary). Future changes in water supply operations costs due to system upgrades and changes are beyond the scope of this study. Water supply re-development needs, options and economics are the subject of a separate study that is to be completed later in 2007.

4.0 DIRECT MAINTENANCE COSTS

4.1 INTRODUCTION

Direct maintenance costs include the purchase of replacement parts and the wide variety of hardware, supplies, small tools and so used up in maintenance work; and as well the routine cost of outside contractors regularly hired to do certain maintenance tasks.

The cost of staff engaged in maintenance work is also a direct maintenance cost. However, all staff costs, whether utilidor crew or head office support, and whether regular or seasonal, are covered in a separate section of this report.

Indirect or overhead maintenance costs, such as the cost of utility vehicles used in maintenance work, and the cost of a workshop building costs, are also dealt with elsewhere.

4.2 MAINTENANCE MATERIALS, SUPPLIES AND SUPPORT

Inuvik's water and sewage utility infrastructure encompasses a huge variety of manufactured items, ranging from building and architectural components through piping and mechanical systems, boilers and their controls, piping and pumping systems and their controls, chemical feed and testing equipment, monitors and alarms, and so on. There is a constant need for a wide variety of materials and supplies to replace worn or failing items, repair leaks, repair damage to utilidor and building envelopes, etc, and to replace consumable shop supplies.

Included here are the costs of manufacturers' support of items, such as the cost of repairs, tests and adjustments done by manufacturers and designates (not under warranty).

Inuvik's 2006 costs for all of the water and sewer utility's routine maintenance materials and support totaled $31,080, freight included. It is understood that this cost is fairly typical and representative, and the figure of $32,000 is adopted for the current purposes of this report. It is recommended that all "typical annual" figures such as this one be reviewed annually, and adjusted in light of experience.

4.3 CONTRACTS FOR SERVICES

4.3.1 Routine Local Maintenance Contracts

Certain maintenance services are routinely obtained through local contracts. Reasons for "outsourcing" include needs for special knowledge or tools (such as general electrical work, and maintenance of controls systems and electronic monitors); needs for heavy equipment (as in earthmoving for maintenance of utilidor rights-of-way); need for additional crews and management during the summer maintenance peak (brush clearing, upkeep of wood box utilidors, inspection and fumigation of timber piles); and occasional need for additional manpower for short-term planned projects or for emergencies ("as-and-when" contracts).

Inuvik's 2006 costs for the water and sewer utility's routine local maintenance contracts was $78,400. It is understood that this cost is fairly typical and representative, and the figure of $79,000 is adopted for the current purposes of this report. It is recommended that this figure be reviewed annually, and adjusted in light of experience.

4.3.2 Special Maintenance Contracts

Occupying a middle range between minor, annual maintenance tasks and large capital replacement projects are various jobs that appear to be maintenance in nature but which are infrequent, significant in cost, and in some cases not readily predictable. Examples include, among others:

- Replacement of anti-corrosion linings on the inside surfaces of large steel tanks including the main reservoir, the East Channel WTP's filters, and the chlorine contact tanks in both water plants.
- Replacement of worn or damaged larger items of mechanical equipment, such as large pumps.
- Major repairs to utilidor and vault foundations and structures.
- Repair of lagoon dikes, and repair of permafrost subsidence or erosion damage elsewhere in the utilidor system (such as Twin Lakes).
- Periodic removal of sludge from lagoons and disposal.
- Repairs following a system mishap, such as fire, a significant freeze-up, vehicle damage to utilidor, or other incident causing significant damage (below insurance deductible limits, or not within insurance coverage).

Occurrences of this scale and nature are not provided for in routine annual operations and maintenance budgets. Instead, they generally are dealt with as minor capital projects. Accordingly, they are discussed and budgeted for in Section 8 rather than in this Section.

4.3.3 Mishap Recovery Contracts

The typical example of a mishap is freezing of a short section of utilidor. Minor freeze-ups occur every two or three winters, with near misses in between. Fire is another threat.

Mishaps will continue to be a consequence of operating a utility system in a difficult setting, not entirely avoidable despite good effort by knowledgeable and alert operations personnel. Such incidents being fairly common in arctic utilities systems, insurance is unlikely to be a cost effective defense. The Utility ultimately will pay the full cost of system damage whether insured or not; either through high insurance premiums and deductibles, or directly.

Nearly all mishaps to date fortunately have been of limited consequence and cost.[1]

Much of the cost of recovering from mishaps is in staff time and overtime, and some is in indirect expenses such as use of fuel and supplies. Staff costs and indirect costs are budgeted for in other Sections.

Direct costs that are budgeted for in this Section are the cost of contractors hired to assist with recovery operation, and special supplies purchased.

---

[1] The freeze-up and destruction of the Co-op Hill "Econodor" in its first winter of operation, about 1970, was of significant consequence and cost.

While there is almost no limit on the potential cost a mishap, based on past events a reasonable amount to budget for the direct cost of a minor mishap is $10,000 to $30,000, with an occurrence frequency of every two to three years; allow $10,000 per year.

4.4 SUMMARY OF DIRECT MAINTENANCE COSTS

Estimates of direct maintenance costs and recommended cost allowances are summarized in Table 4.1.

TABLE 4.1

WATER AND SEWAGE UTILITY
ESTIMATED DIRECT MAINTENANCE COSTS

Project Category	**Allowance** $/year
Maintenance materials, supplies and support	$ 32,000
Routine maintenance contracts	79,000
Mishap supplies and contracts	10,000
Total	**$ 121,000**

5.0 UTILITY STAFF COSTS

5.1 UTILITY STAFF AND RESPONSIBILITIES: OVERVIEW

For many years Inuvik's water and sewage utility was operated and maintained by NTPC, as a very small, somewhat independent unit of NTPC's regional establishment in Inuvik. Management overview was provided by the Inuvik Utilities Planning Committee, whose members were GNWT (MACA), NTPC and Inuvik.

In June 2000 Inuvik undertook complete responsibility for the water and sewage utility, and the IUPC disbanded. Day to day operation and maintenance is performed by a crew of three Inuvik Department of Public Works employees dedicated to the system, which includes the Utilidor Plumber who acts as foreman. Day to day management is provided by Inuvik's Director of Public Works, with advice and senior management input by the Town's Senior Administrative Officer (SAO). Other Town departments, such as finance, lands administration, and personnel, have specific roles.

Policy decisions, including setting of rates, are made by the Mayor and Council. A subcommittee of Council, the Public Works Committee, provides advice to Council.

5.2 UTILITY STAFF COST

5.2.1 Information Provided

Utility staff costs are reported below, as summaries, for confidentiality.

5.2.2 Full-Time Utility Staff

As noted above, Inuvik has a crew of three hired specifically to look after the operation and maintenance of water and sewage infrastructure. Staff costs include wages, overtime pay, the Town's costs of usual staff benefits and allowances, and special allowances (such as for the purchase of protective clothing required).

The current total annual cost of full time utility staff is $246,000.

5.2.3 Part-Time Utility Staff

Summer workers may be hired to do specific tasks, such as re-painting wood box utilidors (needed to resist moisture damage).

In recent years there have been no part-time workers hired directly. Seasonal labour has been provided under "as and when" contracts. The cost is included in the contract costs reported in Section 4.

5.2.4 Town Office Staff Allocation to Water and Sewage Utility

Various members of Inuvik's Town Office staff have water have responsibilities for water and sewage system functions.

The Director of Public Works spends approximately half of his time on water and sewage utility matters, and his administrative assistant about 40 percent. Similar allocations for the SAO, the Director of Finance, and the billing clerk are about 30, 35 and 50 percent respectively.

Accordingly, the current total annual cost of headquarters support of utility matters is estimated to be $169,000.

5.3 SUMMARY OF UTILITY STAFF COSTS

The water and sewage utility's annual cost of assigned staff is $246,000. Its annual cost of town office staff allocated to utility duties is estimated to be $169,000. The estimated annual total is $415,000.

6.0 UTILITY OFFICE AND SHOP COSTS

6.1 INTRODUCTION

As in any business, the operation of a municipal utility system generates a wide variety of indirect and overhead costs, both capital and operating.

Capital costs, or lease equivalents, stem from provision office and workshop building spaces, yards, and furnishings, tools and equipment (including vehicles, and mobile equipment if any).

Office costs include building utilities, building maintenance and janitorial service; office equipment maintenance and repair; software purchase and support; stationery and office supplies; office small purchases; postage; phone and fax long distance. There are also various classes of insurance (for infrastructure; for public and personnel liability; and for vehicle ownership and operation); professional audit, legal and engineering services; lands administration costs; among others.

Shop costs include a range of consumable items including small tools: shop costs such as these have been covered as operations and maintenance costs.

Utility vehicles (or Town vehicles on utility business) comprise another, related cost area.

6.2 SOURCES OF COST

6.2.1 Cost Allocation

The Town Office is the administrative centre for all of the Municipal Corporation's diverse activities and services. Generally, there is no practical way to trace an individual office cost to a specific activity, but total costs can be determined and can be allocated between activities on a rational basis.

6.2.2 Office, Shop and Yard Lease Equivalents

The Town Office, and the Utilidor Shop and its yard are owned by the Town.

If the water and sewage utility was to be set up as a separate entity, it would have to purchase or lease office space at least equivalent to the portion of the Town Office attributable to its operations, and a shop and yard. Town staff estimate that the equivalent current annual lease cost would be $256,000.

This is not a cash payout by the water and sewage utility. On the other hand, this amount represents value that the water and sewer utility is receiving from other sources – probably, from past expenditures by Inuvik's tax base.

6.2.3 Office and Shop Operations and Maintenance Costs

As noted in Section 5, some portion of the total amount of work done in the Town Office relates to the water and sewage utility, directly or indirectly. Accordingly, it is proper to allocate some portion of the Town Office's total operating and maintenance expenses against the utility.

Allocations estimated by Town staff, based on analysis of total annual costs, are listed in Table 6.1.Some shop costs, in particular purchase of materials and supplies, small tools, etc, have been reported in Chapter 4, and therefore are not included here.

TABLE 6.1

**UTILITY OFFICE AND SHOP
ESTIMATED ANNUAL COSTS**

Item	**Cost** $/year
Building maintenance	$ 5,000
Building utilities, Town Office	12,060
Building utilities, Utilidor Shop	16,030
Janitorial	7,080
Office equipment O&M	2,670
Office supplies and stationery	7,000
Courier, freight and postage	4,170
Phone, fax, long distance	5,020
Software purchases and support	16,300
Accounting, auditing	4,070
Total	**$ 79,400**

6.2.4 Insurance Cost

Inuvik purchases all of its insurance, of all classis, in one large package. Town staff estimate that the portion of current annual insurance cost attributable to the water and sewage utility is $62,720. This amount excludes insurance on utility vehicles.

6.2.5 Vehicle Costs

Operating and maintaining a system spread out over the entire townsite requires mobility of personnel and tools. The water and sewer utility has two pick-up trucks with custom-fitted tool boxes. As well, about half of the capital and operating cost of the Director of Public Works' vehicle is attributable to water and sewer utility operations.

In addition, the utility has two quads, needed for access along the Lake B pipeline.

Vehicle costs and allocations estimated by Town staff are summarized in Table 6.2.

TABLE 6.2

**UTILITY VEHICLES
ESTIMATED ANNUAL COSTS**

Item	**Cost** $/year
Trucks capital cost, amortized over 6 yr.	$ 25,000
Quads capital cost, amortized over 10 yr.	2,000
Insurance	4,720
Repairs and maintenance	10,040
Fuel	12,230
Total	**$ 54,000**

6.2.6 Water Licence

Inuvik operates its water and sewage utility under a Water Licence granted by the Gwich'in Land and Water Board (GLWB).

The Licence requires monthly testing of lagoon effluent, and of runoff from the Mt. Baldy landfill, and certain other monitoring, including an annual engineer's inspection of the lagoon dikes. Reports to the GLWB covering a range of specified topics are required quarterly and annually. The total annual Licence maintenance cost, including sample freight and testing, and reporting, is $6,000.

The current Licence was granted in 2006, for a period of ten years (the normal maximum). The cyclic renewal of the Licence typically involves submission of supporting technical studies, presentation at a public hearing, meetings with the Water Board and its Technical Advisory Committee, and compliance with licence conditions. Water Licence renewal costs in 2005-07 (including compliance with conditions requiring additional technical submissions) were $30,000. The average annual cost allowance implied is $3,000.

6.2.7 Operations Engineering Services

Inuvik's Engineering Consultant provides interacts frequently with the Director of Public works and with utilidor O&M staff, providing advice. The Engineer also makes an annual inspection of utilidors for assessment of aging rate and capital planning. In recent years the annual cost has ranged between $7,000 and $17,000. The allowance made for the purposes of this study is $18,000.

6.2.8 Miscellaneous Office Costs

Costs that have been included under miscellaneous office costs include some professional development expenses (which could be classified as a staff cost); service charges, and advertising. The portion of the total of identified miscellaneous costs attributable to the water and sewage utility is $6,900.

6.3 SUMMARY OF UTILITY OFFICE AND SHOP COSTS

Utility office and shop costs, including vehicle costs, are summarized in Table 6.3.

TABLE 6.3

UTILITY OFFICE, SHOP AND YARD ESTIMATED ANNUAL COSTS

Item	**Cost** $/year
Office, shop and yard lease equivalents	$ 256,000
Office and shop operations and maintenance costs	79,400
Insurance	62,700
Vehicle costs, including capital	54,000
Water licence	9,000
Engineering advice	18,000
Miscellaneous	6,900
Total	**$ 486,000**
Total excluding non-cash item (lease equivalent)	**$ 230,000**

7.0 CAPITAL COSTS

7.1 INTRODUCTION

7.1.1 Capital Projects

Capital costs arise from the water and sewer utility due to

- major rehabilitation of utility infrastructure, on a scale too large to be funded routinely from operations and maintenance accounts,
- replacement of utility infrastructure too worn out or obsolete to be rehabilitated, or whose capacity has been overtaken by increased water demand, requirements for higher standards or service, or other overriding need,
- extension of water and sewage services (utilidors) into new development areas, and
- other major changes, such as addition of a second reservoir, change of water supply arrangements to year-round use of East Channel, or change in sewage treatment method from the lagoon system to a mechanical plant.

Capital costs in the third category, utilidor extension projects, are intended to be recovered through sale of the newly-serviced building lots. Accordingly, this category of capital costs is excluded from the calculation of the unit cost of water.[1,2] Capital costs that do affect the unit cost of water are those for rehabilitation work, replacement projects, and other major changes.

7.1.2 Uncertainties in Forecasts

As seen in earlier chapters, most operations and maintenance costs follow seasonal and yearly patterns established by history; a fact that is quite helpful in forecasting and budgeting. Capital costs, on the other hand, tend to be unique large expenses whose timing and magnitude usually are difficult to determine, especially far in advance.

Timing usually depends on some other forecast, such as rate of physical decline or rate of Town growth: parameters that tend to be quite uncertain themselves. Costs tend to be very uncertain in early planning stages before the project has been thought out in any detail; and even following predesign study may be difficult to pin down owing to the unique nature of most utilities projects, and to the many community-specific factors that affect the cost of construction work.

7.1.3 Year-to-Year Variability

Another budgeting problem, additional to uncertainty in forecasts, is the unevenness of capital needs, year to year. One way of preparing for capital needs variability is through

---

[1] Initially the Town carries the full cost of a development, and continues to carry the residual balance of cost until all lots are sold. It is assumed that any costs not recovered from land sales are covered by general taxation rather than the water and sewage utility.

[2] The prices Inuvik charges for lots are, in simple terms, the total of its direct costs (engineering, construction, legal survey, etc.) divided by the number of lots. The prices a private developer would charge would also have to include risk cost, and overhead and profit.

a revolving fund, which is drawn down in years of greater capital needs and is rebuilt in years of less activity. The combined uncertainties in capital planning make it difficult, though, to set a rate of deposit that will safely sustain the fund in short, medium and long terms, without unduly burdening the customer base of the current time. Attempting to strike a reasonable balance between the management of a reserve fund and debt financing may be more acceptable.

7.1.4 Analytical Approach

A usual method of assessing future capital needs is to develop a detailed five-year capital plan and a more general twenty-year one. However, capital planning is a large and separate area of study, well beyond the scope of the current assessment of Inuvik's unit cost of water.

The approach taken here is to examine, first, overall system replacement costs at current price levels, and to attempt to estimate the timing of broad categories of replacement needs. Combined, the estimates of total cost and approximate timing provide a reasonable indication of the of typical average annual capital cost that the Town needs to be prepared to meet for replacement of infrastructure alone.

Subsequently, capital cost allowances are developed for foreseen major changes, and for rehabilitation work.

7.2 CURRENT REPLACEMENT COST, ALL FACILITIES

7.2.1 Overview

For the purposes of this section, Inuvik's water and sewage infrastructure is broken into three broad categories:

- The utilidor system: all outdoor water and sewage mains, including "trunk" water supply mains and main sewers running to the lagoon.
- Water supply facilities: everything needed for extraction and treatment of water, and storage of treated water.
- Sewage treatment facilities: the lagoon system.

7.2.2 Replacement Cost of Inuvik's Utilidor System

At one time Inuvik had 5.4 km of wood box utilidors, all built between 1966 and 1978. By the late 1980's serious levels wood rot were beginning to be seen in the older installations. Since 1989 the Town has been replacing wood box utilidors in stages, as threats of structural collapse appear. The total done to date is about 4.5 km. These projects provide good data for estimating utilidor replacement costs.

It is estimated that the total cost of replacing Inuvik's 18.3 km long utilidor system, including the 15 circulation, reheat, booster pumping stations embedded in it and the truck fill point, would be $113 M, $2007.

7.2.3 Replacement Cost of Water Supply Facilities

Water supply facilities as referred to here include water intakes, raw water supply pipelines, treatment plants, and treated water storage (the Hidden Lake reservoir and valve house). Treated water supply mains (the main from Hidden Lake to J106 at Gwich'in Road) are excluded, having been included in utilidors.

When need for change arises, economics will dictate development of East Channel as Inuvik's year-round water supply, rather than re-development of the Lake B – Hidden Lake water supply system for either year-round or seasonal use.

The cost of a year-round intake and water treatment plant using East Channel are not yet known. Based on costs of somewhat comparable projects in communities of somewhat comparable size, a reasonable figure to use for very early planning purposes is $10 M. Site restoration costs (removal of the Lake B pipeline and other abandoned facilities, and any other restoration or remediation costs) would be additional and would likely be significant. For current planning purposes, the total allowance made is $11 M.

The Hidden Lake reservoir and valve house were built in 1976-77, at a cost of about $750,000 ($1976-77). The boilers in the valve house were added in 1998, at a cost of $245,000 ($1998). The current replacement value of the reservoir and valve house is believed to be around $3 M.

Accordingly, the total replacement value of water supply facilities (based on future change to East Channel as year-round supply) is believed to be in the order of $14 M.

7.2.4 Replacement Cost of Sewage Treatment Facilities

Most of the investment in Inuvik's sewage treatment facilities is in earthwork. Although earthwork requires annual maintenance, as discussed later, aging and eventual replacement are not issues in the same sense as they are for wood and metal structures and mechanical systems. Accordingly, the lagoon system is not included in the discussion of replacement costs.

7.2.5 Summary, Total Replacement Costs

In summary, current replacement costs are estimated to be about $113 M for the entire utilidor system and an additional roughly $14 M for water supply facilities. Excluding the lagoon system, the current total replacement cost of Inuvik's water and sewage infrastructure is believed to be in the order of $127 M.[3]

It can be seen that the utilidor (water distribution and sewage collection) system represents roughly 90 percent of the total replacement costs reported above. Evidently, the need to replace utilidors as they reach the end of useful service life will drive of much of the water and sewage system's capital costs, for so long as the Town exists.

[3] Adding in the cost of the lagoon, and the cost of a few subsystems not directly accounted for (water temperature monitoring system, for instance) brings the total replacement cost of Inuvik's water and sewage infrastructure to approximately $135 M. Concrete bridge and arch bridge overcrossings of utilidors are not included in that total.

Accordingly, in the sections below, anticipated timing of utilidor replacement needs is discussed first, and questions of water supply facilities next.

7.3 USEFUL SERVICE LIFE OF UTILIDORS

7.3.1 General Considerations

Obviously, utilidors are costly assets, and it is well worthwhile to make all reasonable efforts to maintain utilidors in good repair and to extend their useful service lives to the maximum. This involves patrols in shoulder seasons and summer, and thorough restoration of the visible depredations of weather, moisture and aging; frost heave and settlement; careless homeowners/occupants, non-utility workers, pedestrians and vandals; and so on.

In typical urban settings elsewhere in Canada, municipal piping systems of non-corroding materials are buried in stable ground. Isolated from virtually any disturbance, they last a very long time. In Inuvik, where aboveground installation is dictated by thaw-sensitive ground, and use of materials vulnerable to corrosion is dictated by structural needs, utilities are directly affected by ground movement, extremes of weather, and various other agents of deterioration. Even with attentive maintenance, a point will be reached where repair is physically impractical – would involve, in effect, a near-total rebuild - or where the annual cost of repairs becomes a greater burden than the replacement cost would be.

Being a relatively new innovation on the time scale of municipal utilities generally, utilidors have little track record to indicate typical useful service lives. Forecasts of useful service life therefore have wide ranges of uncertainty.

7.3.2 Construction Style

Over the years, half a dozen designs of utilidors have been developed and tried in Inuvik; most of the ones developed in the late 1960's and through the 1970's the reflecting attempts to get around the very high capital cost of the original "HTW-style" utilidor. Several of these are no longer in existence. One of them had the spectacularly short service life of less than one winter. Obviously, within the group of surviving construction styles, some are proving to be more durable and some less so.

As indicated earlier, older styles that remain in service in 2007 include the original HTW one (6.6 km), CMS[4] (0.9 km), wood box (also 0.9 km), and JIPWP[5] (2.4 km).[6] The remainder of the 18.3 km system is made up of buried single mains (mostly water) (0.7 km), new "JIPSP-style" utilidor (6.5 km), and mains in building crawl spaces (0.2 km).

---

[4] Corrugated metal shell water and sewer utilidor.

[5] Jacketed insulated pipe on wood piles, which generally was used for single mains, water or sewer. Most of Inuvik's total length of JIPWP utilidor is in trunk sewage mains leading to the lagoon.

[6] The rest of the system is made up of buried single mains (mostly water) (0.7 km), new JIPSP-style (jacketed insulated pipe on steel piles) utilidor (6.5 km), and mains in building crawl spaces (0.2 km).

7.3.2.1 Wood Box Utilidors

Plywood is not a very durable material in exposed outdoor use. In other communities where wood box utilidors have been tried, useful service lives have been in the order of 20 years. Inuvik, through frequent maintenance of shell exteriors and occasional work on internal framing, has surpassed that figure by a considerable amount.

Even with the most diligent maintenance it is impossible to keep wood box utilidors sealed against intrusion of rain and melt water, especially where they are used as sidewalks. The wood box utilidors opened up in recent years have all been found to be in a state of near collapse, with internal framing and pipe supports largely rotted away over extended sections. Inuvik's surviving wood box utilidors are all of similar age, now 30 to 35 years old, and there is no reason to think that those still in service are in any better condition than those recently examined in detail during demolition.

The wood box utilidor in Block 47 still appears, externally, to be in fair condition, and this may be due to its relative isolation from pedestrian traffic routes. The wood box utilidors in Blocks 44-37-81 and Block 79 are in poor condition and need to be replaced before a collapse occurs.

7.3.2.2 Corrugated Metal Shell (CMS) Utilidors

As the name suggests, CMS utilidors have shells of formed, galvanized corrugated steel, which avoids the delamination and decay issues of plywood. However, the pile-cap-and-beam substructures that carry the shells are all of bolted timber, and do suffer considerably from weathering, and as well from distortion due to pile movement caused by ground heave, subsidence and downslope creep.

The CMS utilidors were built in a single large project in 1970, so now are 37 years old. The shells are in fair condition; though poorly sealed and leaky (which could be overcome by foam-insulating within the shell). Pipes are asbestos cement, brittle but immune to corrosion. The timber substructure is in fair to poor condition, but accessible for emergency patching. The foundation is a single line of locally-supplied piles, very vulnerable to groundline decay and toppling: and most piles have (or need) polesplints.

Although far from robust, the CMS utilidor can be kept in service year-to-year, as long as it is watched and maintained carefully. The greatest threats are foundation failure due to groundline rot, and a freeze-up due to the shell's poor weathersealing. A freeze-up or a structural failure in winter could affect water and sewer service over several blocks.

For estimation of capital needs it is assumed that the need to replace CMS utilidors is at least four or five years away. Barring a serious mishap, and assuming continued good maintenance, it might be put off farther, again on a year-by-year basis. It would probably not be realistic to plan for very long future service life, so it is assumed for current purposes that replacement will be found necessary within the next ten years or so.

7.3.2.3 JIPWP Utilidors

As noted earlier, JIPWP utilidors are single, jacketed insulated pipes on wood piles. Of the 2.4 km total length, 0.2 km is in raw water supply and drain pipes for the East Channel water treatment plant, so if necessary probably would be replaced as part of some future water supply upgrade, and 0.1 km is in a water main link from Block 81 to

Block 4 that would be replaced as part of the Blocks 44-37-81 wood box utilidor. The remaining 2.1 km is in trunk sewer lines leading to the lagoon.

Most of the 2.1 km length of trunk sewers dates from 1975. Most of that appears to be in reasonably good condition externally, except that the single line of locally-supplied supporting piles is very susceptible to groundline rot and most piles have or need polesplints. The pipes, however, are steel originally lined with coal tar epoxy, and their interior condition relative to possible corrosion is not known. Inspection by camera, or, if necessary, by removal of coupons or a test section of pipe, is recommended.

If pipe corrosion is found and begins to become a serious concern, it may be possible to extend the useful life of the steel pipe by lining. Steps can also be taken to increase the security of the foundation, and extend its life; it might also be possible to move the existing pipeline onto a replacement steel-piled foundation installed alongside.

The short run of trunk sewer behind the RDR building from J51 to Int A ("RDR sewer") dates from the late 1950's, not 1975, and is only 200 mm pipe. The line's tributary area includes much of the east side of Town, starting at the hospital, and the Distributor area, starting at the Mackenzie Hotel. Capacity problems may occur here, and force early replacement of about 150 m of pipeline.

With the possible exception of the RDR sewer, and subject to continued maintenance of foundations and to absence or control of any serious internal corrosion of pipe, there is no reason currently apparent why the JIPSP sewers should not continue to serve for another one to three decades before significant capital needs arise from the pipeline itself. There are, however, needs to maintain and improve the right of way and access route, but earthwork maintenance is dealt with separately.

7.3.2.4 HTW Style Utilidors

With its strong structural steel frame, aluminum sheathed panels, and concentrations of panel and flashing screws, the HTW-style utilidor is proving to be a very durable design. As well, its asbestos-cement water and sewer mains do not corrode.

The system's primary weakness is its foundation. Although the piles are imported, most of fairly large diameter, and well treated with fungicide, they are now vulnerable to groundline rot and must be fumigated cyclically and repaired with polesplints when necessary. As well, HTW utilidor traverses a number of flat, poorly drained areas, and suffers considerably in places from pile heave and ground subsidence.

Another threat is fire. Although the foam insulation installed in the late 1990's is self-extinguishing, the high heat generated by surface burning is sufficient to ignite both the wood framing and thin aluminum skin of side panels. Further, it has been found that the chimney draft effect within the open space in the utilidor box above the lower pipe gallery can spread fire quickly along the utilidor's length. A recommendation made at earlier times is repeated: that draft stops be installed at reasonable intervals along the utilidor's length. Putting stops at existing concrete blocks (or equivalent interval) would appear to provide compartments of reasonable size to buy time for active firefighting if need were to arise.[7]

The HTW-style utilidors are now 40 to 50 years old. Subject to continued maintenance of foundations and to absence or control of insulation fires there is no reason currently apparent why they should not continue to serve for a considerable time into the future. The question remains, though, how long will they actually last; at what point in the future will Inuvik need to be prepared to replace them? A typical service life of as much as 70 years seems reasonable to hope for, but one as high as, say, 100 years would not. If a minimum service life of 60 years is chosen for planning purposes, then Inuvik would need to start replacing HTW-style utilidors about the year 2017, and complete the process over a twenty-plus year period.

7.3.2.5 Other Styles of Utilidor

Other styles of utilidor to be considered include pipes within building crawl spaces, buried pipes, and the newer “JIPSP-style” utilidor.

Public water mains (not sewers) pass through the crawl spaces of SAMS and SHSS. For reasons of circulation (for freeze protection) and fire flow delivery, both of these links will need to be replaced, presumably with buried lines, if or when the schools are demolished. It is not known whether GNWT, as owner of the host buildings, would assist with the cost of replacement, made necessary by building removal. The total length of mains in building crawl spaces is only about 215 m, although the total length of utilidor that would be affected by removal of SAMS is somewhat longer.

As noted earlier, pipes buried in stable soil are pretty well isolated from damaging influences. Permafrost soils are, unfortunately, not always stable, and there have been instances (not in Inuvik) of ice wedging effects flattening buried pipes. Barring such problems, or a freeze-up caused by lapse in circulation, there is nothing currently apparent to suggest that Inuvik’s buried lines will need to be replaced within a planning horizon significant to the current assessment of the unit cost of water.

The JIPSP style of utilidor is intended to be more tough and durable than its CMS, wood box and JIPWP predecessors, but much less expensive to build than the highly durable HTW-style utilidor. It is hoped that the JIPSP style of construction will prove to be at least as durable as the HTW style has been, though only time will tell. Use of steel pipe is dictated by structural needs, and the system’s Achilles’ heel is thought to be corrosion of the pipe at breaks in its cement mortar lining – notably at service connection taps and pipe joints. Maintenance will in time be needed to keep corrosion at bay. As in the case of HTW-style utilidor, a typical service life in excess of 60 years seems reasonable to hope for,[8] but one as high as, say, 100 years would not.

7.4 IMPLIED UTILIDOR REPLACEMENT SCHEDULE

Summarizing the preceding discussion of different utilidor construction styles:

---

[7] A better though probably more expensive treatment would be to remove tops and apply a compatible fire retardant on top of the foam.

[8] Assuming that Inuvik’s permafrost is not warmed by climate change so much that existing adfreeze piles cease to carry design loads or to resist heave forces.

- Wood box utilidors are, for the most part, at the end of useful service life, and need to be replaced before a collapse occurs at some inconvenient time of the year.

- Corrugated metal shell utilidors are in fair to poor condition, but can be kept in service year-by-year. For current purposes it is assumed that they will need to be replaced within the next ten years or so.

- JIPWP style utilidors. If Inuvik continues to develop as in recent years, it is likely that the RDR sewer will need to be replaced within the next ten years or so. Other lines need significant annual foundation maintenance (which has been dealt with in an earlier section) and may need to be lined or replaced if corrosion emerges as a threat to the steel pipes. For current purposes it is assumed that the RDR sewer will need to be replaced within ten years, and that other main sewers will need to be replaced within the next 30 years. No allowance is made for major restoration projects (lining, for instance) in the interim.

- HTW-style utilidors. For current purposes it is assumed that deterioration of foundations and loss of grade will force gradual replacement, over a 20 to 30 year period, starting about 2017.

- Other styles of utilidors. There are no clear needs, apart from the possibility that Inuvik may be burdened with costs of restoring water main links when SHSS and SAMS eventually are demolished.

7.5 IMPLIED UTILIDOR REPLACEMENT COST

The aggregate cost of replacement of the wood box utilidors is forecast to be $4.6 M.[9] The two larger projects (Blocks 44-37-81; Block 79) cannot be deferred for long. It is assumed that all of this work will be done in the next four years. The implied average near-term rate of capital investment in utilidor replacement is $1.15 M per year.

The aggregate cost of replacement of the wood box and CMS utilidors and the RDR sewer is forecast to be $11.1 M. If it is assumed that all of this work will be done in the next ten years, the implied average medium-term rate of capital investment in utilidor replacement is $1.11 M per year. Response to any emergencies that emerge in the meantime would be additional.

The aggregate cost of replacement of the wood box, CMS, JIPWP and HTW utilidors is forecast to be $49.5 M. If it is assumed that all of this work will be done in the next 40 to 50 years, the implied average long-term rate of capital investment in utilidor replacement is $1.00 to 1.24 M per year.

In summary, it appears that Inuvik will need to budget between 1.10 and 1.25 M per year (rounded, slightly) for utilidor replacement. In the near term, it appears that the average annual cost will be $1.15 M.

---

[9] All cost forecasts given in this section are at 2007 price levels. If forecasts are used for capital planning purposes, allowance for inflation needs to be added in.

7.6 REPLACEMENT OF WATER SUPPLY FACILITIES

7.6.1 General Considerations

As discussed in an earlier section, when need for major renewal of water supply infrastructure arises, Inuvik will abandon the dual-source water supply system that has served it well for many years and develop supply and treatment system using East Channel year-round.

Existing water supply and treatment infrastructure is old and in some cases shabby, but operational. No serious issues of capacity or condition are currently evident. In the near-to-medium term, the factor that seems most likely to impel change is rise in the quality objectives for treated water, and concurrent rise in consumer expectations.

Existing treated water storage infrastructure remains in good condition, insofar as is known at this time. Inuvik plans an inspection of the interior of the reservoir by a diver later this summer.

Inuvik has for many years carried in its capital plan the twinning of the Hidden Lake reservoir, and the concurrent twinning of the Hidden Lake trunk water main down to Valve House T opposite Ptarmigan Subdivision. Doing so would increase the security of the water supply system, will improve fire flows once the new 250 mm water main link to Block 46 is completed, and will make it possible to take one reservoir out of service for cleaning without service interruption. However, there will be more pressing demands on Inuvik's capital resources for some if not many years, and this concept is unlikely to become a priority in the foreseeable future.

7.6.2 Capital Projects: Water Supply Facilities

It is believed that Inuvik will, in the near-to-medium term, upgrade its water supply and treatment infrastructure to meet incoming standards of water quality. This will involve construction of a year-round intake in East Channel, and construction of a water plant capable of treating East Channel's turbid summertime water and of meeting anticipated standards.

Currently, samples are being taken to record the quality of raw water in East Channel, to be used in initial selection of possible water treatment processes.

At this time not enough is known about the future infrastructure to develop a forecast of capital (or operating) costs. As indicated earlier, it is thought that the capital cost would be, very roughly, somewhere in the neighborhood of $10 M. An allowance of $11 M is made for the entire intake and treatment plant project.

Financing $11 M at 6 percent over 40 years would result in an annual installment of about $730,000.

7.7 SEWAGE TREATMENT FACILITIES

As noted earlier, in 2006 Inuvik was again granted a water licence renewal valid until 2016. Aside from the possibility of relevant regulatory changes not currently foreseen, the Town may continue to treat sewage in its lagoon system at least until that time.

Condition B10 of the 2006 water licence requires Inuvik to submit to the Water Board an "assessment of potential sewage options . . . suitable to allow [Inuvik] to meet territorial and federal guidelines . . . .". Whether or not the required assessment, or in particular any change in territorial or federal guidelines, is likely to result in a change in Inuvik's sewage treatment methods is not foreseeable. Past studies, done within the frame of reference of existing guidelines and their objectives, have not found anything wrong with the existing system.

There are no known major capital requirements arising from sewage treatment works. The need to restore dikes periodically is dealt with elsewhere.

7.8 RESTORATION AND RENOVATION PROJECTS

7.8.1 Introduction

Previous Sections have dealt with major replacement and expansion projects. Capital budgets also need to consider, in addition, a wide variety of restoration and renovation projects. Typically, these aim at protecting existing facilities and extending their useful service lives. Often size alone distinguishes them from ordinary maintenance work. Examples include restoration of lagoon dikes, earthwork restoration of utilidor routes (such as at Twin Lakes, and in recently-developed subdivisions), re-lining of the reservoir; among others.

The timber pile testing and fumigation programs could also be included here, but have already been covered in an earlier chapter.

7.8.2 Recommended Cost Allowances

Ground instability effects are usual and virtually unavoidable in Inuvik. In addition, the earth fill available from local quarries is of only fair quality for earthwork construction.

The lagoon dikes require minor restoration in most years, and occasional major restoration projects. Examination of cost records indicates that lagoon dike restoration costs (adjusted to 2006 levels) average $50,000 per year.

The unstable slope below the main sewer at Twin Lakes requires restoration every ten to fifteen years, and is due for attention now. There is also a considerable backlog of work to be done in restoring settled utilidor rights of way in subdivisions developed from 1990 onward. It is recommended that the average allowance for these items be $50,000 per year. Costs in years immediately ahead are likely to be above this level.

An allowance is also needed for such things as tank lining, replacement of mechanical and electrical components such as pumps, boilers, control systems, utilidor expansion joints; and many other miscellaneous and unforeseen things. There is little track record on which to base an estimate, however. For current purposes the recommended allowance is $30,000 per year: in time, cost accounting records will provide a basis for refining the allowance.

In summary, the total recommended allowance is $130,000 per year.

7.9 SUMMARY OF SUGGESTED CAPITAL COST ALLOWANCES

Recommended capital cost allowances are summarized in Table 7.1.

TABLE 7.1

**WATER AND SEWAGE UTILITY
ESTIMATED CAPITAL COSTS**

Project Category	**Allowance** $/year
Utilidor replacement	$ 1,150,000
New water supply and treatment system	730,000
Restoration and renovation projects	130,000
Total	**$ 2,010,000**

As indicated earlier, there are very wide ranges of uncertainty in forecasts of capital funding needs, arising from both uncertainty about useful service lives of existing components and uncertainty about costs. Regarding the recommended allowances reported in Table 7.1, near-term utilidor replacement costs are known fairly well, but costs in the other two categories are far less clear.

8.0 COST SUMMARY

8.1 INTRODUCTION

In acting as custodian of its water and sewage utility, Inuvik needs to raise the full amount of the system's operations, maintenance and capital costs from its available sources of income. GNWT's annual water and sewage subsidy goes a certain distance toward covering total annual cost, including capital costs. Setting aside general tax revenues, the remaining cost must be raised from charges to customers.

Total costs affecting water and sewage rates are summarized in this Section.

8.2 SUMMARY OF UTILITY COSTS

The utility costs described in earlier Sections are summarized in Table 8.1. The cost base year is 2006. Subtotals are rounded to the nearest $000.

As noted, the Utility's total annual cost is believed to be approximately $3,415,000 (2006). Of that amount, $1,405,000 is for O&M costs, which are reasonably well defined, and $2,010,000 is for capital costs, some of which are considerably less certain.

If the non-cash item of equivalent lease cost for office, shop and yard is taken out, the total annual costs becomes $3,159,000, of which $1,149,000 is for O&M costs.

8.3 UNIT COST OF WATER

In 2006 the total amount of water recorded on water bills issued by Inuvik was 310 ML.

Accordingly, the cost summary reported in Table 8.1 indicates that the 2006 unit cost of water was $11.02/m^3 ($0.0110/L). With the non-cash equivalent lease cost taken out, the unit cost becomes $10.19/m^3 ($0.0102/L).

TABLE 8.1
TOTAL ANNUAL UTILITY COSTS, $1998

Cost Source		**Cost** $/year
Direct Operations		
Chemicals		20,900
Electricity	524,500 kWh/y	246,100
Heat		111,700
Communications		4,100
Subtotal, Direct Operations		**383,000**
Direct Maintenance		
Materials, supplies and support		32,000
Routine maintenance contracts		79,000
Mishap supplies and contracts		10,000
Subtotal, Direct Maintenance		**121,000**
Staff Cost		
Full time utility staff		246,000
Headquarters staff		169,000
Subtotal, Staff		**415,000**
Utility Office and Shop Costs		
Office, shop, yard lease equivalents		256,000
Office and shop O&M		79,400
Insurance		62,700
Vehicle costs		54,000
Water licence		9,000
Engineering advice		18,000
Miscellaneous		6,900
Subtotal, Headquarters		**486,000**
Capital Cost		
Replace utilidors	Near-term avg	1,150,000
Future water supply	Financed	730,000
Restoration and renovations projects	Allow	130,000
Average annual capital cost		**2,010,000**
Utility Total		**$ 3,415,000**

With the non-cash item of office, shop and yard lease equivalents taken out the total is $3,159,000.