Government of Nunavut

Char Lake Replacement Design Brief

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Project Name
Char Lake Replacement

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Prepared By:

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 7H6
Canada

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Prepared By:
exp
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada
T: 613 688-1899
F: 613 225-7337
www.exp.com

REGISTERED PROFESSIONAL ENGINEER
OCT 17/17
D.F. McGOVERN
LICENSEE
N.W.T.

Farrell McGovern, P.Eng.
Consultant

Steven Burden, P.Eng.
Senior Manager – Infrastructure Services

PERMIT TO PRACTICE
EXP SERVICES INC.
Signature
Date 2017-10-17
PERMIT NUMBER: P 483
NT/NU Association of Professional Engineers and Geoscientists

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1 Introduction

1.1 General

The following report is presented as the Design Brief for the replacement of the Char Lake pump house.

1.2 Community Description

The Hamlet of Resolute Bay (Hamlet) is located on Cornwallis Island at N74°42' and W94°52'. Resolute Bay has a reported population of almost 250. The climate is especially challenging in this community. Average annual temperature is -16.7°C and average annual wind speed is 21 km/hour. The lowest temperature recorded at this site is -52.2°C and the highest recorded hourly wind speed is 142 km/hr. Wind chill temperature as low as -72°C has been observed. The extremely low temperatures are combined with a protracted period of dark during the winter. The combination of temperature, high wind and lack of daylight create challenging operating conditions for much of the year.

The Hamlet is made up of two areas; the airport area and the town site. The needs of the airport area are currently met using a truck service delivery system. There is no current intention to modify this servicing scheme. In the late 1970s the majority of the permanent population of the community were relocated to the current town site area. The town site area was developed with piped water distribution and sewage collection networks.

1.3 Project Evolution

The Sustainable Water and Sewer Servicing Study (Trow, 2011) examined a broad range of alternative methods of meeting the water and sewer requirements for the town site area. The assessment considered both capital costs as well as operational needs for a 30 year operating life. A recommended servicing scheme was proposed, and following review, this proposal was ratified by the Government of Nunavut. At that juncture the proposed servicing scheme included rehabilitation of the existing Chat Lake pump house.

A pre-design report was prepared for the proposed new servicing installations. This report presented greater detail regarding the scope of work to be included in a rehabilitation of the Char Lake pump house.

In September 2012, as part of the geotechnical investigation for new water and sewer system, drilling was conducted on the site of the existing pump house. A strong hydrocarbon odour from the drill cuttings was noted. In view of the proximity of the pump house to the community water supply, a further assessment of petroleum contamination was conducted. This included a field program and the preparation in November 2012 of an initial report delineating the extent of contamination.

In January 2013 an opinion was transmitted to the Project Management Office regarding the implications of petroleum contamination of the existing pump house site. Remediation of the contamination was recommended, and it was further noted that this decontamination of the site would require the construction of a new pump house on a new site.

Further assessments of the scope of contamination and the effort required to mitigate this contamination were conducted during the summer of 2015. The findings, opinions and recommendations arising from this program are presented under separate cover. Following the review of this report direction was received from the Project Management Office to proceed with the design of a new pump house at Char Lake, together with the replacement of the watermain connecting the pump house with the water treatment plant.

1.4 Project Scope

Provision of a new pump house and remediation of the site of the new facility will entail the following activities.

- Site works including access and a power line.
- Provision of a new building including electrical and mechanical systems.
- Provision of new intakes into Char Lake
- A new transmission watermain interconnecting the pump house with the water treatment plant.
- Remediation of petroleum contamination of the existing site and management of the contaminated soil.

Continuation of service requires that the existing pump house remain in service during the construction of the new facility. The combination of logistics to the site and local climate raise significant challenges. Among these is recognition in the schedule that the new facility cannot be completed until very late in the year. Prudence suggests that commission be delayed until the following summer when weather and daylight will be more conducive to success.

The opportunities to reuse existing equipment have been considered. This evaluation has considered the requirements for the maintenance of service prior to the commissioning of the new facility and the implications of delaying commissioning into the following summer.

2 Project Scope

The scope of the project can be broadly stated as those works required to take water from Char Lake and transmit that water to the water treatment plant at the town site. This scope includes the following works.

- An intake structure.
- Lake water pumping equipment.
- A transmission watermain linking the pump house with the water treatment plant.
- Measures to reduce the risk of freeze of the transmission watermain including the following.
  - Water temperature tempering capabilities
  - Methods to reduce the risk of freeze between lake water pumping cycles
  - Active heat input along the transmission watermain.
- Supporting services within the pump house including
  - Electrical power supply
  - Emergency electrical supply
  - Heating system
  - Fuel system
- Remediation of the petroleum contamination of the existing pump house site.

3 Service Conditions

3.1 Population Estimate

3.1.1 Town Site Area

The design horizon of 2047 has been selected for the infrastructure replacement and improvement projects in Resolute Bay. This is based upon the anticipation of an in-service date of 2017 and a design life of 30 years. The population is estimated at 365 at this design horizon.

3.1.2 Airport Area

An estimate has been developed of the population in the airport area that must be served based upon information provided by Polar Continental Shelf, Department of National Defence and Narwhal Arctic Services. There is a small permanent population resident in the airport area of 40 persons. In addition allowance must be made for the following occupancies.

- A recent expansion of the Polar Continental Shelf facility can accommodate 62 persons.
- The Polar Continental Shelf facility incorporates the capability to accommodate 140 military personnel.
- A new hotel, opened in 2011, is estimate to represent a further population of 30 persons.

The estimated served population in the airport area in 2017 is 272. At this time there is insufficient information to develop a population estimate for the airport area at the end of the design period.

This population will continue to be served by trucked water delivery.

3.2 Water Demands

3.2.1 Average Day Demands

The Pre-Design Report recommends that the average day demands be estimated in a fashion consistent with the Water and Sewage Facilities Capital Program Standards. These standards recommend an average day design value of 225 litres per capita per day for communities with piped water and sewer. This does not include an allowance for non-residential uses. An allowance for non-residential uses may be estimated using the following relationship.

Total Water Use = RWU(1+(0.00023 x Population))

Where RWU is residential water use.

The above relationship provides a per capital average water demand of 239 litres per capita-day in 2017. This rises to 243.9 litres per day at the end of the design period. This gives rise to an average day water demand, for the town site area, of 65,250 litres in 2017, rising to 89,000 litres at the design horizon.

For the airport area a per capita average daily water consumption estimate of 140 litres was developed during the preparation of the Pre-Design Report. This leads to an average day consumption of 38,100 litres in 2017. Despite the lack of a long term population estimate for the airport area, an allowance must

be provided for growth in demand over the life of the project. For current purposes, it will be assumed that demands in the airport area will grow in comparable fashion to demands in the town site. This leads to an average demand in the airport area of 52,000 litres at the end of the design period.

Combining the demands of the town site and airport area leads to a community wide average demand of 141,000 litres in 2047.

3.2.2 Maximum Day Demands

The Char Lake pump house must be capable of meeting the maximum day demands of the community. The Water and Sewage Facilities Capital Program Standards and Criteria, as published by Department of Municipal and Community Affairs, Government of the Northwest Territories (MACA), recommend a maximum day factor of 2.75 times average demand. This is consistent with the design guidelines of other agencies. This gives rise to a maximum day demand 387,800 litres at the end of the design period. This can be expressed as a flow rate of 4.5 L/s if this demand is met over 24 hours.

3.2.3 Fire Demands

An allowance of 4000 litres per minute has been adopted for the design of the piped water distribution network with the town site. This demand will be provided from the storage at the water treatment plant. Thus, an allowance for fire flows is not required for the Char Lake pump house or the transmission watermain linking the pump house and the water treatment plant.

3.2.4 Bleed Water Demands

Ongoing flow into the sewage collection network is required to offset heat loss from the piping. During the design of the piped sewage collection network an allowance for bleed demands was developed. This water requirement is estimated at 3.0 L/s or 259,200 litres per day at the end of the design period.

3.2.5 Design Water Demands

The various water consumption estimates may be combined as follows.

Table 3.1 – Water Consumption Estimates

• Maximum day demand for Town Site and Airport Area	387,800 litres
• Town Site bleed water demand	259,200 litres
• Community wide demand	647,000 litres

3.2.6 Design Pump House Flow Rate

A list of issues must be considered during the determination of the design flow rate for the Char Lake pump house. Historically very high water demands have arisen due to various factors including poor management of bleed water demands and piping failures. These high demands led to near continuous operation of supply pumps at Char Lake. Replacements for the pumps in the existing Char Lake pump house were acquired in 2010. These replacement pumps are rated at 12.6 L/s at 67 m head (200 USGPM at 220 ft.), which is very similar to the rating of the pumps that were installed during the original construction of the current Char Lake pump house.

The water distribution and sewage collection networks within the town-site are currently being replaced. This replacement system incorporates insulation, on the piping and access vaults, which is superior to the original facilities that dated to the late 1970's. It is thus anticipated that water consumption rates will be lower than those historically experienced.

There is merit in consideration of pumping the maximum daily demand over a period that is shorter than 24 hours. Resolute Bay has a small population with modest water demands. The provision of additional pumping capacity does not give rise to an unusual increase in facility cost. There will be no penalty in the total amount of energy consumed for water heating or pumping. Additional pumping capacity will provide added ability to respond to emergency conditions such as unusually high water demands due to failures. The alternatives of provision of the maximum day demand over 24 and 16 hour periods have been considered. The following table summarizes these pumping rates, together with the current installed capacity at Char Lake.

Table 3.2 – Alternate Pumping Rate

Condition	Flow Rate
Pump maximum day demand plus bleeds over 24 hours	7.5 L/s
Pump maximum day demand plus bleeds over 16 hours	11.2 L/s
Current pumping capacity	12.6 L/s

It is proposed that the design advance on the basis of the installation of a pumping capacity of 12 L/s at Char Lake. It is further anticipated that there may be minor adjustments in this pumping rate based upon the selection of commercially available pumping equipment.

3.3 Climatic Conditions

The water system must operate reliably, with minimum risk of freeze, throughout the year. Weather observations have been made at Resolute Bay Airport for a period of more than 60 years. Based upon this data Environment Canada has calculated Climate Normals that may be found in The National Climate Data and Information Achieve. Of specific relevance to this project is the temperature and wind information provided from these Normals. The following table provides the temperature and wind observed in Resolute Bay.

Table 3.3 –Climatic Normals for Resolute Bay

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Average Temperature	-32.4	-33.1	-30.7	-22.8	-10.9	-0.1	4.3	1.5	-4.7	-14.9	-23.6	-29.2	-16.4
Extreme Minimum Temperature	**-52.2**	-52	-51.7	-42.1	-29.4	-16.7	-3.1	-9.3	-20.6	-37.3	-42.8	-46.1	
Maximum Hourly Wind Speed	103	111	97	113	100	89	101	96	91	102	**142**	108	
Maximum Gust Speed	138	135	117	138	119	109	108	120	107	124	**158**	132	

Soil temperature is of specific interest for the design of buried utilities, as the heat loss from the piping is dependent upon the temperature of the surrounding environment. The table below summarizes typical ground temperatures.

Table 3.4 – Typical Ground Temperatures – Resolute Bay

Depth (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
0.5	-15.3	-17.2	-18.5	-18.3	-15.6	-6.2	0.5	1.1	-0.2	-4.2	-8.5	-12.1	-9.5
1.0	-16.5	-18.7	-20.2	-20.1	-17.6	-8.9	-2.5	-1.6	-2.6	-6.3	-10.4	-13.9	-11.6
1.5	-14.4	-16.5	-18	-18.3	-16.7	-10.7	-4.6	-2.8	-2.8	-5.2	-8.6	-11.8	-10.9

It is noted that the soil temperature at 1.5 metres depth is very similar to the climatic mean. This is consistent with expectations; as changes in temperature at depth are damped from changes at the surface due to a number of factors including soil conductivity, snow cover, soil moisture content and latent hear of fusion. Heat loss estimates for the transmission watermain will be calculated assuming an ambient temperature around the piping of -20^{o}C.

3.4. Hydraulic Parameters

The hydraulic performance of the transmission watermain linking the pump house with the water treatment plant has a direct implication on pumping requirements. The hydraulic performance of this transmission watermain includes losses due to friction and static lift. Static lift is determined based upon Char Lake water elevation and the water level in the storage tank at the water treatment plant. The drawings by UMA for the existing installations provide the following elevation information.

Table 3.5 – Elevation Information for Existing Facility

• Char Lake normal water level	110.0 ft (35.53 m)
• Char Lake low water level	108.0 ft (32.92 m)
• Storage tank overflow level	253.7 ft (77.33 m)

Based upon the above a static lift of 44.4 metres (145.7 ft.) is anticipated.

Friction losses that must be accommodated include losses within the pump house, losses within the water treatment plant and friction losses along the transmission watermain. An allowance for hydraulic losses within the pump house has been assumed. During detailed design this allowance will be confirmed following the selection of equipment. The design team for improvements to the water treatment plant have been consulted regarding the anticipated hydraulic loss for those processes. The following allowances have been assumed for the pump house and water treatment plant.

Table 3.6 – Hydraulic Losses Allowance

• Pump house internal loss	3.0 m (10 ft)
• Water treatment process hydraulic loss	5.5 m (18 ft)

Losses for the watermain are dependent upon the size and length of the piping. The existing transmission watermain is 1,880 metres long. It will be assumed that the replacement transmission watermain will be similar in length. The question of transmission watermain size will be examined later in this design brief.

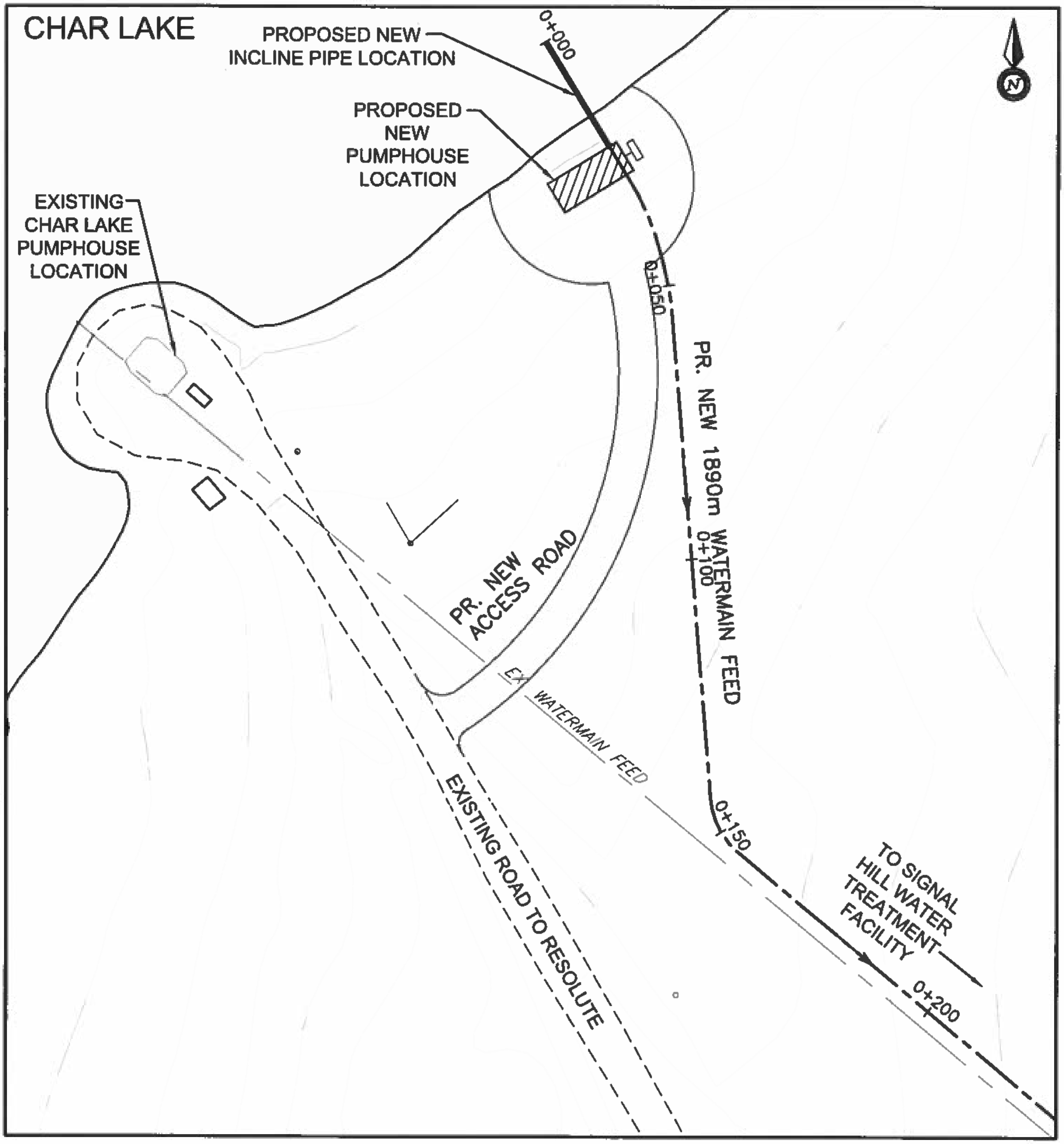
4 Site

As an initial finding it is concluded that Char Lake is the only viable source of drinking water for the Hamlet. It has been reported that the lake adjacent to the airport has been contaminated with petroleum products. All of the remaining lakes within a radius of 5 kilometers of the Town-Site are inaccessible or too shallow to provide an overwinter water source. Location of the pump house at a location that is not in proximity to the existing facility is not desirable, as this would require the construction of a new access road and electrical power line. In addition to the high capital costs of these works, it is likely that provision of a road and power line will extend the construction time for the project by at least one year.

The site for the new pump house should meet the following requirements.

- The site should be approximately 100 m square.
- The site should be at a sufficient distance for the existing pump house so not to interfere with decontamination of the existing site.
- The lake shoreline at the site of the new pump house should accommodate the intake.

A site approximately 60 m east of the existing facility meets the above criteria. This site is depicted on Figure 1. Site access and provision of electrical power will require a short extension of the existing road and pole line. Construction of the new pump house at this location will not interfere with the continued operation of the existing pump house and transmission watermain during construction.



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SCALE 1:1000	PROJECT CHAR LAKE PUMPHOUSE REPLACEMENT	PROJECT No. 206333
DATE January 16		
CAD IPC	TITLE SITE PLAN	DRAWING No. FIG. 1

5 Pump House Design Concept

5.1 Intake Structure

5.1.1 Introduction

There are two methods of providing an intake structure.

1. The current intake makes use of a pumping well fitted with vertical turbine pumps and enclosed within the pump house.
2. An intake can be achieved using an inclined shafts and submersible pumps.

5.1.2 Pumping Well

The current intake arrangement makes use of a well with an intake pipeline extending into Char Lake. An intake for a new pump house could be achieved in a similar fashion. There are two methods of achieving a pumping well. One approach involves the excavation of a shaft near the shoreline and trenching a pipeline into the lake. As a second approach fill can be placed in the lake surrounding a new shaft and pipeline, in a similar fashion to the existing pump house. In both cases the bottom of the shaft should be approximately 1 metre lower than the lowest anticipated elevation of the bottom of the lake ice. There are various advantages and disadvantages to the use of a pumping well.

Advantages

The advantages associated with a pumping well include the following.

- The well and pumps are located within the pump house, facilitating maintenance of the pumping equipment.
- Vertical turbine pumps are typically used in this situation. These pumps tend to be efficient, reliable and durable.
- The above grade location of the motors provides an opportunity for the use of high efficiency motors, leading an energy saving over the life of the project.

Disadvantages

The disadvantages associated with this approach include the following.

- Construction of a pumping well and intake pipeline requires excavation and the placement of fill into Char Lake. The potential sites for a new pump house are in close proximity to the existing water source. Excavation and fill placement have a high likelihood of impairment of raw water quality during construction.
- Construction of the pump house must await completion of the well, intake pipeline and fill placement. This delay, combined with the issues of logistics to Resolute Bay will extend the construction period by 1 to 2 years.
- This alternative raises the potential for loss of service due to a single point failure. Loss of function of the pipeline linking the well to the lake would take this facility and the community water supply out of service.
- Use of a pumping well raises issues of potential thaw settlement. The well would provide a continuous heat input into previously unthawed ground. This matter requires careful investigation and thaw settlement has a high potential for loss of service of the pump house.

5.1.3 Inclined Shaft Intake

Inclined shaft intakes have been employed, with very good success, in the Arctic since the late 1970s. Their application has been principally with truck-fill stations. Typically these intakes are constructed using a ballasted casing resting on a natural or manmade slope. Submersible pumps are installed below the lowest anticipated ice level, and freeze protection is provided using electrical heat tracing cables. The various advantages and disadvantages of inclined shaft intakes include the following.

Advantages

The advantages associated with inclined shaft intakes include the following.

- Inclined shaft intakes permit construction of the intake simultaneous with the construction of the pump house. In the case of Resolute Bay this represents a saving of 1 to 2 years.
- Inclined shafts are adaptable to existing slopes. For the case of Char Lake the existing shoreline slope is suitable for the placement of an inclined shaft without excavation.
- In almost all instances multiple inclined shaft intakes have been provided. This provides redundancy against failure of any element of the intake system.
- For inclined shaft installations a mechanism can be provided to permit flushing of the intake and intake screen using water provided from the pump in the adjacent intake.

Disadvantages

The various disadvantages of inclined shafts must be considered. These include the following.

- Frequently rock fill is placed over inclined shaft intakes as protection against ice. This entails the placement of material into the lake in close proximity to the existing intake.
- Removal of the pumps within the intakes can be very challenging during the winter, especially if there has been a failure of the heat trace cables.
- The electric motors associated with submersible pumps tend to be slightly less energy efficient than those associated with vertical turbine pumps.
- Use of inclined shaft intakes will have an impact upon site access, as vehicle movements between the pump house and the lake will be limited. This is not view to be a substantial impediment.

5.1.4 Analysis

The disadvantages of placement of large amounts of fill in the lake, combined with the delay in commissioning of 1 to 2 years cause the alternative of a pumping well to be unattractive. This is especially evident when it is recognized that the project is driven, in part, by a desire to mitigate petroleum contamination on the existing pump house site. This can be weighed against the good experience that has arisen with inclined shaft intakes in other communities and the opportunity to simultaneously construct the pump house and the intake. On this basis the alternative of an inclined shaft has been selected and design efforts will advance on this basis.

6 Pumping Facility Systems

6.1 Introduction

The concept of a new facility on a site in close proximity to the existing Char Lake pump house has been established. It is proposed that the design of the new facility be advanced on the basis of the use of inclined shaft intakes. The selection of this concept permits the development of details of the various systems that will be required to convey water from Char Lake to the water treatment plant. This also permits the examination of opportunities to reuse equipment currently incorporated into the existing facility.

6.2 Reuse of Existing Equipment

The items of equipment that can be considered for reuse include the pumps, boilers, standby generator and the external fuel tank. The inclined shaft intake concept has been selected for the new pump house. The existing vertical turbine pumps cannot be transferred into the new facility, as submersible pumps will be required.

The anticipated schedule and sequence of construction must be considered when examining opportunities for the reuse of equipment. Due to shipping dates into the community the start of construction of the building is not expected until late summer. Completion of the new facility is anticipated at the end of the construction season. Transfer of service at this date is considered very risky due to deteriorating weather and daylight conditions at the site. Additionally, the soil surrounding the transmission watermain will be refrozen and the internal temperature of the piping will be below freezing. A prudent course for the project would entail commissioning and transfer of service late in the summer following construction. This would provide the opportunity for transfer in an unhurried fashion with site conditions more amenable to the resolution of challenges that arise during commissioning.

Reuse of the existing boilers is not felt to be practical. The existing boilers must remain in service until the completion of transfer of service to the new facility. A continuous source of heating is required is required to prevent freeze of the transmission watermain, as this piping is buried in permafrost, leading to a continuous risk of freeze. Thus, the existing boilers must remain in service until the completion of transfer of service to the new facility.

The opportunity to reuse the existing standby generator has been considered. It was concluded that a different voltage was more appropriate for the new facility. This question will be re-examined during the course of detailed design. More detail on this matter is provided later in this report.

Good Building Practices for Northern Facilities (2011) recommends that a 2 week supply of fuel oil for operation at maximum load be provided. The existing fuel storage tank, which is substantial in size, has been sized to provide this requirement. The existing fuel tank can be incorporated into the new facility. The relocation of the fuel tank will be required, in any case, due to the clean-up activities on the site of the existing pump house. Relocation of the fuel tank will require the provision of a temporary fuel tank during the transfer of service to the new pump house.

6.3 Transmission Watermain

Friction losses for the transmission watermain have been evaluated for 100, 150 and 200 mm DR 17 piping for the flow rates of 7.5, 11.2 and 12.0 litres per second. Details regarding these flows are provided in section 4.2.6 of this report. The following table summarizes the estimates of friction loss for the various diameters and flow rates. A Hazen-Williams C of 120 has been assumed for these calculations.

Table 6.1 – Estimated Friction Losses from Transmission Main

Flow Rate (L/s)	**Diameter (mm)**		
	100	150	200
7.5	23.4	3.6	1.0
11.2	49.0	7.6	2.1
12.0	55.7	8.7	2.4

Based upon the above, 150 mm diameter piping causes significantly less friction loss than 100 mm diameter piping. There is no significant advantage to increasing the pipe size to 200 mm diameter. On this basis 150 mm piping is recommended for the transmission watermain.

The Total Dynamic Head for the pump house, water treatment process and transmission watermain can be summarized as follow for the various flow rates under consideration.

Table 6.2 – Total Dynamic Head

Loss	**Flow Rate**		
	7.4 L/s	11.2 L/s	12.0 L/s
Static lift	44.2	44.2	44.2
Pump house internal loss	3.0	3.0	3.0
Water treatment process internal loss	5.5	5.5	5.5
Transmission watermain friction	3.6	7.6	8.7
Total dynamic head	56.3	60.3	61.4

By way of comparison, the rated operating point for the existing pumps is 12.6 L/s at 67 m TDH.

6.4 Transmission Watermain Freeze Prevention

6.4.1 General

The examination of issues related to freeze prevention must consider the following operating conditions.

- During pumping from Char Lake.
- Between pumping cycles.
- Following loss of flow in the transmission watermain.

For all of the above conditions there must be sufficient heat input to offset heat loss into the surrounding ground. Heat loss from the buried piping is dependent upon various issues including insulation conductivity, insulation thickness and ambient temperature. The following have been assumptions have been incorporated into the estimates of heat loss.

- Piping buried at a depth of approximately 1.5 metres.
- 150 mm (nominal) HDPE piping protected with 75 mm (nominal) thickness of factory installed insulation.
- Input water temperature of 5^0C.
- Ambient temperature at the watermain of -20^0C.

6.4.2 Freeze Prevention during Normal Pumping

Temperature depression is a function of rate of heat loss and residence time in the watermain. An evaluation of a worst case during normal operation has been developed based upon the assumption that the maximum day requirements will be met through pumping over a 24 hour period. This leads to the lowest design pumping rate of 7.4 L/s, which also leads to the longest residence time in the transmission watermain. For an input water temperature of 5^0C and a flow rate of 7.4 L/s the estimated temperature depression is less than 0.5^0C.

It is concluded that excessive temperature depression will not arise during normal pumping.

6.4.3 Freeze Prevention between Pumping Cycles

6.4.3.1 General

There is a significant risk of freeze between pumping cycles if some freeze prevention measures are not incorporated. Electric heat tracing is not attractive as the primary freeze prevention method due to high electrical energy costs in Resolute Bay, together with the risk to the continuing availability of a water supply that would arise from a localized heating cable failure. Currently freeze protection is achieved through pumping tempered water through the transmission watermain at a lower rate between pump cycles. An alternative strategy of emptying the watermain between cycles between pumping cycles has been considered.

6.4.3.2 Transmission Watermain Drain between Pumping Cycles

The transmission watermain slopes generally upwards between Char Lake and the water treatment plant. In principle, it is possible to drain the transmission watermain by gravity into Chare Lake. A pumping sump, with pumps discharging into the inclined shaft intakes, would be required at the pump house, as the watermain will be buried approximately 1.5 m below the pump house floor elevation. Success with freeze protection through draining the watermain requires complete draining of the piping between pump cycles. Any retained water will freeze, and there is no certainty of thaw of this ice during the subsequent pump cycle. Over the service life of the watermain it is likely that some sags will arise in the piping profile. These sags will accumulate ice. It is further noted that a sag of 150 mm or more could potentially prevent drainage of the piping uphill from that point due to ice accumulation.

There is thermal concern, for which a calculated estimate is very hard to develop. Between pump cycles the temperature of the piping will cool towards ambient temperature. The extent of this cooling is hard to predict as it is dependent upon a list of issues including insulation performance, surrounding soil temperature and time period between pump cycles. The refill time for 1.8 km of piping for a flow rate of 12 L/s is estimated at 45 minutes. The water temperature leaving the Char Lake pump house will be the range of 5^0C. It is likely that this water will quickly cool to 0^0C, followed by heat being drawn from latent heat of fusion for much of the distance between Char Lake and the water treatment plant. This situation must be described as hazardous in terms of freeze risk.

Experience and evolution from past success has proven an effective strategy for the design and operation of community infrastructure in Nunavut. It is also noted that Resolute Bay is among the most challenging locations in Nunavut due to climate and logistics. Drainage of long pipelines has not been employed, to date, in Nunavut as a method to reduce freeze risk. The combination of technical concerns, together with a lack of demonstrated success with this freeze prevention technique, indicate that this is not an appropriate strategy.

6.4.3.3 Maintenance of Flow between Pump Cycles

Low flow rate pumping between pump cycles has been part of the freeze protection strategy for the transmission watermain since the late 1970's. This method reduces the risk of freeze through the maintenance of pipeline temperature between pump cycles through the use of a continuous flow of tempered water. The amount of temperature depression between the pump house and water treatment plant can be estimated based upon surrounding soil temperature and the residence time in the pipeline. An allowance for deterioration of the watermain insulation has been incorporated into the estimates of temperature depression, as the insulation system will deteriorate over the 30 to 50 year system life due to aging and water infiltration. Estimates of temperature depression have been developed assuming nominal and doubled thermal conductivity for the insulation. These calculations provide estimates of performance of the insulation at the beginning and end of its service life. These calculations have been performed for the range of 1 to 3 L/s. The rated capacity of the existing low flow pumps of 1.6 L/s has been incorporated into the calculations. It has been assumed that water will leave the pump house at 5^{o}C. The following table summarizes the estimates of temperature depression.

Table 6.3 – Estimated Temperature Depression

Flow (L/s)	**Temperature Depression (^{o}C)**	
	New Insulation	**End of Design Life**
1.0	2.4	4.6
1.6	1.5	3.0
3	0.8	1.6

Based upon the calculated estimates of temperature depression it is felt appropriate to continue operation at the current low flow rate of 1.6 L/s. The ongoing successful operation of the existing transmission watermain supports this opinion.

6.4.3.4 Provision of Low Flow Pumping

The following alternative methods for provision of low flow pumping have been considered.

- Incorporation of low pumps into the duty pump inclined shafts.
- Provision of additional inclined shafts for low flow pumping.
- Operation of the duty pumps in a low flow mode between pumping cycles.

An initial review of submersible pumps exclusively for low flow service indicates that pumps with a nominal diameter of 100 mm would be required. Incorporation of low flow pumps into the same inclined shafts as the duty pumps will be very challenging. Large casing would be required to accommodate both pumps, together with electrical cables, discharge piping and heat trace cables. Maintenance of any of the equipment within the intake would require removal of all of the equipment. Additionally, incorporation of two pumps into a single casing requires a very complex arrangement at the pump house end of the casing.

Provision of separate inclined shaft intakes for the low flow pumps is a technically simple approach. This arrangement would require provision of two casing for duty pumps and a further pair of casing for low flow pumps. The most serious implications of this alternative are cost. In additional to the cost for four intake casings, a larger building will be required to provide sufficient exterior wall space for the casings, together with the internal provisions for installation and removal of the pumps.

It is possible to achieve reduce output from the duty pumps through the use of variable frequency drives (VFD's). Pump output can typically be reduced to 25% of rated output using the strategy. Early in this report a desirable pumping rate of 12 L/s was defined. The output from duty pumps capable of meeting this condition could practically be reduced to approximately 3 L/s, which is higher, by almost twice the amount required for freeze protection of the transmission watermain. Flows at an excessively high rate between pumping cycles are not attractive, as this raises the potential for overflow from the storage tank at the water treatment plant. Division of duty pumping between a pair of pumps has been considered. The low flow requirement of 1.6 L/s would represent a reduction of output of a single duty pump to approximately 30% of rated output, which is achievable with a VFD. Sharing of duty pumping between two pumps provides the opportunity to operate at 6 L/s during period of modest demand; 12 L/s during periods of high demand; and, 1.6 L/s between pumping cycles. The need for redundancy would require provision of a third pump and inclined shaft. Provision of VFD's for all pumps would provide a high level of redundancy for low flow requirements between pumping cycles. It is recommended that the control of flow rate between 6 L/s and 12 L/s be based upon the level in the storage tank at the water treatment plant.

6.4.4 Emergency Freeze Prevention

There is the potential, due to mechanical or electrical failure, that there can be a loss of flow in the transmission watermain due to failures at the Char Lake pump house. Under these circumstances, an alternative method for protection of the transmission watermain should be provided. There are few alternatives, other than electrical heat tracing for this service. It has been confirmed with a supplier of heat trace cable that the 1.8 km pipeline length can be protected as a single run if a 600 volt supply is available. Such cable should operate only following loss of flow, and the cable should be sized to offset heat loss into the surrounding soil. This heat trace cable will not provide sufficient heat input to thaw the watermain, should freeze occur.

6.5 Pump Selection

Based upon the provision of a 150 mm transmission watermain and the estimates of hydraulic losses as detailed in 5.2 above, the required operating point for a pair of lake water pumps providing a total of 12 L/s at 61.4 m TDH. An initial pump selection has been based upon these criteria. This initial selection is a 15 HP submersible pump, with a nominal diameter of 150 mm and 75 mm discharge piping. The total length of this pump is approximately 1.5 m. This pump selection must be confirmed with the supplier as the details of the design are developed.

6.6 Mechanical

6.6.1 Heating

6.6.1.1 Boilers

Two new oil fired cast iron boilers, using fully modulating burners will be installed. The boilers will be used to produce hot glycol that will in turn be used for the heating of the building and to heat the potable water via plate and frame heat exchangers. The boilers will operate to maintain the hot water supply temperature setpoint. Controls will be provided to allow sequential operation of the boilers. Heating of the building would be provided by hot-water glycol unit heaters installed in the room.

A backup for the building heating in the form of an oil fired unit heaters is proposed. This unit heater would protect the building and internal piping should there be a failure of the heating system. The fuel fired heater may be very useful during over the winter that will fall between construction and commissioning.

It is recommended that the boilers be sized with sufficient capacity to heat the potable water to 5ºC at a full flow rate of 12 L/s using two boilers as well as maintaining the pump house heating. The third boiler would be a fully redundant boiler. Each boiler should therefore have an output capacity of 450 MBH. With this capacity, two boilers would be capable of heating the 1.6 L/s low-flow potable water flow rate to 40ºC (105ºF) to help thaw water that may have frozen in the transmission pipe, without compromising the redundancy of the installation.

6.6.2 Hot water injection

A portion of the flow of the water pumped from the lake will be diverted to plate and frame heat exchangers to be heated to a temperature of 40.5ºC (105ºF). This heated potable water will be injected back in the stream of water to Signal Hill to maintain a water temperature of 5ºC. There will be fail open motorized valves to automatically control this process and maintain this temperature.

If high pressure is detected in the transmission pipe, indicating a reduced section of piping potentially due to frozen water, 40.5ºC (105oF) will be sent at a flow of 1.6 L/s in the transmission pipe to thaw the ice.

6.6.3 Ventilation

6.6.3.1 Generator room ventilation

The ventilation of the generator room will meet the requirements of CSA-B139, code for oil burning equipment.

In normal operation, when power is available from the grid, fresh air intake and exhaust air dampers modulate to maintain the room temperature set point. Recirculation dampers are fully opened. This is a natural ventilation system, which means that no mechanical ventilation will be installed for normal ventilation.

On power failure, fresh air damper and exhaust dampers close, combustion air damper opens while re-circulation dampers remain open.

During the operation of the generator, the fan on the generator's radiator will ensure adequate ventilation of the room. Fresh air, exhaust and re-circulation dampers modulate to maintain the room temperature setpoint. Fresh air intake will be localized to optimize the cooling of the engine for better reliability of the installation.

Combustion air damper remains fully opened when the generator is in operation.

A pre-manufactured stainless steel flue vent will be installed with a side-wall outlet.

6.6.3.2 Pump room ventilation

Ventilation of the pump room will be provided by a constant volume fan. A set of dampers will be provided to modulate between 100% outside air ventilation to fully recirculating to maintain the temperature setpoint of the room.

Forced flow heaters will be installed at pump room entrance to reduce the entry of large volumes of cold air when the door is opened.

6.6.4 Fuel System

Existing main fuel storage tank was installed in 2012 will be re-used as it is in good condition and has sufficient capacity. The tanks however will have to be relocated to accommodate the new generator room. Temporary fuel storage will be required to maintain the new building above freezing temperatures before the main tanks are re-located.

Fuel oil piping will be new. For support of the relocated fuel tank a steel skid placed on an engineered granular pad is proposed (similar to that installed in 2012).

The fuel system will include a new double wall day tank located in the room with sufficient storage capacity to meet the requirements of CSA C-282 for autonomy.

6.7. Electrical

6.7.1 Service

The service to the site is supplied by Qulliq Energy Corporation (QEC) at 4160 volts. It is proposed that the exiting primary service that supports the exiting pump house will be extended overhead to the new pump house location. It has been confirmed with Qulliq Energy Corporation that a 600/347 volts 3 phase 4 wire service can be provided. The 600 volt supply is being considered as it would be beneficial to support the heat trace for the water supply line to Signal hill from the main service or the emergency generator in the event of a boiler failure.

The utility transformers will be pole mounted and connected in a primary Delta and grounded wye secondary configuration for reasons of voltage stability and safety. Provision of the pole line extension and transformers will be arranged with the local utility Qulliq Energy Corporation.

The service entrance will include the Main Distribution panel with the related service CT cabinet and utility metering. In addition to the feeder breakers and associated distribution equipment a Transient Voltage Surge Suppressor (TVSS) will be added on to the incoming service entrance.

A new bonding and grounding grid will be installed at the new site to meet the servicing requirements. In the event that the building is steel, the structure will bonded to this grid.

6.7.2 Standby Power

A standby generator will be provided in a separate room. Installation of this generator will include provisions for generator exhaust and combustion air, typical for a Northern climate, and ventilation ductwork including the generator radiator exhaust with room recirculation. As noted above the generator will be selected to suit the utility service supply voltage and the loads being supported.

The installation at 600 volts for the pump house would require the purchase and installation of a new emergency generator. Reuse of the existing generator in the existing upgraded pump house would not be possible due to the voltage but it the existing generator will become available to the GN as a backup to the unit at Signal Hill.

An automatic transfer switch will be required. The output of the emergency transfer switch will feed a new electrical distribution panel which will supply the related service equipment which includes but would not be limited to the following:

- Panels for branch circuits for lighting and convenience outlets in the facility.
- Distribution panel for the generator room.

- Starters for the boiler systems and the associated pumps.
- Starters for the potable water duty and low flow pumps, with the inclined shaft submersible pumps for distribution the use of Variable Frequency drives is being explored to eliminate the requirement for a circulation pump.

6.7.3 Transmission Watermain Heat Tracing

The main water distribution service piping from the lake to the pump house and to Signal Hill will be heat traced for the complete length. In the typical configuration the heat tracing on the supply pipe from the lake to the pump house is supported from the utility supply and not by the generator in the event of a power failure.

In most cases and if we are limited to a 120/208 volt service from the building only the heat tracing on the water supply piping from Char Lake would be maintained on the Generator. During any power failure the water distribution system relies on the heating of the water through the boiler system and the flow through the pipe to prevent freezing of the water.

Installation of a 600 volt service we will permit the feeding the heat tracing on both the transmission watermain and water entry from Char Lake.

6.8. Building Requirements

6.8.1 Space Requirements

Sufficient space must be provided to accommodate the electrical, mechanical and water pumping equipment. The following table summarizes these space requirements.

Table 6.4 - Building Space Requirements

Item	Require Space (m^2)
Electrical and generator	35
Boilers and mechanical	110
Process and lake pump access	25
Total	170

6.8.2 Structural System

6.8.2.1 Foundations

The floor is to be a concrete-slab-on-grade on an engineered granular pad. This will be a suitable floor system for the new mechanical and electrical equipment to be installed and will help to dissipate vibrations. The existing slab for the existing pump house, which has performed suitably for almost 40 years, is a 200 mm (8") reinforced concrete slab-on-grade thickened at the perimeter to 610 mm (24") in thickness over a width of 350 mm (14"); essentially a perimeter grade beam. New concrete slab-on-grade is to be of similar construction with rigid insulation installed on the vertical face at the exposed perimeter of the new foundation. The installation of rigid insulation at the underside of the concrete slab-on-grade, the subbase construction and the compaction of the subbase for the addition will be based upon the recommendations from the geotechnical report.

6.8.2.2 Structure

The new addition would be of steel frame construction with steel beams and columns typically of 200 to 250 mm in depth. The spans of the members are to be kept to a reasonable length to allow easier handling during sealift, erection and assembly on site. Rigid and braced frames are proposed to provide the lateral load resisting system for the building addition.

6.8.2.3 Codes and Practice Guidelines

The following design standards will be used in the design and rehabilitation of the existing structure.

- National Building Code of Canada 2010
- CSA A23.3-04 Design of Concrete Structures
- CSA G40.20-04/G40.21-04 General Requirements for Rolled or Welded Structural Quality Steel / Structural Quality Steel
- CSA-S16-09 Limit States Design of Steel Structures
- CSA W59-03(R2008) Welded Steel Construction (Metal Arc Welding)

6.8.2.4 Building Design Loads

Climatic information for the building design has been taken from the National Building Code of Canada, Division B, Climatic and Seismic Information for Building Design in Canada and is summarized below along with occupancy design loads.

- Ground Snow Load, 1/50 year

  Ss =1.7 kPa

  Sr = 0.1 kPa

  I_S = 1.25 (ULS); I_S = 0.9 (SLS) - post-disaster building design requirement

- Hourly Wind Pressures

  1/10 year 0.54kPa

  1/50 year 0.69kPa

  I_W = 1.25 (ULS); I_W = 0.75 (SLS) - post-disaster building design requirement

- Seismic Information

  S_a (0.2) = 0.30

  S_a (0.5) = 0.15

  S_a (1.0) = 0.083

  S_a (2.0) = 0.025

  PGA = 0.15

  I_E = 1.5 (ULS) post-disaster building design requirement

  R_D = 1.5 for conventional braced frames (system to be confirmed)

  R_O = 1.3 for conventional braced frames (system to be confirmed)

  W = to be determined

- Occupancy Design Loads

  Roof

    Dead 1.35 kPa

    Live 1.5 kPa

    Main Floor

    Live for mechanical and electrical generally 4.8 kPa

  Exterior Walls

    Dead kPa (to be confirmed based on new building envelope)

    Wind (Primary Structural Elements) q = 0.69 kPa

    Wind (Cladding) q = 0.69 kPa

6.8.2.5 Method of Analysis

The addition shall be analyzed using linear elastic methods, which assume individual members behave elastically; and designed using Limit States Design. The limit states to be designed for include ultimate limit states (strength, overturning, etc.) and serviceability limit states (deflections, vibration, etc.). Both analysis and design will be completed in SI (System International) units.

6.8.3 Building Envelope

6.8.3.1 Walls

The new wall system for the existing building and the proposed addition is to be constructed using metal insulated panels with steel studs that spanning approximately 2.5m (8') between structural steel girts (new or existing). The wall system, with a thermal resistance of 5.6 RSI, is to consist of:

- Prefinished exterior metal cladding (profile and colour to be determined)
- Weather barrier
- 38 x 64 horizontal strapping @ 600 o.c.
- 38 mm rigid insulation between strapping
- Two layers rigid insulation between Z-girts (two layers 75 mm thick)
- Membrane vapour barrier
- Pressure treated sheathing
- Prefinished metal liner sheet

6.8.3.2 Roof

The new roofing system for the existing building and the proposed addition is to be constructed using metal insulated panels with steel ‘Z’ purlins that span approximately 1.8 m (6') between structural steel members (new or existing). The roof system, with a thermal resistance of 5.96 RSI, is to consist of:

- Prefinished exterior metal roof (profile and colour to be determined)
- Weather barrier

- Galvanized steel 'Z' girts (two 100 mm deep) @ 400 o.c.
- Two layers of 100 mm rigid insulation
- Membrane vapour barrier
- Prefinished metal liner sheet

6.9 Decommission and Site Remediation

Decommissioning and remediation of the site of the existing facility must await the commissioning of the new facility. Due to logistics and climate this cannot take place until the construction season that follows completion of the new pump house. The scope of these activities includes:

- Demolition of the existing pump house
- Removal of petroleum contaminated soil
- Decommissioning of the existing pumping well including the placement of a concrete plug followed by backfilling the well.
- Backfill of those areas where petroleum contaminated soils have been removed.
- The management of petroleum impacted soils.

The final details are being developed regarding the disposition of petroleum impacted soil. The current cost estimates provide for the transport and disposal of this soil to a licensed site in southern Canada.

7 Cost Estimates

The follow table summarizes the estimated cost for the Char Lake pump house.

Table 7.1 - Cost Estimate

Item	Estimated Cost
Substructure, structure envelope and interior	1,635.000
Mechanical	485,000
Electrical • Service and transformers • Internal electrical work	 220,000 555,000
Site Works	200,000
Site access and power line	120,000
Transmission watermain	2,505,000
Remediation of existing site	300,000
Management of contaminated soil	900,000
Subtotal	$8,720,000
20% Contingency	$175,000
Total	$8,895,000

8 Summary

The findings and recommendations of this Design Brief may be summarized as follows.

- Due to petroleum contamination the existing Char Lake pump house site must be rehabilitated. Rehabilitation of the site will require the removal of the existing pump house.
- It is recommended that a new pump house be constructed on a site to the east of the existing pump house.
- A design flow rate of 12 L/s has been selected for the new Char Lake pump house.
- It is recommended that the new pump house incorporate inclined shaft intakes.
- Flow must be maintained in the watermain connecting the Char Lake pump house to the water treatment plant between storage tank refill cycles as a freeze prevention measure. The flow recommended for this purpose is 1.6 L/s.
- Low flow (1.6 L/s) can be achieved through the operation of the duty pumps at lower speed using a variable frequency drive.
- The selection of variable frequency drives as a strategy to provide low flow set the capacity of each duty pump at 6 L/s.
- A total of 3 inclined shaft intakes, each equipped with a pump rated at 6 L/s are required.
- The recommend size for the transmission watermain linking the pump house to the water treatment plant is 150 mm. This watermain should be protected with 75 mm of factory installed insulation.
- To enhance redundancy it is recommended that a heat trace cable be installed along the transmission watermain. This cable should only be activated when all other methods of thaw prevention are out of service.
- The potential for the reuse of existing pump house equipment has been considered. The only existing equipment that is appropriate for reuse is the outdoor fuel storage tank.
- Three boilers, each rated at 450 MBH should be provided for heating of both potable water and the pump house building. In addition a fuel fire unit heater should be provided.
- A 600/347 volt electrical service should be provided. This service voltage will facilitate the electrical supply for the heat trace cables on the transmission watermain.
- A new standby generator will be required.
- A building space requirement of 170 m2 has been identified.
- A conventional building incorporating a slab on grade, steel framing and insulated metal panels is proposed.
- The existing facility can be decommissioned and the petroleum impacted soil remediated following commissioning of the new facility.

- The estimated cost for the facility may be summarized as follows.

Pump house construction		$3,215,000
Transmission watermain		$2,405,000
Demolition and site remediation		$1,200,000
Contingencies		$175,000
	Total:	$8,895,000