Government of Nunavut

Design Brief

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New Pump House Upgrades

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Table of Contents

Page

List of Appendices

List of Tables

List of Figures

1 Introduction

The water supply needs for the Hamlet of Repulse Bay (Hamlet) are met using a trucked delivery based system. An essential element of this system is the truck-fill station located adjacent to the water supply lake (Nuviq Luktujuq Lake). This truck-fill station includes the following elements:

- A pair of inclined shaft intakes, including submersible pumps and electric heat tracing cables
- A truck loading arm
- A chlorine injection system
- A pair of diesel driven electrical generators that support all power requirements
- A building that provides protection for the electrical and chlorination equipment

The Government of Nunavut (GN) commissioned **exp** Services Inc. (**exp**) to conduct an assessment of the existing truck-fill station. This assessment included a site visit which was conducted in September 2012, a review of the status of the facility with Hamlet representatives and testing of the water quality. The following report summarizes the findings of this site visit and presents recommendations based upon these observations.

2 Consultation

Activities within the Hamlet were initiated with a meeting with the SAO and Assistant Foreman. No specific concerns were expressed regarding the condition of the existing truck-fill facility during this meeting.

An informal on-site meeting was held with the CGS representative in the community. In general no operational challenges were reported. The following specific comments were provided.

- The automated control, alternation of the generators and start-up of lag generator is not currently functional. This was not viewed to be an operational problem as the generators were alternated manually, on a daily basis, by the CGS representative
- No issues were reported with the chlorine injection system.
- The external controls for truck filling were reported to be non-functional. Operation of the pumps using internal controls within the truck-fill station was not viewed to be inconvenient
- Occasional freeze of the truck loading arms was reported

Following the on-site activities a short meeting was convened with the SAO. A summary of the initial findings and impressions developed during the visit was provided.

A short review meeting was convened with the CGS representative following the on-site activities. Additional information was obtained from the operations and maintenance manual during this meeting.

3 Facility Assessment

3.1 General

The Terms of Reference for this project identified systems and areas of interest, for which an assessment and recommendations are sought. During the site visit these elements of the truck-fill facility were examined. During the course of the site program, some additional issues were noted. The subsequent sections of this report deal individually with these systems. These comments are presented in the form of observations regarding the state of each system, followed by recommendations arising from the observations.

In summary, the existing truck-fill station has been in service for almost 25 years. The building and internal equipment was found to be generally in good condition. With the exception of the electrical generators, the internal systems and equipment housed in the building is consistent with the original construction. The condition of all of the equipment demonstrates good and ongoing maintenance attention.

There is very limited space within the existing building to house any additional equipment. Provision of a water treatment process that meets current drinking water quality guidelines within the existing building will not be possible

Very few actions that require immediate action were noted during the inspection. Comments regarding these items are provided in subsequent sections of this report.

The assessment of the existing facilities includes a review of the mechanical and electrical systems. A more detailed report is attached in Appendix A of this report. The following sections of this report include a summary of the electrical and mechanical issues.

3.2 Site

3.2.1 Observations

The truck-fill station is accessed via a 4 km long road from the Hamlet. A truck turn-around loop has been provided approximately 100 m beyond the truck-fill. Water service vehicles were observed to easily manage this turn-around loop. Following the turn-around, water trucks drive directly under the truck-fill arm. No challenges were observed with the placing the truck-fill hose into the fill port on the top of the truck tank. It is not anticipated that winter conditions will cause unusual operational challenges, in terms of truck access to the fill point.

Drainage is generally away from the buildings and reservoir. There are no reports of drainage challenges. The building is sited at a sufficiently high elevation to avoid drainage entry.

General features of the site and access road are depicted in photograph no. 1, presented in Appendix B.

3.2.2 Recommendations

No actions that require short term action were noted in connection with the site or building siting. There is sufficient space, with minor relocation of the access road, to accommodate a larger facility.

3.3 Buildings

3.3.1 Observations

The existing building is a Bally insulated sandwich wall building mounted on steel skids, which houses both the water supply and electrical power functions. There is an internal wall that separates the electrical generator from water supply areas. Separate exterior doors are provided for each section of the building and there is no internal communication between the two areas of the building. The portion of the building devoted to electrical supply is the slightly larger of the two areas.

The building does not display undue distress and of the walls are generally plumb. The building provides sufficient space for the functions that are currently housed within, but there is no separation between the chemical handing area and the other functions within the building. There is insufficient space within the buildings to accommodate any additional equipment.

Insulated buildings of this type have been very successfully applied for this type of service in many communities in Nunavut. In general, the insulation system is appropriate for the temperature experienced in Repulse Bay. It was noted that the door to the water supply portion of the building appears to have been replaced. The existing door does not close tightly due to a large amount of clearance in the upper hinge pin. The weather stripping for this door was missing. The door to the generator section of the building appears to be part of the original construction. The hinges and weather stripping for this door have been damaged. It appears that both doors are left open. This may be, in part done as an operational convenience during the summer. It may also indicate issues with ventilation for the generator room.

It was noted that the insulation in the pipe penetration for the truck loading arm was incomplete and not weather tight.

In summary the building, with the exception of the weather tightness of the doors, is currently meeting requirements.

3.3.2 Recommendations

No immediate recommendations are provided in connection with the existing buildings beyond replacement of the insulation in the wall penetration for the truck fill arm and repairs to the doors. The issue of ventilation is examined later in this report. The principle issue noted, in connection with the building, is the inability to accommodate any additional equipment and the lack of separation of chemical handling from other activities within the buildings.

3.4 Water Treatment Process

3.4.1 Observations

Water samples were taken during the site visit to confirm water quality and to identify parameters that may have an implication upon the selection of a water treatment process. The analytical findings for these samples are presented in Appendix C of this report. The raw water can be described as soft, with low alkalinity and low turbidity. Total coliforms of 10 were observed, but this was for a raw water sample taken prior to the chlorine application point. In general, the samples indicate that the raw water meets the requirements of the Guidelines for Canadian Drinking Water Quality and no parameters that would have an adverse impact on treatment processes were identified.

Water treatment in Repulse Bay is currently limited to chlorination. The chlorine metering pump automatically operates when the water supply pump is in operation.

Chlorine is measured and logged daily on a somewhat sporadic basis. As an example, over the period of June 11 to 17, 2012, the total chlorine was logged as between 0.36 and 0.48 mg/L, and free chlorine was logged as between 0.26 and 0.41 mg/L. The chlorine solution metering pump was found to be in serviceable condition and appeared to be appropriate for this service. A spare chlorine solution metering pump was reported to be stored in the Hamlet.

The chlorine injection point is situated on the discharge piping, immediately before the point where this piping leaves the building. Thus, there is no meaningful contact time prior to discharge into the delivery truck. Travel time to the Hamlet was measured at approximately 5 minutes. This short travel time gives rise to insufficient contact time, prior to delivery. There is no opportunity to install storage to assure appropriate contact time prior to dispensing into the delivery trucks, as there is no space available within the existing building for additional equipment.

It was noted that chlorine is supplied to the community as calcium hypochlorite and that this material is shipped in 45 kg barrels. Shipment of the chlorine in containers that can be kept closed has reduced the issues that can potentially arise from chemical dust. Unusual and excessive corrosion due to chemical dust was not noted during the site visit.

The Guidelines for Canadian Drinking Water Quality direct that water taken from a surface source should be filtered and disinfection provided. No filtration is currently provided, and there is insufficient space within the existing building to provide filtration.

In summary, the existing water treatment process does not meet the requirements of the Guidelines for Canadian Drinking Water Quality, due to contact time and filtration requirements, and there is insufficient space within the building to accommodate the equipment required to meet these guidelines.

3.4.2 Recommendations

Filtration and sufficient contact time must be provided to achieve conformity with the Guidelines for Canadian Drinking Water Quality. There is insufficient space within the current building to provide either of these functions. During the development of the detailed design for the replacement facility the various issues of provision of filtration and appropriate chlorine contact will be examined.

The chlorination chemical should continue to be purchased in 45 kg barrels.

3.5 Truck-Fill Arm

3.5.1 Observations

The truck-fill arm, which is illustrated in photograph no. 2 in Appendix B, was noted to be in good condition. It did not display obvious damage from vehicle traffic. The electrical heat trace appeared to have an open circuit, which suggests that it is currently not functional. This may be the cause for the occasional freeze of this piping reported by local staff.

3.5.2 Recommendations

Recommended short term actions are limited to reinstatement of the heat trace cable.

3.6 Mechanical Systems

3.6.1 Observations

The piping and valves within the truck-fill station were generally found to be sound and serviceable. No specific need for action was noted.

Heating within the water supply area of the building is provided by infrared radiant heaters that appear to date from the original construction. These heaters are currently serviceable, and they provide a load for the generators between truck fill cycles. No complaints were voiced by the operating staff regarding the ability of these heaters to meet current requirements

There is no active heating provided in the generator room as there is sufficient passive heating due to waste heat from the generators to maintain room temperature. The ventilation of the room is achieved by natural ventilation. An exhaust duct, located at the ceiling level removes hot air located in the room. The ductwork for this exhaust duct is partially missing, but it is still functional. During warmer months, the door to the generator room is left open to provide additional cooling and ventilation.

A detailed review of the mechanical systems is presented in the report contained in Appendix A of this report.

3.6.2 Recommendations

Improvements to the ventilation of the generator room, in the form of an enclosed fan, are recommended. This will improve temperature control during warmer periods, and would permit the door to the generator room to be secured during the summer.

3.7 Electrical Equipment

3.7.1 Observations

Electrical power is generated locally by a pair of 12.8 kW diesel drive generators. Power is provided to the pump house, from these generators, through an automatic transfer switch. The automatic features of this transfer switch are reported as not functionally properly. Despite this lack of automatic operation, the switch is meeting current needs and is felt to be suitable by local operating staff.

Electrical Panel ‘A’, which is supplied from the transfer switch, is located in the pump room. This panel is in poor condition and will require replacement within 5 years. The remaining electrical equipment was found to be generally serviceable and meeting current needs.

A detailed review of the electrical system is presented in the report contained in Appendix A of this report.

3.7.2 Recommendations

It is recommended that the current scheme of manual control and alternation of the generators continue. Panel ‘A’ in the pump room will require replacement within the next 5 years.

3.8 Controls and Alarms

3.8.1 Observations

Independent control systems have been provided for water pump operation, heat trace control and generator operation.

The controls associated with the water loading pumps are a relay based system that is currently not in service. Water loading pumps are currently operated using the Hand-Off-Auto controls on the pump starters. This operating arrangement is felt to be satisfactory by the operating staff.

Independent heat trace controllers have been provided for pumps P1 and P2. The heat trace for pump P1 has been replaced and appears to be operating normally. The heat trace cable could not be cycled on during the site visit due to the characteristics of the controller. The heat trace controller for pump P2 appears to be part of the original equipment. Both of the heat trace cables for P2 were in operation and both cables were warm to the touch.

An alarm system that monitors functions such as low and high building temperature was incorporated into the original design. The system made use of a radio link to annunciate alarm conditions. It was reported that this system has not functioned due to issues with radio transmission between the truck-fill station site and the Hamlet. A short term improvement for this communication issue has not been identified.

A detailed review of the controls and alarms is presented in the report contained in Appendix A of this report.

3.8.2 Recommendations

It is recommended that a simple system of control that includes external controls for the truck loading pumps be provided. This system would include an external control panel, an internal selector switch that determines that pump that is in service and an internal auxiliary control station.

3.9 Intake

3.9.1 Observations

There is a pair of inclined shaft intakes that extend into the lake to the rear of the truck-fill station within an embankment. These shafts were constructed using HDPE piping that is protected from freeze by factory installed polyurethane insulation and an external jacket. That portion within the lake is equipped with concrete ballast blocks. Photographs of the intakes are presented in Appendix B.

The intakes do not display indications of movement and the ballast blocks appear to be intact. The piping and insulation jacket did not display signs of distress or vandalism. Comments cannot be provided regarding the condition of any intake screens.

3.9.2 Recommendations

No short term recommendations are presented as regards to the intakes. A future reconstruction of the truck-fill station may require extension of these intakes. The existing intakes are suitable for incorporation into the design of a new truck-fill station.

3.10 Intake Pumps and Heat Tracing

3.10.1 Observations

3.10.1.1 Pumps

Both intake pipelines contain a submersible pump located near the bottom of the intake casing. These pumps cannot operate simultaneously as the Tech-Taylor valve on the discharge piping permits flow from only one pump at any given time.

The specifications for the original construction stipulate these pumps to be Myers model 6S5 275, equipped with 3.7 kW (5 HP) motors and rated at 1,000 litres per minute at a head of 17 m. The time to fill a truck was measured for each pump. Pump 1 provided approximately 1,170 lpm. Pump 2 provided approximately 1,050 lpm. The water truck drivers generally use Pump 1 as this shortens truck fill times.

There is some confusion regarding the precise description of the water loading pumps. Measured motor currents were generally similar to the demand anticipated for 3.7 kW motors. There are some reports that one pump has been replaced, which is not unreasonable in view of the age of the truck-fill station. This reported pump change, combined with the higher discharge from Pump 1 supports the understanding that at least one pump has been changed.

In summary, both existing pumps provide flow which is consistent with the original specifications and current standards for truck-fill stations. The precise characteristics of the current pumps are unknown.

3.10.1.2 Heat Tracing

Each intake was initially provided with a pair of heat trace cables, with one cable in service and the second available as standby. For both intakes the heat trace cables were in service. Both cables for Pump 2 were in operation and were warm to the touch indicating that for Pump 2 the spare heat trace cable was also in service. It was noted that all of the heat trace cables appeared to be relatively new. The heat trace for Pump 1 could not be tested as a method to override the heat trace controller could not be identified. The heat trace for Pump 1 did not appear to be in operation during the visit, but this is likely the result of the set point of the controller.

The heat trace controller for Pump 1 appears to have been replaced in the recent past, while the controller for Pump 2 appears to be part of the original construction. Replacement of one of the controllers suggests that operating staff is attentive to the operation of this equipment. Both controllers appear to be suitable for ongoing service.

3.10.2 Recommendations

No short terms actions were identified for the pumps, pump starters, heat trace cables or heat trace controllers. Replacement of these system elements is appropriate at such time as a new truck-fill facility is constructed. Replacement at that date is appropriate to assure a further 20 or more years of service with a minimum of maintenance effort.

3.11 Fuel System

3.11.1 Observations

The fuel system is limited to that equipment required to provide a supply to the pair of generators. The fuel system includes an internal tank in the generator room, fuel containment and some internal piping. It was noted that there are penetrations of the fuel containment at two locations, with a total of three penetrations at each location, to permit fuel lines to be extended to the generators. It was noted that one of these penetrations was open, which creates the potential for a fuel spill in the event of a failure of any portion of the fuel system within the containment. The risk of a fuel spill is an especially sensitive issue as the truck-fill is adjacent to the community water source. A photograph of this penetration is provided in Appendix C.

It is also noted that the current fuel system does not comply with current code requirements. This system must be brought into compliance with current codes if any changes to the system are undertaken. Compliance with current codes would require the replacement of the entire system.

A detailed review of the fuel system is presented in the report contained in Appendix A of this report.

3.12 Recommendations

It is recommended that the opening in the fuel containment be plugged at the first opportunity. No other short term actions are recommended. In the longer term, any reconstruction of the truck-fill station would require the replacement of the fuel system with one that complies with current code requirements.

3.13 Summary

The preceding sections of this report have provided a "snap shot," of the current condition of the truck-fill facility in Repulse Bay. In general, the buildings continue to provide service that is consistent with the intent of the original design. All of the systems within the buildings are generally serviceable. The existing truck-fill building cannot accommodate any additional equipment. Thus, the existing facility cannot be brought into conformity with current guidelines in terms of chlorine contact time or the health-based turbidity parameters as set out in the Guidelines for Canadian Drinking Water.

Independent of the general observations presented above, there following are some issues that require more immediate attention.

Table 3.1 - Actions Required Immediately

System	Nature of Risk or Issues	Action
Fuel system containment	Public health risk due to potential fuel spill	Close opening in fuel containment

Table 3.2 - Short Term Improvements

System	Nature of Risk or Issues	Action
Pump controls	No exterior pump controls	Provide simplified pump control system

Table 3.3 - Long Term Improvements

System	Nature of Risk or Issues	Action
Truck-fill facility	Cannot provide current standard of water treatment	Provide new truck-fill facility

4 Design Brief

4.1 Introduction

The scope of this design brief is limited to the truck-fill station, and an assessment of the existing water reservoir has not been undertaken.

4.2 Service Conditions

4.2.1 General

The service conditions that the truck-fill station must respond to have been identified. These included the anticipated population, water consumption, water quality requirements and truck loading requirements.

4.2.2 Population

The Nunavut Bureau of Statistics has published population estimates for the various communities in Nunavut. Table 4.1, presented later in this section, summarizes the Bureau of Statistics estimates over the design period.

4.2.3 Water Quality

The water provided by the new truck-fill station should meet the Guidelines for Canadian Drinking Water Quality. The Guidelines direct that water taken from surface water sources be filtered with the target of providing finished water with a turbidity of less than 0.1 NTU. The Guidelines also direct that the drinking water be subject to a disinfection process prior to loading into delivery vehicles.

4.2.4 Truck Fill Rates

The most demanding truck loading rates arise from the requirements to fill trucks during firefighting operations. A minimum truck fill rate of 1,000 L/min is typically stipulated for this service. In some communities a lower truck refill rate is provided during normal operations. Assumption of this lower refill rate carries the advantage of reducing the size of some elements of the truck-fill station, but this is offset by an ongoing operational penalty of longer truck refill times. This is exacerbated by a general movement towards larger water delivery trucks. Combining a refill rate of 500 L/min with the larger water trucks leads to a refill time of approximately 30 minutes. Increasing the normal truck fill rate to 1,000 L/min will improve operational efficiency as less time will be required to fill water trucks, leaving more time available to service buildings.

A truck loading rate of 1,000 L/min will be assumed for the design of the new truck-fill station.

4.2.5 Water Consumption

The Water and Sewage Facilities Capital Program Standards and Criteria (July 1993) provides criteria for the estimation of water consumption. For communities that make use of trucked water and sewage services, the base water consumption rate is assumed to be 90 litres per capita day (l/c/d). In addition an allowance must be made for non-residential water uses such as commercial, institutional and industrial demands. The total community water use per capital is estimated using the following formula.

PCC = RWU (1.0+0.00023 x Population)

Where: PCC is per capita consumption, and

RWU is the residential water consumption (90 l/c/d)

The truck-fill station must meet the maximum day demands of the community. The maximum day factor is a function of the service population. A maximum day factor of 2.75 has been assumed when the population is less than 1,000. The maximum day factor is reduced to 2.50 when the population exceeds 1,000.

The proposed truck-fill station must have sufficient capability to fill sufficient numbers of trucks to meet the needs of the community during a working day. This requires that an estimate of the number of truck-loads required during a day be prepared. In the development of this estimate, it has been assumed that each delivery truck will have a capacity of 12,700 litres. These trucks are somewhat larger than the current trucks, but there has been an on-going general movement towards larger trucks as a method to improve delivery system efficiency.

The following Table 4.1 summarizes the assumptions relating to population, water use and the required numbers of trucks filled over the design period.

Table 4.1 - Population and Water Demand Estimate

Year	Population	Daily Water Demand				Truck-Loads
		RWU (l/c/d)	PCC (l/c/d)	Average Demand (l/d)	Max Day (l/d)	
2013	907	90	108.8	98,682	271,374	21
2018	993	90	110.6	109,826	302,021	24
2023	1079	90	112.3	121,172	302,929	24
2028	1168	90	114.2	133,386	333,464	26
2033	1271	90	116.3	147,817	369,543	29

4.2.6 Summary

The truck fill station must satisfy the following conditions.

Served population (2013)	907
Served population (2033)	1271
Maximum day (2033)	370 m^3
Truck fill rate	1,000 L/min

Water quality that meets the Guidelines for Canadian Drinking Water Quality

4.3 Proposed Facilities

4.3.1 General

The following sections examine the proposed water supply, treatment and delivery equipment, together with the building and buildings services required in support of these water supply systems.

4.3.2 Water Supply

It is proposed that the existing pair of inclined shaft water intakes be retained. The existing intakes appear to be in good condition and they are large enough to accommodate pumps capable of providing 1,000 L/min. A short extension of the intakes into the new truck-fill station may be required.

New water supply pumps and heat trace cables will be required. The existing pumps have been in service for an extended period of time, and it is unlikely that they will provide a further 10 to 20 years of service. In addition, the proposed filtration equipment will cause additional hydraulic resistance, which will reduce the performance of the current pumps below the selected truck fill rate of 1,000 litres/minute. It is initially estimated that a pair of 15 HP submersible pumps operating at 1,000 L/min (265 USGPM) into 46 metres (150 feet) of head will be required. The final selection of these pumps will be confirmed during the course of detailed design.

4.3.3 Water Treatment

The Guidelines for Canadian Drinking Water Quality direct that water taken from surface sources be filtered and that disinfection is required. The following sections examine both of these water treatment processes.

4.3.3.1 Filtration

The Guidelines for Canadian Drinking Water Quality direct that water taken from surface water sources be filtered with the target of providing finished water with a turbidity of less than 0.1 NTU. Incorporation of filtration into the design of this truck-fill station raises some unique and large challenges. The alternative methods of providing filtration that have been considered are.

- Media filters
- Membrane filtration
- Cartridge filtration

Alternative treatment to filtration has also been considered.

<u>Media Filtration</u>

Media filters make use of a filter bed that is typically made up of anthracite, sand and supporting gravel. In municipal water treatment practice, media filters are frequently preceded by chemical addition and flocculation. There are some issues with media filtration that must be examined within the context of application of this process in the north. The Guidelines for Canadian Drinking Water Quality speak directly to the application of this method, as this filtration practice has been applied to most municipal surface water treatment facilities in Canada. Thus, it becomes relatively easy to demonstrate a design intent that meets the requirements of the Guidelines. The most challenging issues arise from the ongoing need for backwash. Media filters must be backwashed on an ongoing basis, with a cycle that varies between daily and weekly, depending on water characteristics. The backwash flow must be considered as a process wastewater and it cannot be returned to the water source. In plant water use for such purposes as backwash can represent between 2% and 10% of total water production. In the instance of Repulse Bay, selection of media filters would give rise to the need for the management of a process wastewater stream. This management would include storage at the truck-fill station, hauling to a disposal site, which is likely the Hamlet sewage lagoon, and disposal of this wastewater.

<u>Membrane Filtration</u>

Membrane filtration, which is often referred to as microfiltration or ultrafiltration, makes use of an engineered membrane to separate particulate matter from water. Typically pressure or vacuum is used to drive water through the membrane. Pore size for microfiltration is nominally in the range of 0.1 microns, and the typical pore size for ultrafiltration is smaller.

There are several issues that must be considered when examining the question of application of membrane filtration. These included the pumping energy required to convey the flow through the membrane, and the ongoing effort and cost associated with membrane replacement. One of the most challenging questions relates to process wastewater. The process of membrane filtration separates materials from the water stream and retains these materials on the supply side of the membrane. This leads to an increase in contaminant concentration on the supply side of the membrane, which leads, in turn, to the need for the disposal of this concentrate. In addition, certain membrane filtration processes utilize backwash in the course of membrane cleaning and maintenance. Disposal of concentrate and membrane backwash both represent process wastewater streams that must be managed. In a similar fashion to media filtration, this wastewater stream must be stored, hauled and disposed.

Cartridge Filtration

Cartridge filtration makes use of disposable polymer based filters. Cartridges are available in a range of nominal pore sized with the finest nominal pore size in the range of 1 micron. Cartridge filters are typically installed in series with finer cartridges each subsequent stage of filtration.

Cartridge filtration is the least operationally complex method of providing filtration, but there are some issues that must be considered. Selection of this filtration method will lead to an ongoing operational requirement and cost for replacement of filter cartridges. No removal credit for viruses can be allocated cartridge filtration. Thus, this method must be followed by free chlorination. The overall performance of cartridge filtration is not well documented as a municipal water treatment strategy. This issue is offset, in part, by the high quality of the raw water in Repulse Bay. One key advantage of cartridge filtration in this application is the small quantity of process wastewater created. Process wastewater generation is limited to filter drainage housing drainage for internal cleaning.

Alternative to Filtration

The turbidity guidelines provide for exclusion of filtration in waterworks, but this exclusion is dependent upon all of the following conditions being met.

- Overall inactivation is met using two methods of disinfection, such as ultraviolet and free chlorination.
- Stringent bacterial quality criteria are met in 90% of the weekly raw water samples for the prior 6 months.
- Source water turbidity, prior to disinfection is measured at least every 4 hours. The average should be around 1.0 NTU. Turbidity should not exceed 5 NTU for more than 2 days in a 12 month period.
- A watershed control program that minimizes the potential for faecal contamination of the source water

Achieving all of the above conditions is a very substantial challenge. Ultraviolet disinfection has not been applied, to date, at a truck-fill station in Nunavut. Selection of this technique carries substantial risks including lack of operational experience, support of complicated equipment, and shortened UV lamp life due to frequent start-up. Selection of this alternative will require weekly laboratory analysis of raw water bacteriological quality, which will be a substantial logistical challenge in Repulse Bay. The turbidity monitoring requirement would require ongoing monitoring through the day, or automated measurement. Either measurement strategy will require specific training and ongoing surveillance of operating personnel. In summary, the strategy of the combination of ultraviolet and chlorine disinfection, without filtration is unattractive as it has technically risk and achievement of all of the prescribed conditions entail challenges due to logistics and requirements for high operator effort and motivation.

Summary

In summary the alternatives of media filtration and membrane filtration are not suitable for application in Repulse Bay. Specific concerns include operational effort and management of the process wastewater. The alternative of the provision of some alternative method to filtration is also unattractive due to operational and logistic challenges, combined with a high likelihood that all of the prescribed conditions will not be met. The remaining, from the potential alternatives is cartridge filtration. It is recognized that this alternative will lead to the ongoing need for cartridge replacement, but this alternative carries the least operational burden. On this basis it is recommended that the design be advanced on the basis of the use of cartridge filtration. The process train would include a course screen followed by successively finer filters in the sequence of 20, 5 and 1 micron. Chlorination should be applied both ahead of the filters and following filtration.

4.3.3.2 Disinfection

There are two potential methods of disinfection, ultraviolet (UV) irradiation and chlorination. UV is a flow through process that has proven effective as a method of inactivation of virus and giardia, but this method leaves no residual in the treated water. Thus, a chemical disinfectant, such as chlorine, must be added to assure continued bacteriological quality during distribution. There is no experience with UV in truck-fill stations in Nunavut. Issues associated with UV treatment include start-up times for the lamps, short lamp life due to frequent starting and the on-going need for disassembly and cleaning to assure reliable disinfection. Based on these issues, combined with the requirement for subsequent chlorination due to delivery system requirements, UV is not recommended at this time.

There is good operational familiarity with chlorination in Repulse Bay. The operators in the community have successfully operated this type of equipment for many years, and there is a history of the necessary testing.

Based on the above comments it is recommended that chlorination be selected as the preferred disinfection method for this project.

The Guidelines present the CT concept for the evaluation of the effectiveness of chlorination as a disinfection process. The under-lying premise is that water and a chlorine solution of sufficient concentration must remain in contact with each other for the full length of the prescribed contact time prior to the water being considered potable. The concept integrates contact time, concentration, temperature and the characteristics of the chlorine contact facility.

The CT value is used as a measurement of the combined effect of disinfectant concentration and the period of length of time that the disinfectant and water have an opportunity to remain in contact. Standards have been developed that correlate the amount of CT with the amount of pathogen inactivation due to chlorination. The CT value is calculated as follows:

CT = (Chlorine concentration, mg/L) (Contact time, minutes)

For water at 0.5^{0}C, the literature indicates a CT of 12 mg-min/L is appropriate for 4 log inactivation of virus. A CT of 12 mg-min/L can be obtained by maintaining a chlorine concentration of 1.0mg/L for 12 minutes. The required contact time would decrease with an increase in chlorine concentration, however we believe 1.0 mg/L is the upper limit that would be acceptable to the Hamlet

The physical characteristics of the chlorine contact facility are incorporated into the evaluation of the CT value through adjustment of the time (and thus volume) to account for the potential of mixing. Mixing enhances the risk of short circuiting, which reduces the assurance that the treated water has remained in contact with the chlorine solution for the required time prior to delivery. For a tank or reservoir with large amounts of mixing, such as a truck filled from an overhead loading arm, complete mixing would be assumed. Therefore as there is no method assuring that this incompletely treated water is not among the first delivered. The time for loading the truck cannot be counted as part of the disinfection time in determining the CT Value. An operational decision to wait the required contact time prior to starting deliveries would provide the required contact time. However it is optimistic and impractical to expect this as an on-going operational practice. The travel time between the truck-fill station and the hamlet can be recognized in the calculation of chlorine contact time. Based on on-site observations, this travel time will be assumed as 5 minutes. It is proposed that the remaining chlorine contact requirements be achieved prior to loading into delivery trucks, and that required contact time be achieved using facilities incorporated into the truck-fill station.

Based upon a pump flow rate of 1,000 L/min, a minimum CT of 12 and chlorine concentration of 1.0 mg/L a minimum chlorine contact time of 12 minutes is required. Five minutes of this contact will occur enroute to the hamlet and the remaining contact will occur within the truck-fill station. The minimum volume of the chlorine facility is calculated as 7,000 litres. The actual volume of the facility incorporated into the truck-fill station must be adjusted inconsideration of the physical characteristics of the facility and the potential for mixing. The alternative of a contact tank, and a contact pipe have been examined.

The alternative of a chlorine contact tank would take the form of a tank with internal baffles. Despite the baffling, some mixing is inevitable, and this mixing must be considered during the sizing of the tank. The required volume to reliably achieve a CT of 12 mg-min/L would be 14,000 to 21,000 litres. Incorporation of this tank within the truck-fill station building envelope would substantially increase the size of the facility. Provision of contact in an external tank represents a mechanically complex system that would include separate truck loading pumps, stored water circulation and re-heating.

A contact pipe provides a very good approximation of a plug flow due to large length to diameter ratio, low velocity and very limited opportunity for longitudinal mixing. The required volume within a contact pipe is 7,000 litres. This can be accomplished within the truck-fill station building envelope. The resulting mechanical arrangement is less complex than a contact tank, as no additional pumping, circulation or re-heating is required. In view of the reduced contact volume and simplicity of installation, it is recommended that chlorine contact be accomplished within a section of piping.

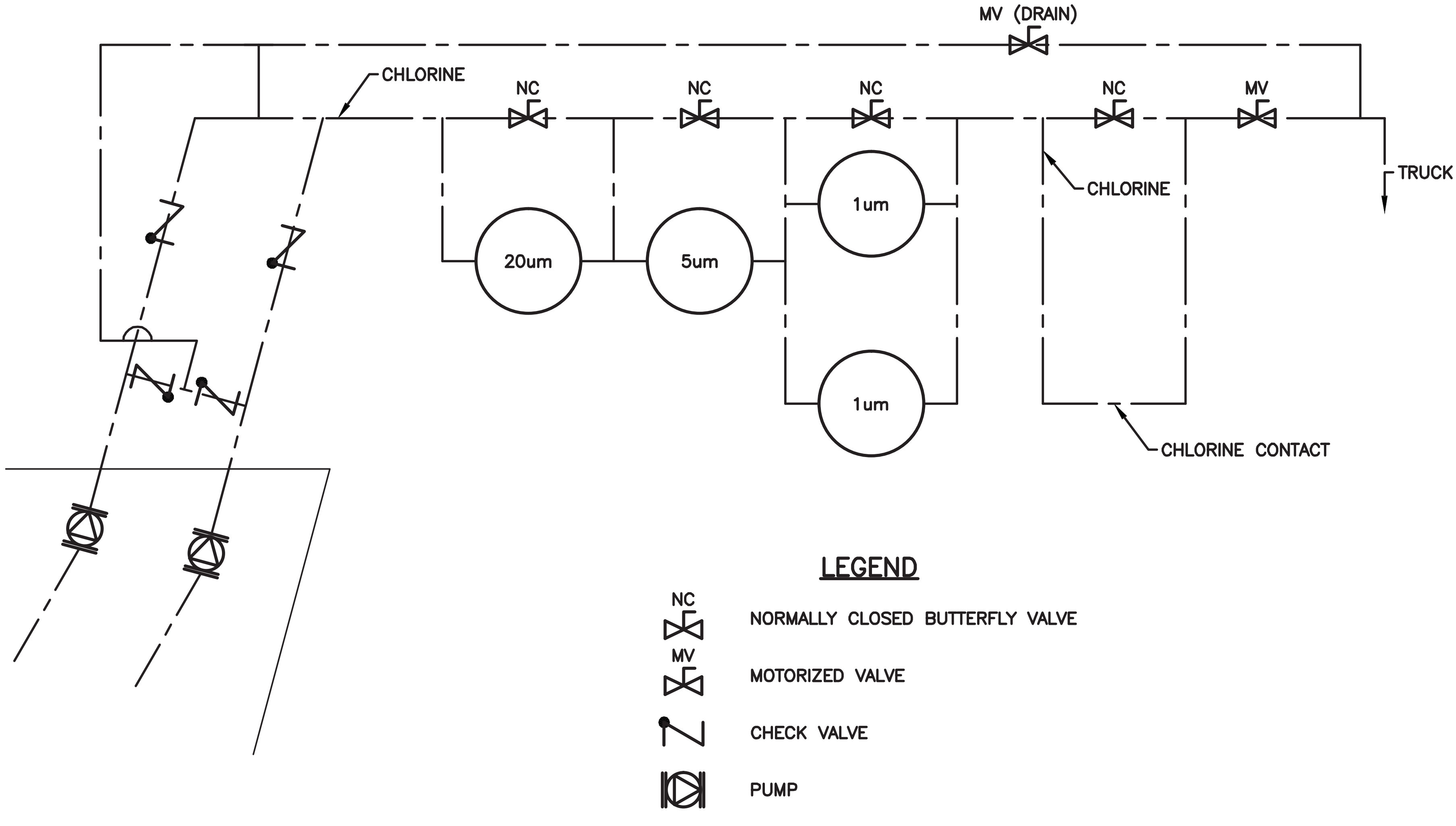
4.3.3.3 Summary of Water Treatment

The recommended water treatment system includes the use of cartridge filters and a chlorine contact pipe. The proposed sequence of filters would include 20 microns, followed by 5 microns, followed by 1 micron filters, all followed by a chlorine contact pipe as shown on Figure 1.

4.3.4 Truck Loading

Table 4.1, in Section 4.2.5 estimates that 29 truck loads will be required to meet the max day demand at the 20 year design horizon. This estimate of the number of loads indicates that truck fill time at the end of the design period will approach 6 hours during maximum day conditions. It also noted that this level of demand is expected to arise less frequently than 10 days annually. This estimated truck fill time implies that the max day demand may require an extension of the work day to meet the demands based on a single truck fill arm and 1,000 litres/minute fill rate.

Provision of the ability to simultaneously fill two trucks, or utilize a higher fill rate is, at first glance, attractive options. Further assessment, however, leads to a contrary conclusion. Specifically, increasing the pumping capacity to allow for a second truck fill arm or to increase the fill rate has many ripple-on effects. Filtration and chlorine contact capacity must double, which in turn leads to an enlargement of the building size and building services. The implications of the simultaneous ability to fill two trucks or fill the trucks at a higher rate are substantial in terms of additional capital cost and this increase in initial investment would be a response to an occasional condition later in the design life of the facility.



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scale: N.T.S	CLIENT: GOVERNMENT OF NUNAVUT	project no.: OTT00208308
date: 07/01/13		
drawn by: M.KELLEY	TITLE: WATER TREATMENT	FIG1

Based on the above it is proposed that single conventional truck loading arm be provided and the design flow-through capacity be based upon desired truck fill rate of 1,000 litres/minute. In addition it is proposed that the future max day demands and the estimate of the time required to fill trucks is best met through an occasional extension of the work day due to the low frequency of maximum day conditions and the high capital cost implications of the alternatives.

4.3.5 Building Space

The current building lacks the space required to accommodate the required water filtration and disinfection process. A suitably sized building must be provided. Figure 2 and Figure 3 present the floor plan and elevation plan for the proposed building. This building incorporates a separate room for the electrical equipment and generator, as well as a separate room for the chlorination equipment. A separate room is proposed for chlorine handling and dispensing to reduce operation problems from corrosion arising from the chlorination chemicals.

4.3.6 Building Services

4.3.6.1 Electrical Power

A three phase electrical supply will be required by the proposed pumping equipment. There is no existing 120/208 volt supply available at the site. This issue is examined in greater detail in a subsequent section of this report.

4.3.6.2 HVAC

It is recommended that a simple heating and ventilation system be provided. Oil fired unit heaters can provide appropriate heating. Avoidance of an external chlorine contact chamber sets aside the need for boilers, circulation pumps, heat exchangers and controls. Electric heating is proposed for the chlorination equipment room. This will permit isolation of the disinfection chemical from the remainder of the facility and will provide a load for the generator during wait times between truck fills.

Ventilation will be required for the chlorine handling room to avoid corrosion damage to the equipment within the truck-fill station. Appropriate ventilation will be required for cooling and combustion air for the proposed generators.

4.3.7 Site

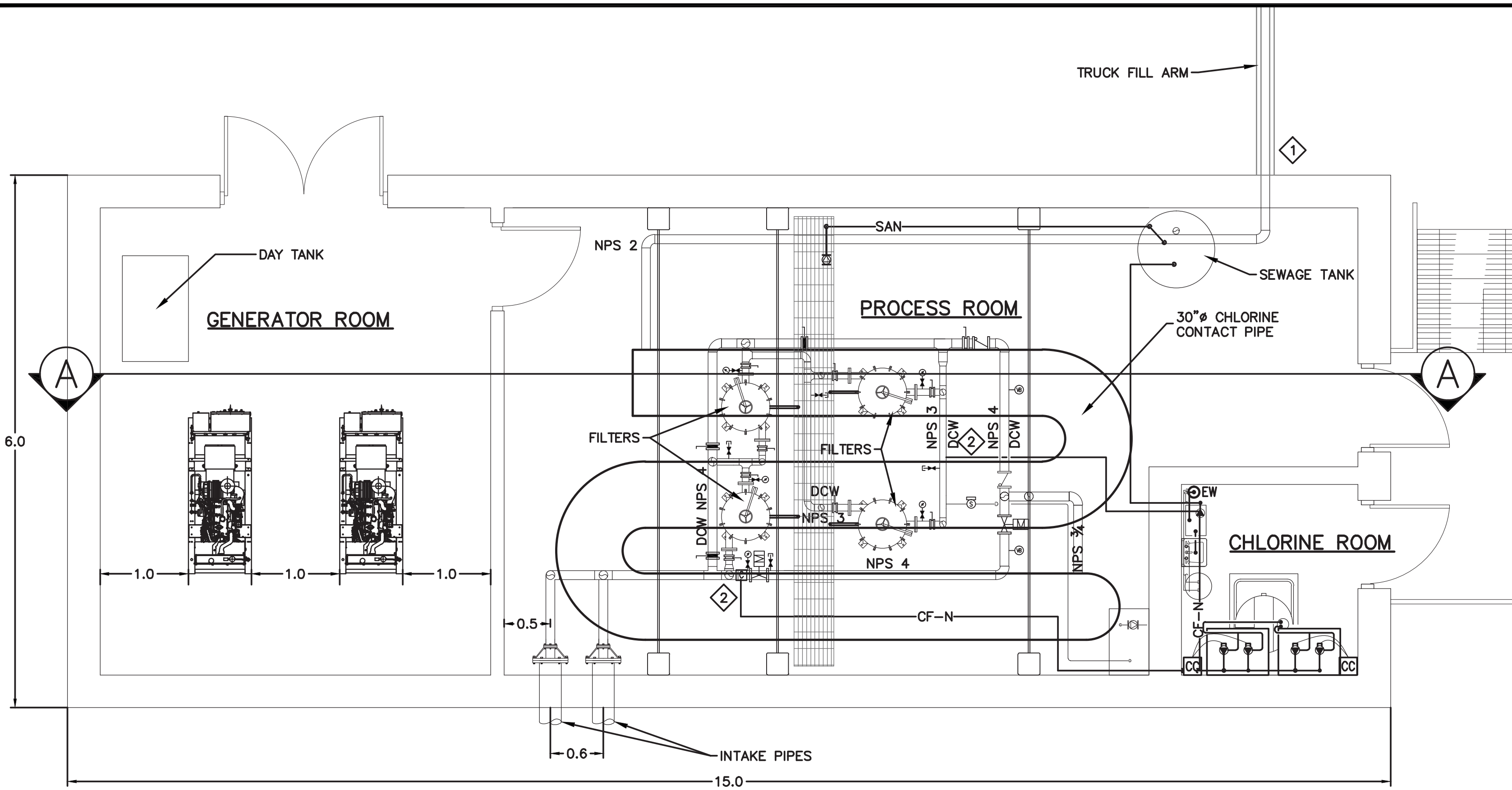
4.3.7.1 General

Site works include the truck access and the electrical supply. The current access road is adequate to support the current facility. Minor relocation of this access road will be required due to the increased size of the proposed truck-fill building. Figure 4 illustrates the proposed site layout, including the access road. It is proposed that the existing turn-around, west of the building be retained.

4.3.7.2 Electrical Power

The electrical requirements at the truck-fill station are currently met by a pair of on-site diesel generators. The alternatives of connection to the utility network and continuation of the current practice have been evaluated. The merits of these alternatives have been examined for a 30 year design life. A cost effective analysis has been applied, which consolidates initial capital costs with the present value of the ongoing operating spending over the 30 year project life. Discount rates of 2, 4 and 8 % have been used to test the sensitivity of the findings of this analysis to long term general economic conditions.

For the alternative of connection to the utility electrical network, the following assumptions have been applied.



GENERAL NOTE:

LAYOUT OF CHEMICAL FEED PIPING IS SHOWN SCHEMATICALLY FOR CLARITY. COORDINATE FINAL LAYOUT ON SITE.

DRAWING NOTES:

1. CONNECT PIPE TO TRUCK FILL ARM WITH FLEXIBLE JOINT.
2. CONNECT CHEMICAL FEED PIPE TO WATER PIPE.

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scale 1:50	CLIENT: GOVERNMENT OF NUNAVUT	project no. OTT00208308
date 07/01/13	TITLE: WATER FILL – PLAN VIEW	FIG2
drawn by M.KELLEY		

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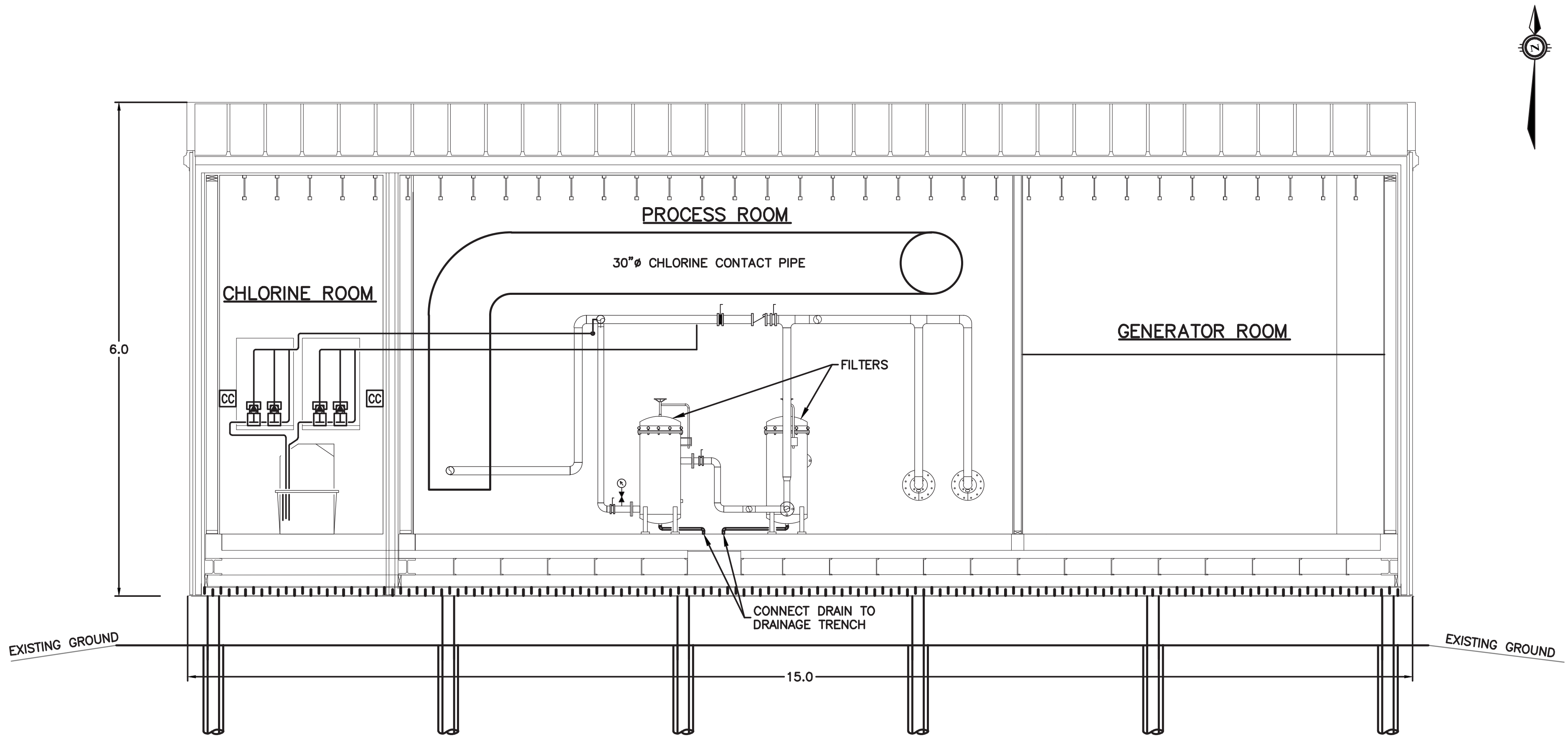

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scale 1:50	CLIENT: GOVERNMENT OF NUNAVUT	project no. OTT0020803
date 07/01/13		
drawn by M.KELLEY	TITLE: WATER FILL – BUILDING ELEVATION	FIG3

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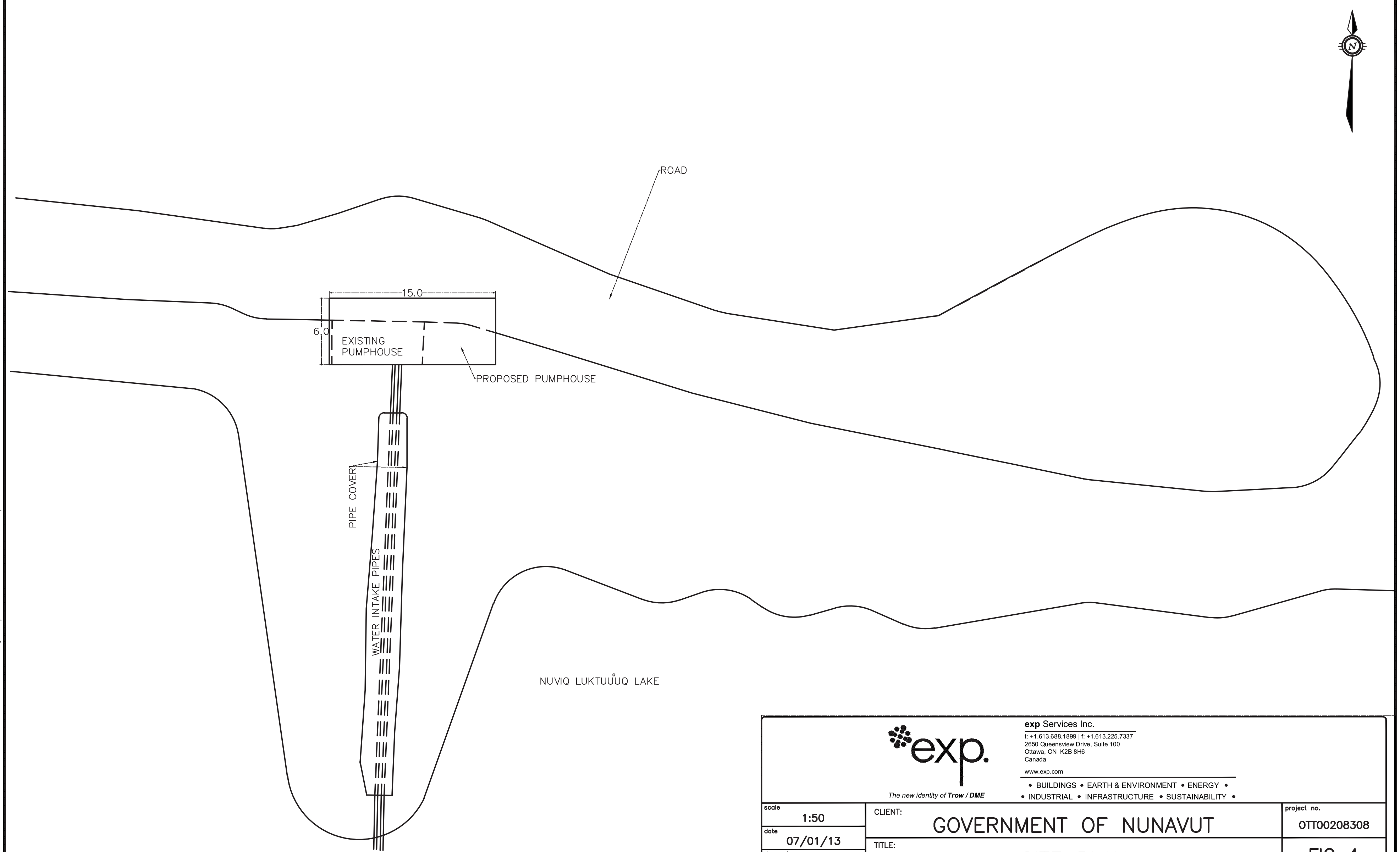

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date 07/01/13	TITLE: SITE PLAN	FIG 4
drawn by M.KELLEY		

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- Initial capital spending:
  - Pole line (4 km) $1,452,000
  - Electrical cable 231,000
  - 45 kVA transformers (3) 15,000

Total $1,698,000

The above capital cost estimate does not include the standby generator, or associated works, that will be required to support the facility during power failures. This cost has not been included as the intention of this analysis is to determine the incremental implications arising from the selection of a method of power supply to the site.

- Ongoing electrical charges
  - Annual consumption – 165,600 kWh
  - Electrical rate - $0.6641 per kWh

No recapitalization is anticipated over the 30 year life of this facility.

For the alternative of local generation, an additional generator will be required to assure continuing power following equipment failure. An allowance has also been incorporated to recognize the added complications in the generator controls and automatic transfer switch as well as the increased complexity in the fuel system. The following assumptions have been applied in the development of a cost effective analysis for the alternative of on-site electrical generation.

- Initial capital spending
  - Additional generator $19,000
  - Additional generator controls 5,000
  - Additional fuel system 4,000
    - Installation 15,000

Total $43,000

Estimated ongoing operating and recapitalization is summarized as follows.

- Fuel consumption – 250 litres/day
- Fuel cost - $1.11/litre
- Annual maintenance cost - $5,000
- Generator service life – 10 years

Generator replacement at end of service file (3 generators) - $78,000Table 1 and 2 in Appendix D summarizes the assessment of the 30 year spending required for the two alternatives at 2% , 4% and 8% discount rates. The estimated present value of expenditures for the two alternatives over a 30 year life cycle, for a discount rate of 4%, are presented in Table 4.2.

Table 4.2 – 30 Year Life Cycle Costs

Alternative	Amount
Connection to the utility electrical network	$3,600,000
Local generation (generators)	$3,544,000

For a 30 year life cycle and a discount rate of 4% the alternative of locally generated electrical power is the most financially efficient. The assumption of a lower discount rate will shift this determination in favour of construction of a power line. Assumption of a higher discount rate favours the alternative of locally generated power.

The implications of selection of a shorter time for this analysis have been examined. Over the initial 10 year or operations, locally generated electrical power is substantially more financially effective, and this is independent of discount rate. At the 10 year in the project service life, reinvestment, in terms of new generators and controls will be required. This reinvestment is larger than the initial expenditure as 2 generators will be required.

Combination of both the short and long term analysis is helpful to set both a short and long term strategy for the project. The 30 year analysis with a discount rate of 4% favours local generation. This indicates that the initial facilities should include local electrical generation. At the 10 year point in the project life, when new generators are required, the most appropriate strategy for the ongoing supply of electrical power should be carefully evaluated, as provision of an electrical pole line may be more appropriate.

4.3.8 Cost Estimate

A Class D cost estimate has been prepared for the replacement of the truck-fill station. This estimate is presented in Table 4.3.

Table 4.3 – Cost Estimate

Description	Amount
Mobilization & Demobilization	$300,000
Demolition and Removal of existing Truck-fill station and generator building, and salvaging of existing equipment	$80,000
Site work, connection to existing water line from reservoir , re-grading access road and underside of new building	$120,000
Substructure construction	$200,000
Superstructure (Architectural, Structural)	$300,000
Process and mechanical work and equipment	$600,000
Electrical, instrumentation and control	$530,000
Subtotal	$2,130,000
20% Contingency	$426,000
Total	$2,556,000

5 Summary

The findings and recommendations of this design brief may be summarized as follows.

1. The existing truck-fill facility was visited during September 2012. During this visit it was noted that the existing facility was largely unchanged from the initial construction. In addition the following were noted:
   a. Most of the internal system remained serviceable.
   b. The existing fuel containment system was not leak-tight, and there was a potential for a fuel spill to spread beyond this containment.
   c. At least one of the truck-fill pumps appears to have been in service for 20 years. The pumps remain serviceable, but replacement would be an appropriate action during the construction of a new facility.
   d. The inclined shaft intakes are suitable for incorporation into a new facility.
   e. Much of the original control system is no longer serviceable and there is no remote annunciation of alarms. Provision of a simple control system with an external control station for truck fill would be appropriate in the short term.
2. The existing facility is not capable of meeting the Guidelines for Canadian Drinking Water Quality. This is the result of a lack of filtration, combined with insufficient chlorine contact time.
3. A review of the features that must be incorporated into a new truck-fill station has been conducted. These requirements are presented in detail in this report and may be summarized as follows.
   a. The design truck fill rate should be 1,000 litres per minute.
   b. A water treatment process that will satisfy the requirements of the Guidelines for Canadian Drinking Water Quality should be provided. This process should include filtration and disinfection.
   c. Alternative methods of filtration have been examined. The most appropriate method for this site in cartridge filtration, as this process leads to minimal quantities of process waste water that must be managed.
   d. Chlorination has been selected as the most appropriate method of disinfection.
   e. Appropriate chlorine contact should be provided. The most appropriate form of chlorine contact facility is a chlorine contact pipe with an internal volume of 7,000 litres. An allowance for contact during the drive to the community has been recognized.
   f. A new building will be required to accommodate the filtration and chlorine contact.
   g. The existing facility is served by on-site electrical generation. A review of the merits of a continuing this practice has been compared against the provision of a pole line. Continuation of the current practice is the most financially efficient alternative. The on-site generators will have a service life of approximately 10 years. The merits of a pole line should be re-examined at such time as replacement of the generators is necessary.
   h. There is sufficient area to accommodate the proposed facility.
4. The estimated cost for the provision of a new truck fill station is $2.6 million.

Appendix A – Electrical and Mechanical Condition Review - Repulse Bay, Nunavut

Department of Community & Government Services, GN

Electrical and Mechanical Condition Review

Repulse Bay, Nunavut

Table of Contents

1.0 Introduction

The following report includes a detailed review of the condition of the electrical and mechanical infrastructure installed at the Repulse Bay Truck-Fill Station. The station consists of a single pre-fabricated building divided into two separate rooms: the generator room and the truck-fill room itself. The generator room houses two generators of which one operates at all times. The truck-fill room includes the controls for the pumps and the water treatment system.

A one-day site visit was conducted on September 5th to review the electrical and mechanical condition of the equipment installed at the site. The following report includes our observations of site conditions as well as comment on the remaining life of the equipment and recommendations for system improvement. This report will also highlight any health and safety or code compliance issues as found on the site.

2.0 Condition Review

2.1 Generator Enclosure Room

2.1.1 Electrical Systems

Generator Power Supply

Electrical service to the site is provided by two local generators located in a common room. The generators are rated for 16 kVA, 12.8 kW at 120/208V. The engine is a Deutz 15.2 kW, 20 Hp, 1800 rpm with a Stamford alternator. The site does not have a connection to the hamlet electrical system as it is 4 km away from the closest 3 phase pole line.

To support the electrical systems and maintain the freeze protection on the supply lines, a single generator is operated at all times. Each day the generators are alternated by manually starting and transferring the load to the other generator. This manual transfer and loading of the generators ensures that the run time hours on each generator are similar which improves the reliability and availability of these types of systems. The units were replaced in 2009 or 2010 and appear to be in good condition. The operator indicated that they have had no operational issues with the generators, although G1 has a slight oil leak which is being trapped in a small oil pan. The original generators for the site were 10 kW/12.5 kVA. The new generators are of sufficient capacity to support the system loads.

Comments

- The existing electrical power generating system at the site is of adequate size and is in good condition. Regular maintenance should continue to ensure operation.
- Generator room needs to be cleaned annually to ensure continued good performance of the equipment.

Recommendation

- The system capacity may need to be increased to allow for station load growth associated with filtration. This requirement will be evaluated as part of the design process. Otherwise the generators are in good operating condition and with proper maintenance should continue to operate for a period of up to 15 years.

Disconnect Switches

Both generators supply 100A, 120/208V, 3 pole disconnect switches mounted on the wall separating the generator room from the pump room. The disconnect switches are clearly identified as Source 1 and Source 2. The disconnect switches are in good condition. From available information, these devices appear to be part of the original installation.

Comments

- The existing disconnect switches and enclosure are in good condition.

Recommendation

- Existing disconnect switches will remain in service if load in the pumping is not increased due to upgrades. This will be evaluated as part of the design process.

Automatic Transfer Switch

The emergency power transfer switch supplies power to the Panel A from generator Source 1 or Source 2. The automatic transfer switch (ATS) in the generator room is rated at 100A, 208V, 3 phase, 4 wire manufactures by Thomson Technology, model TSC 800.

The ATS is equipped with an automatic mode which is intended to automatically start and transfer load from the generator in operation to the standby generator every 10 hours. According to building operations staff the automatic mode of the transfer switch has never operated properly. As a result, building operations staff visit the site each day to start the standy generator and then manually transfer the load, as the automatic mode is not available. Operations staff have no issue with this mode of operation and the manual switching of the generators is reliable. The only disadvantage to not having an automatic mode is that is the operating generator fails at any time the standby generator will not start and pick up the load. Electricians on site have tried to repair the automatic operations without success.

The ATS is also equipped with an hour meter for both generators which appears to function properly. The two generators run times are within 20 hours of each other, which demonstrates that they are being switched regularly to maintain similar run times on each generator.

The front panel of the ATS also includes an analog ammeter. Load levels were generally very low inside the facility. Loading on the units was not confirmed during pump operation.

Other than the lack of automatic operation the transfer switch appears to be in good condition.

Comments

- The existing transfer switch no longer operates in an automatic mode. Transfers can be completed safely manually.
- Lack of an automatic transfer mode causes operational problems if the operating unit fails causing systems to freeze up.

Recommendation

- Continue to use existing transfer switch manually until station building is replaced.

Generator Battery and Charger

The generator batteries are currently operational and are 2 to 3 years old. They were replaced as part of the generators replacement. The battery chargers are original to the installation, Mechron charger; model CR2F120-012-010B, rated for 120V AC input and 12V DC output. The generator ‘A’ charger was operating on manual float mode with 0.0A DC charging at 14.5V DC. The generator ‘B’ charger was operating on manual float mode with 2.6A DC charging at 13V DC.

Comments

- The existing generator batteries are in good overall condition and are of sufficient capacity to crank and start the generators.

- The existing battery chargers are operational and appear to be functioning properly.

Recommendation

- Continue use of batteries and battery chargers.

Heating System

The generator enclosure does not include any heating system other than the heat trace in the enclosure door frame which prevents frost build-up in the door. Separate heating is not necessary for this room considering that the operating generator provides sufficient radiant heat to maintain room temperatures. The facility operators indicated that the room remains above freezing during the winter.

There did not appear to be any provisions for a block heater or battery blanket on the generators. There was no indication from the operators that this has been an issue.

Comments

- There is no heating system in the generator side of the enclosure.

Recommendation

- Continue to operate the system in the present mode.
- No other recommended changes.

Heat Trace Door Frame

The heat trace in the door frame is fed from a 15A, single pole breaker in Panel 'A'. The framing around the door was cool to the touch but the heat tracing may have been out of operational range as temperatures were above 0°C at the time of our visit.

The original door frame to the generator room no longer sits flush as the hinges work improperly. As a result, it is difficult to determine the functionality of the door frame heat trace unit. Building Operations staff indicated that it did not function properly in previous winters.

Comments

- The door frame heat tracing is possibly non operational.

Recommendation

- System to remain as is until building is replaced. It is integral to the enclosure walls and cannot be replaced.

Lighting

The lighting in the generator enclosure consists of four 2x32W fluorescent strip fixtures mounted to the ceiling and the walls of the enclosure as required. The lights are controlled by a local switch beside the main door. The fixtures are industrial type and include protective grilles which are intact. All normal lighting was fully operational.

Emergency lighting in the generator enclosure room consisted of two emergency battery units with double heads, as well as one set of remote heads. The emergency battery units were not accessible to be tested during the visit. The remote heads appear to be in good condition. Neither of the battery units are original to the installation; they have been replaced during the life of the installation.

Comments

- The normal lighting in the enclosure is fully functional.
- The emergency lighting operation was not tested.

Recommendation

- Test and replace the battery units regularly to ensure operation. Replace the units if required.

Receptacles

There are three general duplex receptacles installed in the generator enclosure. The receptacles are in fair condition and are operational. Two of the duplex receptacles supply the emergency battery units.

Comments

- The receptacles in the enclosure are functional.

Recommendation

- No recommendations.

2.1.2 Mechanical Systems

Ventilation

There is a single combustion air intake into the room which is ducted directly to both generators. Combustion air can be drawn from either inside the room or directly from outside. The combustion air intake is equipped with a motorized damper which is controlled by a local thermostat. The motorized damper system is original to the installation and appears to be operational.

The ventilation of the room is achieved by natural ventilation. An exhaust duct, located at the ceiling level removes hot air located in the room. The ductwork for this exhaust duct is partially missing, but it is still functional. During warmer months, the door to the generator room is left open to provide additional cooling and ventilation.

A fresh air intake draws air from outside and delivers the air at the floor level at the rear of the room. It is always fully open. The exhaust duct is in fair but serviceable condition. Two additional 4" air intake holes have been added through the wall of the enclosure on top of the door frame. These air intakes have small covers on the exterior to prevent the entry of rain or snow but are otherwise open. They appear to have been added post construction in order to improve fresh air ventilation into the room.

The two generator exhausts extend through the rear wall of the enclosure. They appear to have been partially redone when the new generators were installed.

Comments

- The combustion air intake set up is functional and can supply adequate fresh air to the generators.
- Additional ventilation has been added by perforating holes through the building exterior.

Recommendation

- Outfit ventilations holes with a screen to prevent access by insects and animals.
- Replace the existing exhaust air chimney with a unit with an enclosed fan to improve the exhaust of heat from the room and to allow the door to remain closed during warmer periods.

Fuel System

The existing fuel system consists of a single wall indoor tank installed in a secondary containment basin. Fuel is drawn directly by the generators from two separate fuel lines and returned to the tank with two separate return lines. An oil filter with water separator is installed upstream of the generator fuel supply.

Based on specification documents in the O&M manual, the tank has a capacity 1135 Litres. It includes a tank vent with whistle and drain valve. The tank is also equipped with a level switch that is connected to the alarm panel. Based on observations the level switch is functional. The fill and overflow pipes are connected through the side wall of the enclosure which allows for filling of the tank from the exterior of the building.

The fuel system installation is original to the fill truck station and has only been slightly modified to run the fill and return lines to the replaced generators.

The fill and return lines for the generators pass through the side of the containment basin at the floor. There are gasketed holes where the lines pass through the basin. It was noted during our inspection that at least one of the gaskets is missing and the fuel containment basin would leak in the event of a fuel leak in the main tank.

Comments

- The fuel system is original to the installation but is functioning well. It is in fair condition. Consideration should be made to replace the fuel system within the next 5 years.
- Opening through the containment basin have not been properly sealed and may leak due to a missing gasket.

Recommendation

- Provide new gasket for the fuel line which passes through the containment basin. Ensure there are no further breaches in the containment.

2.2 Truck Fill Station

2.2.1 Electrical Systems

Electrical Service

Electrical service to the truck fill station is provided via conductors in flex conduit connection through the partition wall in the centre of the enclosure. The cable is supplied from the 100A ATS in the generator enclosure and feeds directly into Panel ‘A’.

Comments

- No comments.

Recommendation

- No recommendations.

Panel “A”

Panel ‘A’ is supplied from the 100A, 120/208V Automatic Transfer Switch. Panel ‘A’ is a Square D 125A, 120/208V panel equipped with the following major breakers:

- 40A 3P Pump P1
- 40A 3P Pump P2
- 30A 2P Heat Trace 1
- 30A 2P Heat Trace 2
- 30A 1P IR Heating

There is a total of 32 breakers installed in Panel ‘A’. The panel has three single-pole spaces remaining for future breaker additions.

The Panel ‘A’ is not original to the truck fill station installation based on the original O&M manuals which indicate Westinghouse shop drawings. It could not be determined what year Panel ‘A’ was replaced. It is in overall poor condition. There are signs of rust damage on the exterior of the panel front. Furthermore, there is a bullet hole in the front cover of the panel. The bullet did not hit the busbars and was removed from the panel. Panel ‘A’ was not opened for inspection as it was in operation. The panel cover does not feature a gasket and the type 3R enclosure is not air tight. The panel and all breakers are still fully operational. There is no panel schedule for Panel ‘A’ and therefore it is difficult to determine which breakers operate which receptacles.

Comments

- The existing Panel ‘A’ is in poor condition and will require replacement within 5 years. There is limited space for the addition of loads.

Recommendation

- Electrician to investigate and create panel schedule in order to aid building operations staff.

- Replace panel in the next 5 years. When panel is updated a larger panel may be desirable to increase the flexibility of the branch circuits. This will be reviewed as part of the design process.

Pump P1 and Pump P2

Pumps P1 and P2 are both 5 HP, 208V 3 phase submersible pumps. The original pumps installed on the site were Myers with Franklin Electric motors. It is currently unknown if the original pumps are still in operation or if they have been replaced.

Pump P1 draws 44A at starting and operates at 19A, 208V. Pump P2 draws 39.5A at starting and draws 17.4A, 208 during operation. Based on these values it is quite possible that one of the pumps is no longer original, or that both pumps have been replaced with different models. The operation of both is within the normal operating range of a 5 HP pump.

Pump P2 has a lower flow rate than Pump P1. As a result, buildings operation staff operate pump P1 more frequently.

Comments

- Pumps P1 and P2 are both fully operational.
- It is difficult to determine the age of the pumps since it is unknown if they have been replaced.

Recommendation

- Continue operating the pumps manually with alternation in order to prevent fatigue on Pump P1.

Pump P1 Starter

The Pump P1 Starter is a Square D motor combination starter which is supplied by a 40A breaker in Panel A. It is original to the pumping station construction. The enclosure appears to be in good condition with no signs of rust or corrosion damage. It is currently in operation supplying Pump P1.

The starter is supplied through a 52A, 208V, 3 phase ground fault interrupter (GFI) which is original to the installation. It is a Federal Pioneer Lifeguard model GP-2-20.

The starter features a running light as well as a hand-off-auto selector switch and a reset button. As the original exterior station controls are no longer operational, the operators start the pump manually via the selector switch by turning it to 'hand' and running the pumps. When the truck is full they switch it back to the 'off' position.

The starter has the original stickers on it for the Franklin Electric Submersible Motor from the original installation. The starter is rated for 5 HP at 208V, 3 phase.

The starter is also connected to a small Square D interlock contactor which turns off both Pump P1 and P2 heat tracing cables while the pump is in operation in order to prevent overload on the generator. The interlock contactor is original to the installation and is operational.

Comments

- The Pump P1 Starter is still in operation and appears to be in good condition.

- Remaining service life of the starter is up to 5 years.
- The starter is operated via the manual selector switch as the exterior controls are no longer operational.

Recommendation

- Continue using the existing Pump P1 starter in manual mode.

Pump P2 Starter

The Pump P2 Starter is a Square D motor combination starter which is supplied by a 40A breaker in Panel A. It is original to the pumping station construction. The enclosure appears to be in good condition with no signs of rust or corrosion damage. It is currently in operation supplying Pump P1.

The starter is supplied through a 52A, 208V, 3 phase ground fault interrupter (GFI) which is original to the installation. It is a Federal Pioneer Lifeguard model GP-2-20.

The starter features a running light as well as a hand-off-auto selector switch and a reset button. As the original exterior station controls are no longer operational, the operators start the pump manually via the selector switch by turning it to 'hand' and running the pumps. When the truck is full they switch it back to the 'off' position.

The starter has the original stickers on it for the Franklin Electric Submersible Motor from the original installation. The starter is rated for 5 HP at 208V, 3 phase.

The starter is also connected to a small Square D interlock contactor which turns off both Pump P1 and P2 heat tracing cables while the pump is in operation in order to prevent overload on the generator. The interlock contactor is original to the installation and is operational.

Comments

- The Pump 21 Starter is still in operation and appears to be in good condition.
- Remaining service life of the starter is up to 5 years.
- The starter is operated via the manual selector switch as the exterior controls are no longer operational.

Recommendation

- Continue using the existing Pump P2 starter in manual mode.

Power Supply to Pumps P1 and P2

Pumps P1 and P2 are supplied with 40A, 208V, 3 phase power directly from the pump starters. Cable is run in conduit around the interior of the truck fill station. The conduit and wiring terminate in twist lock receptacles which are connected to flexible wiring. There is no conduit sheath visible for the wiring and the individual insulated phases are exposed between the pump piping entrance and the twist-lock receptacle.

Comments

- The individual insulated phase wires are exposed between the pump casing and the twist-lock receptacle.

Recommendation

- Replace the wiring to the pump with wiring encased in a liquid tight flexible conduit for wiring protection.

Heat Trace Pump P1

The heat trace for pump P1 is supplied by a 30A, 2 pole breaker in Panel 'A'. The heat trace controller is mounted adjacent to the piping entrance. The control unit is an Urecon URSS1-2 temperature controller.

The heat trace controller is designed for 30A at 240V. The heat trace controller appears to be original to the installation. The heat tracing cable has been replaced at some point, as its model number does not match the model indicated in the original Operations and Maintenance manual. The control panel is in fair condition. The wiring inside of the control panel is still in good condition and the cabling is in operation. The controller appears to be set for 29°C.

A spare heat trace cable is installed in the pipe and was connected to the spare heating outlet. Both the primary and the spare heating cable were in operation. This condition was brought to the attention of the building operation staff as it was questioned whether the system should be operated in this matter.

The heat trace cables are Raychem 100TV2 type 3A model with a rating of up to 33 W/m. They are connected to the controllers via Hubbell twist-lock receptacles.

It was noted by building operations staff that occasionally the heat tracing cannot keep up with the temperatures in the winter and one of the pipelines will freeze. When this occurs, the spare heat tracing cable can be plugged in along with the regular cable. The building operators indicated that this does unthaw the line.

Comments

- The heat trace control system is operational at this time. It has an anticipated remaining life of up to 5 years.

Recommendation

- Unplug the spare cable from the spare outlet as both cables are being powered at the same time. Only do this in the case of extreme cold where the single line may be inadequate to maintain the temperature in the pipeline.
- Install a more robust heat trace system in the future with higher temperature settings.

Heat Trace Pump P2

The heat trace for pump P2 is supplied by a 30A, 2 pole breaker in Panel 'A'. The heat trace controller is mounted adjacent to the piping entrance. The control unit is a newer Urecon unit with no specific product number on the nameplate.

The heat trace controller is designed for 30A at 240V. The heat trace controller is not original to the installation and has been replaced. It is estimated that the replaced heat trace controller is up to 5 years old. The heat tracing cable has also been replaced at some point, as its model number does not match the model indicated in the original Operations and Maintenance manual. The control panel is in good condition. The wiring inside of the control panel is good condition. It could not be determined what temperature the unit was set for as it had been programmed with dip switches and no user manual was available. At the time of our visit, ambient outdoor temperatures were in the range of 1 - 12°C and the water temperature was above freezing. The unit light indicated that the controller was on, but that it had not reached the temperature limit to turn on the heat trace cabling.

A spare heat trace cable is installed in the pipe and was not connected to the spare heating outlet. Neither the primary nor the spare heating cables were in operation. This may be due to the temperature setting of the P2 heat tracing controller.

The heat trace cables are Raychem 100TV2 type 3A model with a rating of up to 33 W/m. They are connected to the controllers via Hubbell twist-lock receptacles.

It was noted by building operations staff that occasionally the heat tracing cannot keep up with the low temperatures in the winter and one of the pipelines will freeze. When this occurs, the spare heat tracing cable can be plugged in additionally to the regular cable. The building operators indicated that this does unthaw the line eventually.

Comments

- The heat trace control system appears to be operational at this time. It has an anticipated remaining life of up to 15 years.

Recommendation

- Verify that the pump P2 heat tracing turns on when temperatures drop. If required, plug the spare cable into the spare outlet for the pump P1 controller as this receptacle and controller is known to be operational.
- Install a more robust heat trace system in the future with higher temperature settings.

Heat Trace Door Frame

The heat trace in the door frame is fed from a 15A, single pole breaker in Panel 'A'. The framing around the door was cool to the touch but the heat tracing may have been out of operational range as temperatures were above 0°C at the time of our visit.

However, the door frame has been modified and/or replaced at some point and the door no longer closes flush. As a result, it is difficult to determine the functionality of the door frame heat trace unit. Building Operations staff indicated that it did not function well in previous winters.

Comments

- The door frame heat tracing is possibly non operational.

Recommendation

- System to remain as is until building is replaced. It is integral to the enclosure walls and cannot be replaced.

Heat Trace Truck Fill Arm

The truck fill arm heat trace is fed from a 15A, single pole breaker in Panel 'A'. It was not plugged into the dedicated outlet at the time of our visit as temperatures were above 0°C. The building operations staff indicated that they have been having issues with the truck fill arm heat trace and that it frequently freezes on them. We measured different resistance values on each leg of the heat trace cable. This indicates that the insulation or cabling inside of the heat trace is breaking down.

Comments

- The truck fill arm heat tracing is not fully operational. Staff are complaining of freezing in the truck fill arm.

Recommendation

- The heat trace cabling in the truck fill arm is damaged or degraded. Heat trace cabling to be replaced immediately with self-regulating cabling.

Enclosure Heating

The building heating system consists of two radiant heaters mounted on the ceiling of the enclosure. Both heaters appear to be original to the installation based on the O&M manuals. They are regulated individually by thermostats and powered from Panel ‘A’. The radiant heaters appear to be in fair condition and are operational.

At this time, the radiant heaters are adequate to heat the truck fill station

Comments

- Both of the original radiant heaters are in fair condition and are still operational. There remaining life span is 5 – 10 years.

Recommendation

- Continue using the existing radiant heaters until they reach end of life.

Lighting

The interior lighting consists of four 64W fluorescent industrial two lamp fixtures. The equipment is functioning properly and is controlled by a switch adjacent to the door.

The building emergency lighting is provided by a two-headed emergency battery unit with one additional set of remote heads. The unit tested as having dead batteries. No testing logs were found on site for the emergency lighting.

Exterior lighting for the entire enclosure consists of a wall pack style light mounted on the enclosure at the entrance doors. A second wall pack fixture is mounted directly above the diesel fuel tank filling point on the exterior of the enclosure. There is an additional outdoor fixture attached to the truck fill arm to provide lighting for the process of filling the truck. There does not appear to be any switches to turn the lights on or off and it is unknown which breaker in Panel ‘A’ they are connected to. As a result, the exterior lighting is on 24hrs per day. All of the lights are currently operational. The acrylic cover on the light at the entrance doors is cracked.

Comments

- All normal lighting is functioning well. The emergency lighting battery unit is dead.

Recommendation

- Replace the batteries in the existing emergency battery unit.

Receptacles

There are 4 general duplex receptacles throughout the pumping station. The receptacles appear to be in fair condition. They are still in operation. A 5th receptacle is dedicated for the mixer. It is no longer used and appears to have a grounding issue. The mixer has been plugged into an alternate receptacle.

Comments

- The receptacles in the enclosure are functional other than the mixer one.

Recommendation

- No recommendations.

2.2.2 Mechanical Systems

Chlorinator

The chlorinator is a Wallace and Tiernan Premia 75 solenoid metering pump which injects a chlorine solution into the water as it is pumped through the truck fill station. It is fed by a 15A, single pole breaker in Panel 'A' and plugged into a dedicated receptacle. It is operated by a flow switch in the piping which turns on the chlorinator as soon as water flow is detected in the pipes. The chlorinator has been recently replaced and is functioning well.

Comments

- The chlorinator is functional.

Recommendation

- No recommendations.

Chlorine Mixer

The chlorine mixer model was not noted. It is fed by a 15A single pole breaker in Panel A and plugged into a dedicated receptacle. The mixer creates the chlorine solution from chlorine powder and water. According to operations staff the solution is mixed bi-weekly and the mixer is still in operation.

Comments

- The mixer is functional.

Recommendation

- No recommendations.

Ventilation

The truck fill station is currently not ventilated.

Comments

There is no significant corrosion in the building as operations staff are careful when mixing the chlorine. Operations staff are provided with protective gear such as masks to wear while mixing the chlorine solution. Furthermore, during warmer weather the doors of the pumping station are generally left open.

Recommendation

Ensure the space is ventilated. Future renovations should make provisions for the installation of a new mechanical ventilation system.

Water Piping System

Both of the main pumps are operational and are in daily use. Pump P2 has a lower flow rate than Pump P1 based on site tests and observations.

The water piping in the facility is showing some slight signs of rust but it appears to be in good overall condition. The current configuration with the Tech-Taylor valve and the sizing of the piping prevents the use of both pumps at the same time.

There is a butterfly valve above the Tech-Taylor valve in the process piping which is installed as an isolation valve for preventing water flowing to the truck fill arm when backwashing the pumps or doing other testing. This valve arm is broken and will be difficult to operate.

Comments

- The existing pumps have a limited flow rate. The time required to fill a truck is approximately 10-12min. This is especially important in case of fire.

Recommendation

- Repair the mechanism on the butterfly valve so that it may be operated properly.

2.2.3 Control Systems

Pump Controller and Relay Panel

The pump controller and relay panel is installed adjacent to the pump starters on the separation wall in the centre of the truck fill station. It appears to be original equipment to the station.

The pump controller features the following features:

- Pump P1/Pump P2 Selector Switch
- Pump Alternator with light
- Flow Meter Totalizer
- Timer

This interior controller is no longer used as the exterior controls it is tied into have been removed. The pump starters are only ever operated in Hand or Manual so the Selector Switch and the Pump Alternator could not be verified to be working.

The flow meter totalizer is operational.

The system was originally designed to be operated by one man with a start and stop button installed along the truck fill arm. The truck fill arm and the exterior control panels are no longer functional and have not been repaired or replaced.

The timer would have been used to stop the pumps and to allow enough time for the water in the system to flow backwards into the reservoir before starting the pumps again. This system is non-operational in the current configuration.

Comments

- The control system overall is non-operational due to the fact that the exterior controls and truck fill arm controls are broken or removed.
- The system continues to function well in manual mode.

Recommendation

- Replace the existing control scheme with a simplified system.
- The new control scheme would feature a new outdoor control panel adjacent to the door to allow the operators to turn on and off the pump remotely.
- A selector switch inside the main control panel would determine which pump would operate.
- An auxiliary control panel inside the door of the control station would provide a secondary ON-OFF point with indicating lights.

Exterior Pump Controls

The exterior pump control panel contains the indicating lights and pushbuttons which would be used by the operators to start and stop the truck fill operation remotely. The pushbuttons and indicator lights are connected back to the pump controller and relay panel inside of the building. This panel has been mostly disconnected and some of the equipment has been removed.

It features the following buttons and indicators:

- Pump 1 or Pump 2 selector switch
- Pump Stop Button
- Pump On Light
- Two Red Lights which were uninstalled and unidentified but which may have been indicator lights P1 and P2 running lights
- A batch flow meter which cannot operate since the flow meter is not connected
- Flow timer

The exterior pump controls have not been in operation for more than 2 years. The red lights have been removed as have some of the connections. The flow meter is non-operational. The enclosure itself is in poor condition with some rust damage due to exposure to the outdoors.

Comments

- The exterior control panel has some damage to the indicator lights and the enclosure itself. It is not in operation.

Recommendation

- The new control scheme should feature a new outdoor control panel adjacent to the door to allow the operators to turn on and off the pumps remotely.

Truck Fill Arm Controls

The truck Fill Arm included a small handheld controller connected to a flexible conduit which allowed the operators to turn on and off the pumps from the top of the water truck. It featured three push buttons:

- Pump 1 Start
- Pump 2 Start
- Pump Stop

It does not include any indicating lights but could be used to start the pumps and then to turn them off. The controller appears to be original to the installation and is tied into the main control panel. It is no longer operational and is not used.

Comments

- The truck fill arm controller is no longer operational. The wiring or the buttons may have been damaged due to use and exposure.

Recommendation

- Replace the truck fill arm controls and wiring if the user needs the functionality. Otherwise the continued use of the manual start on the actual pump starters is adequate.

Alarm System

The alarm system in the truck fill station is fed from a 15A, single pole breaker in Panel ‘A’. There is a back-up battery for the alarm panel in the event of the failure of the generators.

The alarm system monitors the truck fill station low and high temperature alarms via thermostats. It also monitors the high temperature alarm for the generator side of the enclosure. The thermostats associated with this system are beginning to show signs of corrosion.

The alarm system also monitors the diesel fuel tank level and includes indicator lights for 1/4, ½, and full. It also monitors for power failure to the facility in event of generator failure.

The alarm panel has a transmitter selector switch to determine if a signal should be transmitted to the town via an antenna with a Motorola radio transmitter. However, operations staff indicated that the antenna system has never functioned properly and it is currently off. Electricians have been to site in the past to fix the system but it still does not function.

Comments

- The existing building alarm system is not operational as the transmitter does not function. This poses a risk to building operation as the generators are operated in manual mode. If the operating generator turns off then the building power is shut down. This means that the facility could be without power overnight, which would cause the pipes to freeze in the system. Water could not be obtained through the pumping station until the heat tracing cables managed to unthaw the ice build-up. This does not meet the requirements for remote monitoring of the facility.

Recommendation

- Replace the alarm system transmission, including the antenna tower and the transmitter. It may be necessary to replace the existing transmitter with a high tower.

Appendix B – Photographs

Photo 1: Site

Photo 2: Fill Arm

Photo 3: Intake 1

Photo 4: Intake 2

Photo 5: General Arrangement Intake

Photo 6: Fuel Hole

Photo 7: Fuel Hole

Appendix C – Water Quality

Table 1: Metals / Inorganics
Truck Fill Station, Repulse Bay, Nunavut

Sample ID	Health Canada [1] Drinking Water	Units	Truck Fill Station
Sampling Date			**5-Sep-2012**
Aluminum	100	ug/L	15
Antimony	6	ug/L	<0.50
Arsenic	10	ug/L	<1.0
Barium	1000	ug/L	3.7
Beryllium	NV	ug/L	<0.50
Bismuth	NV	ug/L	<1.0
Boron	5000	ug/L	<10
Cadmium	5	ug/L	<0.10
Calcium	NV	ug/L	16000
Chromium	50	ug/L	<5.0
Cobalt	NV	ug/L	<0.50
Copper	1000	ug/L	21
Dissolved Iron	NV	mg/L	<0.02
Iron	300	ug/L	<100
Lead	10	ug/L	0.8
Lithium	NV	ug/L	<5.0
Magnesium	NV	ug/L	3300
Manganese	50	ug/L	<2.0
Molybdenum	NV	ug/L	<0.50
Nickel	NV	ug/L	<1.0
Potassium	NV	ug/L	880
Rubidium	NV	ug/L	1.3
Selenium	10	ug/L	<2.0
Silver	NV	ug/L	<0.10
Sodium	200000	ug/L	3000
Strontium	NV	ug/L	17
Tellurium	NV	ug/L	<1.0
Thallium	NV	ug/L	<0.050
Tin	NV	ug/L	<1.0
Uranium	20	ug/L	1.2
Vanadium	NV	ug/L	<0.50
Zinc	5000	ug/L	<5.0
Anion Sum	NV	me/L	1.36
Bicarb. Alkalinity (calc. as CaCO3)	NV	mg/L	58
Calculated TDS	NV	mg/L	68
Carb. Alkalinity (calc. as CaCO3)	NV	mg/L	<1.0
Cation Sum	NV	me/L	1.27
Hardness (CaCO3)	NV	mg/L	55
Hydrox. Alkalinity (calc. as CaCO3)	NV	mg/L	<1.0
Ion Balance (% Difference)	NV	%	Non Calculable
Langelier Index (@ 20C)	NV	N/A	-0.539
Langelier Index (@ 4C)	NV	N/A	-0.79
Saturation pH (@ 20C)	NV	N/A	8.34
Saturation pH (@ 4C)	NV	N/A	8.59
Total Ammonia-N	NV	mg/L	<0.050
Colour	15	TCU	4
Conductivity	NV	umho/cm	120
Dissolved Organic Carbon	NV	mg/L	2.4
Total Organic Carbon (TOC)	NV	mg/L	2.4
Orthophosphate (P)	NV	mg/L	<0.010
pH	6.5 - 8.5	pH	7.8
Reactive Silica (SiO2)	NV	mg/L	1.1
Total Suspended Solids	NV	mg/L	<10
Dissolved Sulphate (SO4)	500000	mg/L	3
Turbidity	1	NTU	<0.2
Alkalinity (Total as CaCO3)	NV	mg/L	58
Dissolved Chloride (Cl)	250	mg/L	4
Nitrite (N)	3.2	mg/L	<0.010
Nitrate (N)	45	mg/L	<0.10
Nitrate + Nitrite	NV	mg/L	<0.10

1. Health Canada, *Guidelines for Canadian Drinking Water Quality Summary Table* , August 2012
Underline - exceeds the Health Canada Drinking water criteria
NV - no value listed in criteria

Data Entered by: RR
Data Reviewed by: MM
Criteria Entered by: RR
Criteria Reviewed by: MM

Table 2: Trihalomethanes
Truck Fill Station, Repulse Bay, Nunavut

Sample ID (ug/L)	Health Canada [1] Drinking Water	Truck Fill Station
Sampling Date		**5-Sep-2012**
Bromodichloromethane	NV	<0.10
Bromoform	NV	<0.20
Chloroform	NV	<0.10
Dibromochloromethane	NV	<0.20
Total Trihalomethanes	100	<0.20

Table , August 2012
Underline - exceeds the Health Canada Drinking water criteria
NV - no value listed in criteria

Data Entered by: RR
Data Reviewed by: MM
Criteria Entered by: RR
Criteria Reviewed by: MM

Table 3: Microbiology
Truck Fill Station, Repulse Bay, Nunavut

Sample ID	Health Canada [1] Drinking Water	Units	Truck Fill Station
Sampling Date			**5-Sep-2012**
Heterotrophic plate count	NV	CFU/mL	5
Background	NV	CFU/100mL	110
Total Coliforms	None Detectable	CFU/100mL	<u>10</u>
Escherichia coli	None Detectable	CFU/100mL	0

1. Health Canada, *Guidelines for Canadian Drinking Water Quality Summary Table* , August 2012
Act , 2002.
<u>Underline</u> - exceeds the Health Canada Drinking water criteria
NV - no value listed in criteria

Data Entered by: RR
Data Reviewed by: MM
Criteria Entered by: RR
Criteria Reviewed by: MM

Appendix D – Life Cycle Cost Analysis

Table D1 - Life Cycle Costing Analysis: Power Transmission Line

Year	Fuel			Costs			Present Value		
	Consumption (L/year)	Rate ($/L)	Cost ($)	Maintenance ($)	Recapitalization ($)	Total ($)	Discount Rate 2%	4%	8%
2014	165,600	0.6641	109,975				107,819	105,745	101,829
2015	165,600	0.6641	109,975				105,704	101,678	94,286
2016	165,600	0.6641	109,975				103,632	97,767	87,302
2017	165,600	0.6641	109,975				101,600	94,007	80,835
2018	165,600	0.6641	109,975				99,608	90,391	74,847
2019	165,600	0.6641	109,975				97,655	86,915	69,303
2020	165,600	0.6641	109,975				95,740	83,572	64,169
2021	165,600	0.6641	109,975				93,863	80,358	59,416
2022	165,600	0.6641	109,975				92,022	77,267	55,015
2023	165,600	0.6641	109,975				90,218	74,295	50,940
2024	165,600	0.6641	109,975				88,449	71,438	47,166
2025	165,600	0.6641	109,975				86,715	68,690	43,673
2026	165,600	0.6641	109,975				85,014	66,048	40,438
2027	165,600	0.6641	109,975				83,347	63,508	37,442
2028	165,600	0.6641	109,975				81,713	61,065	34,669
2029	165,600	0.6641	109,975				80,111	58,717	32,101
2030	165,600	0.6641	109,975				78,540	56,458	29,723
2031	165,600	0.6641	109,975				77,000	54,287	27,521
2032	165,600	0.6641	109,975				75,490	52,199	25,483
2033	165,600	0.6641	109,975				74,010	50,191	23,595
2034	165,600	0.6641	109,975				72,559	48,261	21,847
2035	165,600	0.6641	109,975				71,136	46,405	20,229
2036	165,600	0.6641	109,975				69,741	44,620	18,730
2037	165,600	0.6641	109,975				68,374	42,904	17,343
2038	165,600	0.6641	109,975				67,033	41,253	16,058
2039	165,600	0.6641	109,975				65,719	39,667	14,869
2040	165,600	0.6641	109,975				64,430	38,141	13,767
2041	165,600	0.6641	109,975				63,167	36,674	12,748
2042	165,600	0.6641	109,975				61,928	35,264	11,803
2043	165,600	0.6641	109,975				60,714	33,907	10,929
Sub-Total							2,463,049	1,901,691	1,238,074
Capital							1,698,000	1,698,000	1,698,000
Total							4,161,049	3,599,691	2,936,074

Table D2 - Life Cycle Costing Analysis: Onsite Power Generation

Year	Fuel			Costs			Present Value		
	Consumption	Rate	Cost	Maintenance	Recapitalization	Total	Discount Rate		
	(L/year)	($/L)	($)	($)	($)	($)	2%	4%	8%
2014	91,250	1.11	101,288	5,000		197,539	193,665	189,941	182,906
2015	91,250	1.11	101,288	5,000		197,539	189,868	182,636	169,358
2016	91,250	1.11	101,288	5,000		197,539	186,145	175,611	156,813
2017	91,250	1.11	101,288	5,000		197,539	182,495	168,857	145,197
2018	91,250	1.11	101,288	5,000		197,539	178,917	162,362	134,441
2019	91,250	1.11	101,288	5,000		197,539	175,409	156,118	124,483
2020	91,250	1.11	101,288	5,000		197,539	171,969	150,113	115,262
2021	91,250	1.11	101,288	5,000		197,539	168,597	144,340	106,724
2022	91,250	1.11	101,288	5,000		197,539	165,291	138,788	98,818
2023	91,250	1.11	101,288	5,000		197,539	162,050	133,450	91,499
2024	91,250	1.11	101,288	5,000	78,000	275,539	221,606	178,985	118,174
2025	91,250	1.11	101,288	5,000		197,539	155,758	123,382	78,445
2026	91,250	1.11	101,288	5,000		197,539	152,704	118,637	72,635
2027	91,250	1.11	101,288	5,000		197,539	149,710	114,074	67,254
2028	91,250	1.11	101,288	5,000		197,539	146,774	109,686	62,272
2029	91,250	1.11	101,288	5,000		197,539	143,896	105,467	57,660
2030	91,250	1.11	101,288	5,000		197,539	141,075	101,411	53,389
2031	91,250	1.11	101,288	5,000		197,539	138,309	97,511	49,434
2032	91,250	1.11	101,288	5,000		197,539	135,597	93,760	45,772
2033	91,250	1.11	101,288	5,000		197,539	132,938	90,154	42,382
2034	91,250	1.11	101,288	5,000	78,000	275,539	181,794	120,916	54,737
2035	91,250	1.11	101,288	5,000		197,539	127,776	83,352	36,335
2036	91,250	1.11	101,288	5,000		197,539	125,270	80,147	33,644
2037	91,250	1.11	101,288	5,000		197,539	122,814	77,064	31,152
2038	91,250	1.11	101,288	5,000		197,539	120,406	74,100	28,844
2039	91,250	1.11	101,288	5,000		197,539	118,045	71,250	26,708
2040	91,250	1.11	101,288	5,000		197,539	115,730	68,510	24,729
2041	91,250	1.11	101,288	5,000		197,539	113,461	65,875	22,897
2042	91,250	1.11	101,288	5,000		197,539	111,236	63,341	21,201
2043	91,250	1.11	101,288	5,000		197,539	109,055	60,905	19,631
Sub-Total							4,538,360	3,500,741	2,272,795
Capital							43,000	43,000	43,000
Total							4,581,360	3,543,741	2,315,795