2018·6·22

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA S. C. H. HORSMAN # 36256

wsp

Memorandum

To	Shane Fenske, RDOS
Copy	Wayne Radomske, P.Eng.(IHA), Liisa Bloomfield, P. Eng (RDOS)
From	Stephen Horsman, P.Eng., Gaurav Ahuja, MEngNZ
Office	Kelowna Office
Date	June 22, 2018
File	D-86207.00
Subject	Willowbrook Water System - Treatment Evaluation and Capital Plan

1. Introduction

Regional District of Okanagan-Similkameen (RDOS) retained WSP to evaluate alternatives to meet the British Columbia (BC) Drinking Water Guidelines for the Willowbrook Water System (system) and to update the Willowbrook Water System Assessment (Assessment Report) to include the preferred treatment approach. The system is located within Electoral Area 'C' of the RDOS between Oliver and Okanagan Falls and provides drinking and fire protection services to approximately 80 lots and 180 residents in the community.

This memo presents alternatives available for the treatment of the source water to meet the British Columbia drinking water standards per Drinking Water Protection Act (DWPA, 2001) and Drinking Water Protection Regulations (DWPR, 2003). The memo also summarizes capital improvements identified in the assessment report and amalgamates them with the technical memo recommendations.

2. Existing System

2.1. Source Infrastructure Characterization

The system relies on groundwater obtained from an unconfined aquifer using two drilled groundwater wells. The original well, which is no longer in service, is located inside the pump station building along with the site electrical and control equipment (MMM Assessment, 2015). The second well, drilled in early 2006, is currently serving as the active well and is reported to have a sustainable yield of 19 L/s (Final Report, Summit Environmental, 2006). Both groundwater wells are located on a common lot owned by RDOS that includes a pump house building that houses the electrical and control equipment for the well pumps.

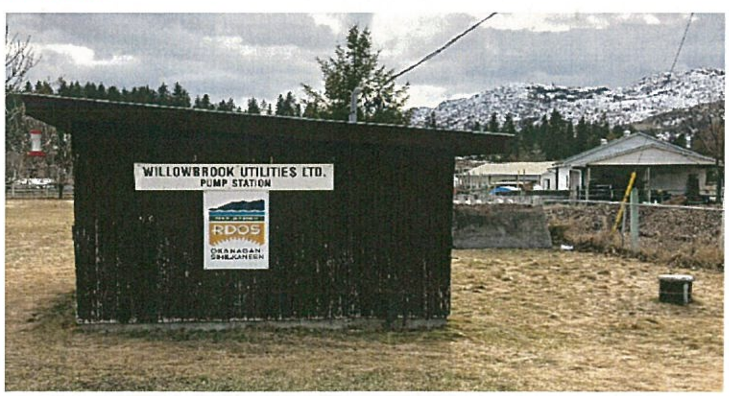


Figure 1 Willowbrook Pump Station (refer to groundwater well at bottom right of photo)

Figure 2 Inside Willowbrook Pump Station (Bottom Left: original well head; Bottom Centre: 2006 Well supply; Top Centre: Inline flowmeter air release valve, and isolation valve; Bottom Right: Common discharge leaving Pump Station)

Water extracted from the well is pumped directly into the distribution system, which includes approximately 4,500 meters of pipe and a small balancing reservoir.

2.2. Water Demand

Flow from the well is monitored continuously using an inline flowmeter located within the adjacent pump station building. The 95th percentile and peak daily groundwater extraction rates from the well are 15 L/s and 18 L/s, respectively. The monthly average daily flow data from 2016 to 2018 is presented in Figure 3.

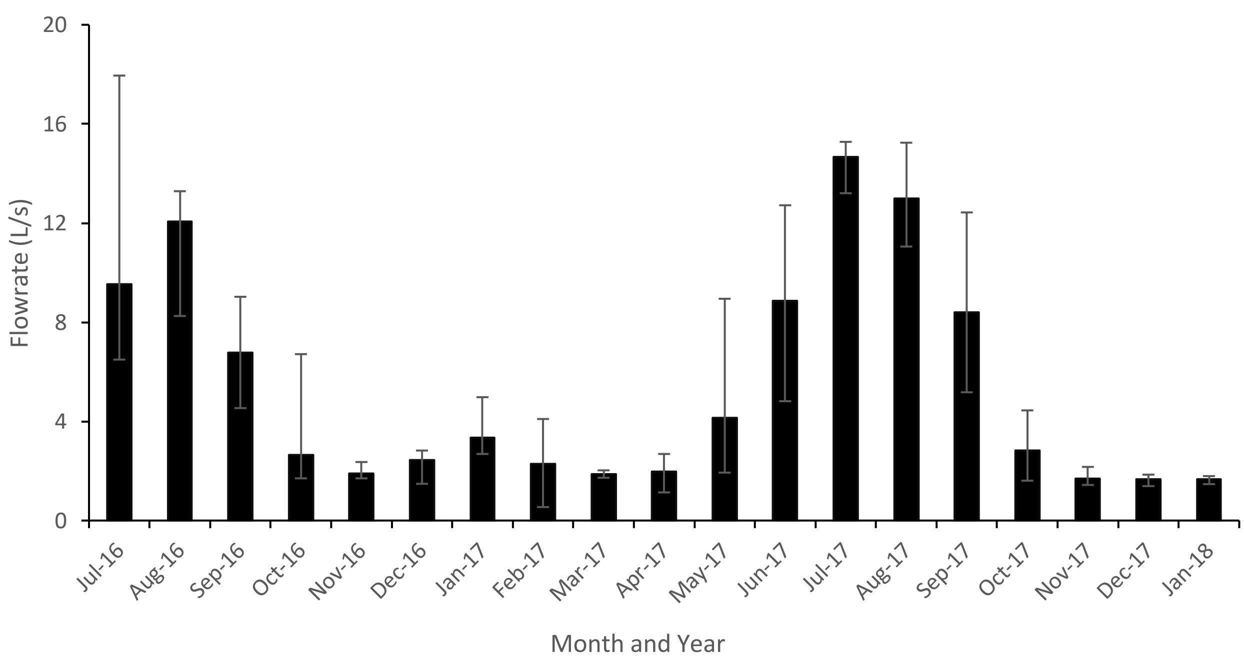


Figure 3 Average, maximum and minimum flow rates (July 2016 to January 2018)

2.3. Water Quality

Based on the hydrological investigations and a GARP assessment by IHA, the groundwater source is characterized as a highly vulnerable aquifer. Sampling results reveal the presence of total coliform counts in the distribution system since November 2016 (Appendix A). Given the location of groundwater wells and proximity to residential properties with septic disposal fields, further treatment and source water protection measures are recommended to reduce the risk of anthropogenic contaminants.

A summary of the water quality sampling data from the water system is presented in Table 1.

Table 1: Willowbrook water system water quality summary (18 January 2016 – 15 May 2018).

Analyte	Unit	MAC	Average	Minimum	Maximum	Number of samples
Conductivity	µS/cm	NA	926	560	1089	53
pH		1.0-10.5	7.64	7.51	7.93	53
Temperature	°C	≤15	10.5	8.2	12	52
Total dissolved solids (TDS)	mg/L	≤500	661	537	774	52
Total Organic Carbon (TOC)	mg/L		3.86	2.36	5.37	2
Turbidity	NTU	1	0.21	0.08	0.52	36
UVT at 254nm	%	NA	90.35	91	89.7	2
E. coli (counts)	CFU/100mL	0	0	0	0	63
Total Coliforms	CFU/100mL	<1	1	1	5	63
Nitrates (as N)	mg/L	10	4.36			1
Nitrate+Nitrite (as N)	mg/L	10	4.36		4.36	2
Sulphates	mg/L	AO<500	143		143	1

Based on the above water quality results, the following were selected for further discussion.

- **Total Dissolved Solids:** Total dissolved solids (TDS) is the measure of inorganic salts and organic matter that is dissolved in water. The average TDS in the Willowbrook water system is 661 mg/L, which exceeds the aesthetic objective specified by Guidelines for Canadian Drinking Water Quality. In drinking water, high concentrations of TDS are predominantly a taste concern. However, it can also result in scaling or corrosion of metallic surfaces such as hot water heaters, toilets, faucets, washing machines and dishwashers. From a water treatment perspective, high TDS also presents increased fouling potential for equipment, such as UV lamp sleeves. This will need to be considered in the treatment equipment selection.
- **Total Organic Carbon:** Total Organic Carbon (TOC) levels are typically low in groundwater. The two samples collected indicate the highest TOC levels at 5.37 mg/L, which is indicative of the surface influences within the unconfined aquifer. TOC does not present a direct health concern, however often contains precursors that lead to disinfection by-product formation. GCDWQ recommend TOC levels below 2 mg/L which is corroborated further by Disinfectants and Disinfection By-Products Rule by the USEPA which specifies maximum total organic carbon of less than or equal to 2 mg/L in treated water and 4 mg/L in source water to ensure acceptable levels of disinfection by-products formation. Additionally, TOC can lead to fouling on UV lamp sleeves, and many manufacturers recommend levels to be below 2 mg/L. Health Canada has not established water quality guidelines for dissolved and total organic carbon but addresses it through various parameters such as turbidity, total dissolved solids and true colour.
- **Turbidity:** Turbidity does not present a direct health risk. However, turbidity values in excess of 1 NTU can reduce the effectiveness of disinfection processes. Turbidity in the Willowbrook source water is consistently below 1 NTU.
- **Total and Fecal Coliforms:** Total coliforms are naturally found in both faecal and non-faecal environments and without correlation to faecal samples, do not necessarily present a direct health risk. The maximum acceptable concentration (MAC) of total coliforms in non-disinfected groundwater leaving the well is less than one detectable per 100 mL. Positive coliforms were detected in 17 of the 63 samples collected, which is indicative of surface influences and the vulnerability of the aquifer as noted previously.
- **Nitrates:** Nitrates occurring in groundwater are often the result of fertilizers and are indicative of surface influences within an aquifer. The concentration of nitrates is 4.36 mg/L, and the total concentration of nitrate + nitrite is 4.36 mg/L (as N) in the groundwater, an indication the species are

exclusively nitrates. Province of BC specifies a maximum of 10 mg/L (as N) nitrates + nitrites in the water to protect against adverse effects in humans due to drinking water as corroborated by Health Canada.

- **Sulphates:** Sulphates in groundwater are often the result of wastes from industries and further confirms the surface water influences in the aquifer. The concentration of the single sample is 143 mg/L. Typical concentration of sulphates in Canadian lakes ranges between 3 to 30 mg/L with the highest concentration at 3040 mg/L, but most of the concentrations are lower than 580 mg/L. The aesthetic objective for sulphate in drinking water is <500 mg/L, and it is recommended to notify health authorities if the concentration is higher than 500 mg/L.

The water quality parameters are well within the maximum allowable value in the case of nitrates where the concentration is lower than 10mg/L. Total dissolved solids are higher than the aesthetic value of 500 mg/L. The presence of dissolved solids may affect the taste of the water, but is still considered acceptable for drinking purposes, howevermay result in excessive scaling in water pipes and household appliances.

The water at Willowbrook is assessed as under the influence of groundwater and hence requires treatment under Drinking Water Protection Act (DWPA,2001) as detailed in the section 'Treatment Objectives'.

3. Treatment Objectives

British Columbia (BC) regulates its drinking water quality through the Drinking Water Protection Act (DWPA, 2001) and the Drinking Water Protection Regulation (DWPR, 2003). *Regional health authorities administer the Act and Regulation at their discretion to enforce the requirements to meet potable drinking water standards. Groundwater supplies 'at risk' of containing pathogens (GARP) require disinfection by treatment methods equivalent to surface water supplies.*

"Drinking Water Treatment Objective (microbial) for Surface Supplies in BC" (2012) outlines the treatment objectives to provide safe drinking water, which uses the 4-3-2-1-0 moniker outlined below.

4 - Virus Reduction: 4-log (99.99%) reduction in viruses

3 - Protozoa Reduction: 3-log (99.9%) reduction for both Giardia and Cryptosporidium

2 - **Barriers** of treatment, as a minimum

1 - **Turbidity**: Maximum allowable turbidity of 1 NTU

0 - **Bacteria**: Zero detectable E. coli (faecal) coliforms and zero total coliforms.

The 4-3-2-1-0 approach is the minimum standard for health authority acceptance, and more strict treatment standards should be directed if water quality deteriorates and presents a higher risk to human health.

Several technologies are available to achieve 4-3-2-1-0 objectives. These include chemical disinfection, UV disinfection, cartridge filtration and conventional filtration. One or more of these technologies can be utilized in combination to satisfy minimum standards for health authority acceptance. In the absence of guidelines for the treatment technologies in BC, the USEPA Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) is utilized to support treatment capabilities/credits (e.g. cartridge filtration).

4. Treatment Alternatives

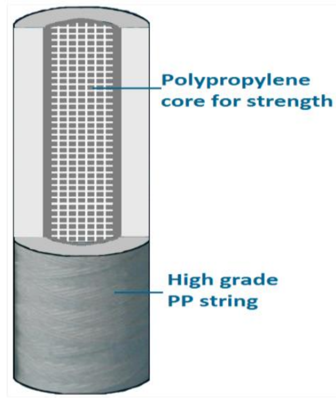
The current system only satisfies the "1" NTU turbidity criteria and additional treatment is required to achieve the 4-3-2-1-0 treatment objectives. Two treatment alternatives were selected to achieve the outstanding treatment objectives; each of which is discussed further in the following sections.

4.1. Cartridge Filtration with Chlorination

This option includes the use of cartridge filtration to provide a physical barrier for removal of protozoa followed by chlorine disinfection. Each of the unit processes is described further.

Cartridge filtration consists of pressure-driven separation devices constructed of rigid or semi-rigid self-supporting filter elements typically designed to remove particles greater than 1 micrometre (µm). The GCDWQ (Guidelines for Canadian Drinking Water Quality) do not provide specific treatment credits for cartridge filtration. However, the LT2ESWTR (USEPA) assigns up to 2.5-log removal for *Giardia* and *Cryptosporidium* for 1 µm cartridge filters operating in series[1]. Figure 4 shows an example of cartridge filter vessels and a typical cross-section of a filter.

(a)



(b)

Figure 4 (a) A cartridge filtration system in a pressure vessel. (b) A cross-sectional area of a cartridge filter.

Chlorination can be sized to provide 4-log virus and 0.5-log *Giardia* inactivation, however, *Cryptosporidium* inactivation cannot be practically achieved using chlorination. The CT values for 4-log virus and 0.5-log *Giardia* inactivation are 8 mg-min/L and 19 mg-min/L, respectively[2]. To meet both conditions, the minimum retention volume required prior to the first customer is 12,000 L[3]. Given the proximity to the first customer, additional contact volume would need to be provided on-site. This could be achieved using a buried "over-sized" pipe (i.e. 40m of 600mm pipe) or a dedicated above ground pressure vessel.

Figure 5 provides an overview schematic of the components required for the option.

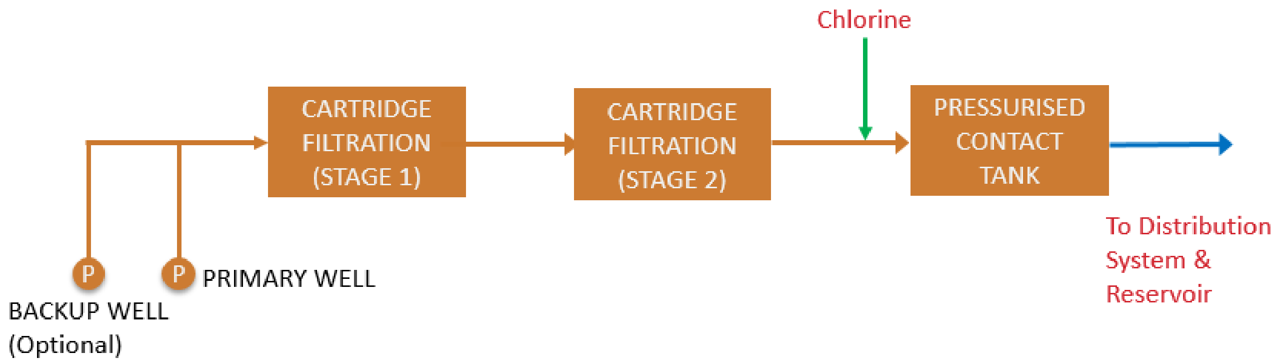


Figure 5 Schematic: Cartridge Filtration and Chlorine Disinfection

Advantages

[1] Based on demonstration testing achieving greater than 3-log removal.
[2] Based on the target chlorine concentration of 2 mg/L, pH 6-9, and temperature of 5 degrees Celsius. For details see Appendix A.
[3] Based on a baffle factor of 0.9

- Provides physical barrier for treatment of water;
- Easy to operate than the UV disinfection system which requires specialised operational skills.

Disadvantages

- Operating pressures increase as the filters foul, increasing operating costs and changing pump performance;
- Only achieves 2.5-log removal for *Cryptosporidium*;
- Higher Operational Costs. (For replacement of filters units).

4.2. UV Disinfection and Chlorination

UV disinfection is a technology commonly used for disinfection of microorganisms in water treatment. It uses closed vessel reactors to achieve 3-log removal for *Giardia* and *Cryptosporidium*. UV reactors rely on a series of lamps to emit UV radiation to inactivate pathogens. Figure 6 shows a typical UV reactors available in the market.

(a) (b)

Figure 6 (a) A typical closed vessel LPHO UV reactor. (b) Medium pressure UV reactor.

Similar to the previous option, 4-log virus removal can be achieved using chlorine and only requires a CT of 8 mg-min/L. This can be achieved using a pressure vessel or a buried pipe having a total volume of 5 m^3.

Figure 7 shows the schematic for the treatment option with UV disinfection and Chlorination.

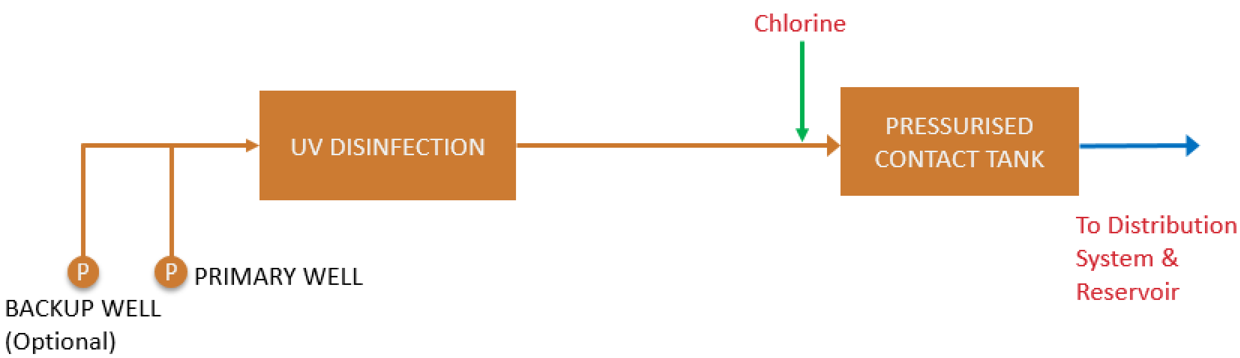


Figure 7 Schematic for the UV disinfection with chlorination.

Advantages

- Achieves all 4-3-2-1-0 treatment objectives;
- Lower Operational Costs (For power and replacement of lamps and ballast).

Disadvantages

- Treatment performance is highly reliant on electrical and controls equipment;
- Sensitive to electrical supply quality and reliability.

4.3. Comparison of Treatment Costs

To evaluate the most economical treatment option, the capital and operational cost for 20 years for each treatment option is considered and compared. The cost of the auxiliary items like piping and valves is kept similar in both the options. The labour costs for the routine operation are considered for both of the options and are similar. Chlorination costs are not included in the operational costs as they are same for both the systems.

Table 2 presents the summary of the costs for both the treatment options.

Table 2 Capital and Operational Costs Comparison for two treatment systems.

Scope of Work	Cartridge Filtration and Chlorination	UV Disinfection and Chlorination
Initial & Civil Works[4]	$ 27,200	$ 27,200
Building Costs	$ 20,100	$ 20,100
Equipment Costs	$ 180,400	$ 144,800
Pipework and Fittings	$ 39,600	$ 45,700
Electrical	$ 62,500	$ 85,000
Commissioning & Decommissioning	$ 3,300	$4,400
Indirect Costs	$ 53,300	$42,700
Engineering, Contingency and PST	$ 170,000	$163,000
Total Capital Cost	***$ 556,000***	***$ 533,000***
Operational Costs (20 years)	$ 132,000	$ 28,000
Capital and Operational Costs	**$ 688,000**[5]	**$ 561,000**

4.4. Summary

- UV disinfection plus chlorination is the most cost-effective solution to achieve 3-log inactivation of Giardia and Cryptosporidium.
- Cartridge filtration and chlorine only achieves 2.5-log inactivation of Giardia and Cryptosporidium and does not meet 4-3-2-1-0 guidelines.
- Capital costs of both treatment approaches are comparable, UV disinfection and chlorination system has significantly lower operational costs than cartridge filtration.
- The capital costs of both treatment options exceed the District budget of $190,000.

[4] The Civil works include only modification of the building. The civil works for new building cost is detailed in Section 5.
[5] Cost estimates in Appendix B

5. Existing Building and Renovations

The main floor of the Willowbrook Pump Station building is located below grade and is prone to flooding. The existing building is simple wood frame construction with cast-in-place concrete foundation. The wood frame structure is nearly 30 years old and nearing its useful service life. With the proposed treatment upgrades it is prudent to consider replacing the wood framing to provide a new structure to match the 20 year service life of the treatment infrastructure.

The building was constructed prior to 1990 and was suspected of containing asbestos and lead. Hazardous material testing completed by Apex EHS services identified lead paint on the wood. The test results showed the presence of lead in the wood paint installed on the exterior of the building with concentrations of 0.59%.

The estimated cost of demolition and reinstatement of the new building is presented in the table below. The detailed cost estimate is presented in Appendix B.

Table 3 Building Demolition and Reinstatement Capital Cost Estimate

Scope of Work	Building Upgrades
General	$ 66,000
Civil Works	$ 53,000
Modifications to Process Piping	$ 23,000
Electrical Upgrades	$ 35,000
Subtotal	$ 157,000
Engineering & Contingency	$ 85,0000
Total Capital Cost	***$ 262,000***

5.1. List of Assumptions

- Replacement of the existing wood frame infrastructure, while retaining the existing foundation. A new floor slab will be poured, level to the existing ground level.
- The new superstructure will be wood frame construction and in compliane with BC Building Code requirements.
- The existing process piping will be removed and replaced with piping at the new slab level.
- Electrical upgrades will only include the reinstatement of the electrical cabinets in the new layout area, HVAC system for the new building and new lighting and building electrical.
- The total cost includes 10% Engineering and 30% Contingency. Refer to Appendix B for more details on construction estimates.

5.2. Summary

- The existing building superstructure should be replaced prior to completing treatment upgrades within the building.
- The capital costs of improvements to the building are estimated between $170,000 and $240,000.

6. Master Plan

The Assessment report by MMM identified various upgrades for the Willowbrook Water System to provide a safe and reliable supply of water to the customers. At the time of assessment report, the treatment needs were not known and therefore not included within the identified improvements. The following provides a brief description of each of the recommended upgrades including the treatment improvements identified in the preceding section of this memorandum.

- ***Building Upgrades***
  - Demolition of the superstructure and construction of the new superstructure using the same foundation. A layout is presented in Appendix C for the proposed upgrades in the building. The floor elevation will be raised to match ground level to prevent flooding.
  - New HVAC system and building electrical systems.
- ***Wellhead Protection***: With the addition of treatment, the risk of contamination would be reduced, but it is recommended to provide wellhead protection to reduce source contamination risks. The scope of works includes raising the wellhead and pouring concrete around the well to stop ingress of water based on the guidelines provided by the province of BC.
- ***Treatment and Building Extension***
  - ***Treatment upgrades***: The stage would include installation of a chlorination system, contact tank, installation of the UV treatment and associated pipework.
    - Chlorination system and associated pipework including dosing pumps, containment, emergency eyewash and contact tank to achieve 4-log virus inactivation.
    - UV disinfection and associated pipework to achieve 3-log bacterial inactivation and compliance with 4-3-2-1-0 guidelines. Electrical scope includes local control panels for UV reactors and UVT analyser.
  - **Building Extension**: The building extension includes a chlorination room for the treatment system and space for future upgrades (e.g. sand filters or cartridge filters) if the water quality follows the trend and continues to deteriorate in future.
  - ***Instrumentation & Control Upgrades:*** including wireless reservoir communication, reservoir level sensing, magnetic flow monitoring, remote communications, power quality monitoring, well monitoring. The electrical and controls upgrade cost estimates and details were provided by the District's Electrical and Controls Consultant, Struthers. Refer to Appendix D for further information.
- ***Standby Power and Electrical System Upgrades***
  - ***Electrical Upgrades***: including new VFD's and disconnects for the pumps.
  - ***Backup generator***: A constant, uninterrupted power is required for the interrupted supply of water. It is recommended to install a backup generator and a transfer switch to maintain power for the treatment and distribution system. For further details refer to Assessment Report.
- ***Backup Well:*** A recommendation to install a second pump in the backup well will provide redundancy to the water supply system. For further details refer to Assessment Report.
- ***Additional Reservoir***: The existing reservoir is undersized as per RDOS standards and can only provide fire flow for 0.5 hours and MDD for 4 hours. Installation of the backup well and backup generator would guarantee an uninterrupted flow of MDD, but still, an extra 300m^3 is required as additional storage. For further details on storage refer to Assessment Report.
- ***Watermain Looping, Pipe Replacement and Installation of Isolation Valves***: The majority of Willowbrook water system contains dead ends main. The looping would improve water quality and mitigate service disruption. Isolation valves would provide maintenance opportunities within the system without shutting down of the system.

For small water systems with limited funding sources, such as Willowbrook, prioritization of upgrades based on a risk reduction approach is often needed to get the best value for money as it becomes available.

Table 4 lists each of the recommended upgrades in order of priority along with the associated project cost. In general, a higher priority has been assigned to achieve treatment compliance and then to increase the level of service and reliability of water supply. Finally, improvements to distribution efficiencies make-up the lower priority improvements. Detailed cost estimates for the treatment upgrades are provided in Appendix B.

Table 4 Willowbrook Water System Phased Upgrades and Associated Costs

Priority	Description	Area	Purpose	Capital Costs
1.[6]	**Civil Works**			**$ 246,000**
1.1	Building modifications	Civil	Demolish existing building and reinstate a new building. Modify process piping to suit installation of treatment system and improve and move electrical equipment.	$167,000
	Engineering, Contingency and PST			*$79,000*
2.	**Wellhead Protection**			**$15,000**
2.1	Wellhead Protection	Supply	Protect wellhead from the influence of surface water.	$15,000
3.	**Treatment and Supply Upgrades**			**$553,000**
3.1	Treatment Upgrades	Treatment	Installation of chlorine dosing system, UV system and associated pipework.	$206,000
3.2	Building Extension		Extension of building to provide room for chlorination.	$77,000
3.3	Instrumentation and Control	Electrical	Instrumentation such as upgrades to SCADA system and other improvements. Scope of Struthers.	$44,000
3.4	Electrical Upgrades to New Building	Electrical	New lights and HVAC system for the building extension for chlorination room.	$20,000
3.5	*Engineering, Contingency and PST*			*$206,000*
4.	**Standby Power and Electrical Upgrades**			**$118,000**
3.1	Electrical Upgrades	Electrical	Electrical Upgrades including new VFD's for pumps and system for power switches.	$20,000
3.2	Backup Generator	Electrical	Provide 60 kW backup generator.	$60,000
	Engineering, Contingency and PST			*$38,000*
5.	**Phase 5 - Backup Well Pump**			**$20,000**
5.1	2nd Backup Well Pump	Supply	Install the second pump in the existing well (Wellhead #1) to provide redundancy in the system.	$ 20,000
6	**Phase 6 - Additional Reservoir**			**$200,000**
6.1	Additional Reservoir	Storage	Provide the second reservoir to have fire water storage and storage for emergency water.	$200,000
7	**Phase 7- Isolation Valves, Watermain Looping & Pipe Replacement**			**$ 737,500**
Overall Budget				**$1,865,500**

[6] For Details see Appendix B- Costs Estimates

Implementation Considerations

Due to limited availability of funds, it is evident that the upgrades of the Willowbrook Water System will need to proceed in a phased manner. The existing building superstructure should be replaced prior to completing treatment upgrades within the building. The District's available budget of $200,000 will be sufficient to complete the building upgrades, however the treatment improvements will need to be completed separately, unless the District is able to access additional funds. Improvements to the wellhead protection should be implemented in conjunction with the building improvements and will reduce the risk of source contamination in the aquifer.

For treatment, UV disinfection followed by chlorination was identified as the most cost-effective solution to achieve 3-log inactivation of Giardia and Cryptosporidium and 4-log virus inactivation. The chlorine and UV treatment systems should be installed concurrently, however, if funding is not available, then chlorination should proceed prior to UV treatment. Given the source water is under the influence of surface water, the water quality monitoring should be ongoing to further characterize the source water and identify if the water quality is deteriorating over time. These results should then be revaluated prior to the implementation of the proposed treatment upgrades to allow for adjustments, as required.

Communication and controls upgrades, by Struthers, should proceed at the same time as the treatment improvements, because they will need to be coordinated with the new infrastructure. Again, if funding is limited, the communication and control improvements should be coupled with the chlorine upgrades.

The remining upgrades are associated with improving the reliability and resiliency of the system and should proceed in the prior listed.

7. Appendices

Appendix A - Chlorine Contact Time

Raw Water Parameters

		Virus	Giardia
Temp(^{o}C)		5	5
pH		7	7
CT $_{Virus}$ (mg/L.min)		8	19
Chlorine Residual (mg/L)		2	2
TDT $_{calculated\ CT}$ (min)		4.0	9.5
Baffling factor		0.9	0.9
TDT $_{T10\ calculated}$ (min)		4.4	10.6

Operational Hours	hrs	20	20
Flowrate	L/s	19	19
Peak Flowrate	L/min	1140.00	1140.00
	L/hr	68400.00	68400.00
	m3/hr	68.4	68.4
	ML/hr	0.07	0.07
	ML/min	0.001	0.001

Diameter of Pipeline	m	0.2	0.2
Area of pipeline	m2	0.031	0.031
Distance to 1st Customer	m	40.0	40.0
CT Volume Available	m3	1.3	1.3
Minimum volume required (summer)	ML	0.01	0.01
Minimum volume required	m3	3.81	10.78

Tank Dimensions

Height of the Tank	m	2.8	2.8
Diameter of the tank	m	1.36	3.85
Area of the tank	m	1.5	11.6

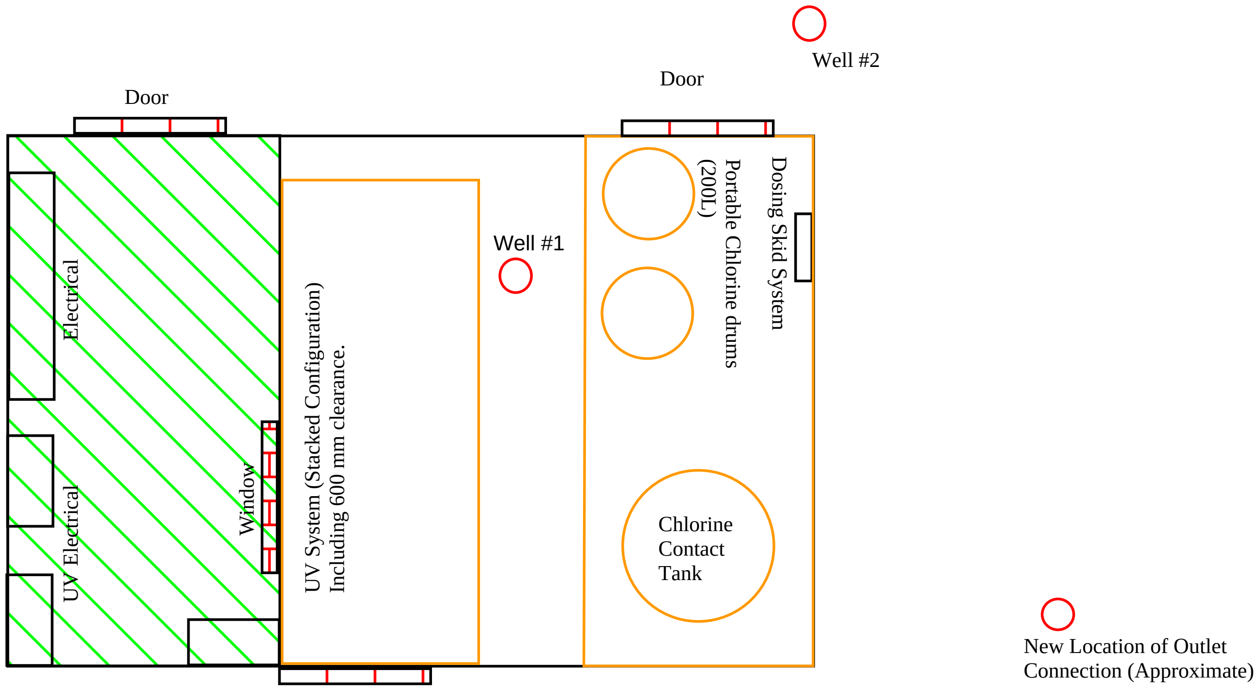
Appendix B - Cost Estimates

	Willowbrook Water System				
	Description	**Unit**	**Qty**	**Unit Cost**	**Cost**
1.General					
	Mobilization and Demobilization	*LS*	*1*	*$ 20,000*	*$ 20,000*
	Quality Control	*LS*	*1*	*$ 2,000*	*$ 2,000*
	Environmental Protection (Dewatering)	*LS*	*1*	*$ 1,000*	*$ 1,000*
	Construction Layout and Survey Control	*LS*	*1*	*$ 2,000*	*$ 2,000*
	Administration\Overhead (~4% Construction Cost)	*%*	*4%*	*$ 170,000*	*$ 6,800*
	Bonding	*%*	*5%*	*$ 170,000*	*$ 8,500*
	Insurance	*%*	*3%*	*$ 170,000*	*$ 5,100*
	Health and Safety	*%*	*2%*	*$ 170,000*	*$ 3,400*
	Contractors Markup	*%*	*10%*	*$ 170,000*	*$ 17,000*
	Total Indirect Costs				**$ 65,800**
2. Civil Works (Building Construction)					
	Import Backfill	*m3*	*28*	*$ 150*	*$ 5,000*
	Concrete Slab and Foundation (150mm Thick)	*LS*	*1*	*$ 10,000*	*$ 10,000*
	Miscellaneous Building Materials(Screw, bolts, extras)	*LS*	*1*	*$ 3,500*	*$ 3,500*
	Roof Trusses and Sheeting	*m^2*	*29*	*$ 175*	*$ 5,040*
	Wood Framing	*m^2*	*18*	*$ 120*	*$ 2,136*
	Insulation - Walls	*m^2*	*18*	*$ 60*	*$ 1,068*
	Insulation - Roof	*m^2*	*29*	*$ 80*	*$ 2,304*
	Outside Metal Cladding	*m^2*	*25*	*$ 120*	*$ 3,000*
	Metal Roof Cladding	*m^2*	*29*	*$ 150*	*$ 4,320*
	Doors	*ea*	*4*	*$ 3,000*	*$ 12,000*
	Painting	*LS*	*1*	*$ 5,000*	*$ 5,000*
	Subtotal				**$ 53,368**
3. Process Piping					
	Modification of existing pipe to suit new treatment	LS	1	*$ 10,000*	*$ 10,000*
	Plumbing	LS	1	*$ 3,000*	*$ 3,000*
	Drywell Rock Pit	*LS*	*1*	*$ 10,000*	$ 10,000
	Subtotal				**$ 23,000**
3. Electrical					
	Relocation of the Existing Electrical Control Panels	*LS*	*1*	*$ 15,000*	*$ 15,000*
	HVAC System for the new building	*LS*	*1*	*$ 10,000*	*$ 10,000*
	Subtotal				**$ 25,000**
	Total Direct Costs				**$ 101,368**
Engineering (10%)			10%		$ 17,000
Contingency (30%)			30%		$ 55,000
PST (Direct Costs Only)			7%		$ 7,000
TOTAL COST					**$ 246,000**

Treatment

	Willowbrook Water System				
	Description	**Unit**	**Qty**	**Unit Cost**	**Cost**
1. General					
	Overheads and Contractor Markup	*%*	*10%*	*$ 385,000*	*$ 38,500*
	Bonding	*%*	*5%*	*$ 385,000*	*$ 19,250*
	Insurance	*%*	*3%*	*$ 385,000*	*$ 11,550*
	Health and Safety	*%*	*2%*	*$ 385,000*	*$ 7,700*
	Total Indirect Costs				**$ 77,000**
2. Initial & Civil Works					
	Mobilization / Demobilization	*LS*	*1*	*$ 40,000*	*$ 40,000*
	Gate Valves(200 mm)	*ea*	*1*	*$ 1,160*	*$ 1,160*
	Subtotal				**$ 41,160**
3. Equipment Cost					
	Chlorine Dosing Pump Skid (Duplex Diaphragm Skid)	*LS*	*1*	*$ 10,000*	*$ 10,000*
	Containment Skid (200L)	*No.*	*1*	*$ 1,000*	*$ 1,000*
	Injection quill (Retractable 316LSS)	*LS*	*1*	*$ 2,500*	*$ 2,500*
	Contact Tank for Chlorine (5m3 Pressure Vessel)	*LS*	*1*	*$ 15,000*	*$ 15,000*
	Emergency Eye Wash	*No.*	*1*	*$ 8,000*	*$ 8,000*
	UV Reactor	*No.*	*2*	*$ 54,434*	*$ 108,868*
	Subtotal				*$ 145,368*
	Mark-up		10%		$ 14,537
	Installation		LS		$ 30,000
	Subtotal				**$ 189,905**
4. Pipework & Fittings					
	SCH80 PVC Piping (Hypochlorite)	*LS*	*1*	*$ 7,500*	*$ 7,500*
	SCH40 Steel (Coated\Lined) or 304L Stainless Steel	*LS*	*1*	*$ 15,000*	*$ 15,000*
	Butterfly Valves (100 mm)	*ea*	*3*	*$ 350*	*$ 1,050*
	Actuated Valves (100 mm)	*ea*	*2*	*$ 3,600*	*$ 7,200*
	Butterfly Valves (100 mm)	*ea*	*5*	*$ 350*	*$ 1,750*
	Reducers (100 x 250)	*ea*	*4*	*$ 800*	*$ 3,200*
	Subtotal				**$ 35,700**
5. Electrical					
	Pump Controls	*LS*	*1*	*$ 5,000*	*$ 5,000*
	Chlorine and ORP Anaylzer Panel	*LS*	*1*	*$ 6,500*	*$ 6,500*
	UVT Analyzer	*LS*	*1*	*$ 10,500*	*$ 10,500*
	Flowmeter	*No.*	*1*	*$ 4,500*	*$ 4,500*
	UV Installation	*LS*	*1*	*$ 12,000*	*$ 12,000*
	Instrumentation and Control(By Struthers)	*LS*	*1*	*$ 45,000*	*$ 45,000*
	Electrical Upgrades to New building Extension	*LS*	*1*	*$ 20,000*	*$ 20,000*
	Subtotal				**$ 40,700**
6. Well Upgrades					
	2nd Backup Well (From Masterplan)	*ea*	*1*	*$ 20,000*	*$ 20,000*
	Wellhead Protection (From Masterplan)	*ea*	*1*	*$ 15,000*	*$ 15,000*
	Subtotal				**$ 38,500**
7. Building Extension					
	Extension of the building	ea	17	$ 4,500	$ 76,500
	Subtotal				**$ 76,500**
8. Commissioning & Decommissioning	*Commissioning of new system*	*Hr*	*40*	*$ 110*	*$ 4,400*
	Subtotal				**$ 4,400**
	Total Direct Costs				**$ 385,705**
Engineering (10%)			10%		$ 46,000
Contingency (30%)			30%		$ 153,000
PST (Direct Costs Only)			7%		$ 27,000
TOTAL COST					**$ 612,000**

Appendix C - General Layout


Well #2
Door
Door
Well #1
Dosing Skid System
Portable Chlorine drums (200L)
Electrical
UV Electrical
Window
UV System (Stacked Configuration) Including 600 mm clearance.
Chlorine Contact Tank
New Location of Outlet Connection (Approximate)

Appendix D - Struthers Electrical Scope of Work

Project Management

Project management for this project will include the following

- Developing and maintaining project schedule
- Biweekly reports
- On-site meetings

Willowbrook Location

<table>
<tr><th>Priority</th><th>Description</th></tr>
<tr><td>n/a</td><td>SCADA control hardware

A control cabinet will be designed and installed to house all the required SCADA control hardware. A Schneider M221 PLC is the most cost-effective solution for this application. The recommended PLC can handle all required I/O, Modbus TCP, and Modbus RTU communication. The M221 PLC is programmed using SoMachine software which does not have any license fees associated with it and software is included with the PLC.

StruthersTech can offer a solution with an M340 PLC programmed in Unity Pro if RDOS would like to standardize on this processor. The additional cost of $5,000 for the M340 option is not included in this proposal as it is not considered to be the most cost-effective option for this application. The M340 is a more powerful PLC and has far more capacity than will ever be required at Willowbrook. The M221 is a cost-effective standalone nano-PLC. The M221 is highly reliable, has more than adequate processor speed for this application, has on board Ethernet communication, has 10-bit analog resolution, and can perform 1,000 instructions in 0.3ms. A local display can also be added if required. The SoMachine software for the M221 is user-friendly and license free so it can be installed on more than one computer. By comparison Unity Pro requires a license per computer at a cost of $1,300.

M221 I/O (input/output) expansion modules are available for future upgrades but the proposed solution provides 25% spare I/O typically required on most projects.

The control cabinet will include all power wiring, terminals, ethernet switch, and 24VDC power supply. All equipment will be panel or DIN rail mounted and all wires will be secured in wire duct. The control cabinet will be CSA certified prior to being shipped to site.

All existing pump control will be wired to the control cabinet as well as any new equipment including well monitoring, magnetic flow meter, and radio communication from remote reservoir.

The control cabinet will include space for installation of power monitoring equipment and SCADA remote communication equipment. This equipment can be installed during the project or at a future date depending on available budget and selected priorities.

Deliverable: Wiring drawings, mechanical assembly drawings</td></tr>
<tr><td>1</td><td>Well pump remote alarm

The existing pump control will be moved to the new PLC included as part of the SCADA control hardware. Any VFD or motor starter devices will remain in place and will interface with the PLC. No specific hardware is required for this priority beyond the SCADA hardware listed above.

The PLC will be provided fully programmed ready for commissioning. Pump control logic will include operator start/stop control, pump trip first-out capture (PLC will store and record the reason for pump trip), pump failure and trouble alarms as well as pressure indication. All information will be available through the remote SCADA communications and will be integrated to the existing RDOS water treatment plant monitoring system.

Deliverable: Logic drawings, PLC program logic</td></tr>
</table>

2	**Wireless communication to reservoir**
	
	A battery powered AccuTech level transmitter (see priority 4) with on-board wireless radio will be installed to monitor reservoir level. A YAGI antenna will be installed externally from the transmitter on a 20' to 30' mast to improve communications with the pump house.
	
	A 900MHz radio receiver will be installed at the pump house. This device will communicate to the remote location using a secure point-to-point 900Mhz radio signal and will communicate to the PLC using Modbus RTU. The radio system will be programmed to transmit reservoir level every 2 minutes to reduce demand on the battery at the reservoir. The battery life is expected to be 2 years.
	
	Both locations will have antennas located on masts at a height to be determined during detailed engineering. All antennas located on masts will be installed with lightning arrestors for electrical safety.
	
	Line of sight is required for this installation. It is expected from visual inspection during the site-visit that line of sight exists. Further testing will be performed with test equipment provided by the vendor of the specified device.
	
	The proposed solution is by far the more cost-effective solution for this application. By using a battery powered system there is no need to provide power to the remote location. This solution is used in many locations and is operating reliably. This solution is proposed pending communication testing. Should a higher power transmitter be required then the following contingency solutions are available.
	
	1) Battery power satellite phone
	2) 900Mhz Eaton Elpro 900Mhz radio with the following power options
	    a. Solar power supply
	        i. a study is required due to anticipated limited solar exposure at the remote location
	        ii. solar panels are often used for target practice by hunters when installed in remote locations
	    b. Fuel cell
	        i. small liquid fuel burner that charges batteries in the same way solar panels charge batteries
	        ii. replace fuel tanks every 3 months
	    c. Hardwired power from local power distribution system
	        i. requires installation of one or two telegraph poles
	
	Pricing for contingency options to be confirmed if required.
	
	Deliverable: wiring drawings, installation drawings, radio specifications

3	**Reservoir level monitoring** The reservoir level will be monitored by the existing float switches and/or the new level transmitter. The PLC will be provided fully programmed ready for commissioning. PLC alarms will be indicated both locally and remotely through the remote SCADA communications and will be integrated to the existing RDOS water treatment plant monitoring system. If the level transmitter is not purchased at this stage the logic will programmed and in place ready for the installation of the transmitter at a later date. Deliverable: logic drawings, PLC program logic

4	**Reservoir level** AccuTech (Schneider) gauge pressure transmitter will be supplied with submersible probe for level measurement. The level transmitter will be installed in the reservoir access hatch. This level transmitter has been selected as it is battery powered with on-board wireless communications. The antenna included will be installed externally from the device on a 20’ to 30’ mast to improve communications with the pump house. Using a battery powered device removes the need to provide power to the remote reservoir location and results in significant cost savings. The battery life is expected to be 2 years. Selected device will be installed in a non-insulated location and will operate to -40DegC. Deliverable: installation drawings, transmitter specifications
5	**Incoming power quality** Phase loss monitoring and protection will be provided at the pump house. All hardware will be located in the control cabinet. At this stage it is anticipated that full power quality monitoring (harmonic analysis) is not required given the application. Deliverable: wiring drawings
6	**Magnetic flow metering** ABB Watermaster flow meter will be installed in existing piping. 4-20mA output will be wired to PLC for flow monitoring and remote display. Flow monitoring will include instantaneous flow as well as resettable daily, weekly, monthly, and yearly flow totals as requested by RDOS and will be available through the remote SCADA communications and will be integrated to the existing RDOS water treatment plant monitoring system. Deliverable: installation drawings, transmitter specifications, logic drawings, PLC program
7	**Well level monitoring** Herron well level monitoring equipment to be installed in the existing 52’ well. 4-20mA output will be wired to the PLC for level monitoring and remote display. Wiring installation will require a short trench being dug between pump house and well head. The trench will comply with the Canadian Electrical Code and will be backfilled. Selected device will be installed in a non-insulated location and will operate to -40DegC. Deliverable: installation drawings, transmitter specifications, logic drawings, PLC program

8	**Communications to RDOS SCADA** As there is limited cell coverage at Willowbrook a satellite phone will be installed at this location. No additional hardware will be required at the RDOS water treatment plant as data can be accessed using the existing internet connection. The satellite network has 'bank level' security and is a secure reliable form of SCADA communication. The existing RDOS water treatment plant monitoring software will be programmed to alarm and display information using data received across the satellite network. A data plan will be required with a service provider and will be an ongoing cost. RDOS should plan to purchase either the \$75/month plan for alarming only or the \$125/month plan for monitoring. StruthersTech would also like to propose an alternate solution. A radio repeater could be installed on Mt Hawthorne (or equivalent location). A GE MDS 900MHz radio would then be installed at Willowbrook in place of the satellite phone. The radio network would be dedicated to RDOS and could be used for more than just SCADA communication as the whole Okanagan Valley would have access to the secure radio network (for RDOS operations only). Other uses include two-way voice communication allowing operators in remote locations away from cell signal to communicate with RDOS water treatment plant at all times. This option would not have any data plan requirements. This option would be a significant infrastructure change and as such is not included in the pricing for this proposal. Estimated costs for installing the radio repeater would be \$30,000. Deliverable: installation drawings, radio specifications, network programming