Shawnigan Lake Water Treatment Plant Pre-design

Technical Memo #1

Water Treatment Options Study

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Executive Summary

This technical memorandum (TM) No. 1 discusses 1) potential options for drinking water treatment of Shawnigan Lake's supply water, and 2) the preliminary design criteria for a new water treatment plant. Currently, water supplied by Shawnigan Lake is treated only with chlorine disinfection. Additional treatment is proposed to reduce the potential for disinfection by-product (DBP) formation and to provide a multi-barrier treatment strategy for pathogens. Over the last 4 years, two DBP's, total trihalomethanes (TTHM's) and haloacetic acids (HAA's) have been on an increasing trend in the distribution system, withHAA's exceeding the Canadian drinking water guideline limits. Organics are known precursors to disinfection by-products and are therefore made the treatment target in this TM. Multi-barrier treatment has become an industry standard approach for surface waters in order to reduce the risk pathogen contamination.

A treatment study by Genivar (2012) suggested the use of pressure filtration for its relatively low footprint and process simplicity. However, it is likely that pressure filtration would only have a marginal effect on the removal of dissolved organics and would not be able to satisfy pathogen disinfection requirements without the use of both ultraviolet (UV) and chlorine disinfection. Moreover, the system would require regular backwashing in order to maintain treatment flowrates. This backwash stream can be significant (typically around 5-7% of the total treated flow), hence requiring further management of the residuals which may not be feasible given the footprint constraints of the existing site.

This TM investigates the potential for a greater removal of organics through three innovative technologies: ceramic ultrafiltration membrane (CUF), hollow fibre nanofiltration (HFNF) and integrated treatment of biological and reverse osmosis (Integrated). For each option, pathogen reduction without the need for additional processes, and the potential to offer zero or low liquid-waste production or direct discharge of waste to the environment is considered.

Treatment goals

Section 2 of this TM discusses regulatory requirements and drinking water treatment goals. Under B.C.'s *Drinking Water Protection Act (DWPA)* and *Drinking Water Regulation* (DWPR), the Cowichan Valley Regional District (CVRD) must provide potable drinking water that is considered safe from disease-causing microorganisms, such as viruses, protozoa and bacteria. The Act and Regulation on Vancouver Island are administered by Vancouver Island Health Authority (VIHA) who mandated that "4-3-2-1-0" treatment objective be applied to Shawnigan Lake North Water System to provide safe drinking water. The policy includes the following treatment goals:

- 4-log (99.99%) reduction in viruses. This is normally achieved through the addition of chlorine disinfection with the provision of chlorine contact time.
- 3-log (99.9%) reduction in protozoa. Treatment for *Giardia* and *Cryptosporidium* is typically through filtration, or UV disinfection, or both. Some reduction in *Giardia* can be achieved through chlorination providing there is sufficient contact time, though not for *Cryptosporidium*.

- 2 treatment processes for surface water. A single treatment process may be effective against some microorganisms, but not against others. Combining more than one process for treatment allows for a multi-barrier approach against a range of microorganisms.
- 1 NTU turbidity or less. Well established filtration technologies can consistently reduce turbidity in the water from less than 0.1 to 1 NTU.
- No detectable *E. coli*, fecal coliforms, and total coliforms. This is typically achieved through disinfection (such as chlorination and/or UV disinfection) or a combination of disinfection and filtration.

All treatment processes considered herein would need to maintain the current use of chlorination to provide a multi-barrier approach, virus treatment credits, and secondary disinfection in the distribution system.

Historical Water Quality

Section 3 of this TM discusses Shawnigan Lake's source water quality from Shawnigan Lake. Shawnigan Lake water typically experiences turbidity <1 NTU and would therefore meet the unfiltered turbidity criteria for water supplies. However, the water has relatively high levels of organic content that is causing elevated HAA concentrations in the distribution water system. The concentration levels of HAA have exceeded the GCDWQ limit of 80 µg/L since 2013 with an observed increasing trend. The TTHM concentration levels has also seen an increasing trend that is approaching the limit of 100 µg/L. Figure ES-1 shows distribution TTHM's and HAA's measured between 2012 and 2016.

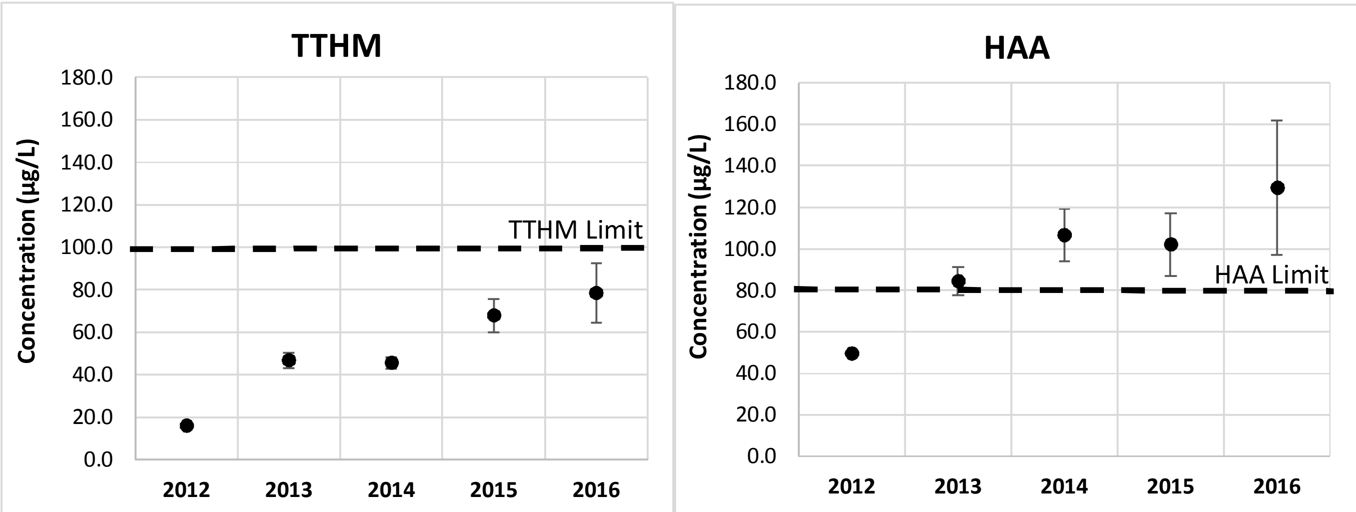


Figure ES-1: Distribution System TTHM's and HAA's

System Demands and Flows

Section 4 of this TM provides a discussion on the historical population and provides projections for future demands from the system. An annual rate of 1.17% population growth over the next 20 years was estimated for the Shawnigan Lake community. Future projections of the water demand were estimated using the current maximum water consumption per capita of 1,169 lcpd. Based on this, the projection for the future 20-year maximum daily demand (MDD) for Shawnigan Lake is 2,508 m^3/day. This projection is proposed for the design flow for a new water treatment plant. Table ES-1 provides a summary of the 20-year population and demand projections for Shawnigan Lake.

Table ES- 1 Projected Maximum Daily Demand

Year	Population	ADD m^3/day	MDD m^3/day
2016	1,700	838	1,987
2026	1,910	942	2,232
2031	2,024	998	2,366
2036	2,145	1,058	2,508

Treatment Comparison

Section 5 of this TM discusses three innovative treatment technologies that are potential options for treating Shawnigan Lake's water. Table ES-2 summarizes the process descriptions of the three considered treatment technologies.

Table ES- 2 Innovative Treatment Technologies

Treatment Barrier	Description
Ceramic Ultrafiltration (CUF)	Raw water is pre-screened to remove any coarse particles. Following the screening, coagulant is added at the inlet to the high solids contact reactor (HSCR), where rapid mixing is used for an efficient coagulation process. Coagulation is required for the removal of organics and improved turbidity reduction. From the HSCR tank water is pumped into the membrane module in a cross flow arrangement. A percentage of unfiltered water remaining in the membrane module is circulated back to the HSCR and produces high concentrate solids, which will then dewatered to a 3% to 10% solids sludge using a de-watering system. Waste volume is anticipated to be 0.3 % of the overall process volume. As such, the produced sludge can be locally stored for off-site disposal by vacuum truck. Overall system efficiency is expected to exceed 99.7%.
Hollow Fibre Nanofiltration (HFNF)	Raw water is pre-screened to remove any coarse particles. Raw water is pumped to the NF fibres in a cross flow arrangement. A small reject stream is continuously wasted from the membrane system as a measure to control solids concentration and optimize permeate quality. This stream is typically ~20% of the treatment WTP flow. The membranes are maintained by frequent backwashing where treated water is applied to the membrane in the reverse filtration direction to dislodge any retained particles in the membrane pores. Backwash flow accounts for ~5% of the total treatment flow and are free of chemicals.
Integrated Biological and Reverse Osmosis (Integrated)	Raw water is pre-screened to remove any coarse particles. This treatment process then consists of two stages. In the first stage, water flows through a series of biofilters. Bacteria growth is

Treatment Barrier	Description
	promoted in these filters and the bacteria effectively consume assimilible organic carbon (AOC) and capture colloidal solids. In the second stage, water is pumped through a series of spiral wound, reverse osmosis (RO) membranes for the removal of any remaining organic and inorganic contaminants. The treated water is biologically stable water that is free of dissolved organic carbon (DOC) and minerals. pH adjustment is recommended at the end of treatment to reduce the corrosion potential. UV disinfection would be required to meet the 3-log inactivation target for protozoa.

Each of the above treatment processes will be followed by chlorine disinfection system to provide 4-log reduction in viruses and to maintain a chlorine residual in the distribution system. As noted above, the Integrated Biological and Reverse Osmosis treatment option will also require UV to provide the 3-log inactivation target for protozoa.

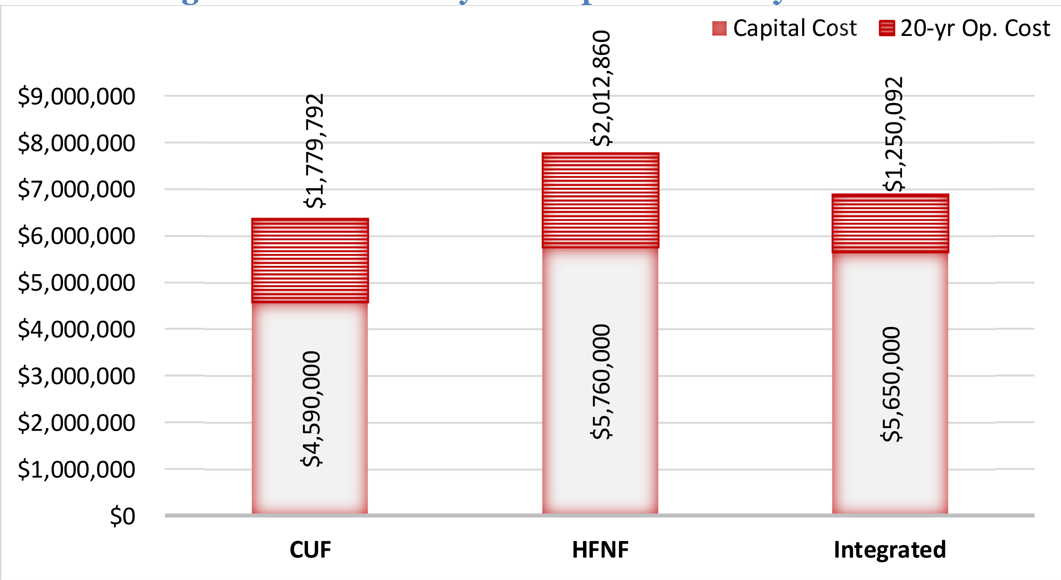
Lifecycle Cost Analysis

In Section 8, a lifecycle cost analysis was performed to provide a comparative life cycle costs for the three technologies introduced in this TM. The life cycle analysis was for a 20-year lifespan on the WTP using a 7% interest rate factor. Table ES-3 and Figure ES-2 provide comparative results of the life cycle costs analysis.

Table ES- 3 Total Lifecycle Cost Comparison

	Ceramic Ultrafiltration	Nanofiltration	Integrated Biological & RO
Capital Cost	$4,600,000	$5,600,000	$5,650,000
20-yr Present Worth	$1,779,792	$2,012,860	$1,250,092
Total Lifecycle Cost	**$6,379,792**	**$7,612,860**	**$6,900,092**

Figure ES-2 Summary of comparative lifecycle costs



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1 Introduction and Project Background

1.1 Project Description

Shawnigan Lake North water system is supplied by one surface water source (Shawnigan Lake) and two low-volume groundwater wells (Ingot Road K1 and K2). The combined raw water is treated on Decca Road with 12% sodium hypochlorite, followed by two chlorine contact chambers to provide disinfection contact time prior to distribution. Following chlorine disinfection, water is pumped through a dedicated supply line to a PRV station, where water is distributed to an upper and lower pressure zone. Two above ground reservoirs with volumes of 455 m^3 and 750 m^3 are located up the hill about 3.8 km from the treatment building. Currently, the raw water reportedly experiences seasonal turbidity, odour and colour issues from the lake. Chlorine dosages in the existing system have resulted in consumer complaints of strong chlorine smell. Regulatory issues for Shawnigan Lake water quality include elevated chlorine disinfection by-products (DBP's) in the distribution system, and the lack of treatment for protozoa (i.e. *Giardia* and *Cryptosporidium*). The Cowichan Valley Regional District (CVRD) is required by the regulatory authority, Vancouver Island Health Authority (VIHA), to upgrade the Shawnigan Lake water treatment system and comply with Drinking Water Protection Act (DWPA).

This technical memorandum (TM) provides an overview of the water treatment options that will provide the Shawnigan Lake water system with high quality drinking water that meets VIHA's treatment requirements for a surface water source. The options are considered based on their efficiency in turbidity as well as organic removal and residual management requirements, as footprint and siting options of the new WTP are limited.

1.2 Project Context and Previous Work

In 2010, CVRD requested that Genivar complete a high level assessment of suitable technologies to treat Shawnigan Lake's water and meet the turbidity removal requirements. The study considered five treatment options, including pressure filtration, membrane ultrafiltration (UF), dissolved air flotation (DAF), granular activated carbon (GAC), and slow sand filtration (SSF).

Pressure filtration uses a granular bed to retain particulate contaminants in the water. Filter media such as sand, anthracite coal, and dual media of anthracite coal over sand are typical in pressure filter operations. Coagulant and/or polymer pre-treatment is commonly used to enhance the removal of contaminants in the water during filtration. Power consumption is typically low to moderate, depending on the filter media and the existing head pressure.

Membrane UF is a very effective method of removing turbidity from the water. Raw water is forced through a porous tube, physically straining out the contaminants. Due to its relatively high filtration rates and the absence of the necessity of clarification as a pre-treatment step, membrane treatment generally requires a smaller footprint when comparing filtration technologies for turbidity removal. However, power requirements are typically higher, and there is relatively high system complexity. Membrane UF does not remove organics from the water, unless a coagulant pre-treatment step is introduced upstream of filtration.

DAF is generally effective for treating organics and colour in the water. However, the process consists of a 3-stage process consisting of coagulation and flocculation, DAF clarification, followed by mixed media filtration. Following coagulation and flocculation, dissolved air is injected into the DAF tank. The tiny air bubbles attach to the flocs, allowing the particles to float to the surface. The accumulated float is then skimmed off for disposal. Following the DAF clarification step, the water is then treated in a mixed media filter. Power requirements for DAF is also high due to the multiple process stages in the system. Compared with the other technologies considered, DAF would have a larger overall footprint.

GAC treatment is achieved by passing water through carbon granules, which adsorb contaminants as water passes through it. The efficiency of the treatment is directly proportional to the total volume of carbon present, which may cause a substantial annual media replacement cost. Power requirements for GAC is comparable to direct filtration.

Slow sand filtration (SSF) removes turbidity by passing raw water through a fine sand filter at very low loading rates. Most of the turbidity and microbial removal that occurs in a slow sand filter is in the biological layer that forms on the surface, called a “schmutzdecke” layer. Over time, headloss builds above the schmutzdecke layer. Instead of backwashing the filter, the filter cell is removed from service and the top layer of sand is scraped off. Eventually, after enough layers of sand are scraped off the filter additional sand needs to be added. SSF is a standalone treatment process for turbidity reduction, and typically does not remove organics from the water without a coagulant pre-treatment step. Genivar’s assessment on the different treatment options determined that pressure filtration would be be the most suitable for treating Shawnigan’s supply water. Compared to the other considered options, pressure filtration has the lowest capital costs and comparatively small building footprint. A three-filter system with a future fourth filter was proposed to provide for the expected maximum day demand of 36 L/s. Two booster pumps would be installed upstream of the treatment to overcome head loss through the filters, with another booster pump potentially required for backwashing the filters. Treated water would be disinfected with ultraviolet light (UV) and chlorine for *Giardia/Cryptospridium* and virus disinfection, respectively. A temporary holding tank or settling pond for the backwash waste stream would be required.

Due to the constrained space at the Decca Road facility, Genivar recommended that the WTP to be built at the reservoir site. A new dedicated supply watermain and a new electrical conduit between Decca Road and the reservoir would be required.

The recommended route of the new watermain is 3.6 km long and intersects CVRD and Shawnigan School right-of-ways. A permit from the Ministry of Transportation as well as a statutory right-of-way from the Shawnigan School would be necessary for the watermain installation.

Table 1-1 Estimated Capital Cost for the Proposed WTP by Genivar

Item	Est. Capital Cost
Pressure Filter Plant	$ 1,050,000
BC Hydro Service Upgrade	$ 100,000
New Supply Watermain	$ 930,000
Class D Estimated Total	**$2,080,000**

1.3 References

Cowichan Valley Regional District. (2016, April). Request for Proposal for the Provision of Review of the Shawnigan Lake Water Source Treatment and Preliminary Design, Including Cost Estimate. *Request for Proposal No. ES-004-16* . Duncan, BC, Canada: Cowichan Valley Regional District.

Genivar. (2010). *Shawnigan Lake Surface Water Treatment Study*. Duncan: Genivar.

2 Treatment Goals

2.1 VIHA Requirements

British Columbia regulates municipal drinking water quality through its Drinking Water Protection Act (DWPA) and Drinking Water Protection Regulation (DWPR). The Act and Regulation on Vancouver Island are administered by VIHA who mandated that the "4-3-2-1-0" treatment objective for surface water supplies be applied to Shawnigan Lake. The 4-3-2-1-0 treatment objective includes the following water treatment goals:

- 4-log (99.99%) reduction in viruses. This is normally achieved through the addition of chlorine disinfection with the provision of chlorine contact time.
- 3-log (99.9%) reduction in protozoa. Treatment for *Giardia* and *Cryptosporidium* is typically through filtration, or UV disinfection, or both. Some reduction in *Giardia* can be achieved through chlorination providing there is sufficient contact time, though not for *Cryptosporidium*.
- 2 treatment processes for surface water. A single treatment process may be effective against some microorganisms, but not against others. Combining more than one process for treatment allows for a multi-barrier approach against a range of microorganisms.
- 1 NTU turbidity or less. Well established filtration technologies can consistently reduce turbidity in the water from less than 0.1 to 1 NTU.
- No detectable *E. coli*, fecal coliforms, and total coliforms. This is typically achieved through disinfection (such as chlorination and/or UV disinfection) or a combination of disinfection and filtration.

In addition to the 4-3-2-1-0 approach, the treatment system must also address the high concentrations of disinfection by-products (DBP's) in the treated water, which are related to the organics concentration in the source water.

2.2 Canadian Drinking Water Standards

Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ) provides guideline limits on microbial, chemical, physical, radiological substances in drinking water. In the GCDWQ, health-based limits on a substance are assigned a Maximum Acceptable Concentration (MAC). The GCDWQ also assigns an Aesthetic Objective (AO) to substances that do not cause risk to human health, but will influence consumer acceptance of the water based on factors such as taste, odour and colour.

Table 2-1: Key Treatment Objectives

Parameter	MAC	AO
TDS (mg/L)	-	≤ 500
True Colour (TCU)	-	≤ 15
Turbidity (NTU)[1]	1.0/0.3/0.1	-
pH	-	6.5-8.5
Virus Inactivation	>99.99% (4-log)	-
Protozoa Inactivation	>99.9% (3-log)	-
THM (µg/L)	100	
HAA (µg/L)	80	

1 Treated water turbidity objective depends on the type of filtration, and is selected based on the expected performance of the filtration technology.

Table 2-1 summarizes the maximum acceptable concentration (MAC) and aesthetic objective (AO) values from GCDWQ that are used as treatment goals in this study. These are consistent with United States Environmental Protection Agency (USEPA) requirements and industry best practice.

Table 2-1: Key Treatment Objectives

Parameter	MAC	AO
TDS (mg/L)	-	≤ 500
True Colour (TCU)	-	≤ 15
Turbidity (NTU)[1]	1.0/0.3/0.1	-
pH	-	6.5-8.5
Virus Inactivation	>99.99% (4-log)	-
Protozoa Inactivation	>99.9% (3-log)	-
THM (µg/L)	100	
HAA (µg/L)	80	

1 Treated water turbidity objective depends on the type of filtration, and is selected based on the expected performance of the filtration technology.

3 Raw Water Source

3.1 Shawnigan Lake and Groundwater Wells

Shawnigan Lake is the main water supply source for the Shawnigan Lake water system. Shawnigan Lake has a surface area of 537 ha and a mean depth of 12 m, containing a total of 64 Mm^3 of water. The lake receives three inflows: from Shawnigan Creek at the south end, McGee Greek on the west shore and the West Arm inflow in the northwest corner of the lake. Water level in the lake is controlled by a dam on Shawnigan Creek, 450 m downstream from the lake outlet. CVRD holds water licences for the abstraction of water from the Lake totalling to an annual maximum of 127,387,500 IGPY (an average of 1,587 m^3/day) and a water storage license of 3,487.5 m^3/day. In addition to being the primary drinking water source for the community, Shawnigan Lake is also a popular destination for recreational and camping activities. The lake water reportedly experiences seasonal algae, organics and turbidity events.

In addition to Shawnigan Lake, there are two low-volume groundwater wells that also supply the community. The wells supply water to the community on on seasonal basis. Two of the low-volume ground water wells are located on Ingot Road (Wells K1 and K2). Ingot Road Well K2 is shared equally with the Shawnigan Lake School. According to CVRD the three wells provide a combine rate of 1.2 m^3/day to the water system, however they have been shut off during the past summer due to a decline in production.

3.2 Water Quality

Shawnigan Lake's historic water quality data indicates that the water is generally of good quality. . The historic turbidity indicates that the water is typically less than 1 NTU and generally meets the unfiltered criteria for water supplies. However, a popular recreational area, the lake is not in protected watershed. The lake reportedly experiences seasonal algae and organics events which consequently requires higher chlorine consumption. There have been complaints with respect to odour issues, and water quality testing has shown the occurrence of disinfection by-product formation in the distribution system.

CVRD's sampling program is conducted on an alternating schedule between the inlet raw water and the distribution system. In 2013 the distribution water and Wells K1 and the Shawnigan Lake School Well were sampled and tested for extensive list of parameters by Maxxam in Victoria. It is undertood however, that the groundwater well supply to the CVRD is limited and would not be considered as a longterm source.

Table 3-1 summarizes the raw water quality data from the lake provided by CVRD.

Table 3-1 Shawnigan Lake Raw Water Quality Data (2012 and 2014)

Parameter	No. of Samples	Min.	Max.
Total Coliform (CFU/100 ml)	2	22	82
Faecal Coliform (CFU/100 ml)	1	0	0
Alkalinity (mg/L as $CaCO_3$)	2	17.9	25
Turbidity (NTU)	2	0.39	0.8
pH	2	7.34	7.4
Total Colour (TCU)	2	3.35	10
Tannins & Lignins (mg/L)	2	0.169	0.23

The chlorination DBP's, TTHM's and HAA's, are tested for on a quarterly basis (February, May, August, and November) by CVRD at McKean Road. The historical TTHM and HAA data indicate that the concentrations of both DBP's have increased over time. The average concentrations of HAA's the last 4 years exceed the Maximum Allowable Concentration (MAC) in drinking water under the GCDWQ for drinking water of 80 µg/L for HAA. The average concentration of TTHM is also approaching the MAC limit of 100 µg/L for TTHM under the GCDWQ for drinking water. Figure 3-1 presents the annual average concentration of TTHM and HAA the last 4 years at the sampling location. TTHM's and HAA's are suspected carcinogens, and are formed in the reaction of chlorine with organics in the water. This trend underscores the importance of treatment for not only turbidity, but also for organics reduction.

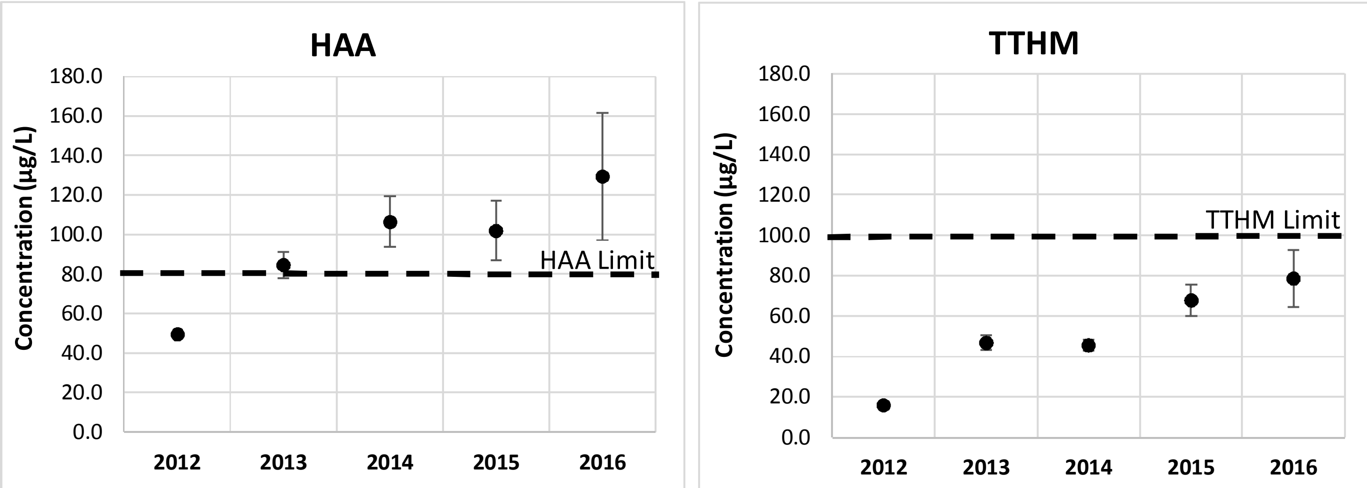


Figure 3-1 Historical TTHM and HAA in Distribution System: a). TTHM, b). HAA

4 System Demands and Design Hydraulics

The purpose of this section is to establish the proposed WTP flow rate design criteria.

4.1 Population and Growth

The current population was estimated based on a total of 680 land parcelsand a rate of 2.5 persons per parcel, as provided by CVRD. A total increase of 110 parcels is expected over the next 20 years and as well as another 10% increase of population to account for future suites development. Based on this growth scenario, the service population is projected to increase at a growth rate of 1.17% from 2016 until 2036. Table 4-1 and Figure 4-1 summarize the population projection for Shawnigan Lake over a 20-year interval.

Table 4-1 Shawnigan's Projected Population at 1.17% Annual Growth Rate

Year	Population
2016	1,700
2026	1,910
2031	2,024
2036	2,145

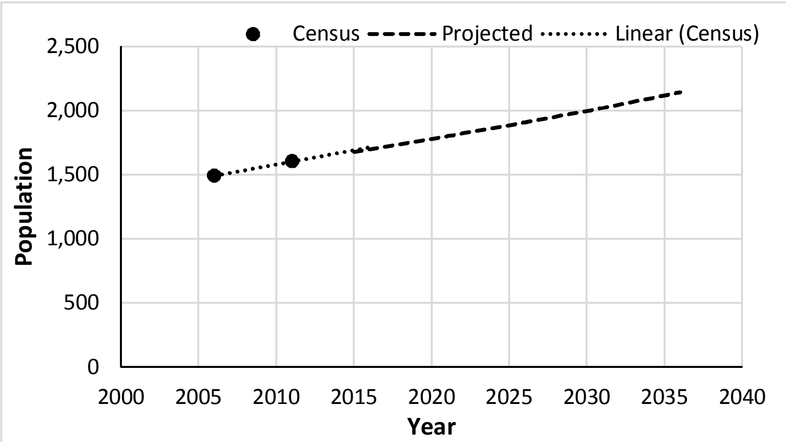


Figure 4-1 Census Data and 25-year Population Projection

4.2 Historical Demands

Historic water consumption records indicate the following:

- The community's daily water consumption has steadily declined for the last 10 years from 1,057 m^3/day in 2005 to 725 m^3/day in 2014.
- The median water consumption between 2005 and 2014 was 841 m^3/day (9.7 L/s).
- The maximum day demand (MDD) has also declined from 2,315 to 1,989 m^3/day (23 L/s) in the last 10 years. Based on a 2016 population of 1,700 persons, this equates to a consumption rate of 1,169 litres per capita per day (lpcd).
- A peak hour demand (PHD) for Shawnigan Lake is assumed as three times the ADD, following the MMCD design guidelines.

Figure 4-2 displays the declining ADD and declining MDD rates between 2005 and 2014. Figure 4-3 summarizes the seasonal consumption rate of Shawnigan Lake, averaged monthly, highlighting the determined ADD, MDD and PHD values.

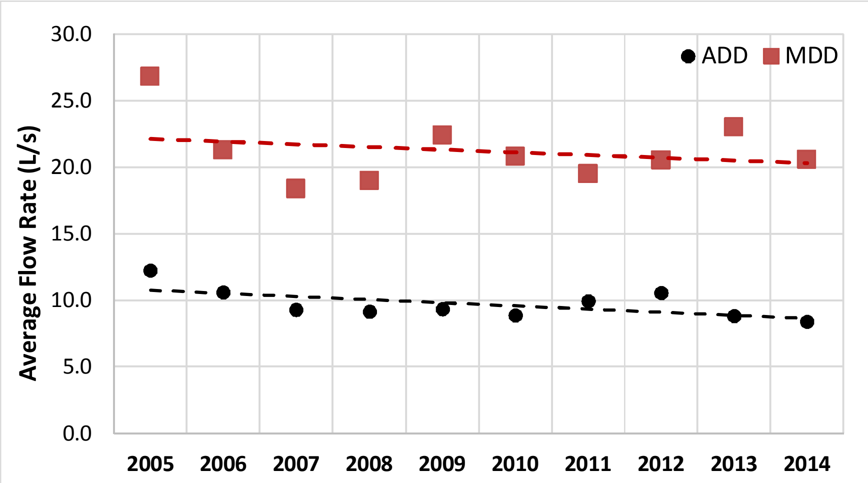


Figure 4-2 Shawnigan Lake Historic Daily Water Consumption between 2005 and 2014

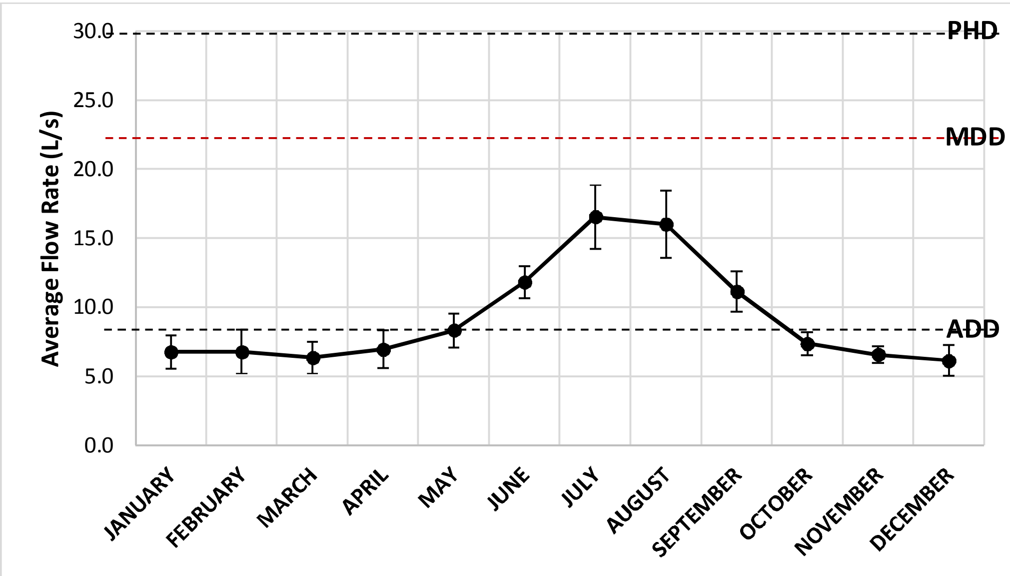


Figure 4-3 Seasonal Average Monthly Water Demand in Shawnigan Lake between 2005 and 2014

4.3 Projected Demands

Projected demands of Shawnigan Village was estimated based on the following:

- An annual growth rate of 1.17% was applied to estimate the total projected population at the end of the 20-year water treatment plant design period.
- A maximum water consumption per capita of 1,169 lpcd based on a 10-year consumption data was used to project the future water demand given the estimated population.

Figure 4-2 summarizes the 20-year projection of Shawnigan Lake's population and maximum daily demand.

Table 4-2 Projected Average Daily and Maximum Day Demand

Year	Population	ADD m^3/day	MDD m^3/day	MDD L/s
2016	1700	838	1,987	23
2026	1,910	942	2,232	26
2031	2,024	998	2,366	27
2036	2,145	1,058	2,508	29

4.4 Hydraulic Design Criteria

Water from Shawnigan Lake is drawn from the intake and intake chamber located 85 m into the lake and 7.6 m below water level. Water is disinfected using 12% sodium hypochlorite and pumped into two chlorine contact chambers with a total capacity of 92 m^3 at the Decca Road facility (~ El. 123). Two 50 HP vertical turbine pumps feed the treated water into the distribution system via a dedicated supply main to a PRV station, where water is distributed to the upper and lower pressure zones, and into the treated water reservoirs. The pumps are controlled by the level of the above grade reservoirs (~TWL El. 137). The two reservoirs, made of concrete and steel, are 750 m^3 and 455 m^3, respectively. The following schematic presents the simplified hydraulic profile of the Shawnigan Lake intake water system.

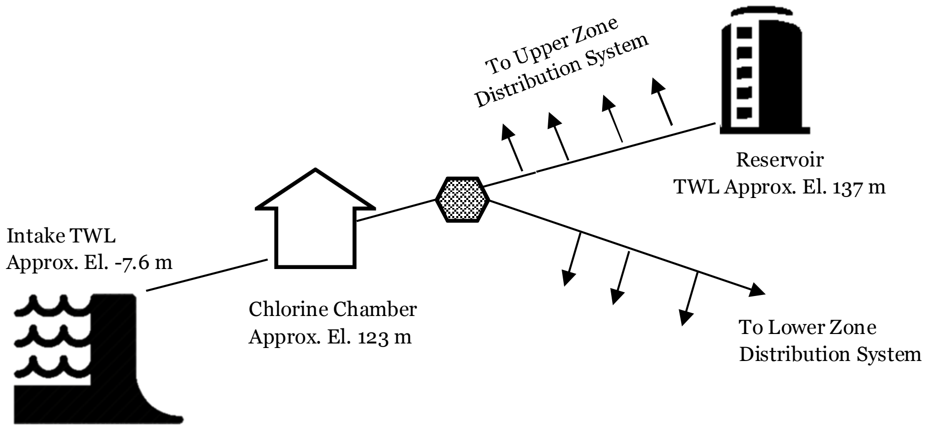


Figure 4-4 Simplified Hydraulic Profile of Shawnigan Lake Water System

5 Treatment Comparison

5.1 Pressure Filtration

Shawnigan Lake's treated water quality is historically high in TTHM and HAAs. Both parameters have continued to increase, with HAA having to exceedthe Canadian drinking water guidelines in the last 4 year. In order to minimize DBP formation, treatment should be provided to reduce organics in the water prior to disinfection. Genivar's treatment recommendation of pressure filter may be suitable for turbidity reduction but is not considered effective for organics reduction. In addition, in order to meet the 3-log inactivation credit for *Giardia* and *Cryptosporidium*, UV disinfection will be required.

Pressure filtration would produce a backwash water waste stream in the amount of approximately 5-7% of the total treated water flow. The backwash water residuals will need to be treated and/or disposed of. Due to the land constraints at the Decca Road facility, Genivar recommended that the WTP be constructed at the reservoir site, and the installation of a new dedicated raw water supply watermain to the reservoir site.

Genivar's Class 'D' cost estimation of $2,080,000 included the construction of the proposed 36 L/s pressure filter plant, a new 3.6 km supply watermain and a 30% contingency. Our recent construction projects of comparable treatment plants indicate the project costs appear low. Table 5-1 provides a summary of similar sized WTP constructed recently, ranging from $2,400,000 for UV/chlorination disinfection only, to $6,700,000 for membrane filtration/chlorination. Supply main costs are not included.

Table 5-1 Comparative Construction Costs of Similar Treatment Plants Projects between 2014 and 2016

Plant	Capacity	Treatment	Year Completed	Cost
Watson Lake WTP	21 L/s	Greensand Filtration + chlorination	2016	$5.2M
Sicamous WTP	36 L/s	Membrane Ultrafiltration + chlorination	2016	$6.7 M
Faro WTP	35 L/s	UV disinfection + chlorination	2014	$2.4M
Queen Charlotte City WTP	10 L/s	DAF Filtration + chlorination	2009	$3.1 M

The estimate of approximately $260/m for the raw water supply main appears to also be low; for example, installation of 200 mm diameter PVC is typically in the range of $300 - $400/m. This excludes clearing and grubbing or any rock blasting that may be required.

We would therefore recommend considering other treatment process options to meet the treatment goals of DBP formation reduction and pathogen credits which would be required by VIHA.

In the following sections, we present three innovative treatment options: ceramic membrane ultrafiltration (CUF), hollow-fibre nanofiltration (HFNF), and integrated treatment of biological and membrane filtration (Integrated). All three technologies have the potential of achieving higher organics removal in addition to turbidity removal. Minimizing and handling treatment residual waste streams were also considered with technologies. The following sections provide further discussion on these three innovative technologies.

5.2 Ceramic Ultrafiltration Membrane (CUF) Overview

Ceramic ultrafiltration (CUF) is a water treatment technology that combines treatment ideologies from ceramic filtration and membrane ultrafiltration (UF). In ceramic ultrafiltration, the ceramic barrier is manufactured to have a pore size similar to a UF membrane. The ceramic media is typically 100% silicon carbide (SiC), which makes it very resistant to abrasion as well as chemical and biological reactions. The fine UF pore size in the media allows it to reject particles, colloidal material, bacteria, and other pathogens. Due to these characteristics, CUF also has the highest operational flow rate (flux) of all UF membrane systems and lowest footprint requirements per volume of water treated. The robust material of the membrane allows it to have a membrane lifespan of 25 years.

CUF treatment requires pre-screening of the raw water to remove any coarse particles. Following the screening, coagulant is added at the inlet to the high solids contact reactor (HSCR), where rapid mixing is used for an efficient coagulation process. Coagulation is required for the removal of organics and improved turbidity reduction. A suitable type and dose of coagulant must be determined through a pilot study.

From the HSCR tank, water is pumped into the membrane module in a cross flow arrangement. After passing through the membrane, the filtered water would be disinfected prior to discharge to distribution. A waste stream is generated during membrane cleaning through an automatic maintenance cleaning cycle. A percentage of the waste stream water is circulated back to the HSCR in order to reduce the volume of wastewater and to produce a high concentrate solids, which would then dewatered to a 3% to 10% solids sludge using a dewatering system. Waste volume is anticipated to be 0.3% of the overall process volume, compared to 10% for DAF/ultrafiltration. As such, the produced sludge can be locally stored for off-site disposal by vacuum truck. Overall system efficiency is therefore expected to exceed 99.7%. Figure 5-1 shows a typical block process flow diagram of a CUF membrane WTP.

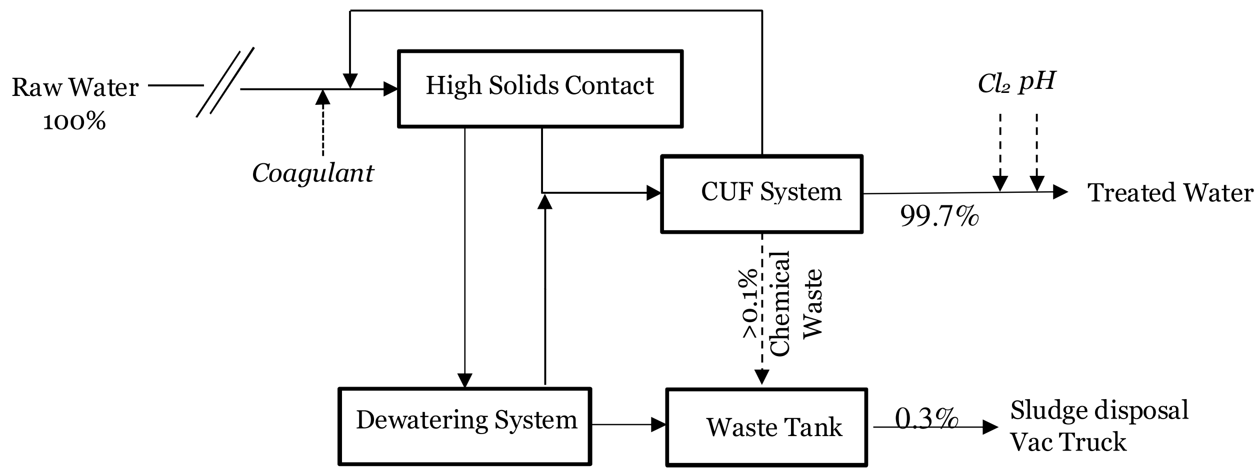


Figure 5-1 Typical block process diagram of Ceramic Ultrafiltration membrane

An automated frequent maintenance cleaning of the CUF is conducted to dislodge any foulants that are attached. Occasionally, a full maintenance cycle is activated, which includes a combination of heat, high cross-flow flux (similar to a backwash), as well as chemical applications of either acid and/or caustic which will scrub and dissolve residual foulants from the membrane. Overall this chemical waste constitutes less than 0.1% of the total treatment flow. Disposal of this waste can be combined with the waste from the dewatering system and contained for vacuum truck disposal.

Post-CUF treatment, chlorine disinfection is required to provide 4-log removal of virus and a chlorine residual for secondary disinfection. However, the amount of chlorine addition is expected to be minimal as the organics present in the water after filtration would be reduced, resulting in a lower chlorine demand. pH adjsutment would likely be required post-treatment due to the reduction in alkalinity following coagulation.

An example of a North American manufacturer that supplies and installs full-scale CUF water treatment facilities is Purifics. Two full-scale facilities with capacities of 3,800 m^3/day and 3,300 m^3/day are currently operating in Mississippi and Delaware, respectively. A budget quotation from Purifics was obtained to estimate the CUF capital costs in Section 8.0.

The proposed water treatment plant would include the CUF membrane process, chlorine disinfection system, office/lab, chemical room, washroom and electrical room. The water treatment plant's footprint would be approximately 355 m^2. A conceptual layout of the water treatment plant is shown in Figure 5-2, and was developed to provide a comparative cost estimate to the other technologies. The footprint layout for the selected technology would be further developed in the next stages of design.   A preliminary estimate of the power requirements for a CUF system were provided by the vendor, and are approximately 0.16 kwh per cubic metre of treated water. The main consumers of power in this process are the pumps used to circulate water continuously between the high solids contact tank and the CUF.

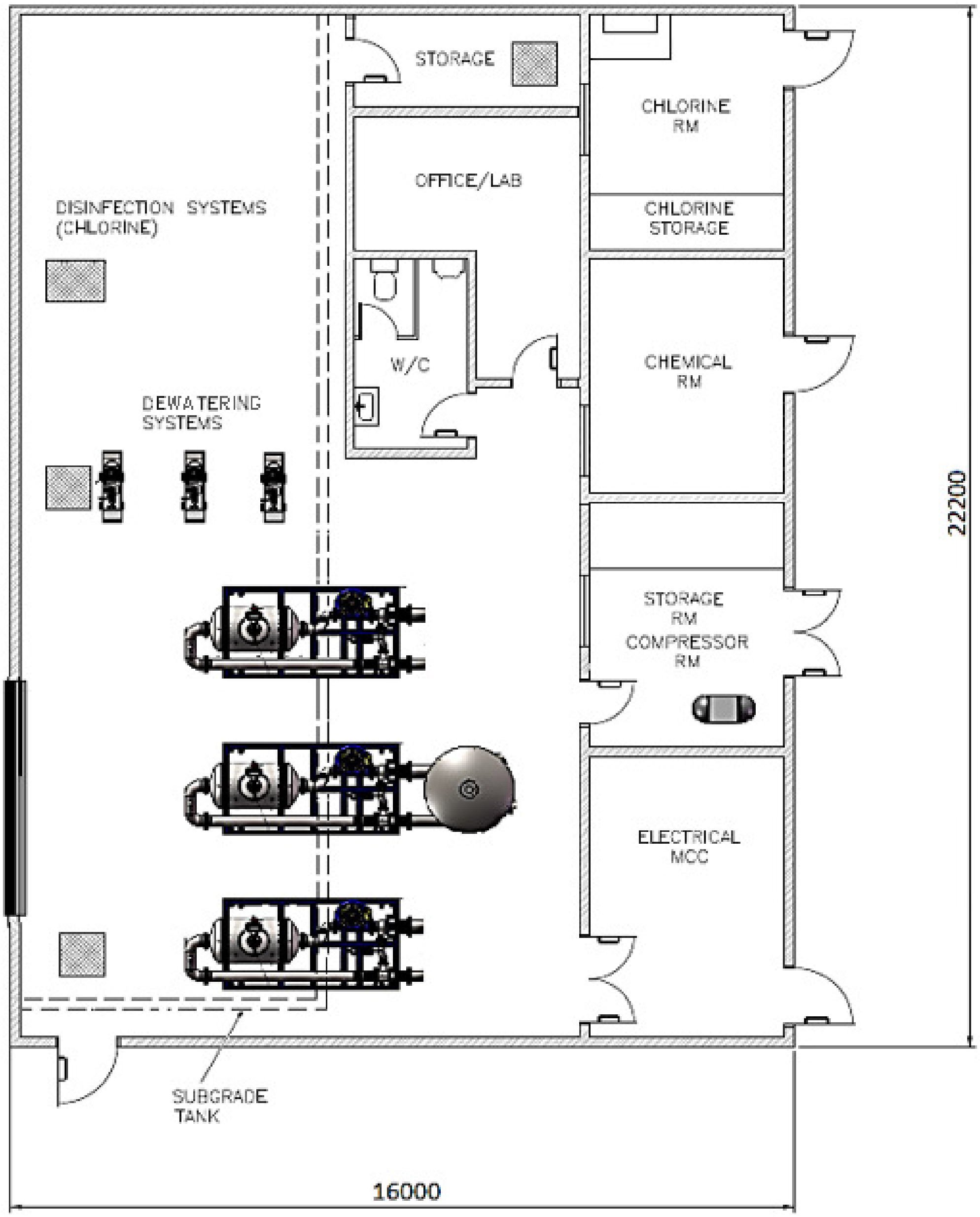


Figure 5-2 Conceptual layout for Ceramic Ultrafiltration treatment

5.3 Hollow Fibre Nanofiltration Membrane (HFNF) Overview

Nanofiltration (NF) provides a physical treatment barrier with pore size of 1-10 nanometers. The small pore size allows for the removal of large molecular weight organics, suspended solids, and >4-log removal of bacteria and viruses in a one-step process without chemical coagulation. As no chemical addition is needed, environmental discharge of the waste stream may be viable. NF can treat raw water with turbidities up to 25 NTU down to less than 0.1 NTU, reduce colour to less than 5 TCU, and achieve a typical removal of 80% to 90% of dissolved organic carbon (DOC).

Typically, raw water is pumped to the NF fibres in a cross flow arrangement. A small reject stream is continuously wasted from the membrane system (*feed-and-bleed* operation) as a measure to control retained solids concentration in the system, which otherwise can potentially affect the treated water quality. The reject stream is typically around 5% of the treatment flow. The membranes are maintained by frequent backwashing where treated water is applied to the membrane in the reverse direction to dislodge any retained particles in the membranes. Backwash flow accounts for around 20% of the total treatment flow. Aside from the elevated solids and colour concentrations, the backwash stream is free of chemicals, which potentially allows for direct environmental discharge.

Periodically, the membranes must be chemically cleaned by immersing the membrane modules in chlorine, sodium hydroxide and/or hydrochloric acid solution. As the cleaning is conducted in the treatment tank, this process is known as Clean-in-Place (CIP). High pH cleaning is typically performed every 3 to 4 days to remove biological foulants trapped on the membrane surface. Low pH cleans are typically required every 13 weeks, and are conducted to remove mineral scales or metal oxides/hydroxides originating from the raw water. This chemical waste constitutes less than 0.1% of the total treatment flow, and is the only waste stream that requires special handling and disposal. Alternately, a neutralization stage can be added to treat the chemical waste which may enable the plant directly discharge to the environment with the backwash stream.

The treated water from the NF process would be about 75% efficient, wasting about 25% of the total flow, and would have a consistent water quality regardless of the source water turbidity. UV-disinfection is not required as >3-log *Giardia* and *Cryptosporidium* reduction credits are achieved through the NF treatment and verified by daily membrane integrity tests. Chlorine disinfection is required following NF treatment for residual disinfection in the distribution system. It is anticipated that the reduced organics in the water post-filtration would reduce the chlorine demand of the water. Figure 5-3 shows a typical block process diagram of a NF system.

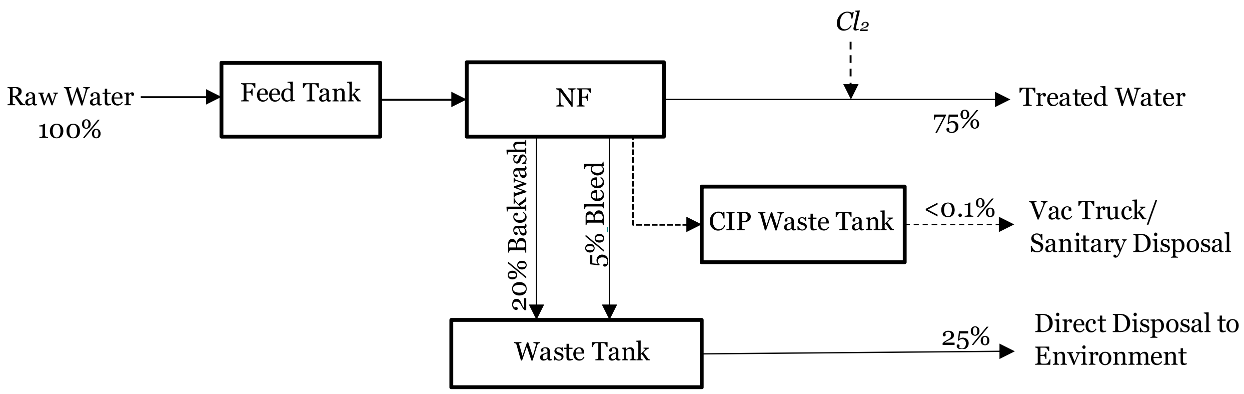


Figure 5-3 Typical block process diagram of Nanofiltration membrane system

The proposed water treatment plant would include NF treatment system, staff washroom, chlorine room, office/ lab, storage room, chemical room, a tank area as well as a below-grade chlorine contact tank, and electrical room. The building would have an approximate footprint of 500 m^2. A conceptual layout of the water treatment plant is shown in Figure 5-4, and was developed to provide a comparative cost estimate to the other technologies. The footprint layout for the selected technology would be further developed in the next stages of design. Power requirements are based on NF circulation pumps, backwash pumps and forward flush pumps and estimated to be 0.22 kwh per cubic metre of water produced.

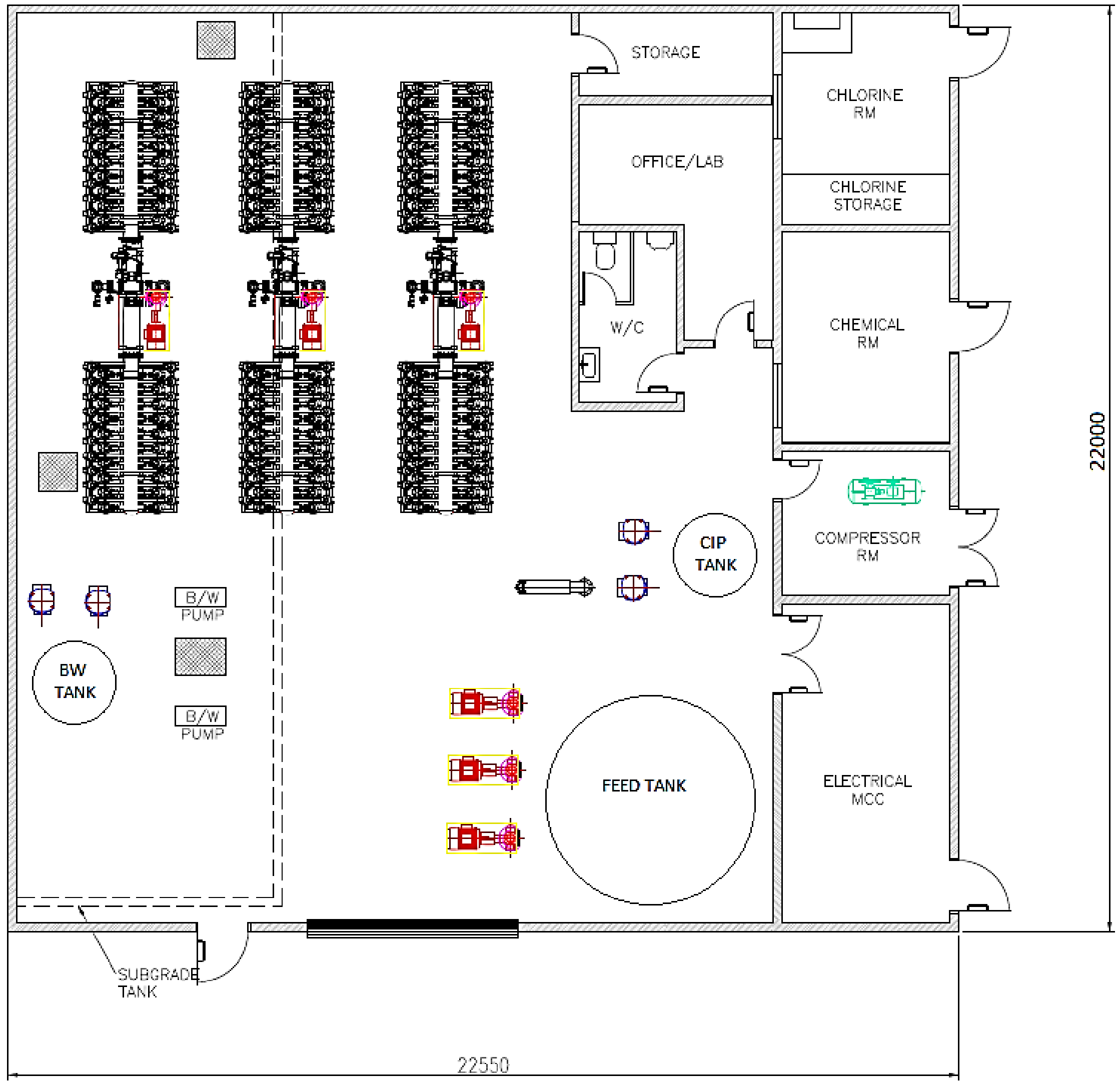


Figure 5-4 Conceptual WTP layout for Hollowfibre Nanofiltration treatment

5.4 Integrated Biological and Reverse Osmosis (RO) Overview

Reverse osmosis (RO) and NF membranes are susceptible to irreversible fouling from organic contaminants, this is known as biofouling. To reduce membrane biofouling, biological filtration as a pre-treatment step for either RO or NF membranes has become a more common concept in the last decade for drinking water treatment. Pre-treating raw water through a biological filter can effectively reduce organic compounds that promote biofouling to improve membrane performance.

In the first stage of the treatment process, water flows through a series of biofilter tanks operated under conditions ideal for the colonization of the water treatment bacteria. The bacteria consume a portion of the organics, the assimilable organic carbon (AOC), and remove substances such as iron and ammonium. In the second stage of treatment, water is pumped through a series of tight-woven membranes such as RO or NF for the removal of any remaining organic and inorganic contaminants. The treated water is biologically stable water with reduced organic carbon and minerals. Treated water is re-mineralized and adjusted for pH at the end of treatment to avoid corrosion. UV disinfection is however required due to RO's limitations to verify membrane integrity as a required protection against protozoa. Chlorine disinfection would follow UV disinfection to provide 4-log removal of viruses and as a protection against biofilm growth in the distribution system.

Since no pre-treatment chemicals are required to operate the biofilters and RO unit, the reject from the RO could potentially be discharged to the environment under permit. However, the biofilters must be periodically backwashed to remove accumulated suspended solids and bio-mass growth. It is anticipated that the biofilters backwash water can be blended with the RO reject for direct discharge to the environment. Additionally, a clean in place (CIP) processll occasionally be required to chemically clean the RO membranes. The spent membrane cleaning chemicals are expected to be stored in a waste tank for periodic disposal by vacuum truck. Figure 5-5 illustrates a typical process diagram of an integrated biological and reverse osmosis system.

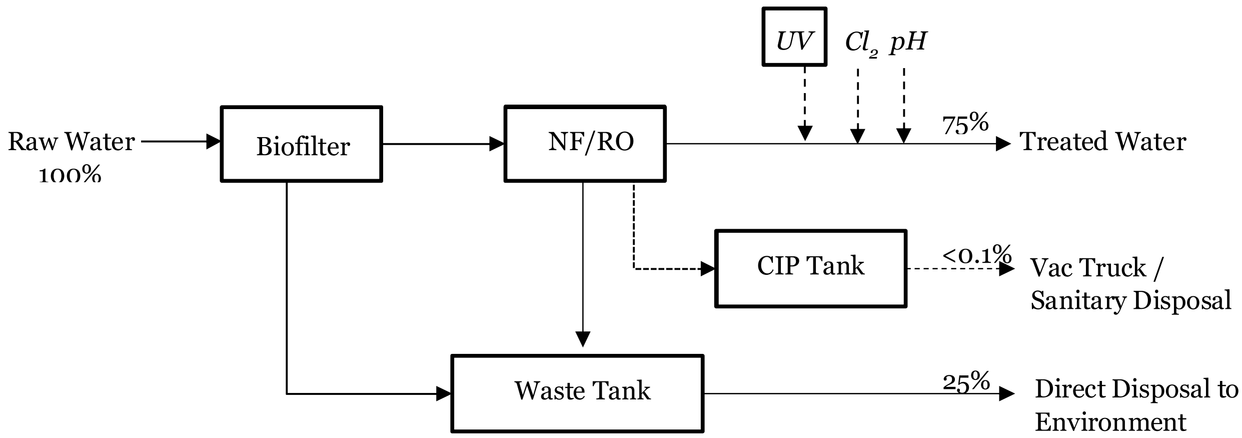


Figure 5-5 Typical block process diagram of Integrated Biological and Reverse Osmosis Treatment

An example of a Canadian manufacturer that supplies and installs full-scale integrated treatment facilities is Sapphire, with proprietary system known as SIBROM (Sapphire Integrated Biological Reverse Osmosis Membrane). Their system is currently servicing twelve communities in Saskatchewan.

The proposed water treatment plant would include treatment area (biological tanks and RO membranes), washroom, UV-Chlorine disinfection system, office/lab, storage, below-grade contact tank, chemical room, and electrical room. The total estimated water treatment plant footprint required to include these items is 500 m². A conceptual layout of the water treatment plant is shown in Figure

5-6 and was developed to provide a comparative cost estimate to other technologies. The footprint layout for the selected technology would be further developed in the next stages of design. Power requirements to operate the SIBROM system is estimated to be 0.3 kwh per cubic metre of treated water based on preliminary estimates from the vendor.

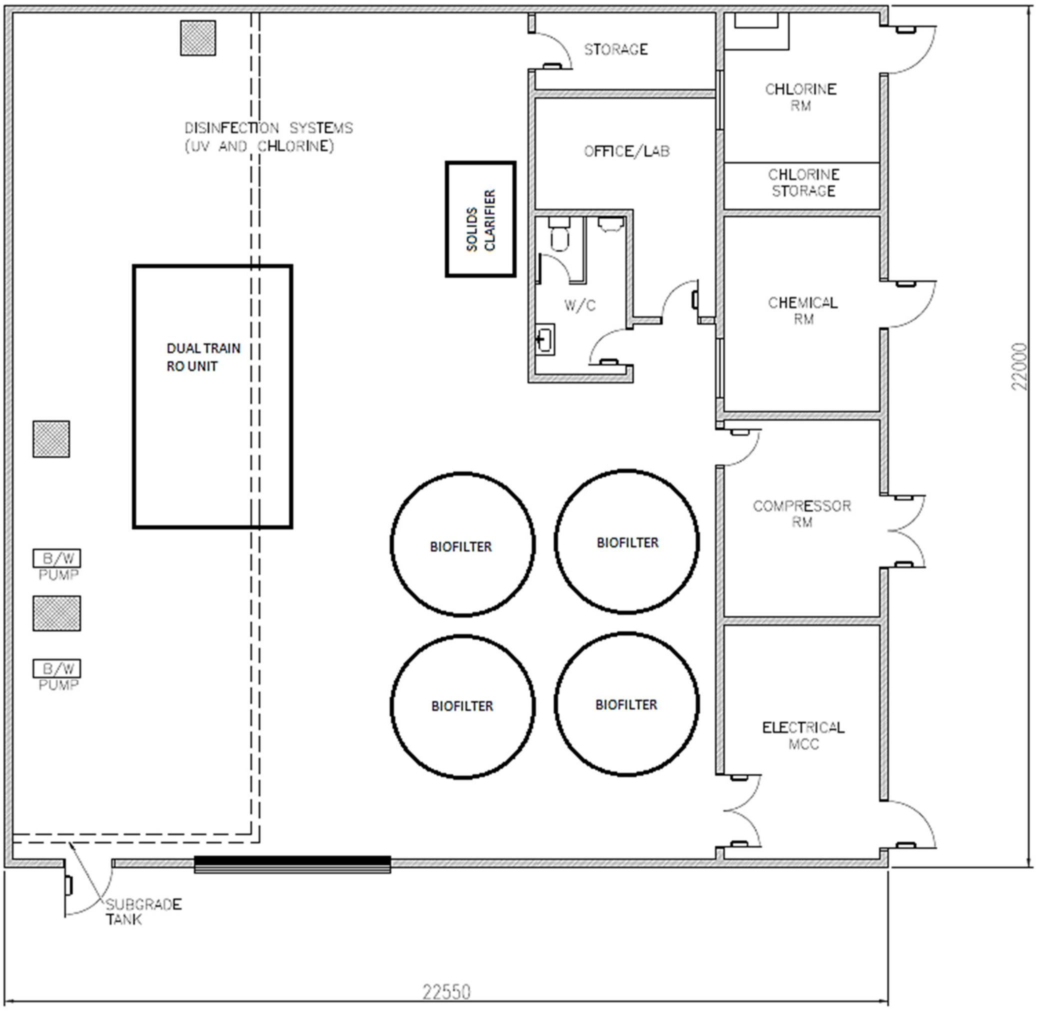


Figure 5-6 Conceptual layout for Integrated Biological treatment and RO

6 Residuals Handling

The technologies discussed herein offer a number of advantages in residuals production over conventional technologies. Residual handling requirements can be significantly reduced to 0.3% of the total treated water using CUF if a dewatering system is included. The small volume of waste produced can be contained onsite and removed periodically by a vacuum truck. With HFNF and integrated biological and RO treatment, there is the potential for direct waste discharge to the environment as the waste stream is chemical free. In the absence of an accessible watercourse, an on-site soak-away pond or a rock-pit could allow a slow discharge of the waste stream into the ground. Alternately, a dewatering system could be added as a part of the treatment to reduce liquid waste discharge. In addition to treatment waste handling, sewage disposal via a septic tank and field or holding tank would be required for on-site sewage management.

7 Disinfection

As previously discussed, UV disinfection is required for the integrated biological/RO treatment option to achieve the target minimum 3-log removal of *Giardia* and *Cryptosporidium*. For all of the options, chlorine disinfection is required for 4-log virus inactivation and for secondary disinfection to prevent against bacterial growth in the distribution system. To achieve a 4-log reduction of viruses the system must provide a contact time (CT) of 8 mg/L-min, assuming a minimum water temperature of 5^{o} C.

Currently contact time is provided with the existing 92 m^3 contact chamber and a 200 mm diameter x 800 m long pipe to the PRV prior to distribution. A combined CT of 10 mg/L-min is provided in the system, based on the following:

- Contact tank baffle factor: 0.7 (tank with baffles)
- In-Pipe baffle factor: 1.0
- Peak Hour Demand (Current): 29 L/s (1.74 m^3/min)
- Chlorine Residual: 0.2 mg/L

8 Lifecycle Cost Analysis

Preliminary (Class D) construction and operating costs estimates for the different treatment options were developed in Table 8-1 and Table 8-2 to provide a comparative evaluation of the three technologies.

Table 8-1 Comparative construction cost estimates for the different treatment options

	Ceramic Ultrafiltration	Nanofiltration	Integrated Biological & RO
Capital Cost	$4,600,000	$5,600,000	$5,650,000

Table 8-2 Comparative operating cost estimates of the different treatment options

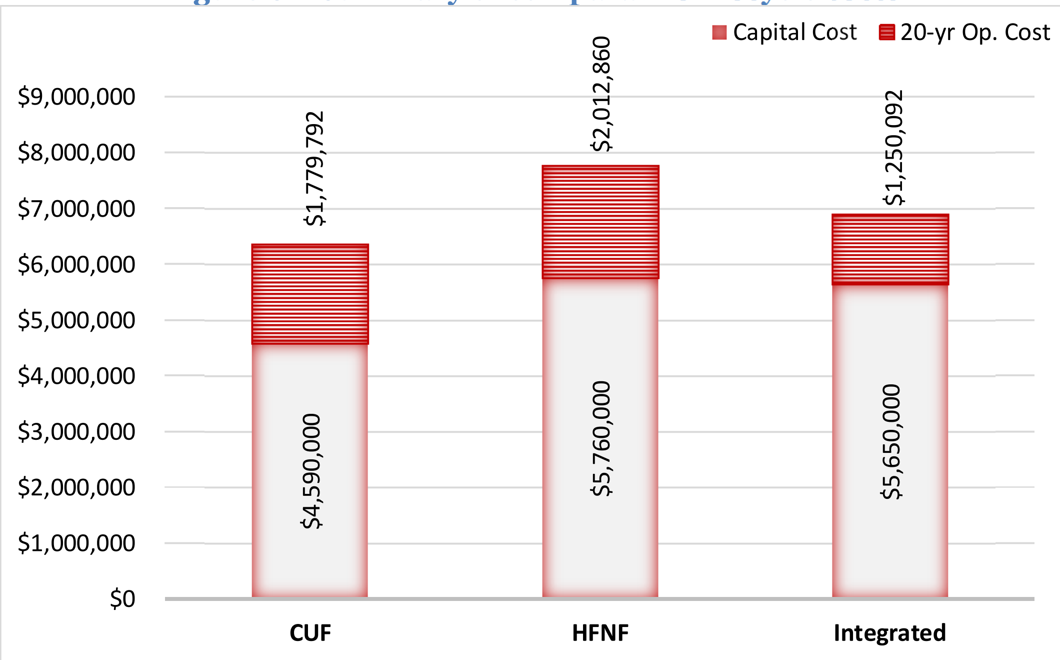
Cost Element	Ceramic Ultrafiltration	Nanofiltration	Integrated Biological & RO
Chemical	$ 50,000	$ 20,000	$ 30,000
Waste	$ 20,000	$ 0	$ 10,000
Power	$ 13,000	$ 15,000	$ 18,000
Parts	$ 50,000	$120,000	$ 10,000
Labour	$ 35,000	$ 35,000	$ 50,000
Total	**$168,000**	**$190,000**	**$118,000**
20-yr Op. Cost	**$1,779,792**	**$2,012,860**	**$1,250,092**

Based on the estimated construction and annual operating costs, a lifecycle cost analysis was calculated over the 20-year lifespan on the plant using a 7% interest rate factor. Table 8-3 and Figure 8-1 compare the lifecycle costs of the considered options.

Table 8-3 Total lifecycle cost comparison

	Ceramic Ultrafiltration	Nanofiltration	Integrated Biological & RO
Capital Cost	$4,600,000	$5,600,000	$5,650,000
20-yr Present Worth	$1,779,792	$2,012,860	**$1,250,092**
Total Lifecycle Cost	**$6,379,792**	**$7,612,860**	$6,900,092

Figure 8-1 Summary of comparative lifecycle costs



9 Treatment Technology Summary and Recommendations

A summary of the technologies considered is provided in Table 9-1 below:

Table 9-1 Summary table comparison of the treatment options

Performance Indicator	Ceramic Ultrafiltration	Nanofiltration	Integrated Biological & RO
System Complexity	Simple	Moderate	Very Complex
Maintenance	Low	High	Moderate
Reliability	Robust and readily available components	High likelihood of frequent membrane breakage & repair	Monitoring of backwash, occasional RO clean-in-place
Organics Removal	65% to 70%	80% to 90%	> 98%
Treated Turbidity	<0.1 NTU	<0.1 NTU	<0.1 NTU
Waste Stream	Sludge waste 0.3% of total flow	Direct discharge to environment 25% of total flow	Discharge to environment, plus CIP collection for disposal. 25% of total flow
Disinfection Requirements	Chlorine	Chlorine	UV and Chlorine
Post Treatment	pH adjustment due to coagulation	No change in water chemistry	pH and alkalinity adjustment
Footprint	355 m²	500 m²	500 m²
Capital Cost	$4,600,000	$5,600,000	$5,650,000
Total Lifecycle Cost	**$6,369,792**	**$7,772,860**	**$6,900,092**

We would recommend further development of the ceramic ultrafiltration (CUF) option for the new water treatment plant. Our recommendation is based on CUF having the lowest estimated total lifecycle cost, least footprint, relatively low system complexity, low residual handling requirements and organics removal capacity. We believe that the treatment capacity of CUF and lifecycle cost will outperform the recommended pressure filter by Genivar. Pressure filter is a good treatment for turbidity removal, but only marginal for organics removal and would not be able to satisfy pathogen disinfection requirements without the use of both ultraviolet (UV) and chlorine disinfection. The amount of waste produced by a pressure filter is also significantly higher than that of CUF, at 5-7% of the total treated water volume. Furthermore, the land constraints at Decca Road would force the water treatment plant to be constructed at the reservoir site and the installation of a new dedicated raw water supply watermain to the reservoir site. All this would further expose the project to high capital spending with less treatment efficiency.

Pilot testing of this option would be essential. We recommend that rigorous pilot testing is performed to: 1) confirm the validity of the process to the specific water quality characteristics of the Shawnigan Lake, 2) confirm design criteria so that the HCSR tank, filtration system, chemical systems, and residuals handling systems are appropriately sized to meet CVRD's requirements, and minimize operational headaches later on. It is anticipated that such pilot testing will need to be performed for 3 to 6 months duration at a total cost of approximately $100,000.

Land availability at the Decca Road site and other site location options are discussed in the following section.

10 Water Treatment Plant Site Options

The assessment completed above compared options based on a standard layout that included a treatment room, chlorine room, chemical storage room, MCC room, lab/office and washroom. The CUF option space requirement based on the standard layout is estimated to be 355 m3, which is too large to fit on the constrained Decca Road site.

We completed the following high level assessment: 1) determine whether it is potentially feasible to build a CUF plant on the Decca Road site by deleting some of the non-essential space in the plant (lab/office and washroom); and, 2) compare the cost of locating the plant at two other potential sites identified by CVRD.

Either of the alternate sites would require a dedicated raw water supply main to it. The dedicated supply watermain to the PRV station, which currently conveys chlorinated water, would be converted to a raw water supply main and extended to the proposed alternate plant sites. Both site options would also need to include a treated water distribution pumping system, with the pumping system at Decca Road being retained for raw water pumping. Communication between the Decca Road pump station and the water treatment plant would be needed to control raw water pumping.

The three location options for the new water treatment plant are the following and are shown in Figure 10.2:

1. The existing treatment building at Decca Road
2. CVRD ROW
3. Shawnigan Hills Park

Option 1 – Decca Road Site: The existing treatment plant is located on the north side of Shawnigan Lake on Decca Road, shown below:

Figure 10-1 Decca Road Site

The areas labelled 1 through 4 are considered developable with the following areas:

Location	Dimensions	Area
1	5 m x 6 m	30 m²
2	8 m x 5 m	40 m²
3	8 m x 6 m (triangle)	24 m²
4	5 m x 5m	25 m²
	TOTAL	**119 m²**

Note that the area to the right of Area 4 is the where the pump station is located which would be retained for pumping.

The estimated area needed for each WTP room is shown in the following table:

Room	Dimensions	Area
Disinfection	5 m x 5 m	25 m^2
Dewatering	5 m x 5 m	25 m^2
Chemical Room	3 m x 3 m	9 m^2
Chlorine Storage	1 m x 3 m	3 m^2
Chlorine Room	3 m x 3 m	9 m^2
Compressor Room	3 m x 3 m	9 m^2
Electrical MCC	5 m x 3 m	15 m^2
	TOTAL	**95** m^2

From the above, the footprint needed is marginally available at the Decca Road site.

Option 2 – CVRD ROW: CVRD has a drainage right-of-way located between Renfrew and Albright, about one half block to the east of the PRV station, which would be large enough to site the water treatment plant. This location is close to the PRV station and therefore only a small extension (approximately 300 m into the site) of the existing dedicated water line to the PRV station would be needed, as shown in Figure 10-2.

Option 3 – Shawnigan Hills Park: This site is located further away so would require a raw water supply main extension of approximately 750 m, as shown in Figure 10-2. This site has the advantage that it is close to a sewerline to the washrooms on the park site.

The following table indicates high level relative costs for each site:

	Decca Rd.	CVRD ROW	Shawnigan Hills Park
Water Treatment Plant*	$4,600,000	$4,600,000	$4,600,000
Treated Water Pumping System	$0	$250,000	$250,000
Water Supply Line Extension**	$0	$150,000	$600,000
TOTAL	**$4,600,000**	**$5,000,000**	**$5,450,000**

*price for full footprint, will be reduced for smaller footprint

Based on cost, the Decca Road site is preferred, even with the additional design and construction effort to work within the constrained site. The ROW site is the next least cost option based on its proximity to the end of the dedicated line to the PRV station.

It is, therefore, recommended that a detailed site survey be completed and a layout option(s) be developed for the Decca Road site.

Appendix : Capital Cost Breakdowns

Ceramic Ultrafiltration				
	Description or Classification of Work	**Approx. Qty**	**Unit Price ($)**	**Total Price ($)**
Mob/Demob, Bonding and Insurance				$75,000
			Subtotal Item 1 - Mob/Demob, Bonding and Insurance	**$75,000**
Earthworks				
a)	All Siteworks (gravel parking area, access road, site grading and drainage)	1	120,000.00	$120,000.00
b)	Import Structural Fill for Building Foundation	200	$60.00	$12,000.00
c)	Fencing	1	$20,000.00	$20,000.00
			Subtotal Item 2 - EARTHWORKS	**$152,000.00**
Concrete				
a)	Water treatment plant foundation and subgrade tanks	270	$2,300.00	$621,000.00
b)	Outside sidewalk	10	$150.00	$1,500.00
			Subtotal Item 3 - CONCRETE	**$622,500.00**
Miscellaneous Metalwork and Fibreglass				
a)	All miscellaneous metalwork and fibreglass for water treatment plant	1	$50,000.00	$50,000.00
			Subtotal Item 4 - MISC. METALS & FIBREGLASS	**$50,000.00**
Architectural				
a)	Pre-engineered building	355	$1,000.00	$355,000.00
b)	Interior finishing	1	$65,000.00	$65,000.00
			Subtotal Item 5 - ARCHITECTURAL	**$420,000.00**
Outside Piping				
a)	New watermains and appurtenances			$150,000
			Subtotal Item 6 - OUTSIDE PIPING	**$150,000.00**
Mechanical				
a)	Mechanical piping and equipment	1	$150,000.00	$150,000.00
			Subtotal Item 7 - MECHANICAL	**$150,000.00**
Plumbing				
a)	Plumbing work	1	$25,000.00	$25,000.00
			Subtotal Item 8 - PLUMBING	**$25,000.00**
Heating and Ventilation				
a)	HVAC work	1	$55,000.00	$55,000.00
			Subtotal Item 9 - HVAC	**$55,000.00**
Corrosion Protection and Painting				
a)	Architectural	1	$12,000.00	$12,000.00
b)	Mechanical piping and equipment	1	$12,000.00	$12,000.00
			Subtotal Item 10 - CORROSION PROTECTION & PAINTING	**$24,000.00**

Ceramic Ultrafiltration				
	Description or Classification of Work	**Approx. Qty**	**Unit Price ($)**	**Total Price ($)**
Electrical				
a)	Electrical MCC (VFDs in vendors scope)	1	$250,000.00	$250,000.00
b)	MCC control section	1	$175,000.00	$175,000.00
c)	Instrumentation	1	$100,000.00	$100,000.00
d)	All other associated electrical work (conduits, cables, etc.)	1	$100,000.00	$100,000.00
			Subtotal Item 11 - ELECTRICAL	**$625,000.00**
Treatment Equipment				
a)	Package Treatment Plant: ZLD CUF + DeWRS	1	$1,100,000.00	$1,100,000.00
b)	Chlorination System	1	$25,000.00	$25,000.00
c)	Caustic Feed System	1	$20,000.00	$20,000.00
d)	Start-up, testing and commissioning	1	$30,000.00	$30,000.00
			Subtotal Item 12 - TREATMENT EQUIPMENT	**$1,175,000.00**
	SUBTOTAL ITEMS 1 though 12			**$3,523,500.00**
	CONTINGENCY (20%)			**$704,700.00**
	ENGINEERING (10%)			**$352,350.00**
	TOTAL (EXCLUDING GST)			**$4,580,550.00**
			SAY	**$4,600,000**

Nanofiltration (HFNF)			
Description or Classification of Work	**Approx. Qty**	**Unit Price ($)**	**Total Price ($)**
		OPTION A	
Mob/Demob, Bonding and Insurance			$75,000
		Subtotal Item 1 - Mob/Demob, Bonding and Insurance	**$75,000**
Earthworks			
a) All Siteworks (gravel parking area, access road, site grading and drainage)	1	140,000.00	$140,000.00
b) Import Structural Fill for Building Foundation	250	$60.00	$15,000.00
c) Fencing	1	$25,000.00	$25,000.00
		Subtotal Item 2 - EARTHWORKS	**$180,000.00**
Concrete			
a) Water treatment plant foundation and subgrade tanks	300	$2,300.00	$690,000.00
b) Outside sidewalk	10	$150.00	$1,500.00
		Subtotal Item 3 - CONCRETE	**$691,500.00**
Miscellaneous Metalwork and Fibreglass			
a) All miscellaneous metalwork and fibreglass for water treatment plant	1	$60,000.00	$60,000.00
		Subtotal Item 4 - MISC. METALS & FIBREGLASS	**$60,000.00**
Architectural			
a) Pre-engineered building	496	$1,000.00	$496,000.00
b) Interior finishing	1	$70,000.00	$70,000.00
		Subtotal Item 5 - ARCHITECTURAL	**$566,000.00**
Outside Piping			
a) New watermains and appurtenances (allowance)			$150,000.00
		Subtotal Item 6 - OUTSIDE PIPING	**$150,000.00**
Mechanical			
a) Mechanical piping and equipment	1	$100,000.00	$140,000.00
		Subtotal Item 7 - MECHANICAL	**$140,000.00**
Plumbing			
a) Plumbing work	1	$25,000.00	$25,000.00
		Subtotal Item 8 - PLUMBING	**$25,000.00**
Heating and Ventilation			
a) HVAC work	1	$60,000.00	$60,000.00
		Subtotal Item 9 - HVAC	**$60,000.00**
Corrosion Protection and Painting			
a) Architectural	1	$15,000.00	$15,000.00
b) Mechanical piping and equipment	1	$15,000.00	$15,000.00
		Subtotal Item 10 - CORROSION PROTECTION & PAINTING	**$30,000.00**
Electrical			
a) Electrical MCC (VFDs in vendors scope)	1	$250,000.00	$250,000.00

Nanofiltration (HFNF)				
	Description or Classification of Work	**Approx. Qty**	**Unit Price ($)**	**Total Price ($)**
b)	MCC control section	1	$175,000.00	$175,000.00
c)	Instrumentation	1	$50,000.00	$50,000.00
d)	All other associated electrical work (conduits, cables, etc.)	1	$100,000.00	$100,000.00
			Subtotal Item 11 - ELECTRICAL	**$575,000.00**
	Treatment Equipment			
a)	Package Treatment Plant: NF	1	$1,700,000.00	$1,700,000.00
b)	Chlorination System	1	$25,000.00	$25,000.00
c)	Start-up, testing and commissioning	1	$30,000.00	$30,000.00
			Subtotal Item 12 - TREATMENT EQUIPMENT	**$1,755,000.00**
	SUBTOTAL ITEMS 1 though 12			**$4,307,500.00**
	CONTINGENCY (20%)			**$861,500.00**
	ENGINEERING (10%)			**$430,750.00**
	TOTAL (EXCLUDING GST)			**$5,599,750.00**
			SAY	**$5,600,000**

Biofilter + RO + UV			
Description or Classification of Work	**Approx. Qty**	**Unit Price ($)**	**Total Price ($)**
Mob/Demob, Bonding and Insurance			$75,000
		Subtotal Item 1 - Mob/Demob, Bonding and Insurance	**$75,000**
Earthworks			
a) All Siteworks (gravel parking area, access road, site grading and drainage)	1	140,000.00	$140,000.00
b) Import Structural Fill for Building Foundation	250	$60.00	$15,000.00
c) Fencing	1	$25,000.00	$25,000.00
		Subtotal Item 2 - EARTHWORKS	**$180,000.00**
Concrete			
a) Water treatment plant foundation and subgrade tanks	300	$2,300.00	$690,000.00
b) Outside sidewalk	10	$150.00	$1,500.00
		Subtotal Item 3 - CONCRETE	**$691,500.00**
Miscellaneous Metalwork and Fibreglass			
a) All miscellaneous metalwork and fibreglass for water treatment plant	1	$60,000.00	$60,000.00
		Subtotal Item 4 - MISC. METALS & FIBREGLASS	**$60,000.00**
Architectural			
a) Pre-engineered building	496	$1,000.00	$496,000.00
b) Interior finishing	1	$70,000.00	$70,000.00
		Subtotal Item 5 - ARCHITECTURAL	**$566,000.00**
Outside Piping			
a) New watermains	168	$250.00	$150,000.00
		Subtotal Item 6 - OUTSIDE PIPING	**$150,000.00**
Mechanical			
a) Mechanical piping and equipment	1	$100,000.00	$190,000.00
		Subtotal Item 7 - MECHANICAL	**$190,000.00**
Plumbing			
a) Plumbing work	1	$25,000.00	$25,000.00
		Subtotal Item 8 - PLUMBING	**$25,000.00**
Heating and Ventilation			
a) HVAC work	1	$60,000.00	$60,000.00
		Subtotal Item 9 - HVAC	**$60,000.00**
Corrosion Protection and Painting			
a) Architectural	1	$15,000.00	$15,000.00
b) Mechanical piping and equipment	1	$15,000.00	$15,000.00
		Subtotal Item 10 - CORROSION PROTECTION & PAINTING	**$30,000.00**
Electrical			
a) Electrical MCC (VFDs in vendors scope)	1	$250,000.00	$250,000.00
b) MCC control section	1	$175,000.00	$175,000.00

Biofilter + RO + UV				
	Description or Classification of Work	**Approx. Qty**	**Unit Price ($)**	**Total Price ($)**
c)	Instrumentation	1	$50,000.00	$50,000.00
d)	All other associated electrical work (conduits, cables, etc.)	1	$100,000.00	$100,000.00
			Subtotal Item 11 - ELECTRICAL	**$575,000.00**
	Treatment Equipment			
a)	Package Treatment Plant: SIBROM	1	$1,550,000.00	$1,550,000.00
b)	UV Disinfection System	2	$65,000.00	$130,000.00
c)	Chlorination System	1	$25,000.00	$25,000.00
d)	Start-up, testing and commissioning	1	$30,000.00	$30,000.00
			Subtotal Item 12 - TREATMENT EQUIPMENT	**$1,735,000.00**
	SUBTOTAL ITEMS 1 though 12			**$4,337,500.00**
	CONTINGENCY (20%)			**$867,500.00**
	ENGINEERING (10%)			**$433,750.00**
	TOTAL (EXCLUDING GST)			**$5,638,750.00**
			SAY	**$5,650,000**

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