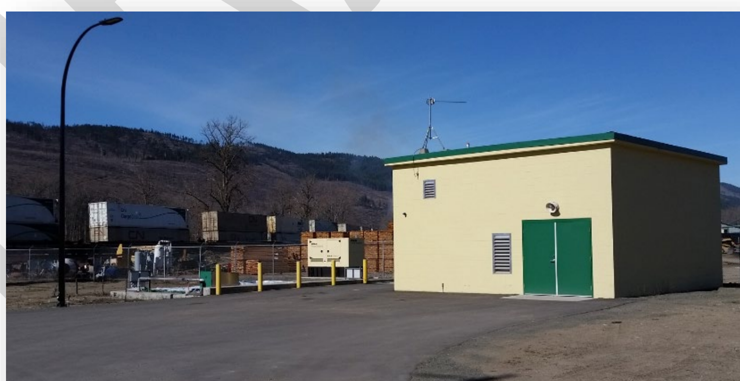
Wastewater Treatment Feasibility Study

District of Barriere



April 2021

Project No. 346-381

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1	R Wall	3/30/2021	Feedback from client review

Report Submission

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Table of Contents

List of Tables

List of Figures

List of Acronyms

BOD_5	Carbonaceous Biochemical Oxygen Demand
MOE	Ministry of Environment
MSR	Municipal Sewage Regulation (1999)
MWR	Municipal Wastewater Regulation (2012)
SBR	Sequential Batch Reactor
TRUE	TRUE Consulting
TSS	Total Suspended Solids
USBF	Upflow Sludge Blanket Filter

Units of Measure

ft	feet
Igpm	Imperial gallons per minute
km	kilometre
L/d	Litres per day
L/m	Litres per minute
L/s	Litres per second
lpcd	Litres per capita per day
m	metre
mg/L	milligrams per Litre
mm	millimetre
NTU	Nephelometric Turbidity Units
psi	pounds per square inch
USgpm	US gallons per minute

Referenced Reports

1 USEPA. The Living Machine® Wastewater Treatment Technology: An Evaluation of Performance and System Cost. EPA-832-R-01-004. 2001.

2 ECO-TEK Ecological Technologies Inc. Barriere SAS Facility Operating Plan. Rev 1. 2016.

3 Conestoga-Rovers & Associates. Septage Management Feasibility Study. Thompson-Nicola Regional District, BC. 2012.

1.0 Introduction

Centralised wastewater collection and treatment has come relatively recently to Barriere. Until the past decade, all wastewater was treated and disposed of on-site. Development trends in the township are trending towards smaller lot sizes which do not allow on-site disposal.

The District has been working towards increased centralization of the wastewater system. So far, 195 of the properties within the municipality are connected. This equates to ~5km of sewer and three wastewater treatment plants. There is also a septage receiving facility designed to service the local and surrounding area.

The District constructed a novel 'Solar Aquatics' wastewater treatment process for the main system that was designed to mimic the natural water purification processes of streams and wetlands. This process had been implemented previously on the University of British Columbia campus. The plant would treat the wastewater to a standard suitable for effluent reuse as irrigation water on municipal parks. The District has had ambitious plans for the system. The 2020 Strategic Plan set the following objectives;

- Create a revenue stream from the Solar Aquatics plant
- Implement SAWRC Operational Sustainability Plan (grow marketable plants in SAWRC)
- Continue to improve the quality of effluent to irrigation standards
- Explore feasibility of turning excess heat from SAWRC into electricity
- Provide wastewater collection throughout the community

Unfortunately, the system has failed to meet basic effluent standards and cannot operate as intended. The design build contractor is no longer in business and cannot be called upon to address the issues. A transformer failure in November 2020 caused a complete shut down. The transformer has been replaced, but many other elements of the process are in poor condition, or do not operate effectively due to poor design.

This feasibility study has been commissioned to examine options for the replacement of the Solar Aquatics treatment process with a conventional treatment system.

FIGURE 1-1: SOLAR AQUATICS TREATMENT SYSTEM

2.0 Service Areas

The District of Barriere has constructed three collection systems / wastewater treatment facilities since 2010.

Riverwalk Subdivision WWTP (2010)	Upflow sludge blanket filter (USBF) designed to treat up to 59 m^3/d of municipal wastewater from the Riverwalk Subdivision
Septage Receiving Facility (2013)	Headworks screen and sequential batch reactor process designed to treat trucked septage.
Solar Aquatics WWTP (2015 – 2016)	Solar Aquatics process designed to treat 250 m^3/d of municipal wastewater from the Barriere Phase One area. Space was set aside for expansion to a capacity of 500m^3/d.
Siska / Clary WWTP (2016)	Small type 3 activated sludge WWTP servicing the McLean Road subdivision.

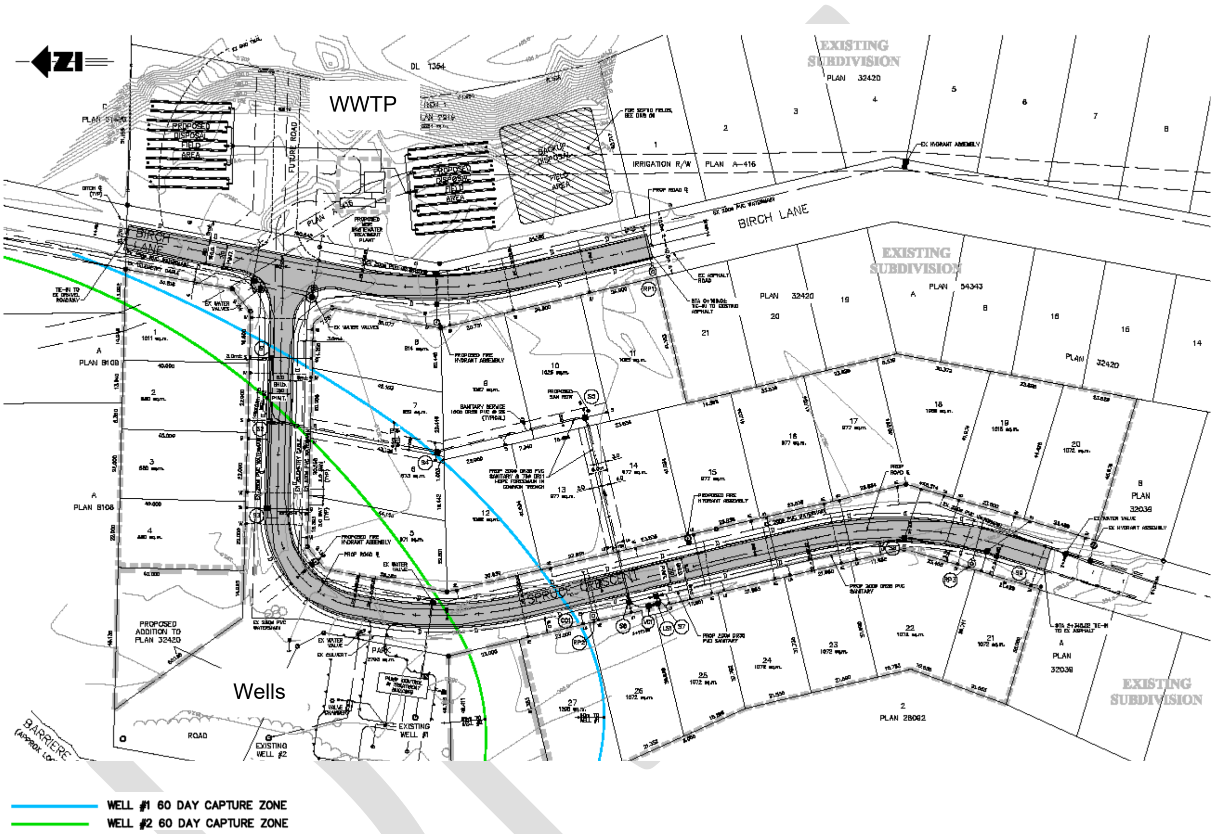
The Siska / Clary WWTP is not discussed in this report.

2.1 Riverwalk Subdivision Service Area

2.1.1 Service Area Boundary

The Riverwalk system serves an area considered to be within the zone of influence of the Spruce Crescent water wells. These wells are the main source of water for the community.

FIGURE 2-1: RIVERWALK SERVICE AREA



2.1.2 Service Area Flows

The Riverwalk (formerly Barriere Acres) subdivision is not the primary focus of this report. It is included because the District would prefer to see the wastewater treatment function consolidated in one location. As such, in future, it may be that the sewage flows from Riverwalk are pumped to the main treatment plant.

At this time 16 properties are connected out of a total of 27 in the designated service area. Based on current flows, there will still be spare capacity in the system for additional flow at full build out. If water treatment is initiated at the Spruce Crescent site, then backwash water could be treated at this site.

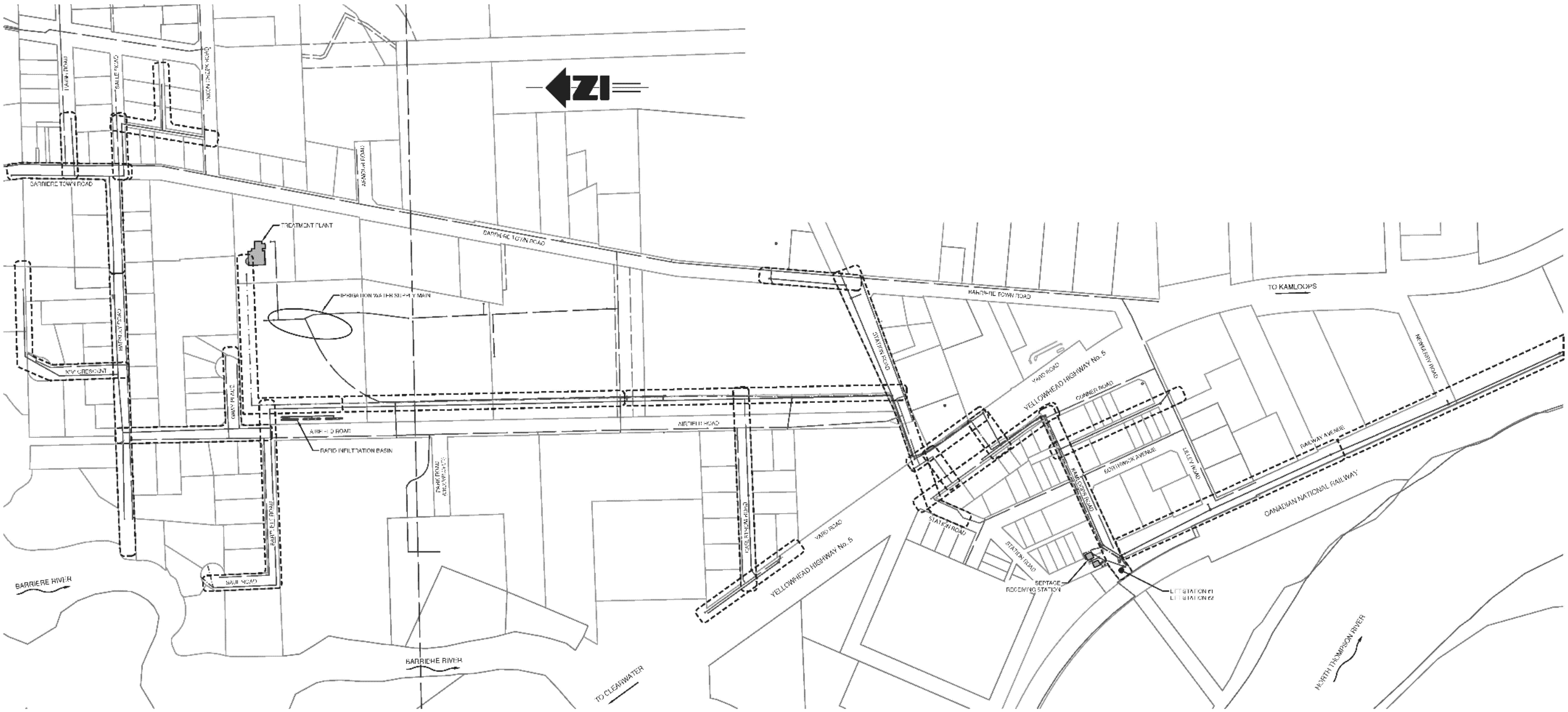
2.2 Barriere Phase One Service Area

2.2.1 Service Area Boundary

At the time of construction, the entire town of Barriere was to be brought onto a centralized wastewater collection and treatment system in phases. Phase One of this project is complete, as indicated by Figure 2-2. It consists of approximately 4,300 meters of 200mm / 250mm diameter DR35 PVC sanitary sewer main and around 1,400 meters of 150mm diameter DR25 C900 PVC sanitary sewer force main.

No further phases are planned until the wastewater treatment system is operating to the satisfaction of the District.

Figure 2-2: Phase One Service Area

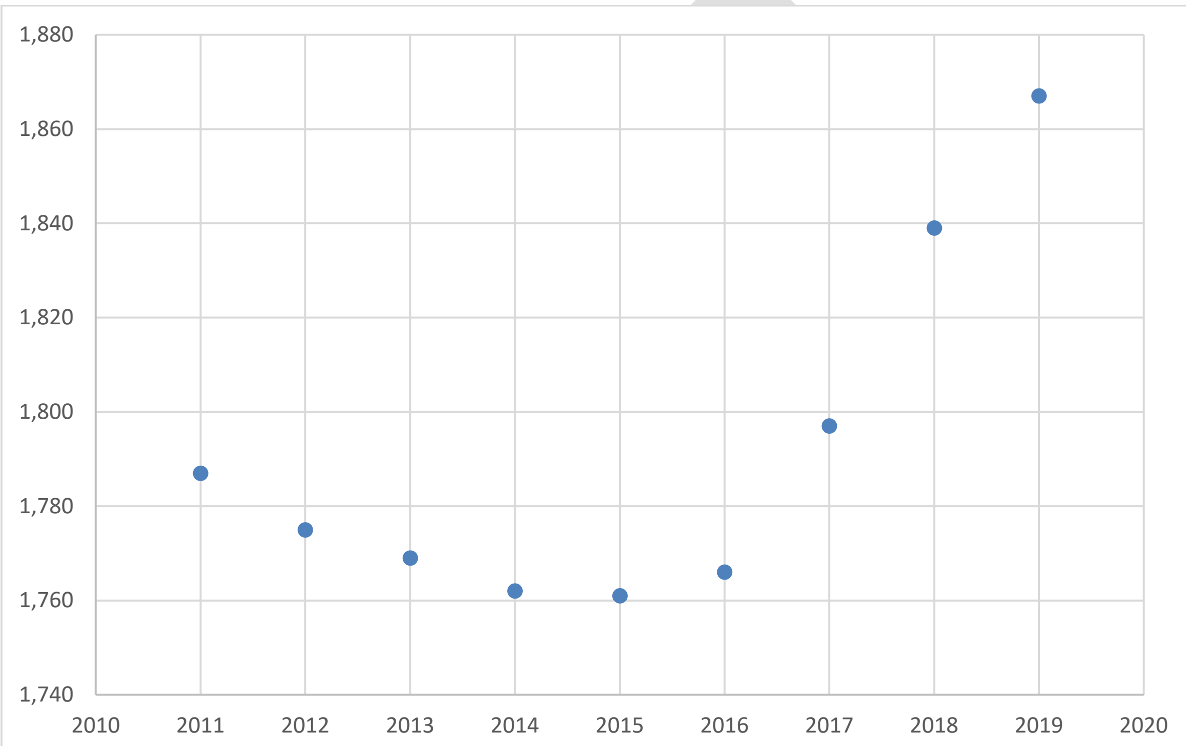


2.2.2 Service Area Flows

The Phase One servicing area is expected to produce flows up to 250m^3/d with flow increasing to 500 m^3/d once the service area is extended to incorporate the Phase Two area. At present, the actual flows are nearer 150m^3/d.

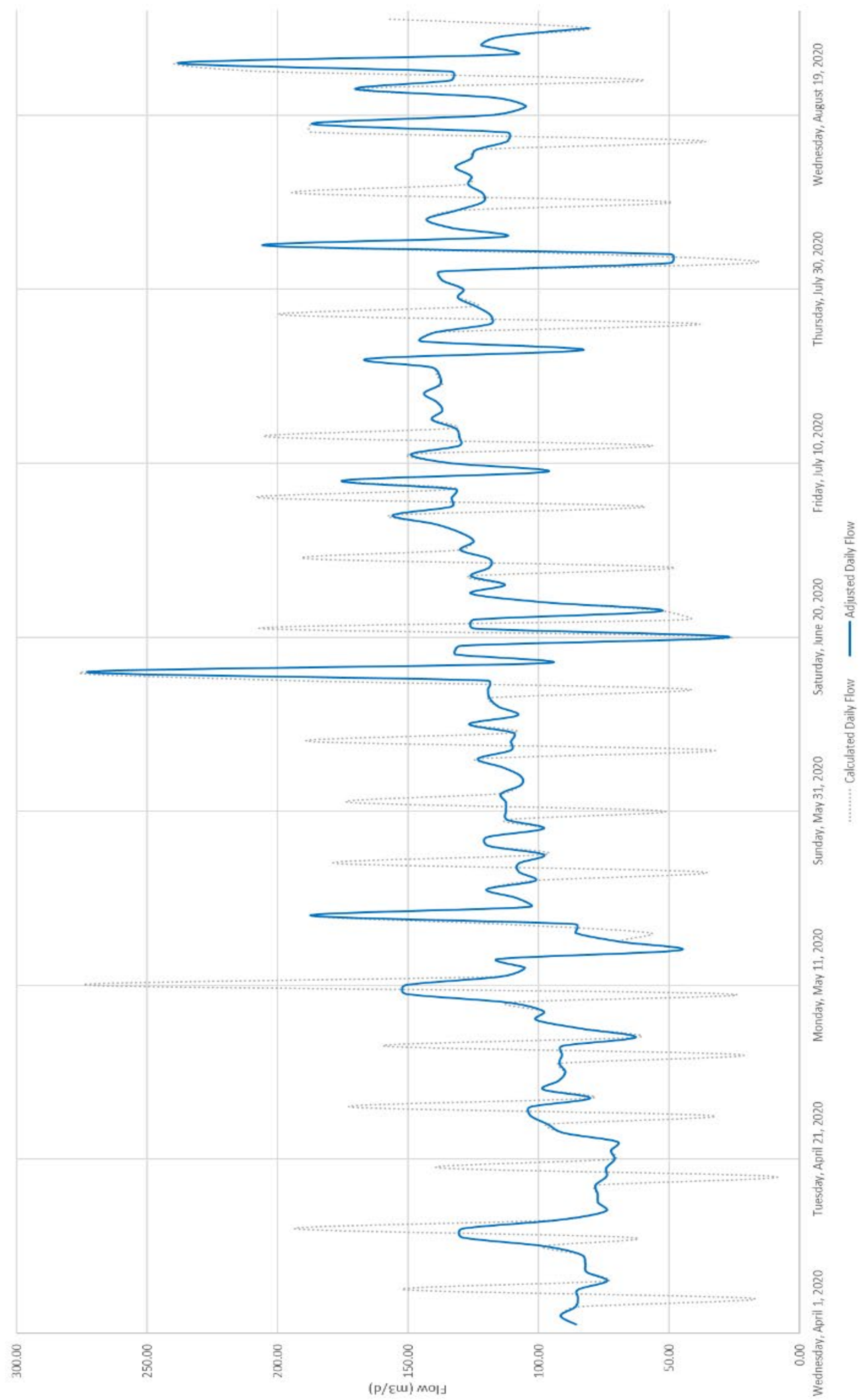
The Barriere census population was 1773 in 2011 and 1713 in 2016. BC Stats have estimated significant growth in the years 2017, 2018 and 2019 as shown in Figure 1-2. This is consistent with reports of recent demand for housing.

FIGURE 2-3: BARRIERE ESTIMATED POPULATION (BC STATS, 2020)



A total of 179 properties are connected in the Phase One area. There are plans to build a 24 unit affordable housing complex adjacent to the wastewater treatment plant. This would be connected to the collection system and is expected to increase the daily flow by approximately 50m3/d. This is a significant increase over the existing flows, which average 100 – 150m3/d (see Figure 2-4) and would exacerbate the issues with the Solar Aquatics plant.

FIGURE 2-4: BARRIERE PHASE ONE AREA FLOWS



3.0 Existing Infrastructure

3.1 Riverwalk Subdivision

3.1.1 Design Criteria

The plant is designed to treat 59 m^3/d of municipal wastewater from Riverwalk Subdivision. Current flows average around 5.2m^3/d. The authorized maximum daily discharge is 36.82 m^3/d. Other authorized parameters are;

BOD_5	10 mg/L
TSS	10 mg/L
Fecal coliforms	400 MPN/100 ml

At the time of design (2009) the wastewater effluent target was Class A as specified in Table 1 of the British Columbia Municipal Sewage Regulation (MSR) Schedule 4, and the plant design was to comply with the MSR Schedule 7, Category II standard. As such, the design criteria used were as follows;

BOD_5	10 mg/L
TSS	10 mg/L
Nitrate	10 mg/L
Total Nitrogen	20 mg/L
Turbidity	2 NTU
Fecal coliforms	2.2 CFU/100 ml

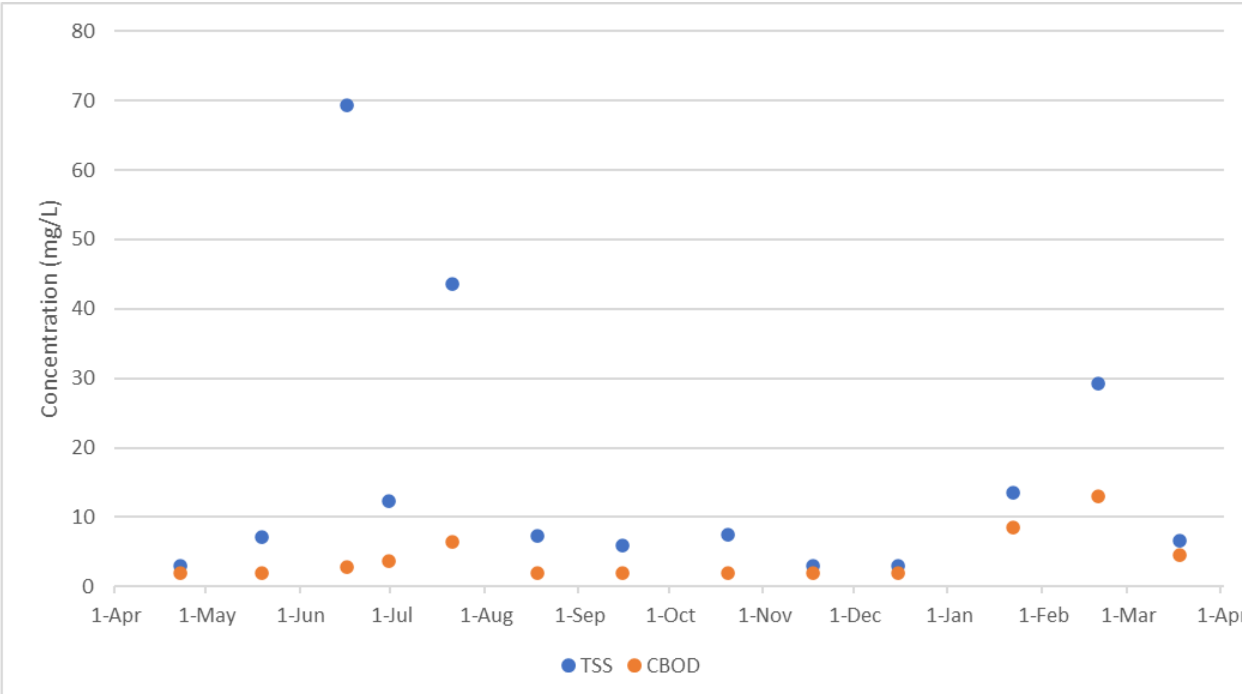
These MSR criteria have been superseded by the Municipal Wastewater Regulation (2012). The design effluent quality would meet the criteria for reuse under the greater exposure potential category (Municipal Wastewater Regulation). It would therefore be feasible to use the effluent for the irrigation of District parks and school grounds.

The EOCP classification is Class 2.

3.1.2 Actual Performance

The actual performance of the plant broadly meets the design criteria; as indicated in Figure 3-4. There were some episodes of poor performance. Further analysis would be required to determine the cause of these events.

FIGURE 3-1: RIVERWALK PLANT EFFLUENT QUALITY (2020-21)

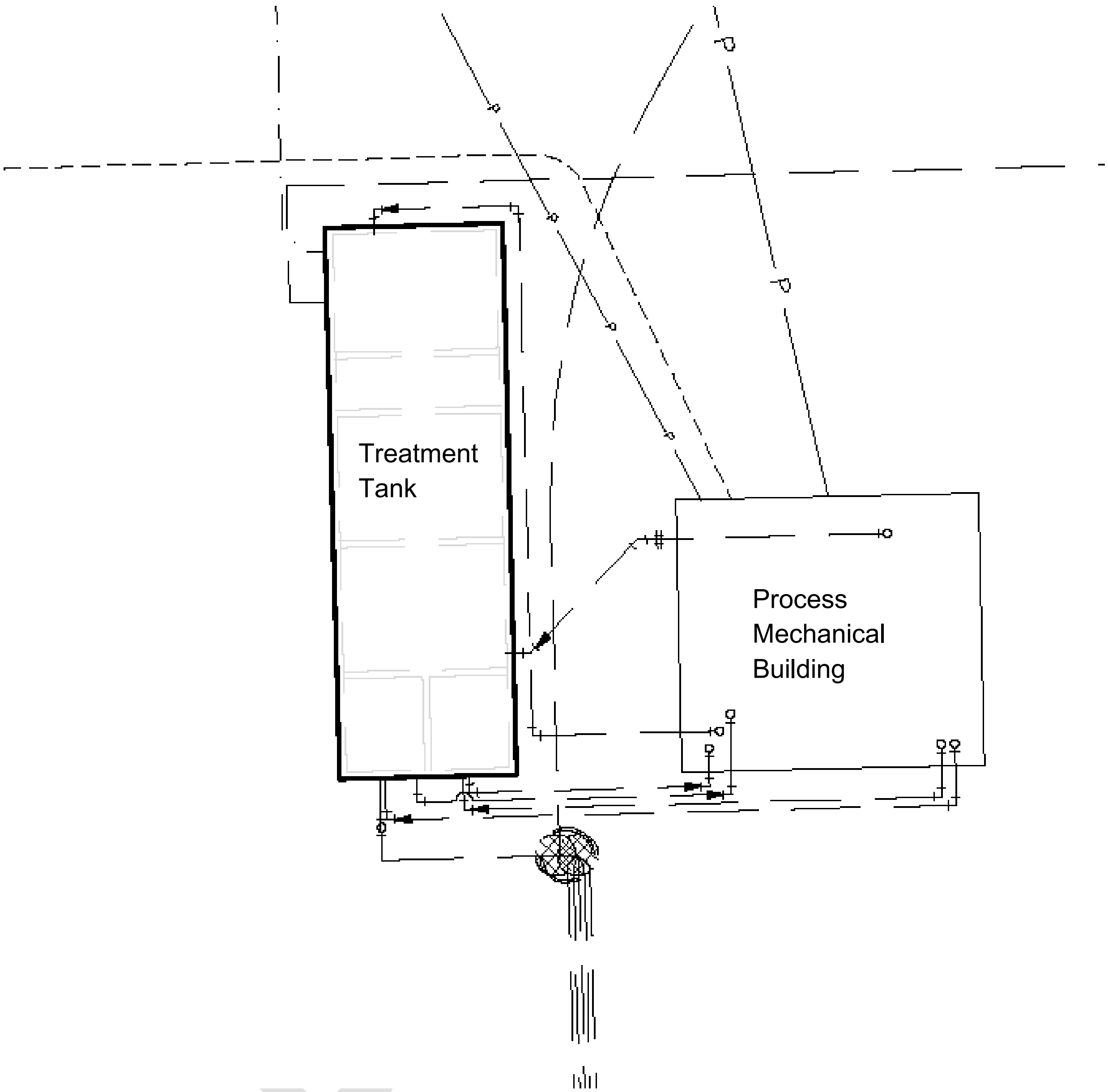


3.1.3 Installed Infrastructure

The plant is a small Upflow Sludge Blanket Filter (USBF) package plant supplied by Ecofluid.

Influent enters the plant through a 12mm bar screen located in the equalization tank. The equalization tank is provided with coarse air bubble diffusers and a set of submersible pumps controlled by level float switches, and timers.

FIGURE 3-2: RIVERWALK WWTP SITE PLAN



The bioreactor anoxic compartment is equipped with coarse air bubble spargers designed to provide conditions for the influent sewage mixing with activated sludge, recycled by means of airlift RAS pumps from the bottom of the USBF. Wastewater then flows to the Aeration Compartment, which is equipped with fine bubble aeration diffusers for vigorous aeration of the wastewater. Separation of water from the biology takes place in the prism-shaped USBF installed inside the bioreactor. Clarified treated effluent is collected in a trough on top of the USBF before flowing by gravity to Filter Feed Tank.

Two sand filters then remove remaining solids from the effluent prior to UV Disinfection. There are two Viqua Pro 30 UV units. Two are duty and one is a standby unit. Each unit is provided with intensity and temperature monitors. Unit capacity is 0.95 l/s at 50% UV transmittance.

Waste sludge is pumped to a holding tank. Approximately 60m^3 of sludge is trucked to disposal each year. There is no sludge dewatering process installed. This means dilute liquid sludge must currently be trucked to Kamloops for disposal. There were plans to include sludge dewatering at the completed septage receiving facility. This would have been available for dewatering of sludge from the Riverwalk plant.

There is a ~118m^3 emergency storage pond adjacent to the plant for use in the event of plant failure or significant maintenance.

FIGURE 3-3: PLANT BUILDING AND TREATMENT TANK

TABLE 3-1: RIVERWALK WWTP EQUIPMENT SUMMARY

EQUIPMENT	INFLUENT SCREEN	EQ TANK	EQ PUMP	BIOREACTOR / CLARIFIER	EFFLUENT FILTER	UV DISINFECTION	SLUDGE STORAGE TANK	EFFLUENT DOSING PUMP	AIR BLOWER
NUMBER	1	1	2	2	2	2	1	2	2
MAKE & MODEL	Bar Screen	-	Myers SRM4-11	ECOfluid USBF	Triton TR 140	Viqua Pro 30	-	Zoeller N 145	Roots URAI 32-2-2
DESIGN CAPACITY			1.6 L/s	Flow 59 m^3/d / 5.7 m^3/h BOD: 10 kg/d	2 L/s	1.5 L/s		2.2 L/s	135 Nm^3/h @ 48kPa
SIZE	12mm	7.0 m^3	-	~70m^3	-	-	9.5 m^3	-	-
MOTOR			0.3 kW, (0.4 Hp) 115/1/60					0.75 kW (1 Hp), 115/1/60	3.7 kW (5 Hp) 575/3/60

Anoxic Mixer, Filter Feed Pump, and Filter Backwash Pump excluded from table for simplicity

3.1.4 Discussion

The plant is drastically underloaded at present. The extent of the underloading is surprising, as the reported flows per household are much less than typical values. Flow is currently 325 litres per household per day, where a value around 1,300 L/house/d would be common for a single-family home[1] with multiple occupants. Using typical flows, the expected average flow at full buildout would be 35m^3/d, which is consistent with the design of the plant. It is not recommended that the District should commit to accepting flows from new areas, given that the wastewater flows could easily increase. For example, existing residents who are living alone may be replaced by families.

As a result of the lower than expected flows, there were plans in 2013 to trial the treatment and disposal of a limited quantity of pretreated septage at the Riverwalk WWTP. This septage would have been trucked from the septage receiving station. However, the District has elected to hold off on providing any septage receiving service, as the treatment infrastructure at the septage receiving site may be needed for sewage treatment.

If a water treatment process is reinstated at the Spruce Crescent wells, there may be benefits in discharging the backwash water off site, rather than make use of the existing soakage system. The soakage system is located within the 60 day zone of influence for both existing wells. If this is the case, then the Riverwalk WWTP may be well suited to accepting the backwash water. The water treatment plant waste will have minimal organic content and will primarily affect the hydraulic capacity of the plant.

[1] Ministry of Health. Sewerage System Standard Practice Manual Version 3. Three bedroom home = 1300 L/d

3.2 Solar Aquatics WWTP

3.2.1 Design Criteria

The design criteria are defined by the Barriere SAS Facility Operating Plan (2016). The Solar Aquatics plant was designed to treat 250m^3/d with space for expansion for the treatment of 500 m^3/d.

The plant was originally designed to produce water suitable for unrestricted reuse. As such it was designed to achieve the 'Greater Exposure Potential' requirements for reclaimed water (MWR, 2012), as follows;

$CBOD_5$	10 mg/L
TSS	10 mg/L
pH	6.5 – 9
Turbidity	Average 2 NTU, max 5 NTU
Fecal Coliforms	Median 1 CFU/100 ml, max 14 CFU/100ml

Under MOE Authorization Number 107685, the effluent is required to achieve a minimum of the MWR Class B standard for discharge to ground, as follows;

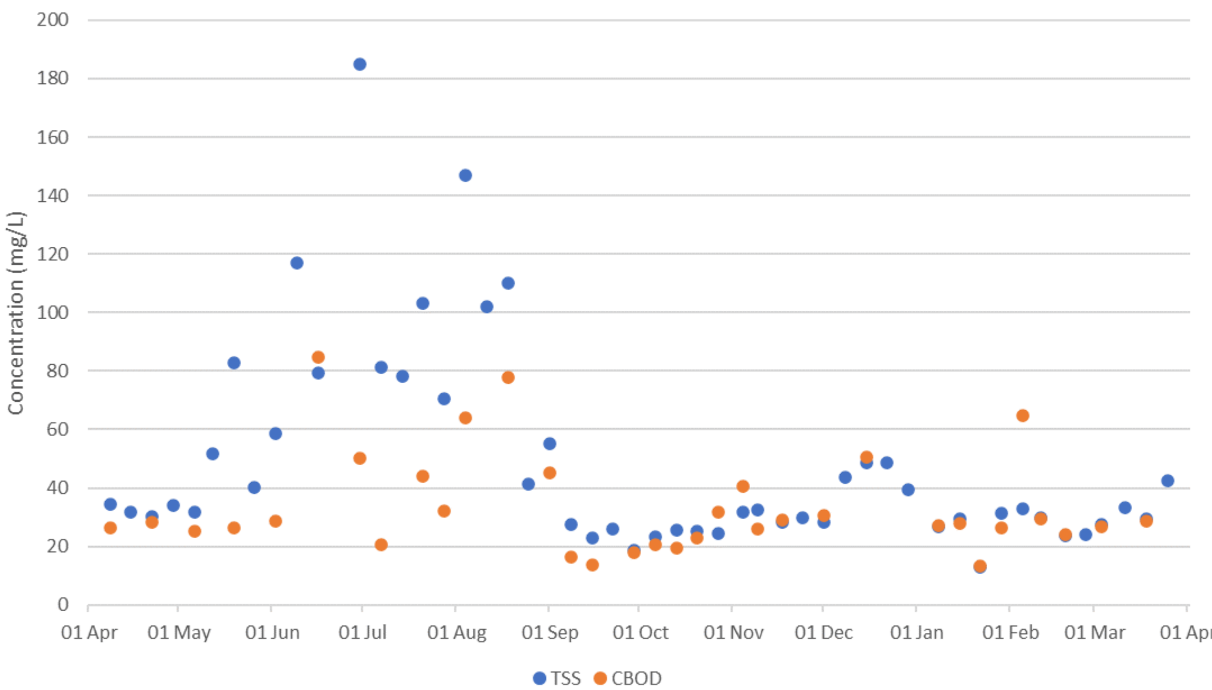
$CBOD_5$	10 mg/L
TSS	10 mg/L
Fecal Coliforms	400 CFU/100 ml

The EOCP classification is Class II.

3.2.2 Actual Performance

The actual performance of the plant falls well short of the design criteria; as indicated in Figure 3-4. Nevertheless, the performance has been significantly better than the historical levels since improvements were made by operations staff late in 2020.

FIGURE 3-4: SOLAR AQUATICS PLANT EFFLUENT QUALITY (2020-21)



3.2.3 Installed Infrastructure

Surge / Blending Tank

Flow entering the plant from the SRS / Headworks is directed to the Surge / Blending Tank. The surge / blending tank is a flow balancing tank is a circular concrete tank with a composite steel / concrete deck slab roof. The style of construction is very similar to a reservoir, although the joints were not built watertight. A plastic liner was installed when the leaks could not be repaired.

There is infrastructure for circulation and aeration of the contents but there is no effective mixer and there is no pump to draw the water level down below the full water elevation of the solar tanks. As a result, the tank operates in a similar manner to a high rate septic tank. A significant quantity of sludge will have accumulated in this tank and will need to be removed.

The concrete tank roof is a composite steel / concrete deck slab. The steel deck is designed to contribute to the strength of the structure. The steel deck under the slab is exposed to a very humid and corrosive atmosphere and appears to be compromised. A structural engineer should confirm the safety of the structure. Even without structural advice, it is apparent that the roof will need to be replaced if this tank is to be used in the future. The walls are plastic lined and are expected to be in acceptable condition.

FIGURE 3-5: CORROSION OF THE STEEL DECK IN THE SURGE / BLENDING TANK

Aeration Tanks

There are eight 20m^3 tanks constructed from steel wire grid with a plastic liner. The tanks host various plants which were intended to contribute to treatment.

Critical wastewater treatment plant structures have an importance category of 'post disaster' in the building code. As such, the seismic forces used in designing a post-disaster building are 1.5 times greater than those used to design a standard building in the location. The tanks would not comply with a seismic design requirement. In fact, the tank structure poses a relatively high risk of failure after minimal wear and tear, and would not be suitable for long term use.

It may be feasible to use the tanks as a form for a concrete wall external to the liner.

Several tanks are fitted with a cyclone aeration unit. These are not able to achieve appropriate dissolved oxygen levels in the tanks.

FIGURE 3-6: 'SOLAR' AERATION TANKS

Effluent Filter

The effluent filter is a drum filter with a spray wash feature for self-cleaning. It came fitted with plates of fine mesh media. Due to the poor effluent quality the filter was not able to pass the flows required. The original media has been replaced with a netting that is sufficient to remove large particles that would block the nozzles in the disposal field.

When drum filters are used for filtration of wastewater a deep pile media is normally used to increase the ability of the media to store solids. A purpose-built effluent filter is also commonly backwashed differently. The filter that has been installed is designed for use in the fish farming industry and does not cope with the current effluent standard. The operators have been forced to replace the filter panels with a sheet of netting in order to keep the filter operating.

It is possible that the performance could be improved by experimenting with another media, but the unit also appears to be undersized for the flow.

FIGURE 3-7: EFFLUENT FILTER

Effluent Polishing Processes

There is an effluent polishing mechanical room with equipment intended to treat a portion of the flow for reuse. The primary components are ultrafiltration membranes and ultraviolet disinfection.

The ultrafiltration membranes were purchased as bare modules without the normal supporting backwashing equipment. As such, there appears to be no infrastructure for the proper cleaning and care of the units. The actuated valves are simple irrigation control valves which would not be intended for use with effluent. In addition, they may not be intended for installation inside a building.

The UV disinfection units are primarily designed for water service, but should be acceptable for the treatment of effluent produced by ultrafiltration membranes.

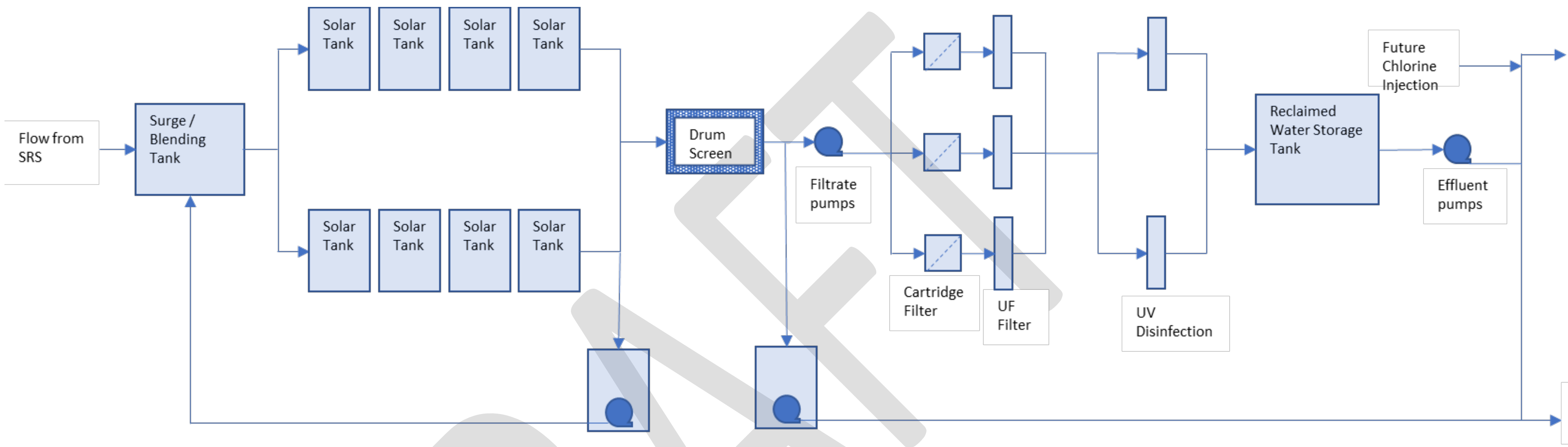
The planned chlorine disinfection system was not installed. Chlorination is required for effluent reuse, but is not necessary for discharge to an underground disposal field.

FIGURE 3-8: EFFLUENT POLISHING EQUIPMENT

Table 3-2: Solar Aquatics Equipment Summary

EQUIPMENT	SURGE/ BLENDING TANK	SOLAR TANKS	EFFLUENT DRUM FILTER	UF FILTER	UV DISINFECTION	RECLAIMED WATER STORAGE TANK	EFFLUENT PUMPS
NUMBER	1	8	1	3	2	1	2
MAKE & MODEL	Concrete tank	Plastic membrane inside steel mesh	PR Aqua RFM32	Inge Ultra S 250mm	Viqua UVMAX Pro 50	Concrete tank	Goulds e-SV 10SV6GB30 3450 rpm
DESIGN CAPACITY					$18m^3/h$ for 2.5-log Cryptosporidium & Giardia inactivation credit at 75% UVT		
SIZE	Volume = $243m^3$ Diameter = 8.1m Depth = 4.6 m	8 x 20 m^3 Diameter = 3.0m Depth = 2.7m				70 m^3	
MOTOR	-		0.33 hp				5hp

FIGURE 3-9: PROCESS FLOW DIAGRAM - SOLAR AQUATICS PLANT



3.2.4 Discussion

The Solar Aquatics treatment system was officially opened in June 2016. The facility is housed in a greenhouse, and the process has been patented under the Solar Aquatics™ brand name.

A number of other Solar Aquatics systems have been installed in Canada. The Solar Aquatics system was installed and operated by UBC in their ‘Centre for Interactive Research on Sustainability’ in 2011. There is a lightly loaded system at Christina Lake, serving the Visitors Centre. Some systems have been replaced, including

- Bear River WWTP (Annapolis County, NS). This plant has been converted to sequencing batch reactor.
- Beaverbank WWTP (Halifax Regional Municipality, NS). This plant was replaced with a recirculating sand filter system.

The USEPA[2] studied the "Living Machine" concept in 2001 (report EPA-832-R-01-004). This is similar to the Solar Aquatics™ system. The effect of the plants immersed in the tanks was dismissed as minimal. This was because the deep tanks with their limited water surface area, limits the number of plants that can be used in the system. As a result, the plant roots occupy a relatively small fraction of the total tank volume and the plants (and solar energy) are believed to play a marginal role in providing treatment. However, the plants do provide significant aesthetic benefits and can serve to enhance public acceptance of the process. This is not necessarily trivial.

The Cynthia WWTP in Brazeau County (AB) is a successful Solar Aquatics installation. It treats 30 – 50 m^3/d average dry weather flow. The design flow is 44 m^3/d. Peak flow can be as much as 150m^3/d due to inflow and infiltration. This plant has a similar configuration to the Barriere WWTP with the addition of hopper bottom clarifiers for solids separation. The solar tanks originally had vortex aerators but these were replaced with conventional aeration diffusers due to clogging and performance issues. Interestingly, the sludge from the clarifier is pumped back to the solar tanks and the only solids removal is sludge from the surge-balancing tanks and dead plants from the solar tanks. Effluent filtration is by drum screen and coarse media filter and the effluent is stored and discharged to an unnamed creek twice a year. The effluent quality is reported by staff to be <10 mg/L BOD/TSS.

[2] EPA-832-R-01-004. The Living Machine® Wastewater Treatment Technology. An Evaluation of Performance and System Cost. September 2001

FIGURE 3-10: CYNTHIA WWTP

There were significant issues during construction of the Barriere plant and the design-build contractor went out of business part way through construction. As a result, the District was forced to complete the project themselves. As a part of the sequence of events, a number of important features appear to have been lost from the design, such as

- The surge / blending tank has a constant water level so there is no real balancing of inflow. It operates as a septic tank, with the solids being retained until they are pumped out. The design of the tanks makes sludge removal highly impractical.
- The vortex aerators do not seem to receive their design flowrate and would be prone to blockage if they did. Aeration is effectively absent from the system.
- The clarifiers were deleted.
- The sand filters were substituted for a single small drum filter.

The designer also appears to have assumed that there would be no waste solids from the process. As a result, solids have gradually accumulated in the tanks, reducing treatment capacity.

3.3 Septage Receiving Station

3.3.1 Design Criteria

The plan for the Septage Receiving Facility was to accept delivery of septic tank waste from residents who live within the TNRD's Electoral Area 'O' after the Solar Aquatics WWTP was completed[3]. The septage volume for the local area was originally determined by taking the average septage load for the Barriere Landfill for 1999-2010, as provided by the TNRD. Using this method, the total volume of septage disposed was estimated to be 716 m^3/year. Accordingly, the Septage Receiving Station was designed to accept 3.6m^3 per day based on six month (summer) operation. The system is designed to screen the septage then treat it on-site to approximately the strength of domestic sewage before the effluent is pumped to the Solar Aquatics WWTP.

3.3.2 Installed Infrastructure

Lift Stations

SRS Lift Station #1 receives flow from Barriere and pumps the wastewater on to the headworks system. These lift station pumps are VDF controlled.

SRS Lift Station #2 received flow from the headworks and pumps it to the Solar Aquatics plant.

Headworks Grinder and Screen

The pretreatment process consists first of a macerator unit which reduces the particle size of the waste stream to approximately 8mm. An inclined screen and screw conveyor is located downstream of the macerator. The screen perforations are 6mm in diameter. Debris trapped by the screen is conveyed out of the screening tank, washed and bagged.

The JWCE Muffin Monster 30004T-1204-DI Inline Grinder and JWCE Honey Monster SRS3235-XE screen are designed for a maximum flow of 60 L/s. The capacity is intended to keep pace with a tanker delivery while the incoming sewage lift station (SRS Lift Station #1) is also operating. The screen perforation size is 6mm.

When a septage delivery is occurring the flow automatically diverts to the septage treatment tank. At other times the flow goes to SRS Lift Station #2.

[3] As communicated to the Ministry of Environment in 2013

Septage Treatment

The septage treatment system is similar to the system used by the District of Clearwater. It is based on an aerobic digester design which aerobically degrades the wastewater, which will predominantly consist of anaerobic septic tank sludge.

The screened septage waste is conveyed by gravity to a 20m^3 surge tank. A transfer pump lifts septage waste from the surge tank into a 100m^3 aeration tank. The aeration tank consists of a recirculation pump and a baffle wall to prevent short-circuiting. The recirculation pump continuously lifts septage waste through an IPEX double vortex aeration system to impart dissolved oxygen. This system is rated to provide 4.8 kgO_2/h.

When the maximum water level in the aeration tank has been reached the recirculation pump will stop to allow solids to settle in the chamber.

Once the solids have settled, a floating decanter system draws down the top ~1m of the tank contents. This decanted pretreatment effluent is then pumped to the Solar Aquatics WWTP via Lift Station 2. The decanter unit currently requires repair.

Standby Power

A 101 kVA standby generator is capable of keeping the lift stations and screen operational during a power outage.

FIGURE 3-11: BARRIERE SEPTAGE RECEIVING STATION

FIGURE 3-12: PROCESS FLOW DIAGRAM - SRS

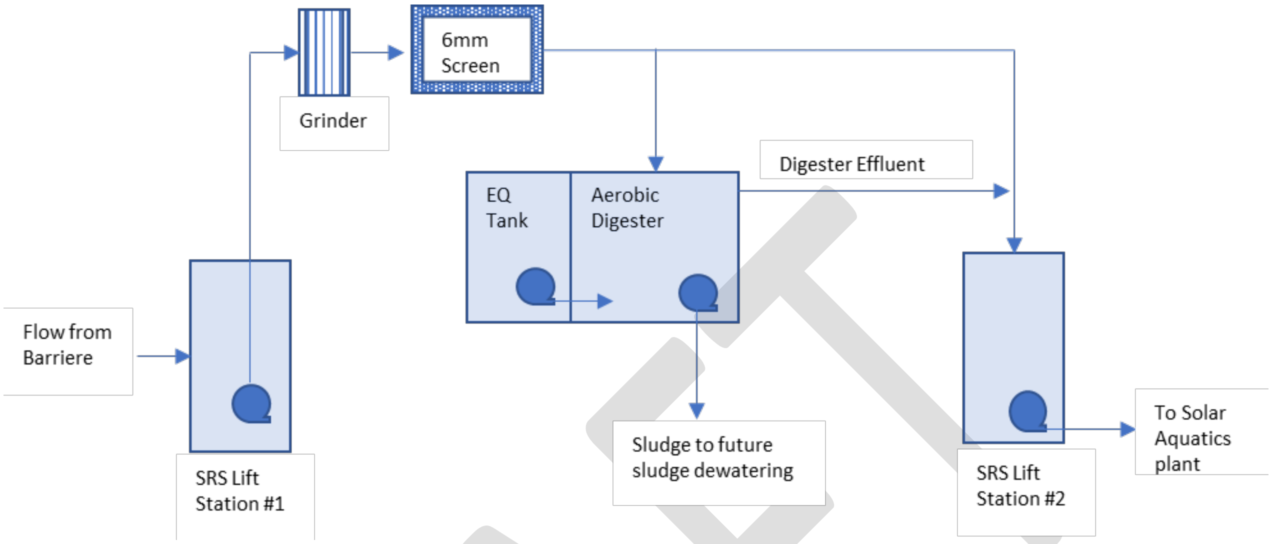


TABLE 3-3: SRS EQUIPMENT SUMMARY

EQUIPMENT	INFLUENT LIFT STATION	GRINDER	HEADWORKS SCREEN	EQ TANK	EQ PUMP	TREATMENT TANK	SRS SLUDGE PUMPS	SLUDGE DE-WATERING	WWTP LIFT STATION
NUMBER	2	1	1	1	1	1	2 (planned)	Future	2
MAKE & MODEL	Flygt NP-3153.091 HT with 253mm impeller	JWCE Muffin Monster 30004T-1204-DI Inline Grinder	JWCE Honey Monster SRS3235-XE		Flygt CP3045HT, 252 impeller	Aerobic Digester	Flygt CP3045HT, 252 impeller proposed	-	Flygt NP-3153 HT DN 100
DESIGN CAPACITY	25 L/s		60 L/s						20 L/s
SIZE			6mm perforated screen	20 m³		103 m³	-	-	-
MOTOR	10hp (VFD)	5hp	2hp	-	1.8hp	-	2.5hp		15hp

3.3.3 Discussion

At this time the headworks system is in use and operating effectively. The septage receiving and pre-treatment system cannot be used until there is effective treatment of wastewater from the residential collection system. The District still wishes to accept septage in the future.

In general terms the infrastructure at the SRS station is in good condition and is fit for purpose. However, the decanter needs to be repaired. The future upgrade to the aeration system based on aeration diffusers and a blower, as indicated on the drawings would be a valuable improvement. This configuration would tend not to disrupt flocs that need to settle effectively for solids separation.

It will also be necessary to install the solids dewatering facilities that were originally planned for the facility. The system that was originally envisioned was a Flo Trend Roll Off Container Filter, as is used by the District of Clearwater at their septage receiving facility. The system selected depends on the prioritization of features. The Flo Trend system can only achieve a relatively wet sludge, but it is very inexpensive and easy to operate. It may remain the best option for Barriere.

3.4 Effluent Disposal System

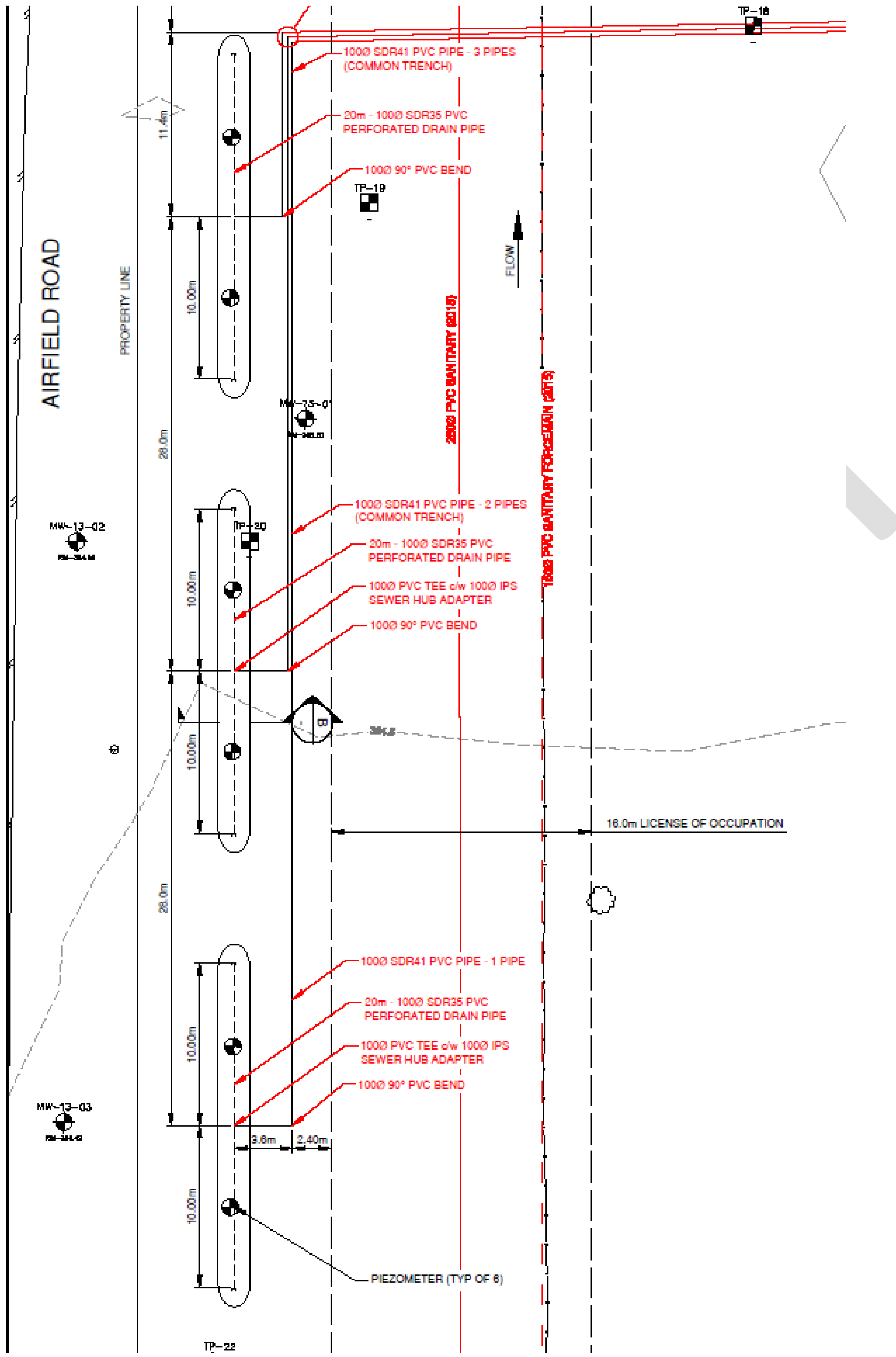
The existing effluent disposal system comprises three 100mm diameter, 20m long perforated pipes buried in an infiltration trench. The infiltration system is similar in configuration to a residential effluent drainage field.

There are many municipal disposal fields of this type in operation. There are nearby community systems using similar fields at Paul Lake and Rayleigh. The most successful examples treat the effluent to a high standard to protect the soil matrix from clogging.

Clearly the disposal system was designed to accept high quality effluent. This is a factor in the sizing of the infiltration trenches. The effluent that is currently being disposed of is equivalent to septic tank effluent, which will tend to cause accelerated biomat development and blinding of the infiltration zone. The infiltration trenches have already been replaced. The filter cloth that was used during the rehabilitation was not correct for the application. As a result, effluent is surfacing through the ports. The filter cloth is to be replaced in 2021.

If the original design effluent quality cannot be achieved by future treatment systems, then it may be that disposal to infiltration basins is more practical. These are used in municipal systems for the disposal of treated municipal effluent of at least 45:60 mg/L (BOD / TSS) quality. These basins are common for larger systems because they can be maintained when needed to keep them functioning effectively. They are also relatively efficient in their use of land area. The down side is that the effluent is on the surface, rather than being concealed underground.

FIGURE 3-13: INFILTRATION SYSTEM



4.0 Improvement Option 1: Solar Aquatics Plant Upgrade

Clearly, it would be possible to upgrade this plant to achieve similar performance to the Cynthia WWTP described earlier in this report. The key factors leading to the superior performance of the Cynthia plant are as follows;

- The pre-treatment surge-balancing tank retention time at the Cynthia plant is twice as long as in Barriere (based on average day design flow) and staff can remove solids regularly.
- Their solar tank retention time is four times as long (based on average day design flow).
- Cynthia has dedicated clarifiers to separate solids from effluent (Barriere does not have a clarifier).
- Cynthia has effluent filtration (Barriere does not have functional filtration).

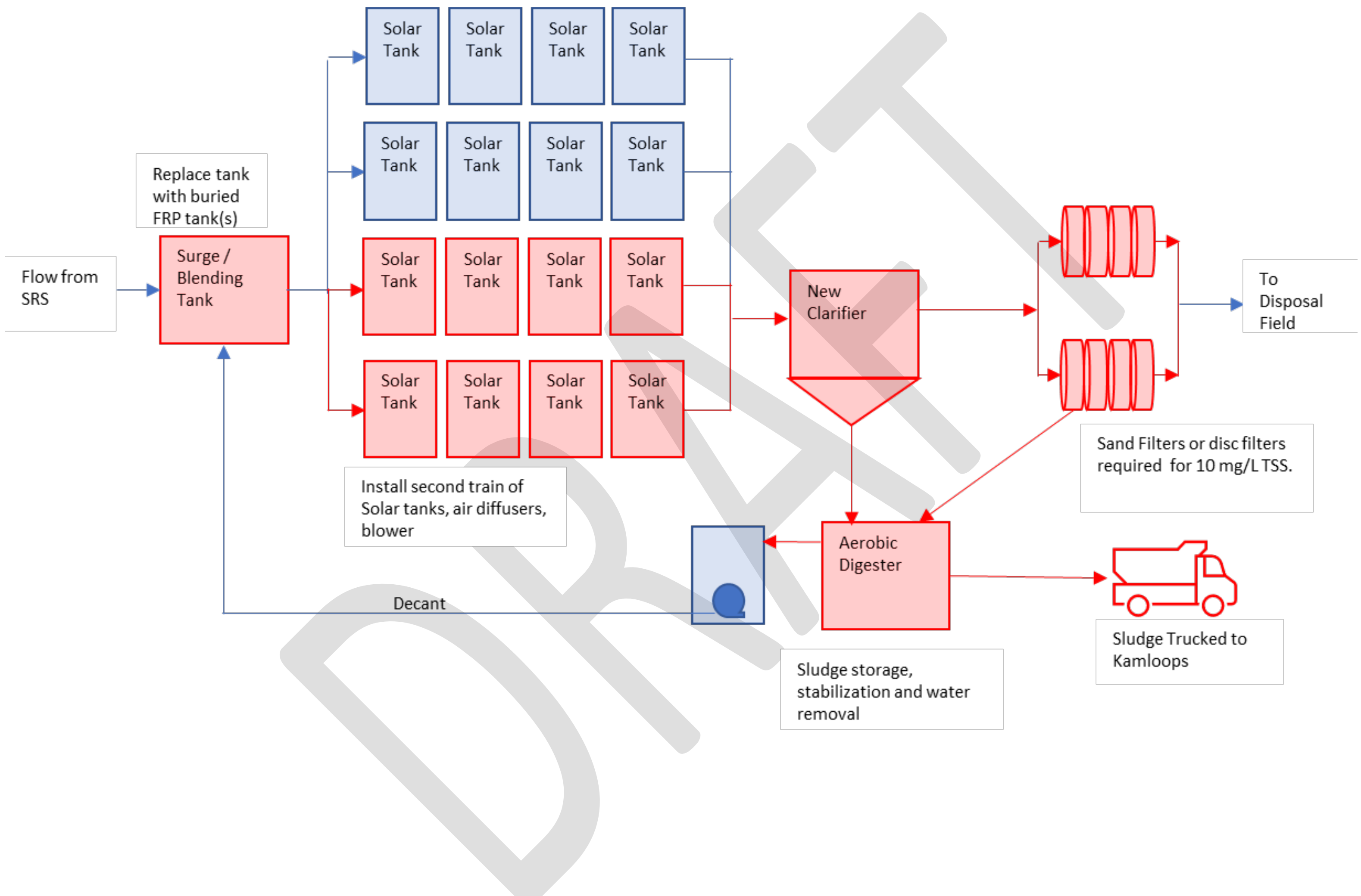
To make the plants similar in capacity, the Barriere system would require a second surge-balancing tank and improved access for sludge removal, twenty-four more solar tanks, an aeration upgrade, new clarifiers and new filters.

This upgrade would only allow the plant to treat the existing flows. If the plant is to treat 500m^3/d then every element will need to be doubled in capacity. It is also suggested that the method of sludge management used at Cynthia needs to be improved.

This design concept has been summarized in terms of advantages and disadvantages below;

Advantages	Disadvantages
▪ Retain original process	▪ Solar aquatics tanks would still be undersized relative to Cynthia plant ▪ No ability to expand to 500m^3/d ▪ Must repair surge-balancing tank without removing it from service, which is near to impossible. ▪ There would be no easy way to regularly remove sludge from surge-balancing tank ▪ Odour from surge-balancing tank will be a significant concern when desludging. ▪ Must build new clarifiers at solar aquatics site. ▪ New building required for sand filters and possibly clarifiers. ▪ Sludge processing occurs at solar aquatics site (odour, awkward access) ▪ Cannot accept septage as the capacity of the plant is not sufficient for basic needs, let alone adding more load.

FIGURE 4-1: DESIGN SCHEMATIC FOR PHASE ONE (250M³/D)



5.0 Alternative Treatment Technologies

Various technologies are available that could be used for treating the wastewater. Common alternatives are discussed in this section.

5.1 Sequential Batch Reactor

The existing aerobic digester located at the septage receiving station was designed to pre-treat septage for discharge to the municipal treatment system. This system could be repurposed relatively easily to treat town wastewater as the flows already go to this site.

The existing aerobic digester tank could very easily be converted for operation as a sequential batch reactor. With SBR treatment it is best to have a minimum of two tanks to allow for a practical fill and draw cycle. The 250m^3/d design flow would require a total of at least three 100m^3 tanks.

Advantages	Disadvantages
▪ No change to existing design principle. ▪ Non-proprietary technology ▪ No change to headworks	▪ Relatively large plant footprint ▪ Further treatment needed to achieve 10/10 effluent. ▪ Fluctuating water level can put limits on plant hydraulic profile. ▪ Flow equalization may be required.

If the effluent is to be reused, then an additional filtration stage would be required. However, it should be noted that municipal subsurface disposal fields routinely include effluent filtration in order to protect the disposal system.

The capacity of the filtration stage would need to accommodate the relatively high flow that occurs when the tanks are in their decant phase. Alternatively, the filters could be installed downstream of an equalization tank.

In order to implement this process, the following would be required:

- Construct two new treatment cells.
- Install fine bubble aeration and new blowers in all cells.
- Install effluent filtration

Because an SBR system relies heavily on the control system, events such as lightning strikes can create serious operating problems. It can also be necessary to involve controls contractors for process changes.

The SBR process is in use locally at Tobiano and the Caravans West Resort. The Caravans West system has effluent sand filters and an underground disposal field downstream.

FIGURE 5-1: TOBIANO SBR

It could be feasible to use the SBR process in the existing tank as a temporary pre-treatment stage to the solar aquatics process. The plant would be highly loaded and effluent quality would not meet normal secondary standards. Experimentation and optimization would be required to set up such a process. This system would function purely as an emergency measure until a permanent system can be implemented.

5.2 Membrane Bioreactor

A membrane bioreactor primarily consists of an aeration tank and a bank of separate or submerged membranes that filter the effluent through microscopic pores. The resulting effluent quality can be very good, meeting the requirements for reuse once it is treated by chlorine disinfection system.

An MBR system is configured as either a submerged (membranes immersed in the tank) or an external system (membranes outside the tank). Either system would require a new building protecting the mechanical systems. A submerged membrane system can be installed into a covered tank.

The membranes require both physical and chemical cleaning. Backwashing (reverse flow through the membrane) occurs routinely. Chemical cleaning can occur every 6 months (or less) when the trans-membrane pressure increases to a point which indicates clogging of the membrane pores. Chemical cleaning uses sodium hypochlorite combined with mineral or organic acids. A chemically enhanced backwash combines backwashing and chemical cleaning, and may be required on a product specific basis. This may occur daily.

There are many product specific design features such as coarse bubble aeration around the membrane for mixing and to inhibit fouling. The choice of cleaning products is also product specific.

FIGURE 5-2: COVERED TREATMENT TANK - PINECREST ESTATES WWTP

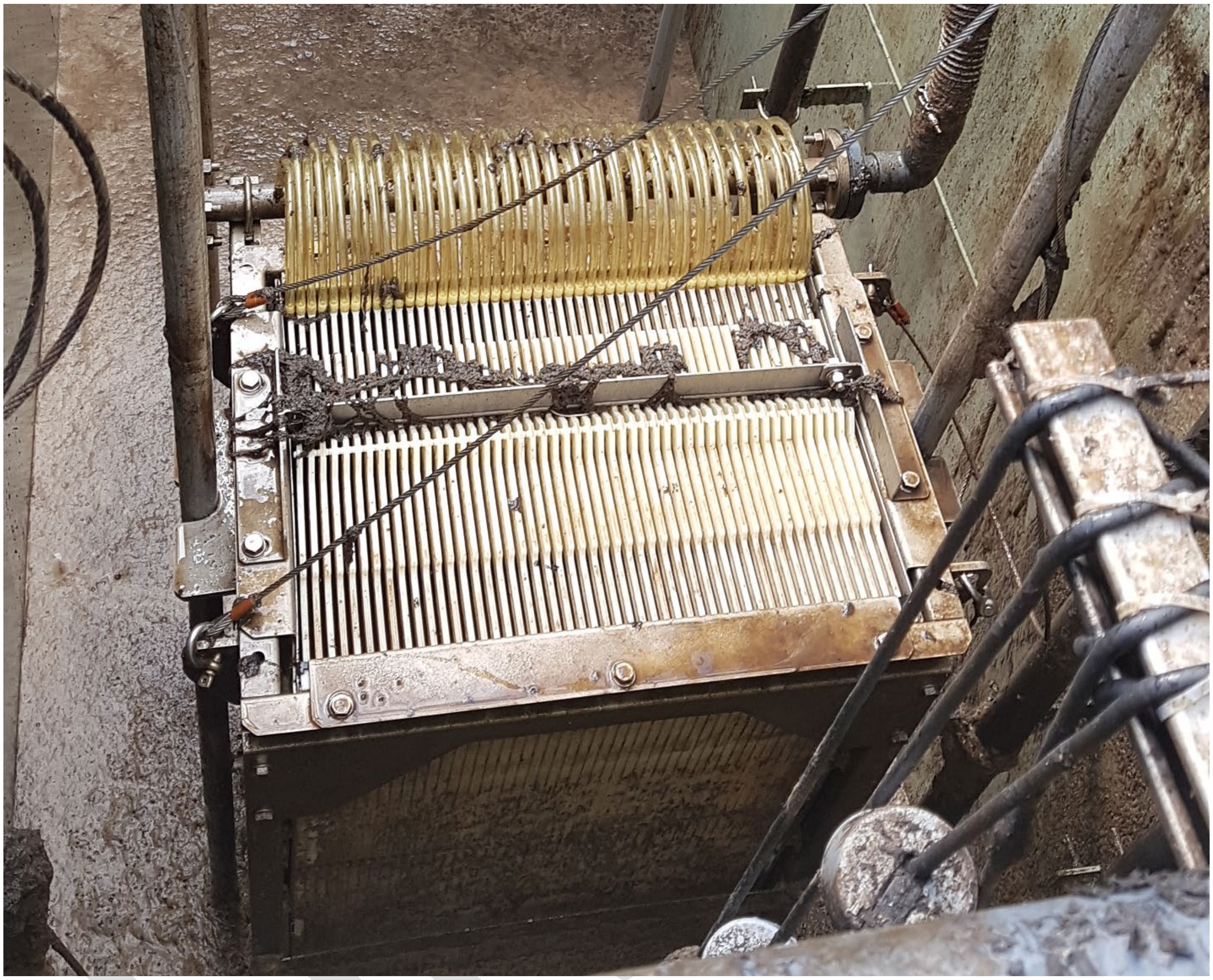
The headworks screen would be retrofitted with a 1mm screen suitable for prescreening for membrane filtration. This would significantly reduce the screen capacity.

Taking the Pinecrest WWTP (pictured) as an example, an equalization and bioreactor volume of 100m^3 is required to a peak flow of 65m^3/d. The design average day flow at Pinecrest was 40 m^3/d. While the Pinecrest system was generously sized, it is still true that the existing 100m^3 tank is too small to effectively treat 250m^3/d. At least one more tank would be needed to allow for adequate flow equalization in order to minimize membrane capacity. Feedback from system suppliers has confirmed this.

It is also notable that the up front and life cycle costs for the membrane system are relatively high. The membranes themselves have a life between five and ten years.

Advantages	Disadvantages
▪ Excellent, consistent effluent quality which would be suitable for many different reuse applications. ▪ Relatively high waste sludge solids concentration	▪ They use proprietary technology that can be phased out by the manufacturer ▪ They are typically relatively expensive to build and operate. ▪ The membranes need to be replaced every 5 – 10 years. ▪ There is little flexibility if design capacity is exceeded. ▪ Relatively complex equipment ▪ Headworks screen size will have to be reduced which reduces screen capacity.

FIGURE 5-3: FLAT SHEET MEMBRANE - PINECREST ESTATES WWTP



5.3 Moving Bed Biofilm Reactor (MBBR)

A Moving Bed Biofilm Reactor (MBBR) consists of an aerated concrete tank containing neutrally buoyant media which retains high concentrations of microorganisms without washout. An MBBR could be installed as pre-treatment upstream of the existing Solar Aquatics system, or operate as a standalone treatment process.

Based on a 50% media filling rate the existing treatment tank could treat 250m^3/d to an effluent BOD concentration of 10 mg/L.

FIGURE 5-4: PEENOX™ MBBR MEDIA

The standalone treatment configuration must include a sedimentation basin, or equivalent, to remove solids. Some systems are configured as MBBR-DAF which yields a relatively concentrated sludge. A DAF system is more complex than sedimentation, with higher operating costs, which would be offset to a greater or lesser degree by reduced sludge handling costs and complexity.

The comparison depends on the specifics of the design.

Advantages	Disadvantages
▪ Small bioreactor volume ▪ Simple operation ▪ The coarse bubble aeration diffusers require little maintenance ▪ Non-proprietary technology ▪ Minimal changes to headworks	▪ Further treatment needed to achieve 10/10 effluent. ▪ Relatively high air requirement. ▪ Media must be removed from the tank to access aeration diffusers.

There is an example of MBBR treatment in Radium Hot Springs, BC. This reactor has a clarifier downstream and the treated effluent flows to partial mix aerated lagoons for polishing. Sludge from the clarifier goes to an aerobic sludge digester.

FIGURE 5-5: MBBR TANK AT RADIUM HOT SPRINGS

In order to implement MBBR pre-treatment at the septage receiving station the following equipment would be required

- Coarse bubble aeration system
- 2 x 5hp blower
- 50m^3 of MBBR media
- Media retention strainer
- Antifoam dosing system

If the system were to be used for treatment in place of the Solar Aquatics plant, a solids separation process would also be required. A clarifier or dissolved air flotation unit would enable the plant to achieve 30mg/L TSS which would comply with the MWR criteria for ground disposal (45mg/L).

If a temporary plant was needed quickly, AWC Solutions Ltd have a rental trailer mounted dissolved air flotation system of the correct size that may be rented for emergency use at a cost of $1,200 per day.

If the existing registration criterion of 10mg/L TSS is to be achieved, then effluent filtration would need to be added. The most likely location for a new filtration system would be at the Solar Aquatics site. Suitable filter designs include sand filters and disc filters.

5.4 Upflow Sludge Blanket Reactor (USBF)

There are many other treatment systems available that could be considered, but do not lend themselves to installation into the existing SRS tank. These could be considered as an independent upgrade. An example would be variants on the activated sludge process, such as the Ecofluid USBF system (used at Riverwalk) with an effluent filter to achieve 10mg/L TSS.

Advantages	Disadvantages
▪ District already using a similar process ▪ No change to headworks ▪ Medium energy and maintenance costs	▪ Relatively large footprint (similar to SBR) ▪ All new infrastructure

5.5 Rotating Biological Contactor

A rotating biological contactor with clarifier and effluent filtration could achieve the 10/10 effluent target. This is the process used at the Paul Lake WWTP operated by the TNRD.

RBCs rely on the rotor for treatment. The rotor media requires replacement from time to time and metal fatigue will eventually lead to shaft failure. As a result, rotor replacement is typically scheduled every 20 years.

This option does not make use of the existing infrastructure and would not be cost effective in this case.

Advantages	Disadvantages
▪ Simple operation ▪ The system requires little maintenance ▪ No change to headworks ▪ Any odours are easily contained ▪ Low energy costs	▪ Primary treatment required ▪ Crane access needed for installation ▪ Rotor / media life approx. 20 years.

5.6 Alternative Septage Treatment

Clearly if the septage treatment tank is used to treat the main flow the septage pre-treatment function would need to be replaced. One option is to make use of the septage treatment tank temporarily until a full replacement treatment system is constructed. Another option would be to consider a different method for managing septage.

If it is feasible to accept septage during warmer months only then a septage treatment system marketed by Bishop Environmental based on filtering the solids using geotube bags would be feasible. These systems use a geotextile bag to collect and store the solids. The bag is left to dewater and then the solids can be disposed of to landfill. The bag must be replaced with each use. Bags can also be laid out in rented roll-off bins with the bins replaced in the normal way.

The bags cost $1,200 each and their polymer system can be rented for $1,250 per week. This is a basic venturi based emulsion dispersion system which is available for purchase at $25,000. Motor driven emulsion dispersion or dry polymer makeup systems offer better performance. However, sludge dosing is a relatively forgiving application.

Because septage solids are odorous, it is recommended that the system be trialed prior to committing to it. This would also give an opportunity to test the filtrate strength to see what the impact on downstream treatment would be.

As the BOD of the filtrate is likely to remain very high and will have an impact on downstream treatment processes, it may be better to retain the septage treatment tank and build new above ground tanks for wastewater treatment.

That option needs to be weighed against increasing the capacity of the wastewater treatment system to accommodate the impact of the septage filtrate. This may be the most practical option if the high concentration flows can be stored and introduced during off peak periods.

FIGURE 5-6: BISHOP WATER SEPTAGE TREATMENT SYSTEM, EGANVILLE ONTARIO.

6.0 Improvement Option 2: MBBR Pre-Treatment for Solar Aquatics Plant

It is proposed that the most feasible upgrade scenario for the Barriere system is to undertake the majority of treatment at the septage receiving station, with effluent disposal continuing to be managed from the Solar Aquatics building. The most cost effective method of treatment that can be retrofitted to the existing tanks is the moving bed bioreactor described in Section 5.3. Under this option, the MBBR process is added to the existing tank.

Under improvement option 2, the wastewater would be treated in the MBBR tank, but solids would not be separated on-site. After treatment, the mix of effluent and treatment bacteria would be pumped to the solar aquatics plant for further aeration and solids separation. The surge-balancing tank may be converted to a solids separation clarifier in order to avoid build a new tank.

It should be noted that the Municipal Wastewater Regulation requires the duplication of most unit processes, including aeration tanks. As a result, at least one more tank will be needed both for treatment capacity and to allow for maintenance / system failure. At this stage, it has been assumed that the duplication of unit processes would occur in phase two of the upgrade.

This option has a number of advantage and disadvantages.

Advantages	Disadvantages
▪ Minimizes construction of new infrastructure. ▪ Lack of solar aquatics capacity not an issue. Does not give the appearance of a major change to the Solar Aquatics system. ▪ Effluent filters could be installed in greenhouse building, if required by MOE. This would also make it feasible to provide reclaimed water by chlorinating. ▪ Can expand to 500m^3/d by adding MBBR tank. Will need second clarifier tank for MWR reliability requirements.	▪ If used as a clarifier, the exact condition and quality of construction of the surge balancing tank is unknown so costs for rehab could be high (including contractor's risk allowance). Surge-balancing tank off-line for an extended period during construction which affects ability to operate plant. Not necessarily easy to convert tank. Proposed clarifier next to affordable housing. ▪ Performance of the solar tanks is hard to predict. ▪ Sludge processing occurs at solar aquatics site (potential odour, awkward access) ▪ In theory we need two treatment trains for MWR reliability requirements. It is assumed that we apply to construct phase one as a single train. ▪ Cannot accept septage unless go to geotube type system. Septage treatment capacity may depend on balancing the load through the day.

FIGURE 6-1: DESIGN SCHEMATIC FOR PHASE ONE (250M³/D)

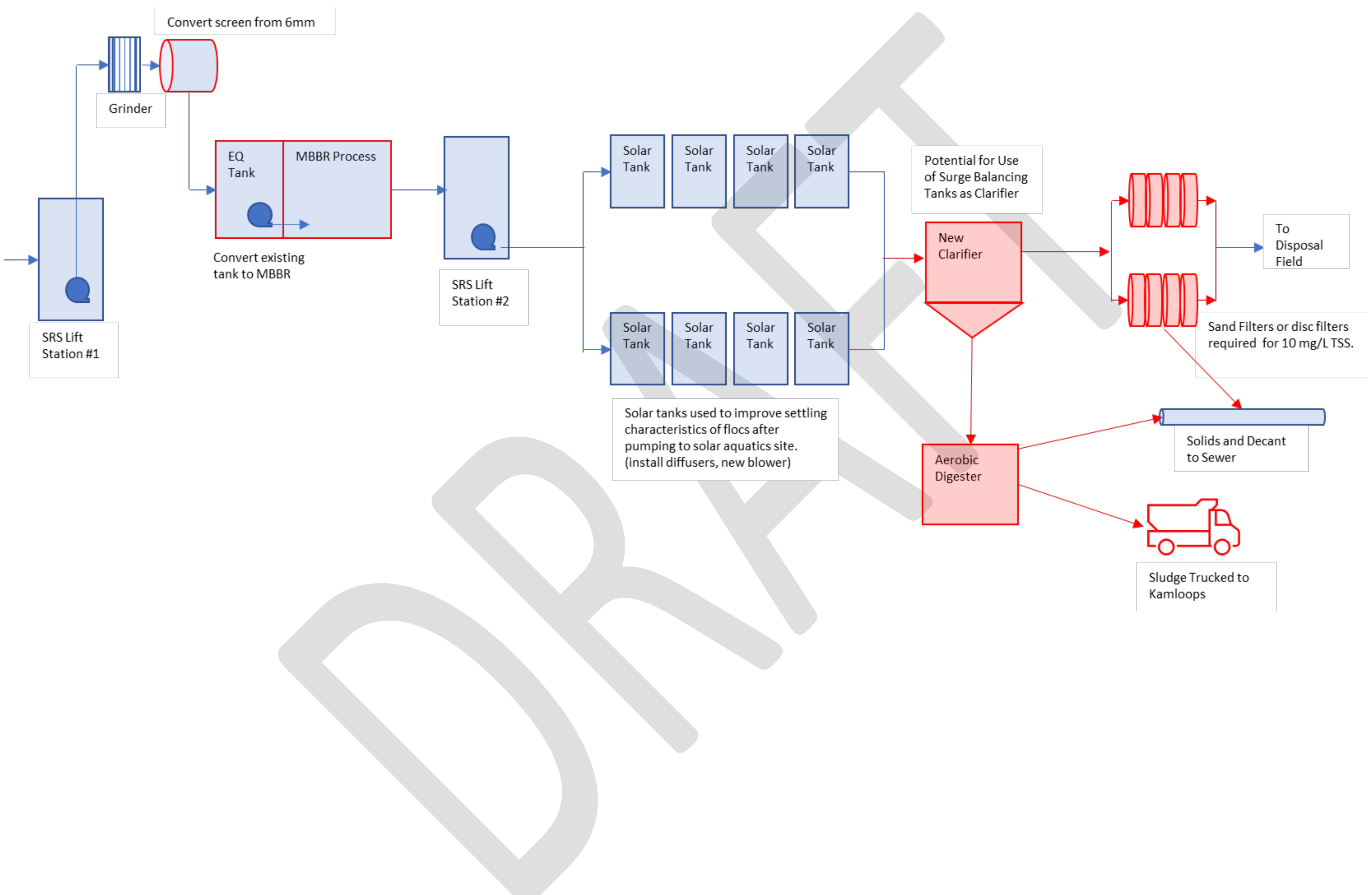
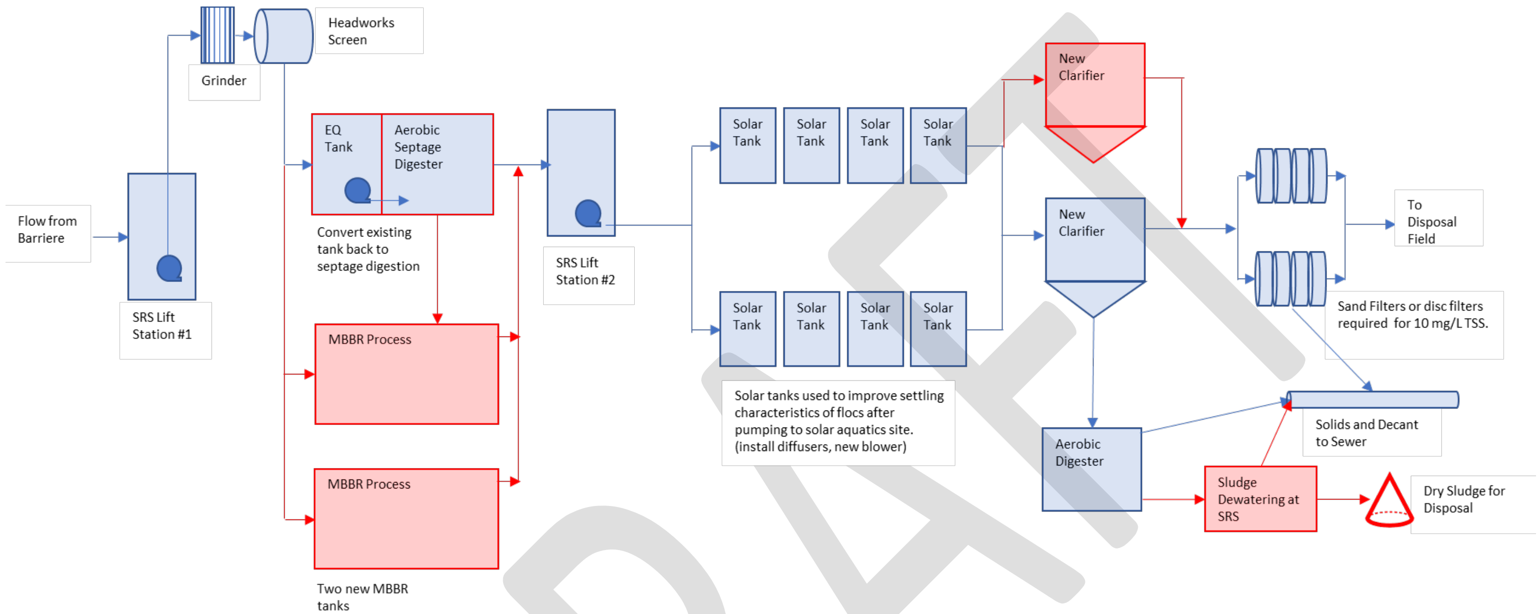


FIGURE 6-2: DESIGN SCHEMATIC FOR PHASE TWO (500M³/D)



7.0 Improvement Option 3: MBBR / Clarifier / Solar Aquatics 'Wetland'

The most cost effective and reliable treatment is expected to be achieved by building a conventional MBBR treatment process at the septage receiving station with treated effluent being pumped to the solar aquatics site for polishing or direct disposal. Sludge removed by the clarifier would be dewatered at the septage receiving facility site.

Under this scenario, a clarifier would be built at the septage receiving station so that secondary effluent is pumped to the Solar Aquatics site, bypassing the surge-balancing tank. If desired, the solar tanks at the solar aquatics site could be used as a form of constructed wetland to remove a portion of the nutrients and possibly achieve a degree of filtration. The solar tanks could also be bypassed for maintenance as necessary without having a significant effect on treatment. It may be that filtration of the effluent is deferred.

If filtration is installed under this upgrade, the solar building would be a practical location. Filter residue could be discharge to the sewer, rather than process it on-site.

This option has a number of advantages and disadvantages.

Advantages	Disadvantages
▪ Effluent Leaves SRS site at 10mg/L BOD ▪ Uses proven technology in a standard configuration so could expect a process guarantee on MBBR performance ▪ Solar tanks used but can be bypassed if they're not performing. Lack of solar aquatics capacity not an issue. Does not give the appearance of a major change to the Solar Aquatics system. ▪ Most of the operation and maintenance occurs at septage receiving facility site. ▪ Can abandon failing surge balancing tank. May be used for effluent storage in a future reclaimed water system. ▪ Only odour would be at SRS (sludge handling, etc.) ▪ Effluent filters could be installed in greenhouse building, if 10mg/L BOD / TSS required by MOE. This would also make it feasible to provide reclaimed water by chlorinating. ▪ Potential for repurposing the solar aquatics building for something else (depending on whether there are filters required).	▪ Must build a new buried clarifier at SRS site which has a high groundwater table (increasing construction costs). ▪ Solar aquatics tanks could make the effluent slightly worse. ▪ Without effluent filters, the infiltration trenches may need more regular replacement than they would otherwise. ▪ Still need to make surge balancing tank safe, even if not using it. ▪ In theory we need two treatment trains for MWR reliability requirements. It is assumed that we apply to construct phase one as a single train and duplicate at phase two. ▪ Cannot accept septage, unless go to geotube type system. Septage treatment capacity may depend on balancing the load through the day.

FIGURE 7-1: DESIGN SCHEMATIC FOR PHASE ONE (250 M^3/D)

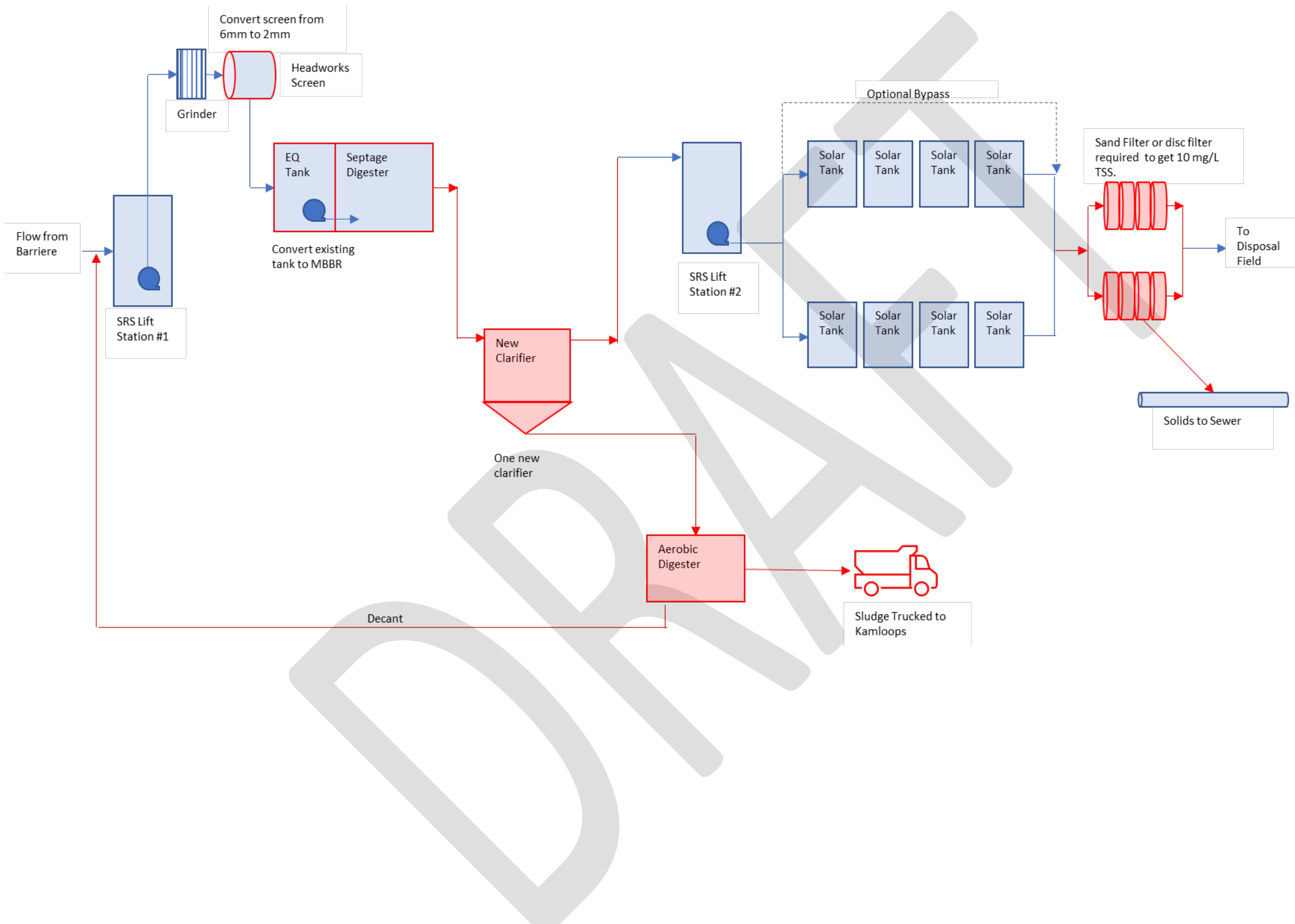
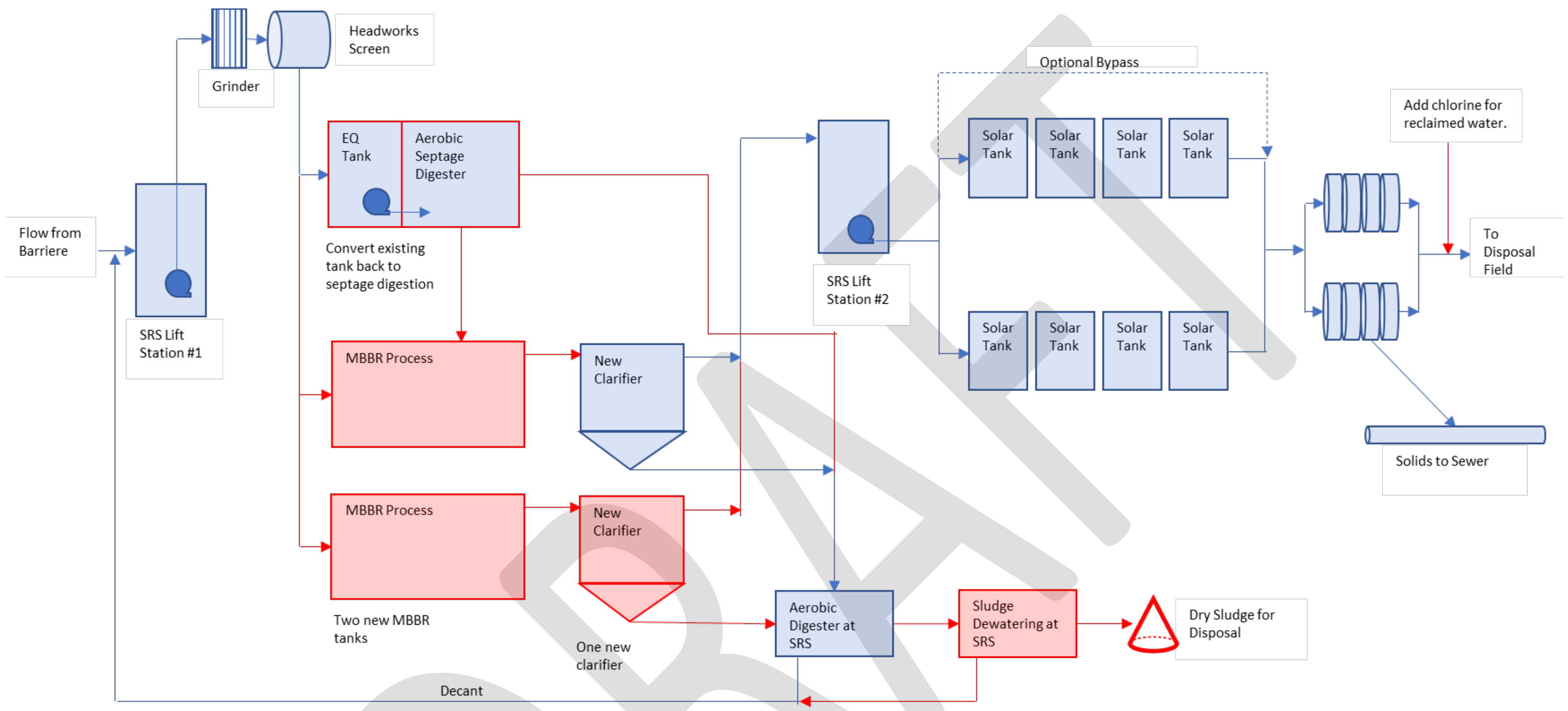


FIGURE 7-2: DESIGN SCHEMATIC FOR PHASE TWO (500M³/D)



8.0 Sludge Treatment and Disposal

There is currently no system for the dewatering of sludge in Barriere. This includes the Riverwalk USBF plant. Whatever the final treatment configuration, it is expected to be more cost effective to dewater sludges. Obviously, in the case of accepting septage, relatively little is achieved if the septage is accepted, digested and then trucked as a liquid to a third-party site.

A dewatering system used at a small municipality needs to use appropriate technology. As such it should be relatively simple.

Most commonly the sludge from small wastewater treatment systems is stored in an aerobic digester. The digester achieves the following

- Destroys up to half of the solids by digestion
- Decanted from time to time to increase solids concentration
- Can achieve class B biosolids for beneficial reuse
- Improves dewatering characteristics
- Stores the sludge so that dewatering can be undertaken when staff are available.

After digestion, the sludge is normally dewatered to reduce disposal costs. There are many alternative technologies, and the selection would be finalized as part of detailed design. Some key considerations for systems in common use in BC are as follows.

System Type and Examples	Comments
Roll off container filter system (District of Clearwater)	▪ Simple to operate ▪ Low capital cost ▪ Low % solids achieved ▪ Could potentially be operated semi outdoors
Draimad bag filter (Village of Montrose, Village of Greenwood)	▪ Simple to operate ▪ Reasonably compact ▪ Must stockpile bags to get dry sludge. ▪ Relatively easy to dispose of bags
Screw press (Village of Salmo)	▪ Higher capital cost ▪ Relatively Dry sludge ▪ Reported to be relatively complex to set up
Centrifuge (Village of Keremeos)	▪ Higher capital cost ▪ Relatively complex operation ▪ High energy consumption ▪ Relatively Dry sludge ▪ More common for larger systems.
Belt Press (Village of Kaslo, Village of Cache Creek)	▪ Higher capital cost ▪ Relatively dry sludge ▪ Low energy consumption

9.0 Conclusions and Recommendations

9.1 Preferred Site

In general terms it is preferable to locate a wastewater treatment plant away from built up areas. At present the plant does not have close neighbors, but there are plans for the construction of multi-family housing adjacent to the WWTP site. This places a significant constraint on the acceptable level of odour from the wastewater treatment processes. At present the odour generated by the surge / blending tank has led to complaints, which are expected to intensify with planned housing in the immediate area. It would be preferable to relocate the treatment processes to a different site so as not to limit development in the Barriere CBD.

As relatively little of the existing infrastructure is suitable for its purpose, it is proposed that the bulk of the wastewater treatment operation occurs at the septage receiving facility site. It should be noted that the groundwater table is seasonally high and a buried treatment tank would be more costly to build than one that is largely above ground.

9.2 Recommended Treatment

Based on the analysis undertaken for this report, Option 3 is recommended for preliminary design (refer to Section 7.0). This chiefly consists of an MBBR system making use of existing tankage at the SRS plant, as well as a new clarifier tank. This MBBR system would be compliant with the MWR requirement of 45 mg/L BOD / TSS for Class C effluent. It is suggested that an application be made to amend the waste discharge to allow for Class C effluent. The Ministry of Environment and Climate Change Strategy may accept this change based on an Environmental Impact Assessment that indicates minimal adverse impacts. This application would need to be supported with evidence from sampling of disposal field monitoring wells.

Based on this scenario, filtration may be needed in the future to achieve 10mg/L TSS required for effluent reuse. The rate of BOD removal could be increased to achieve the 10 mg/L requirement for Class A or B effluent and for effluent reuse by adding reactor media as it is needed. Given the growing population and impending water shortage, a system that can easily be adapted to reuse seems appropriate.

TABLE 9-1: OPTION 1 (SOLAR AQUATICS PLANT)

ITEM	COST
Replace surge-balancing tank with 3 x 80m^3 septic tanks	$310,000
8 x new 20m^3 Solar Tanks and reinforce existing tanks	$80,000
Aeration system installed in Solar Tanks	$175,000
Clarifier installed at Solar Aquatics plant	$226,000
Filtration Building	$105,000
Effluent filtration system in new building	$450,000
Demolish Surge-Balancing Tank and other redundant structures	$50,000
Misc pipework, etc	$40,000
Aerobic digester	$220,000
MCC and control system improvements, SCADA System	$100,000
Sub-total	**$1,750,000**
Engineering and Contingency	**$610,000**
TOTAL	**$2,360,000**

TABLE 9-2: OPTION 2 (MBBR PRE-TREATMENT FOR SOLAR AQUATICS PLANT)

ITEM	COST
Replace 6mm headworks screen with 2mm screen	$17,000
Moving bed bioreactor installed in SRS treatment cell	$295,000
Aeration system installed in existing Solar Tanks	$75,000
Clarifier installed at Solar Aquatics plant	$230,000
Effluent filtration system in Solar Building	$450,000
Demolish Surge-Balancing Tank and other redundant structures	$50,000
Aerobic Digestion	$220,000
Misc pipework, etc	$20,000
SCADA System	$40,000
Sub-total	**1,390,000**
Engineering and Contingency	**490,000**
TOTAL	**$1,880,000**

TABLE 9-3: OPTION 3 (MBBR – CLARIFIER WITH SOLAR AQUATICS POLISHING)

ITEM	COST
Replace 6mm headworks screen with 2mm screen	$17,000
Moving bed bioreactor installed in SRS treatment cell	$295,000
Clarifier installed at SRS plant	$226,000
Aeration system installed in existing Solar Tanks	$75,000
Effluent filtration system in Solar Building	$450,000
Demolish Surge-Balancing Tank and other redundant structures	$50,000
Aerobic Digestion	$170,000
Misc pipework, etc	$20,000
SCADA System	$40,000
Sub-total	**1,463,000**
Engineering and Contingency	**560,000**
TOTAL	**$2,170,000**

Additional allowances may be required for improvements at the Solar Aquatics plant site, such as to improve the building ventilation and replacement of failing disposal fields.

9.3 Annual Operating Costs

Annual operating costs for Option 3 (MBBR-Clarifier with Solar Aquatics Polishing) have been calculated below. These annual operating costs relate primarily to staff time, sludge disposal and electricity. Sludge processing will be a significant expense until dewatering can be implemented.

TABLE 9-4: POWER CONSUMPTION COSTS

Item	kW	No. Connected	No. Duty 1	Runtime (hr/day)	kW-hr/d
Existing equipment / buildings					120
Aeration Blower	3.73	2	1	24	89.5
Filtration	1	2	1	24	24
Sludge Handling	1	2	1	2	2

Total Electricity	236 kWh
Assumed Electrical Cost	$0.10
Total Daily Power Costs	$23.60
Total Annual Power Costs	**$8,500**

TABLE 9-5: OTHER CONSUMPTION / DISPOSAL COSTS (PRIOR TO DEWATERING)

Type	Quantity (m^3/d)	Estimated Unit Cost ($/$m^3$)	Daily Cost
Trucking of Dilute Sludge to Clearwater including Septage Disposal Charges	3	$100	$300

Total Daily Consumption Costs	$300
Total Annual Consumption Costs	**$110,000**

TABLE 9-6: OTHER CONSUMPTION / DISPOSAL COSTS (WITH DEWATERING)

Type	Quantity (m^3/d)	Estimated Unit Cost ($/$m^3$)	Daily Cost
Trucking of Dewatered Sludge to Hefley Creek Landfill including Disposal Charges	0.5	$100	$50

Total Daily Consumption Costs $50
Total Annual Consumption Costs **$18,300**

TABLE 9-7: LABOUR COSTS

Type	Description	Hours/wk	Daily Cost
Daily	Visual check of equipment at additional site	16	$137
Weekly	Sludge processing	4	$34

Total Daily Labour Costs $171
Total Annual Labour Costs **$62,400**

Annual O&M Costs Summary (Without Dewatering)

Total Annual Power Cost	$7,600
Total Annual Consumption / Disposal Cost	$110,000
Total Annual Labour Costs	$50,000
Total Estimated Annual O&M Costs	**$170,000**

Annual O&M Costs Summary (With Dewatering)

Total Annual Power Cost	$8,600
Total Annual Consumption / Disposal Cost	$36,300
Total Annual Labour Costs	$62,400
Total Estimated Annual O&M Costs	**$90,000**

9.4 Lifecycle Costs

The annual cost of facility ownership for the upgrade has been calculated for Option 3 at full buildout, taking into account the costs of constructing and operating the system. These costs are summarized in this section. The life cycle cost is broken down as follows:

Life cycle cost = Ownership Cost + Operating Cost

Ownership cost has been calculated based on the following formula:

Ownership Cost = Initial Cost / AP

Where,

AP = [(i(1+i)N)/((1+i)N -1]

i = 5% (inflation 2% and discount rate 3%)

N = The number of years of expected life

TABLE 9-8: EXPECTED OWNERSHIP COST FOR TREATMENT PLANT

	Civil	Mechanical / Electrical
Facility Capital Cost	$360,000	$1,520,000
Expected Life (years)	80	20
Factor	0.05	0.08
Annual Value of Replacement Cost	$18,000	$122,000

The Life Cycle Cost for the wastewater treatment upgrade at buildout is summarized as follows;

Ownership cost $140,000 per annum

Operating cost $90,000 per annum

Life cycle cost $230,000 per annum

It is proposed that a capital asset replacement fund would set aside funds to cover the ownership of the new assets.

9.5 Staging

9.5.1 Immediate Term Operational Changes

District staff have made a number of recent changes to the system which have led to some significant improvements in plant performance. These have included;

1. Aeration improvements in the septage treatment tank which is currently being used as part of the main treatment process.
2. Vortex aeration replaced with air diffusers in six of the eight solar tanks.
3. New 150 micron screens on the effluent drum filter.
4. 1 micron bag filters
5. Increased cleaning of the quartz sleeves inside the UV disinfection units.

The District also plans to repair the effluent decanter unit that would normally allow settling of solids in the septage treatment tank. This would allow the tank to be operated as a high rate sequential batch reactor. Some simple control improvements will be needed to allow the plant to operate as a sequential batch reactor. The main challenge with this approach will be that the plant lacks adequate flow balancing to fully permit effluent decanting while inflow continues. The balancing tank practical working volume is up to around $15m^3$. This may only allow 15 – 20 minutes of decanting at peak times before the flow starts to enter the aeration tank.

While the tank will be overloaded for production of secondary quality effluent, it will perform a useful role as pre-treatment for the Solar Aquatics plant. Sludge removed at the SRS site will be either pumped out and stored for trucking to disposal, or pumped with the treated wastewater to the Solar Aquatics plant.

The District will also convert the headworks screen from a 6mm perforation to a 2mm perforation in 2021 in order to further reduce the load on downstream processes.

9.5.2 Phase One Collection System

The recommended improvements described in Section 9.2 of this report relate to achieving close to the original treatment objectives for the Phase One collection system plus the planned affordable housing development.

If budget limitations require, the proposed Option 3 upgrade could be split into stages. The staging could be as follows;

1. Install the headworks screen upgrade, the MBBR media and the aeration system to reduce the load on the existing plant.
2. Install clarification to allow the process to operate without the existing Solar Aquatics system.
3. Install filtration to get effluent BOD and TSS down to target levels.
4. Construct permanent sludge handling systems.

5. Demolish redundant structures.

The original SRS system design allowed space for a blower in the existing electrical room. Therefore, a new blower room could be delayed to Phase Two under the concepts being considered. If a dewatering building is constructed at the SRS site then it would be combined with the blower building.

9.5.3 Phase Two Collection System

The Phase One treatment includes the short-term upgrades that would be needed to allow the District to meet its obligations for regulatory compliance. The upgrade would be based on a single train treatment system. A two train system will be needed to comply with MOE requirements and for reliability and practicality of maintenance. This second treatment train is proposed for Phase Two (subject to the consent of MOE).

Phase Two represents the longer-term collection system scenario with an upgrade of treatment to 500m^3/d. This could be completed once grant funding was secured. The Phase Two costs have not been calculated at this time.

The Phase Two upgrade is expected to consist of the duplication of the treatment process. The duplication would allow the process to treat 75% of the flow with one train out of service, which will improve overall reliability as well as ease of maintenance. The effluent disposal fields would also be extended. Other items that may form part of the Phase Two scope include;

- Improve treatment / disinfection systems for unrestricted beneficial reuse of effluent and potentially extend the effluent reuse distribution system. Effluent with 'greater exposure potential' for people requires a high level of treatment and chlorine disinfection.
- Rehabilitate Surge / Balancing tank for additional effluent storage.
- Construct septage receiving treatment infrastructure.
- Connect the Riverwalk collection system to the main treatment system to reduce the number of plants that must me maintained and operated.
- Upgrades for effluent re-use with potential for human contact, such as irrigation of Bradford Park with reclaimed water from the Riverwalk WWTP.

9.6 Recommendations and Next Steps

The suggested approach to upgrading the facilities would be Option 3. It is effectively equal in cost to option 2 and keeps the wastewater treatment function primarily at the SRS site. Treatment performance is expected to be more predictable as the process is relatively conventional and sludge treatment and dewatering can occur at the same site.

It is clear that the costs indicated for the full phase one upgrade are prohibitive for an unbudgeted and internally funded project. As a result, it may be necessary to limit the initial work to the MBBR system and clarifier. Aspects such as filtration, and sludge management may need to be deferred.

Deferring filtration will mean that the 10mg/l effluent TSS target is not achieved. Deferring sludge management will mean that dilute liquid sludge will need to be trucked to Kamloops for disposal.

The next phase in this project would typically be to prepare a preliminary design and more detailed costing based on the preferred design concept.

The circumstances and details of this design are relatively complex. As such, we would be pleased to present the concepts and challenges to the Councilors and staff at their convenience.

APPENDIX A

MBBR Literature